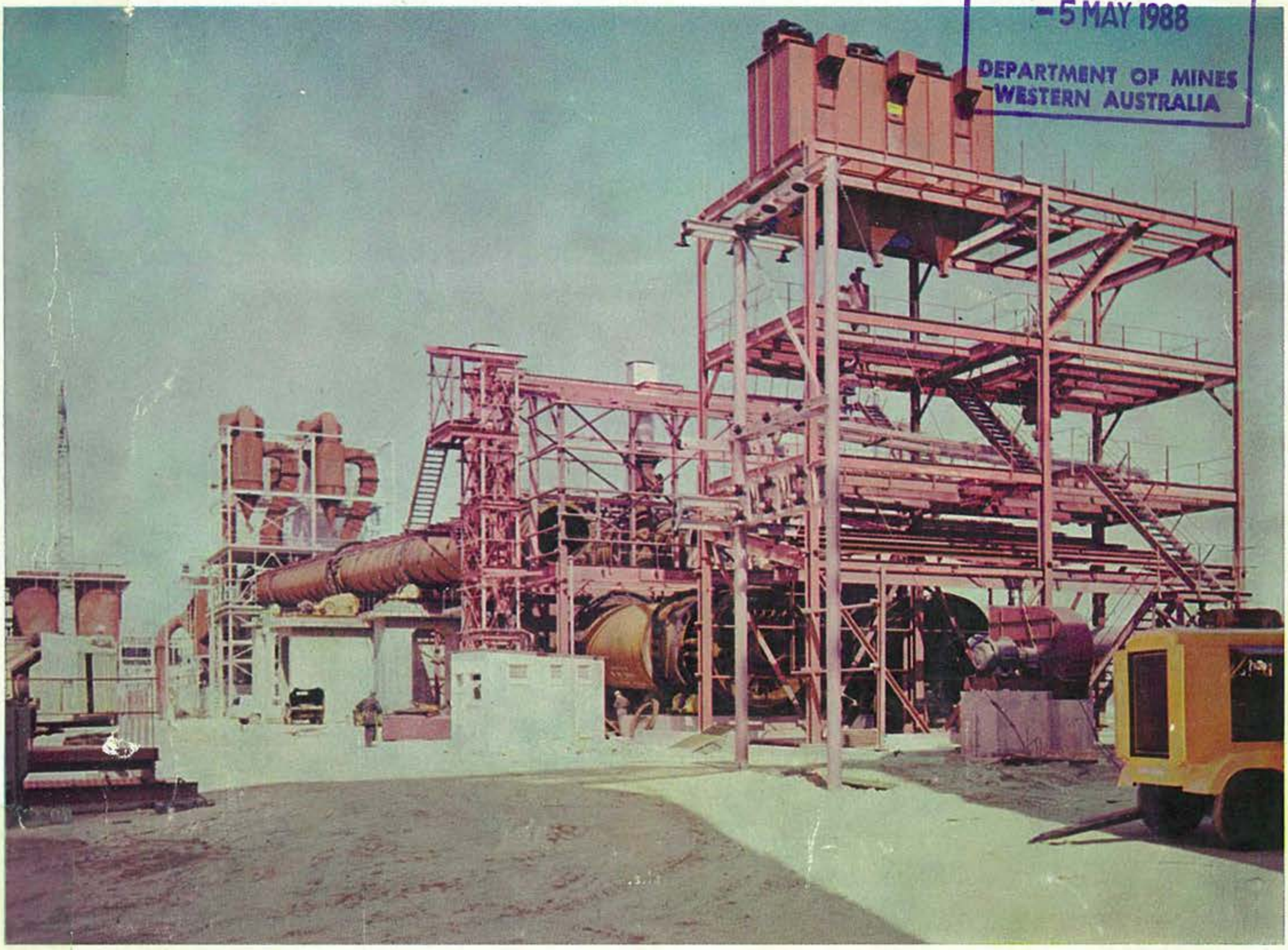

ALUMINA REFINERY, KWINANA, W.A.

ANNUAL REPORT

1962 DEPARTMENT OF MINES WESTERN AUSTRALIA

PRESENTED TO BOTH HOUSES OF PARLIAMENT BY HIS EXCELLENCY'S COMMAND

R E P O R T O F T H E

DEPARTMENT *of* MINES

WESTERN AUSTRALIA

FOR THE YEAR 1962

By Authority: ALEX. B. DAVIES, Government Printer
1963

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To the Hon. Minister for Mines.

Sir,

I have the honour to submit the Annual Report of the Department of Mines of the State of Western Australia for the year 1962, together with reports from the officers controlling Sub-Departments, and Comparative Tables furnishing statistics relative to the Mining Industry.

I have the honour to be, Sir,

Your obedient Servant,

A. H. TELFER,

Under Secretary for Mines.

Perth, 1963.

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STATE OF WESTERN AUSTRALIA

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Report of the Department of Mines for the Year 1962

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DIVISION I

The Honourable Minister for Mines:

I have the honour to submit for your information a report on the Mining Industry for the year 1962.

The estimated value of the mineral output of the State for the year was £A23,096,800, an increase of £A719,960 in value compared with that for the preceding year, constituting yet another all time record for the sixth successive year.

The estimated value of gold received at the Perth Branch of the Royal Mint and exported in gold-bearing material was £A13,435,730, being the fifth highest value recorded for that mineral, and equalled 58.17 per cent. of all minerals for 1962.

(See footnote to Table (1) (a), Part 11.)

Other minerals realised: Coal £1,980,778; asbestos, £1,693,036; iron ore (for export), £1,309,643; manganese, £1,155,862; iron ore (for pig), £1,016,290; ilmenite, £911,606; pyrites (for sulphur), £356,290; tin concentrates, £334,269; copper ore and concentrates, £196,718; silver, £117,661; cupreous ore and concentrates (fertiliser), £94,569; gypsum, £87,879; talc, £71,810; clays, £62,076; tanto-columbite ores and concentrates, £58,874; zircon, £44,343; beryl, £32,452; monazite, £28,544; limestone, £24,008; rutile, £19,906; lead ores and concentrates, £15,156; leucoxene, £10,767; copper (metallic by-product), £8,680; glass sand, £7,708; felspar, £6,884; scheelite, £3,883; barytes, £3,116; building stone (spongolite), £2,994; magnesite, £1,593; bentonite, £1,213; phosphatic guano, £680; fuller's earth, £480; petalite, £403; spodumene, £347; diatomaceous earth, £300; semi precious stones (chalcedony), £200; bismuth, £40; and quartz grit, £21.

Coal production from the two operating Companies in the Collie Coalfield showed an all round improvement in tonnage, value and men employed, whilst the proportion of deep and open cut coal mining was maintained on a comparable basis with that of the previous year, as was the overall average value per ton.

Comparative figures for the last three years were as follows:

	1960	1961	1962
Tons	922,393	765,740	919,112
Total Value	£2,439,195	£1,680,259	£1,980,778
Average value per ton	52·888 sh.	43·886 sh.	43·102 sh.
Average effective workers	984	582	757
Proportion of deep mined coal	86·53%	66·12%	65·12%

Evidence of a steadily expanding sphere of activity was reflected by the value of £7,680,292 reported for Minerals other than Gold and Coal, which figure created another all time record for the seventh successive year and an advance of 9.88 per cent. over the preceding year, bringing the annual aggregate for all minerals to £23,096,800, the highest mineral production value ever achieved by the State.

(See Tables 1 and 1 (a), Part 11.)

Dividends paid by gold mining companies amounted to £2,085,802, a decrease of £99,981 when compared with the previous year. (See Table 5, Part 11.)

To the end of 1962, the progressive total distributed by gold mining companies was £68,786,913.

To the same date the progressive value of the whole mineral production of the State amounted to £580,568,452, of which gold accounted for £470,814,744. (See Table VI at back.)

GOLD

The quantity of gold reported as being received at the Perth Branch of the Royal Mint (854,829.18 fine ounces), together with that contained in gold-bearing material exported for treatment (4,539.02 fine ounces), totalled 859,368.20 fine ounces, which was 12,476.77 fine ounces less than the previous year (vide Table 1 (A) of Part II.)

The total gold yield reported directly to the Department by the producers was 860,039.22 fine ounces, a decrease of 10,618.68 fine ounces.

The variation between the two annual totals being principally due to the fact that the gold advised as being received at the Mint and contained in material exported for treatment, is not necessarily produced during the calendar year under review, a certain quantity being always in the transitory stage from the producer at the end of the year. The former total is accepted as the official gold production of the State on account of its realised monetary value, whilst the latter is utilised in tracing the gold back to its source, i.e. individual mine production, to which its respective ore tonnage can be applied, and so furnish a record of the physical aspect of mining so necessary and valuable for geological and professional purposes.

The tonnage of ore reported to have been treated in 1962, viz. 2,989,653 tons, was 5,195 tons more than the previous year and constituted 69.66% of the State record tonnage established in 1940.

The following tonnage increases were reported from the respective Goldfields—West Pilbara 83, Murchison 4,527, Yalgoo 492, North Coolgardie 2,267, East Coolgardie 11,646, Coolgardie 9,438 and Dundas 6,823; those fields showing a reduction in tonnage being Pilbara 2,991, Gascoyne 32, Peak Hill 990, East Murchison 358, Mt. Margaret 13,374, Broad Arrow 285, Yilgarn 11,926 and south-West Mineral Field 143.

East Coolgardie Goldfield, with an ore treatment output of 2,027,855 tons, showed an increase of 11,646 tons and came within 41,309 tons of its highest figure established in 1960.

An interesting feature which perhaps could be mentioned here is that the famous "Golden Mile" locality of Kalgoorlie and Boulder mining centres, contained in this goldfield, has to date contributed 55.66 per cent. of the State's ore tonnage and 55.94 per cent. of its gold.

During the current year the four principal companies now operating there, treated ore averaging a shade lower in grade as compared with the previous year with the 12,946 tons increase by the Lake View & Star Ltd., more than compensating the slight variations reported elsewhere.

Central Norseman Gold Corporation N.L. virtually accounted for the whole increase reported from the Dundas Goldfield, where their grade of ore treated rose to 11,550 dwts, from a previous 11.226 dwts. per ton.

In the Murchison Goldfield the Hill 50 Gold Mine N.L. treated 165,698 tons for a recovery of 10.525 dwts. per ton, an increase of 8,502 tons in comparison with last year's operations when a similar grade of ore was handled. This tonnage increase, however, was partially offset by the 2,464 ton recession reported by Eclipse Gold Mines N.L. which treated 6,086 tons of higher grade ore averaging 22.206 dwt. per ton against the 18.386 dwts. shown during the previous year.

The drop in the Mt. Margaret Goldfield was due to the restricted operations of the Sons of Gwalia Ltd. which treated 14,222 tons of ore less, and of a slightly lower grade, than the previous period under comparison.

The 9,438 ton improvement in the Coolgardie Goldfield was occasioned by the Paris Gold Mines Pty. Ltd., which completed its first full year's run of the new grinding and flotation plant, and its throughput of 18,276 tons was an advance of 12,736 tons over the previous year's operations. The Bayley's South mine operated by Gold Mines of Kalgoorlie (Aust.) Pty. Ltd. produced only 12,530 tons as against the 17,219 recorded for the previous year, whilst the grade of ore there dropped from 11.266 dwts. to 7.399 dwts. per ton.

In the North Coolgardie Goldfield the Moonlight Wiluna Gold Mines Ltd. showed a slight all round improvement in tonnage, recovery and grade.

The gold mining industry is most fortunate in the harmonious relationship which has existed in its working forces over a considerable period, and is to be congratulated on the manner in which it has steadfastly sought to alleviate the constant threat of rising costs in the production of a static priced commodity.

As the average value of the State's gold yield in recent years approximates £13½ millions, and comprises 80% of the Commonwealth gold output, its relative economic significance as a national asset is quite apparent, and the industry would appear well worthy of particular consideration for its conservation, especially in view of the future increased trading prospects of the nation.

West Australian gold included in sales on open dollar markets by the Gold Producers' Association Ltd., for the period from August 1961 to July 1962, totalled 528,827.20 fine ounces; the extra premium received therefrom in excess of Mint Value amounted to £A8,104, an overall average of 3.678 pence per fine ounce. This amount, less expenses was distributed to the producer members during the year and approximated 3.064 pence per fine ounce.

Subsidy payments made by the Commonwealth Government during the year under the Gold Mining Subsidy Act 1954, totalled £621,569, an increase of £146,318 on the previous year. Of the amount distributed, £590,239 went to Large Producers, and £31,330 to Small Producers in this State.

In general terms, the year 1962 may be considered as a period in which Western Australia's mineral industry greatly enhanced its status in the future national economy, and maintained its overall progress in terms of exploration, development consolidation and productivity.

COMPARATIVE MINERAL STATISTICS

——	1961	1962	Variation
GOLD—			
Reported to Department (Mine Production)—			
Ore (tons)	2,984,458	2,989,653	+ 5,195
Gold (fine ounces)	870,658	860,039	— 10,619
Average Grade (dwts. per ton)	5·835	5·753	— 0·082
Persons Engaged—			
(a) Effective Workers (excluding absentees)	4,945	4,963	+ 18
(b) Total Pay Roll	5,337	5,353	+ 16
Dividends (£A)	2,185,783	2,085,802	— 99,981
Mint and Export (Realised Production)—			
Gold (fine ounces)	871,845	859,368	— 12,477
Estimated Value (£A) (including Overseas Gold Sales Premium)	13,706,890	13,435,730	— 271,160
COAL—			
Reported to Department (Mine Production)—			
Tons	765,740	919,112	+ 153,372
Value (£A)	1,680,259	1,980,778	+ 300,519
Persons Engaged—			
Effective Workers (excluding absentees)	582	757	+ 175
OTHER MINERALS—			
Reported to Department—			
Value (£A)	6,989,691	7,680,292	+ 690,601
Persons Engaged—			
Effective Workers (excluding absentees)	1,530	1,501	— 29
TOTAL ALL MINERALS—			
Value (£A)	22,376,840	23,096,800*	+ 719,960
Persons Engaged—			
Effective Workers†	7,057	7,221	+ 164

* Sixth successive all time record.

† Excluding Oil Search Men which engaged an average of 45 men in the field in 1961 and 154 men in the field in 1962.

PART II—MINERALS.

During the year Royalty totalling £126,248 as against £99,149 for the preceding year, was collected under legislation passed in 1958, on certain prescribed minerals obtained from land held under the Mining Act.

Gold was exempted from royalty liability, and payment on Copper, Lead and on Mineral Beach Sands, temporarily suspended on account of the depressed state of the market.

Royalty has been collected on Coal practically from inception of production and on Iron Ore (for Export), from 1951.

Particulars for the year are shown hereunder:—

Mineral	Amount per ton s.	d.	Royalty collected £	s.	d.
Asbestos	1	6	1,092	15	0
Barytes		6	12	8	0
Bentonite		6	12	2	6
Beryl	2	0	15	6	0
Building Stone	1	0	33	19	0
Clays		6	1,006	1	11
Coal		3	11,121	11	3
Felspar		6	24	12	6
Fullers Earth		6	3	0	0
Glass Sand and Quartz Grit		6	233	7	0
Gypsum		6	1,287	12	4
Iron Ore (export only)	1	6	100,911	6	0
Limestone		6	421	19	2
Magnesite	1	6	111	15	0
Manganese	1	6	7,458	9	9
Ochre		6	7	8	6
Petalite	1	0	1	10	0
Phosphatic Guano	1	0		8	0
Pyrites	1	0	2,266	11	0
Spodumene	1	0	1	19	6
Tanto/Columbite	*		189	14	6
Tin	2	0	34	2	0
Total			£126,247	18	11

* One-half per centum of the realised F.O.B. Value.

The systematic investigation of the iron ore resources of Western Australia has been continued this year and has confirmed that this State can be ranked among the largest iron ore regions of the world.

Deposits in the Hamersley Range eclipse in magnitude all others in the State and Commonwealth and a great deal of work remains to be done before the total potential of this region can be reliably assessed.

From the data available the total known iron ore potential of the State is of the order of 8,000 million tons. It appears certain that further exploration will substantially increase these reserves, particularly those of the higher grade, direct shipping hematite—goethite ores.

The Mount Goldsworthy Associates have carried out extensive exploratory work on the iron ore deposits in the Mount Goldsworthy area and investigations regarding the proposed railway, harbour and townsites in connection with the venture.

At Tallering Peak and Koolonooka, the Western Mining Corporation has been carrying out extensive surveys regarding their deposits with a view to obtaining contracts for the export of iron ore to Japan within the next two or three years.

Work on the Alumina Refinery at Kwinana is ahead of schedule and Western Aluminium expect to commence treating bauxite from the Darling Range before the end of 1963.

A thorough examination of the Greenbushes Tin Field is being undertaken by Aberfoyle Tin N.L. If the results prove satisfactory it is likely that the Company will in the near future undertake production on a large scale.

The Whim Creek copper mine is being examined by Japanese experts and the installation of machinery at the mine will commence shortly.

COAL

During the year ended the 31st December, 1962, the coal production amounted to 919,112 tons an increase of 153,372 tons over last year's production.

The coal contracts continue to operate satisfactorily and as indicated by the above figures the production is keeping pace with the demand for coal.

OIL

The search for oil has been continued, but without success. Several new Permits to Explore have been taken up, and geological and seismic surveys have been carried out.

WATER

The Department's Hydrological Branch of the Geological Survey is very fully occupied on the survey of the water potential of the State. Drilling for water is being done for other Government Departments. Assistance has been given to property owners to find water on their locations.

TABLE 1

Quantity and Value of Minerals, other than Gold and Silver, produced during Years 1961 *and* 1962
Western Australia

Description of Minerals	1961		1962		Increase or Decrease for Year compared with 1961	
	Quantity	Value	Quantity	Value	Quantity	Value
	Tons	£A	Tons	£A	Tons	£A
Asbestos (Chrysotile)	156·13	2,629	52·50	1,103	— 103·63	— 1,526
(Crocidolite)	14,086·59	1,532,540	15,616·95	1,691,933	+ 1,530·36	+ 159,393
Barytes	....	....	494·35	3,116	+ 494·35	+ 3,116
Bauxite	9,849·00	†	....	....	— 9,849·00	†
Bentonite	586·70	1,598	485·00	1,213	— 101·70	— 385
Beryl	260·85	40,079	195·46	32,452	— 65·39	— 7,627
	Lb.		Lb.		Lb.	
Bismuth	911·00	371	181·00	40	— 730·00	— 331
	Tons		Tons		Tons	
Building Stone	4·45	53	....	....	— 4·45	— 53
(Spongolite)	....	....	669·00	2,994	+ 669·00	+ 2,994
Clays (Cement Clay)	17,864·00	17,909	21,634·73	21,149	+ 3,770·73	+ 3,240
(Fireclay)	26,383·75	30,710	24,784·50	28,808	— 1,599·26	— 1,902
(White Clay—Ball Clay)	771·60	3,067	682·00	4,030	— 89·60	+ 963
(Brick, Pipe and Tile Clay)	*16,218·00	17,791	*7,112·00	8,080	— 9,106·00	— 9,711
Coal	765,739·73	1,680,259	919,112·00	1,980,778	+ 153,372·27	+ 300,519
Copper (Metallic By-product)§	16·46	2,128	47·20	8,680	+ 30·74	+ 6,552
Copper Ore and Concentrates	6,188·72	320,371	5,063·22	196,718	— 1,125·50	— 123,653
Cupreous Ore and Concentrates (Fertiliser)	7,383·82	157,488	9,275·18	94,569	+ 1,891·36	— 62,919
Dolomite	374·00	1,496	....	....	— 374·00	— 1,496
Diatomaceous Earth	....	....	15·00	300	+ 15·00	+ 300
Felspar	1,190·00	5,210	1,267·00	6,884	+ 77·00	+ 1,674
Fullers' Earth	40·76	163	120·00	480	+ 79·24	+ 317
Glass Sand	8,214·78	5,861	10,325·62	7,708	+ 2,110·84	+ 1,847
Gypsum	45,145·03	62,844	51,650·13	87,879	+ 6,505·10	+ 25,035
Iron Ore (For Pig)	80,437·00	1,088,192	72,168·00	1,016,290	— 8,269·00	— 71,902
(For Export)	1,284,768·00	1,274,053	1,320,355·00	1,309,643	+ 35,587·00	+ 35,590
Lead Ores and Concentrates	597·05	25,766	443·03	15,156	— 154·02	— 10,610
Limestone	*14,199·15	18,839	*36,481·25	24,008	+ 22,282·10	+ 5,169
Lithium Ores—Petalite	96·00	409	84·00	403	— 12·00	— 6
Spodumene	5·00	85	24·15	347	+ 19·15	+ 262
Magnesite	9,624·92	64,977	224·01	1,593	— 9,700·91	— 63,384
Manganese (Metallurgical, Battery and Low Grades)	67,652·14	884,262	89,602·58	1,155,862	+ 21,950·44	+ 271,600
Mineral Beach Sands (Ilmenite)	123,538·46	557,889	205,804·96	911,606	+ 82,266·50	+ 353,717
(Monazite)	1,005·20	25,699	950·15	28,544	— 55·05	+ 2,845
(Rutile)	552·84	11,953	874·27	19,906	+ 321·43	+ 7,953
(Leucoxene)	268·10	4,120	788·55	10,767	+ 520·45	+ 6,647
(Zircon)	6,098·90	61,314	4,132·47	44,343	— 1,966·43	— 16,971
Ochre (Red)	117·22	702	....	....	— 117·22	— 702
(Yellow)	177·05	1,068	....	....	— 177·05	— 1,068
Phosphatic Guano	115·00	807	68·00	680	— 47·00	— 127
Pyrites Ore and Concentrates (For Sulphur)	52,397·00	369,094	49,461·00	356,290	— 2,936·00	— 12,804
Quartz Grit	58·20	58	25·00	21	— 33·20	— 37
	Lb.		Lb.		Lb.	
Semi-precious Stones (Chalcedony)	....	....	448·00	200	+ 448·00	+ 200
	Tons		Tons		Tons	
Talc	51,149·28	64,581	4,980·95	71,810	— 168·33	+ 7,229
Tanto/Columbite Ores and Concentrates	14·20	22,917	19·24	58,874	+ 5·04	+ 35,957
Tin	341·16	235,580	465·44	334,269	+ 124·28	+ 98,689
Tungsten Ores and Concentrates —Scheelite	....	....	7·35	3,883	+ 7·35	+ 3,883
Total	....	8,594,932	....	9,543,409	....	+ 948,477

TABLE 1 (A)

Quantity and Value of Gold and Silver Exported and Minted during Years 1961 *and* 1962

Description of Minerals	1961		1962		Increase or Decrease for Year compared with 1961	
	Quantity	Value	Quantity	Value	Quantity	Value
	Fine oz.	£A	Fine oz.	£A	Fine oz.	£A
Gold (Exported and Minted)	871,844·97	‡13,706,890	859,368·20	‡13,435,730	— 12,476·77	— 271,160
Silver (Exported and Minted)	179,992·12	75,018	248,460·93	117,661	+ 68,468·81	+ 42,643
Total	....	13,781,908	....	13,553,391	....	— 228,517
GRAND TOTAL	....	22,376,840	....	23,096,800	....	+ 719,960

* Incomplete—figures relate only to production reported to the Department from holdings under the Mining Act.
† Value not available for publication.
‡ Including Overseas Gold Sales Premium.
§ Product of Gold Mining.

DIAGRAM OF GOLD OUTPUT

SHOWING TONNAGES TREATED AS REPORTED TO MINES DEPT., THE TOTAL OUTPUT OF GOLD BULLION CONCENTRATES ETC. ENTERED FOR EXPORT AND RECEIVED AT THE PERTH MINT AND THE ESTIMATED VALUE THEREOF IN AUSTRALIAN CURRENCY

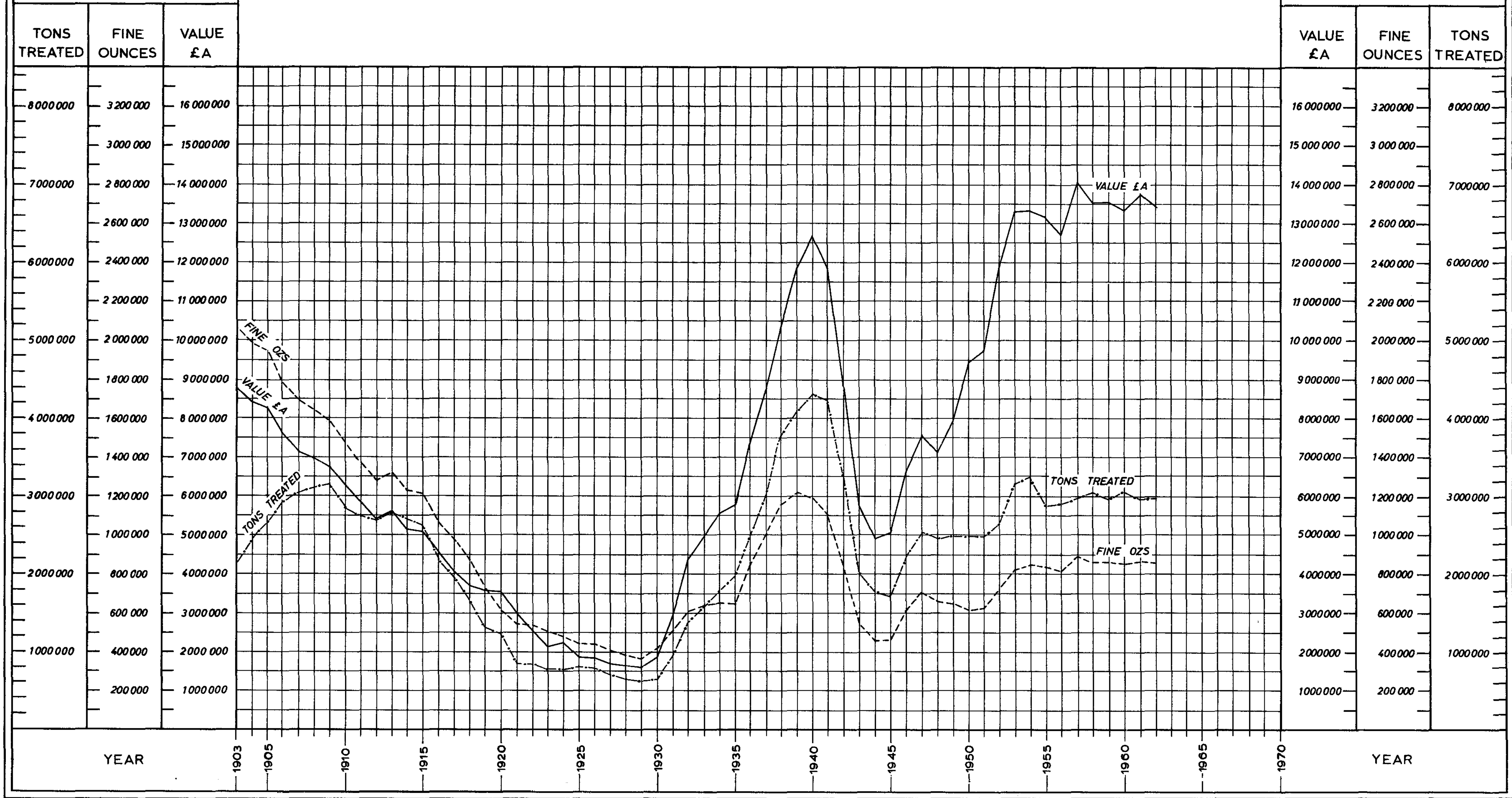


TABLE 2

Value of Total Exports and Mineral Exports from Western Australia, as compared with Total Value of Mineral Production as from 1900

Year	Total Exports †	Mineral Exports (exclusive of (Coal)	Total Mineral Production
	£	£	£
1900	6,852,054	5,588,299	6,179,535
1901	8,515,623	6,789,133	7,439,470
1902	9,051,358	7,530,319	8,094,616
1903	10,234,732	8,727,060	8,971,937
1904	10,271,489	8,625,676	8,686,757
1905	9,871,019	7,731,954	8,555,841
1906	9,832,679	7,570,305	7,905,506
1907	9,904,860	7,544,992	7,669,468
1908	9,518,020	7,151,317	7,245,002
1909	8,860,494	5,906,673	7,056,079
1910	8,299,781	4,795,654	6,522,263
1911	10,606,863	7,171,638	6,105,853
1912	8,941,008	5,462,499	5,768,567
1913	9,128,607	4,608,188	6,036,115
1914	8,406,182	3,970,182	5,534,273
1915	6,291,934	2,969,502	5,478,149
1916	10,878,153	6,842,621	4,893,417
1917	9,323,229	5,022,694	4,629,028
1918	6,931,834	2,102,923	4,265,577
1919	14,279,240	6,236,585	4,061,600
1920	15,149,323	3,096,849	4,233,915
1921	10,331,405	1,373,810	3,470,597
1922	11,848,025	2,875,402	3,041,113
1923	11,999,500	3,259,476	2,747,108
1924	13,808,910	1,424,319	2,776,791
1925	13,642,852	173,126	2,393,890
1926	14,668,184	1,597,698	2,371,863
1927	15,805,120	472,041	2,202,438
1928	16,911,932	996,099	2,128,179
1929	16,660,742	1,802,709	2,087,893
1930	19,016,639	6,370,396	2,287,376
1931	14,266,650	4,333,421	3,353,923
1932	16,771,465	5,657,870	4,721,620
1933	18,098,214	5,328,869	5,239,498
1934	16,784,705	5,759,324	5,908,881
1935	17,611,547	5,698,721	6,132,811
1936	19,564,716	7,130,381	7,818,684
1937	21,594,942	9,026,313	9,210,079
1938	24,220,864	10,417,458	10,906,527
1939	23,244,509	11,969,562	12,331,659
1940	25,800,562	12,480,721	13,228,660
1941	24,536,777	12,411,316	12,398,141
1942	20,681,284	8,476,622	9,509,646
1943	18,014,340	6,539,295	6,401,594
1944	19,453,001	(*a*) 1,282,867	5,737,096
1945	20,170,624	205,587	5,910,518
1946	26,342,125	211,890	7,693,951
1947	42,389,125	4,162,892	8,862,292
1948	57,779,996	342,646	8,584,843
1949	58,197,775	465,124	9,629,300
1950	78,804,864	531,245	11,489,897
1951	115,880,457	7,479,601	12,706,228
1952	101,620,138	7,952,834	17,126,506
1953	106,678,014	13,239,076	19,358,268
1954	79,955,207	5,342,462	19,953,665
1955	113,044,633	17,145,741	18,893,161
1956	142,852,512	9,531,471	19,447,510
1957	148,128,361	12,483,343	21,007,393
1958	123,624,508	5,464,465	20,570,701
1959	137,067,544	4,536,105	21,796,605
1960	190,494,475	43,302,398	21,826,524
1961	197,204,812	21,070,266	22,376,840
1962	176,424,488	10,893,040	23,096,800

† Including Ships' Stores.

(*a*) Full value and use of gold, not always exported, as utilised by the Commonwealth Treasury in the financing of Australian Trade Economy from 1944, not available.

TABLE 3

Showing for every Goldfield the amount of Gold reported to the Mines Department as required by the Regulations, also the percentage for the several Goldfields of the total reported and the average value of the yield in pennyweights per ton of ore treated

Goldfield	Reported Yield		Percentage for each Goldfield		Average Yield per ton of ore treated	
	1961	**1962**	1961	**1962**	1961*	**1962***
	Fine oz.	Fine oz.	Per cent.	Per cent.	Dwts.	Dwts.
1. Kimberley	16	**31**	·002	**·004**	....	....
2. West Kimberley	....	....	....	....	....	....
3. Pilbara	4,639	**1,603**	·533	**·186**	12·608	**7·340**
4. West Pilbara	4	**9**	....	**·001**	3·333	**1·682**
5. Ashburton	....	....	....	....	....	....
6. Gascoyne	452	**274**	·052	**·032**	65·985	**52·190**
7. Peak Hill	329	**269**	·038	**·031**	1·923	**2·212**
8. East Murchison	373	**353**	·043	**·041**	7·018	**10·014**
9. Murchison	91,877	**94,679**	10·553	**11·009**	10·812	**10·851**
10. Yalgoo	86	**153**	·010	**·018**	18·298	**5·222**
11. Mt. Margaret	33,977	**27,186**	3·902	**3·161**	4·898	**4·337**
12. North Coolgardie	15,849	**17,567**	1·820	**2·042**	10·547	**10·871**
13. Broad Arrow	2,455	**935**	·282	**·109**	14·049	**5·826**
14. North-East Coolgardie	161	**138**	·019	**·016**	5·008	**4·313**
15. East Coolgardie	540,473	**526,478**	62·076	**61·216**	5·361	**5·192**
16. Coolgardie	13,834	**11,888**	1·589	**1·382**	10·144	**6·476**
17. Yilgarn	64,301	**65,138**	7·358	**7·574**	3·145	**3·282**
18. Dundas	98,890	**110,252**	11·358	**12·819**	11·181	**12·002**
19. Phillips River	†2,720	**†2,987**	·313	**·347**	....	....
20. South-West Mineral Field	114	**41**	·013	**·005**	10·404	**10·933**
21. State Generally	108	**58**	·012	**·007**	....	....
	870,658	**860,039**	100·000	**100·000**	5·835	**5·753**

The total yield of the State is shown in Table 1, being the amount of gold received at the Royal Mint, the gold exported in bullion and concentrates and alluvial and other gold not reported to the Mines Department.

When comparisons are made as to the yield from any particular Field with the preceding year, the figures reported to the Department are used.

* Gold at £A15 12s. 6d. per fine ounce or 15s. 7½d. per pennyweight.

† By-product of Copper Mining.

TABLE 4

Output of Gold from the Commonwealth of Australia during 1962

State	Output of Gold	Value*†	Percentage of Total
	Fine oz.	£A	Per cent.
Western Australia	859,368	13,427,626	80·393
Victoria	28,134	439,594	2·632
New South Wales	11,712	183,000	1·096
Queensland	67,729	1,058,266	6·336
Tasmania	28,673	448,016	2·682
South Australia	48	750	·004
Northern Territory	73,297	1,145,266	6·857
Total	1,068,961	16,702,518	100·000

* £A15 12s. 6d. per fine ounce.

† Exclusive of Overseas Gold Sales Premium by Gold Producers' Association.

TABLE 5

Dividends, etc., paid by Western Australian Mining Companies during 1962, *and the total to date*
(Mainly compiled from information supplied to the Government Statistician's Office by the Chamber of Mines of Western Australia)

Goldfield	Name of Company	Dividends Paid 1962	Dividends Paid Grand Total to end of 1962
		£	£
Pilbara	Various Companies	....	26,513
Peak Hill	do. do.	....	199,305
East Murchison	do. do.	....	1,914,053
Murchison	Eclipse Gold Mine N.L.	12,600	67,200
	Hill 50 Gold Mine N.L.	600,000	6,915,626
	Various Companies	....	2,764,945
Mt. Margaret	Sons of Gwalia Ltd.	....	2,075,050
	Various Companies	....	958,286
North Coolgardie	Moonlight Wiluna G.M.s Ltd.	....	15,000
	Various Companies	....	712,551
Broad Arrow	do. do.	....	92,500
North-East Coolgardie	do. do.	....	129,493
East Coolgardie	Gold Mines of Kalgoorlie (Aust.) Ltd.	207,264	2,806,146
	Great Boulder G.M.s Ltd.	218,750	9,371,900
	Lake View & Star Ltd.	437,500	(*b*) 10,243,250
	North Kalgurli (1912) Ltd.	154,688	3,104,061
	Various Companies	....	(*a*) 19,496,816
Coolgardie	do. do.	....	410,000
Yilgarn	do. do.	....	(*c*) 1,205,556
Dundas	Central Norseman Gold Corporation N.L.	455,000	5,492,500
	Various Companies	....	786,162
	Totals	2,085,802	68,786,913

(*a*) Excluding £45,091 in bonuses and profit-sharing notes in years 1935–1936 by Boulder Perseverance Ltd., and £55,000 Capital returned in year 1932 and £43,000 in bonuses and profit-sharing notes in the year 1934 by Golden Horseshoe (New) Ltd.

(*b*) Excluding £75,000 in bonuses and profit-sharing notes and £93,750 Capital returned in 1932–1935.

(*c*) Excluding £67,725 Capital returned in 1948 by Edna May (W.A.) Amalgamated, N.L.

TABLE 6

Total Coal output from Collie River Mineral Field, 1961 *and* 1962, *estimated Value thereof, Number of Men employed, and output per Man as reported Monthly*

Year	Total Output	Estimated Value	Men Employed: Above Ground	Men Employed: Under Ground	Men Employed: Above and Under Ground	Output per Man Employed: Above Ground	Output per Man Employed: Under Ground	Output per Man Employed: Above and Under Ground
	Tons	£A	No.	No.	No.	Tons	Tons	Tons
Deep Mining—								
1961	506,307	1,314,007	105	384	489	4,821	1,318	1,035
1962	598,501	1,539,941	130	500	630	4,527	1,183	950
Open Cut Mining—								
1961	259,433	366,252	93	....	93	2,784	....	2,784
1962	320,611	440,837	127	....	127	2,524	....	2,524
Totals—								
1961	765,740	1,680,259	198	384	582	2,867	1,994	1,315
1962	919,112	1,980,778	257	500	757	3,576	1,838	1,214

PART III—LEASES AND OTHER HOLDINGS UNDER VARIOUS ACTS RELATING TO MINING.

TABLE 7

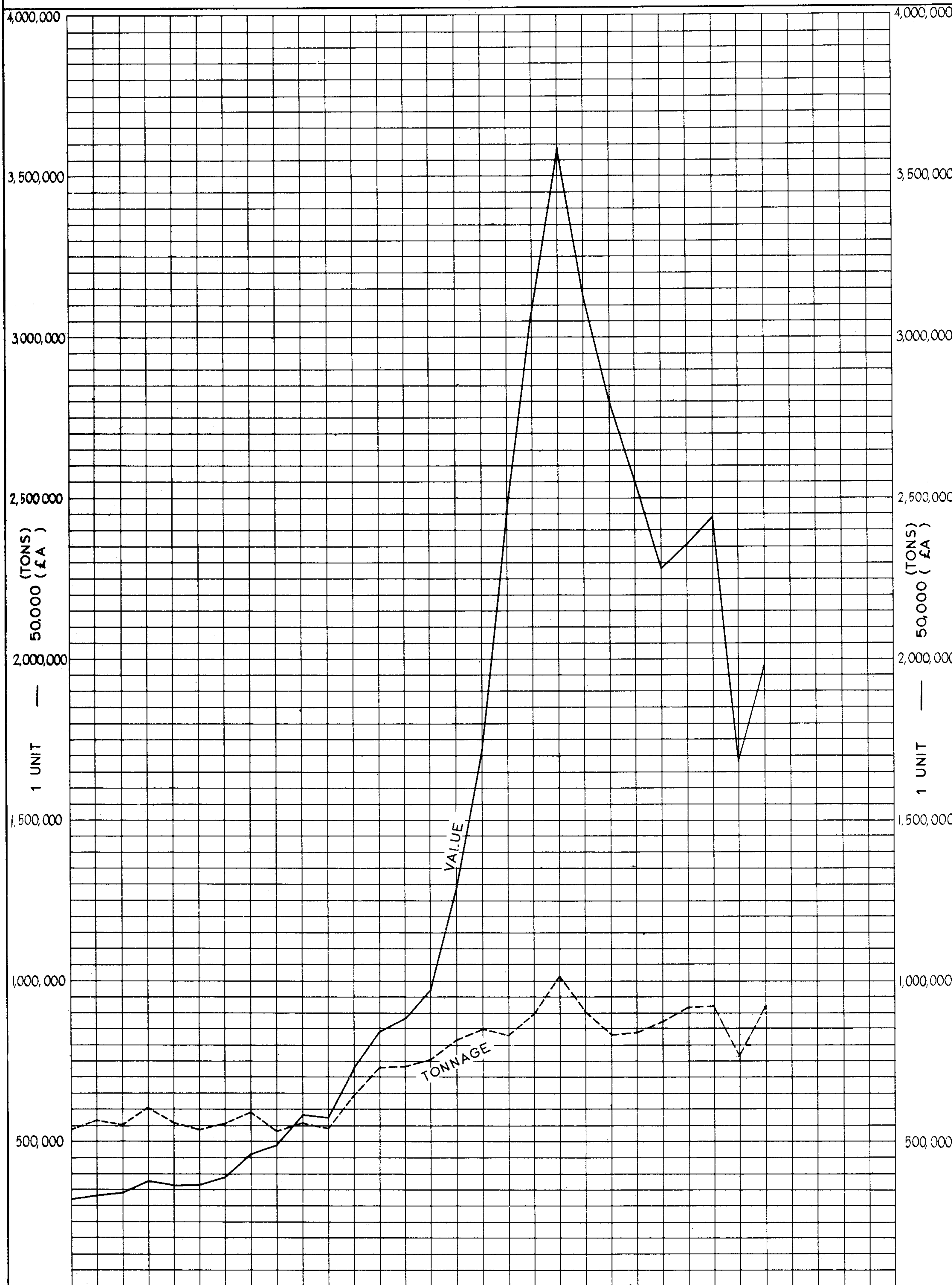
MINING ACT

Total Number and Acreage of Mining Tenements applied for during 1962 *and in force as at* 31*st December,* 1962 (*Compared with* 1961)

——	Applied for				In Force			
	1961		**1962**		1961		**1962**	
	No.	Acreage	No.	Acreage	No.	Acreage	No.	Acreage
Gold—								
Gold Mining Leases	89	1,519	**80**	**1,468**	1,026	18,756	**983**	**18,025**
Dredging Claims	....	....	....	....	1	12	**1**	**12**
Prospecting Areas	515	8,040	**568**	**9,836**	435	7,496	**454**	**7,711**
Temporary Reserves	30	7,796	**57**	**15,373**	25	6,845	**83**	**21,663**
Total	634	17,355	**705**	**26,677**	1,487	33,109	**1,521**	**47,411**
Coal—								
Coal Mining Leases	18	5,440	**8**	**2,240**	67	19,882	**72**	**21,329**
Prospecting Areas	2	6,000	**1**	**1,550**	....	....	....	....
Temporary Reserves	2	4,800,000	....	....	2	4,800,000	**2**	**4,800,000**
Total	22	4,811,440	**9**	**3,990**	69	4,819,882	**74**	**4,821,329**
Other Minerals—								
Mineral Leases	6	131	**21**	**637**	114	2,564	**107**	**2,690**
Dredging Claims	21	634	**87**	**15,877**	140	7,518	**148**	**7,916**
Mineral Claims	252	37,956	**135**	**21,892**	673	58,476	**769**	**71,081**
Prospecting Areas	108	2,528	**91**	**1,969**	82	1,752	**66**	**1,420**
Temporary Reserves	541	58,825,326	**90**	**15,500,160**	90	149,578,240	**208**	**117,246,453**
Total	928	58,866,575	**424**	**15,540,535**	1,099	149,648,549	**1,298**	**117,329,560**
Other Holdings—								
Miner's Homestead Leases	1	103	**8**	**288**	363	33,334	**361**	**31,527**
Miscellaneous Leases	1	1	**5**	**42**	98	1,705	**109**	**1,782**
Residence Areas	3	2	....	....	71	27	**69**	**23**
Business Areas	3	3	**1**	**1**	27	20	**24**	**19**
Machinery Areas	3	26	**7**	**24**	26	78	**30**	**86**
Tailings Areas	1	2	**3**	**7**	20	64	**21**	**82**
Garden Areas	1	2	**1**	**5**	78	229	**80**	**246**
Quarrying Areas	4	60	....	....	10	80	**8**	**74**
Water Rights	8	43	**12**	**83**	183	2,420	**134**	**2,460**
Licenses to Treat Tailings	17	....	**32**	....	17	....	**37**	....
Total	42	242	**69**	**450**	1,293	37,957	**873**	**36,299**
Grand Totals	2,526	63,695,612	**1,209**	**15,571,652**	3,948	154,539,497	**3,766**	**122,234,599**

GRAPH OF COAL OUTPUT

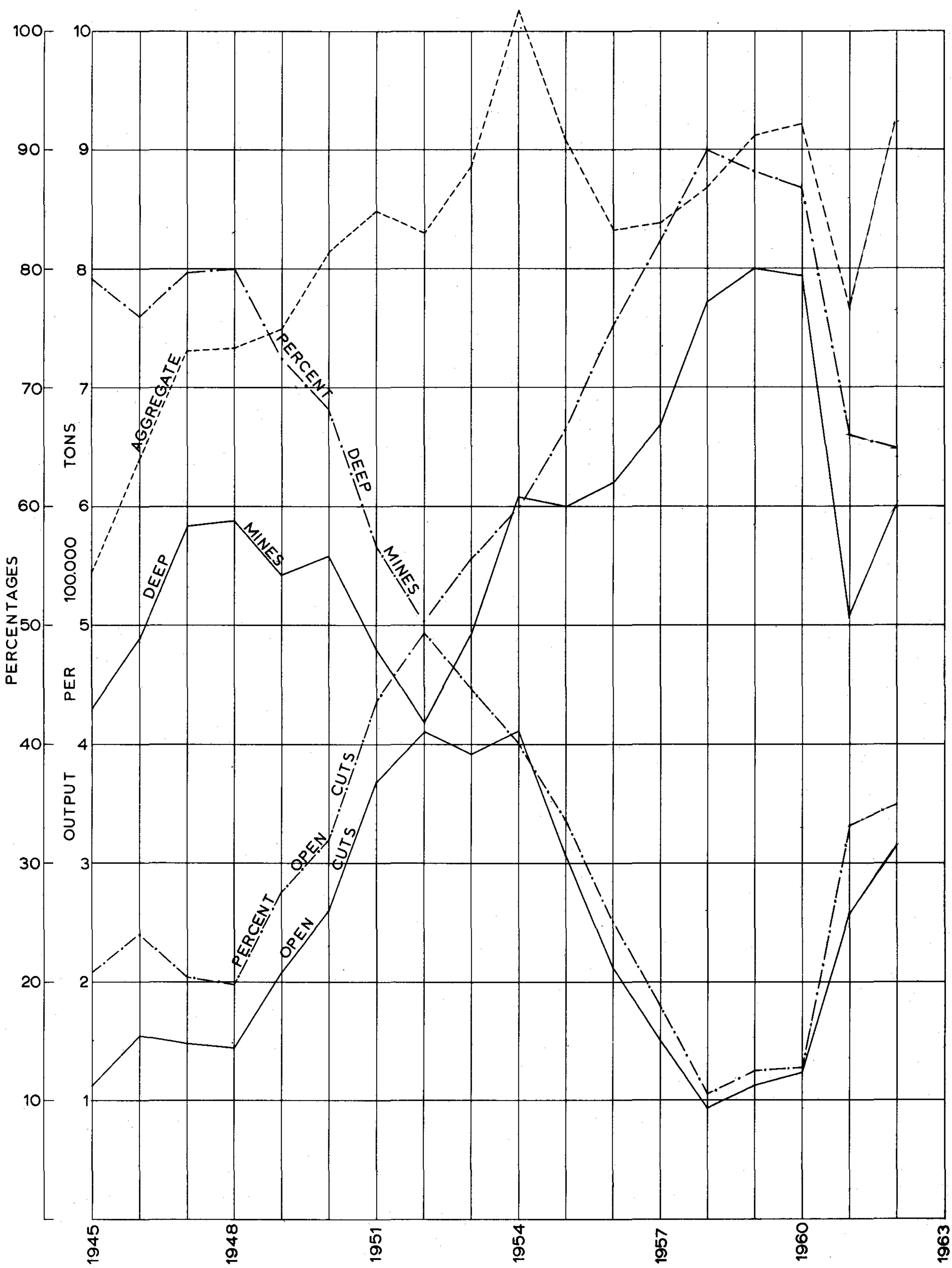
SHOWING QUANTITIES AND VALUES AS REPORTED TO MINES DEPT.



YEAR	VALUE £A	TONS
1935	318013	537188
1936	331565	565075
1937	340444	553510
1938	375083	604793
1939	362811	557535
1940	364500	539427
1941	389278	556574
1942	461495	581176
1943	489721	531546
1944	583075	558322
1945	572896	543363
1946	730104	642287
1947	840249	730506
1948	880236	732938
1949	972245	750594
1950	1,287,749	814351
1951	1,716,788	848475
1952	2,457,296	830461
1953	3,073,073	886182
1954	3,588,818	1,018,343
1955	3,132,074	903,792
1956	2,797,506	830008
1957	2,552,655	838660
1958	2,280,649	870882
1959	2,356,534	917434
1960	2,439,195	922393
1961	1,680,259	765,740
1962	1,980,778	919,112
1963		
1964		
1965		
1966		
1967		

GRAPH OF TREND IN COAL OUTPUT

SHOWING COMPARISON OF ANNUAL TONNAGE AND PERCENTAGES
BETWEEN DEEP AND OPEN CUT MINING



PART IV—MEN EMPLOYED

TABLE 8

**Average number of Men reported as engaged in Mining during* 1961 *and* 1962

Goldfield	District	Total 1961	Total 1962
Kimberley	....	4	4
West Kimberley	....	....	....
Pilbara	Marble Bar	24	20
	Nullagine	24	37
West Pilbara	....	3	3
Ashburton	....	....	....
Gascoyne	....	....	....
Peak Hill	....	12	6
East Murchison	Lawlers	11	18
	Wiluna	3	2
	Black Range	5	2
Murchison	Cue	27	25
	Meekatharra	26	22
	Day Dawn	10	7
	Mt. Magnet	237	248
Yalgoo	....	5	4
Mt. Margaret	Mt. Morgans	2	2
	Mt. Malcolm	256	242
	Mt. Margaret	6	5
North Coolgardie	Menzies	100	113
	Ularring	35	40
	Niagara	4	5
	Yerilla	26	25
Broad Arrow	....	78	89
North-East Coolgardie	Kanowna	18	30
	Kurnalpi	8	13
East Coolgardie	East Coolgardie	2,973	3,085
	Bulong	8	11
Coolgardie	Coolgardie	186	191
	Kunanalling	19	19
Yilgarn	....	429	368
Dundas	....	402	376
Phillips River	....	2	2
South-West Mineral Field	....	2	4
Total, Gold Mining	....	4,945	4,963

Minerals Other than Gold—	1961	1962
Asbestos	405	416
Barytes	....	2
Bentonite	1	1
Beryl	43	45
Building Stone	....	1
Clays	13	10
Coal	582	757
Copper	141	133
Cupreous Ore (Fertiliser)	70	45
Dolomite	1	....
Felspar	6	5
Glass Sand	3	3
Gypsum	19	16
Iron Ore	401	359
Lead	19	3
Limestone	15	15
Magnesite	6	7
Manganese	83	73
Mineral Beach Sands (Ilmenite, etc.)	146	199
Ochre	1	....
Phosphatic Gyano	2	....
Pyrites	101	102
Talc	3	5
Tanto/Columbite	2	4
Tin	49	57
Total, Other Minerals	2,112	2,258

* Effective workers only and totally excluding non-workers for any reason whatsoever.

PART V—ACCIDENTS

TABLE 9A

Goldfield	Killed		Injured		Total Killed and Injured	
	1961	1962	1961	1962	1961	1962
1. Kimberley	....	....	....	....	....	....
2. West Kimberley	....	....	13	5	13	5
3. Pilbara	....	2	6	1	6	3
4. West Pilbara	....	1	2	13	2	14
5. Ashburton	....	....	2	....	2	....
6. Gascoyne	....	....	....	....	....	....
7. Peak Hill	....	....	1	....	1	....
8. East Murchison	....	....	....	....	....	....
9. Murchison	....	....	13	18	13	18
10. Yalgoo	....	....	....	....	....	....
11. Mount Margaret	....	....	22	24	22	24
12. North Coolgardie	....	....	2	2	2	2
13. North-East Coolgardie	....	....	....	....	....	....
14. Broad Arrow	....	....	....	1	....	1
15. East Coolgardie	4	3	233	217	237	220
16. Coolgardie	....	....	6	5	6	5
17. Yilgarn	....	....	19	13	19	13
18. Dundas	....	....	29	30	29	30
19. Phillips River	....	....	35	19	35	19
Mining Districts—						
Northampton	....	....	....	....	....	....
Greenbushes	....	....	....	....	....	....
Collie	1	....	68	70	69	70
South-West	2	2	9	14	11	16
Total	7	8	460	432	467	440

TABLE B.—*According to Causes of Accidents*

	1961		1962		Comparison with 1961	
	Fatal	Serious	Fatal	Serious	Fatal	Serious
1. Explosives	....	1	....	5	....	+ 4
2. Falls of Ground	5	41	2	52	— 3	+ 11
3. In Shafts	....	6	....	8	....	+ 2
4. Miscellaneous Underground	1	297	4	278	+ 3	— 19
5. Surface	1	115	2	89	+ 1	— 26
6. Fumes	....	....	....	....	....	....
Total	7	460	8	432	+ 1	— 28

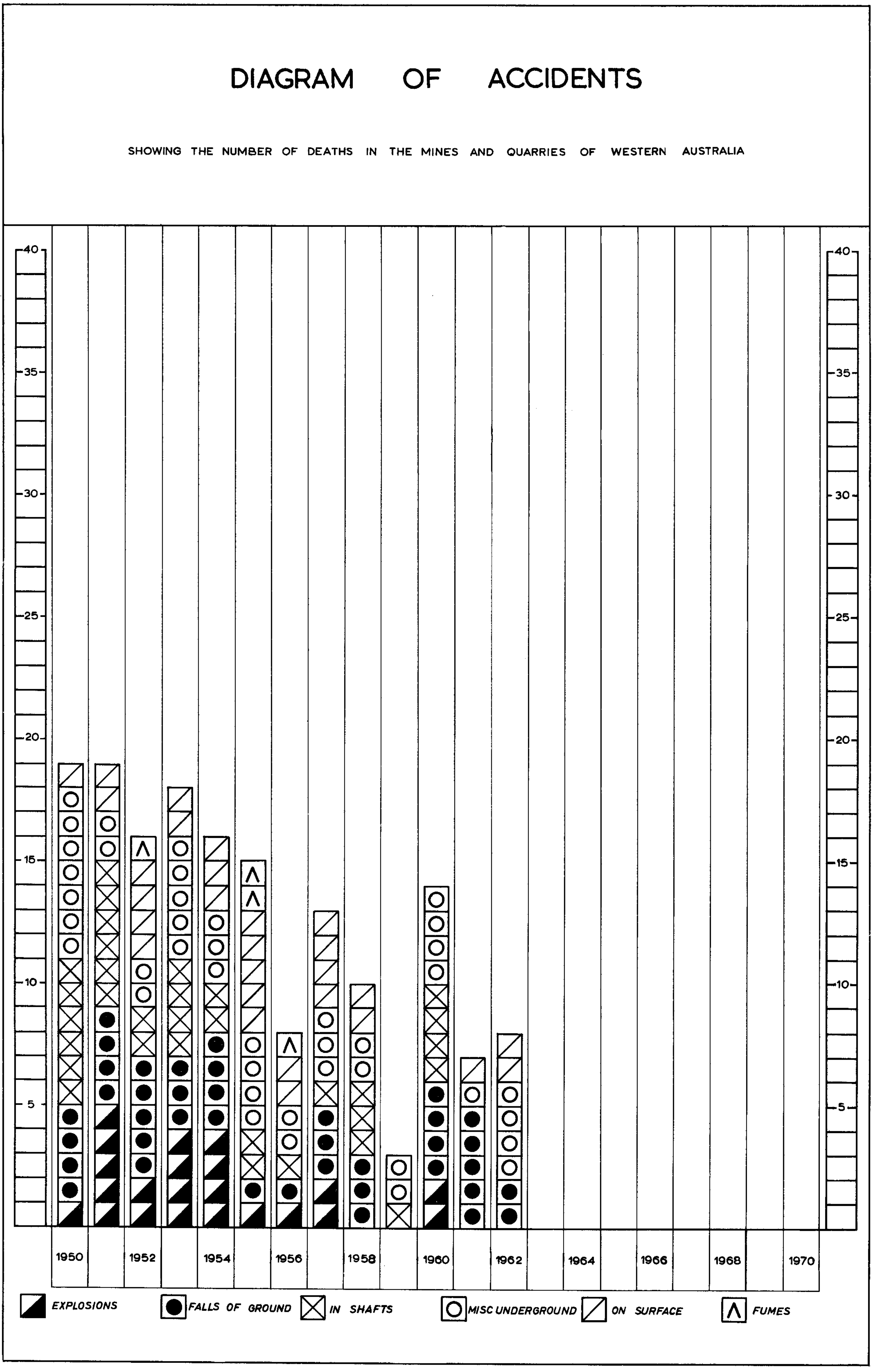


DIAGRAM OF ACCIDENTS
SHOWING THE NUMBER OF DEATHS IN THE MINES AND QUARRIES OF WESTERN AUSTRALIA
40
35
30
25
20
15
10
5
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
EXPLOSIONS
FALLS OF GROUND
IN SHAFTS
MISC UNDERGROUND
ON SURFACE
FUMES

Additions to the Kalgoorlie Metallurgical Laboratory commenced in 1961 were still not complete at the end of this year. During the year no other work was done on the buildings which are generally in good condition.

The Advisory Committee met on 10 occasions. Equipment to the approximate value of £6,100 was approved for purchase.

Five reports of investigations and 391 certificates of testing or analysis were issued by the Kalgoorlie Metallurgical Laboratory during the year, and numerous free assays were made for prospectors and others.

The Students Association was active during the year and the usual functions were held.

(b) Norseman.

The number of students enrolled was 69, an increase of 4 by comparison with the previous year.

Eighteen subjects were taught and as in previous years use was made of mine workshops for practical work in Workshop Practice and Welding.

The Reg Dowson Scholarships for 1962 were awarded to G. L. Rassmussen and to K. W. Giles. The two students who received Reg Dowson Scholarships in 1961 both completed a satisfactory year's work in 1962.

Two meetings of the Advisory Committee were held in 1962 with Mr. Dutton as Chairman. The only new member of the Committee was Mr. J. A. Richards, the Headmaster of the Junior High School at Norseman.

(c) Bullfinch.

The number of students enrolled was 27, a decrease of 33 by comparison with the previous year. The decrease was expected as it was known early in the year that Great Western Consolidated would close down at the end of the year or thereabouts. The School was kept open during the year to enable a few of the better students to complete some additional subjects.

Nine subjects were taught at Bullfinch and in addition three subjects were made available to Bullfinch students as external students from Kalgoorlie.

One student completed the Mine Surveyor's Certificate Course and obtained his Certificate of Competency as a Mine surveyor from the Mines Department, and two others almost completed the same Course.

Every assistance was received from Great Western Consolidated and without this it would have been difficult and almost impossible to establish and continue the School. The Company provided assistance and co-operation during the ten years of the School's life.

(d) Wittenoom.

Although the result of the work done in 1961 was very disappointing, it was decided to continue classes in 1962 in the hope that interest in the School would grow. As this did not happen all classes were discontinued in May, 1962 and equipment was returned to Kalgoorlie.

PART VIII—INSPECTION OF MACHINERY.

The Chief Inspector of Machinery reports that the number of useful boilers registered at the end of the year totalled 7,957 against 7,634 for the preceding year, showing an increase of 323 boilers under all adjustments.

Of the 7,957 useful boilers 1,926 were out of use at the end of the year; 4,900 thorough and 1,075 working inspections were made and 4,875 certificates were issued.

Permanent condemnations total 78 and temporary condemnations 1; 113 boilers were transferred beyond the jurisdiction of the Act.

The total number of machinery groups registered was 45,512 against 45,170 for the previous year, showing an increase of 342.

Inspections made total 30,646 and 6,253 certificates were granted.

The total miles travelled for the year, were 110,503 against 113,001 miles for the previous year, showing a decrease of 2,498. The average miles travelled per inspection were 3.01 as against 3.25 miles per inspection for the previous year.

453 applications were received and dealt with for Engine Drivers and Boiler Attendants' Certificates, and 404 Certificates all classes were granted as follows:—

Winding Competency (including certificates issued under Regulation 40 Section 60)	16
First Class Competency (including certificates issued under Regulations 40 and 45, and Sections 60 and 63)	17
Second Class Competency (including certificates issued under Regulation 40 and Section 60 of the Act)	11
Third Class Competency (including certificates issued under Regulations 40 and 45 and Sections 60 and 63)	7
Locomotive and Traction Competency (including certificates issued under Regulation 40 and Section 60)	2
Diesel Locomotive "A" Class certificates of Competency (including certificates issued under Regulation 40 and Sections 53 and 56)	2
Diesel Locomotive "B" Class Certificates of Competency (including certificates issued under Regulation 40 and Sections 53 and 56)	3
Internal Combustion Competency (including certificates issued under Regulation 40 and Section 60)	29
Crane and Hoist Competency (including certificates issued under Regulation 40 and Section 60)	228
Boiler Attendant Competency (including certificates issued under Regulation 40 and Section 60)	79
Copies	10
	404

The total Revenue from all sources during the year was £16,126 18s. 11d. as against £15,901 5s. in the previous year, showing an increase of £225 13s. 11d.

The total Expenditure for the year was £38,598 2s. 4d. against £38,970 11s. 10d. for the previous year, showing a decrease of £372 9s. 6d.

PART IX—GOVERNMENT CHEMICAL LABORATORIES.

The Director has reported that this year again has been a difficult one in regard to staff requirements, and that it has not been possible to maintain a full professional staff. At the end of the year there were seven vacancies spread over four of the six Divisions.

The close association of the Laboratories with other Government Departments and with kindred associations was maintained during 1962.

It is pleasing to report that the building of extensions to the Laboratories commenced in October, 1962. Three portions of the extensions are now under construction, but the need for the completion of the whole of the proposed extensions is again emphasised.

The total number of registrations during 1962 was 3,793, an increase of 12½ per cent. over the number for 1961 (3,372.) The number of samples accepted in 1962 was 10,658, a reduction of 10 per cent. on the number received in 1961 (11,921.) This lower acceptance of samples in 1962 enabled us to pick up some of the back-log of samples; the samples in hand (received but not reported) was 880 at the 1st January, 1963, compared with 2,124 at the 1st January, 1962. Thus samples dealt with in 1962 were practically the same as in 1961.

The number of registrations and of samples gives some measure of our activities but does not completely describe our work. A major factor in this is the enormous variation in the amount of work associated with different samples, but also it is not possible to give a statistical account of the time and effort devoted to the various Committees previously mentioned, advice to Government Departments and the public, attendance at Courts, visits to industrial establishments and so on.

In previous Annual Reports I have referred to the large number of Government Departments for which we do work as an indication of the influence exerted by these Laboratories on Government expenditure. In my Annual Report for 1961 I furnished a Table showing the State Government Departments for which our individual Divisions did work; 1962 showed a similar pattern, samples were received from 15 of the 28 Government Departments shown in the Public Service List 1962. In the reports of the Divisions which follow are included Tables 2 and 27 for the Agriculture, Forestry and Water Supply and for the Food and Drug Divisions respectively showing the source and type of samples received. These Tables have been compressed for publication purposes, the original Tables show 107 types of samples from 21 different sources for Agriculture, Forestry and Water Supply Division, and 97 types of samples from 23 sources for the Food and Drug division.

The samples accepted were allocated to the various Divisions of these Laboratories according to the specialised work undertaken by each Division. In a number of cases work was done on the same sample(s) by more than one Division and this applies particularly to the Physicist whose X-ray examination of minerals is usually on samples registered to the Mineral Division. Such samples are not usually doubly registered but others are, so the total shown in Table I is greater than the total of samples given earlier in this report.

Other examples of the co-ordination between divisions will be found in (a) dust separation and particle sizing with the Engineering Chemistry Division and the Fuel Technology Division (b) clays, shales and dust identification with Fuel Technology Division and Mineral Division (c) ores and product analyses between Engineering Chemistry Division and Mineral Division.

This co-operation between Divisions helps to foster the policy that we are one Government Chemical Laboratories, not six separate Divisions as separate entities, that problems in one Division may be assisted by specialists from another Division. It is also further support for the value of one centralised chemical laboratory instead of chemical sections in various Government Departments.

Fees were charged for work undertaken for some Government Departments, for Commonwealth Government Departments, Hospitals, Milk Board and the general public but the greater part of our work is done free for State Government Departments together with an appreciable amount of free mineral identification and assay to assist prospectors.

Agriculture, Forestry and Water Division.

The main function of this Division has again been the examination of a wide variety of material for the advisory research sections of the Department of Agriculture.

During the year the Division examined samples of water from various sources with a view to determining their suitability for human consumption, industrial use, irrigation and domestic use and to make recommendations for treatment where necessary.

Twenty-nine samples of fertilisers were analysed and reported under the Fertiliser Act and these indicated no abuses of the Act.

Samples of stock foods received numbered 56. In no case of a deficiency or excess was there any appreciable deviation from the registered analysis.

Engineering Chemistry Division.

As in the previous year, three original research projects were undertaken during the year. Two of the projects, viz. the recovery of sulphur from Kalgoorlie ore concentrate, and the calcination of calcareous beach sand, were continued from the previous year, whereas the third, the beneficiation of Robe River (Pilbara) iron ore, was initiated during the year at the request of the Geological Survey Branch.

Additional investigations were also carried out into the upgrading of ilmenite, mainly to clarify problems arising from the pilot plant at Capel.

Apart from the above, work was also undertaken on behalf of private interests.

Food, Drugs, Toxicology and Industrial Hygiene Division.

The greater proportion of the work carried out by this Division consisted of chemical examinations for the Departments of Public Health, Police, Agriculture and Public Works, as well as for the Milk Board of Western Australia and the Swan River Conservation Board, but the usual variety of miscellaneous work was also performed for other Government Departments and for the general public.

Fuel Technology Division.

173 samples and investigations were allotted to this Division during 1962. These included coals, clays, dusts, sulphide ores, gases, an investigation into production of light weight aggregates and a commencement with assessment of air pollution.

Industrial Chemistry Division.

Of the 183 samples examined by the Division, 166 fall under the general heading of building materials. This heading includes paints, concrete additives, floor tiles and miscellaneous materials used in the construction and fitting out of structural and civil engineering undertakings.

Mineralogy, Mineral Technology and Geochemistry Division.

The total number of samples examined during year was 2,463 compared with 2,653 in the previous year.

With the completion early in the year of the basic survey of dust conditions associated with foundry work, the number of dust samples dealt with fell off considerably from 372 (1961) to 44 (1962.)

The most marked increase in sample numbers occurred in the cases of tin (from 41 in 1961 to 131 in 1962,) iron (380 to 451) and tantalite—Columbite (93 to 126), a fairly accurate reflection of the increased interest in these ores.

One hundred and sixty-seven specimens were added to the Mineral Division during the year, bringing the total to 3,367. The big majority originated from within the State and included specimens of minerals recorded of the first time from a Western Australian locality.

PART X—EXPLOSIVES.

There have been no staff changes during the year 1962 but recent developments and implementation of the potentially large field of Dangerous Goods control will necessarily require augmented inspectorial and clerical assistance. There will, also, be some further space required, particularly a room for the inspector.

As in 1961, the State's nitro-explosive and blasting powder requirements were substantially met by consignments shipped and railed from Nobel's factory near Melbourne. Approximately the same tonnage arrived by each method of conveyance as last year, until a significantly lower consumption later in the year reflected the wide inroads made by blasting agents into the conventional explosives domain, particularly as applied to goldmining. Ammonium nitrate, the main component, also imported from the Eastern States was supplemented by a special grade prilled product from the

United States of America. Some French explosive was imported for use in the oil-drilling industry. The use of Esperance for discharge of ammonium nitrate is receiving consideration and already a small shipment to Esperance has occurred.

Goldmining accounted for 57.7 per cent. of the total usage of explosives, coal 10.7 per cent., geoseismic firing 6.7 per cent, quarrying and non-auriferous mining 13.7 per cent, construction 7 per cent, State Public Works 1.4 per cent, local government work 0.5 per cent. and miscellaneous purposes 2.3 per cent.

Ammonium nitrate, the principal component in blasting agents, comprised 17 per cent, of the total commercial explosives importations and taking into account the fuel oil, the figure becomes about 18 per cent.

The quality of explosives during the year has been satisfactory.

Storage of explosives in magazines and stores has been usually up to requirements. The security drive in connection with the storage of explosives has been continued, and conditions for blasting agent material have been formulated.

Under the provisions of the Explosives and Dangerous Goods Act, 1961 fireworks regulations were gazetted in October, 1962. Explosives regulations have been prepared, circulated and redrafted and are now with the Crown Law Department.

There were less fireworks imported in 1962 and these were generally of a smaller and simpler type. The season was almost free from accident.

Before the gazettal of the fireworks regulations, occasional unsatisfactory or even dangerous practices at public fireworks displays came under notice. Two displays held in 1962 were conducted without incident.

PART XI—MINERS' PHTHISIS ACT AND MINE WORKERS' RELIEF ACT.

The State Public Health Department, under arrangements made with this Department, continued the periodical examinations of mine workers, the work being carried on throughout the year at the Kalgoorlie Laboratory, and a mobile x-ray unit visited the Coolgardie, North Coolgardie, Yilgarn, Dundas, Mt. Margaret, Murchison, East Murchison, Pilbara, West Pilbara and the Philips River Goldfields and the South West Mineral Field.

Examinations under the Mine Workers' Relief Act during the year totalled 5,760 an increase of seven over the previous year. Under the Mines Regulation Act, 1,812 miners were examined. These were in addition to the 5,760 examinations under the Mine Workers' Relief Act. There was a decrease of 321 examinations under the Mines Regulation Act compared with those of 1961. Of the total of 1,812 men examined 1,454 were new applicants and 358 were re-examinees.

The amount of compensation paid during the year under the Mines' phthisis Act totalled £10,696 11s. 8d. compared with £11,683 1s. 3d. for the previous year. The total number of beneficiaries on the 31st December, 1962 was 98, being eight ex-miners and 90 widows.

The regulations under the Mine Workers' Relief Act were extensively amended, but in the main these were consequential upon the 1961 amendments to the Act.

Dr. P. F. Maguire, M.B., Ch.M., D.P.H., was appointed to the medical staff of the Kalgoorlie Laboratory in October, 1962.

PART XII—CHIEF DRAFTSMAN.

Considerable increases in the work of the different sections were brought about by the increased interest shown in the development of the iron and mineral resources of the State. Due to the demand a number of our maps required reprinting, and new issues were produced.

Our cadets continued to make good progress, and some gained valuable field experience with our contract surveyors, while other worked in the field with departmental geologists.

Close liaison with various Government and local Government Departments was maintained in connection with problems arising from the increased mineral activity.

STAFF.

The year 1962 has been another extremely active one for the Department. The interest in minerals which has been so marked over recent years has been maintained. The consequent increase in mining operations generally and the revived interest in the search for oil have greatly expanded the work of the Department. Officers of the Department, both in Head Office and at Outstations have carried out their duties loyally and efficiently, and I would like to take this opportunity of thanking them for their efforts.

The expanded Geological Survey Branch has enabled the Department to take a more active role in examining our mineral deposits and exploring the potential water resources of the State.

In this summary of the various activities of the Department, I have commented only on the principal items.

Divisions 11 to X of this publication contain the detailed reports of the responsible Branch Officers.

A. H. TELFER,
Under Secretary for Mines.

Department of Mines, Perth.

DIVISION II

Report of the State Mining Engineer for the Year 1962

Under Secretary for Mines:

I submit the Annual Report of the State Mining Engineer compiled by the Assistant State Mining Engineer.

Gold mining has continued at about the same level as for recent years. Sons of Gwalia, Great Western and Bayley's Reward are either exhausted or nearing the end of reserves but the principal mines at Kalgoorlie are in sound condition and some smaller mines, the Paris at Widgiemooltha and the Pinnacles near Cue show some promise.

In the base metal field lead is very quiet but interest in copper has been maintained. It is anticipated that Whim Creek will come into production shortly and Ravensthorpe Copper although experiencing some trouble is continuing. The small producers are active and some exploration is under way.

The Blue Asbestos industry at Wittenoom Gorge was seriously affected by a major fall in the workings. Fortunately there was no loss of life and although work was seriously affected there was comparatively little damage. A white asbestos treatment plant at Marble Bar is nearing completion.

In the south-west area the beach sands industry is expanding, the bauxite operation is close to starting, and a revival of tin mining at Greenbushes is planned.

Iron is approaching the completion of the exploratory stage and the mining phase will commence very soon. Good progress has been made with the development of Koolan Island.

No difficulty has been experienced in meeting the demand for coal.

A good deal of future mining is likely to be on the surface—either open cut or dredging and some revision of the Mines Regulation Act which is based on underground practice is likely to be necessary.

The new regulations governing the issue of Mine Managers' Certificates appear to be quite acceptable so far as the First Class Certificate is concerned but the Second Class Certificate may not meet the needs of the industry.

It may be necessary to revise these regulations after practical trial.

The placing of Inspectors at Perth and Port Hedland to meet the demands of recent developments is working out well except that the area around Meekatharra is now somewhat isolated. This causes some difficulty during staff shortages.

The drilling section has done good work in developing a water supply for La Porte Industries and gave considerable assistance to engineering investigations such as the standard gauge railway and various harbour works.

E. E. BRISBANE,
State Mining Engineer.

State Mining Engineer:

Mining activities for the year 1962 are described in this report which is based on informaton suppled by the Statistican and Inspectors of Mines. The section on drilling written by Inspector Haddow and the report of the Board of Examiners for Mine Managers and Underground Supervisors Certificates appear as appendices to this report.

STAFF.

Early in the year, District Inspector of Mines A. W. Ibbotson was transferred from Cue to Port Hedland. This transfer followed increased mining activity in the Pilbara and West Pilbara Goldfields. Mines in the Mount Magnet District, Northampton and Yalgoo fields are now included in the districts inspected from Perth and the Peak Hill and part of the Murchison Goldfields have been added to the Kalgoorlie Inspectorate.

ACCIDENTS.

Fatal and serious mine and quarry accidents reported to the Department are shown below. The corresponding figures for 1961 are shown in brackets.

There were 8 (7) fatal and 449 (460) serious accidents.

In gold mines there were 4 (4) fatal and 306 (318) serious accidents. The number of men employed in such mines was 5,353 (5,337). The accident rate per 1,000 men was thus 0.75 (0.75) for fatal accidents and 57.16 (59.58) for serious accidents.

Two men, a State Battery driver and a conveyor belt attendant on a asbestos mine, were killed by machinery in motion.

One man died from injuries received in a fall at an ilmenite plant.

A quarryworker was killed by a fall of limestone.

A classification of serious accidents showing the nature of the injuries is given in Table "A".

Table "B" shows the fatal, serious and minor accidents reported and the number of men classified according to mineral mined.

Accidents classified according to causes for the various districts are shown in Table "C".

TABLE A.

Serious Accidents for 1962.

Class of Accident	West Kimberley	Pilbara	West Pilbara	Ashburton	Broad Arrow	Murchison	Mt. Margaret	North Coolgardie	East Coolgardie	Coolgardie	Yilgarn	Dundas	Phillips River	South West	Collie	Total
Major Injuries—Exclusive of Fatal—																
Fractures :																
Head	....	....	1	....	....	....	....	....	1	....	1	....	....	....	1	4
Shoulder	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Arm	....	....	1	....	....	....	1	....	....	....	....	....	....	1	....	3
Hand	....	....	1	....	....	....	....	....	4	....	....	1	1	....	....	7
Spine	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Rib	....	....	....	....	....	....	1	....	3	....	....	....	....	....	2	6
Pelvis	....	....	1	....	....	....	1	....	....	....	1	....	....	....	....	3
Thigh	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Leg	....	....	....	....	....	....	....	....	4	....	....	....	....	....	....	4
Ankle	....	....	1	....	1	....	1	....	1	....	....	1	....	1	....	6
Foot	....	....	....	....	....	....	....	....	3	....	....	....	....	....	....	3
Amputations																
Arm	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Hand	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Finger	1	....	....	....	....	1	1	....	3	1	....	....	....	4	2	13
Leg	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Foot	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Toe	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Loss of Eye	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	1
Serious Internal	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Hernia	....	....	....	....	....	....	1	....	5	....	....	....	1	....	....	7
Dislocations	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1
Other Major	5	....	1	....	....	....	....	....	4	....	....	....	....	1	2	13
Total Major	6	....	6	....	1	1	7	....	28	1	2	2	2	7	8	71
Minor Injuries—																
Fractures :																
Finger	....	....	1	....	....	....	3	....	8	....	....	2	....	1	2	17
Toe	....	....	....	....	....	....	....	....	4	1	....	....	....	....	1	6
Head	....	....	....	1	....	....	1	....	3	....	2	....	2	4	1	14
Eyes	....	....	1	....	....	2	....	....	4	....	....	1	....	....	1	9
Shoulder	....	....	....	....	....	1	2	....	9	....	....	....	....	1	2	15
Arm	1	....	....	....	....	....	1	1	22	....	1	1	1	....	2	30
Hand	....	....	1	....	....	8	5	....	38	2	1	7	7	2	5	76
Back	1	....	1	....	....	2	2	....	28	....	1	3	4	2	24	68
Rib	....	....	....	....	....	....	....	....	3	....	....	2	1	....	1	7
Leg	....	....	1	....	....	2	1	....	41	....	5	5	1	2	11	69
Foot	1	1	2	2	....	2	1	....	23	....	1	4	1	2	5	45
Other Minor	1	....	....	....	....	....	1	1	6	1	....	3	....	2	7	22
Total Minor	4	1	7	3	....	17	17	2	189	4	11	28	17	16	62	378
Grand Total	10	1	13	3	1	18	24	2	217	5	13	30	19	23	70	449

There were no serious accidents reported in the year under review in the following Goldfields :—

Kimberley, Peak Hill, Gascoyne, East Murchison, Yalgoo, Northampton, North-East Coolgardie, Greenbushes.

TABLE B

Accidents segregated according to mineral mined.

Mineral	Men Employed	Accidents		
		Fatal	Serious	Minor
Asbestos	416	1	12	116
Beryl	45	....	....	....
Coal	757	....	70	198
Copper	178	....	20	122
Gold	5,353	5	306	1,411
Gypsum	16	....	....	....
Ilmenite	199	1	11	39
Iron Ore	359	....	5	1
Manganese	73	....	....	2
Oil Exploration	154	....	17	24
Pyrite	102	....	5	16
Tin	57	....	....	....
Other Minerals	53	....	....	....
Rock Quarries	274	1	3	1
Totals	8,036	8	449	1,930

TABLE C

Fatal and Serious Accidents showing Causes and Districts

District	Explosives		Falls		Shafts		Fumes		Miscellaneous Underground		Surface		Total	
	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious
Kimberley	....	....	....	....	....	....	....	....	....	....	....	....	....	....
West Kimberley	....	....	....	....	....	....	....	....	....	....	....	10	....	10
Pilbara	....	....	....	....	....	....	....	....	1	....	1	1	2	1
West Pilbara	....	....	....	3	....	....	....	....	1	8	....	2	1	13
Ashburton	....	....	....	....	....	....	....	....	....	....	....	3	....	3
Peak Hill	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Gascoyne	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Murchison	....	....	....	1	....	....	....	....	....	9	....	8	....	18
East Murchison	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Yalgoo	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Northampton	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Mt. Margaret	....	3	....	2	....	2	....	....	....	12	....	5	....	24
North Coolgardie	....	....	....	....	....	....	....	....	....	2	....	....	....	2
Broad Arrow	....	....	....	....	....	....	....	....	....	1	....	....	....	1
North-East Coolgardie....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
East Coolgardie	....	....	1	42	....	1	....	....	2	143	....	31	3	217
Coolgardie	....	....	....	....	....	2	....	....	....	3	....	....	....	5
Yilgarn	....	....	....	1	....	3	....	....	....	6	....	3	....	13
Dundas	....	....	....	....	....	....	....	....	....	26	....	4	....	30
Phillips River	....	....	....	....	....	....	....	....	....	14	....	5	....	19
Greenbushes	....	....	....	....	....	....	....	....	....	....	....	....	....	....
South-West	....	2	1	....	....	....	....	....	....	1	1	20	2	23
Collie	....	....	....	3	....	....	....	....	....	53	....	14	....	70
Total for 1962	....	5	2	52	....	8	....	....	4	278	2	106	8	449
Total for 1961	....	1	5	41	....	6	....	....	1	297	1	115	7	460

FATAL ACCIDENTS

A brief description of fatal accidents, reported during the year, is given below.

Name and Occupation	Date	Mine	Details and Remarks
Gilbert, Arthur Laurance (Conveyor Belt Attendant)	23/2/62	Colonial Mine, Australian Blue Asbestos Pty. Ltd., Wittenoom	Asphyxiated when he was caught between a roller and the belt of the number two conveyor.
Harris, William James (Bogger)	2/4/62	Blue Spec Mine, North West Mining N.L., Nullagine	Death was due to injuries received when he fell about 100 feet down the No. 2 level winze from his working place in the intermediate drive.
Mattson, Enar Jarl (Engine Driver)	14/5/62	State Battery, Bamboo Creek	Mattson was fatally injured when he attempted to replace a moving flat belt which operated the water circulating pump in the power house.
Bizzaca, John Steven (Sampler)	6/6/62	Kalgurli Shaft, North Kalgurli (1912) Ltd., Fimiston	Suffered head injuries when the ladderway in the 300 feet level Birthday South lode winze collapsed beneath him. The ladderway collapse was due to the failure of the top bearer hooks and rusted wire ties.
Stickland, Kenneth Leslie (Plant Operator)	Injured 28/6/62 Died 29/6/62	Western Titanium N.L., Capel	Received head injuries when he fell from the 33 feet high pilot plant platform. It is believed that he slipped whilst attempting to get on to the ladder.
Baker, Reginald Keith (Loader Driver)	11/7/62	Belombra's Quarry, Location 101, Wanneroo	Suffocated when buried under limestone which fell when the quarry face collapsed.
Chamberlain, Harold (Fitter)	5/11/62	Paringa South Shaft, Gold Mines of Kalgoorlie (Aust.) Ltd., Fimiston	Chamberlain suffered multiple fractures and internal haemorrhage when he fell down the 1,000 feet level ore pass.
Williams, Maurice Franklin (Timberman)	21/11/62	Edwards Shaft, Great Boulder Gold Mines Ltd., Fimiston	Crushed by a fall of rock in the 3,100 feet level Edwards lode stope.

WINDING MACHINERY ACCIDENTS.

Twenty-five accidents involving winding machinery were reported during the year and are briefly as follows:

Fatal.—Nil.

Overwinds.—(4). The left hand cage in Lane Shaft was overwound on the 8th March when the driver's foot slipped off the brake pedal as the cage approached the landing position. A cross beam supporting the catchplate was slightly damaged.

During ore hauling operations on the 31st May the driver at the Internal Shaft, Iron Duke started the winder in the wrong direction. The cage was suspended at the catchplate by the detaching hook. All cage attachments were changed before work resumed.

On the 10th July a cage was overwound at the Nevoria Shaft when the driver started the surface cage in the wrong direction. The cage and attachments were undamaged.

An overwind occurred, at the Internal Shaft of the Main Shaft, Great Boulder, during testing and setting of the overwind limit cam. The rope was cut and re-shod and the attachments changed.

Cages Hung Up.—(1) Whilst hauling ore from the No. 28 level Enterprise Shaft on the 8th February the right-hand descending skip was hung up just below the No. 3 level. The driver noted rough running of the ascending skip which was brought steadily to a stop. Investigation showed that the mishap was due to a dislodged studdle.

Cage Out of Control.—(1). At the commencement of the shift on the 30th January the driver at the North Royal Shaft declutched the free drum and commenced to lower the right hand empty skip. The skip got out of control and came to rest at the bottom of the shaft. Later that day the motor was removed without spragging the drum with the result the rope left the drum and damaged the lagging.

Mechanical Failure.—(1) The counterweight broke away from the top cross member and fell to the bottom of the Copperhead Shaft on the 19th April. The driver noticed a high motor current draw and stopped the winding engine but not befor the cross member draw bar section slipped out into the service cage compartment and jammed the cage. A skid in the counterweight compartment was broken.

Derailments.—(14). During the year Central Norseman Gold Corporation reported five derailments in the Regent Shaft and three in the Royal Shaft. At the Main Shaft, Sons of Gwalia there were six derailments. No serious personal injury resulted from any of these accidents.

Miscellaneous.—(4). A descending ore skip at the Enterprise mine was caught up in the east compartment of the Victoria Shaft. The accident was caused by a shunting locomotive partially pushing a twelve foot leg into the shaft at the 2,300 level.

A truck fell down the Internal Shaft of the Oroya on the 25th July. This accident was brought about by misinterpretation of signals. Instructions were issued that no truck was to be taken from the cage until the cage was chaired.

On the 5th December in the New North Boulder Shaft a cage gate was damaged when it fouled the shaft timbers. Apparently the gate had not been properly latched.

A rigger received lacerations to one foot when it was caught between part of the winder and the concrete base. The accident occurred when the riggers were engaged in rewinding the rope on a drum at the Paringa Shaft.

PROSECUTIONS.

It was found necessary to prosecute eight persons, one man twice, during the year. All cases were successfully conducted by our inspectors. The men were prosecuted for the following breaches of the Mines Regulation Act and Regulations.

Failure to use ventilation equipment provided (3). Boring in butt or the remaining portion of a hole in which a charge of nitro glycerine compound had been previously exploded (3). Firing outside the prescribed times (1). Boring in a rock face containing a misfire (1). By negligence did cause personal injury to and endanger the safety of a workmate (1).

SUNDAY LABOUR PERMITS.

Gold Mines of Kalgoorlie applied for and was granted a permit to work on one Sunday to complete an investigation of the Mt. Charlotte mine.

AUTHORISED MINE SUVEYORS.

The Survey Board issued four certificates during the year.

CERTIFICATES OF EXEMPTION (SECTION 46).

Six certificates were issued as compared with 18 in 1961.

PERMITS TO FIRE OUTSIDE PRESCRIBED TIMES (REGULATION 51).

Seven permits were issued.

A permit was issued to Gold Mines of Kalgoorlie (Aust.) Ltd., during the sinking of Prices internal shaft at Coolgardie. All mining was concentrated on the shaft sinking.

The other permits were issued for experiments and the testing of ammonium nitrate fuel oil explosive at selected sites.

PERMITS TO RISE (REGULATION 64).

Sixty-five permits were issued for 104 rises totalling 12,145 feet. Forty-two of these rises were constructed using the rising gig method.

ADMINISTRATIVE.

Mines Regulation Act—The Mines Regulation Act Amendment Act, 1961, was proclaimed and came into operation on the 23rd February, 1962. This Act deals with the qualifications required of Inspectors of Mines and Underground Managers, Sunday labour in the Yampi Sound area, and small hoists.

A notice in the *Government Gazette* (No. 19) of the 9th March defined the districts covered by Inspectors of Mines.

The ban on the use of batteries for shotfiring was lifted by an amendment to Regulation 57 appearing in the *Government Gazette* of the 1st August.

The *Government Gazette* (No. 102) of the 19th December included amendments to Regulations 30, 31, 32, 33 and 41. These regulations cover the Board of Examiners' requirements for applicants for the Mine Managers and Underground Supervisors' certificates. Amendments to Regulations 94, 99 and 105 appear in the same *gazette*.

Mining Act.—A new regulation appearing in the *Government Gazette* of the 2nd July exempted the Perth Shire Council from the payment of royalties on limestone produced for its own use.

Survey fees were amended by a notice appearing in the *Government Gazette* of the 10th August.

Mine Workers' Relief Act.—During the year a number of minor amendments were made to this Act. These amendments are covered in the report of the Superintendent, Mine Workers' Relief Act.

VENTILATION.

Routine inspections of underground workings on both day and afternoon shifts were carried out during the year. Crushing sections at quarries received more attention than in previous years. This was necessary because of inadequate dust collection machines. Assistance was again given freely to mine operators in the making of ventilation surveys and advice on the design and installation of various ventilation appliances. In most mines the standard of ventilation is satisfactory. Improvements have been made to ventilation circuits by the installation of air doors, extra fans or the use of existing fans to better advantage.

There has been an increased use of air-water blasts for reducing the dust hazard after firing in development headings.

Results of dust counts taken during the year are tabulated below:—

Dust Samples From	Samples Giving Over 1,000 p.p.c.c.	Total Number of Samples	Average Count
Development	22	417	278
Stoping	28	881	284
Levels	16	427	278
Surface	45	213	525
Totals	111	1,938	308

The average dust count was well above the average of 274 p.p.c.c. recorded in 1961. One hundred and eleven samples had dust counts in excess of 1,000 p.p.c.c. as compared with 87 for the previous year. The biggest increase was in those samples obtained from dry crushing sections on the surface.

Dark field illuminators for use with our Watson Konimeters were purchased and used regularly when counting particles in samples obtained from sources outside Kalgoorlie. It became apparent that the dust concentrations were of a higher order when using the illuminator as compared with the previous method of counting using oblique light. Comparison of the two methods show that particles appearing as 4-5 microns under oblique light appear to increase at least 1 micron in diameter when viewed under the dark field. Particles of 1-2 microns viewed under the dark field vanish when viewed under oblique light. Of 128 samples counted using both methods the average dark field count was 296 p.p.c.c. as compared with 187 p.p.c.c. using oblique light. This variation is quite large and will partly explain the sudden rise in the average dust counts recorded in 1961 and 1962. During 1963 all dust samples will be counted using a dark field illuminator.

The glass slide adhesive, formerly supplied by the Konimeter manufacturer, has been replaced by an adhesive developed in South Africa. This solution consists of yellow petroleum jelly in xylol with a concentration of 1 gram per 100 ccs.

In conjunction with a Medical Department health survey a dust and temperature survey was carried out in the Collie mines. The average dust count was 289 p.p.c.c. for facework, 244 p.p.c.c. for beltwork and 351 p.p.c.c. in other places underground. The average count around surface screens and railway trucks was 560 p.p.c.c.

It is with pleasure that I report that for the sixth year in succession there has not been a fatal accident due to fumes of explosives. Nineteen minor fuming accidents were reported and all were investigated.

During underground trials using AN-FO explosive some samples were taken of fume created in various working places. Results of sampling the 1,000 level Fault lode north drive of Great Boulder Pty. Gold Mines Ltd. are given below. These samples were taken during an inspection by the Chief Inspectors of Mines on the 13th September. The total explosive used was 35.7 lbs. which included 31 lbs. AN-FO and 4.7 lbs. semigel.

CO	CO_2	O_2	Ratio	NO_2	Remarks
% *Nil*	% 0·14	% 20·80	CO : CO_2 0	p.p.m. *Nil*	Sampled during charging operations.
0·160	1·00	20·09	1 : 6·25	260	5 mins. after firing—No ventilation.
0·156	1·03	20·08	1 : 6·60	215	20 mins. after firing—No ventilation.
0·049	0·36	20·70	1 : 7·35	Trace	35 mins. after firing and 10 mins. after turning on air-water blast.

The 1956 Annual Report contains the results of investigations on fumes from firing various grades of gelignite. For comparison with AN-FO above, the best result of sampling AN60 Gel. Special A fumes shortly after firing was 0.27% CO, 2.27% CO_2, and 19.65% O_2.

During the year, Great Boulder Pty. Gold Mines Ltd. installed a surface fan some 400 feet east of Edwards Shaft. The present output of the fan is 65,000 cumins against a head of 5.8 inches S.W.G. Output will increase when the resistance is reduced by enlarging some small openings on the 1200, 1933 and 2050 levels.

In October the ventilation circuits of the underground workings of Australian Blue Asbestos at Wittenoom were disrupted by a major collapse. Total air flow is now 76,000 cumins which represents just over 50% of the flow prior to the collapse. Work is in hand to restore the air flow to at least its previous level.

Ground Vibration.

A service to industry and other State Departments is now provided by the Mines Department. Late in 1961 a sprengnether Portable Blast and Vibration Seismograph was purchased for the purpose of measuring ground movement caused by blasting operations. This 100 magnification instrument measures all three components of the resultant wave. Several Departments and contractors have been assisted by advice on the use of explosives and recommendations made as to maximum charges that could be fired without damage to nearby structures.

Seismograms were obtained from blasts at the following sites—

(a) AN-FO blast at Muja open cut, Collie—Griffin Coal Mining Co. Ltd.

(b) Removal of granite outcrop near corner of Festing and Mill Streets, Albany—Main Roads Department.

(c) Rock quarries at Gosnells.—Australian Blue Metal Ltd.

(d) Dempster Head, Esperance—Town and Country Water Supplies, P.W.D.

(e) Railway Bridge site, Fremantle—Maunsell and Partners.

(f) Harbour deepening, Geraldton—Harbours and Rivers, P.W.D.

(g) AN-FO blast for removal of floor pillar below the No. 5 level, Paringa—Gold Mines of Kalgoorlie (Aust.) Ltd.

GOLD MINING.

The ore treated during the year amounted to 2,989,653 tons as compared with 2,984,458 tons in the previous year. Gold recovered amounted to 860,039 fine ounces as compared with 870,658 fine ounces for 1961.

Grade of ore mined was slightly lower, recovery being 5.75 dwts. per ton as against 5.83 dwts. per ton for 1961.

The calculated value of the gold produced was £13,444,861 which included £6,752 distributed by the Gold Producers' Association from the sale of 528.827 fine ounces of gold at an average premium of 3.68d. per fine ounce.

The Mint value of gold throughout the year was £15 12s. 6d. per fine ounce.

There was a small increase in the number of men employed in the industry from 5,337 in 1961 to 5,353 in 1962. Average production of ore per man was 558 tons valued at 90.10 shillings per ton as compared with 559 tons valued at 91.71 shillings per ton for 1961. Gold recovery per man averaged 160.66 fine ounces as compared with 163.14 fine ounces in the previous year.

Statistics relating to the gold mining industry are tabulated as follows:—

Table "D"—Gold Production Statistics.

Table "E"—Classification of Gold Output for 1962 by Goldfields.

Table "F"—Mines that have produced 5,000 ounces and upwards in any one of the past five years.

Table "G"—Development Footage.

TABLE D

Gold Production Statistics

Year	Tons Treated (2,240 lb.)	Total Gold Yield	Estimated Value of Yield	Value of Yield per ton	Number of Men Employed	Average Value of Gold per oz.	Average Yield per ton of Ore
	Tons	Fine oz.	£A	Shillings A		Shillings A	Dwts.
1933	1,588,979	636,928	4,884,112	61·48	9,900	153·36	8·01
1934	1,772,931	639,871	5,461,004	61·60	12,523	170·69	7·22
1935	1,909,832	646,150	5,676,679	59·45	14,708	175·71	6·77
1936	2,492,034	852,422	7,427,687	59·61	15,698	174·27	6·84
1937	3,039,608	1,007,289	8,797,662	57·99	16,174	174·68	6·64
1938	3,759,720	1,172,950	10,409,928	53·38	15,374	177·50	6·24
1939	4,095,257	1,188,286	11,594,221	56·62	15,216	195·14	5·80
1940	4,291,709	1,154,843	12,306,816	57·35	14,594	213·15	5·38
1941	4,210,774	1,105,477	11,811,989	56·10	13,105	213·70	5·25
1942	3,225,704	845,772	8,840,642	54·81	8,123	209·04	5·24
1943	2,051,011	531,747	5,556,736	54·19	5,079	209·00	5·19
1944	1,777,128	472,588	5,966,451	55·89	4,614	210·18	5·32
1945	1,736,952	469,906	5,025,039	57·86	4,818	213·87	5·41
1946	2,194,477	618,607	6,657,762	60·70	6,961	215·25	5·64
1947	2,507,306	701,752	7,552,611	60·25	7,649	215·25	5·59
1948	2,447,545	662,714	7,132,748	58·28	7,178	215·25	5·42
1949	2,468,297	649,572	7,977,200	64·64	6,800	245·62	5·26
1950	2,463,423	608,633	9,428,745	76·55	7,080	309·83	4·94
1951	2,471,679	648,245	10,042,392	81·26	6,766	309·83	5·25
1952	2,626,612	727,468	11,809,047	89·92	6,394	324·66	5·54
1953	3,169,875	823,331	13,290,100	83·85	6,359	322·84	5·20
1954	3,240,378	861,992	13,492,209	83·27	6,128	313·04	5·32
1955	2,865,048	834,326	13,055,574	91·13	5,845	312·96	5·82
1956	2,870,273	813,617	12,724,923	88·67	5,612	312·80	5·67
1957	2,951,011	849,741	13,304,752	90·17	5,385	313·15	5·76
1958	3,021,072	874,819	13,674,193	90·53	5,352	312·62	5·79
1959	2,959,202	860,969	13,453,808	90·93	5,769	312·52	5·82
1960	3,056,445	869,966	13,593,462	88·95	5,430	312·51	5·69
1961	2,984,458	870,658	13,684,867	91·71	5,337	314·36	5·83
1962	2,989,653	860,039	13,444,861	90·10	5,353	312·66	5·75

TABLE E

Classification of Gold Output for 1962 by Goldfields

Goldfield	Unclassified Sundry Claims, Alluvial, etc.	Up to 500 ozs.		501–1,000 ozs.		1,001–10,000 ozs.		10,001–50,000 ozs.		Over 50,000 ozs.		Total
		No. of Producers	Gold	No. of Producers	Gold	No. of Producers	Gold	No. of Producers	Gold	No. of Producers	Gold	
	fine ozs.		fine ozs.		fine ozs.		fine ozs.		fine ozs.		fine ozs.	fine ozs.
Kimberley	31	....	....	....	....	....	....	....	....	....	....	31
West Kimberley	....	....	....	....	....	....	....	....	....	....	....	....
Pilbara	450	2	202	1	951	....	....	....	....	....	....	1,603
West Pilbara	6	1	3	....	....	....	....	....	....	....	....	9
Ashburton	....	....	....	....	....	....	....	....	....	....	....	....
Peak Hill	20	4	249	....	....	....	....	....	....	....	....	269
Gascoyne	1	1	273	....	....	....	....	....	....	....	....	274
Murchison	339	10	387	....	....	1	6,757	....	....	1	87,196	94,679
East Murchison	170	3	183	....	....	....	....	....	....	....	....	353
Yalgoo	136	1	17	....	....	....	....	....	....	....	....	153
Mount Margaret	963	3	273	....	....	....	....	1	25,950	....	....	27,186
North Coolgardie	549	15	1,514	1	576	1	1,223	1	13,705	....	....	17,567
Broad Arrow	254	11	681	....	....	....	....	....	....	....	....	935
North-East Coolgardie	51	2	87	....	....	....	....	....	....	....	....	138
East Coolgardie	955	14	654	2	1,653	....	....	....	....	4	523,216	526,478
Coolgardie	1,164	14	743	....	....	2	9,981	....	....	....	....	11,888
Yilgarn	525	12	775	....	....	2	2,486	....	....	1	61,352	65,138
Dundas	40	6	706	....	....	....	....	....	....	1	109,506	110,252
Phillips River	....	....	....	....	....	1	2,987	....	....	....	....	2,987
South-West	....	1	41	....	....	....	....	....	....	....	....	41
State Generally	58	....	....	....	....	....	....	....	....	....	....	58
Totals	5,712	100	6,788	4	3,180	7	23,434	2	39,655	7	781,270	860,039
Production 1961	6,829	109	7,842	5	3,140	8	30,699	2	45,443	7	776,705	870,658
Production 1960	6,507	135	10,565	3	1,922	9	28,512	2	47,574	7	774,886	869,966
Production 1959	7,932	147	8,590	5	4,219	6	9,438	4	75,251	7	755,539	860,969
Production 1958	6,072	134	8,807	5	3,617	7	12,879	3	57,830	7	785,614	874,819

TABLE F

Mines that have Produced 5,000 ozs. and Upwards in any One of the Past Five Years

Mine	1962			1961			1960			1959			1958		
	Tons Treated	Fine ozs.	Dwts. per ton	Tons Treated	Fine ozs.	Dwts. per ton	Tons Treated	Fine ozs.	Dwts. per ton	Tons Treated	Fine ozs.	Dwts. per ton	Tons Treated	Fine ozs.	Dwts. per ton
Central Norseman Gold Corporation N.L.	181,834	109,506	12·04	175,124	98,305	11·23	190,679	101,291	10·62	182,996	101,203	11·06	182,822	108,176	11·83
Eclipse Gold Mines N.L.	6,086	6,757	22·21	8,550	7,860	18·39	6,969	7,690	22·07	7,514	12,048	32·07	2,840	2,942	20·72
Gold Mines of Kalgoorlie (Aust.) Ltd.	518,747	140,919	5·43	518,244	152,964	5·90	569,116	150,319	5·28	496,981	134,002	5·39	519,168	147,310	5·67
Great Boulder Pty. Gold Mines Ltd.	450,192	121,628	5·40	452,145	129,388	5·72	448,398	123,875	5·52	454,474	124,041	5·46	488,761	134,307	5·50
Great Western Consolidated N.L.	390,462	61,352	3·14	390,700	58,477	2·99	390,353	63,434	3·25	393,252	67,100	3·41	459,119	76,641	3·34
Hill 50 Gold Mines N.L.	165,698	87,196	10·52	157,196	82,953	10·55	156,844	82,988	10·58	155,471	81,907	10·54	133,081	77,209	11·60
Lake View and Star Ltd.	694,054	172,001	4·96	681,108	166,031	4·88	683,950	165,032	4·83	669,927	162,576	4·85	665,998	161,899	4·86
North Kalgurli (1912) Ltd.	368,350	84,559	4·59	373,795	90,220	4·83	372,053	87,841	4·72	361,344	89,007	4·93	345,983	84,199	4·87
State Batteries	48,154	13,697	5·69	40,673	13,835	6·80	39,219	14,704	7·50	39,048	14,700	7·53	41,806	13,498	6·46
The Sons of Gwalia Ltd.	121,773	25,950	4·26	135,995	32,947	4·85	138,618	32,983	4·76	135,932	33,469	4·92	137,377	30,269	4·41
Timoni (Moonlight Wiluna G.M. Ltd.)	24,493	13,705	11·19	23,871	12,496	10·47	29,880	14,591	9·77	32,229	15,879	9·85	31,838	15,746	9·89
Total	2,969,843	837,270	5·64	2,957,401	845,476	5·72	3,026,079	844,748	5·58	2,929,168	835,932	5·71	3,008,793	852,196	5·66
Other Sources (excluding large Retreatment Plants)	19,810	10,841	10·94	27,057	13,131	9·71	30,366	12,613	8·31	30,034	12,051	8·02	12,279	10,623	17·30
Total (excluding large Retreatment Plants)	2,989,653	848,111	5·67	2,984,458	858,607	5·75	3,056,445	857,361	5·61	2,959,202	847,983	5·73	3,021,072	862,819	5·71
Lake View and Star Retreatment	....	9,094	....	....	8,339	....	....	9,187	....	....	9,844	....	....	8,989	....
State Batteries Tailings Treatment	....	2,834	....	....	3,712	....	....	3,418	....	....	3,142	....	....	3,011	....
Grand Total	2,989,653	860,039	5·75	2,984,458	870,658	5·83	3,056,445	869,966	5·69	2,959,202	860,969	5·82	3,021,072	874,819	5·79

TABLE G

Development Footages Reported by the Principal Mines

Gold or Mineral Field	Mine	Shaft Sinking	Driving	Cross-Cutting	Rising and Winzing	Diamond Drilling	Total
Gold—		feet	feet	feet	feet	feet	feet
Murchison	Hill 50 Gold Mines N.L.	432	3,490	1,295	1,541	13,515	20,273
	Eclipse Gold Mines N.L.	....	596	369	600	2,014	3,579
Mount Margaret	The Sons of Gwalia Ltd.	....	1,531	453	1,857	7,952	11,793
North Coolgardie	Timoni (Moonlight Wiluna G.M. Ltd.)	155	1,681	242	521	....	2,599
East Coolgardie....	Lake View and Star Ltd.	126	21,743	4,375	4,604	28,244	59,092
	Great Boulder Pty. Gold Mines Ltd.	11	16,086	1,770	4,173	7,096	29,136
	North Kalgurli (1912) Ltd.	....	12,214	825	2,220	26,172	41,431
	Gold Mines of Kalgoorlie (Aust.) Ltd.	....	20,430	5,807	5,510	27,074	58,821
Coolgardie	Gold Mines of Kalgoorlie (Aust.) Ltd.	144	851	116	66	3,053	4,230
	Paris Gold Mines Pty. Ltd.	121	1,596	247	748	1,595	4,307
Yilgarn	Great Western Consolidated N.L.	....	....	....	....	....	....
	Radio	....	152	34	76	....	262
Dundas	Central Norseman Gold Corporation N.L.	754	9,076	475	3,341	42,037	55,683
	Total in Gold Mines	1,743	89,446	16,008	25,257	158,752	291,206
Asbestos—							
West Pilbara	Australian Blue Asbestos	....	3,839	55	1,144	3,614	8,652
Pilbara	Lionel	154	243	....	....	....	397
	Total in Asbestos Mines	154	4,082	55	1,144	3,614	9,049
Pyrite—							
Dundas	Norseman Gold Mines N.L.	....	225	57	43	182	507
Copper—							
Phillips River	Ravensthorpe Copper Mines N.L.	....	2,153	46	178	989	3,366
Peak Hill	Thaduna Copper Mine	....	238	91	216	....	545
West Pilbara	Depuch Shipping and Mining Co. Pty. Ltd	117	118	....	....	15,446	15,681
	Total in Copper Mines	117	2,509	137	394	16,435	19,592
Iron—							
West Kimberley	Australian Iron and Steel Ltd.	....	130	....	....	....	130
Pilbara	Mount Goldsworthy Mining Associates	....	....	1,930	....	4,025	5,955
	Total in Iron Mines	....	130	1,930	....	4,025	6,085
	Total in All Mines	2,014	96,392	18,187	26,838	183,008	326,439

OPERATIONS OF THE PRINCIPAL MINES.

EAST COOLGARDIE GOLDFIELD.

The total ore treated in this goldfield amounted to 2,027,855 tons with a recovery of 526,478 fine ounces of gold at an average of 5.19 dwts. per ton. This output was equal to 61.2 per cent of the gold production for the State. In the previous year 2,016,209 tons of ore averaging 5.36 dwts. were treated for a recovery of 540,473 fine ounces of gold.

Production in the *Bulong District* amounted to 13 fine ounces from the treatment of 8 tons of ore.

In the *East Coolgardie District* 526,465 fine ounces were recovered from the treatment of 2,027,847 tons of ore. Following are notes on the activities of the principal producers in the district.

Lake View and Star Ltd., with a production of 694,054 tons of ore for a return of 172,001 fine ounces of gold at an average recovery of 4.96 dwts. per ton, was the State's leading producer. Retreatment of tailings yielded an additional 9,094 fine ounces.

The previous year's production was 166,031 fine ounces from the treatment of 681,108 tons plus 8,339 fine ounces from tailings retreatment.

Estimated ore reserves as at the 1st July were 3,699,800 short tons for an average grade of 4.92 dwts.

Nearly 31,000 feet of development work was completed during the year. This was 3,572 feet more than the total for the previous year. A new office block has been erected and the company reports the completion of the wet fill installation at the Lake View mine.

A programme for the improvement of ventilation and mechanical handling continued throughout the year. Fifty electric powered secondary ventilation fans are now installed and additional mechanical loaders, scrapers and battery locomotives introduced to improve the handling and transport of ore. The hydraulic filling system has been extended and now nearly 10 per cent. of the ore mined is from flat back cut and fill stopes.

Gold Mines of Kalgoorlie (Aust.) Ltd. produced 140,919 fine ounces from the treatment of 518,747 tons at an average recovery of 5.43 dwts. per ton. The Kalgoorlie group of mines produced 135,934 ounces from 505,490 tons with an average recovery of 5.38 dwts. per ton.

Ore reserves as at the 31st March were 1,139,000 tons at 5.9 dwts. per ton.

Placement of sand filling in old shrink stopes in the Perseverance and South Kalgurli mines has stabilized these workings and enabled the company to exploit the remaining lodes. A plat was cut at the No. 6 Perseverance level and this horizon developed. Development at the Paringa was concentrated on the Nos. 8, 9 and 10 Federal lode levels. Pillars in the Oroya shoot provided a cheap and readily available source of ore.

Extensive diamond drilling on the Mount Charlotte leases has indicated a massive low grade ore body some 700 feet long and 100 feet wide. Preparations are in hand to treat this free milling ore at the Company's mill. A telluride flotation section has been added to the mill to provide separate treatment of telluride and sulphide minerals. Auriferous pyritic concentrates railed to Perth fertilizer works yielded, in addition to gold, the equivalent of 5,470 tons of sulphur.

Great Boulder Pty. Gold Mines Ltd. treated 450,192 tons of ore for a recovery of 121,628 fine ounces of gold, average recovery being 5.40 dwts. per ton. During the previous year 452,145 tons yielded 129,388 fine ounces at an average grade of 5.72 dwts. per ton.

Ore reserves are 2,096,596 short tons averaging 5.5 dwts. per ton.

The bottom working level of this mine has been established at the 4,000 feet horizon off the Internal shaft. Production from stoping is now proceeding between the 3,100 and 4,000 feet levels.

In order to improve ventilation at depth and throughout the mine a return airway situated about 400 feet east of Edwards shaft has been established by connection of the 800 level to the surface. An exhaust fan has been installed on the surface above the airway and is exhausting 70,000 cumins which output should be increased when small openings on the 12, 19 and 20 levels are enlarged.

In the mill calcine washing has been adopted to reduce the usage of cyanide, lime and copper sulphate.

North Kalgurli (1912) Ltd. treated 368,350 tons of ore for a recovery of 84,559 fine ounces of gold at an average recovery of 4.59 dwts. per ton. In the previous year 90,220 ounces were recovered from 373,795 tons of ore.

Estimated ore reserves as at the 27th March were 2,233,976 tons at 5.33 dwts. per ton. Completed during the year were 12,214 feet of driving, 825 feet of crosscutting, 461 feet of rising, 1,759 feet of winzing, and 26,172 feet of diamond drilling. Major faulting in some of the larger ore blocks in the Kalgurli section indicates that increased exploration will be necessary where the lodes leave the quartz dolerite and extend into the calc schist.

The new power plant brought into commission in September is operating efficiently and the Company will benefit from reduced power costs.

Mining at Mount Monger declined during the year and only two mines were continuously worked. The *Daisy* produced 891 fine ounces from 1,068 tons of ore. For a small mine the owner has developed and proved a satisfactory reserve of 1,600 tons. The *Rosemary* had a successful year with a production of 761 fine ounces from 1,056 tons of ore.

DUNDAS GOLDFIELD.

The production of 110,252 fine ounces of gold from the treatment of 183,719 tons of ore represented 12.8 per cent. of the State's total production. In the previous year 176,895 tons of ore yielded 98,890 fine ounces.

Central Norseman Gold Corporation N.L. treated 181,834 tons for a recovery of 109,506 fine ounces. Gold recovery was at the rate of 12.04 dwts. per ton which compares favourably with the previous year's grade of 11.23 dwts. per ton when 175,124 tons yielded 98,305 ounces.

At the end of March the calculated ore reserves were 595,569 tons at 10 dwts. per ton.

Crown reef development during the year consisted mostly of rising and winzing for level connections between the No. 16 and No. 32 levels, and for preparation of stoping blocks. Most ore was obtained from stopes on the 19 and 22 levels. Surface diamond drilling was continued to test the southern extension of the Crown reef.

High grade ore is still mined at the Princess Royal although mining is at present confined to the remnants of previously worked stopes. The North Royal shaft was advanced to 3,793 feet and the No. 22 level established. Shaft sinking operations were ventilated by and EF6 Meco 24 inch electric fan sited 800 feet below the No. 13 level and exhausting 8,000 cumins through 30 inch diameter ducting to the No. 10 level. A second EF6 fan sited 50 feet above the exhaust fan was used to blow to the shaft bottom.

Prospectors at Beete had satisfactory year with a return of 682 fine ounces from 830 tons of ore.

MURCHISON GOLDFIELD.

174,504 tons of ore were treated in this goldfield for a return of 94,679 fine ounces of gold. This production was equal to 11.0 per cent. of the State's total. In the previous year 91,877 ounces were obtained from the treatment of 169,957 tons.

Gold output from various claims in the *Cue and Day Dawn Districts* amounted to 146 ounces from the treatment of 461 tons.

In the *Meekatharra District* 284 ounces were recovered from the treatment of 1,696 tons of ore. The most successful producers were the *Prohibition* with 76 ounces and the *Tumbulgum North* with 46 ounces.

The *Mount Magnet District* produced 94,249 fine ounces of gold from the treatment of 172,347 tons of ore. The principal producer was *Hill 50 Gold Mines N.L.* with 87,196 fine ounces from 165,698 tons. Average recovery was 10.52 dwts. per ton which was a little below the previous year's average of 10.55 dwts. when 82,953 ounces were produced.

Sinking of the main shaft was continued and the advance for the year was 432 feet. In March another pentice was built in the shaft below No. 9 level. Considerable trouble was experienced with ground in the shaft and continuous rock bolting and timbering was necessary. Early in the new year it is anticipated that the shaft will have reached the No. 11 level horizon (about 2,470 feet). This level was developed from winzes sunk below the Nos. 8 and 9 levels.

To explore the Brownhill lode, stripping has commenced in the shaft on G.M.L. 1536M "Pat Omeara" and preparations made for the installation of power, air and water lines.

The ore reserves on the 3rd July were 431,800 short tons averaging 10.0 dwts.

Eclipse Gold Mines N.L. Production for 1962 was 6,757 fine ounces of gold from 6,086 tons averaging 22.21 dwts. recovered for each ton of ore treated Ore reserves are limited at the Eclipse but the company is interested in the Pinnacles mine near Cue.

YILGARN GOLDFIELD

Production for the year was 65,138 fine ounces of gold from 396,944 tons averaging 3.28 dwts. per ton recovery. In the previous year 408,869 tons yielded 64,301 fine ounces at the rate of 3.1 dwts. per ton. This goldfield in 1962 was responsible for 7.6 per cent. of the State's production.

Great Western Consolidated N.L. milled 390,462 tons for a recovery of 61,352 fine ounces of gold averaging 3.14 dwts. per ton. Production for the previous year was 58,477 fine ounces from 390,700 tons.

No development work was carried out on any of the Company mines during the year. About one half of the ore broken was from quarry operations at Copperhead and Fraser's. Pressure twisted and snapped a number of steel sets in the Copperhead Internal shaft during July. Repair and maintenance costs would have outweighed the returns from the remaining ore so the shaft was abandoned after salvage was completed.

Production from the Pilot mine at Hope's Hill ceased in May. Salvage operations were practically complete by the end of the year in the underground workings at the Fraser's mine at Southern Cross. Only a small block of ore on the No. 6 level remains to be broken and hoisted before the shaft is closed. At the Nevoria mine operations at the end of the year were confined to one block on the No. 4 level.

It is expected that the Company will cease operations early in 1963.

The *Radio* mine in the Golden Valley centre produced a total of 1,335 fine ounces of gold from the treatment of 1,714 tons of ore and retreatment of 585 tons of sands. The sands were treated by Great Western Consolidated. Development work consisted of 152 feet of driving, 34 feet of cross-cutting and 76 feet of rising.

The *Frances Furness* at Marvel Loch produced 1,151 ounces from 1,640 tons. A new ore body discovered on the 230 level should greatly increase the life of the mine. At Edwards Find the King Solomons gold mine produced 453 ounces from the treatment at Bullfinch of 1,539 tons of ore.

During the year prospectors were active at Forrestonia, Eenuin, Marvel Loch, Mount Rankin and Parker's Range.

MOUNT MARGARET GOLDFIELD.

The total ore treated in this gold field was 125,371 tons which yielded 27,186 fine ounces of gold at an average rate of 4.34 dwts. per ton. This output represented 3.2 per cent. of the State's total. In the previous year 138,745 tons averaging 4.9 dwts. recovery were treated for a yield of 33.977 fine ounces.

The Sons of Gwalia Ltd. operating in the Mount Malcolm District produced 25,950 fine ounces from the treatment of 121,773 tons of ore. Average recovery was 4.26 dwts. per ton. In the previous year 135,995 tons yielded 32,947 fine oz. at the rate of 4.85 dwts. per ton.

The failure of the crankshaft of the Main Shaft winder on the 23rd March caused a loss of production during the 16 days shutdown of the underground workings.

Some improvement in tonnage and grade is expected in 1963 as there has been encouraging development on the No. 16 level West lode. Ore reserves as at the end of June were estimated at 217,150 tons of 4.92 dwts. per ton.

At Lake Darlot the *Monte Christo* produced 131 ounces from 1,709 tons. This low grade laterite deposit can be worked at a profit as the sands, which are not included, assay about 4 dwts. per ton.

A small rich seam carrying two ounce values was discovered some 16 miles north of Leonora by two weekend prospectors. The area was worked in the early days and the latest find has produced 53 ounces from 27 tons.

Prospecting generally has been at a low ebb, with no reported production from the *Mount Margaret District* and only 47 ounces from the *Mount Morgans District*.

NORTH COOLGARDIE GOLDFIELD.

Production from this goldfield amounted to 17,567 fine ounces of gold recovered from 32,319 tons of ore averaging 10.9 dwts. per ton. As a comparison the production for the previous year was 15,849 ounces from 30,053 tons averaging 10.5 dwts. Output for this goldfield was 2 per cent. of the total.

In the *Menzies District* the leading producer was *Moonlight Wiluna Gold Mines Ltd.* operating the Timoni mine at *Mount Ida*. From this mine 13,705 ounces were obtained from 24,493 tons. Ore reserves at the end of June were 92,000 tons at 9.5 dwts. per ton. Southward development has continued in good values and it is expected that there will be increased production in 1963. A 330 h.p. Ruston Hornsby engine direct coupled to a Lancashire Alternator ex Captain's Flat was installed in anticipation of extra output from the mine. Development work completed during the year included 155 feet of shaft sinking, 1,681 feet of driving, 242 feet of cross-cutting and 485 feet of winzing.

Production from the *Goodenough* mine trebled with a return of 498 ounces from 1,720 tons. The *First Hit* at Menzies reported 167 ounces from 481 tons crushed.

In the *Ularring District* the production was 1,003 fine ounces of gold recovered from the treatment of 666 tons of ore. The *Oakley* mine at Davyhurst now down some 1,100 feet on an underlay of 25-30 degrees produced 576 ounces from 174 tons. The *First Hit* at Morley's Find, down 400 feet, crushed 220 tons for a return of 212 ounces and the *Golden Wonder* at Mulline obtained 140 ounces from 180 tons.

The principal producer in the *Niagara District* was the *Altona* at Kookynie with 181 ounces from 626 tons. This ore was extracted from a block on the north end of the 300 level.

In the *Yerilla District* 2,387 tons were treated for a return of 1,321 fine ounces of gold. Most of this production was from the *Yilgangie Queen* with a return of 1,223 fine ounces from 1,802 tons crushed at the Yarri State Battery. Development of the 450 ft. level provided most of the ore from the mine which is worked under a tribute agreement with the Western Mining Corporation.

COOLGARDIE GOLDFIELD.

During 1962, 36,712 tons of ore were treated for a return of 11,888 fine ounces of gold at an average recovery rate of 6.5 dwts. per ton. In the previous year 27,274 tons yielded 13,834 fine ounces.

Gold Mines of Kalgoorlie (Aust.) Ltd. operating the Bayley's mine at Coolgardie reported the production of 4,636 fine ounces from 12,530 tons of ore. In addition, tributers on the Barbara and Surprise Mines produced 349 fine ounces from 727 tons.

Price's internal shaft was sunk 144 feet and the Nos. 14 and 15 levels established. Reduced production and development at this mine indicate that its life is limited.

Paris Gold Mines Pty. Ltd. produced 5,003 fine ounces of gold from the treatment of 18,276 tons of ore. Included in this production was 819 fine ounces obtained from a total of 214 tons of concentrate shipped to Sweden and Japan. These concentrates also contained 47 tons of copper and 2,254 ounces of silver valued at £9,699 f.o.b. Esperance. Preparations have been made to sink Findlay's shaft to the No. 4 level. A winze has been sunk and a crosscut to the shaft completed as it is proposed to rise from the No. 4 level and then strip the rise to shaft dimensions.

Among the smaller producers the best return was from the *Little Nipper* at Ryans Find with 173 fine ounces from 17½ tons.

PHILLIPS RIVER GOLDFIELD.

Ravensthorpe Copper Mines N.L. reported the production of 2,987 fine ounces of gold made up of 1,117 ounces recovered in the mill and 1,870 ounces contained in 5,063 tons of copper concentrates sent overseas. Also contained in the concentrates were 4,167 fine ounces of silver and 979 tons of copper. This production was from the treatment of 74,709 tons of ore obtained from the Elverdton, Cattlin and Beryl mines at Ravensthorpe.

No other gold production was reported.

PILBARA GOLDFIELD.

In this goldfield 1,603 fine ounces of gold were recovered from 4,368 tons of ore averaging 7.3 dwts. per ton.

North West Mining N.L. re-opened the Blue Spec mine at Nullagine and in six months produced 951 ounces from 1,539 tons. The mine closed again early in August. Lack of finance and extraction difficulties were the main causes for the closure.

Prospectors working part of the *All Nations* obtained 120 ounces from 212 tons from a comparatively shallow depth.

At Bamboo Creek 479 tons of ore from the *Prince Charlie* yielded 128 fine ounces of gold. The *True Blue* at the same centre crushed 1,235 tons at the State Battery for a poor return over the plates but the sands are expected to yield over a half ounce per ton when cyanided.

BROAD ARROW GOLDFIELD.

Total production for the year was 935 fine ounces of gold from the treatment of 3,210 tons of ore.

The *Gimlet South* was the leading producer with 332 fine ounces from 1,529 tons. Lack of water had a marked effect on production but output in 1963 should increase when scheme water will be available for use by the syndicate. Most of the remaining production in this goldfield was obtained from State Battery sands retreatment and numerous small crushings treated for week end and part time prospectors.

EAST MURCHISON GOLDFIELD.

In this Goldfield, which produced 353 fine ounces from 705 tons, active mining was mostly confined to operations at the *Goanna Patch* on Wildara Station and the *Scheelite* leases at Barrambie. The total production from prospecting areas on Wildara Station was 159 ounces from 365 tons. At the *Scheelite* mine 121 tons of ore, won from an underhand stope at the 100 ft. horizon, yielded 114 fine ounces of gold. A new shaft has been sunk at this mine to cut the reef at 150 feet.

GASCOYNE GOLDFIELD.

The total output of 274 fine ounces from 105 tons was obtained from a gold prospect on Mangaroon Station. Although the returns were good, no real effort has been made to test the extent of the ore body.

PEAK HILL GOLDFIELD.

Production totalled 269 fine ounces of gold recovered from the treatment of 2,432 tons of ore. The *Morning Star* was the only notable producer with 160 ounces from 1,314 tons. Most of the remaining production came from the treatment of low grade lateritic material from leases around Peak Hill.

YALGOO GOLDFIELD.

Ore crushed in this goldfield totalled 585 tons which yielded 153 fine ounces of gold. The best returns were obtained from prospects at Wadgingarra, 36 ounces from 16 tons, and Schuman's Find with 58 ounces from 85 tons.

NORTH EAST COOLGARDIE GOLDFIELD.

This goldfield produced 138 fine ounces from 641 tons of ore. The only producer of note was the *Kanowna Red Hill* with 80 ounces from 170 tons. Other sources within the State produced 139 fine ounces of gold from 182 tons of ore treated.

MINERALS OTHER THAN GOLD.

The production of minerals, other than gold, for 1961 and 1962 is shown in the table following.

MINERAL OUTPUT (EXCEPT GOLD).

Mineral	1961		1962	
	Tons	Value £A	Tons	Value £A
Asbestos—				
Chrysotile	156·13	2,629	52·50	1,103
Crocidolite	14,086·59	1,532,540	15,616·95	1,691,933
Bauxite	9,849·00	*	....	....
Barite	....	....	494·35	3,116
Bentonite	586·70	1,598	485·00	1,213
Beryl	260·85	40,079	195·46	32,452
Bismuth	0·41	371	0·08	40
Building Stone	4·45	53	....	....
Clays	61,237·35	69,477	54,213·23	62,066
Coal	765,739·73	1,680,259	919,112·00	1,980,778
Copper—				
Ore and Concentrates	6,205·18	322,499	5,277·26	205,399
Fertilizer Grade	7,383·82	157,488	9,275·18	94,569
Dolomite	374·00	1,496	....	....
Diatomaceous Earth	....	....	15·00	300
Felspar	1,190·00	5,210	1,267·00	6,884
Fuller's Earth	40·76	163	120·00	480
Glass Sand	8,214·78	5,861	10,325·62	7,708
Gypsum	45,145·03	62,844	51,650·13	87,879
Ilmenite	123,538·46	557,889	205,804·96	911,606
Iron Ore—				
Exported	1,284,768·00	1,274,053	1,320,355·00	1,309,643
For Pig	80,437·00	1,088,192	72,168·00	1,016,290
Lead Ore and Concentrates	597·05	25,766	443·03	15,156
Leucoxene	268·10	4,120	788·55	10,767
Limestone	14,199·15	18,839	36,481·25	24,008
Lithium Ore—				
Petalite	96·00	409	84·00	403
Spodumene	5·00	85	24·15	347
Magnesite	9,624·92	64,977	224·01	1,593
Manganese	67,652·14	884,262	89,602·58	1,155,862
Monazite	1,005·20	25,699	950·15	28,544
Ochre	294·27	1,770	....	....
Phosphatic Guano	115·00	807	68·00	680
Pyrite	52,397·00	369,094	49,461·07	356,290
Quartz Grit	58·20	58	25·00	21
Rutile	552·84	11,953	874·27	19,906
Scheelite	....	....	7·35	3,883
Semi-Precious Stones—				
Chalcedony	....	....	0·20	200
Silver (fine ozs.)	179,992·12	75,018	248,460·93	117,661
Spongolite	....	....	669·00	2,994
Talc	5,149·28	64,581	4,980·95	71,810
Tantalo/Columbite	14·20	22,917	19·24	58,874
Tin Concentrates....	341·16	235,580	465·44	334,269
Zircon	6,098·90	61,314	4,132·47	44,343
Totals	....	8,669,950	....	9,661,070

* Value not available for publication.

Brief notes on mineral production are given below.

ASBESTOS.

Old dumps at Lionel were the source of the 52½ tons of chrysotile produced in the Pilbara. A plant, to treat white asbestos ore, from deposits at Lionel and Soansville, is being erected at the Comet mine near Marble Bar and should be ready for operation late in 1963.

Australian Blue Asbestos Ltd. at Wittenoom produced 15,617 tons of crocidolite valued at £1,691,933. The average number of men employed throughout the year was 416 made up of 196 surface and 220 underground employees.

A collapse between the Nos. 2 and 5 levels in the Colonial mine on the 22nd October caused some loss of production. To ensure against further collapse a large barrier pillar was left between the collapsed area and current workings. This major subsidence disrupted the primary ventilation circuits and it was several weeks before satisfactory air flows were established along the working levels. The company has carried out a number of tests, in the mill building to find the most satisfactory type of dust extractor to replace or augment the existing overloaded dust collection equipment.

In addition to production losses caused by the fall of ground some restriction was placed on production following increased competition and loss of some overseas markets to South African producers. All available storage space at Port Samson has been taken up with bags of fibre.

BAUXITE.

Alcoa of Australia Pty. Ltd. and its subsidiary *Western Aluminium N.L.* had a busy year on construction of the alumina refinery at Kwinana and test work associated with the mining of bauxite.

The railway line between Jarrahdale and Kwinana was nearing completion at the end of the year and it is expected that alumina production will start in August 1963.

BARITE.

From Chesterfield in the Murchison Goldfield 494 tons of barite valued at £3,115 f.o.r. were mined and railed to Perth for milling.

BENTONITE.

Bentonite production at Marchagee totalled 485 tons valued at £1,213 f.o.r. The bentonite is collected during the summer months from flat clay pan-like deposits.

BERYL.

One hundred and ninety five tons containing 2,223 units of beryllium oxide valued at £32,452 were obtained from claims in the Pilbara, West Pilbara, Ashburton, Gascoyne, Murchison, Yalgoo, Coolgardie, and Phillips River goldfields. Main producing centres were Warda Warra with 962 units, Marble Bar with 394 units, Yinnietharra with 236 units, Roebourne with 136 units and Poona with 127 units.

CLAYS.

Reported clay production from the Metropolitan area, Clackline, Glen Forrest and Goomalling totalled 54,213 tons valued at £62,066. Output is well in excess of the above tonnage as most of the clay used in the brickmaking industry is obtained from private property and is not reported to this Department.

COAL.

The total output from all mines in the Collie Coalfield was 919,112 tons valued at £1,980,778 at the pit head. Open cut production at 320,611 tons represented 35 per cent. of the field's output.

The Griffin Coal Mining Co. Ltd. operating the Hebe mine and the Muja open cut produced 554,634 tons. The main development headings, in the Hebe mine, are in good condition, reasonably dry and gradually flattening out with present gradient of 1 in 25. Bad roof conditions encountered in the No. 3 Left District necessitated the replacement of roof bolting by timber supports. Ventilation of the mine was improved by the installation of a new fan delivering 90,000 cumins as compared with 68,000 cumins delivered by the original machine.

In the open cut, overburden removal progressed at a greater rate than coal extraction, and at the end of the year the quantity of coal uncovered was 294,000 tons. Open cutting operations commenced on the eastern section of the deposit during June.

Western No. 2 mine of *Western Collieries Ltd.* with a production of 290,325 tons was the largest deep mine producer in the field. A little trouble was experienced with soft floor conditions in the main development slants. Development work progressed fairly well in the Western No. 4 mine notwithstanding faulted and generally wet working places with an inferior roof. Ventilation was improved in Western No. 4 when a connection was made between the 1st and 2nd entry in the bottom seam and a second ventilating unit installed.

COPPER.

Ravensthorpe Copper Mines N.L. produced 5,063 tons of concentrate from 74,709 tons of ore containing 97,867 units valued at £196,718 f.o.b. Esperance. In addition 2,987 fine ounces of gold, 4,167 fine ounces of silver, and 26 tons of fertiliser grade ore were produced. Below average grade exposures has resulted in the closure of the Beryl mine and the Cattlin operations will be suspended on extraction of the remaining blocked out ore. Work was concentrated between the No. 3 and 5 levels of the Elverdton.

During the year *Paris Gold Mines Pty. Ltd.* exported 214 tons of gold/copper concentrates containing 47 tons of copper.

Production of copper ore, for use as a trace element in fertilizers, was 9,275 tons as compared with 7,384 tons for the previous year. Average grade at 5% Cu was half that of the 1961 production. This sudden decline in average grade was brought about by the sale of 3,621 tons of 2% Cu sands from Gabanintha. This production and the production of 3,361 tons of 6.5% Cu ore by the *Thaduna Copper Mining Co.* in the Peak Hill Goldfield had a marked effect on the average grade for the State. The company's output was valued at £44,151.

Other notable producers of copper ores and concentrates were the *Copper Hills Copper Mine* in the Pilbara with a production of 272 tons of 15.3% ore valued at £11,900, *L.T. Parkinson* at Kumarina with 260 tons of 9.7% ore valued at £7,495 and *O'Callaghan and Howlett* of Warriedar with 161 tons of 8.2% ore valued at £2,817.

At Whim Creek, the *Depuch Shipping and Mining Co. Pty. Ltd.* has carried out a development and diamond drilling programme to prove the value and extent of the Whim Well ore body. Results were sufficiently encouraging and a treatment plant capable of treating 150 tons of ore per day is being erected. Production should start in September, 1963.

DIATOMACEOUS EARTH.

Fifteen tons valued at £300 was obtained from Lake Gnangarra.

FELSPAR.

Australian Glass Manufacturers Co. Pty. Ltd. reported the production of 1,267 tons from their quarry at Londonderry. This production was valued at £6,884 f.o.r. Coolgardie.

FULLER'S EARTH.

One hundred and twenty tons were obtained from the Marchagee deposit.

GLASS SAND.

Production from the Lake Gnangarra deposit amounted to 10,326 tons valued at £7,708.

GYPSUM.

Plaster manufacturers obtained their supplies of raw material from Yellowdine, Lake Brown and Lake Cowcowing. This output of 31,174 tons was valued at £26,693. Cement manufacturers obtained 1,747 tons for Nukarni. Garrick Agnew Pty. Ltd. exported through Esperance 18,669 tons of Lake Cowan gypsum valued at £59,684. Total production for the year, including 60 tons for agricultural purposes was 51,650 tons having a value of £87,879.

ILMENITE, LEUCOXENE, MONAZITE, RUTILE, ZIRCON.

Overseas shipments of ilmenite totalled 205,805 tons valued at £911,606 f.o.b. Bunbury. An additional £103,560 was obtained from the sale of associated minerals.

Western Titanium N.L. operating at Capel produced 110,251 tons of ilmenite assaying 54.95 per cent. titanium dioxide, 750 tons of leucoxene, 950 tons of monazite, 874 tons of rutile, and 4,132 tons of zircon. This company was the sole producer of monazite, rutile and zircon. Mining by sluicing was concentrated on a 30 ft. high face 600 feet wide situated about two miles south west of Capel.

Westralian Oil Ltd. produced 51,323 tons of ilmenite assaying 59.21 per cent. TiO_2 and 38 tons of leucoxene from the Yoganup deposit. An area of approximately 2,700 feet by 500 feet has been mined and most of it has been backfilled. Additional plant has been added for the extraction of other minerals recovered in the wet plant.

Ilmenite Pty. Ltd. operating at Wonnerup near Busselton produced 22,683 tons of concentrates assaying 55.10 per cent. TiO_2. Their production, which is shipped to Tasmania, is expected to increase in 1963.

Cable (1956) Ltd. produced 21,548 tons averaging 55.50 per cent. TiO_2. The area mined by scraper and bulldozer is adjacent to their plant at Bunbury.

IRON ORE.

During 1962, 1,320,355 tons of iron ore were shipped from Cockatoo Island by *Australian Iron and Steel Ltd.* This ore destined for the Eastern States averaged 63% Fe. Work at Koolan Island included the completion of a modern housing, schooling, and shopping settlement. Construction continued on wharf and ship loading facilities. A tunnel 130 feet in length was driven to connect the 60,000 ton ore bin with the primary and secondary crusher stations.

During 1962 there was a considerable amount of activity in the exploration for, and assessment of, iron ore deposits in the Yilgarn, Ashburton, Pilbara, West Pilbara, West Kimberley and Kimberley Goldfields. Exploration of the Tallering and Koolanooka deposits in the South West Mineral Field continued. At Mount Goldsworthy four adits totalling 1,930 feet were driven, 4,025 feet of diamond drilling and 20,180 feet of percussion drilling completed. Estimated reserves at Mount Goldsworthy is now 66 million tons averaging 62% Fe.

The *Charcoal Iron and Steel Industry* at Wundowie obtained 72,168 tons of ore averaging 61.74% Fe from the Koolyanobbing deposit. Pig iron produced was 46,195 tons valued at £1,016,290.

LEAD.

Production in the Northampton Mineral Field declined still further because of the depressed price of this metal. Recorded production of 443 tons of concentrate valued at £15,156 was the lowest for many years. The only mine active during the year was the *Mary Springs Lead Mine* north of Galena which treated 657 tons of ore at the State Battery for a return of 156 tons of concentrate containing 115.27 tons of lead valued at £6,045 f.o.b. Geraldton.

LIMESTONE.

Limestone production, from holdings covered by the Mining Act, totalled 36,481 tons. This figure is well below the actual production which is used for lime burning, road building, fertilizer production, cement production, the building industry, and pig iron production. Most of the limestone used is obtained from quarries situated within 25 miles of Perth.

LITHIUM ORE.

Eighty-four tons of petalite were obtained by hand picking in the felspar quarry at Londonderry. A deposit near Ravensthorpe in the Phillips River Goldfield yielded 24 tons of spodumene.

MAGNESITE.

Basic Materials Co. Pty. Ltd. exported through Esperance 224 tons of magnesite obtained from the Bandalup Creek deposit near Ravensthorpe.

MANGANESE.

Exports from Port Hedland totalled 67,601 tons of 49½% Mn ore valued at £889,775 f.o.b. Producers were *Northern Mineral Syndicate* with 38,399 tons from Woody Woody, *Westralian Ores Pty. Ltd.* with 17,206 tons from Skull Springs, *D. F. D. Rhodes Pty. Ltd.* with 7,218 tons from Mt. Sydney, *Pindan Pty. Ltd.* with 2,560 tons from Nimingarra, and *Wright Prospecting Pty. Ltd.* with 2,218 tons from Mt. Nicholas.

In the Peak Hill Goldfield, *Westralian Ores Pty. Ltd.* obtained 22,002 tons from the Horseshoe deposit. This ore which included 217 tons of battery grade material was exported through Geraldton.

PHOSPHATIC GUANO.

Reported production from the Jurien Bay area was 68 tons valued at £680.

PYRITE.

Norseman Gold Mines N.L. railed 37,120 tons of concentrate containing 17,677 tons of sulphur, to superphosphate works in the metropolitan area. This output was valued at £287,914 f.o.r. Norseman. This mine has not worked to capacity since the completion of the main shaft in 1953. Ore reserves are in a healthy position at 2,865,000 tons containing 25% pyrite.

Gold Mines of Kalgoorlie (Aust.) Ltd. forwarded to works at Fremantle 12,341 tons of auriferous pyritic concentrate containing 5,470 tons of sulphur valued at £68,376.

QUARTZ GRIT.

Production for local use at Collie was 25 tons.

SCHEELITE.

2,500 tons of sands from the old Golden Pole Mine at Davyhurst yielded 7.35 tons of scheelite valued at £3,883.

SILVER.

Silver as a by-product of gold, copper, and lead mining amounted to 248,461 fine ounces valued at £117,661.

SPONGOLITE.

Six hundred and sixty-nine tons of sawn blocks of Ravensthorpe spongolite were used in the building industry.

TALC.

Three Springs Talc Pty. Ltd. reported the production of 4,981 tons from their open cut at Three Springs. A primary crushing section was installed at the mine and now most of the production is crushed to minus 2 inch, bagged and railed to Welshpool. A drilling programme has been undertaken to determine ore reserves.

TANTALO-COLUMBITE.

Nineteen tons of concentrate containing 843 units of Ta_2O_5 and Nb_2O_5 valued at £58,874 were produced in the State. The main producing centres were Marble Bar with 6.69 tons, Warda Warra with 4.13 tons, Roebourne with 3.66 tons, and Greenbushes with 2.97 tons.

At Warda Warra, situated about 55 miles north west of Mount Magnet, a shaft was sunk 20 feet to exploit the tapiolite which occurred in small lenses. Most of the minerals won from other fields were obtained from alluvial deposits except for tantalite recovered as a by-product of tin mining at Greenbushes.

TIN.

Production for the year was 465 tons of concentrate containing 323.5 tons of the metal. Tin producers in the Pilbara were responsible for all but 23 tons of concentrate. Principal producers were *Mineral Concentrates Pty. Ltd.* with 121 tons, *J. A. Johnston* with 111 tons, *H. V. Leonard* with 99 tons, *Northern Mineral Syndicate* with 72 tons, *Pilbara Exploration N.L.* with 31 tons, and *Austin Bros.* at Greenbushes with 17 tons.

Aberfoyle Tin N.L. continued their examination of the Greenbushes field with an intensive boring and sampling programme. At Moolyella two groups have pegged, between them, more than 10,000 acres of potential tin bearing ground.

J. K. N. LLOYD,
Assistant State Mining Engineer.

APPENDIX No. 1.

State Mining Engineer:

REPORT ON DRILLING ACTIVITIES FOR YEAR ENDED 31st DECEMBER, 1962.

The Mines Department Drilling Section only had two machines in operation for the full year, the remaining seven being used only for some of the period, however the footage drilled showed an increase of 91 feet to 8,839 over that drilled last year.

Water Supply bores kept number 2 rig, the Failing, busy for the year. Three holes totalling 2,836 feet were bored at Australind. No. 3 hole showed 27,000 gals. per hour on test, No. 4 gave 20-30,000 g.p.h. and No. 5 about 40,000 g.p.h. The water in No. 4 was above the limit of salinity desired and cementing was done in an effort to seal off the bottom aquifer. This was completed but did not have the hoped for result.

The Bore at Mandurah gave an artesian flow of approxi. 10,000 g.p.h. but the water proved too saline for normal use and will be utilised solely for irrigating playing fields.

In the course of these operations the drilling mast on the Failing rig became bent whilst attempting to pull stuck casing. Repairs took one month to effect.

Rig No. 3 drilled six holes at Wilgie Mia in the search for iron, totalling 2,110 feet. This programme has been completed and the equipment returned to store for overhaul.

Rig No. 4 was hired for some weeks to Sunny West Dairies at Boyanup where a percussion hole was deepened from 400 feet to 866 feet through basalt, which the percussion rig was unable to penentrate. This was for water supply purposes. For the remainder of the year the machine was inactive.

Rig No. 5 was overhauled and refitted during the year. It was used for a short period in cementing off the lower aquifer in No. 4 Bore at Australind. Nil footage is returned for this machine.

Rig No. 6 drilled 1,216 feet for Iron at Wilgie Mia in three holes. Two of these holes were abandoned before reaching planned depth due to extremely difficult caving conditions encountered.

Rig No. 7 was hired by Westminster Dredging Coy. for exploratory drilling connected with Fremantle Harbour extensions. Later it was hired by the Public Works Department for harbour investigations at Exmouth Gulf related to the projected Radio Base for the United States Navy.

Rig No. 8 was on hire to the Sons of Gwalia Mine for the period and no record of footages drilled has been received.

HYDROLOGICAL SECTION.

Ruston Bucyrus Rig No. 1 was on hire to Public Works Department at Wicherina for the whole year and no footage return has been recorded.

Percussion Rig No. 2 drilled two holes totalling 677 feet for the period under review.

At Gosnells 566 feet was done in one bore for water and 111 feet was done at Watheroo. Water too saline for human consumption was recorded in both instances.

Assistance was rendered to many outside drilling firms and individuals in the way of plant and equipment during the year and this has been reciprocated in one or two instances when necessary items of equipment are not available from our resources and have been borrowed.

J. F. HADDOW,
Inspector of Mines (Drilling).

TABLE SHOWING FOOTAGE DRILLED FOR YEAR ENDED 31st DECEMBER, 1962

Rig No.	Machine	Place	Purpose	Footage	Total	Basis	Remarks
2	Failing	Australind	Water Supply	2,836		Contract	
		Mandurah	Water Supply	2,000		....	
					4,836		
3	Mindrill A.3000	Wilgie Mia	Iron Ore Resources	2,110	2,110	Contract	
4	Mindrill A.2000	Boyanup	Water Supply	....	....	....	Hired.
5	Mindrill A.2000	....	....	*Nil*	....	....	Refit.
6	Mindrill A.2000	Wilgie Mia	Iron Ore Resources	1,216	1,216	Contract	
7	Mindrill F.20	Fremantle	Harbour Works	....	....	....	Hired.
		Exmouth	Harbour Works	....	....	....	
8	Mindrill E.500	Gwalia	....	....	....	....	Hired by Sons of Gwalia.
			PERCUSSION RIGS				
1	Ruston-Bucyrus	Wicherina	Water Supply	....	....	....	Hired by P.W.D.
2	Ruston-Bucyrus	Gosnells	Water Supply	566			
		Watheroo	....	111			
					677	Wages	
					8,839		

APPENDIX No. 2.

School of Mines,
Post Office Box 62,
Kalgoorlie, February 25, 1963.

The Chairman,
Board of Examiners,
Mines Department,
Perth.

ANNUAL REPORT.

Herewith I submit the Annual Report on the activities of the Board of Examiners for Mine Managers and Underground Supervisors Certificates for the year 1962.

Mining Law Examination:

An examination in Mining Law for the Mine Managers Certificate of Competency was held on April 9, 1962. Details were as follows:—

Entries	4
Admitted	4
Passed	2
Failed	2

The names of the successful candidates are as follows:—

P. J. McGushin.
H. I. Chamberlain.

Six (6) copies of the examination paper are attached.

At the July meeting of the Board a reciprocal Mine Managers Certificate of Competency was granted to R. J. Salone who was successful at the special examination held at Wittenoom on August 29, 1961.

Underground Supervisors Examination:

The examination for the Underground Supervisors Certificate of Competency was held on September 11, 1962, and attracted applicants from the following centres:—

Coolgardie	1
Kalgoorlie	19
Norseman	2
Ravensthorpe	1
Wittenoom	5
Total	28

Twenty-one applicants were admitted, the five (5) applicants from Wittenoom being rejected on grounds of insufficient first aid training and two (2) applicants from Kalgoorlie were rejected on grounds of no first aid.

Eighteen applicants sat for the examinations with the following results:—

Examined	18
Passed	13
Failed	5
Did not sit	3

Secretary,
Board of Examiners.

Certificates of Competency were issued to the successful candidates whose names were as follows:—

S. C. Meadows.
S. Erceg.
R. C. Tarr.
L. A. Pusey.
J. I. Peydo.
A. E. Hanson.
P. Kelsall.
B. D. Rymer.
F. R. Banks.
A. T. Roberts.
N. R. Hooker.
R. L. Hug.
J. H. Hewitt.

Six (6) copies of the examination paper are attached.

Mine Managers Certificate:

Two applications for Mine Managers Certificates and for a Reciprocal Mine Managers Certificate were received during the year. One of the applications was approved and the reciprocal certificate granted.

The names of the successful applicants were as follows:—

A. J. Murphy.
R. J. Salone (Reciprocal Certificate issued, Mr. Salone held a South Australian Mine Manager's Certificate of Competency, First class, No. 34).

The amendment to the Minies Regulation Act, to provide for First and Second Class Mine Managers Certificates of Competency was proclaimed on December 19, 1962.

General:

Four meetings of the Board of Examiners were held during the year.

During the year Mr. L. J. Carroll, Secretary of the Board of Examiners, was transferred and his position was taken over by Mr. C. S. Mason.

The Board of Examiners visited the following centres during the year and examined candidates orally for the Underground Supervisors Certificate of Competency.

Coolgardie.
Kalgoorlie.
Norseman.
Ravensthorpe.

(Sgd.) C. S. MASON,
Secretary, Board of Examiners.

Mines Regulation Act, 1946

Examination for Mine Manager's Certificate of Competency

MINING LAW

April, 1962

Time Allowed—Three (3) Hours

Attempt Six (6) Questions from Section A

Attempt All Questions from Section B

Candidates should note—

(a) The Mining Act and Regulations may be used at the examination but Not the Mines Regulation Act.

(b) In answering questions in Section B reference to the appropriate sections of the Act or to the Regulations alone will not be sufficient. Candidates must summarise the requirements of the Act and/or Regulations and should also make reference to the relevant section(s) or regulation(s).

(c) Candidates are required to pass in both sections of the paper.

SECTION A.

(MINES REGULATION ACT AND REGULATIONS.)

Attempt Six (6) Questions from this Section.

Do Not Attempt More than Six (6) Questions from this section.

Marks Allowed are Ten (10) Per Question.

What is required by the Mines Regulation Act and/or Regulations regarding the following:

1. (a) The use of the English language in or about mines.
   (b) Sunday labour in mines.
2. (a) The employment of:
      (i) A registered manager.
      (ii) An underground manager.
   (b) Obligation of the manager regarding abandonment of mining operations.
3. (a) Times of blasting.
   (b) Men working alone.
4. (a) Appointment and duties of ventilation officers.
   (b) Ventilation plans.
   (c) Return airways.
5. (a) Handling of explosives.
   (b) Electric firing.
6. (a) Rises in mines.
   (b) Penthouses.
   (c) Underground dams.
7. (a) Hours and days of employment.
   (b) Obligations of the registered underground manager with regard to the Mines Regulation Act and Regulations thereunder.
   (c) Crib places.

SECTION B.

(MINING ACT AND REGULATIONS.)

Attempt All Questions from this Section.

Marks Allowed are Ten (10) Per Question.

8. (a) When must the labour conditions be complied with on:
      (i) A Gold Mining Lease?
      (ii) A Mineral Claim?
      (iii) A Mineral Lease?
   (b) How many men must be engaged *bona fide* working the above holdings to fulfil the labour conditions thereon?
   (c) What are the obligations of the holder of a mining tenement regarding exploratory bore holes drilled on his property?
9. (a) Under what conditions may leases, other than Coal Mining Leases, be amalgamated, and what labour is required to work the leases which are amalgamated?
   (b) How would you mark off (or peg) and make application for a Gold Mining Lease:
      (i) In a new find?
      (ii) On ground that is identical with a previously surveyed lease which has been forfeited or surrendered?
10. (a) What is a mine?
    (b) What is necessary before gold or minerals can be mined on private property as defined in the Mining Act?
11. (a) A Subterranean Water Right entitles the holder to do certain work. What may the holder do?
    (b) Under what conditions may a drain be constructed through a mining tenement?
    (c) Can a lessee prevent water from an adjacent lease being discharged through a natural channel on his own lease?

Western Australia

Mines Regulation Act, 1946-61

Examination for Certificate of Competency as Underground Supervisor

MINING

September 1962

Time allowed three (3) Hours

Attempt six (6) questions only

Note: Read the Examination Paper Carefully.

Answers must be Written in Ink

Candidates should illustrate with sketches where possible.

1. Describe in detail how you would install ladders underground in mines in the following:—
   - (a) A permanent ladderway in a three compartment vertical shaft.
   - (b) A winze being sunk to 100 feet depth on an underlay of 60 degrees.
   - (c) A vertical winze 80 feet deep used as a manway into a stope.

Sketches of the lay-out must be given.

2. Describe fully the precautions you would take for safe working when:—
   - (a) Cleaning broken ore from a leading stope.
   - (b) Cleaning out spillage from the bottom of an operating shaft.
   - (c) Firing stripping adjacent to a working plat.

3. What are the principles of good mine ventilation? Draw a sketch including a shaft, winzes, three levels, stopes and extension development work showing the correct ventilation required.

4. Describe in detail two methods of stoping an orebody. Explain why you would use each method. Sketches are required.

5. Rails are to be laid in a drive for a distance of 600 feet.
   - (a) Estimate the weight and cost of rails to be used. The weight per yard of rail is 14 lb. and the cost £50 per ton for rails.
   - (b) Estimate the labour cost to lay the rails, allowing £3 18s. per shift per man. Two men take 5 shifts to complete the job.

6. Describe how you would timber a leading stope 6 feet wide:—
   - (a) Where the walls are good.
   - (b) Where the walls are not good.

Sketches showing draw points and manways are required.

7. What methods are adopted for the protection of men engaged in shaft sinking whilst ore is being hoisted from levels above?

Describe one method and illustrate with sketches.

8. Describe fully the steps to be taken in rescuing:—
   - (a) A man who has been overcome by fumes in a winze.
   - (b) A man who is buried by broken ore in a rill stope.

Western Australia

Mines Regulation Act, 1946-61

Examination for Certificate of Competency as Underground Supervisor

MINING LAW

September 1962

Time Allowed Two (2) Hours

Note.—Read the Examination Paper Carefully.

Answers Must be Written in Ink.

What is required by the Mines Regulation Act or the Regulations made under that Act concerning the following:—

Section One

Attempt Four (4) Questions from this Section. Do Not Attempt more than Four Questions from Section One.

1. Time of blasting.
2. Misfires when using safety fuse.
3. Winzes.
4. Safety belts.
5. Safety precautions when raising or lowering men in a cage or skip. Give Any Three safety precautions.
6. What is necessary before a person may take charge of a locomotive underground?

Section Two

Attempt Ten (10) Questions from this Section. Do Not Attempt more than Ten Questions from Section Two.

7. Drawing off ore from shrink stopes.
8. Repairing shafts.
9. Stoppings and doors.
10. Waste timber underground.
11. Inspection of roads used by locomotives underground.
12. Underground dams.
13. Ventilation of development ends.
14. Sinking signals.
15. Precautions to be taken when workings are approaching a dangerous accumulation of water.
16. Men working alone.
17. What is required when firing more than three (3) charges.
18. Boring in butts.
19. Clearing passes and chutes.
20. Burning rate of Safety Fuse.
21. Fuse igniters.

Index to State Mining Engineer's Annual Report for 1962

DIVISION III

Report of the Superintendent of State Batteries—1962

Under Secretary for Mines:

For the information of the Hon. Minister for Mines, I have the honour to submit my report on the operations of the State Batteries for the year ended 31st December, 1962.

Crushing Gold Ores.

One 20 head, five 10 head, and twelve 5 head mills crushed 48,154 tons of ore made up of 633 separate parcels, an average of 76.07 tons per parcel. The bullion produced amounted to 16,162 oz., which is estimated to contain 13,697 oz. of fine gold, equal to 5 dwt. 16 grs. of gold per ton of ore.

The cost of crushing, including administration was 64s. 11d. per ton, a decrease of 6s. 6d. per ton compared with the previous year when 40,673 tons were crushed at a cost of 71s. 5d. per ton.

The average value of the ore after amalgamation, but before cyanidation was 2 dwt. 22 grs. Thus the average head value of the ore was 8 dwt. 14 grs. which is 1 dwt. 4 grs. less than the previous year's average.

Values in this ore before cyanidation can be segregated as follows:—

	Tons	Per Cent
Over 2 dwt. 8 grs. per ton	19,059	39.6
1 dwt. 18 grs. to 2 dwt. 8 grs. per ton	5,529¾	11.5
Under 1 dwt. 18 grs. per ton	23,210¼	48.2
Refractory	354¾	.7
	48,153¾	100.0

Cyaniding.

Seven plants treated 19,760 tons of tailings from amalgamation for a production of 2,834 fine oz. of gold worth £44,379. The average content was 3 dwt. 15 grs. before cyanidation, while the residue after treatment averaged 1 dwt. 2 grs. The theoretical extraction was therefore 73%. The actual extraction was 72%.

The cost of cyaniding was 45s. 1d. per ton, a decrease of 6d. per ton on the previous year, when 25,177 tons were treated at a cost of 45s. 7d. per ton.

Estimated Overall Recovery.

Figures for estimated recovery are:—

	Content Fine Oz.	Per Ton Crushed Dwt.	Per Ton Crushed Grs.	Per Cent.
Head Value	20,713	8	14	100
Amalgamation Recovery	13,697	5	16	66.0
Cyanidation Recovery	2,834	1	4	13.6
Total Recovery ..	16,531	6	20	79.6

Treatment of Ores other than Gold.

Lead Ores.

During the year the Northampton State Battery crushed 1,220¾ tons of lead ore with an estimated average content of 18.53% lead. There were seven separate parcels, giving an average of 174.4 tons of ore per parcel.

A total of 270.9 tons of concentrates were produced. The concentrates averaged 76.9% lead giving an estimated content of 208.6 tons of lead in concentrates.

949.7 tons of tailings were discarded. These had an average content of 1.8% lead, giving a total of 17.7 tons of lead discarded in tailings.

The recovery of lead in the concentrates was 92.1% of the lead in the ore delivered to the plant.

The cost of operating the Northampton State Battery, including administration, was £7,131 9s. 9d. being 110s. 6d. per ton of ore crushed. Revenue received was £1,428 18s., 22s. 2d. per ton. The corresponding figures for 1961, when 2,472½ tons of ore were crushed, were operating cost £9,438 7s. 7d., 76s. 4d. per ton and revenue £2,957 8s. 6d., 23s. 11d. per ton.

Sales of lead concentrates from the Northampton State Battery for the year were valued at £10,589.

Tantalite Ore.

During the year the Northampton Battery crushed 70¼ tons of ore for 1 ton 6 cwt. 1 qtr. of concentrates valued at £5,800.

Agriculture Copper Ore.

The Meekatharra Battery crushed 19 tons of ore valued at £450.

Value of Production.

The estimated value of production from the State Batteries since their inception, excluding the value of gold tax paid to the Commonwealth, is:—

GOLD

	1962 £	Grand Total £
Par Production—		
Crushing	58,183	8,755,827
Cyanidation	12,127	2,162,779
Gold Premium—		
Crushing	155,840	5,354,447
Cyanidation	32,253	1,517,573
Open Market Premium—		
Crushing	210	32,191
Cyanidation	43	10,660
Total Gold Production	£258,656	£17,833,477

OTHER ORES REALISED

	£	£
Tin—		
Ores	Nil	94,005
Residues	Nil	572
Tungsten Concentrates	Nil	18,850
Agricultural Copper Ore	450	5,966
Lead Concentrates	10,589	301,751
Tantalite Concentrates	5,800	10,600
Total Other Ores	£16,839	£431,744
Grand Total	£275,495	£18,265,221

Financial.

	Tons	Expenditure	Receipts	Loss
		£	£	£
Crushing (Gold Mills)	48,153¾	156,427	24,090	132,337
Crushing (Northampton)	1,291	7,132	1,429	5,703
Cyaniding	19,760	44,511	22,359	22,152
	....	208,070	47,878	160,192

The loss of £160,192 is an increase of £705 on the previous year. It does not include depreciation and interest on capital.

Capital Expenditure, all from General Loan Fund, was incurred as below:—

	£	s.	d.
Boogardie—Renewal of Electrical Wiring	133	17	2
Kalgoorlie—Rebuild No. 1 and 2 Mills	4,371	0	9
Marble Bar—Gas Stove	117	0	0
Meekatharra—			
Renewal of Electrical Wiring	1,512	0	8
Renewal of Cyanide Plant	11,383	6	11
Nullagine—New Living Quarters	442	4	1
Yarri—Renewal of Electrical Wiring	1,292	9	9
	£19,251	19	4

Cartage Subsidies.

	Tons	Cost
Ore carted to State Plants	17,639	£9,334

Comparative figures for the last three years are:—

Year	Tons Crushed	State Plants: Tons Subsidised	State Plants: Per cent. Subsidised	State Plants: Cost	Private Plants: Tons Subsidised	Private Plants: Cost	Tota Cost
				£		£	£
1960	39,219	12,986	33·1	6,661	296	152	6,813
1961	40,673	13,402	32·9	6,347	298	184	6,531
1962	48,153¾	17,639	36·6	9,334	*Nil*	*Nil*	9,334

Administrative.

Expenditure amounted to £21,027 13s. 4d., equivalent to 6s. 1d. per ton of ore crushed and cyanided, compared with an expenditure of £21,287 16s. 3d., 6s. 6d. per ton, for 1961.

	1961 £	s.	d.	1962 £	s.	d.
Salaries	12,232	10	8	12,179	5	1
Pay roll tax	3,314	7	5	3,310	7	3
Workers Compensation	4,068	15	8	3,969	4	4
Travelling and Inspection	1,259	14	10	889	0	9
Sundries	412	7	8	679	15	11
	21,287	16	3	21,027	13	4

Staff.

V. Jenkin was apointed Assistant Manager of the Ora Banda State Battery.

I wish to thank all Officers for their capable and willing service during the year.

General.

The gold mills crushed 7,481 tons more than in 1961, but the average grade of ore was lower, resulting in a small reduction in the gold recovered by amalgamation. The big increases in tonnages crushed were at the Kalgoorlie and Coolgardie Batteries, being 4,437 tons and 2,377 tons respectively. These two plants normally crush bigger tonnages at lower costs per ton than the other Batteries, and the increased tonnages in 1962 allowed them to further reduce the crushing costs per ton. These increased tonnages at Kalgoorlie and Coolgardie were mainly responsible for the decrease of 6s. 6d. per ton in the average cost of crushing at all State Batteries.

The low amount cyanided, 5,407 tons less than last year, caused an increase in untreated purchased tailings, making it necessary to obtain a further £5,000 from the Treasury for the purchase of tailings. At only a few Batteries is it now possible to engage men to empty and fill vats by hand. To get tailings cyanided it is necessary to build scraper hauler plants, which give good recoveries at lower operating costs, but have comparatively high construction costs. These plants can therefore be built only where there is a considerable tonnage of tailings to be treated. A scraper hauler cyanide plant will begin operating at Meekatharra early in 1963, and it is proposed to construct one at Norseman during 1963.

The Northampton lead plant again worked at low capacity, the low tonnage treated causing a very high cost per ton. A big increase in the price of lead will be necessary before increased production of lead ore is likely.

K. M. PATERSON,
Superintendent of State Batteries.

SCHEDULE No. 1

Return showing tons crushed, Gold Yield by Amalgamation, Average per ton in shillings, and Total value without Premium for the Year Ended 31st December, 1962

Battery	Tons Crushed	Gold Yield Bullion ozs.	Value per Ton in shillings	Total Value without Premium
				£
Bamboo Creek	776·75	136·25	12·66	490·50
Boogardie	268·25	244·85	65·75	881·46
Coolgardie	6,624·50	2,019·30	21·92	7,269·48
Cue	783·00	236·35	21·75	850·86
Kalgoorlie....	13,791·25	4,294·25	22·42	15,459·30
Lake Darlot	2,213·25	535·90	17·42	1,929·24
Leonora	1,543·00	573·55	26·75	2,064·78
Marble Bar	937·00	33·40	2·58	120·24
Marvel Loch	3,515·00	1,673·60	34·25	6,024·96
Meekatharra	2,098·75	685·70	23·50	2,468·52
Menzies	3,899·00	1,370·35	25·33	4,933·26
Norseman	2,251·25	987·00	31·58	3,553·20
Nullagine	1,116·00	291·05	18·75	1,047·78
Ora Banda	2,759·50	948·80	24·75	3,415·68
Paynes Find	558·00	121·45	15·66	437·22
Peak Hill	2,432·00	294·20	8·66	1,059·12
Sandstone	124·00	98·65	57·25	355·14
Yarri	2,463·25	1,617·30	47·25	5,822·28
Total	48,153·75	16,161·95	24·16	58,183·02

SCHEDULE No. 2

Number of Parcels Treated, Tons Crushed and Head Value for the Year Ended 31st December, 1962

No. of Parcels Treated	Battery	Tons Crushed	Yield by Amalgamation Bullion		Yield by Amalgamation Fine Gold		Tailings Gross at 100%		Total Contents of Ore Fine Gold		Average per Ton Fine Gold		Gross Value per Ton Fine Gold at £4 4s. 11½d. per Ounce
			oz.	dwts.	oz.	dwts.	oz.	dwts.	oz.	dwts.	dwts.	grs.	£ s. d.
7	Bamboo Creek	776¾	136	5	115	9	665	13	781	2	20	3	4 5 6
12	Boogardie	268¼	244	17	207	10	25	7	232	17	17	9	3 13 10
107	Coolgardie	6,624½	2,019	6	1,711	7	884	2	2,595	9	7	20	1 13 3
22	Cue	783	236	7	200	6	89	17	290	3	7	10	1 11 6
116	Kalgoorlie	13,791¼	4,294	5	3,639	8	1,723	12	5,363	....	7	19	1 13 1
30	Lake Darlot	2,213¼	535	18	454	4	329	4	783	8	7	2	1 10 1
28	Leonora	1,543	573	11	486	2	180	1	666	3	8	15	1 16 8
9	Marble Bar	937	33	8	28	6	730	....	758	6	16	4	3 8 8
64	Marvel Loch	3,515	1,673	12	1,418	8	543	17	1,962	5	11	4	2 7 5
24	Meekatharra	2,098¾	685	14	581	2	290	11	871	13	8	7	1 16 3
61	Menzies	3,899	1,370	7	1,161	7	445	11	1,606	18	8	6	1 15 2
35	Norseman	2,251¼	987	....	836	10	269	13	1,106	3	9	20	2 1 9
12	Nullagine	1,116	291	1	246	13	134	4	380	17	6	20	1 9 1
44	Ora Banda	2,759½	948	16	804	2	357	5	1,161	7	8	10	1 15 9
8	Paynes Find	558	121	9	102	19	25	16	128	15	4	15	19 8
18	Peak Hill	2,432	294	4	249	7	121	8	370	15	3	1	12 11
3	Sandstone	124	98	13	83	12	26	5	109	17	17	17	3 15 3
33	Yarri	2,463¼	1,617	6	1,370	13	173	15	1,544	8	12	13	2 13 3
633	Total	48,153¾	16,161	19	13,697	5	7,016	1	20,713	6	8	14	1 16 6

Average Tons per Parcel .... 76·07
Average Yield by Amalgamation per ton (Fine Gold) .... 5 dwts. 16 grs.
Average Head Value of Tailings .... 2 dwts. 22 grs.

SCHEDULE No. 3

Segregation of Tailings Produced according to Value, Year Ended 31st December, 1962

Battery	Payable			2 dwts. 8 grains to 1 dwt. 18 grains			1 dwt. 18 grains and under			Refractory			Total		
	tons	oz.	dwts.	tons	oz.	dwts.	tons	oz.	dwts.	tons	oz.	dwts.	tons	oz.	dwts.
Bamboo Creek	776¾	665	13	....	....	....	....	....	....	....	....	....	776¾	665	13
Boogardie	109½	14	11	61	6	4	97¾	4	12	....	....	....	268¼	25	7
Coolgardie	2,098¼	611	14	613	66	9	3,845½	193	12	67¾	12	7	6,624½	884	2
Cue	360	64	5	....	....	....	423	25	12	....	....	....	783	89	17
Kalgoorlie	6,628½	1,326	5	400¾	38	3	6,762	359	4	....	....	....	13,791¼	1,723	12
Lake Darlot	1,807½	294	7	238¾	25	13	167	9	4	....	....	....	2,213¼	329	4
Leonora	404½	93	....	319½	42	10	819	44	11	....	....	....	1,543	180	1
Marble Bar	897	728	9	....	....	....	40	1	11	....	....	....	937	730	....
Marvel Loch	1,820½	387	19	962	106	....	732½	49	18	....	....	....	3,515	543	17
Meekatharra	1,163	216	....	103¾	11	9	545	26	1	287	37	1	2,098¾	290	11
Menzies	793¾	248	10	902½	91	....	2,202¾	106	1	....	....	....	3,899	445	11
Norseman	532½	165	1	378	30	12	1,340¾	74	....	....	....	....	2,251¼	269	13
Nullagine	488	96	2	236	16	18	392	21	4	....	....	....	1,116	134	4
Ora Banda	990¾	222	9	964½	92	3	804¼	42	13	....	....	....	2,759½	357	5
Paynes Find	....	....	....	....	....	....	558	25	16	....	....	....	558	25	16
Peak Hill	49	9	16	....	....	....	2,383	111	12	....	....	....	2,432	121	8
Sandstone	124	26	5	....	....	....	....	....	....	....	....	....	124	26	5
Yarri	15½	5	15	350	28	10	2,097¾	139	10	....	....	....	2,463¼	173	15
Total	19,059	5,176	1	5,529¾	555	11	23,210¼	1,235	1	354¾	49	8	48,153¾	7,016	1

SCHEDULE No. 4

Details of Extraction Tailings Treatment, 1962

Battery	Tons Treated	Head Value		Contents	Tail Value		Contents	Re-covery	Call	Recovery	Shortage	Surplus
		Dwts.	Grs.	Dwts.	Dwts.	Grs.	Dwts.	%	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Bamboo Creek	1,568	9	1	14,181	4	3	6,441	55	1,644 17 3	1,511 2 2	133 15 1	....
Coolgardie	3,926	3	9	13,300	....	20	3,280	75	2,129 15 1	2,085 18 0	43 17 1	....
Kalgoorlie	5,700	4	2	23,300	....	22	5,218	78	3,840 15 4	3,875 18 0	....	35 2 8
Lake Darlot....	2,589	3	10	8,900	....	16	1,759	80	1,520 14 9	1,575 4 10	....	54 10 1
Marvel Loch	1,962	2	13	4,980	....	16	1,340	73	773 2 3	738 17 7	34 4 8	....
Menzies	2,990	3	7	9,801	....	17	2,101	78	1,636 16 4	1,695 12 0	....	58 15 8
Ora Banda	1,025	3	20	3,940	....	20	880	78	651 2 6	643 17 5	7 5 1	....
Total	19,760	3	15	78,402	1	2	21,019	73	12,197 3 6	12,126 10 0	219 1 11	148 8 5

Net Shortage .... £70 13s. 6d.
Head Value .... 3 dwts. 15 grains
Tail Value .... 1 dwt. 2 grains
Theoretical Recovery .... 73 per cent.
Actual Recovery .... 72 per cent.

SCHEDULE No. 5

Direct Purchase of Tailings, Year Ended 31*st December,* 1962

Battery	Tons of Tailings Purchased	Amount Paid at £4 4s. 11½d. per oz.	Amount Paid Account of Premium
		£ s. d.	£ s. d.
Bamboo Creek	699·00	1,603 10 4	4,005 18 6
Coolgardie	1,930·25	1,089 16 1	2,823 10 5
Cue	324·00	63 13 3	146 3 1
Kalgoorlie	5,531·25	1,501 17 3	4,071 2 5
Lake Darlot	1,519·75	335 7 9	978 8 7
Leonora	509·50	206 14 7	474 12 10
Marble Bar	858·50	1,834 12 0	4,211 13 8
Marvel Loch	1,466·75	511 18 4	1,309 7 0
Meekatharra	1,014·75	669 2 1	1,536 1 1
Menzies	780·50	472 11 11	1,302 19 4
Norseman	598·00	289 1 11	663 5 6
Nullagine	496·00	85 3 9	195 11 3
Ora Banda	1,201·00	478 0 9	1,158 19 3
Peak Hill	27·75	9 8 5	21 14 8
Sandstone	111·50	33 12 3	77 3 3
Total	17,068·50	9,184 10 8	22,976 10 10

SCHEDULE No. 6

Cyanide Yield, 1962

Battery	Tons	Fine oz.	Value	Premium	Total
			£	£	£
Bamboo Creek	1,568	351·52	1,511·107	3,999·475	5,510·582
Coolgardie	3,926	490·06	2,085·899	5,586·932	7,672·831
Kalgoorlie	5,700	906·66	3,875·900	10,316·668	14,192·568
Lake Darlot	2,589	370·84	1,575·244	4,219·177	5,794·421
Marvel Loch	1,962	173·81	738·880	1,977·670	2,716·550
Menzies	2,990	389·12	1,695·598	4,428·499	6,124·097
Ora Banda	1,025	151·58	643·872	1,724·574	2,368·446
Total	19,760	2,833·59	12,126·500	32,252·995	44,379·495

SCHEDULE No. 7

Statement of Receipts and Expenditure for the Year Ended 31st December, 1962

Milling

Battery	Tons Crushed	Management and Supervision	Wages	Stores	Total Working Expenditure	Cost per Ton	Repairs and Renewals	Sundries	Gross Expenditure	Cost per Ton	Receipts	Receipts per Ton	Profit	Loss
		£ s. d.	£ s. d.	£ s. d.	£ s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.	s. d.	£ s. d.	s. d.	£ s. d.	£ s. d.
Bamboo Creek	776¾	687 16 7	1,571 15 6	584 18 2	2,844 10 3	73 3	716 12 7	306 7 3	3,867 10 1	99 7	430 5 2	11 9	....	3,437 4 11
Boogardie	268¼	186 7 6	606 5 1	150 13 1	943 5 8	70 4	339 1 1	377 11 10	1,659 18 7	123 9	123 12 10	9 2	....	1,536 5 9
Coolgardie	6,624½	2,259 12 4	5,055 19 5	2,917 6 5	10,232 18 2	30 11	1,260 18 9	2,325 6 4	13,819 3 3	41 8	3,124 7 1	9 3	....	10,694 16 2
Cue	783	1,650 19 2	928 18 3	605 19 4	3,185 16 9	81 4	719 14 1	685 17 2	4,591 8 0	117 3	534 15 6	13 7	....	4,056 12 6
Kalgoorlie	13,791¼	4,519 12 6	8,683 3 0	9,639 4 6	22,842 0 0	33 1	5,284 1 4	4,915 2 1	33,041 3 5	47 11	6,598 1 10	9 6	....	26,443 1 7
Lake Darlot	2,213¼	1,667 1 9	3,919 16 0	1,739 7 2	7,326 4 11	66 2	680 15 8	715 6 0	8,722 6 7	78 9	1,384 7 6	12 6	....	7,337 19 1
Laverton	....	....	174 0 0	....	174 0 0	....	....	35 11 3	209 11 3	....	113 2 2	....	....	96 9 1
Leonora	1,543	1,967 3 7	2,377 3 9	1,151 17 1	5,496 4 5	71 3	1,197 18 2	888 4 8	7,582 7 3	98 3	733 16 3	9 6	....	6,848 11 0
Marble Bar	937	2,418 2 0	1,177 18 3	1,285 18 7	4,881 18 10	104 2	702 10 1	1,816 16 11	7,401 5 10	157 11	516 5 6	11 0	....	6,885 0 4
Marvel Loch	3,515	1,929 16 1	5,805 8 1	1,796 5 6	9,531 9 8	54 3	1,022 2 8	1,258 7 1	11,811 19 5	67 2	1,921 13 7	10 11	....	9,890 5 10
Meekatharra	2,098¾	2,898 6 6	3,173 13 4	1,575 0 0	7,646 19 10	72 10	1,603 5 10	1,729 13 10	10,979 19 6	104 7	1,081 9 7	10 4	....	9,898 9 11
Menzies	3,899	1,456 7 1	3,977 19 1	1,643 0 9	7,077 6 11	36 4	902 18 8	1,324 19 0	9,305 4 7	47 8	2,036 15 11	10 5	....	7,268 8 8
Norseman	2,251¼	1,561 9 1	4,013 8 6	1,627 8 11	7,202 6 6	64 0	475 3 1	807 13 8	8,485 3 3	75 5	1,038 17 5	9 3	....	7,446 5 10
Nullagine	1,116	2,154 16 1	2,459 7 2	908 6 8	5,522 9 11	98 11	2,609 17 6	978 18 9	9,111 6 2	163 3	559 16 8	10 0	....	8,551 9 6
Ora Banda	2,759½	2,023 0 1	2,306 16 7	1,772 7 5	6,102 4 1	45 1	573 7 2	981 11 3	7,657 2 6	55 5	1,070 3 1	7 9	....	6,586 19 5
Paynes Find	558	827 4 6	1,411 18 0	291 13 11	2,530 16 5	90 8	160 17 8	250 5 4	2,941 19 5	105 5	297 13 10	10 8	....	2,644 5 7
Peak Hill	2,432	1,359 3 9	2,652 16 6	1,010 4 3	5,022 4 6	41 4	470 9 0	1,078 9 2	6,571 2 8	54 0	1,088 9 0	8 11	....	5,482 13 8
Sandstone	124	140 13 11	322 7 11	64 19 0	528 0 10	85 2	229 0 10	126 5 6	883 7 2	142 5	97 6 6	15 8	....	786 0 8
Yarri	2,463¼	1,714 8 0	2,981 7 9	1,174 7 7	5,870 3 4	47 8	883 12 10	1,031 7 3	7,785 3 5	63 2	1,322 15 1	10 9	....	6,462 8 4
Head Office	....	....	....	....	....	....	....	....	....	....	16 8 8	....	16 8 8	....
Sub-Total	48,153¾	31,422 0 6	53,600 2 2	29,938 18 4	114,961 1 0	47 9	19,832 7 0	21,633 14 4	156,427 2 4	64 11	24,090 3 2	10 0	16 8 8	132,353 7 10
Northampton (Lead)	1,291	2,124 1 9	1,502 15 8	1,375 11 2	5,002 8 7	77 5	1,324 14 1	804 7 1	7,131 9 9	110 6	1,428 18 0	22 2	....	5,702 11 9
Total	49,444¾	33,546 2 3	55,102 17 10	31,314 9 6	119,963 9 7	48 6	21,157 1 1	22,438 1 5	163,558 12 1	66 2	25,519 1 2	10 2	16 8 8	138,055 19 7
Net Loss	....	....	....	....	....	....	....	....	....	....	....	....	....	138,039 10 11

SCHEDULE No. 8

Receipts and Expenditure, 1962

Cyaniding

Battery	Tons	Management and Supervision	Wages	Stores	Total Working Expenditure	Cost per Ton	Repairs and Renewals	Sundries	Gross Expenditure	Cost per Ton	Receipts	Receipts per Ton	Loss
	No.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	s. d.	£ s. d.	£ s. d.	£ s. d.	s. d.	£ s. d.	s. d.	£ s. d.
Bamboo Creek	1,568	208 5 1	1,492 1 8	655 10 2	2,355 16 11	30 0	87 5 10	1,176 18 5	3,620 1 2	46 2	678 8 1	8 8	2,941 13 1
Coolgardie	3,926	845 6 4	4,692 16 9	1,142 12 9	6,680 15 10	34 0	549 5 9	1,671 18 4	8,901 19 11	45 4	4,933 8 3	25 2	3,968 11 8
Kalgoorlie	5,700	1,935 14 5	4,045 3 2	3,133 17 3	9,114 14 10	32 0	366 17 5	2,591 2 6	12,072 14 9	42 4	7,317 15 6	25 8	4,754 19 3
Lake Darlot	2,589	513 1 10	1,730 10 0	1,791 19 11	4,035 11 9	31 2	77 12 9	820 17 4	4,934 1 10	38 1	4,428 10 6	34 3	505 11 4
Marvel Loch	1,962	1,067 0 1	2,052 3 9	1,024 3 6	4,143 7 4	42 3	168 14 8	1,068 2 6	5,380 4 6	54 10	1,890 7 3	19 2	3,489 17 3
Menzies	2,990	836 5 5	3,703 10 1	1,209 3 6	5,748 19 0	38 5	355 3 11	1,097 2 4	7,201 5 3	48 2	3,818 15 0	25 6	3,382 10 3
Ora Banda	1,025	190 16 3	1,272 4 4	453 2 2	1,916 2 9	37 4	83 2 10	401 19 5	2,401 5 0	46 10	1,452 3 9	28 4	949 1 3
Total	19,760	5,596 9 5	18,988 9 9	9,410 9 3	33,995 8 5	34 5	1,688 3 2	8,828 0 10	44,511 12 5	45 1	24,519 8 4	24 10	19,992 4 1
Interest Paid to Treasury	....	....	....	....	....	....	....	....	....	....	2,160 0 0	....	2,160 0 0
											22,359 8 4		
Gross Loss	....	....	....	....	....	....	....	....	....	....	....	....	22,152 4 1

STATE BATTERIES

Trading and Profit and Loss Account for the Year Ended 31st December, 1962

1961		1962	
£		£	£
	Trading Costs—		
114,146	Wages	113,234	
39,053	Stores	40,725	
27,394	Repairs, Renewals and Battery Spares	22,845	
31,435	General Expenses and Administration	31,266	
212,028			208,070
	Earnings—		
52,541	Milling and Cyaniding Charges		47,878
159,487	Operating Loss for the Year		160,192
	Other Charges—		
25,153	Interest on Capital	26,017	
12,643	Depreciation	13,684	
2,603	Superannuation—Employers Share	2,771	
40,399			42,472
£199,886	Total Loss for the Year		£202,664

STATE BATTERIES

Balance Sheet as at 31st December, 1962

31st December, 1961	Funds Employed	31st December, 1962	
£		£	£
	Capital—		
606,962	Provided from General Loan Fund	626,163	
137,235	Provided from Consolidated Revenue Fund	137,204	
744,197			763,367
	Reserves—		
28,622	Commonwealth Grant—Assistance to Goldmining Industry	28,622	
13,786	Commonwealth Grant—Assistance to Metalliferous Mining	13,786	
42,408			42,408
	Liability to Treasurer—		
998,951	Interest on Capital		1,024,969
	Advance for Purchase of Tailings		5,000
	Other Funds—		
1,521,833	Provided from Consolidated Revenue Fund (Excess of payment over collections)		1,691,163
3,307,389			3,526,907
	Deduct—		
	Profit and Loss :		
2,913,695	Loss at Commencement of year	3,113,581	
199,886	Loss for Year	202,664	
3,113,581	Total Loss from Inception		3,316,245
£193,808			£210,662
	Employment of Funds		
	Fixed Assets—		
738,606	Plant, Buildings and Equipment	757,776	
629,222	Less Depreciation	642,906	
109,384			114,870
	Current Assets—		
4,677	Debtors	4,436	
71,041	Stores	78,344	
2,069	Battery Spares	2,528	
	Purchase of Tailings :		
10,815	Treasury Trust Account	1,836	
39,508	Tailings not treated	52,709	
5,649	Estimated Gold Premium	7,183	
133,759			147,036
243,143			261,906
	Total Assets		
	Deduct—		
	Current Liabilities :		
11,823	Creditors	10,206	
29,540	Liability to Treasurer (Superannuation—Employers Share)	32,310	
	Purchase of Tailings :		
2,323	Creditors	1,545	
5,649	Estimated Premium Due	7,183	
49,335			51,244
£193,808			£210,662

DIVISION IV

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Annual Report of the Geological Survey Branch of the Mines Department for the Year 1962

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DIVISION IV

Annual Report of the Geological Survey Branch of the Mines Department for the year 1962

The Under Secretary for Mines

I submit herewith for the information of the Honourable Minister for Mines my report on the activities of the Geological Survey for the year 1962, together with some reports on investigations made for departmental purposes.

REORGANISATION.

Recruitment for the enlargement of the Geological Survey, explained in the 1961 Annual Report, continued and by the end of 1962 all positions had been filled, but five appointees had not arrived.

Delays in filling the new positions have been due to shipping, appointees accepting a position and later reversing their decisions, and the desire to obtain the best available staff.

Due to the great demand for hydrological services a new position of Chief Hydrogeologist was created. Mr. E. P. O'Driscoll has been appointed to this position and is expected to take up his duties early in 1963.

The reorganisation has created a heavy load on the administrative side of the Survey but this is expected to ease when all staff become familiar with their new positions and with the geology and geography of the State.

The demand for geological services has grown even more rapidly than the staff This applies in particular to the Hydrology and Engineering Division.

STAFF.

Appointments.

Professional:

Name	Position	Effective Date
R. C. Horwitz, D.Sc. (Switz.)	Senior Geologist	3/1/1962
N. J. Mackay, B.Sc. (Hons.)	Deputy Govt. Geologist	9/1/1962
P. E. Playford, Ph.D., B.Sc. (Hons.)	Senior Geologist	11/1/1962
W. N. MacLeod, Ph.D., M.Sc.	Senior Geologist	15/1/1962
F. R. Gordon, B.Sc., A.O.S.M.	Geologist	24/1/1962
I. Gemuts, B.Sc. (Hons.)	Geologist, Grade 2	26/1/1962
J. R. Passmore, B.Sc. (Hons.)	Geologist, Grade 2	30/1/1962
A. D. Allen, M.Sc.	Geologist, Grade 2	12/3/1962
D. L. Rowston, B.Sc.	Geophysicist	16/4/1962
D. C. Lowry, M.Sc.	Geologist, Grade 2	27/4/1962
G. R. Ryan, B.A. (Hons.)	Geologist, Grade 1	4/5/1962
H. S. Edgell, Ph.D., B.Sc. (Hons.)	Palaeontologist	11/5/1962
A. F. Trendall, Ph.D., B.Sc. (Hons.)	Petrologist	14/5/1962
R. Halligan, B.Sc. (Hons.)	Geologist, Grade 2	23/5/1962
C. Emmenegger, D.Sc. (Switz.)....	Geologist, Grade 2	2/8/1962

Clerical and General:

N. Stoyanoff	Typist	13/3/1962
H. F. Rettig	Core Librarian	2/7/1962
P. F. Jefferies	Laboratory Assistant	16/7/1962

Promotions:

W. R. K. Jones	Geologist Grade 2 to Geologist Grade 1	15/1/1962
J. D. Wyatt	Geologist Grade 2 to Geologist Grade 1	15/1/1962

Transfers:

R. D. MacIiver	Clerk — transferred to Mines Dept.	16/4/1962
S. C. Crew	Clerk — transferred from Mines Dept.	16/4/1962

Resignations:

W. M. Bock	Geologist, Grade 2	17/8/1962

ACCOMMODATION.

The accommodation provided for the Geological Survey is unsatisfactory from an administrative viewpoint. The Survey occupies three separate office buildings and a fourth is being prepared. The scattered nature of the office accommodation and the isolation from the Drafting Branch and Head Office of the Department, all create many time consuming difficulties.

The storage of rock collections, drill cores, drill samples and camping equipment is spread between Welshpool, the W.A. Museum and our store at Dianella. The latter must be enlarged as the store at Welshpool is required by the Department of Industrial Development and the Museum has moved the Survey's rock and mineral collection from display to temporary storage.

It is urged that plans should be made now for the future housing of the Survey together in suitable office accommodation and for the enlargement of the Dianella Store.

OPERATIONS.

The programme of work set down for 1962 was followed and items not completed are included in the 1963 programme set out later in this report.

The Government Geologist attended the Southern Queensland Conference of the Institute of Mining and Metallurgy and inspected the Moonie and Roma oil and gas fields as a guest of the Queensland Geological Survey. The Jubilee Conference of the Australian and New Zealand Association for the Advancement of Science was attended in Sydney.

The Deputy Government Geologist attended the Underground Water Conference in Adelaide. The next meeting will be held in Perth in 1963. As a result of the conference, the Honourable Premier arranged for a State Committee on Underground Water to be established with the Government Geologist as Convenor. The main function of this inter-departmental committee is to co-ordinate and to advise on underground water problems within the State.

HYDROLOGY AND ENGINEERING DIVISION.

K. Berliat (Senior Geologist), F. R. Gordon, J. D. Wyatt, K. H. Morgan, C. Emmenegger, J. R. Passmore and A. D. Allen.

Hydrology.

The investigation of the underground water resources of the Perth Basin was continued during the year.

In the Byford-Kwinana area four exploratory bores were completed and the drilling programme is continuing. The object of the drilling programme is to correlate Jurassic and Cretaceous aquifers across the Basin, and to assess their lateral continuity, salinity and capacity.

Drilling was commenced in the Lake Allanooka area, centred 20 miles south-east of Geraldton, to ascertain the potential of Mesozoic aquifers in the area as an additional source for the Geraldton town water supply. Three exploratory bores were completed and the drilling programme is continuing.

Exploratory drilling for domestic water supplies was carried out at Jurien Bay, Mandurah, Busselton, Billeranga Hills and Whitby Falls.

Three bores were drilled at Australind to successfully complete the programme which obtained a large supply of good quality water for industrial use by Laporte Titanium Ltd.

Hydrological advisory work and an assessment of ground water resources in the Halls Creek district was carried out in conjunction with regional mapping in the East Kimberley area.

An extensive bore siting programme was undertaken for orchardists in the Karagullen-Pickering Brook-Kalamunda area.

Miscellaneous investigations as required were carried out on a State-wide basis.

Engineering Geology.

A detailed examination was made of the Avon Valley Deviation of the Standard Gauge Railway between Midland Junction and Northam. These geological observations formed the basis of the site investigation reports issued by the consulting engineers (Maunsell and Partners) to all prospective tenderers. Several relocations were suggested or approved, the stability of deep cuts was assessed, and drilling results for bridge and route investigations were rationalized. Ballast and borrow sources were delineated and evaluated. Geological reconnaissance was carried out on the proposed route between Northam and Kellerberrin, and ballast and borrow sources were also investigated.

Examination of borehole samples and geological reconnaissance enabled preliminary recommendations as to damsite locations, investigations and further drilling at South Canning, Gooralong Brook and Upper and Lower Wongong damsites for the Metropolitan Water Supply Department.

Detailed work on the Ord River Damsite was designed to give an assessment of the problems of stability and water leakage and the feasibility of underground construction. Seismic refraction work with a portable seismic timer was used to evaluate spillway conditions.

Preliminary geological and geophysical work was commenced at the Dimond Gorge Damsite on the Fitzroy River and at the site of the proposed barrage of the Fitzroy River near Gogo Station.

SEDIMENTARY (OIL) DIVISION.

P. E. Playford (Senior Geologist), G. H. Low, and D. C. Lowry.

Field work was conducted during the year in the Canning and Perth Basins. In the Canning Basin a detailed study of the Devonian reef complexes exposed on the Lennard Shelf was initiated, and this will continue during 1963. In the Perth Basin regional geological mapping was undertaken in the Augusta-Nannup area at the southern end of the Basin. This project will also be continued in 1963, extending the mapping to as far north as Perth.

The progress of oil exploration in Western Australia was followed closely during the year.

The Senior Geologist accompanied the Government Geologist on a visit to the Moonie oil field and the Roma gas field in Queensland during August. They also attended the Australasian Institute of Mining and Metallurgy annual conference in Southern Queensland, the theme of which was "Oil in Australasia", and the Jubilee Congress in Sydney of the Australian and New Zealand Association for the Advancement of Science.

REGIONAL GEOLOGY DIVISION.

R. C. Horwitz (Senior Geologist), J. Sofoulis, G. R. Ryan, M. J. B. Kriewaldt and I. Gemuts.

Three geologists were engaged in mapping on the Dampier and Roebourne 1:250,000 Sheets. Dampier Sheet was completed.

One geologist was engaged in mapping on the Widgiemooltha 1:250,000 Sheet, and, accompanied by the Senior Geologist, a reconnaissance of the Warburton Range area was made.

One geologist was engaged in mapping on the Gordon Downs and Dixon Range 1:250,000 Sheets in conjunction with the Bureau of Mineral Resources. Gordon Downs Sheet was completed.

The Senior Geologist worked with the Dampier-Roebourne and Widgiemooltha parties for various periods during the field season.

Short reports were written on hydrological and mineral resources problems in areas covered by the geological sheets being mapped and in other areas of the State.

MINERAL RESOURCES DIVISION.

W. N. MacLeod (Senior Geologist), L. E. de la Hunty, W. R. K. Jones and R. Halligan.

The major task of this Division was a regional investigation of the iron ore deposits of the Hamersley and Ophthalmia Ranges in the North-West Division. This involved mapping of the Mt. Bruce 1:250,000 Sheet and portions of the Yarraloola, Wyloo, Roy Hill and Mt. Newman Sheets, together with sampling and examination of the numerous and varied iron ore deposits. Close liaison was maintained with the mining companies engaged in exploratory and assessment programmes in the region. The extent of the Hamersley Iron Province was determined and relationships between the ore deposits and the stratigraphy were established. An overall estimate of the iron resources of the Province was made.

Weld Range, near Cue, was mapped and an additional seven iron ore lenses were discovered. Drilling to test the previously known iron ore lenses was completed.

The low-grade manganese deposits near Ravensthorpe were re-examined for the purpose of planning a drilling programme to test the persistence and grade of the material in depth.

Portion of the Greenbushes Tinfield was examined and drilled following a request from the Shire Council for release of ground for orcharding purposes. Cassiterite was found in part of the area tested.

The Senior Geologist also examined the iron ore deposits at Mt. Goldsworthy, Yampi Sound, Koolyanobbing, Mt. Jackson, Bungalbin, Windarling, Tallering Peak and Koolanooka during the year.

COMMON SERVICES DIVISION.

Petrology (A. F. Trendall).

During the year the more important collections of rocks described came from the Weld Range, the Dampier-Roebourne area, the Hamersley Iron Province, and the Widgiemooltha area. Specimens were also examined from the Warburton Range and the Ord River area, and rocks received both from the public and from other Divisions of the Geological Survey were identified. Two hundred and two rocks were added to the registered collection, 460 thin sections were prepared in the laboratory, and 22 file reports were written. Most of the work was carried out for the Regional Geology and Mineral Resources Divisions but some work was done for the Hydrology and Engineering Division.

Although brief examination and description of almost all rocks collected is an important part of survey petrological work, detailed studies of particular aspects of the rocks of an area contribute more, in the long run, to the general understanding of Western Australian geology. Such special studies included the porphyries of the Widgiemooltha area, dolerite of Weld Range, a particular horizon of banded ironstones of the Hamersley succession, basalt drill core from Boyanup, and acid volcanic rocks from the Hamersley and Dampier areas. The last named topic is reported on elsewhere in this Annual Report.

Palaeontology (H. S. Edgell).

Previous palaeontological activity by the Geological Survey was prior to 1926 (by Etheridge, Chapman, Glauert, etc.) and consisted of description of new and known species which have provided the basic stratigraphy of the State. Much more taxonomic work of this kind is required in advancing our knowledge of the geology of the State.

The emphasis of palaeontological investigations has been on palynology and studies of microplankton. These methods are particularly applicable to the largely non-marine or paralic sediments in the marginal basins of Western Australia. Palynology, or spore and pollen analysis, has now been established in the Geological Survey as a means of age determination and correlation of samples from bores for oil and water as well as suitable surface samples. During the year macerations have been examined palynologically from some 300 samples representing 20 bores, mostly in the Perth Basin.

Palynological age determination of cores from Hawkstone Peak No. 1 Well were carried out at the request of West Australian Petroleum Pty Ltd. Determinations of the age of 90 thin sections of Tertiary limestone samples from Barrow Island were also made for West Australian Petroleum Ltd.

Megafossil determinations included interesting discoveries from the Precambrian of the Pilbara area, surface Triassic ammonites from the Perth Basin, and stromatolites from the East Kimberley area. In connection with reef-studies by the Sedimentary (Oil) Division, palaeontological study of Devonian algae and stromatoporoids from the Lennard Shelf (West Kimberley area) was initiated.

Geophysics (D. L. Rowston).

Field activities were restricted by the initial shortage of geophysical instruments to several brief experimental and practical surveys mainly concerned with hydrological and engineering problems. An increased demand for practical assistance in 1963 is anticipated as geophysical equipment on order is received.

Several experimental resistivity surveys were carried out at orchard properties in the Carilla-Karragullen area to evaluate the use of the method in groundwater search. A resistivity survey was also made in the Belka Valley for the Soils Division of C.S.I.R.O. to delineate saline aquifers and to determine the depth to granitic bedrock.

A residual gravity interpretation of available gravity data of the Mt. Hill-Geraldton area defined a shallow sedimentary basin with an area of about 25 square miles. Exploratory drilling carried out during the groundwater search of the area confirmed the thickness of sediments.

Refraction seismic surveys were carried out in several places using "Dynametric" seismic timer equipment. At the South Canning damsite additional information augmenting borehole data was obtained. At the request of the Main Roads Department, a refraction seismic survey obtained bedrock information to aid foundation design and specifications of a proposed bridge over the Helena River near Mundaring Weir.

Technical Information Office (R. R. Connolly).

This section, embracing library, laboratory, clerical and general staff, was hard pressed during the year to keep pace with necessary administrative reorganisation and the increased work output of the enlarged professional staff.

A new unpublished series of Records was commenced and 24 Records had been issued by the end of the year. Editing and preparation for the Government Printer of publications was continued. Two information pamphlets were prepared and two mineral exhibits were arranged.

General library services were maintained by the Library Assistant, and recataloguing of library books and serial publications were completed.

The core library at Dianella Store was organised by the Core Librarian, and laboratory facilities for the Petrologist and Palaeontologist were maintained.

ACTIVITIES OF THE COMMONWEALTH BUREAU OF MINERAL RESOURES.

Both geological and geophysical work was carried out by the Bureau of Mineral Resources within the State. The following projects were undertaken:—

(1) Regional mapping of the Gordon Downs and Dixon Range 1 : 250,000 Sheets in the East Kimberley area, jointly with the Geological Survey of Western Australia.

(2) Continuation of the reconnaissance seismic survey between Giles and Carnegie homestead in the southeastern part of the Canning Basin, together with gravity readings at 78 stations.

(3) Seismic surveys of the Poole Range structure in the Canning Basin.

(4) Regional gravity survey of 55,000 square miles in the southeastern part of the Canning Basin using helicopters.

(5) Magnetic survey of the Scott River iron ore deposits.

PROGRAMME FOR 1963.

HYDROLOGY AND ENGINEERING DIVISION.

Hydrology:

(i) Continuation of the hydrological survey of the Perth Basin.

(ii) Hydrological investigations and exploratory drilling for underground water supplies in the following areas:—

Allanooka and Wicherina for Geraldton town supply.
Lake Gnangara for Perth town supply.
Mandurah for town supply.
Eaton for town supply.
Capel for town supply.
Arrowsmith River for Morawa town supply.
Byford-Kwinana.
Hyden-Forrestonia.

(iii) Hydrogeological investigation of the "Hills," Chittering and Bridgetown fruit growing areas.

(iv) East Kimberley area—hydrological assistance to pastoralists:—

(a) Regional geological mapping in conjunction with the Commonwealth Bureau of Mineral Resources.

(b) Bore site selection as required by pastoralists.

(v) Miscellaneous investigations as requested from other Departments and the public.

Engineering Geology:

(i) Ord River Damsite—rock testing for underground power house when required.

(ii) Fitzroy River Barrage—supervision of drilling.

(iii) Standard Gauge Railway — Merredin-Southern Cross and Koolyannobbing Sections, and reassessment of Northam-Merredin Section.

(iv) Investigation of damsites for Metropolitan Water Supply Department:—

Wungong Brook (2 sites).
South Canning.
Gooralong Brook.
Dandalup Brook (2 sites).

SEDIMENTARY (OIL) DIVISION.

(i) Active interest in the exploratory programmes of companies engaged in oil prospecting in this State.

(ii) Investigations pertinent to oil prospecting in the Perth Basin.

(iii) Continuation of the geological survey of the Lennard Shelf area, Canning Basin.

(iv) Miscellaneous investigations as required.

REGIONAL GEOLOGY DIVISION.

(i) Completion of regional mapping on the Widgiemooltha 1 : 250,000 Sheet in the Kalgoorlie-Norseman Area.

(ii) Continuation of regional mapping on the Roebourne and Pyramid 1 : 250,000 Sheets in the Pilbara Area.

(iii) Continuation of regional mapping, in conjunction with the Bureau of Mineral Resources, of the Dixon Range and Lissadell 1 : 250,000 Sheets in the East Kimberley area.

MINERAL RESOURCES DIVISION.

(i) Continuation and completion of the regional investigation of the Hamersley Iron Province. This involves mapping on the following 1 : 250,000 Sheets:—

Yarraloola, Wyloo, Turee Creek, Newman, Robertson and Roy Hill.

(ii) Investigation of low-grade manganese deposits near Ravensthorpe in conjunction with a drilling programme by the Bureau of Mineral Resources.

(iii) Investigation of the clay deposits of the Metropolitan Area (if required).

(iv) Investigation of the pegmatites of the Yalgoo and Murchison Goldfields.

(v) Miscellaneous investigations as required.

PUBLICATIONS AND RECORDS.

At the end of 1962 there were three Bulletins and one Annual Report with the Government Printer awaiting publication. Due to the long delay in printing and in order to release technical information, an innovation in the form of Records series was introduced. This met the need for quick dissemination of reports to interested parties and presented technical reports in a more enduring form. Records, which are duplicated, are not true publications in that they cannot be obtained freely by the public. They are issued under three classifications: *Confidential,* for departmental use only, *Restricted,* for departmental use and for interested persons entitled to the information, and *Unrestricted,* which can be perused at the Survey library or be made available to interested parties.

Records of enduring scientific or of other value will be selected for publication in the Annual Report together with a list of the Records produced each year.

In addition, it is proposed to issue a new Information Pamphlet series. These will be small duplicated pamphlets on items of general geological interest intended to assist prospectors or persons interested in the search or development of the mineral resources of this State. The first two titles "How and Where to Look for Copper in W.A." and "Opening an Aggregate Quarry," should be available early in 1963.

Issued During 1962:

Annual Progress Report for 1960.

In the Press:

Annual Progress Report for 1961.

Mineral Resources of Western Australia, Bulletin No. 8, Copper.

Bulletin No. 115, The Geology of Portion of the Pilbara Goldfield covered by the Marble Bar and Nullagine 4-mile Sheets.

Bulletin No. 116, The Geology of the Manganese Deposits of Western Australia.

In Preparation:

Geological Map of the Boorabbin 1 : 250,000 Sheet (SH51-13 International Grid) with Explanatory Notes.

Geological Map of the Balfour Downs 1 : 250,000 Sheet (SF51-9 International Grid) with Explanatory Notes.

Geological Map of the Dampier 1 : 250,000 Sheet (SF50-2 International Grid) with Explanatory Notes.

Geological Map of the Mt. Bruce 1 : 250,000 Sheet (SF50-11 International Grid) with Explanatory Notes.

Bulletin, Palaeontological Contributions to the Geology of Western Australia Series VIII.

Records Produced:

No.	Author(s)	Title
1962/1	Berliat, K. .... Morgan, K. H.	Report on Exploratory Drilling for Water at Jurien Bay, W.A.
1962/2	MacLeod, W. N.	Report on Drilling of Portion of the Greenbushes Tinfield.
1962/3	Berliat, K.	Report on Exploratory Drilling for Water at the Mental Hospital, Whitby Falls.
1962/4	Sofoulis, J.	Report on Gold Prospect PA7077, Lake Cronin Area, Yilgarn Goldfield, W.A. (*Restricted.*)
1962/5	Kriewaldt, M.	Report on Underground Water at Point Sampson, West Pilbara G.F., North West Division.
1962/6	Sofoulis, J.	Report on Water Supply, Cundeelee Mission, N.E. Coolgardie Goldfield, W.A.
1962/7	Gordon, F. R.	Report on Rock Stability, Mundaring Weir pumphouse.
1962/8	MacLeod, W. N.	Interim Report on the Pilbara Iron Ore Deposits. (*Confidential.*)
1962/9	Sofoulis, J.	Report on Groundwater Potentialities, Central Aborigines Reserve, Eastern Division, W.A.
1962/10	Playford, P. E.....	Notes on the Devonian—Lower Carboniferous Rocks of the Lennard Shelf, Western Australia.
1962/11	Gordon, F. R.	South Canning Damsite—A Preliminary Appraisal.
1962/12	Passmore, J. R.	Report on Laporte Nos. 1, 2, 3 and 4 Water Bores, Australind W.A. (*Restricted.*)
1962/13	Playford, P. E..... Lowry, D.	Wells Drilled for Petroleum Exploration in Western Australia to the end of 1962.
1962/14	Sofoulis, J.	Report on a Copper Prospect, Higginsille area, Coolgardie Goldfield, W.A. (*Restricted.*)
1962/15	MacLeod, W. N.	An Outline of the Results of Recent Iron Ore Exploration in Western Australia, 1961–62. (*Confidential.*)
1962/16	Sofoulis, J.	Water Supply Eyre Highway, Eucla Division.
1962/17	MacLeod, W. N.	Report on the Exploration for Iron Ore in the North Pilbara by Mt. Goldsworthy Mining Associates. (*Confidential.*)
1962/18	Passmore, J. R.	Report on G.S.W.A. Mandurah No. 1 Water Bore, Mandurah, W.A.
1962/19	Passmore, J. R.	Report on Busselton Shire Council Water Bore, Milne St., Busselton, W.A.
1962/20	Rowston, D. R. Gordon, F. R.	Geophysical Investigation of the Helena River Bridgesite, Kalamunda-Mundaring Road.
1962/21	Trendall, A. F.	Plagioclase Phenocrysts in a Basalt from Boyanup, Western Australia.
1962/22	Sofoulis, J.	The Occurrence and Hydrological Significance of Calcrete Deposits in Western Australia.
1962/23	Edgell, H. S.	The Correlative Value of Microplankton in the Cretaceous of the Perth Basin, W.A.
1962/24	Edgell, H. S.	Precambrian Fossils from the Hamersley Range, Western Australia and their bearing on Diagenesis in Jaspilite Formation.

15th March, 1963.

J. H. LORD,
Government Geologist.

AN ASSESSMENT OF THE UNDERGROUND WATER RESOURCES OF WESTERN AUSTRALIA.

by

N. J. Mackay.

INTRODUCTION.

In September, 1962, the Underground Water Committee of Western Australia was requested by Public Works Department to prepare an assessment of the underground water resources of the State. The assessment was required for inclusion in a report giving an assessment of the surface and underground water resources of Australia for the Standing Committee of the newly formed Water Resources Council.

Information supplied by Public Works Department, Metropolitan Water Supply Department, Department of Agriculture, and the Geological Survey was used in the compilation.

The State was divided into eight sedimentary basins and seven hard-rock provinces, and some of these basins and provinces were subdivided into areas for the purpose of the assessment. A map (Plate I) of the State showing the underground water basins and provinces accompanies this assessment. Areas where underground water is developed are also shown on this map.

The Standing Committee requested that the assessment be made under two main headings, Pressure Water and Non-Pressure Water, and that details for each basin or province be given under six standard sub-headings.

METHOD OF ASSESSMENT.

The assessment is presented under the following main headings and units of area:—

Pressure Water:

Perth Basin.
Carnarvon Basin.
Canning Basin.
Bonaparte Gulf Basin.
Ord Basin.
Officer Basin.
Eucla Basin.
Collie Basin.

Non-pressure Water:

Perth Basin.
Carnarvon Basin.
Canning Basin.
Bonaparte Gulf Basin.
Ord Basin.
Officer Basin.
Eucla Basin.
Collie Basin.
South-West Shield Province.
North-West Province.
Pilbara Province.
Kimberley Province.
Halls Creek Province.
Musgrave Province.
Blackstone Province.

Details under each Main Heading for each Unit of Area. (Where water yields are given or reserves are estimated, they are classified in terms of quality under the general "type of use" headings of domestic; irrigation; stock; other):

(a) Area of each unit. Area within each unit—
prospected; or
developed for underground water.

(b) The number of bores from which water is obtained and an indication of location or intensity of bores in more important areas.

(c) An estimate of the amount of water withdrawn during 1961-62.

(d) Area within each unit not prospected but regarded as having high potential; estimate of possible yield.

(e) Recharge characteristics, if known.

(f) An estimate of the total reserves of underground water.

PRESSURE WATER.

Perth Basin.

(a) Approximately 23,000 square miles.

(i) *Northern Area:*

Approximately 12,000 square miles from Perth north to Geraldton and the Greenough River. Main aquifers are Mesozoic sandstones.

Inadequately prospected by about 15 bores; slight development by about 6 bores.

Artesian and sub-artesian water.

(ii) *Southern Area:*

Approximately 3,000 square miles from Perth south to Busselton. Main aquifers are Mesozoic sandstones.

Inadequately prospected by about 70 bores; developed mainly as town and private supplies at Bunbury and Busselton, and as industrial supplies in the Bunbury-Busselton area.

Artesian and sub-artesian water.

(iii) *Perth Area:*

Approximately 140 square miles of the Perth Metropolitan Area. Main aquifers are Mesozoic sandstones, with some production from Tertiary sandstones.

Well prospected by at least 50 bores; developed as town and private supplies.

Mainly artesian water.

(b) At least 130 bores.—Greatest intensity is at Bunbury (at least 50 bores in an area of 5 square miles) and in the Perth Area (at least 50 bores in an area of 140 square miles).

(c) Only very approximate information available, except for town supplies at Perth, Bunbury and Busselton.—Estimated total withdrawn during 1961-62—approximately 3,000 million gallons. Quality of water is mainly domestic.

(d) Mesozoic aquifers: (i) In the large area between Perth and the Arrowsmith River, and (ii) south of Busselton to the southern coast, have potential yields of 500,000 gallons per day per bore, quality ranging from domestic to stock.

(e) Recharge is from local rainfall and from run off from the Darling Range in the southern half of the Basin. Dams in the Darling Range may have an effect on recharge in the future. No information on rates of depletion and recharge.

(f) Total reserves unknown, but must be very large for the Mesozoic aquifers.

Carnarvon Basin.

(a) Approximately 50,000 square miles.

(i) *Western Area:*

Approximately 30,000 square miles from Exmouth Gulf south to the Murchison River. Main aquifers are the Birdrong Formation (Lower Cretaceous) and Tumblagooda Sandstone (Lower Silurian). Less important aquifers are the Windalia Radiolarite (Lower Cretaceous) and the Lyons Group (Lower Permian).

Adequately prospected by at least 200 bores; development restricted to pastoral requirements (approximately 14,000 square miles). No development in the Exmouth Gulf area where the aquifers are over 2,500 feet deep, or in the south-eastern section of the area.

Artesian water restricted to the coastal area 30 to 60 miles wide, sub-artesian elsewhere inland.

(ii) *Eastern Area:*

Approximately 10,000 square miles from Lyndon River south to Murchison River. Main aquifers are Permian sandstones (Byro Group, Wooramel Group, Lyons Group).

Inadequately prospected by about 40 bores; development restricted to pastoral requirements.

Sub-artesian water only.

(b) At least 250 bores.—Greatest intensity of bores is in the Western Area between the Gascoyne River and the Murchison River (at least 150 bores in an area of 10,000 square miles). The other bores are scattered through the Eastern Area and north of the Gascoyne River.

(c) Only very approximate information available. Estimated total withdrawn during 1961-62 —approximately 22,000 million gallons. Quality of water is stock.

(d) In the section of the Eastern Area between Lyndon River and Minilya River, the Wooramel Group (Permian) has a good potential for sub-artesian water, quality ranging from domestic to stock.

(e) The main intake area of the most important aquifer (Birdrong Formation) is the Kennedy Range, 80 miles east of Carnarvon. Another important intake area for this aquifer is in the north-eastern side of the Basin between the Ashburton River and the Lyndon River.—Recharge appears adequate at present as there is no known appreciable reduction in flow of artesian bores. The artesian flows are unrestricted and if production is increased substantially, recharge of the main aquifers in the Western Area may become inadequate. No information on rates of depletion and recharge.

(f) Total reserves unknown, but must be very large for the two main aquifers (Birdrong Formation and Tumblagooda Sandstone).

Canning Basin.

(a) Approximately 175,000 square miles.

(i) *Fitzroy Drainage Area:*

Approximately 17,000 square miles from King Sound south-east to Luck Range. Main aquifers are Permian sandstones (Liveringa Formation, Poole Sandstone, Grant Formation), with some production from Mesozoic sandstones and Devonian limestones and conglomerates.

Adequately prospected by at least 550 bores; development restricted to pastoral requirements.

Mainly sub-artesian water, few artesian bores.

(ii) *Coastal Area:*

Approximately 5,000 square miles, from Breaker Inlet north-east to Cape Leveque. Main aquifers are Mesozoic sandstones (Alexander Formation, Wallal Sandstone, Erskine Sandstone).

Inadequately prospected by about 50 bores; development restricted to pastoral requirements.

Mainly sub-artesian water, artesian only along a narrow coastal strip.

(b) At least 600 bores.—At least 550 bores are scattered through the Fitzroy Drainage Area (approx. 17,000 sq. miles). Other bores are restricted to the Coastal Area.

(c) Only very approximate information available. —Estimated total withdrawn during 1961/62 —approx. 3,000 million gallons. Quality of water ranges from mainly domestic in the Fitzroy Drainage Area to mainly stock in the Coastal Area.

(d) (1) Mesozoic and Permian aquifers in the large inland area of the Canning Basin have potential yields of 500,000 gallons per day per bore, quality ranging from domestic to stock.

(ii) Mesozoic aquifers in the Dampier Peninsula (between King Sound and Broome) have a high potential for sub-artesian water, quality ranging from domestic to stock.

(e) Recharge is from local rainfall with additional recharge in the Fitzroy Drainage Area by the Fitzroy River, Lennard River and smaller streams when they flow in the "wet" season. Recharge appears adequate at present, but a prolonged drought could have a marked effect on recharge in the Fitzroy Drainage Area. No information on rates of depletion and recharge.

(f) Total reserves unknown, must be very large.

Bonaparte Gulf Basin.

(a) Approx. 2,000 sq. miles.

Palaeozoic aquifers inadequately prospected by about five scattered bores which are developed for pastoral requirements.

Sub-artesian water, some of which may be non-pressure water.

(b) About five bores.

(c) Estimated total withdrawn during 1961/62—approx. 10 million gallons. Quality of water is unknown, presumably stock or better.

(d) The Palaeozoic aquifers have potential yields of about 20,000 gallons per day per bore, quality ranging from domestic to stock.

(e) Recharge is from local rainfall and from stream flow in the "wet" season.

(f) Total reserves unknown.

Ord Basin.

(a) Approx. 6,000 sq. miles.

Aquifers are Cambrian sediments and volcanics. Approx. 1,000 sq. miles inadequately prospected by about 30 bores; development restricted to pastoral requirements.

Sub-artesian water, some of which may be non-pressure water.

(b) About 30 bores.—The bores are mainly scattered over 4 small areas totalling approx. 1,000 sq. miles.

(c) Estimated total withdrawn during 1961/62—approx. 50 million gallons. Quality of water is mainly domestic, occasionally stock.

(d) The unprospected 5,000 sq. miles of the Basin have potential yields of about 20,000 gallons per day per bore, quality ranging from domestic to stock.

(e) Recharge is from local rainfall and by the Ord River and smaller streams in the "wet" season.

(f) Total reserves unknown.

Officer Basin

(a) Approx. 75,000 sq. miles.—No prospecting or development known.

(b) None known.

(c) None known.

(d) None known.

(e) Recharge is from local rainfall.

(f) Total reserves unknown.

Eucla Basin.

(a) Approx. 50,000 sq. miles.

Tertiary and Mesozoic aquifers inadequately prospected by about 40 bores; development restricted to several areas totalling about 1,000 sq. miles and to along the Transcontinental Railway Line.

Sub-artesian water except at Madura where the water is artesian. Some of the water may be non-pressure water.

(b) About 40 bores.—About 17 bores are scattered along 250 miles of the Transcontinental Railway Line and about 14 bores are in an area of 800 sq. miles in the central-western part of the basin.

(c) Estimated total withdrawn during 1961/62—Approx. 30 million gallons. Quality of water ranges from stock to saline.

(d) None known; parts of the Basin have potential yields of about 10,000 gallons per day per bore, but the quality ranges from stock to saline.

(e) Recharge is from local rainfall.

(f) Total reserves unknown.

Collie Basin.

(a) Approx. 90 sq. miles.—Permian sandstones prospected by more than 60 coal-exploration and other bores; no development known. Mainly artesian water.

(b) None known.

(c) None known: Quality of water is mainly domestic.

(d) None known.

(e) Recharge is from local rainfall and from flow of the Collie River.

(f) Total reserves unknown.

NON-PRESSURE WATER.

Perth Basin.

(a) Approx. 23,000 sq. miles.—Approx. 18,000 sq. miles between the Greenough River and south of Busselton. Main aquifers are river sands and gravels, coastal limestones, Tertiary and Mesozoic sandstones, and older sediments. Adequately prospected over most of the area; development restricted to approx. 11,000 sq. miles.

(b) At least 12,000 bores and wells, probably many more.—Greatest intensity is in the Perth Metropolitan Area (at least 9,100 bores and wells in an area of 200 sq. miles). At Wicherina there are 13 producing bores in 6 sq. miles.

(c) Only very approximate information available, except for five town supplies.—Estimated total withdrawn during 1961/62—approx. 4,500 million gallons. Quality of water is mainly domestic, occasionally stock.

(d) Mesozic aquifers in the area between the Moore River and the Greenough River have potential yields of 20,000 gallons per day per bore, quality ranging from domestic to stock.

(e) Recharge is from local rainfall with additional recharge by the major rivers of the Basin. Recharge appears adequate.

(f) Total reserves unknown.

Carnarvon Basin.

(a) Approx. 50,000 sq. miles.

(i) Scattered prospecting and development of sands and gravels along the main rivers (Gascoyne, Minilya, Lyndon, Wooramel, etc.). Full development of river sands and gravels for six miles upstream along the Gascoyne River from Carnarvon.

(ii) Scattered prospecting and development of Quaternary, Tertiary, and Cretaceous aquifers in the northern part of the Basin between Cape Range and Cape Preston (6,000 square miles).

(iii) Slight prospecting and development of Quaternary sand dunes along the central part of the western coast from Maud Landing to Shark Bay (2,000 square miles).

(iv) Slight prospecting and development of coastal limestones along the northern and southern parts of the western coast (3,000 square miles).

(v) Springs along the Kennedy Range in the central part of the Basin have been developed for pastoral requirements.

(b) At least 1,000 bores and wells, probably many more.—The bores and wells are scattered mainly along the streams and the coastal part of the Basin. Greatest intensity is near Carnarvon where about 350 bores and wells along six miles of the Gascoyne River are used for irrigation and town supplies.

(c) Only very approximate information available, except for irrigation and town supplies at Carnarvon and town supply at Onslow.—Estimated total withdrawn during 1961-62—approximately 2,200 million gallons. Quality of water is mainly domestic, occasionally stock.

(d) None known.

(e) Recharge is from local rainfall with additional recharge of river sands and gravels by the main rivers. Recharge appears adequate at present but lack of river flow in droughts has a marked effect on recharge, especially in developed areas such as Carnarvon.

(f) Total reserves unknown.

Canning Basin.

(a) Approximately 175,000 square miles.

(i) *Fitzroy Drainage Area.*—Approximately 17,000 square miles from King Sound south-east to Luck Range. Scattered prospecting of river sands and gravels and Mesozoic aquifers; development restricted to pastoral requirements and Derby town supply.

(ii) *Coastal Area.*—Approximately 5,000 square miles from Breaker Inlet north-east to Cape Leveque. Scattered prospecting of Mesozoic aquifers; development restricted to pastoral requirements, settlement supplies and Broome town supply.

(iii) About 26 shallow wells developed along about 300 miles of the Canning Stock Route across the inland part of the Basin.

(iv) Springs in Devonian limestones and along the south-western margin of the Fitzroy Drainage Area have been developed for pastoral requirements.

(b) At least 400 bores and wells.—The bores and wells are scattered mainly through the Fitzroy Drainage Area and along the Coastal Area.

(c) Only very approximate information available, except for town supplies at Derby and Broome.—Estimated total withdrawn during 1961-62—approximately 800 million gallons. Quality of water is mainly domestic, occasionally stock.

(d) Mesozoic and Permian aquifers in the large inland area of the Canning Basin have potential yields of 10,000 to 20,000 gallons per day per bore, quality ranging from domestic to stock.

(e) Recharge is from local rainfall with additional recharge of river sands and gravels in the Fitzroy Drainage Area by the Fitzroy River, Lennard River and smaller streams. Recharge appears adequate at present.

(f) Total reserves unknown.

Bonaparte Gulf Basin.

(a) Approximately 2,000 square miles.—Virtually unprospected.

(b) None known; some of the five bores in the Basin may be drawing from non-pressure water.

(c) None known; all water withdrawn is included in the pressure water figure for the Basin.

(d) Sands and gravels along the main streams have potential yields of 20,000 gallons per day per bore, quality mainly domestic.

(e) Recharge is from local rainfall and from flow of the main streams.

(f) Total reserves unknown.

Ord Basin.

(a) Approximately 6,000 square miles.—Approximately 1,000 square miles inadequately prospected.

(b) None known; some of the 30 bores in the Basin may be drawing from non-pressure water.

(c) None known; all water withdrawn is included in the pressure water figure for the Basin.

(d) Sands and gravels along the Ord River and smaller streams have potential yields of 20,000 gallons per day per bore, quality mainly domestic.

(e) Recharge is from local rainfall, and from flow of the Ord River and smaller streams.

(f) Total reserves unknown.

Officer Basin.

(a) Approximately 75,000 square miles.—No prospecting or development known.

(b) None known.

(c) None known.

(d) None known.

(e) Recharge is from local rainfall.

(f) Total reserves unknown.

Eucla Basin.

(a) Approximately 50,000 square miles.—Inadequately prospected over about 1,000 square miles and along the Transcontinental Railway Line.

(b) None known; some of the 40 bores in the Basin may be drawing from non-pressure water.

(c) None known; all water withdrawn is included in the pressure water figure for the Basin.

(d) None known; parts of the Basin have potential yields of about 10,000 gallons per day per bore, but the quality ranges from stock to saline.

(e) Recharge is from local rainfall.

(f) Total reserves unknown.

Collie Basin.

(a) Approximately 90 square miles.—Adequately prospected and developed by at least 20 bores.

(b) At least 20 bores and wells scattered through the Basin.

(c) Estimated total withdrawn during 1961-62—approximately 15 million gallons. This figure does not include approximately 500 million gallons withdrawn during dewatering of coal mines in the Basin. Quality of water is mainly domestic.

(d) None known.

(e) Recharge is from local rainfall and from flow of the Collie River. Recharge appears adequate.

(f) Total reserves unknown.

South-West Shield Province.

(a) Approximately 350,000 square miles.

Non-pressure water occurs in superficial zones of weathering and sediments overlying igneous rocks (mainly granite), and in alluvial deposits associated with rivers and internal drainage areas.

Widespread prospecting and development of Area "A" (approximately 80,000 square miles) for farming and pastoral requirements and six town supplies. Scattered prospecting and development of Area "B" (approximately 160,000 square miles) for pastoral requirements and five town supplies. Area "C" (approximately 110,000 square miles) is virtually unprospected or developed.

(b) At least 37,000 bores and wells.—Greatest intensity is in Area "A" (at least 30,000 bores and wells in an area of approximately 80,000 square miles). About 7,000 bores and wells are scattered through approximately 150,000 square miles of Area "B." At Wiluna in the northern part of the Province there are about 60 bores in an area of 10 square miles.

(c) Only very approximate information available, except for 11 town supplies.—Estimated total withdrawn during 1961-62—approximately 16,000 million gallons. Quality of the water ranges from domestic to stock.

(d) Some internal drainage areas in Area "B" and Area "C" north of Latitude 29 degrees have a high potential for domestic and irrigation supplies. Potential yields could be as high as 200,000 gallons per day per bore.

(e) Recharge is from local rainfall with additional recharge by the main rivers and by percolation along internal drainage areas.

(f) Total reserves unknown.

North-West Province.

(a) Approximately 95,000 square miles.—Non-pressure water occurs in bedding planes and zones of weathering and fracturing in Proterozoic sediments and volcanics, and in sands and gravels along the main rivers (Fortescue River, upper part of the Ashburton River, etc.) and smaller stream.

(i) Scattered prospecting and development of approximately 30,000 square miles of the Western Area (approximately 60,000 square miles) for pastoral requirements and one town supply. The Eastern Area (approximately 35,000 square miles) is not prospected or developed except for the Canning Stock Route.

(ii) Numerous springs and spring-fed pools, particularly along the Fortescue River, are used for pastoral requirements.

(b) At least 1,000 bores and wells, scattered through approximately 30,000 square miles of the Western Area.

(c) Only very approximate information available, except for Wittenoom town supply—Estimated total withdrawn during 1961-62—approximately 700 million gallons. Quality of water ranges from domestic to stock.

(d) The Eastern Area is considered to have potential yields similar to the Western Area. Some internal drainage areas may have a high potential for domestic and stock water.

(e) Recharge is from local rainfall with additional recharge of river sands and gravels by the main rivers. Recharge appears adequate except during periods of extended drought conditions.

(f) Total reserves unknown.

Pilbara Province.

(a) Approx. 33,000 sq. miles.

Non-pressure water occurs in superficial zones of weathering and sediments overlying igneous and and metamorphic rocks, and in sands and gravels along the main rivers (De Grey, Oakover, Coongan, Shaw, Turner, Yule, etc.,) and smaller streams.

Widespread prospecting and development of the *Western Area* (approx. 22,000 sq. miles) for pastoral requirements and for three town supplies. The *Eastern Area* (approx. 11,000 sq. miles) is not prospected or developed.

(b) At least 1,500 bores and wells.—Greatest intensity is the Roebourne—Marble Bar—Port Hedland area and along the De Grey—Oakover river system.

(c) Only very approximate information available, except for three town supplies. Estimated total withdrawn during 1961/62—approx. 1,100 million gallons. Quality of water ranges from domestic to stock.

(d) In the Eastern Area internal drainage areas (Rudall River, Cotton Creek, etc.) draining into the Lake Dora—Lake Blanche system have a high potential for domestic and stock supplies.

(e) Recharge is from local rainfall with additional recharge of river sands and gravels by the De Grey, Oakover, Coongan, Shaw, Turner, Yule and smaller streams. Extended drought conditions and lack of river flow have a serious effect on recharge.

(f) Total reserves unknown.

Kimberley Province.

(a) Approx. 53,000 sq. miles.

Non-pressure water occurs in bedding planes and zones of weathering and fracturing in Proterozoic sediments and volcanics, and in sands and gravels along the main streams.

Slight prospecting and development of approx. 1,000 sq. miles in two small areas in the southern part of the Province.

(b) About 25 bores and wells, scattered over two areas totalling approx. 1,000 sq. miles.

(c) Only very approximate information available.—Estimated total withdrawn during 1961/62—50 million gallons. Quality of water ranges from domestic to stock.

(d) Proterozoic sediments over most of the Province have a good potential for pressure and non-pressure water, quality ranging from domestic to stock. Potential yields are 20,000 gallons per bore, per day.

(e) Recharge is from local rainfall with additional recharge by the main rivers. Recharge appears adequate.

(f) Total reserves unknown.

Halls Creek Province.

(a) Approx. 15,000 sq. miles.

Non-pressure water occurs in superficial zones of weathering overlying igneous (mainly granite) and metamorphic rocks, and in sands and gravels along the main streams.

Scattered prospecting and development of approx. 3,000 sq. miles in the eastern part of the Province for pastoral requirements and one town supply.

(b) At least 70 bores and wells, scattered through approx. 3,000 sq. miles in the eastern part of the Province.

(c) Only very approximate information available, except for Halls Creek town supply.—Estimated total withdrawn during 1961/1962—130 million gallons. Quality of water is mainly stock, occasionally domestic.

(d) The area north of Turkey Creek has a good potential for stock supplies, potential yields being 10,000 gallons per day per bore.

(e) Recharge is from local rainfall with additional recharge by the main streams. Recharge of the Halls Creek town supply is not affected by seasonal conditions, but bores drawing from superficial zones of weathering are affected by extended drought conditions.

(f) Total reserves unknown.

Musgrave Range Province.

(a) Approx. 20,000 sq. miles.

Non-pressure water occurs in bedding planes and zones of weathering and fracturing in Proterozoic sediments, and in sands and gravels along Sturt Creek.

Slight prospecting and development of approx. 350 sq. miles in two small areas in the northern part of the Province.

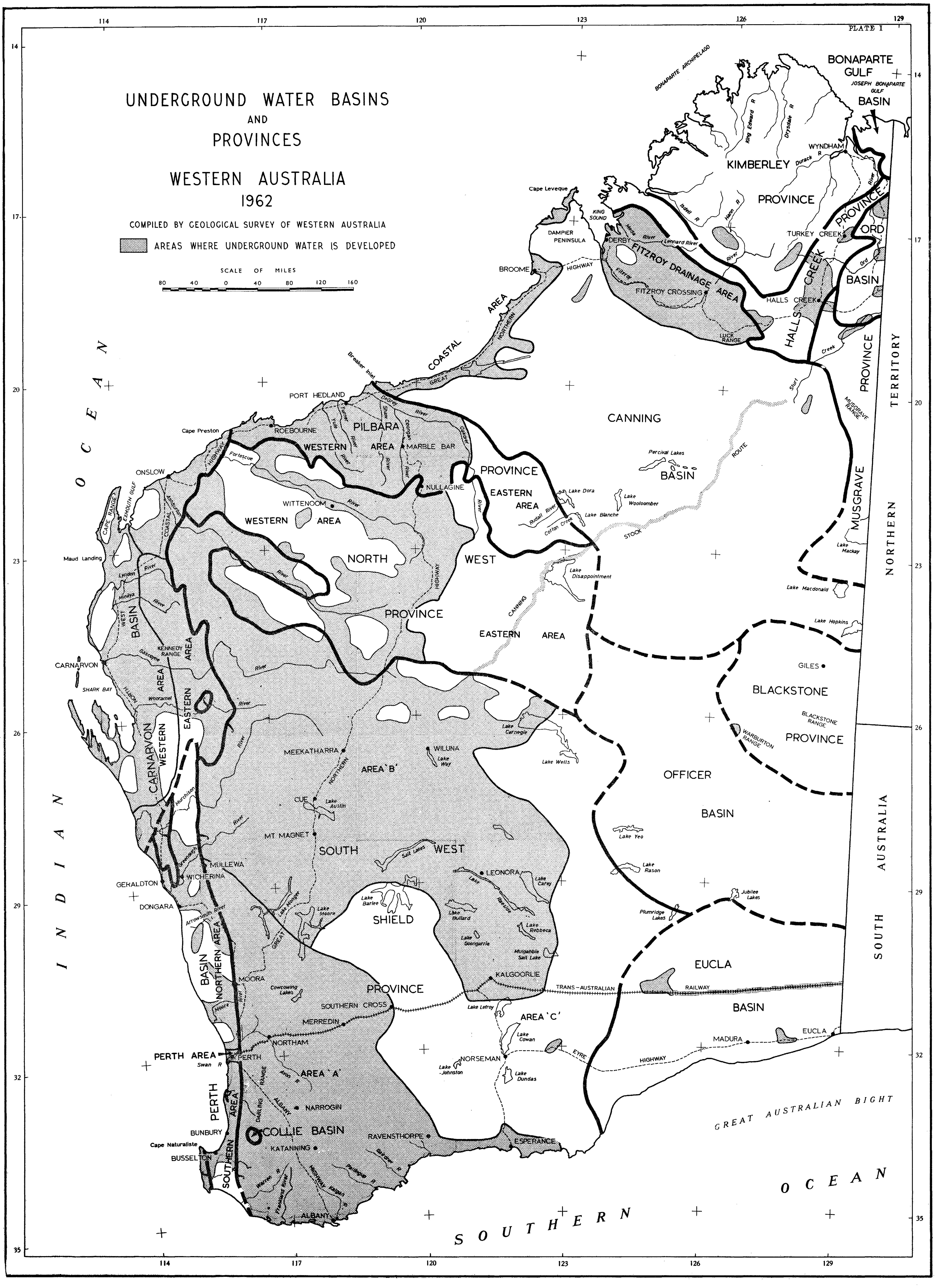
(b) About 15 bore sand wells, scattered over two small areas totalling approx. 350 sq miles.

(c) Only very approximate information available.—Estimated total withdrawn during 1961/62—30 million gallons. Quality of water is mainly stock.

(d) Internal drainage areas scattered through the Province may have a potential for domestic and stock water.

(e) Recharge is from local rainfall with additional recharge by percolation along internal drainage areas. Recharge could be seriously affected by extended drought conditions.

(f) Total reserves unknown.


UNDERGROUND WATER BASINS
AND
PROVINCES
WESTERN AUSTRALIA
1962
COMPILED BY GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
AREAS WHERE UNDERGROUND WATER IS DEVELOPED
SCALE OF MILES
80 40 0 40 80 120 160
BONAPARTE GULF
JOSEPH BONAPARTE GULF BASIN
KIMBERLEY PROVINCE
ORD BASIN
HALLS CREEK PROVINCE
FITZROY DRAINAGE AREA
NORTHERN COASTAL AREA
PILBARA WESTERN AREA
PROVINCE EASTERN AREA
NORTH WEST PROVINCE
WESTERN AREA
CANNING BASIN
EASTERN AREA
MUSGRAVE PROVINCE
BLACKSTONE PROVINCE
OFFICER BASIN
EUCLA BASIN
CARNARVON BASIN
WESTERN COASTAL AREA
EASTERN AREA
SOUTH WEST SHIELD PROVINCE
AREA 'B'
AREA 'A'
AREA 'C'
PERTH BASIN
NORTHERN AREA
PERTH AREA
SOUTHERN AREA
COLLIE BASIN
INDIAN OCEAN
SOUTHERN OCEAN
GREAT AUSTRALIAN BIGHT
NORTHERN TERRITORY
SOUTH AUSTRALIA
WYNDHAM
TURKEY CREEK
HALLS CREEK
FITZROY CROSSING
DERBY
BROOME
PORT HEDLAND
ROEBOURNE
MARBLE BAR
NULLAGINE
WITTENOOM
ONSLOW
CARNARVON
MEEKATHARRA
WILUNA
CUE
MT MAGNET
LEONORA
MULLEWA
WICHERINA
GERALDTON
DONGARA
MOORA
SOUTHERN CROSS
MERREDIN
NORTHAM
PERTH
NARROGIN
BUNBURY
BUSSELTON
KATANNING
RAVENSTHORPE
ESPERANCE
ALBANY
KALGOORLIE
NORSEMAN
MADURA
EUCLA
GILES
TRANS-AUSTRALIAN RAILWAY
EYRE HIGHWAY
CANNING STOCK ROUTE
GREAT NORTHERN HIGHWAY
114 117 120 123 126 129
14 17 20 23 26 29 32 35

Blackstone Province.

(a) Approx. 30,000 sq. miles.

Non-pressure water occurs in superficial zones of weathering overlying igneous and metamorphic rocks, and in alluvial deposits associated with internal drainage areas.

Slight prospecting and development of approx. 25 sq. miles at Warburton Mission and several bores at Gile Meteorological Station in the northern part of the Province.

(b) About 10 bores and wells, mostly in 25 sq. miles at Warburton Mission.

(c) Only very approximate information available.—Estimated total withdrawn during 1961/62—5 million gallons. Quality of water is mainly domestic.

(d) Internal drainage areas in the Warburton Range area and in the northern part of the Province have a good potential for domestic and stock water.

(e) Recharge is from local rainfall with additional recharge by percolation along internal drainage areas. Recharge could be seriously affected by extended drought conditions.

(f) Total reserves unknown.

Table 1.

SUMMARISED ESTIMATE OF UNDERGROUND WATER DEVELOPED IN WESTERN AUSTRALIA.

Unit of Area	Pressure Water		Non-Pressure Water		Total	
	No. of Bores	Annual Yield (million gals.)	No. of Bores	Annual Yield (million gals.)	No. of Bores	Annual Yield (million gals.)
Perth Basin	130+	3,000	12,000+	4,500	12,130+	7,500
Carnarvon Basin	250+	22,000	1,000+	2,200	1,250+	24,200
Canning Basin	600+	3,000	400+	800	1,000+	3,800
Bonaparte Gulf Basin	5	10	....	....	5	10
Ord Basin	30	50	....	....	30	50
Officer Basin	....	....	....	....	....	....
Eucla Basin	40	30	....	....	40	30
Collie Basin	....	....	20+	15	20+	15
South-West Shield Province	....	....	37,000+	16,000	37,000+	16,000
North-West Province	....	....	1,000+	700	1,000+	700
Pilbara Province	....	....	1,500+	1,100	1,500+	1,100
Kimberley Province	....	....	25	50	25	50
Halls Creek Province	....	....	70+	130	70+	130
Musgrave Province	....	....	15	30	15	30
Blackstone Province	....	....	10	5	10	5
Totals	1,055+	28,090	53,040+	25,530	54,095+	53,620

Total No. of Bores :—At least 54,000.

Annual Yield :—At least 53,000 million gallons.

NEW GEOLOGICAL INFORMATION OBTAINED FROM AN EXPLORATORY BORE FOR UNDERGROUND WATER AT JURIEN BAY, PERTH BASIN.

by K. Berliat.

Location of the Drill Site.

New geological information was obtained from a departmental exploratory bore for domestic water at Jurien Bay, 194 miles by road north of Perth via Moora and Badgingarra. The drill site, close to the Indian Ocean, is at latitude 30°18′15″S and longitude 115°2′20″E.

General Geology.

Jurien Bay is in the central part of the Perth Basin, lying over the Beagle Ridge, a shallow sub-surface basement high, bounded to the east by the Beagle Fault. The fault runs south from latitude 29°30′S to latitude 30°18′S, and at Jurien Bay is approximately 4 miles east of the coast.

The nearest Mesozoic outcrops of Lower Jurassic Cockleshell Gully Sandstone occur approximately 9 miles east of the drill site. In the coastal area the Mesozoic sediments are obscured by Pleistocene Coastal Limestone and by beach sand dunes, in which the drill site is located.

Stratigraphy.

The bore, completed at a total depth of 628 feet, penetrated a sequence of grey, argillaceous, micaceous, partly calcareous siltstones and sandstones, and grey, micaceous, silty mudstones. Palynological examinations of sludge samples from 500 feet and 620 feet, carried out by B. E. Balme, indicated a Middle to Upper Triassic age for the 500 feet sample, whilst the 620 feet sample is correlated with the Upper (non-marine?) section of the Lower Triassic Kockatea Shale. It is considered, on lithological grounds. that the sequence from 87 feet (base of the Coastal Limestone) to 595 feet, is of Middle to Upper Triassic age, and that from 595 feet to 628 feet is of Lower Triassic age (Kockatea Shale).

Hydrology.

Two aquifers were encountered in the bore hole, viz. the 10 feet to 87 feet interval, and the 505 feet to 595 feet interval.

The top aquifer derives its supply from superficial sand dunes and from the underlying Coastal Limestone. The salinity of the water within this zone increases rapidly with depth, i.e. from 4,710 p.p.m. at 20 feet to 27,600 p.p.m. at 87 feet (total dissolved solids).

The second aquifer produced from 90 feet of Middle to Upper Triassic sandstones directly overlying the Kockatea Shale. The salinity of this aquifer is very high, total dissolved solids amounting to 49,300 p.p.m.

Contribution to Geological and Hydrological Knowledge.

Stratigraphically the bore has shown that in the Jurien Bay area the Jurassic is not represented to the west of the Beagle Fault, and that the youngest sediments underlying the Pleistocene Coastal Limestone are of Upper to Middle Triassic age.

Hydrologically it has indicated that underground water, suitable for domestic purposes, does not occur in the Triassic sediments to the west of the Beagle Fault. The Kockatea Shale, in which the bore bottomed, is known from previous experience (Geraldton bores, B.M.R. Beagle Ridge No. 10 and No. 10A stratigraphic holes) to contain only highly saline water. In these bores the Kockatea Shale has a thickness in excess of 1,000 feet. In the Beagle Ridge bores the formation is underlain by Permian sediments, which are equally unsuitable as a source for domestic water.

The favourable area to carry out further deep drilling is to the east of the Beagle Fault, where Jurassic sediments, known to contain suitable aquifers, can be expected.

Subsequent shallow drilling has shown that, locally, fresher ground water overlies the main body of saline water. Supplies of up to 2,000 gallons per hour have been located in poorly consolidated aeolianites and beach deposits at depths of less than 30 feet. The salinity of this water, however, is near the maximum permissable for domestic use.

ENGINEERING GEOLOGY OF THE ORD RIVER MAIN DAMSITE NO. 2, KIMBERLEY DIVISION.

By F. R. Gordon.

METHODS AND SCOPE.

Two drilling and investigational programmes have been completed at the Ord River Main Damsite No. 2, with 27 drill holes and two adits supplying material for a preliminary picture of foundation conditions. Geological mapping and supervision of the diamond drilling were carried out by Geologist J. D. Wyatt, and the results obtained have been embodied in two comprehensive reports, published in the Annual Reports of Geological Survey for 1960 and 1961. The main conclusions arrived at were that the site was quite suitable for the construction of a 180 foot high concrete gravity-section dam, but that the western abutment contained clay-filled shears, possibly liable to movement if saturated and under pressure from a filled reservoir.

The writer with the guidance of Geologist Wyatt made a brief examination of the damsite in order to appraise its suitability for the building of an earth and rockfill dam. In addition, detailed work on joints and faults was initiated so that rock mechanics methods could be applied to the question of underground construction and also to assess the problem of water leakage under the dam, and the possibility of structural failure.

With the aid of the Public Works Department's new R117 Seismic Timer, several sections were explored in the spillway area, and by using the existing boreholes for correlation purposes, an assessment was made of the type and nature of the rock materials. Seismic section lines were also run across the sandy flats of the river channel in order to determine the depth to bedrock and the nature of the rock surface.

SITE GEOLOGY.

Stratigraphy.

The stratigraphy and structure of the Main Damsite have already been dealt with in some detail by Geologist Wyatt. A geological plan incorporating additional field work done during the 1962 season is appended (Plate II), together with an engineering plan showing the proposed concrete dam and ancillary works (Plate III.)

In the general area of the damsite, there occurs a succession of Precambrian rocks, consisting of phyllites, quartzites, phyllitic quartzites, sandstones, shales and siltstones. These rocks have been severely faulted and folded and later eroded by the cutting of river gorges and the infilling of depressions.

At the site itself, thin bedded phyllitic quartzites overlie a massive white quartzite, 30 to 250 feet thick, which is found above a grey-green phyllite or slaty shale.

Topography.

The Ord River Damsite is located on the south-eastern edge of the Halls Creek Ridges physiographic unit, which constitutes the roughest country in the area and contains numerous strike ridges and controlled streams. Bandicoot Bar is situated on the northern edge of the same rugged area which is about 40 miles wide, with the Ord River largely contained in gorges between the two sites. South of the Main Damsite No. 2 is the Ord River Basin, largely consisting of undulating plain, while to the South of Bandicoot Bar, the Cambridge Gulf Lowlands consist of large areas of sandy lowlands.

The proposed No. 2 site is situated at the second constriction of the Ord valley downstream from Argyle Downs, and immediately upstream there is an area of flat plain about a mile square before the first constriction or old No. 1 site is encountered. North of Argyle Downs Station, extensive black soil plains occur, and extend north and east for many miles. Through these extensive alluvial plains the lower Ord and its tributaries meander as old rivers. In the gorge area the river may be classed as mature, with the main work, the shifting of vast quantities of alluvial materials in flood time.

The Ord is reduced to a mere trickle in the winter months, but it rises rapidly and irregularly in the monsoonal "wet" or summer season, and the peak flow at Coolibah Pocket has exceeded 1 million cusecs average over 24 hours on two occasions since records have been taken. Due to overgrazing, especially round the water holes and courses, active erosion has commenced in the upper water shed with gullying, causing canyons in silt as much as 60 feet deep. This has resulted in a large suspended sediment load that at flood time has been recorded as high as 250 tons of mud per second.

Rock Types and Properties.

Massive quartzite caps the western abutment and forms the major part of the eastern foundation. It is white when free of staining. Surfaces covered sporadically by the river show a golden brown or even an iridescent bluish-black surface colouring. The rock itself is iron-stained pinkish-red to a depth of about 40 feet below the ground surface, this being due to the inworking of ferruginous material from largely open joints.

Although physical tests have yet to be carried out on the rock, in general it has excellent engineering properties, being dense, largely homogeneous, and physically strong against compressive and shear forces. The rock is highly jointed (Fig. 1) tending to the belief that it is brittle, but this is not strictly correct as the greatest difficulty is experienced in breaking the joint blocks to a smaller dimension. The joint pattern varies markedly from place to place, but the general tendency is the formation of large sheet joints parallel to the ground surface, then the formation of blocks 2 feet by 4 feet by 1 foot with the two major joints dipping into the hillside on the western abutment and standing vertically on the eastern abutment. The joints are usually open in the river bed to about 20 feet and are filled with ferruginous and clay materials in the abutments. Such faulting as could be examined, especially on the eastern abutment, did not produce a crush or gouge zone; minor adjacent breakage, slickensides and displacement being the usual signs. In some cases the fault zone which may have had an opening up to 1½ inches wide, is partially filled with ferruginous material or secondary silica.

In the adits driven in the western abutment (Plate VII) the quartzite is free standing, and although there are drummy sections these are mainly the result of stress relief, and blocks remain locked in the arch until actively dislodged by outside forces. About 60 per cent. of the exposed tunnel shows ferruginous staining on what must have been almost microscopic joints. In this fashion a little overbreak is to be expected in any tunnel or underground excavation, and with the likelihood that there will be less joints at depth, consequently the break to the joint planes will give an irregular profile. The quartzite, as noted, tends to break in blocks down the joint spacing, then in elongated fragments with conchoidal faces. This material is very abrasive. Due to the coherent nature of the rock some difficulty will be experienced in excavating underground or surface structures. Only short pulls from each tunnel-round will be feasible—say 7 feet from a 5 feet hole, and drilling holes will be very demanding on machines and steel.

Fig. 1. Quartzite exposed on west abutment.

Phyllite is found underneath the massive quartzite, is well bedded, and strongly jointed, and is of a light greenish-grey colour in the unweathered state which is usually found about 100 feet below the ground surface. The oxidised material, as in the outcrop 150 feet downstream of the dam centreline, is a dull red, and the phyllite exposed in the adits near the quartzite contact is a light creamy-green with brown-stained joint faces. Physically, the phyllite from these three localities differs also. The deeper bore material gives good cores with the rock apparently quite firm in compression. Due to the thin bedding the shear and tensile strengths are low and, furthermore, this material like the adit phyllite, quickly gives up included water and separates readily on the bedding planes. Apart from this, the adit material is extensively crushed and broken by joints, most of which are at least partially filled with clay. The most conspicuously clay-filled joint is along the bedding plane, showing that alternate wetting and drying has already allowed a minor degree of slaking. The phyllite exposed on the surface is also strongly contorted and broken by faulting and jointing, but the material has reached some degree of induration. Due to curling and crumpling this material would consolidate under pressure to a small extent.

Examination of the core logs of holes drilled through the western abutment indicates that the phyllite is notably affected for at least 40 feet from the quartzite contact (Drillhole 4M).

Excavation of the phyllite will be characterized by reasonably easy drilling, and the production of tabular masses breaking off on the bedding planes. Overbreak will be thus governed by the local inclination of the bedding. Long pulls will be possible but this may be compromised if overbreak tends to be excessive. The most undesirable feature of "slaking" means that special measures have to be taken where it is desired to pour concrete against phyllite or where a clean face is desired. Underbreak to within 1 foot of the final line followed by excavation immediately before concreting, or spraying with bitumen or gunite on excavation are possible remedies. The tabular pieces produced by a tunnel round will be somewhat difficult to load due to the tendency of the shovel to be guided along the dominant planes of large pieces rather than into the pile.

Thin bedded or phyllitic quartzite is found on the eastern abutment above the massive quartzite. It weathers much more rapidly than the massive material and usually the outcrop is obscured under 5-10 feet of rubble, as in the spillway section. Exposed in the cliff section above the tributary creek, are bands of white massive quartzite-sandstone up to 4 feet thick, separated by 1 foot 6 inch bands of red coloured phyllite. Differential weathering of the phyllite has allowed the formation of overhangs and rock falls. Elsewhere, the material is much thinner bedded, as shown in drillhole 18M.

Physically the strength of the rock is governed by the strength of the phyllitic portions and while slaking is not a conspicuous feature in the surface rock, undoubtedly this undesirable property will be encountered in some measure in the less oxidised material at depth. Possibly, too, some form of "rebound" would occur in deep excavations in this material. Laboratory or field testing of samples, especially the determination of the modulus of elasticity, would be of value in the estimation of any tendency for elastic rebound.

Most of the joints exposed in the phyllitic quartzite are sheet joints along the bedding planes. Two other joints are usually present, but the dominantly anticlinal folding on the eastern abutment has meant separation along the weaker layers. The drillhole records from the underground powerhouse and spillway areas shows that the phyllitic quartzite is less jointed, and that adjacent faulting as well as arching has been responsible for the formation of joints.

The tendency of this material is to break in flat tabular pieces, and hence the inclination of the bedding plane to any excavation will largely govern the amount of overbreak. Drilling speeds in this rock will vary, but will in general be reasonably fast. Loading of a rock pile will be difficult due to the dominance of tabular pieces.

Jointing.

The jointing in the vicinity of the Ord River Main Damsite is both complex and abundant:—

(a) The complexity of the jointing is directly related to a series of major high-angle faults trending in a general north-northeasterly direction and to numerous additional faults, the largest of which trend either N. 45° E. or N. 20° W.

(b) The abundance of the jointing can be related to the competence of the rock type, a comparatively brittle quartzite, which has obtained relief from the various imposed stresses by complex fracturing.

The underlying, less competent phyllite, whilst showing fewer joint openings, has obtained relief by the formation of intricate fold patterns. This folding is evident on the surface in the immediate vicinity of the west abutment, but diamond drill cores, especially from drillhole 11M., on the southern spillway have revealed similar folding.

Bearing in mind the importance of rock fractures to dam design, grout hole orientation, underground rock excavation, and slope stability predictions, an analysis of the various fracture patterns was carried out, and a series of joint rosettes prepared.

These rosettes have been superimposed on the geological structural map of the two abutments of the damsite, (Plates IV and V), and show the direction and percentage of the various rock fractures and their relationship to the dam, river flow, and thus the probable water seepage directions.

For the purpose of making fracture analyses, a series of structural blocks was recognised either on the basis of their position between major joint openings, faults and flexures, or by virtue of their topographic position, as isolated river channel outcrops.

Within each structural block, two lines mutually at right angles were chosen. Along each of these measured lines every joint plane intersection was recorded as to direction, dip, tightness, and persistence. From these measured results a density per square yard could be calculated.

Eighteen different areas were analysed, in close proximity to the proposed dam wall or ancillary structures, and in all, 1,960 joints were recorded.

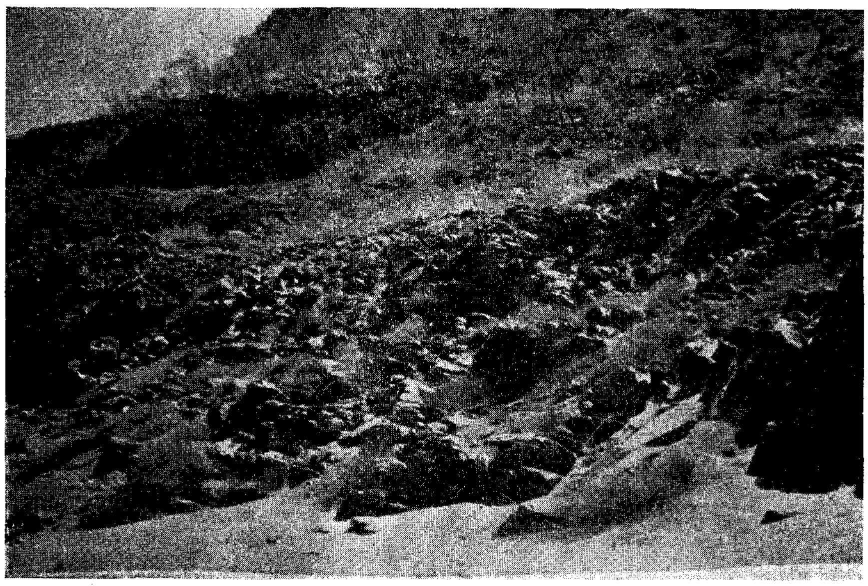


Fig. 2. Upper portion of east abutment showing block mosaic.

Overburden Conditions.

In the present river bed, unconsolidated sands, silts and small gravels lie on top of the quartzite floor to a maximum depth of 40 feet. As the quartzite crops out in the middle of the sand terraces, there are two channels, with the western one containing the 1962 winter river flow. The sands are saturated with water, ground water level being from 1 foot to 2 feet below the surface. About 100 yards above the dam site boulder beds with stones up to 1 foot 6 inches diameter, occur but except for material lying on the rock floor, only fine grained alluvials are apparent at the dam site. In view of their size, lack of consolidation and saturation, it is apparent that dewatering will have to be accomplished by the well-point method when excavation is made for the foundation of the dam. Flat angles to the batter slopes will also be essential.

On the western abutment no overburden as such is in evidence, except for the sandy terrace at the foot of the slope and a pile of rock rubble upstream of the lower adit.

The eastern abutment displays a series of nearly vertical sheet joints below rock terraces. These are formed on bedding planes and are broken by faulting. On the lower terraces especially, there are large quantities of sand. Above the highest terrace (Figure 3) thin bedded phyllitic quartzite occurs under a scree of rock rubble.

CHARACTER AND CONDITION OF FOUNDATION.

East Abutment.

The eastern abutment rises in a series of structural blocks or steps, separated by faults or big joints, with bedding joints forming the slightly inclined surfaces, and extensive near-vertical jointing breaking the whole rock mass into a mosaic of blocks with individual pieces generally about 9 inches by 9 inches. The rock exposed, as high as R.L. 240 on the centre line, is an open jointed ferruginous quartzite, and this is conformably overlain by thin bedded phyllitic quartzite to the crest at R.L. 300. Vertical displacement on faults both parallel and (mainly) at right angles to the river has affected the contact between the two rock types, and downstream of the centre line, the massive quartzite is stepped up as high as R.L. 270.

The composite joint rosette (Plate VI) shows the summation of the joint patterns for the abutment area. The structure is dominated by the bedding plane joints dipping from 14°E to 19°E away from the river and the high angle joints (dipping 45° to 80°), that dip into the river and strike between N50°W and N10°E. The other numerically prominent joint, trending N55°E, is nearly parallel to the centre line, thus at right angles to the direction of water pressure, and will be little used as a primary leakage path. The bedding-plane joint is favourably disposed as a leakage path, and the major bedding joints at 10 feet intervals will be especially prone to the entry of water under pressure. The situation of the tributary stream means increased opportunity for water entry.

One construction detail to which some consideration must be given is the production of a more or less smooth surface on which the core wall will be constructed. The accompanying photo. (Figure 2) indicates the nature of the irregular block mosaic, and with the bedding joint dipping in the wrong direction, blasting will be of limited value. A fair quantity of dental concrete would appear necessary, otherwise an irregular rock surface seems certain to be produced, and in order to obtain proper bond, wetter-than-optimum material, specially compacted with power tamping, may be necessary. All the steeper step faces will have to be cut down in order that the slopes do not exceed 1:1.

A considerable quantity of sand obscures the lower and upstream portion of the foundation rock and also fills many of the joint interstices. Much of this will be removed during the general trimming of the abutment, but the joints especially will have to be washed and/or blown clean.

As the bedrock quartzite is hard but badly broken and irregular, the making of an adequate bond will be exteremly difficult. For this reason a concrete cut off is considered essential.

The amount of rock to be removed from this abutment will be governed by the consideration of getting an evenly graded surface on which to lay the core wall and cut-off. This may mean an average cut of about 3 feet. Removal of about 2 feet down the abutment will be sufficient to clear off the widely opened surface joints, then the cut-off will need to be embedded a further 5 feet as there is no alteration in the condition of the joints down to about 20 feet, when the openings are largely filled. The average thickness of rock that will have to be removed will thus be of the order of 5 feet overall, plus 5 feet for the core wall.

Deeper stripping will be necessary in the phyllitic quartzite above R.L. 240, and a minimum of 7 feet of cutting with the core wall embedded a further 6 feet may be found necessary

River Bed.

Jetting has established the general shape of the rock surface in the river bed and this has been supplemented by two seismic profiles. The bedrock surface in detail will be irregular but rounded, something in the nature of a washboard profile. This will lead to difficulties in securing adequate compaction of the first layers of earthwork, as already noted for the east abutment.

Drillholes 4M and 24M show quite massive quartzite largely joint-free in the river bed, but the fact that they were drilled parallel to the strongest joint has to be considered. Lack of coverage in the deepest part of the river bed, 45 feet wide, means the foundation picture is not clear. (See later, Foundation Problems and Proposed Treatment).

There are two outcrops of quartzite within the main river channel, one midstream, in the vicinity of drillhole 24M and the other situated off the north tip of the west abutment. These were analysed for joint features but as the areal extent of each was small, they only provided a sample of the jointing in the rock at present obscured by alluvial deposits. A total of 140 joints was examined, and frequencies varied appreciably from five joints per square yard (in the river bed) to 37 joints per square yard (off the west abutment). The joint patterns obtained, however, are very similar to those showing in the west abutment, with a high proportion of sets striking north, roughly parallel to the river direction dipping about 45 degrees, with two other minor sets at N. 70° E. and N. 70° W. dipping both up and downstream at varying angles. The changes in joint significance from midstream to the east abutment is related largely to topographic situation.

From a construction point of view, the midstream outcrop which at the present site will fall beneath the main dam wall, is more important that the northern outcrop which is situated close to the downstream toe. Jointing in midstream will have a much greater significance after construction because, as with the west abutment, most of the joint sets trend in the general direction of river flow and water seepage. They dip both to the west and to the east at angles of 25°-60°.

In constructing an impervious core wall, it will be necessary to commence on a more or less level surface and this will mean that the existing outcrops will have to be removed; indeed all the numerous irregularities will need planing off.

Few joints run at right angles to the river banks and of these only a few dip upstream with the tendency to be closed by pressure from the impounded water. It is obvious from the examination of the jointing and the drillhole results that a comprehensive grouting programme will be required in the river channel section of the dam foundations.

West Abutment.

The western abutment consists of a thin slab of massive quartzite, lying on shaly phyllite dipping into the river and downstream.

A detailed examination has been made of the joints in the adits, and these results are shown on the joint rosettes (Plate IV). Furthermore, all the big joints or faults in the two openings have been recorded (Plate VII), and study of this data reveals two significant factors: (a) sheet joints, forming surfaces parallel to the ground surface, are of major importance as almost all reveal some evidence of movement (slicken), are usually partially clayfilled and appear to be continuous. Of these sheet joints, the most significant appears to be the surface at the phyllite-quartzite contact, because of the presence of clay minerals in a 10 ft broken zone and the discovery of free moisture in the lower adit. (b) The most abundant joint dips into the hillside and show fracture zones but rarely slickensiding. This joint persists over the whole site and appears to be part of a regional pattern, parallel to major fault movement.

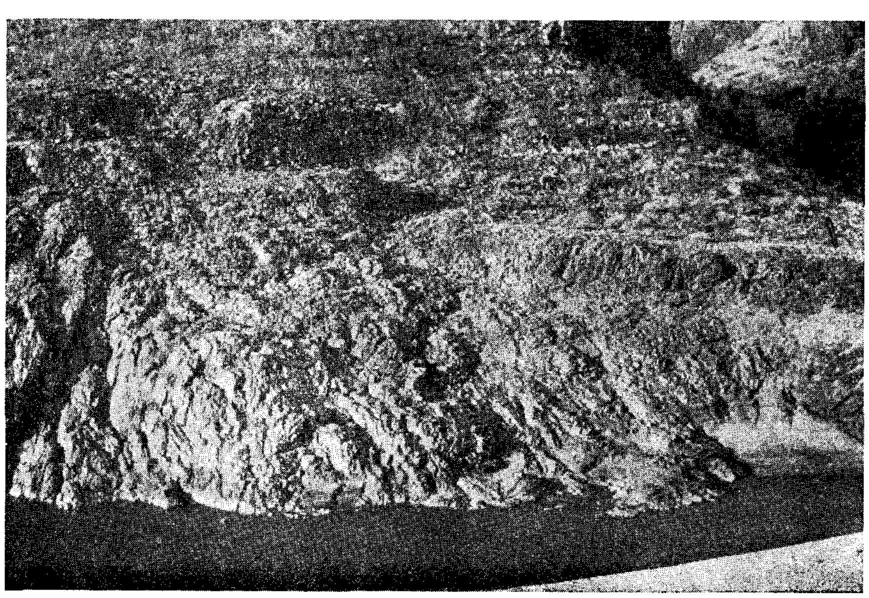


Fig. 3. East abutment showing topographic steps.

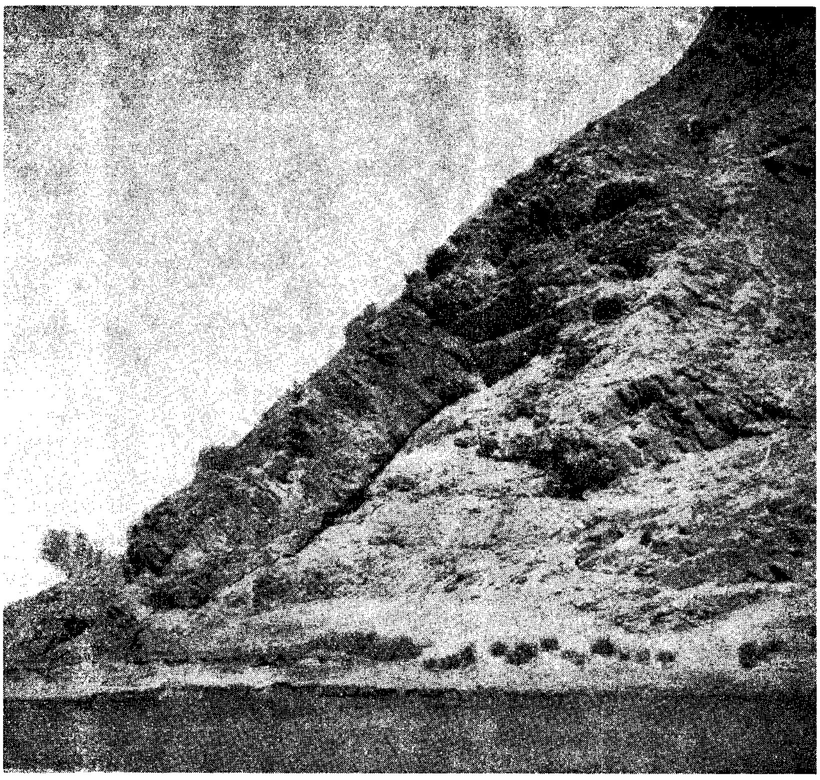


Fig. 4. West abutment showing sheet joints.

A composite joint rosette of the west abutment (Plate VIII) clearly indicates the major joint set striking N. 10° E.-N. 40° W., and dipping either into or away from the river at 30°-60°. The joint direction (when dipping into the abutment) is a shear direction which is usually brecciated and is controlled by both local and major faulting. The joint set that dips away from the abutment (sheet joints) shows slickensiding, and is probably a slip plane due to flexuring parallel to the bedding.

Both the major joint sets are weakness planes which will pose problems either along the quartzite/phyllite contact or within the phyllite, if allowed to become lubricated. Contrary to surface indications, these joints do not become completely water-tight at depths of at least 70 feet below the surface, as shown by seepages examined in the inspection adits. The topography of the abutment is largely defined by the sheet jointing, which has formed layers of rock largely parallel to the existing surface. Parts of some of these sheets have been removed largely due to the local incidence of big joints. However, this partial removal has left considerable overhang and a lot of this material will have to be removed down to a joint plane surface as the surviving sheet joints show openings as much as 2 feet wide. This will mean in effect the removal of a block of rock 10 feet thick by 100 feet high by 60 feet wide. The joint surface at 45° will be a reasonable surface on which to construct a core wall. Once this material has been removed, consideration will also have to be given as to the most effective method of pinning the relatively thin mantle of quartzite to the underlying phyllite. Most aspects of the contact between the two rock types show an apparently abrupt and plane surface. The fact that there is a gap at some contacts of as much as 12 inches, and the badly broken surface of the phyllite, suggest that overthrusting of the quartzite over the phyllite has taken place. However, a bedding thrust such as this could be equally as well explained for small movements by assuming the phyllite responded to compressive forces by folding, while the overlying rigid quartzite only arched slightly, giving separation and relative movement between the two rock types.

Apart from the joint contact, the physical condition of the phyllite revealed in the adits calls for some comment. The five feet of material exposed by the lower adit is profoundly disturbed, with clay in joints and layers of bedding planes, with the usual spacing about ⅛ inch, in places as close as 1/32 inch in deeply weathered and contorted zones. Comminution of the phyllite due to movement has produced clay layers, which may be expected throughout the entire abutment close to the contact, as the clay is undoubtedly an attrition product due to local movement.

In the upper adit the phyllite is occasionally interbedded with 2-3 inch bands of quartzite, but the material as a whole is in extremely poor condition due to local breakage.

LEAKAGE AND REMEDIAL TREATMENT.

To prevent leakage under the dam, only a comparatively thin curtain (if it is a good one) will be required. It can probably be obtained by using one line of drill holes or two lines close together, located near the upstream face of the dam.

The picture derived from the cores and drilling logs is not entirely consistent with the conditions as seen in the two adits, as there are open joints revealed in the boreholes, whereas many of the adit joints are filled with clay or ferruginous materials. However, the drillhole picture pertains to the river bed, where water movement in the joints has cleared them of any filling. In the abutment area where the adits are situated there has been no water pressure clearing the joints. The filling of the dam with water and the use of the adits as inspection galleries will almost certainly allow the gradual washing out of some of the joints into the tunnels. For this reason it is considered that the joints in this abutment should be washed out before grouting, furthermore the grout curtain should be situated 20-30 feet upstream of the centre line of the tunnels.

The cross section shown on Plate IX has been prepared from the drill logs and core photos., and it shows that the foundation area may be divided vertically into three zones: (a) zone of somewhat open joints and some rock breakage due to near surface weathering; (b) zone of partially filled and closed joints; (c) zone of largely massive rock with tight joints. The top two zones are generally about 20 feet thick, whilst the third zone extends down to the phyllite contact and ranges from 30 feet to over 100 feet in thickness. This would suggest that primary or low pressure grouting to a depth of 45 feet is needed. One row of holes may be considered sufficient, with the final hole spacing about 5 feet.

Optimum conditions for the injection of grout will be present when the grout holes are at right angles to the most prominent joint opening. The dominant joint over the dam site as a whole is the set striking N. 20° W. and dipping 55° S.W., but the division of the dam into structural elements with local dominant joints requires the situation of grout holes to be a little more complex. It is perhaps unfortunate that none of the exploratory drillholes was directed to the north, as pressure testing on a drillhole in this direction would have yielded more valuable data than was obtained from the southerly directed drillholes that were tested.

Phyllite Contact Grouting.

Critical conditions with regard to leakage exist at the phyllite-quartzite contact in the western abutment. About 4½ chains upstream from the centre line an eroded triangular notch about 50 feet wide at the base (Figure 5) may allow the pounded water to obtain access to the sheet jointing parallel to the rock face.

Apart from the immediate near-surface joint, the phyllite contact has the largest opening, as the drillholes show water loss and shattered cores from the area. The phyllite is noticeably affected by the breakages, which may be linked with step faulting, and in the lower adit free moisture was detected in two places in the broken material west of the quartzite contact. Most of the joint planes are partially filled with attrition debris in the form of clay, and the grouting operations will be complicated. It is considered that compressed air, then lengthy washing at a low pressure, followed by grouting at a low pressure would represent the best approach, as the use of high pressures would displace the myriad minor fragmentary blocks and close the fissures to grout, but possibly not to water percolating along the joint from another direction.

Some crude wetting and drying tests of the abutment phyllite showed a tendency for accelerated slaking, possibly due to swelling of the clay-filled joints and bedding planes. In fact, the picture presented by the presence of such decomposed and broken phyllite is disturbing, and the utmost efforts should be made to protect it from the effects of water entry. To this end, an additional grout curtain on the western abutment to intersect the sheet jointing, particularly near the entry or 'notch', is considered essential.

Fig. 5. West abutment showing "notch" area.

FOUNDATION PROBLEMS AND PROPOSED TREATMENT.

The diamond drilling programme has shown that most of the dam site is free of large structural defects that would require treatment. It must be pointed out, however, that a blind area, 45 feet wide, that has not been traversed by drilling, exists under the river bed. This could contain a geologic structure parallel to the major joint direction and in the deepest part of the river bed (Plate IX). In view of the probability of some structural control of the river's course to take it through the gorge areas, the existence of a fault must be considered. There is possibly displacement of the phyllite surface as picked up in the drillholes 7M and 19M and as intersected in 4M. Displacement in the opposite sense would be the case however between drillholes 20M and 24M, and these two apparent displacements may well be the result of flexure and rolling of the phyllite-quartzite contact. On the structure contour map (Plate X) this shows as a syncline, with the axis passing between drillholes 19M and 4M. Apart from this, movement on the fault could have been transcurrent, i.e. essentially horizontal shearing.

A faulted zone in this midstream position would be a probable leakage path, and a zone of weakness if loading pressures were high, as in the case of concrete gravity section, An earth dam, however, does not impose high unit loads, so except for the existence of a wide gouge or pug zone, not a great deal of remedial work would be necessary.

The entire foundation area, except for the eastern slope above drillhole 3M, will be underlain by largely similar massive quartzite, and the foundation problems will be mainly governed by local jointing in the various areas. These have been separately discussed in an earlier part of the report, but in dealing with the dam foundation as a whole, it may be recorded that the massive quartzite has excellent physical characteristics and no consolidation or remedial grouting will probably be necessary. The area where some work may be needed will be in the river bed area, and, until the rock surface has been exposed, no final decision is possible. It may be found that the joints in the river bed are open enough to warrant grouting in order to prevent minor consolidation on loading. A grout curtain to prevent leakage will of course be needed, and also a cut-off wall, but structurally there are few defects in the quartzite rock. The phyllite-quartzite contact is another matter, and merits detailed examination.

It is considered essential that the river alluvials should be removed to allow adequate emplacing of the earth dam, and a barrier upstream of the core wall will be necessary to stop water moving into the excavation. As the whole of the sand and gravel flats are saturated with water, it may be necessary to instal a well-point system to do this job.

The western abutment consists of a sheet of massive quartzite generally between 50 to 80 feet thick, with a minimum dimension of 30 feet, dipping downstream and into the river at angles ranging between 60° and 30°. The quartzite overlies strongly deformed phyllite, which appears on the surface about 150 feet downstream from the dam centre line, where the quartzite ends abruptly in a small cliff. The quartzite is strongly jointed but is remarkably coherent and stands well in the adits without any timbering. There are a few big joints and minor faults which divide the quartzite into blocks and the nature of these is shown on Figure 1. The phyllite, especially near the contact with the quartzite, is extremely broken, and the joints and even many of the bedding planes have a parting of clay minerals. With bedding parallel to the ground surface, i.e. striking parallel with the stream channel, and the entry of water assured either from ponding or from storm water, then the conditions appear optimum for the sliding of the quartzite cap under the downstream pressure exerted by a full reservoir.

The proposal to build an earth and rockfill type dam would be of decided assistance in lessening the tendency of the structure to slide, as the heavy weight of the earthfill dam provides a component efficiently opposing movement in the lower foundation areas. However, higher on the abutment this influence will be slighter, and remedial measures are essential in order to preserve stability and to provide an adequate factor of safety.

Every possible effort must be made in order to prevent water from entering the phyllite-quartzite contact zone in the west abutment. There should be two grout curtains in the abutment, and a further grout barrier some distance upstream to prevent entry of water from the eroded "notch".

The idea that sliding is possible at a point west of the contact in the broken phyllite, should be tested by shear tests in the laboratory, or preferably in the field. Samples of quartzite-phyllite, then one sample of phyllite may be pressed by a certain known load and the force required to induce sliding (with respect to the other half of the sample) can be measured, both under dry and under saturated conditions. It is possible to use a soil shear machine for this test, but a field test is preferred, using a block in which the required layers are exposed; the layers can be capped with concrete and loaded vertically, and then thrusts may be applied to the blocks with hydraulic jacks.

It would be most desirable to carry out the normal physical testing of block samples in order to get a more accurate assessment of rock strength. Special care would be necessary in securing the phyllite samples but by treating the sampling as a normal soil mechanics operation and sealing the blocks in wax after securing fresh material, reasonable specimens should be procurable.

The quartzite block liable to movement on the west abutment may have dimensions such as 60 feet thick by 150 feet wide by 200 feet long, and if the unit weight of quartzite is taken as 165 lb. per cubic foot then the block will weigh about 133,000 tons.

This block is sitting on partially-filled clay seams in the phyllite with the dip of the underlying surface at 27° in a downstream direction. As the frictional value or slip resistance for rock of this nature is between 15° and 25°, we may assume that the stability of the mass against sliding forces is low.

If the dam is 150 feet high, and assuming 1 cubic yard of quartzite gives 1.4 cubic yards of rock fill, with 0.1 cubic yards of void later filled with fines, then the pressure exerted on the foundation rock will be:—

$$150 \times 165 \times \frac{1}{1.3} = 19{,}100 \text{ pounds per square foot}$$
$$= 132 \text{ pounds per square inch}$$

If a factor of safety of 10 is used, as is usual in rock mechanics, then the quartzite is still not anywhere near its allowable compressive strength.

In addition to this, two other surfaces of breakage will be necessary in order to release the block, one parallel to the river and cutting through the quartzite, and another at right angles to the river and also reaching the phyllite or near to it. These requirements are available in the local joint sets, as detailed earlier in the report.

While grouting will be the major factor in preventing movement, a key wall may have to be constructed across the phyllite-quartzite contact, extending at least 20 feet into the phyllite and 5 feet into the quartzite, and running from near the crest to the river-bed foundation, i.e., about 250 feet long. Further adits may be necessary in order to secure access and ventilation during excavation of this slot and its filling with concrete. The undesirable property that the phyllite has of slaking and fragmenting on exposure to air means that every freshly excavated surface in the phyllite should be gunited or asphalted immediately on opening out, in order to prevent deterioration. An alternative would involve leaving the last foot of excavation until immediately before concreting.

The final decision as to whether a key wall is required may be deferred until the results of the shear and physical properties tests are known. Calculation would then enable the determination of the factor of danger—or safety.

UNDERGROUND STRUCTURES.

Introduction.

At the Ord River Main Damsite No. 2 the topographic situation has imposed severe limitations on the construction of a conventional outdoor power house. The proposal to place the facility underground involves the investigation of quite detailed properties of the rock material, as not only the load bearing potential but also the whole field of the mechanical behaviour of the rock mass has to be covered.

The important consideration in designing underground openings is the type and amount of support required during excavation; the next question is the type of permanent support that may be necessary.

The answers to these problems require a detailed study of the gross geological properties of the site as well as the microfeatures. The inherent strength of the individual rock fragments, the usable strength of the rock mass composed of interlocked blocks and the possibility of destructive or constructive reactions from residual stresses in the rock must all be considered.

The design proposal is for an intermediate type installation with the conduits both upstream and downstream of the power house of about the same length, with the whole system under pressure, without any surge tank. The layout is taken as shown on Plate III.

Intake.

The point of entry of the intake tunnel to the power house is in the tributary creek that joins the Ord on the eastern bank 200 feet upstream from the dam centre line. It is thus situated on the southern boundary of the east abutment, at the base of a steep cliff face with extensive deposits of scree material. The formation of this scree slope is the result of slip parallel to the bedding. The bedding at this point dips at various angles to the south-east as a result of strong local downwarping. There is a profound drop of the thin-bedded quartzites from where seen above the northern bank of the stream to their position under the alluviated cover below the northern bank. Seismic section line No. 8, made with the seismic timer, showed that the rock surface continued its cliff-like character downwards until a level surface was found at 60 feet below ground level.

The present proposal is that water will be admitted to the intake tower and will fall vertically before being conducted through a horizontal tunnel to the underground power house. Thus the entry channel is in effect a pressure shaft. However, the extremely poor foundations disclosed by drillhole 23M and the surface investigation make this layout rather difficult, if not impracticable.

Close to the shaft inlet, the rock type is a thin bedded phyllitic quartzite, which has formed the extensive scree slope against the southern edge of the abutment. The quartzite, which was exposed in situ in a drill platform cut into the side of the cliff, is interbedded with thin layers of phyllite, forming bands of quartzite which range in thickness from 2 inches to 14 inches.

The rock is comprehensively broken up by three main joints, and the fact that this breakage continues with depth is indicated by the nature of the core recovered from drillhole 23M, and this is shown effectively in the core photograph (Fig. 6).

Fig. 6. Core recovery from Bore 23M.

It would appear that weathering along phyllitic seams and a minor downhill movement resulting from settlement on such eroded partings has resulted in the initial fragmentation of the local rock.

Furthermore, the intercept of the massive quartzite at 43 feet in drillhole 23M is no guarantee of good foundation, as the small length penetrated to 50 feet depth, was not adequate to allay fears that the quartzite also had been locally affected by extensive breakage.

There is no doubt that the rock could be vastly improved by an extended grouting programme involving washing and low pressure grout injection before shaft sinking commenced. Even so, the formation of a consolidated sector in an area of such extensive breakage would involve wide extension of grout treatment in an endeavour to tie the plug round the shaft to more solid material away from the cliff area. The shaft lining would have to be at a maximum.

In view of these problems it is undoubtedly preferable to move the inlet further up the tributary creek in a north-easterly direction for a distance of at least 100 feet. This would allow its emplacement in what appears to be much more quartzitic and massive material, apparently unbroken by local movement. This site would be on the western limit of anticlinal folding (Wyatt 1961, Fig. 12), and the incidence of the local fractures is shown in the joint diagram (Plate V). There will be a tendency for water to enter the shaft, and this can be better evaluated by the drilling of a diamond drill hole at the proposed location. Emphasis will of course be on core recovery, and particular attention should be focussed on the nature of the joints and their fillings, if any.

A further point must be emphasised, and that is the presence of large blocks of rock in positions of potential rock-fall near the top of the hill, immediately above the intake and its associated structures. For example, immediately above the inlet, massive quartzite layers up to 20 feet thick are interbedded with phyllitic layers. Some of the thin phyllite bands show evidence of movement with the formation of clay minerals. Furthermore, weathering and jointing has produced on the outer face of the slope, a series of quartzite blocks, some as large as 20 feet by 20 feet by 20 feet and thus weighing up to 60 tons. These blocks are lying on bedding planes dipping downhill at about 16° (Plate V), right at the critical angle for instability under saturated conditions.

Further to the northeast above the above proposed inlet, the bedding planes dip downhill at about 12°, so conditions are not so critical.

Whatever inlet position is selected, it would be necessary to remove the uphill blocks before any excavation or construction work commences.

Inlet Pressure Tunnel.

A longitudinal section drawn along the centre line of the proposed inlet tunnel (Plate XI) shows that two major problems, imposed by local geology will have to be considered.

Rock Breakage.—Firstly the large amount of broken phyllitic quartzite with highly-weathered in situ rock beneath, that will be encountered in the initial entry, will present some difficulty to tunnelling operations in that close setting and lining will be necessary. This area will have to be fully lined and reinforced for completion, and the rock will also have to be improved by grouting in order to meet the imposed stresses, as the joints are quite open and in some instances filled with soil and rock debris. Grouting will initially have to be conducted from the surface, but the steep cliff section will preclude long holes. The whole grouting operation is likely to be drawn out due to the need for careful washing-out of the joints, and the use of low pressure grout injection, necessarily done in several stages. These broken rock conditions may be expected to persist for as much as 50 feet from the portal.

As the breakage is largely in the phyllitic quartzite, conditions will improve greatly in the massive quartzite that will be encountered further into the hillside. As the bedding appears to dip quite flatly towards the portal, the tendency in the phyllitic quartzite and initially in the massive quartzite will be for long wedges of rock to fall into the tunnel. This can be countered by pattern rock bolting, preferably at right angles to the bedding. As a cover of 10 feet of massive quartzite may be considered necessary before reduction of bolting frequency, then bolts up to 12 feet long will be necessary.

Rock bolting will be a significant feature of safety measures in the massive material, as it will be used for securing blocks and broken areas.

Faulting.—The second major feature of the tunnel is that it will intersect at least five faults, almost at right angles to the tunnel direction. On the surface the faults are quite conspicuous and dip from 75 degrees to 85 degrees to the north (Plate II). They show as 6 inch zones of minor breakage and slickensiding with openings of up to $1\frac{1}{2}$ inches. Vertical displacements do not appear large, the observed maximum being 4 feet, and in all cases the south side is down. As shown on the section (Plate XI) the faults cover a zone 200 feet wide, first intersecting the tunnel about 120 feet from the portal and extending to half-way across the machine hall. At depth the fault zones may be filled with quartz fragments and ferruginous material, but they constitute significant waterways that will have to be sealed off. Drillhole 5M passed through most of these faults and heavy breakages of the core at 18½-21 feet, 30½-31½ feet, 33-34½ feet and 76-77 feet, as well as water losses at 2 feet and 33 feet indicate that the zone of shattering is relatively small. However, it may be desirable to reinforce these areas.

The tunnel in its original position may also be intersected near the power house by a strong fault that shows at the eastern end of the spillway as a brecciated zone about 20 feet wide. No surface indications are available of any continuation of this feature into the hill containing the underground structures but there is ample room for it to pass between vertical drillholes 18M and 23M. If present, this fault zone will require considerable attention with reinforcement and grouting necessary.

The faults may have had a beneficial effect also, in that they represent release of stress, and it is unusual to have high residual stresses in broken or faulted areas.

Jointing and Bedding.—The bedding of the quartzite appears to steepen in dip from about 5 degrees at the portal to about 23 degrees at the power station. This is probably due to movement on the faults. This means in effect that the tunnel will be driven largely "face on" to the grain, and overbreak in the crown will tend to be moderate. The joint distribution, shown on the rosette (Plate V), is also good as only a minor joint direction is parallel to the tunnel direction. If we take into account the joint distribution and the moderate bedding dip, then pressures will tend to be fairly uniform, and a two-dimensional stress distribution may be assumed. The actual load on the crown will vary between zero and 0.25B where B is the width. Thus for a 12 foot wide tunnel the maximum rock load would be 0.25 x 12 x 165 = 495 pounds per square foot.

The unknown factor is the residual stress in the rock and its direction, and this can only be determined by in situ measurements. However, in view of the surface topography it would not be surprising if there were a high vertical compression, and two nearly-equivalent horizontal stresses, somewhat greater than the vertical stress.

As mentioned in the section on the intake structure, a reasonable alternative would involve a shift up the tributary creek of 100 feet. The tunnel would then start in solid rock, and only a little reinforcing would be required. The length of the tunnel would be greater if the power house remained in its proposed position, but as it would be beneficial to move the power house in order to place it in homogeneous rock, then the length of the tunnel would not be greatly altered.

A horizontal diamond drill hole along the tunnel line finally adopted or a pilot or exploratory tunnel to the power house, later to be enlarged to full size, would have the two-fold object of enabling the power house rock to be physically tested, and the leakage paths into the tunnel to be determined.

Power House and Transformer Halls.—Projection of the contact between quartzite and phyllitic quartzite indicates that the south-eastern top corner of the power house will be in phyllitic quartzite, with the strike almost at right angles to the length of the hall and the dip towards the intake at 23°. Within the massive quartzite itself, there is also a physical boundary between jointed, iron-stained quartzite and less jointed unstained material, and this surface is nearly parallel to the long side of the power station, and dips towards the Ord River at about 30°. However, its position with regard to the power house excavation precludes shifting the opening to a site exclusively in better material. The optimum position with regard to rock type and openings involves a northerly shift of about 70 feet. This would also clear the excavation from the influence of the phyllitic material.

The effect would be to place the power house excavation by its own width further into the hillside. This would involve alteration of the position of the inlet tunnel further up the tributary creek, a situation which is also desirable from the viewpoint of foundations of the tower and initial entry of the tunnel.

The site of the underground power house has been traversed by two inclined diamond drillholes (5M and 15M). These covered a block of rock at machine hall level measuring 65 feet by 125 feet out of design dimensions of 70 feet by 160 feet. As was found at the Snowy Mountains Tumut (T1) Power Station site, the cores from the inclined diamond drillholes are of very limited value for determining the pattern of joints and faults; these features are better determined from an exploratory tunnel and from surface exposures. The rocks exposed immediately above the proposed power house are thin bedded phyllite quartzites, and their jointing pattern is not the same as the underlying massive quartzites. Data taken from the nearest exposure of massive quartzite indicate that the dominant joints—

	Per Cent.
340° at 19°E away from the river (bedding)	19
335° at 77°W towards the river	33
190° at 80° towards the river	33

are largely at right angles to the length of the excavation, which is N. 70°E. This particular joint pattern is excellent from the viewpoint of orientation of the excavation, but some minor problem will arise with roof control because of the 19°-23° bedding joints. The solution will involve the use of roof bolts placed at right angles to the bedding planes. As the bedding frequency is 1 every 2 feet, then bolts longer than 2 feet would be necessary, and in view of the different drilling conditions, an optimum length of 10 feet is suggested. The frequency of the two sets of near vertical joints averages 3 feet. This indicates that a reasonably close spacing of the bolts will be necessary, and the ratio of length to spacing will have to be 2 or greater. Thus the bolts will have to be about 3 feet apart. For the bolts to be most effective it is desirable that they be installed as early as possible in order to control initial movements. It is also essential to commence bolting on a predetermined pattern, and to adhere to that pattern in order to avoid stress concentrations. Within the limits of the pattern it should be possible however to place each individual bolt in a position of maximum efficiency, i.e., it would be wrong to place a bolt to secure a thin sliver of rock when a 1 foot shift could secure a much thicker section.

As it is proposed that the majority of the bolts are to be at right angles to the bedding, it will be necessary to use angled washers (20°) to secure the nut to the bolt. To ensure permanency the bolts should be grouted after tensioning. Furthermore, when the roof excavation has been completed, the entire roof can be covered with wire mesh, attached to the bolts. As the stress pattern round the excavation will change markedly during excavation, it seems reasonable to defer the construction of the permanent roof support until the excavation has reached an advanced stage. This means that the permanent support will be more closely integrated with the rock than would be the case if supports were installed immediately on excavation of the roof slice. The rock walls as they are exposed may also be bolted, also in patterns, but a much wider spacing will be feasible, say 6 feet. In all cases the bolts may be stressed to a nominal load of 20,000 lb. tension, using 1 inch nominal diameter mild steel bars.

It is not possible to determine the type of permanent support for the power house and transformer hall roofs without some knowledge of the residual rock stresses. These can only be determined by in situ measurements, and consideration must be given to the driving of an exploratory tunnel to the power house area to enable the tests to be carried out. As several openings will have to be carried to the underground station—inlet and tailrace tunnels, access tunnels, cable tunnel, and lift shaft—it should be possible to utilise the exploratory opening for later use. In any case, some investigation of the proposed new position of the power house is desirable, as well as some knowledge of the transformer hall area. These objects could be achieved by means of diamond drilling from the exploratory tunnel.

Tailrace Tunnel.

The tunnel has been investigated by one inclined drillhole (12M) and the most important features revealed were the softer sandstone lenses about 1 foot thick that occurred every 10 feet or so, and the marked absence of joints, due to the fact that the drillhole was inclined nearly parallel to the most important set (335° at 77°W towards the river). Within the tunnel limits there are two sandstone lenses and a small broken area, but the quartzite on the whole appears quite massive.

The joint pattern for the area, as shown on the structure plan (Plate V), is favourably disposed to the tunnel alignment, and roof control should be easily achieved except in the area around the tunnel outlet. There is pronounced sheet jointing near the outlet, with at least one fault, striking along the tunnel length. This means that a full grouting programme will be necessary, and that some little trouble will be experienced on initial opening. Full concrete lining with reinforcing will be necessary at the outlet portal and from the draft tubes through the branch tunnels into the tailwater tunnel, elsewhere only concrete lining may be necessary.

INVESTIGATION OF NORTHERN SPILLWAY.

Seismic Timer Traverses.

An R117 seismic timer manufactured by Dynametric, Inc. was supplied by the Public Works Department for the investigation of the north-east spillway area. Four drillholes had already been completed in this area at the end of the 1961 season, and conflicting results made additional investigations desirable.

The first traverse passed along the line of drillholes 16M, 17M, and 27M. The resulting time travel graphs were all clear cut, indicating a thin cover of unconsolidated rock rubble overlying either a high velocity material which became more compact at depth (signified by the gradually increasing velocity curve), or a constant velocity material which contained high velocity layers. Either description would fit the thin bedded phyllitic quartzite as intersected in drillhole 9M.

The longest traverse ran in an east-west direction up the centre of the spillway through drillhole 9M. The velocity curves obtained were similar to those already recorded for the first traverse, that is, a low velocity cover of unconsolidated material overlying a denser, higher-velocity material.

The other two traverses were equally spaced and at right angles to the main line, and gave similar results. However, in some instances they showed very high velocities, probably due to the presence of massive quartzite, and these were recorded at the south end of each traverse. This agrees with the surface mapping which shows a massive quartzite bed underlying the thin bedded quartzite which dips flatly to the north and occupies the bulk of the spillway area.

Of the four drillholes on the intake side of the spillway, 16M, 17M and 27M indicated a sandy material commencing at various depths ranging from 2 feet to 30 feet. Seismic work in the vicinity of these holes gave no indication of sand zones, apart from the near-surface unconsolidated rubble and debris of drillhole 27M, which showed as a zone 12½ feet thick in the seismic traverse. The presence of the "sand" may be explained for the other holes in geological terms. Three possibilities may be mentioned:—

(i) The sand may exist as a bed of low velocity beneath a quartzite of higher velocity and would not be picked up by the timer.

(ii) The sand could exist as a sandy phyllite bed, interbedded with the thin layered quartzite. However, diamond drill evidence is that any phyllite lens would be of a minor nature and not as thick as the 28 feet apparently shown in drillhole 27M.

(iii) The sand could exist as an infilling in a joint or a fractured zone, intersected by the drillhole.

In view of the seismic results (coupled with surface mapping) it is most probable that drillhole 16M intersected a thin phyllite bed not more than 10 feet in thickness. Drillhole 27M most probably intersected broken phyllite in a faulted zone or sandy material filling a joint, and drillhole 17M may have done the same, although the material in this case is more likely to be drainage channel debris.

The occurrence of several phyllite outcrops amongst the quartzite scree material along the northern side of the spillway indicates that phyllite occurs beneath the quartzite rubble and boulders which litter the slope. This is most likely, as abundant phyllite also occurs on the outlet section of the spillway. In any case it is almost certain that spillway excavation will be mostly in thin bedded phyllitic quartzite containing layers of phyllite and quartzite of different thicknesses. This cut material should be rippable most of the way, especially that portion of the spillway in the vicinity of drillhole 9M.

It should be noted that the three other traverses, B-C, D-E, and E-F, all showed a few feet of rubble over phyllitic quartzite, which had a velocity range of 2,500-10,000 fps. A large percentage of the velocities do fall in the 2,000-4,000 fps range which indicates a thin bedded phyllitic quartzite, but the occasional high velocities of 8,000-10,000 fps are no doubt due to massive quartzite outcrops up to a few feet thick. These can be expected to be interbedded with the thin bedded quartzite and will no doubt require explosives for their excavation.

Therefore, from the seismic results obtained on the north-east spillway it is likely that the whole of the spillway, as investigated by the traverses, will be rippable, with explosives being necessary only where occasional thicker quartzite beds, probably on the southern side of the spillway, are encountered.

Geological Setting.

The spillway structure envisaged with a rockfill dam consists of a large open cut through a topographic saddle approximately 1,200 feet downstream from the dam on the right hand or eastern bank. In considering a spillway with a gated crest and unlined chute with no training walls, the direction of the spillway with respect to the bedding and major joint sets becomes of prime importance. The present proposal places the spillway largely along the easterly strike of thin bedded phyllitic quartzites which dip to the north between 10 degrees and 25 degrees. This means that the softer phyllitic beds will immediately erode with respect to the quartzite or harder bands, and the profound grooving thus initiated will seriously affect any hydraulic design, especially if the beds do not strike entirely along the excavation, an almost certain situation. It would thus appear essential to have a concrete chute.

The stability of the spillway walls will be determined by the positional relationship of the spillway to the joints and bedding and by the extent of weathering, past and future, in the phyllitic quartzite. The more prominent joints appear to be (1) N. 80° E. dipping 60°-80° and (2) N. 20° W. dipping 90°-80°, but these do not appear to present any great problems provided the batter slope is no steeper than 60 degrees. However, at least 30 feet of the section on top of the slope should be 1 : 1. The bedding striking along the excavation will dip into the cut at about 20 degrees on the southern slope. This is a situation which is fraught with difficulties as the interbedded massive and platy quartzite is thus in a favourable situation for sliding. This trend may be further aggravated if there is a tendency for the phyllitic material to slake on exposure, and the annual removal of surface detritus by floods would lead to wholesale deterioration. The slaking characteristic could no doubt be arrested by coating the exposed walls of the cut with gunite, immediately on opening out, but such a gunite skin would not survive the passage of flood waters. Thus to effectively deal with this problem, immediate coverage followed by the erection of a training wall will be necessary. This does not add to the overall slope stability however, and it will be necessary to provide some method of control to insure safety. The most economical solution is the use of rock bolts, set at right angles to the bedding to effectively bind the rock layers together. Hollow mild steel bars, of maximum length (say 30 feet) may be employed, to be grouted up immediately on tensioning. The recesses cut to receive the bearing plate should be brought up to the original slope surface, with concrete if below maximum flood height, in order to preserve uniform flow conditions.

The eroding potential of a flood discharge through the spillway is liable to be great in the existing channel area. The tendency will be for the eroding area to work downstream, as the beds dip in that direction. However, it is expected that the fissile phyllite beds, in particular, will erode quickly allowing the quartzite to be "plucked" or quarried. High water velocities likely to occur near the intake are also liable to cause damage due to the heterogeneous nature of the foundation rock and its differential erodibility.

As it is proposed to have a gated crest, it is essential to explore the foundation area thoroughly for the competency of the bearing materials as any differential settlement will cause the gates to jam and thus put the spillway out of service. In this connection the wide shear zone (N. 15° W., dipping at 75 degrees to the west) that shows on the southern edge of the spillway near the saddle (Plate II) is of particular interest. Drillhole 9M which was drilled largely to test the rock as a source of concrete aggregate, shows sandy ferruginous phyllite alternating with ferruginous quartzite which confirms surface indications. Two inclined holes, crossing symmetrically and drilled on the crest line, would be necessary for a full appraisal of this foundation.

It is considered that most of the material derived from the spillway excavation will be unsuitable for use as rockfill as thin slabs only are liable to be produced and these are further liable to breakdown on handling and placing. Furthermore, the suspected tendency of the phyllite to slake would render a further decrease in size suitability. Some of the massive quartzite bands encountered could be used but on the evidence available they would not account for more than 10 per cent. of the total rock section.

RESERVOIR AREA.

Examination of the reservoir area shows that the most likely path for leakage would be through the narrow phyllite ridge with occasional quartzite cappings that runs mainly parallel to the Ord, and forms the western bank, from the No. 2 damsite upstream to the No. 1 site. The most critical situation occurs about ½ mile upstream from the No. 2 site where sheet jointing resulting from folding in the quartzite has meant the presentation of continuous vertical joints to the reservoir side, and thus through the ridge to the adjacent stream valley. As shown on Fig. 7, joints spaced about 1 foot apart occur over a distance of 30 yards and some openings are as wide as 1 foot 6 inches with the average size of about 2 inches at the surface.

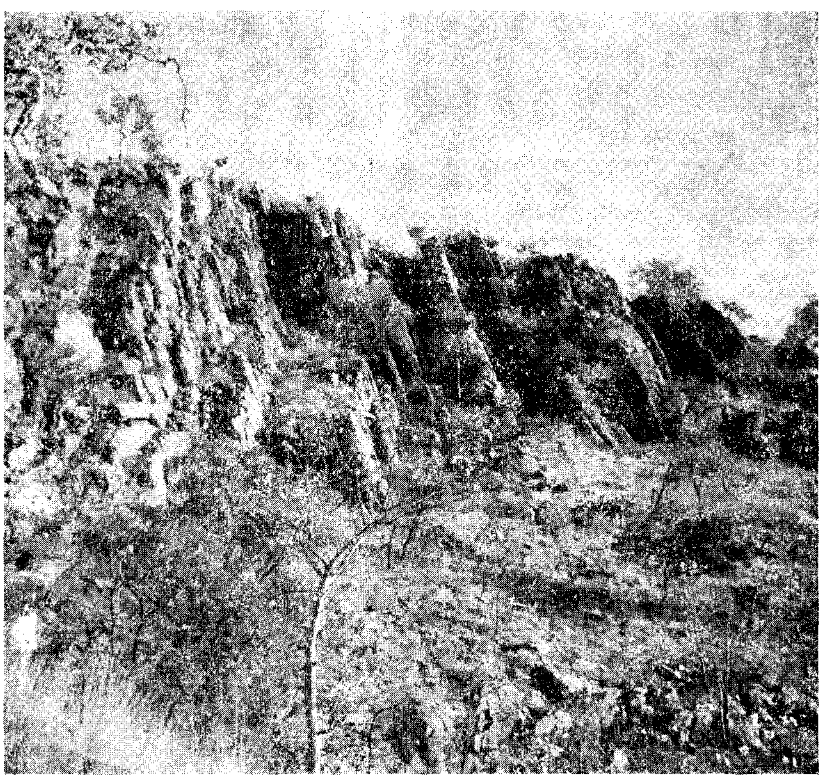


Fig. 7. Sheet jointing in quartzite, west bank.

This structure in massive quartzite is favourable to the leakage of water and is underlain by thin bedded phyllite, which offers a percolation but not a leakage path to water. Thus the height of the reservoir will determine whether leakage will take place or not, and in the absence of adjacent levels, estimation by eye suggests that the water level will not be high enough to allow entry to the structure. Reservoir level should be established in this vicinity, as the jointed sheets would readily break into good-sized blocks and prove a useful source of dimension stone if free to be used. If reservoir level does in fact reach the jointed area, then a small grout curtain will be needed with the holes angled from the ridge crest to intersect the joints at as flat an angle as possible.

Another part of this phyllite ridge which must be considered is the area of the proposed Southern Spillway, this being the thinnest part of the ridge. Most of the relevant data is shown on the cross section for drillhole 11M (Wyatt, 1960). The rock, a highly folded phyllite, is extremely broken due to surface weathering for the top 40 feet, i.e., to R.L. 336, and is oxidised for 100 feet to R.L. 270.

With the top of the dam at R.L. 300, only the bottom 50 feet of this hole need to be considered. The weight of the water will tend to close the bedding planes (dipping 85° to 45° into the Ord), while the cleavage planes (dipping 60° away from the river), although unfavourably situated, are of such sporadic appearance that they do not constitute potential leakage paths. Horizontal vuggy and broken layers occur between R.Ls. 286 and 290, and there was a 100 per cent. water loss at R.L. 297; but the phyllite generally is in good condition, and this, combined with the fact that the leakage path will be at least 500 feet long, indicates that no serious leakage will occur and that no grouting treatment will be necessary.

EARTHQUAKE RISK.

There are no instrumental recordings of major earthquakes originating in the Kimberley Division. Indeed there are very few references to tremors felt in the area, and this is not surprising when the small and scattered nature of the population is considered, allied with the lack of local recording media such as newspapers. There is no doubt that the number of tremors *felt* will increase greatly with the establishment of a permanent townsite and the installation of a seismograph at Kununurra.

As earthquakes are the result of earth movement, for shallow earthquakes usually occur on faults, the determination of recently active faults would show the presence of intermittent local earthquake activity. Careful search of the air photos covering the immediate vicinity of the Ord damsite failed to reveal any fault that could be classed as *recently* active. Three local shocks of intensity IV, recorded by Mr. J. D. Wyatt (pers. com.) in 1960, were undoubtedly situated on minor features, and the energy released was quite small.

Experience with isoseismic patterns in New Zealand and California has shown, for structures founded on the same type of material, that an earthquake of MM intensity IX at the epicentral region is still destructive (MM VIII) for a distance of about 50 miles, and semi-destructive (MM VII) to 100 miles. This means that for a structure to be endangered by an earthquake it must be within 100 miles of the epicentre of a major earthquake. This distance is modified by the fault direction and according to the type of material the structure is founded on, i.e., earthquake destruction is less effective on hard rock than on soft, and is worse on loose unconsolidated ground, especially if the loose deposits are relatively thin, say 100 feet or less.

Minor earthquakes occur almost anywhere as practically all seismological stations have recorded some earthquakes in their immediate vicinity. It is expected that minor local earthquakes will be recorded at the Kununurra station. As far as major earthquakes occurring on known faults are concerned, the Ord region must be considered aseismic. It is not thought that any special design precautions are warranted on the evidence thus far available.

SOURCES OF AGGREGATE.

Cement-Aggregate Reaction.

Deleterious cement-aggregate reaction occurs between soluble silica in aggregate and the alkali-hydroxides derived from Portland cement, and produces abnormal expansion and cracking of mortar and concrete. The definitely established reactive constituents of natural aggregates are opal, acid and intermediate volcanic glass, cristobalite, tridymite and chalcedony. All these minerals can be described as highly siliceous materials which are thermodynamically metastable at ordinary temperatures, i.e., silica not tied up in a crystalline structure that is stable under normal ambient conditions. All the known reactive aggregate constituents except cristobalite and tridymite may occur either as individual pieces in aggregates or as constituents of rocks in aggregates.

In addition to these reactive silica-minerals, certain phyllites are known to have caused deterioration of concretes through cement aggregate reaction, with hydromica as the possibly reactive component. The Tennessee Valley Authority now considers that phyllite is deleterious in aggregate for concrete (Technical Report No. 12) as does the U.S. Bureau of Reclamation (Concrete Manual, 6th Ed.). Aggregates containing more than 0.25 per cent. by weight of opal or more than 5 per cent. by weight of chalcedony are noted as causing deleterious reactions. Further, the maximum expansion tends to increase as the particle size of the reactive material decreases for sizes down to the No. 200 to No. 325 fraction.

Examination of the gravels in the Ord River immediately above the damsite has revealed the presence of pebbles of numerous varieties of chalcedonic silica. Sard, prase, agate, opal-jasper chalcedony, chalcedonic chert and jasper are conspicuous, with the minerals varying in size from sand grains to 6 inches diameter geodes of agate. There appears to be a concentration in the smaller sizes, with the $\frac{3}{8}$-$\frac{3}{4}$ inch range heavily charged. These silica minerals were almost certainly derived from the Antrim Plateau basalts and the Tertiary limestones drained by the Ord River. A noteworthy occurrence is the large deposit of jasper resting directly on basalt a few miles below the junction of the Ord and Negri Rivers.

The intention to use aggregate from the extensive gravel deposits 4½ miles downstream from the damsite should be critically examined in view of the probable contamination by deleterious minerals, both in the form of the quartz minerals and in locally derived phyllite.

There are three methods of avoiding the dangers of deleterious cement-aggregate reaction, (1) a specification limit can be put on the alkali content of any cement used, (2) the second approach is to avoid reactive aggregate by recognizing it and using an alternative source of non-reactive aggregate economically available, (3) part of the cement may be replaced with a very finely ground reactive material—a pozzolan.

The answer to the problem will of course be based on economic considerations. However, in view of the probability of an earth and rock-fill dam type being preferred to a concrete gravity type, much less aggregate will be required, and the expense of washing and hauling aggregate-stone from the downriver deposit may not be justified. Thus the setting up of a small quarry and crusher close to the site on a massive quartzite outcrop would neatly avoid the reaction problem and probably be economically attractive. However, if the river gravels are used, detailed petrological examination and analysis (A.S.T.M. C295) on truly representative samples, along with the commencement of long term concrete tests (at least over two years) appear to be of immediate importance.

Pozzolan.

An examination of published geology of the Kimberleys revealed only one definite reference to a possible pozzolan (Traves, 1955). This concerned an altered rhyolitic tuff, found on the track from Springvale Station to Bedford Downs Station about 4½ miles from Springvale. The outcrops were examined and samples of three different varieties were submitted to the Petrologist of the Geological Survey (Dr. A. F. Trendall) for examination. His report indicated that the tuff was welded and highly deformed, and consequently the grindability would be quite high. Examination of the rock shows that the induration imposed during alteration has developed a very hard compact rock type, so that fine grinding would be a very expensive process and thus the use of this material is probably precluded.

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS.

Conclusions.

An earth and rockfill type dam is preferred to a concrete gravity section due to an increased factor of safety against sliding in the western abutment. However, the fact that potential borrow material from the spillway area is largely not suitable as rockfill, and the need for lining the spillway means that there will be no great difference in the cost of the two types of structure.

Due to the presence of clay filled joints, mainly parallel to the downstream pressure of a filled reservoir, the possibility of sliding in the western abutment must be considered high, especially at the phyllite-quartzite contact. Means of reducing this propensity are—

(1) the construction of an earthfill dam;

(2) pivoting the dam axis so that an obtuse angle is made with the western abutment;

(3) the grouting of areas where water has access to sheet jointing;

(4) provision of a double grout curtain in the west abutment;

(5) the possible construction of a key wall.

Further physical tests on the rock will assist in elucidating this problem.

Slight uncertainty exists as to foundation conditions due to incomplete drilling coverage across the river bed. As the joints in this area have been washed clean, some consolidation may be achieved on loading, but this can only be assessed by exposure of bed rock in the river course. Of the three rock types constituting the foundation materials, the quartzite is extensively broken by joints, and in particular the contact with the underlying phyllite is a zone of heavy breakage. A grouting programme for the prevention of leakage should be at least 40 feet deep and should be designed to be largely directed at right angles to the dominant joint planes.

The underground installations as tentatively designed are not in harmony with the rock environment and other layouts can be considered. Further exploration and especially rock testing from a heading is considered essential.

The protection of the northern spillway against scour-grooving and slope failure will mean the provision of a concrete chute, gunited batters, the erection of a training wall on the southern side, rock bolting and suitably designed slopes. The provision of a gated crest will involve further drilling exploration.

All historical and instrumental records so far available indicate that the Ord District is practically aseismic. Installation of a seismograph at Kununurra will doubtless reveal numerous local earthquakes but large tremors are unlikely, and special design precautions are not warranted on the evidence available.

Recommendations.

The following recommendations for future work are made:—

(1) The drilling of a diamond drill hole from the lower adit entrance at a bearing of 260 degrees and angle of depression 45 degrees east, with a probable length of 190 feet. This is desirable especially if a concrete gravity dam-type is adopted.

(2) The drilling of two drill holes at the crest of the proposed spillway, with a probable length of about 200 feet each.

(3) Some test shooting in the proposed aggregate quarries.

(4) Petrological examination of a representative sample of aggregate gravel from the Ord River.

(5) An exploratory tunnel or shaft to be driven to the site of the underground power station and this to become part of the permanent installation. Measurements of modulus of elasticity, residual stress (preferably by the flat-jack method), groundwater level and physical determinations of joints and rocks should be made. Roof bolting and pulling tests would also be of value.

(6) The possibility of sliding in the western abutment should be investigated by physical tests of phyllite and quartzite in the adits, including field jacking tests to determine the forces necessary to induce sliding. Definition of properties such as specific gravity, water absorption, compressive and shear strengths, modulus of elasticity and wetting and drying properties should also be undertaken.

(7) Consideration should be given to a new layout of underground installations with regard to the new knowledge of the gross geologic features such as faulting and jointing, presented in this report.

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THE AVON VALLEY DEVIATION, W.A.G.R. STANDARD GAUGE RAILWAY, SOUTH-WEST DIVISION.

By F. R. Gordon.

INTRODUCTION.

This report concerns certain selected topics from a large compilation of data detailing the engineering geology of the route of the proposed standard gauge railway between Midland Junction and Northam, in particular in the gorges and river valleys of the Swan-Avon River system. The work was done for the purpose of assisting the detailed site drilling and investigation, and was intended to supplement, not to supersede, that examination. However, the drilling results posed nearly as many problems as they solved, and their rationalisation was largely dependent on geological advice.

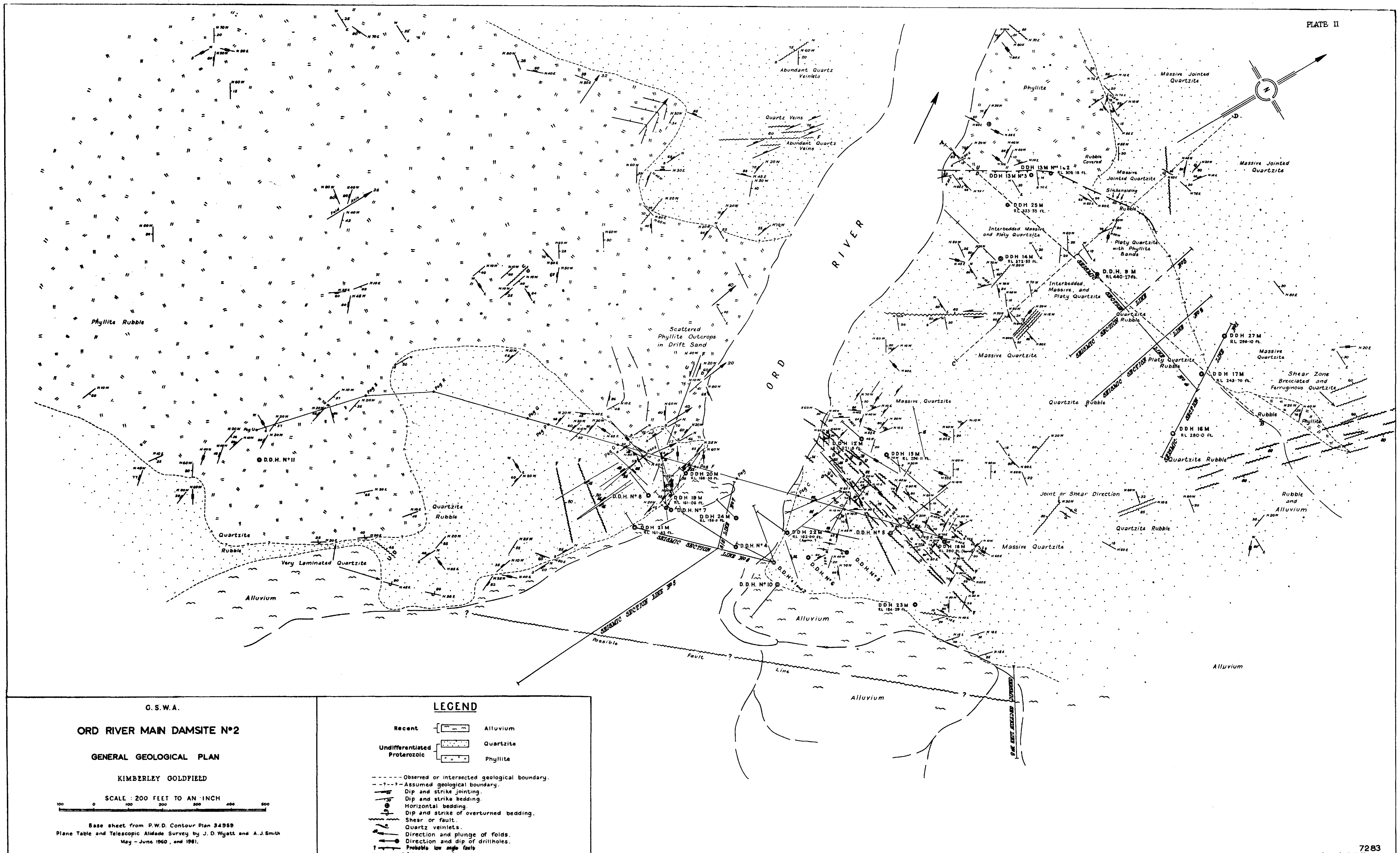
The engineering works were let as a series of three contracts, in chronological order:—

Contract 1: 15m. 40c to 29m.00c. (North of Midland Junction to 2 miles up the Swan Gorge).

Contract 2: 52m. 20c. to 71m.00c. (West Toodyay to Northam).

Contract 3: 29m.00c. to 52m.20c. (The Swan-Avon Valley to West Toodyay).

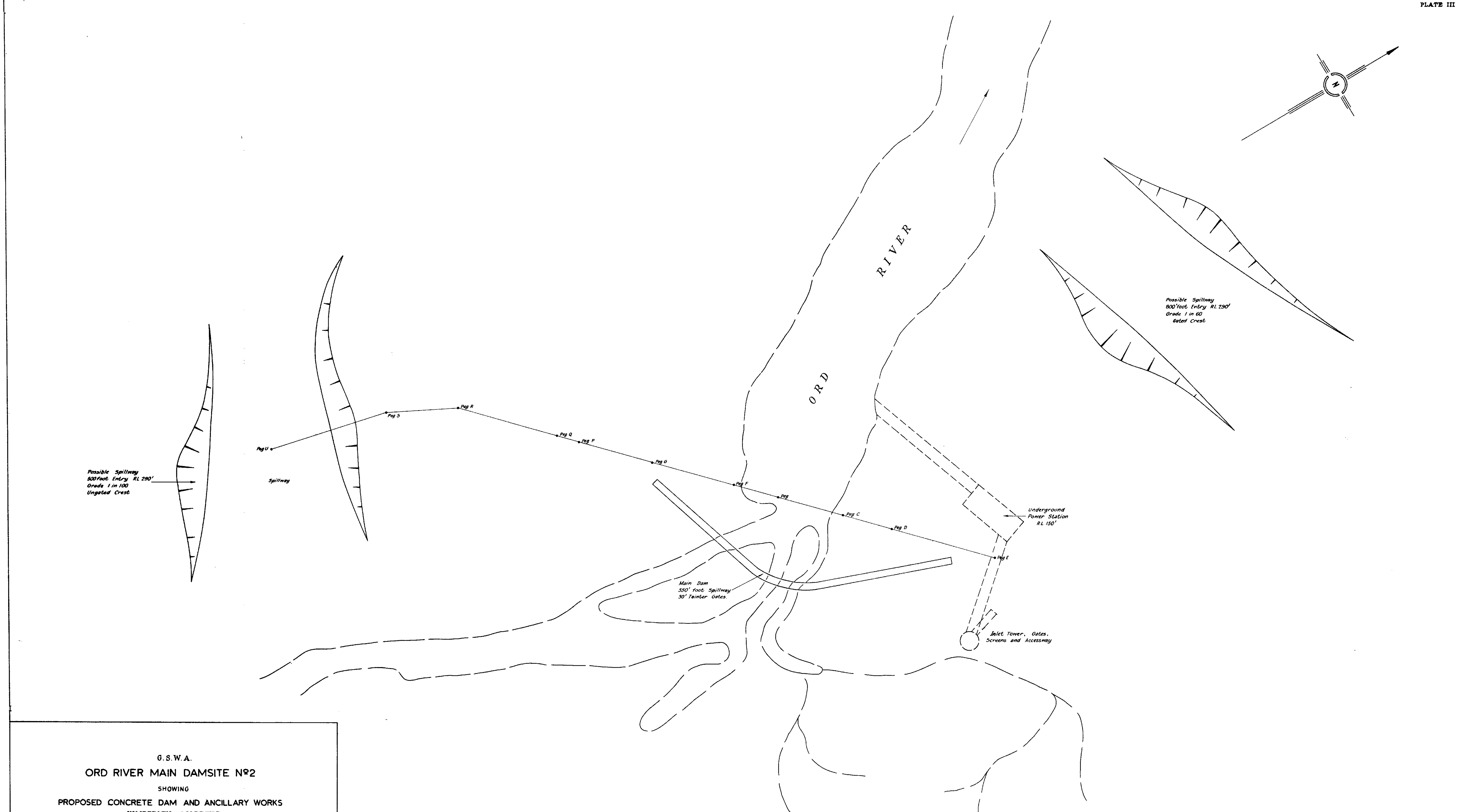
Geological appraisals were carried out in sections largely corresponding to these contract areas, but equal standards of accuracy were not possible, as survey data was incomplete at the time of the examination. A pegged centre line was available for the 1st Contract section, a line drawn on air



7283

Revised 19. 11. 62

PLATE III



G.S.W.A.

ORD RIVER MAIN DAMSITE Nº2

SHOWING

PROPOSED CONCRETE DAM AND ANCILLARY WORKS

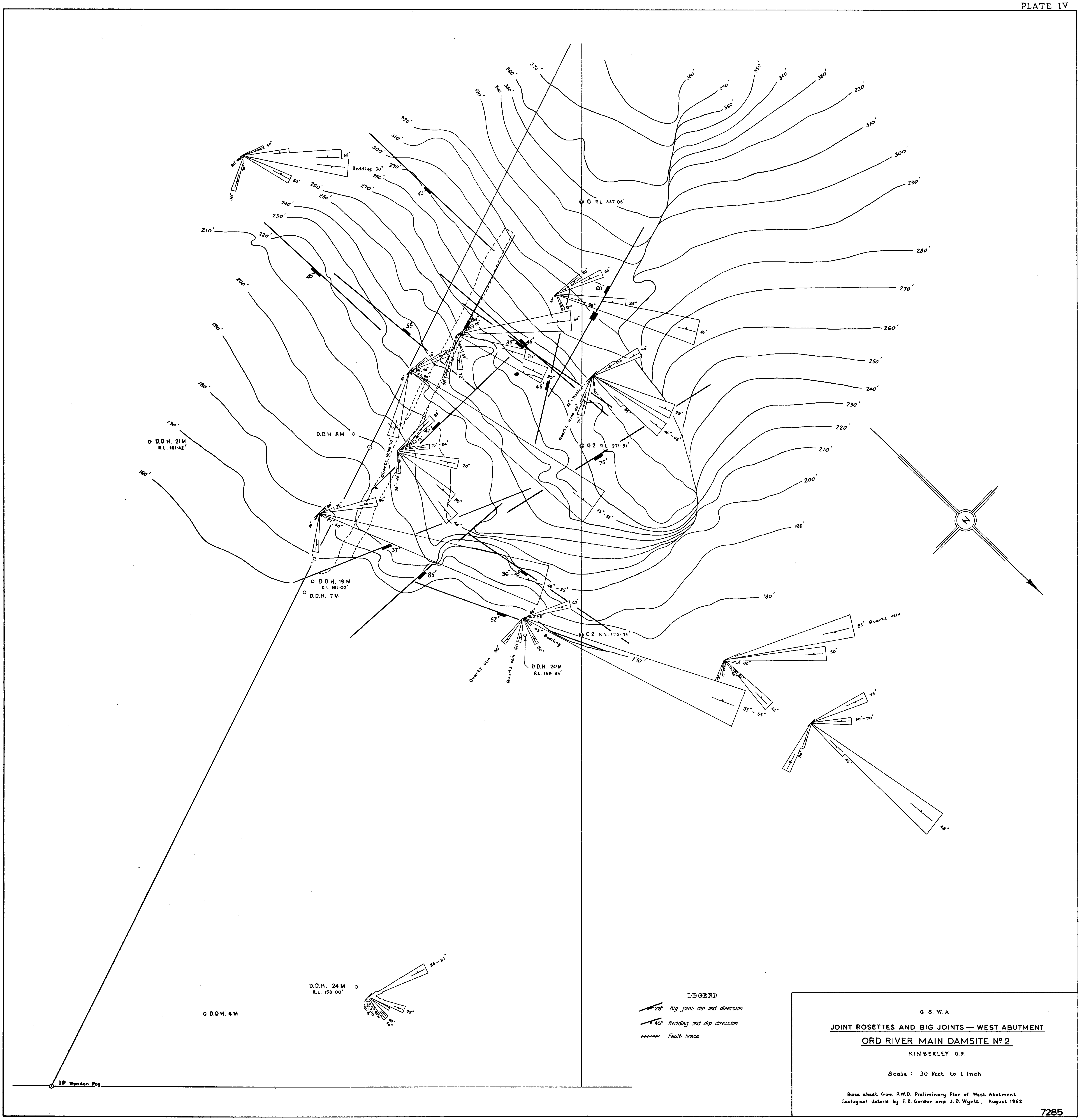
KIMBERLEY GOLDFIELD

SCALE : 200 FEET TO AN INCH

100 0 100 200 300 400 500

Based on P.W.D. Contour Plan 34959
As to 30. 4. 62.

7284



G. S. W. A.

JOINT ROSETTES AND BIG JOINTS — WEST ABUTMENT

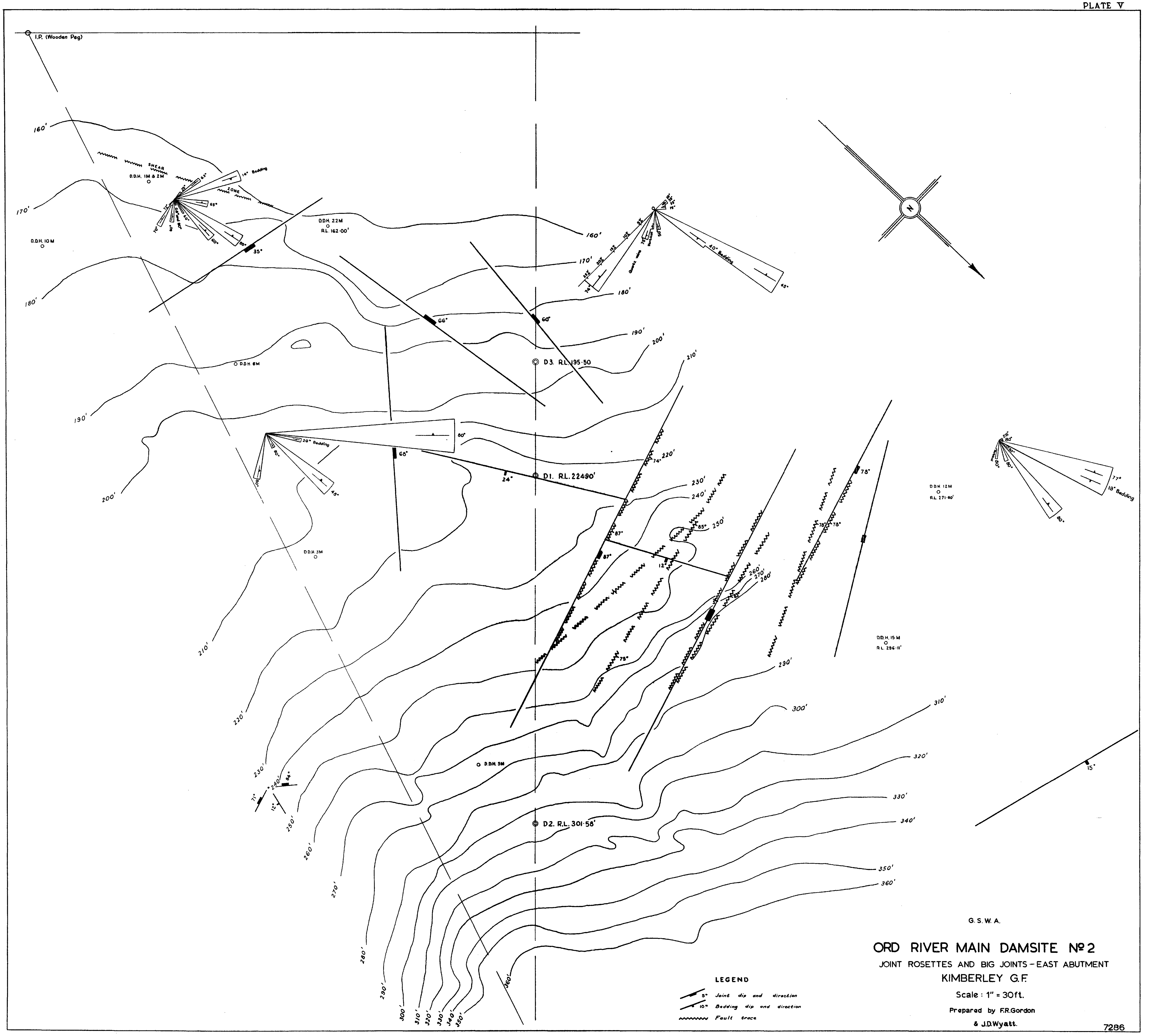
ORD RIVER MAIN DAMSITE Nº 2

KIMBERLEY G.F.

Scale : 30 Feet to 1 Inch

Base sheet from P.W.D. Preliminary Plan of West Abutment
Geological details by F.R. Gordon and J.D. Wyatt, August 1962

7285



G. S. W. A.

ORD RIVER MAIN DAMSITE No 2

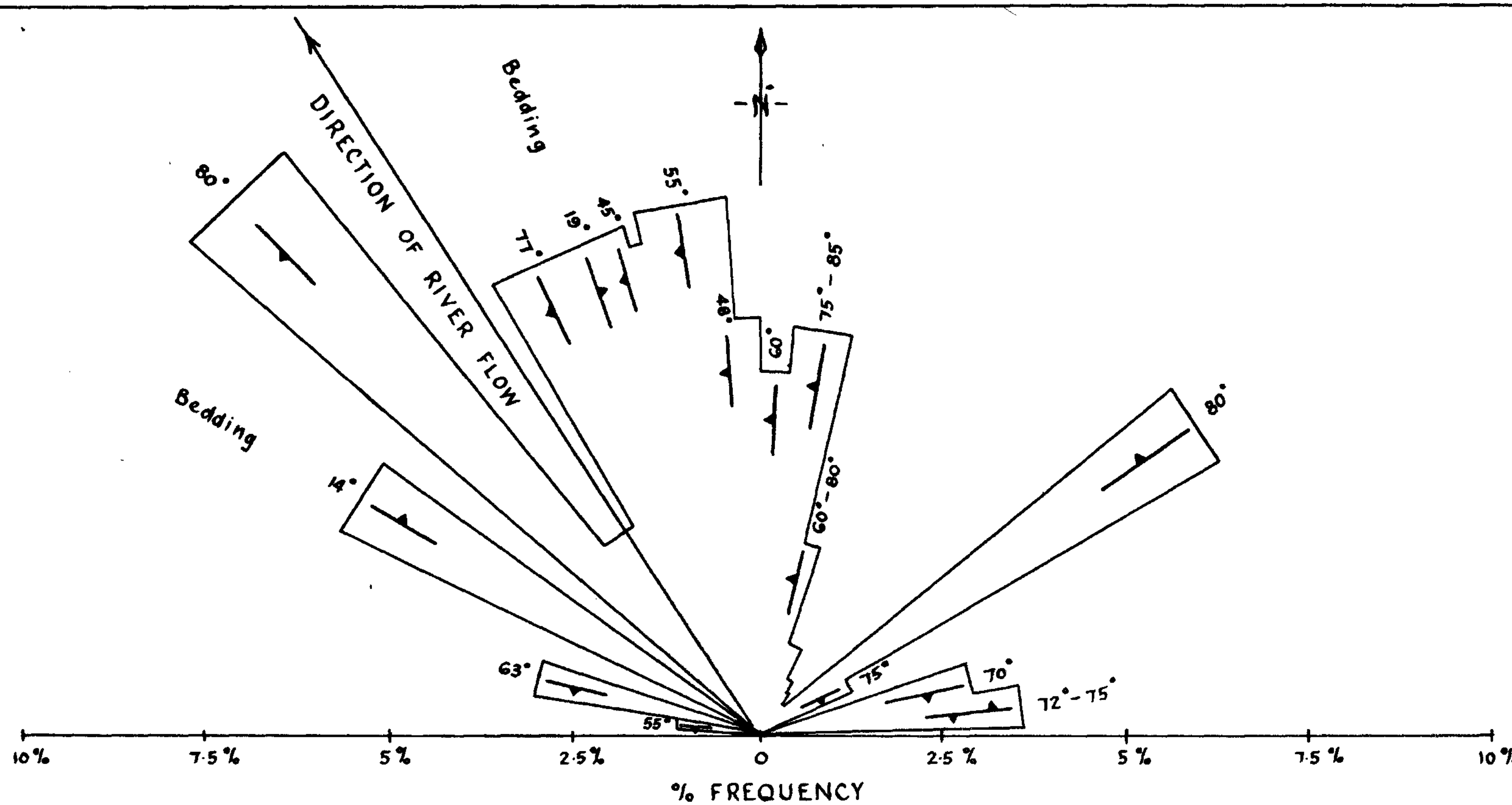
JOINT ROSETTES AND BIG JOINTS – EAST ABUTMENT

KIMBERLEY G.F.

Scale : 1" = 30 ft.

Prepared by F.R.Gordon & J.D.Wyatt.

7286



G. S. W. A.

COMPOSITE JOINT ROSETTE

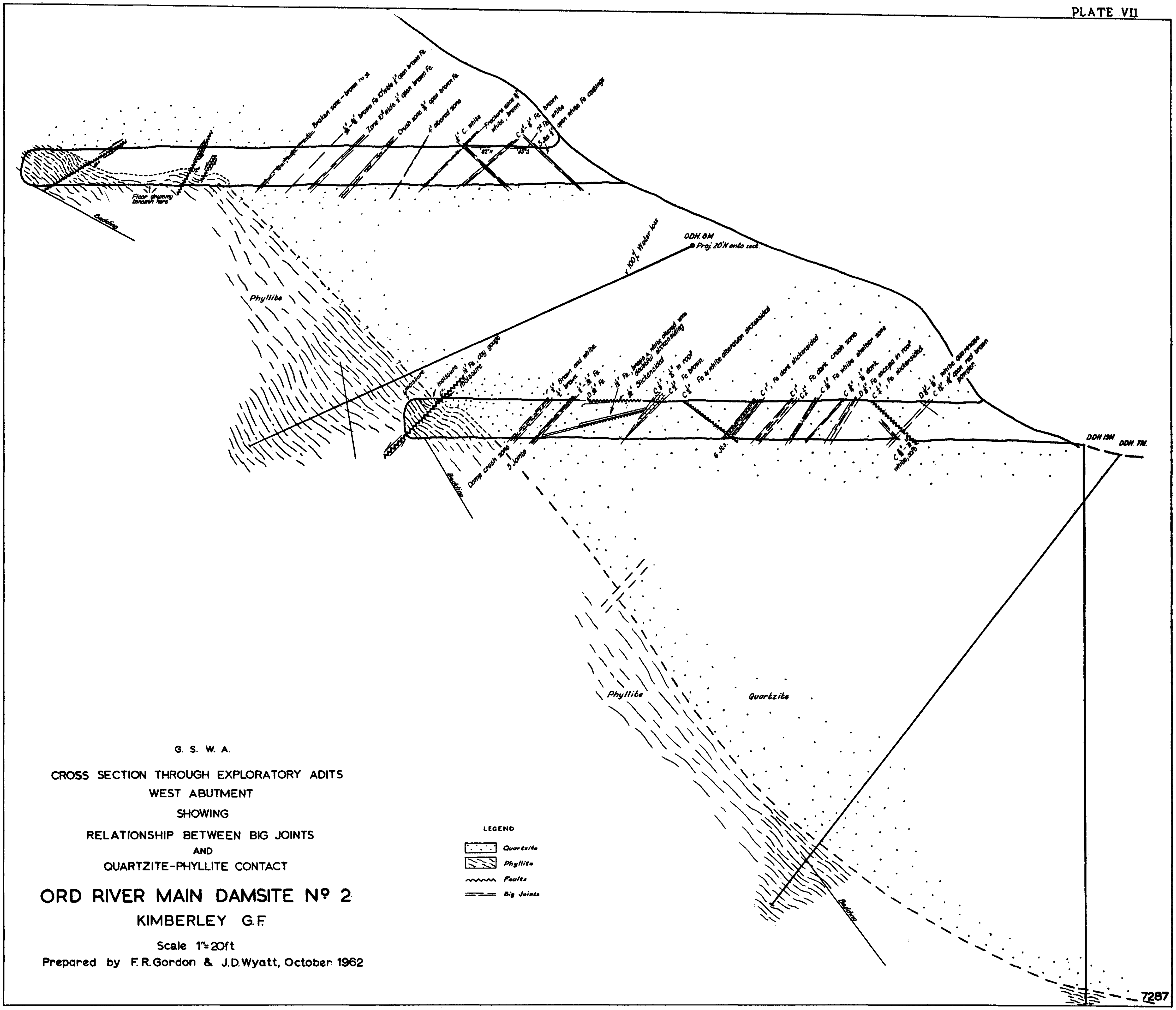
EAST ABUTMENT

ORD RIVER No.2 MAIN DAMSITE

KIMBERLEY G.F.

J. D. Wyatt, Aug. 1962.

7288



G. S. W. A.

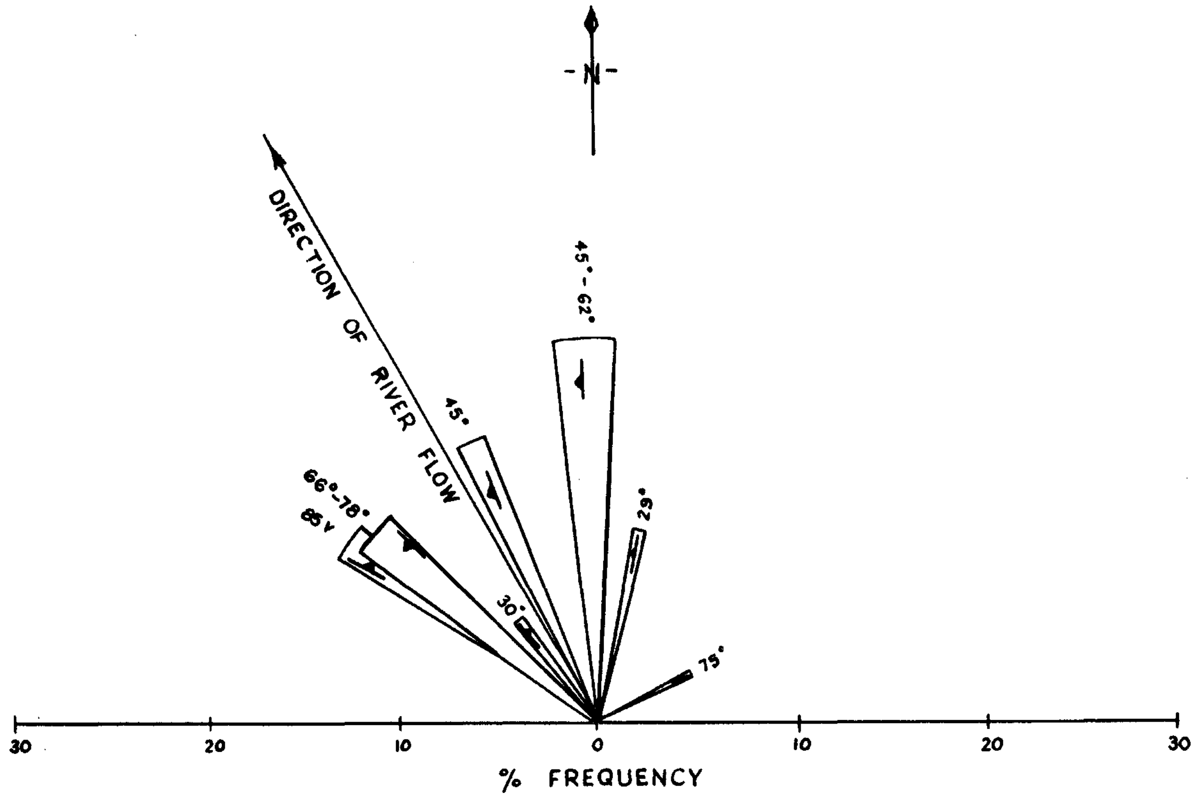
CROSS SECTION THROUGH EXPLORATORY ADITS
WEST ABUTMENT
SHOWING
RELATIONSHIP BETWEEN BIG JOINTS
AND
QUARTZITE-PHYLLITE CONTACT

ORD RIVER MAIN DAMSITE Nº 2

KIMBERLEY G.F.

Scale 1"=20ft

Prepared by F.R.Gordon & J.D.Wyatt, October 1962



G. S. W. A.

COMPOSITE JOINT ROSETTE

WEST ABUTMENT

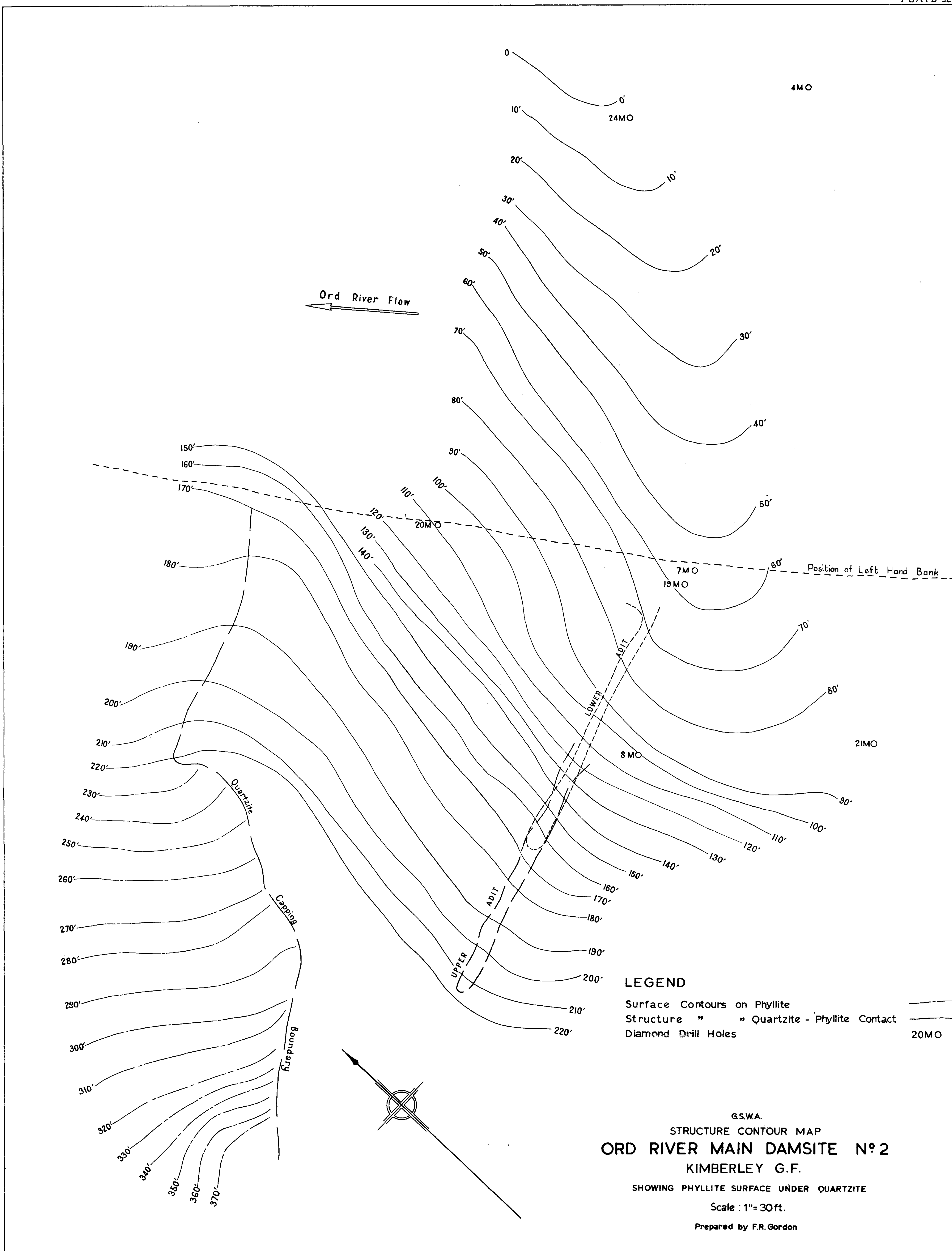
ORD RIVER No 2 MAIN DAMSITE

KIMBERLEY G.F.

F.R. Gordon, Aug. 1962

7289


Top Level of Dam
WEST
EAST
PARTIALLY FILLED AND CLOSED JOINTS
UPPER ADIT
LOWER ADIT
D.D.H. 8M.(Proj 8 onto section) Bearing 263°M. Dep. 25°
100% W.L. 14'
Grey/Cream/Red phyllite (oxidised)
Bedding
D.D.H. 19M Vertical
D.D.H. 7M Bearing 260° Mag. Angle of dep 52°
ORD RIVER
Sand Surface
Silt, sand and gravel
90% W.L. 23'
OPEN JOINTS WEATHERED
Ferruginous quartzite
FILLED & CLOSED JOINTS
Massive, white quartzite
Grey phyllite
most prominent fracture joint
100% W.L.
Bedding and cleavage
Joint trace
D.D.H. 4M Bearing 243° mag. Angle of dep-40°
100% Water loss
Ferruginous quartzite
D.D.H. 2M. Bearing 237½ M. Angle of dep-45°
At 20', 50% Water loss
At 33', 100% Water loss
BROKEN OPEN JOINTS
Ferruginous quartzite 48' Caved
At 55' Caving
OPEN JOINTS
BADLY BROKEN AND WEATHERED
D.D.H. 6M. Vertical
FAIRLY BROKEN
OPEN JOINTED
FILLED & CLOSED JOINTS
100% W.L.
Jointing trace
D.D.H. 3M Vertical
HIGHLY BROKEN OPEN JOINTED
Bedding Trace
Jointing Trace
Ferruginous and non-Ferruginous quartzite
101' temporary W.L.
Quartz injection
151' 0"
240'
220'
200'
180'
160'
140'
120'
100'
80'
60'
40'
20'
LEGEND
Quartzite
Phyllite
Fault zone
Quartz vein
W.L. Water loss
Core loss or zone of breakage.
GSWA
PHYSICAL DIVISIONS OF BEDROCK
ORD RIVER MAIN DAMSITE No 2
KIMBERLEY G.F.
CROSS SECTION THROUGH D.D.H.'S 8M,7M,4M,2M,6M,3M
LOOKING NORTH — ALONG ORIGINAL CENTRE LINE
Scale 1inch to 30 feet
Prepared by F.R. Gordon & J.D Wyatt. Aug. 1962.
7290



G.S.W.A.

STRUCTURE CONTOUR MAP

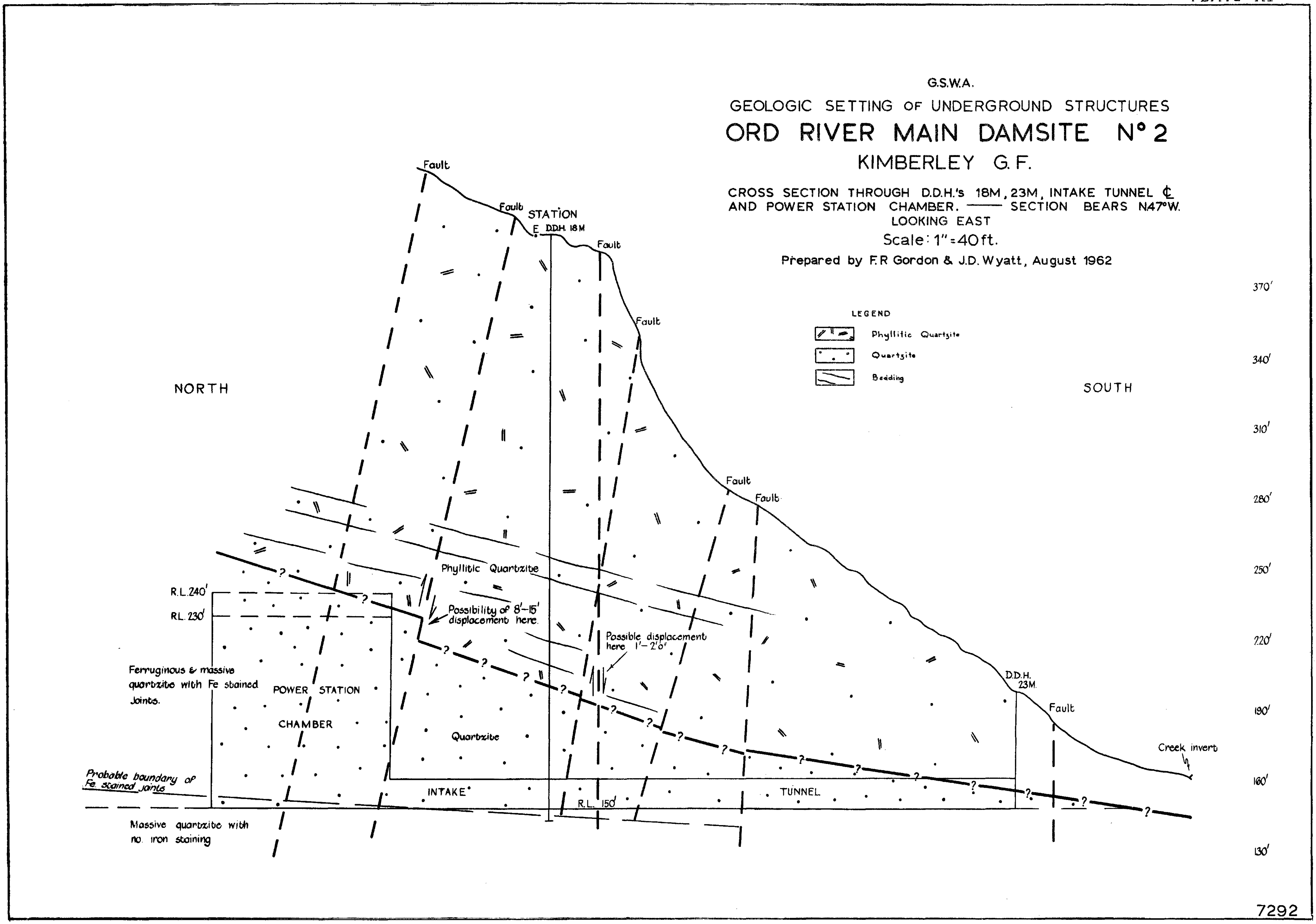
ORD RIVER MAIN DAMSITE Nº 2

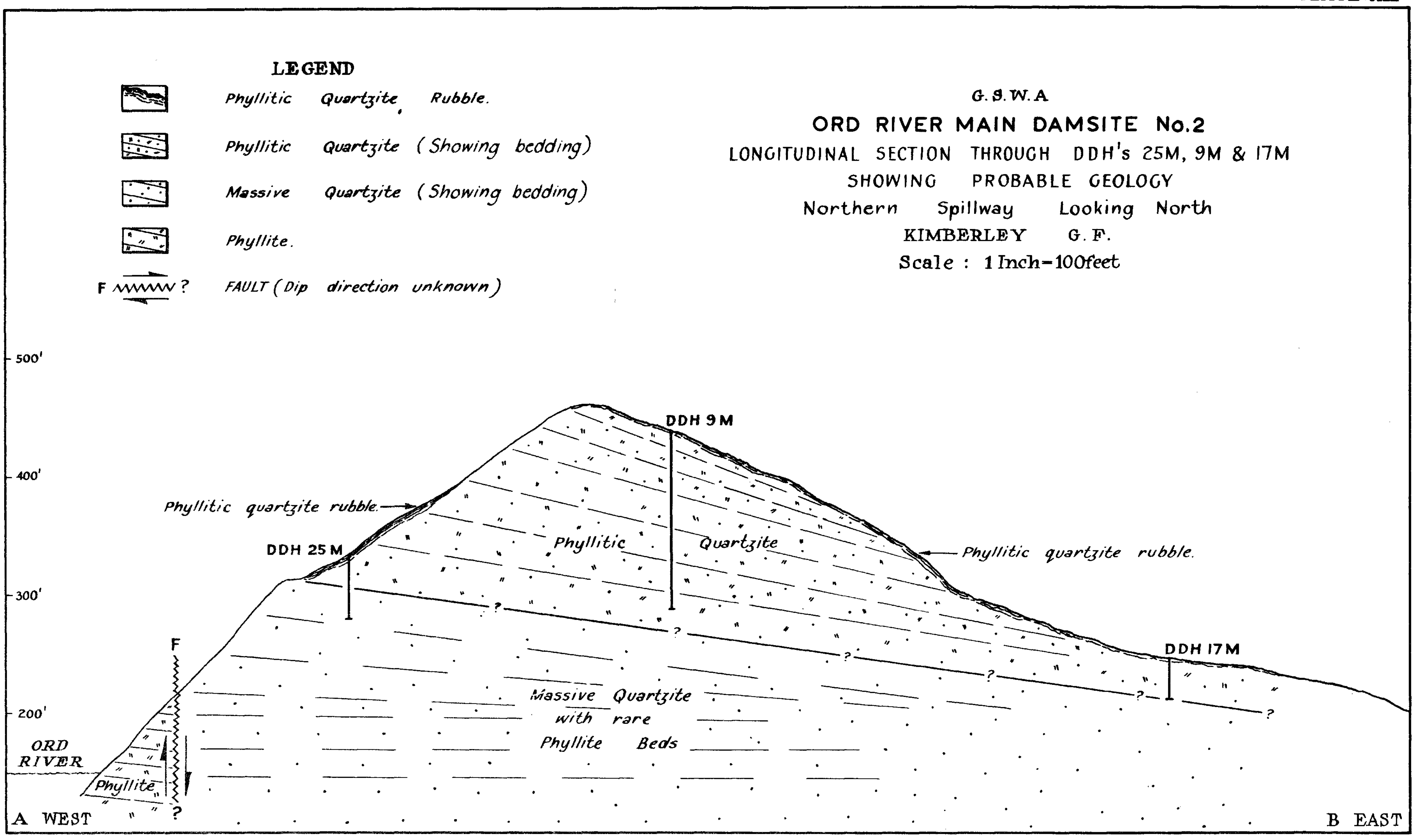
KIMBERLEY G.F.

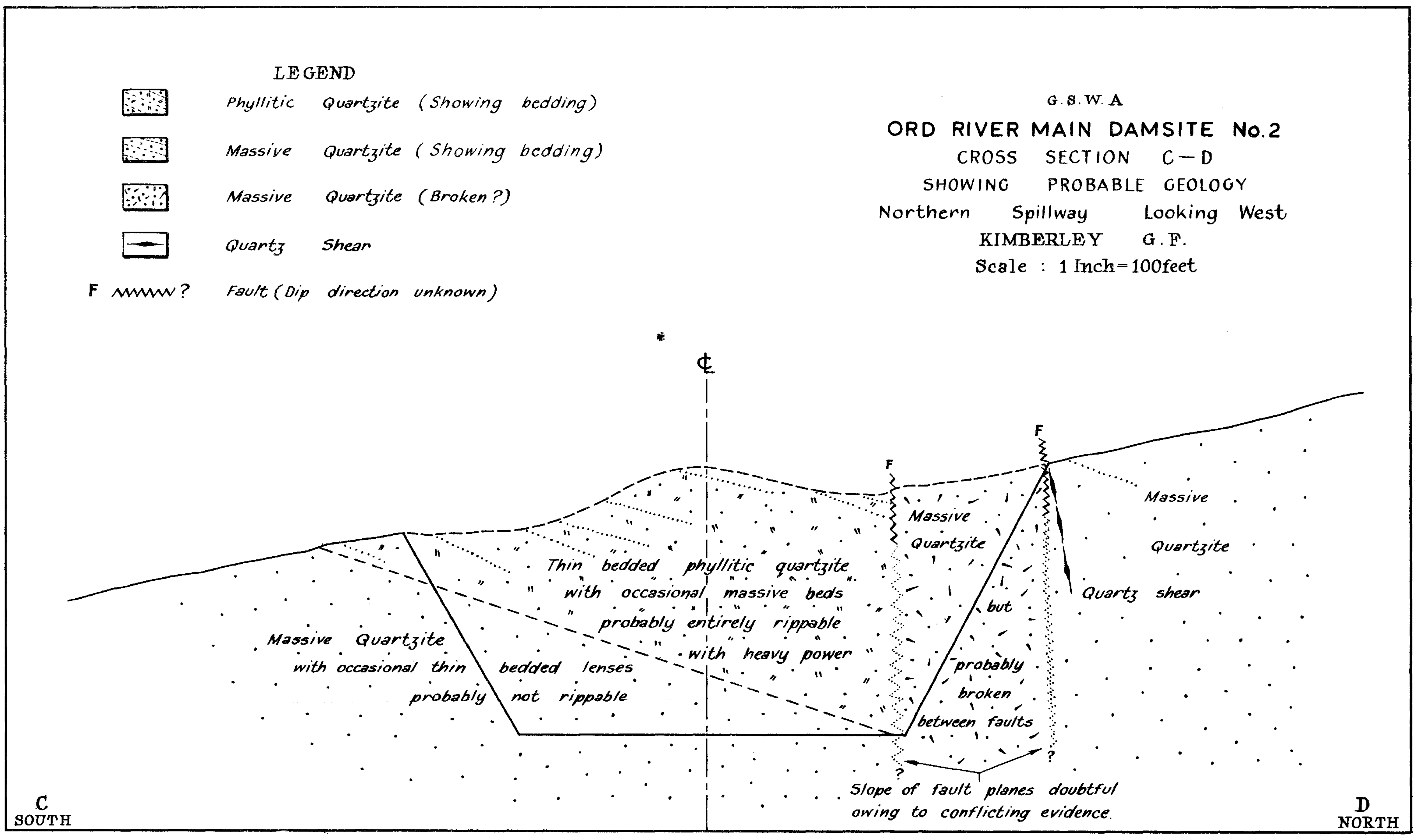
SHOWING PHYLLITE SURFACE UNDER QUARTZITE

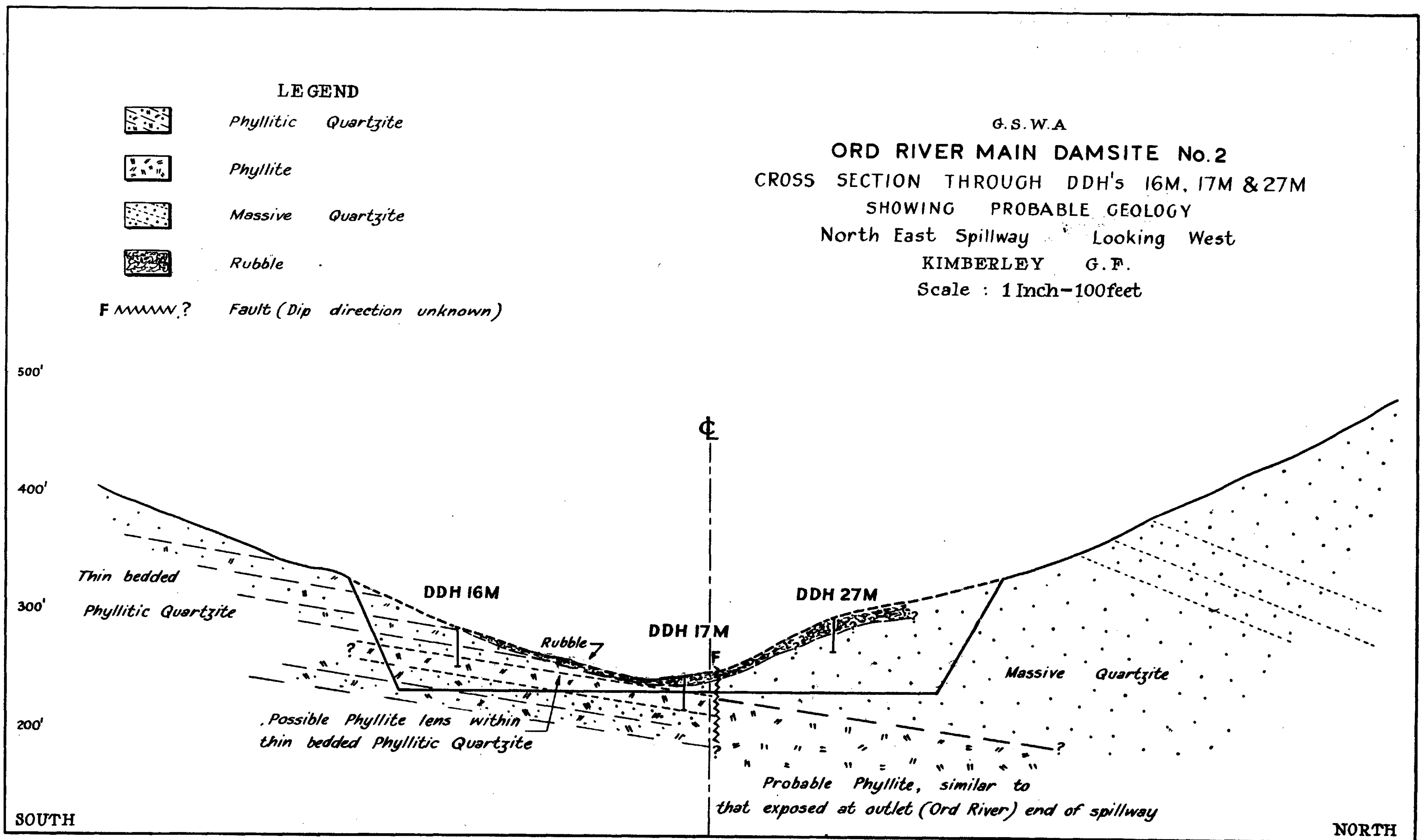
Scale : 1" = 30 ft.

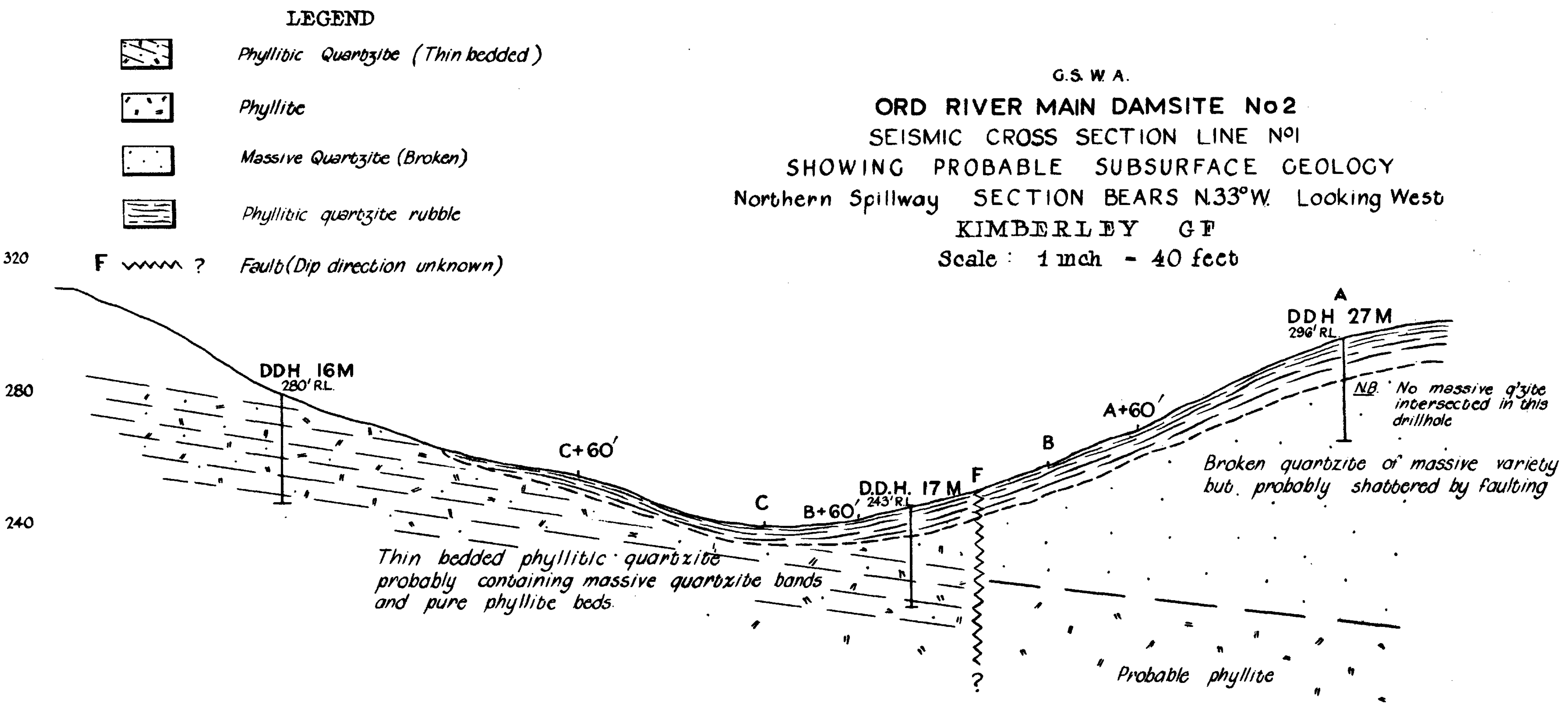
Prepared by F.R. Gordon

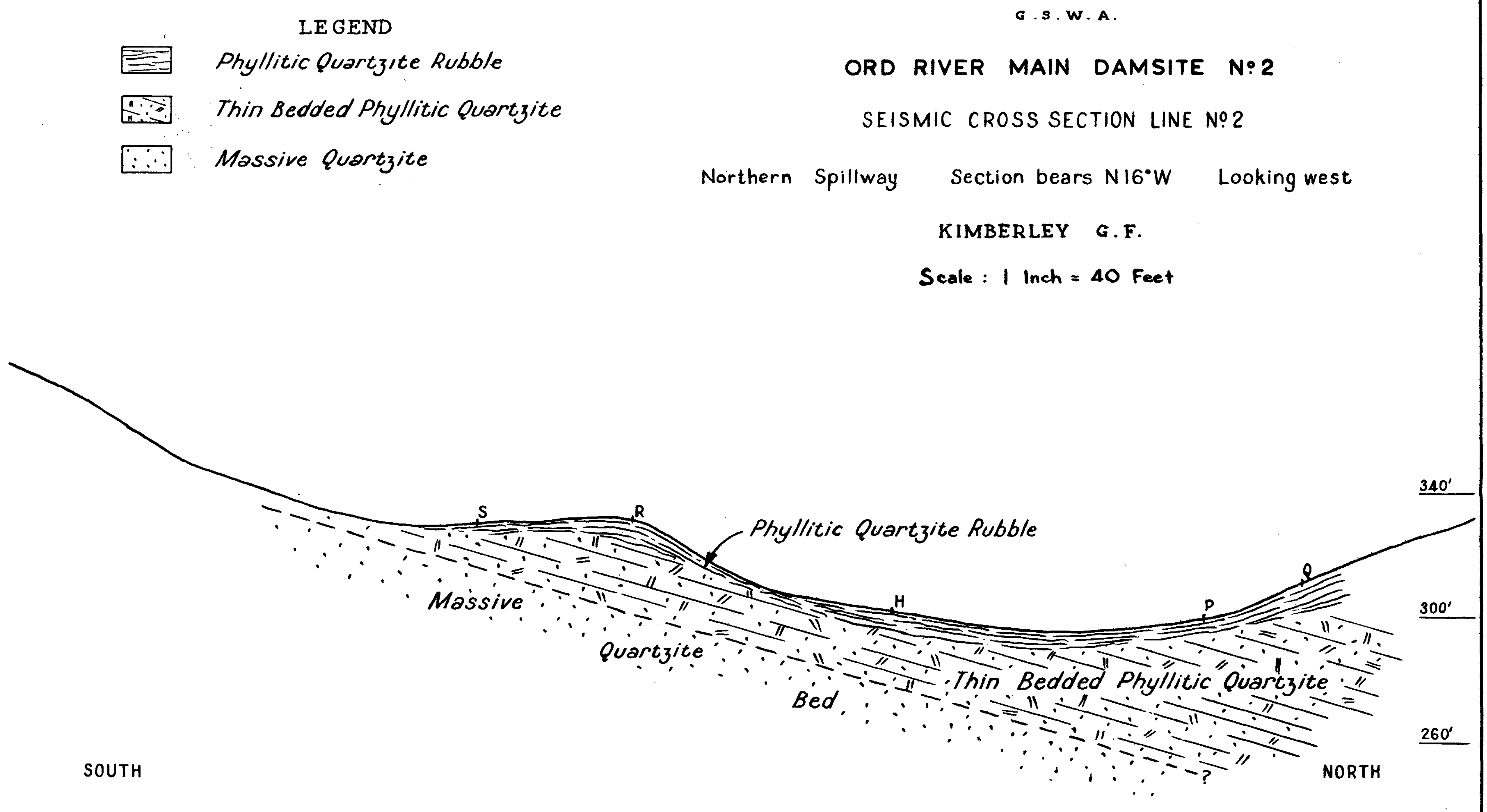

G.S.W.A.
GEOLOGIC SETTING OF UNDERGROUND STRUCTURES
ORD RIVER MAIN DAMSITE N° 2
KIMBERLEY G.F.
CROSS SECTION THROUGH D.D.H.'s 18M, 23M, INTAKE TUNNEL ℄
AND POWER STATION CHAMBER. —— SECTION BEARS N47°W.
LOOKING EAST
Scale: 1" = 40 ft.
Prepared by F.R Gordon & J.D. Wyatt, August 1962
LEGEND
Phyllitic Quartzite
Quartzite
Bedding
NORTH
SOUTH
Fault
STATION
E
D.D.H. 18M
Phyllitic Quartzite
Possibility of 8'–15' displacement here.
Possible displacement here 1'–2'0"
R.L. 240'
R.L. 230'
Ferruginous & massive quartzite with Fe stained Joints.
POWER STATION
CHAMBER
Quartzite
Probable boundary of Fe. stained joints
INTAKE
R.L. 150'
TUNNEL
Massive quartzite with no iron staining
D.D.H. 23M.
Creek invert
370'
340'
310'
280'
250'
220'
190'
160'
130'

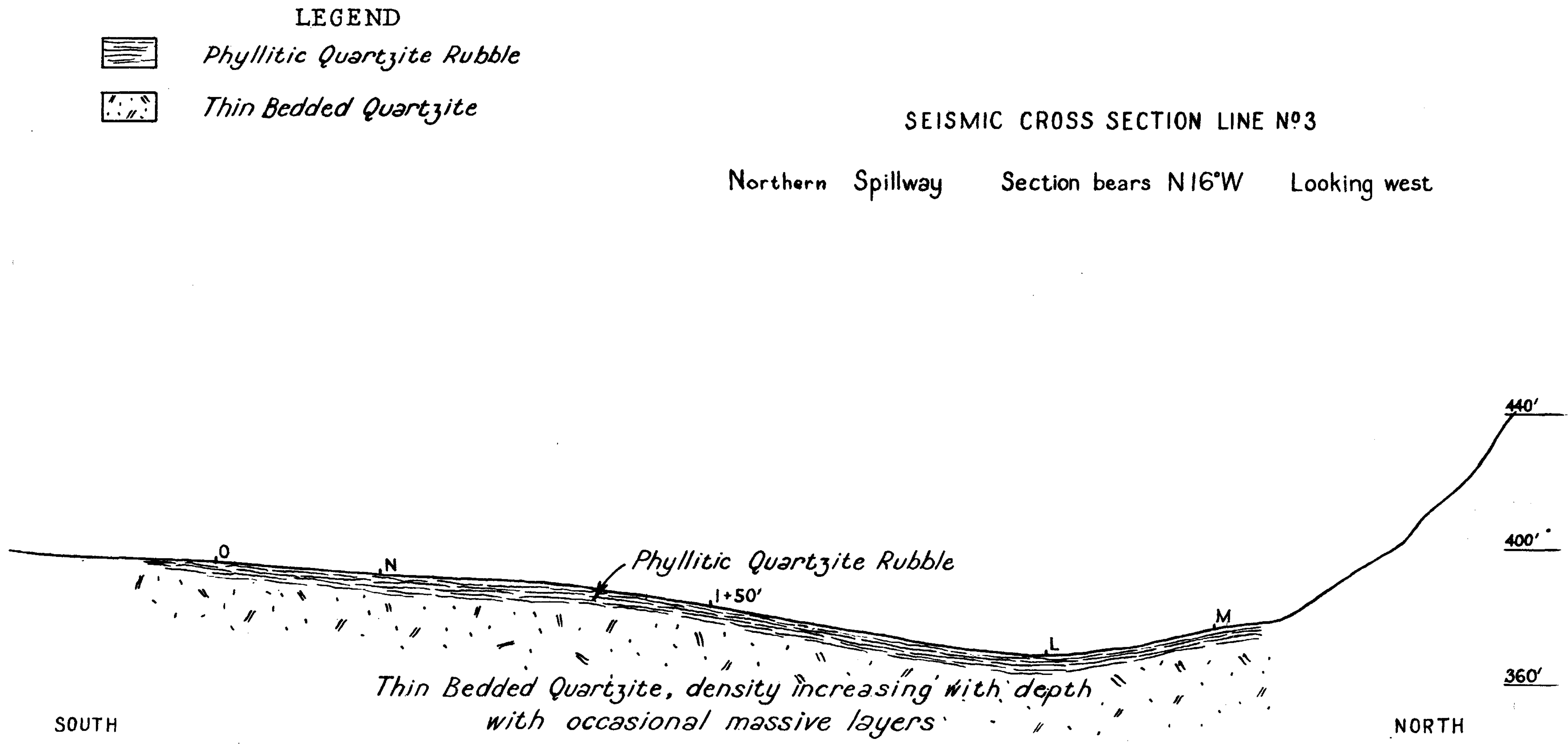

LEGEND
Phyllitic Quartzite Rubble.
Phyllitic Quartzite (Showing bedding)
Massive Quartzite (Showing bedding)
Phyllite.
F ? FAULT (Dip direction unknown)
G.S.W.A
ORD RIVER MAIN DAMSITE No.2
LONGITUDINAL SECTION THROUGH DDH's 25M, 9M & 17M
SHOWING PROBABLE GEOLOGY
Northern Spillway Looking North
KIMBERLEY G.F.
Scale : 1 Inch-100feet
500'
400'
300'
200'
DDH 9M
DDH 25M
DDH 17M
Phyllitic quartzite rubble
Phyllitic Quartzite
Phyllitic quartzite rubble.
Massive Quartzite
with rare
Phyllite Beds
ORD
RIVER
Phyllite
F
A WEST
B EAST

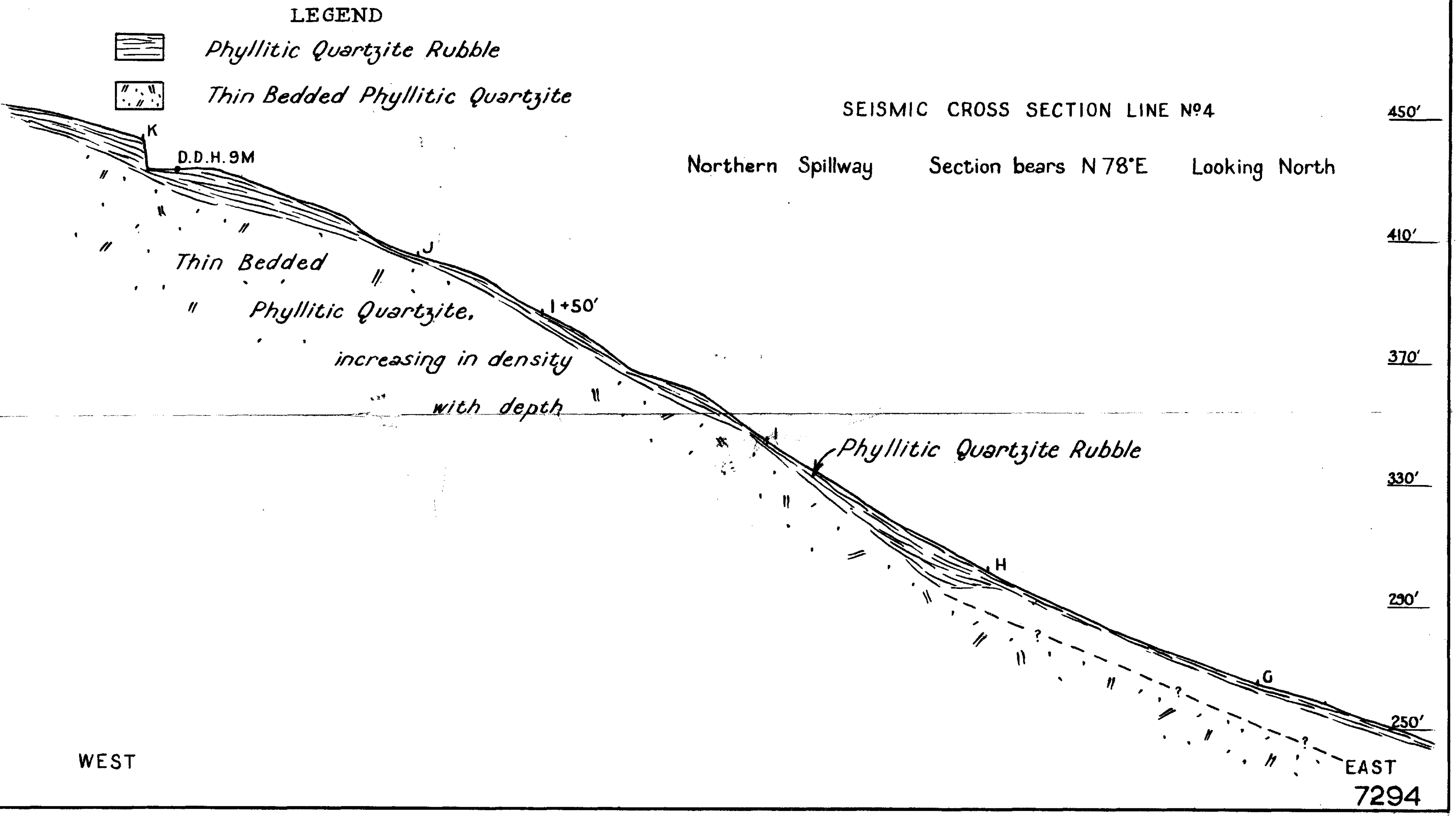

LEGEND
Phyllitic Quartzite (Showing bedding)
Massive Quartzite (Showing bedding)
Massive Quartzite (Broken ?)
Quartz Shear
F ? Fault (Dip direction unknown)
G.S.W.A
ORD RIVER MAIN DAMSITE No.2
CROSS SECTION C—D
SHOWING PROBABLE GEOLOGY
Northern Spillway Looking West
KIMBERLEY G.F.
Scale : 1 Inch=100feet
℄
F
F
Massive Quartzite
Massive Quartzite
Thin bedded phyllitic quartzite
with occasional massive beds
probably entirely rippable
with heavy power
Massive Quartzite
but
probably
broken
between faults
Quartz shear
Massive Quartzite
with occasional thin bedded lenses
probably not rippable
Slope of fault planes doubtful
owing to conflicting evidence.
C
SOUTH
D
NORTH

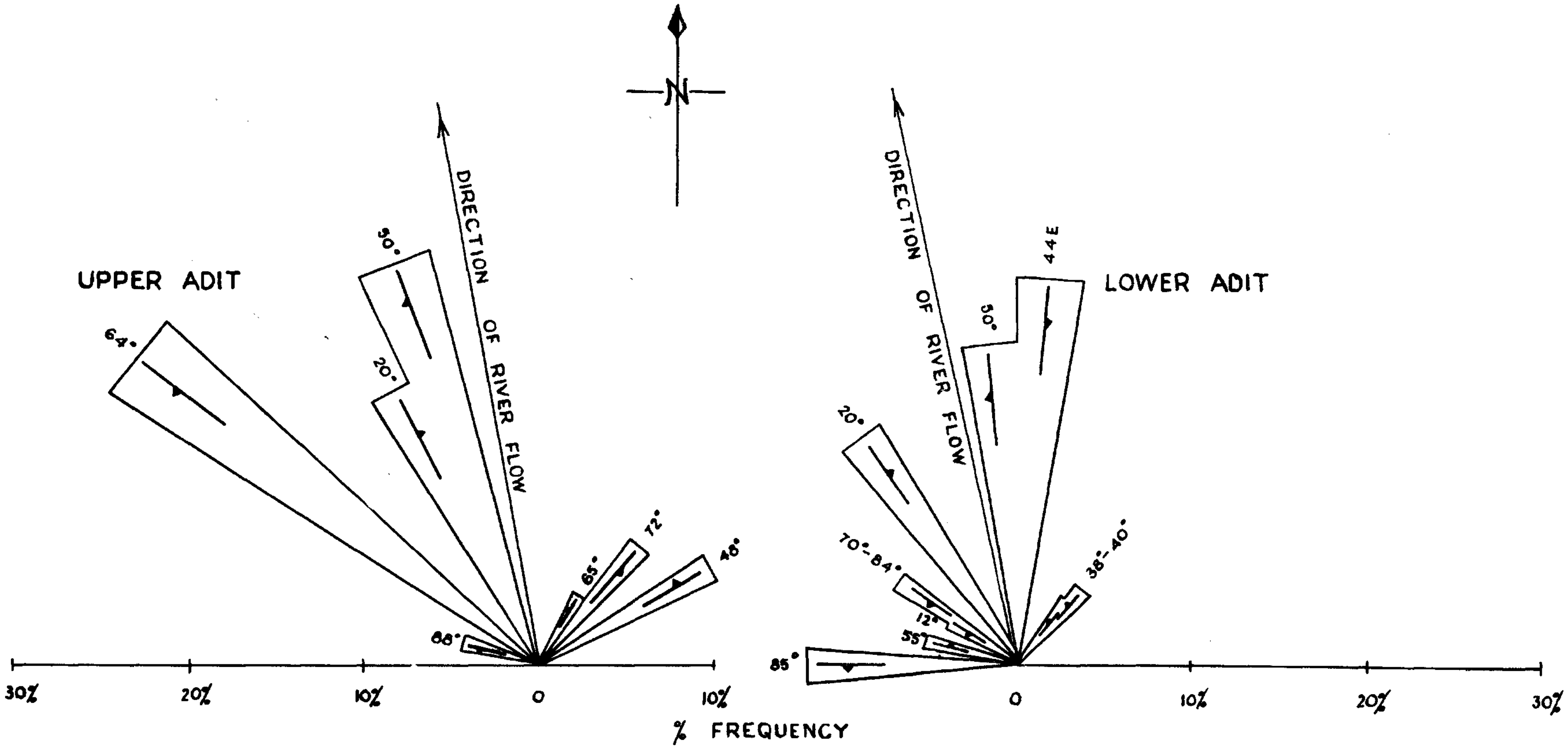

LEGEND
Phyllitic Quartzite
Phyllite
Massive Quartzite
Rubble
F ? Fault (Dip direction unknown)
G.S.W.A
ORD RIVER MAIN DAMSITE No.2
CROSS SECTION THROUGH DDH's 16M, 17M & 27M
SHOWING PROBABLE GEOLOGY
North East Spillway Looking West
KIMBERLEY G.F.
Scale : 1 Inch-100feet
500'
400'
300'
200'
℄
Thin bedded
Phyllitic Quartzite
DDH 16M
Rubble
DDH 17M
F
DDH 27M
Massive Quartzite
Possible Phyllite lens within
thin bedded Phyllitic Quartzite
Probable Phyllite, similar to
that exposed at outlet (Ord River) end of spillway
SOUTH
NORTH


LEGEND
Phyllitic Quartzite (Thin bedded)
Phyllite
Massive Quartzite (Broken)
Phyllitic quartzite rubble
F ? Fault (Dip direction unknown)
G.S.W.A.
ORD RIVER MAIN DAMSITE No 2
SEISMIC CROSS SECTION LINE No1
SHOWING PROBABLE SUBSURFACE GEOLOGY
Northern Spillway SECTION BEARS N.33°W. Looking West
KIMBERLEY G.F.
Scale: 1 inch - 40 feet
320
280
240
DDH 16M
280' RL
C+60'
C
B+60'
D.D.H. 17M
243' RL
F
B
A+60'
A
DDH 27M
298' RL
NB No massive q'zite intersected in this drillhole
Broken quartzite of massive variety but probably shattered by faulting
Thin bedded phyllitic quartzite probably containing massive quartzite bands and pure phyllite beds
Probable phyllite
?


LEGEND
Phyllitic Quartzite Rubble
Thin Bedded Phyllitic Quartzite
Massive Quartzite
G.S.W.A.
ORD RIVER MAIN DAMSITE No 2
SEISMIC CROSS SECTION LINE No 2
Northern Spillway Section bears N16°W Looking west
KIMBERLEY G.F.
Scale: 1 Inch = 40 Feet
340'
300'
260'
S
R
Phyllitic Quartzite Rubble
H
P
Q
Massive Quartzite Bed
Thin Bedded Phyllitic Quartzite
SOUTH
NORTH


LEGEND
Phyllitic Quartzite Rubble
Thin Bedded Quartzite
SEISMIC CROSS SECTION LINE No 3
Northern Spillway Section bears N16°W Looking west
440'
400'
360'
O
N
Phyllitic Quartzite Rubble
I+50'
L
M
Thin Bedded Quartzite, density increasing with depth with occasional massive layers
SOUTH
NORTH


LEGEND
Phyllitic Quartzite Rubble
Thin Bedded Phyllitic Quartzite
SEISMIC CROSS SECTION LINE No 4
Northern Spillway Section bears N78°E Looking North
450'
410'
370'
330'
290'
250'
K
D.D.H. 9M
J
I+50'
I
H
G
Thin Bedded Phyllitic Quartzite, increasing in density with depth
Phyllitic Quartzite Rubble
WEST
EAST

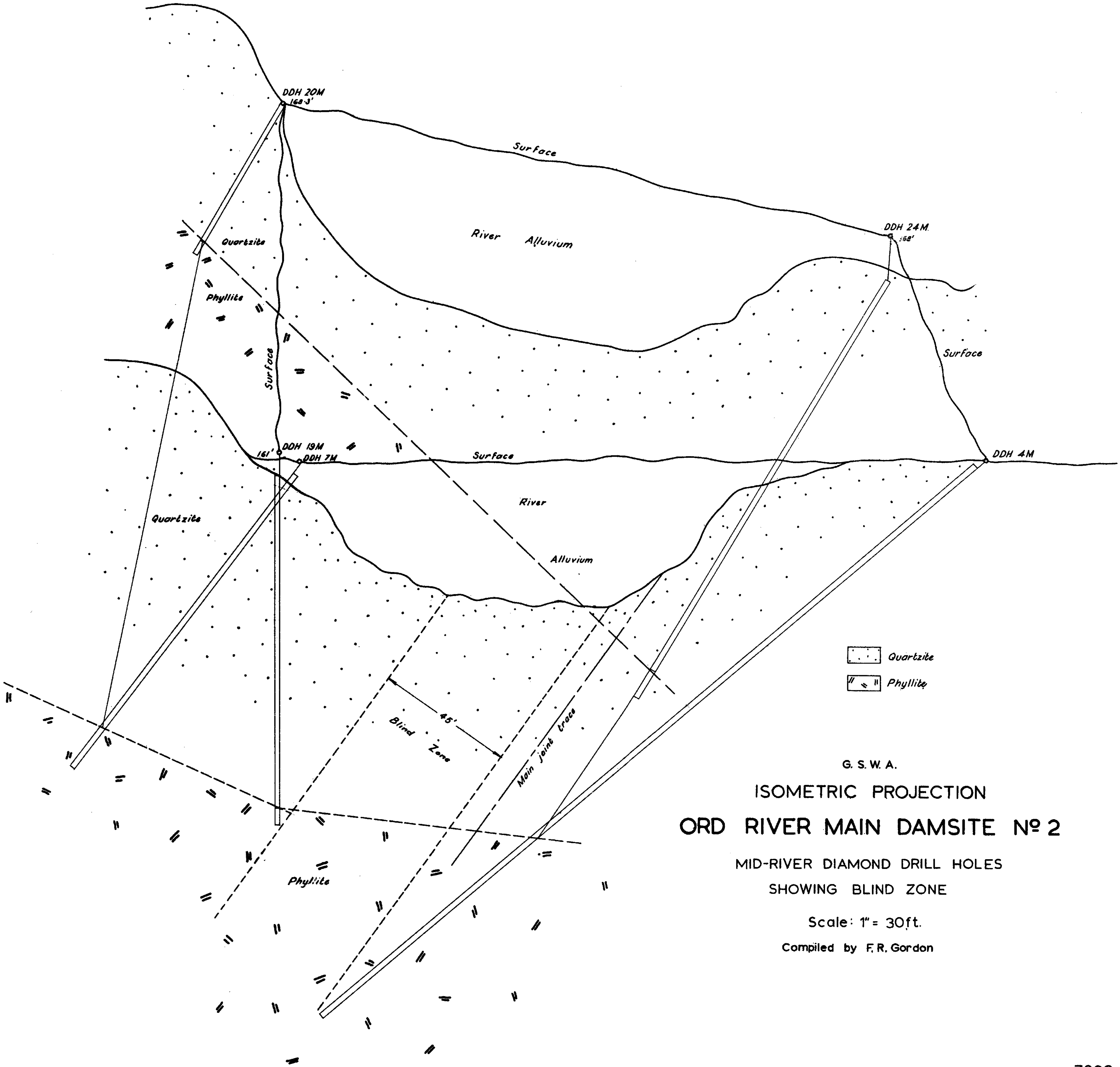


G. S. W. A.

JOINT ROSETTES IN EXPLORATORY ADITS ORD RIVER No.2 MAIN DAMSITE

KIMBERLEY G.F.

J.D.Wyatt, August 1962



G. S. W. A.

ISOMETRIC PROJECTION

ORD RIVER MAIN DAMSITE No 2

MID-RIVER DIAMOND DRILL HOLES
SHOWING BLIND ZONE

Scale: 1" = 30ft.

Compiled by F. R. Gordon

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photos indicated the centre line for the length of Contract 2, and a line on a topographic plan along with some survey tangent lines, cut on the ground, was all that was available for most of Contract 3. As this was an area of largely uniform, rugged topography, in places heavily bush-covered, location, and especially level location, was most difficult.

The writer was assisted in the field by Geologist J. D. Wyatt and, for a brief period, by Geologist I. Gemuts. About 4 months was spent in field work, involving route examination and ballast sources.

GEOLOGICAL SETTING.

Historical.

From the 1870s, when the proposal was first made to link the Goldfields to the coast, it was realised that the Swan Valley afforded a unique natural route through the dissected topography of the Darling Ranges. In 1880 the Government Engineer estimated the cost of a railway up the river route as £256,500 as against £190,000 for the direct line over the hills. The cost of the river route was beyond the means of the Government at that time and as a result the 3 ft. 6 in. line was laid down between Midland and Northam by way of the direct line up the Darling Scarp, with very steep grades and tight curves avoiding cuttings. This economy was of course illusory, and with the necessity for long fast trains, this section of the line became a bottleneck, and operation and maintenance costs were extreme.

An agreement between the State of Western Australia and B.H.P. Ltd. for the latter to establish an integrated iron and steel industry at Kwinana required that the State should construct a standard gauge (4 ft. 8½ in.) railway between Kwinana and major iron ore deposits at Koolyanobbing. A parallel agreement between the Commonwealth Government and the State has laid down that standard gauge should be carried from Kalgoorlie to Fremantle. This proposed Standard Gauge Railway with an obligation for flat grades, was of necessity routed through the Swan-Avon Valley, from near Midland Junction to Northam, thus forming the Avon Valley Deviation (see Plate XVI).

Previous Geological Investigations.

Small areas of the Swan-Avon Valley have been geologically surveyed in detail but no large scale or comprehensive geological investigation has been published. However, background information was readily made available by Professor R. T. Prider of the University of Western Australia, and considerable assistance in the investigation of ballast and borrow materials was gained from the maps of the Metropolitan Survey, published by the Geological Survey of Western Australia in 1951.

Physiography.

From west to east the following broad and contrasting elements are found in the Perth metropolitan area:—

(i) Recent sand dunes and beaches.
(ii) Coastal limestone belt.
(iii) Vegetated sand dunes.
(iv) Piedmont alluvials—sand, lateritic gravels, etc.
(v) The Darling Scarp, possibly a fault scarp.
(vi) The Darling Ranges—a dissected plateau about 800 feet above sea level formed on a complex of granites and granite-gneisses, with subordinate epidiorite and quartz dolerite intrusives.

The Swan-Avon River system displays relatively subdued upper valleys (mature) with the valleys parallel to the strike of the rocks, and the structure is followed faithfully except in the gorge area where there is control by the major joint pattern or along shear zones. The principal gorges are thus in west running valleys while the N.W. and S.E. valleys are generally mature. The general maturity of the valley means that a natural transportation is available, and the fact that only one major river tributary has to be crossed (Wooroloo Brook) is of great advantage to any construction. With a fall of about 450 feet in the distance of 60 miles between Midland and Northam, first class grades are possible.

Areal Geology.

There are two main elements to be considered:—

(a) The Precambrian basement complex of the Darling Peneplain (or range) and the Darling Scarp.
(b) The superficial deposits of Tertiary and Recent Age, covering the sedimentary basin of the Coastal Plain, and mantling the weathered Precambrian rocks.

The Precambrian rocks consist of a complex of crystalline igneous and metamorphic rocks, dominantly granites and gneisses, with minor amounts of basic igneous and schistose metasedimentary formations.

Above the 700 foot contour, the Precambrian rocks are covered by a layer, up to 20 feet thick, of massive and pisolitic laterite ("ironstone gravel"). The laterite usually overlies highly weathered country rock, which may extend to as deep as 100 feet before fresh unweathered basement rock is encountered. The sediments of the Coastal Plain close to the Scarp consist of alluvial clays and loams, along with river deposits of sand and alluvium in the Swan-Avon valley.

ROUTE DETAILS.

Introduction.

The geological appraisal of an engineering project such as the Avon Valley Deviation involves the accumulation of a mass of detail concerning depth and nature of overburden over bedrock; the relationship of rock to the railroad structure, the quantity and workability of the rock, areas of undesirable material, and the location of borrow pits or waste areas. In addition, the stability of the materials encountered, both of the back slopes and of the subgrade, and seepage possibilities must be considered along the route. Much of this information can be shown on geological plans and sections, and typical compilations are shown in Plates XVII and XVIII.

More localised topics concern the effect of gross geologic features such as faulting, the existence or possibility of sliding and bridge site appraisal, and certain of these features are detailed in this report. Description of some of these geologic features formed the basis of the Reports on Site Investigations provided by the Consulting Engineers (G. Maunsell and Partners) for the general guidance of tenderers for each of the contract sections.

Rock Excavation.

The cost of rock excavation is one of the few items in modern construction work that has decreased, and this is largely due to the greater power available from excavating machinery and more efficient drilling and blasting techniques. This means that deeper cuts are economically feasible and that cutting for river or route diversion is often preferable to bridging.

The original design proposals for the Avon Valley Deviation envisaged seven major bridges, consisting of three double crossings of the Swan-Avon largely in order to avoid tight curves, and a bridge crossing Wooroloo Brook. Alternative proposals for each of the double crossings were accepted because the low unit cost of rock excavation, accentuated by competitive tendering, revealed substantial economies for deep rock cuttings as opposed to the proposed bridging programme.

Each of the six abandoned bridge sites showed unusual geological features, and some of the wider applications of these are worthy of record.

Bridge Site 1 (Plate XVII).

A large exfoliating boss of granite gneiss forms most of the left-hand-bank of the Swan, with the exfoliation joints giving onion-skin layers of rock about 8 feet thick. The river direction appears to be controlled by a prominent joint-set in the quartzose granite of the bed with the dip about 60 degrees to the North. The right-hand-bank shows a 15-foot high alluvial terrace with horizontally banded sands, silts and humus. No solid rock shows in the bank and the terrace extends for 2½ chains where a granite spur is encountered. However, site investigations have disclosed the presence of a buried river channel 17 feet below the level of the existing channel. This former waterway is about 120 feet wide and about 10 feet of the channel bottom is filled with cobbles and small boulders. This buried river course indicates a Recent 20 feet depression, which is also shown by the drowned flood plains of the Lower Swan.

Bridge Site No. 2 (Plate XVII).

At the No. 2 site the river is running along the strike of a succession of altered sediments, and this southerly direction is also one of prominent shearing and jointing. The metasediments dip at 80 to 85 degrees to the west, and consist of hornblende and mica schists and highly siliceous cherty banded rocks. An exceedingly hard quartzose granite also forms part of the sequence, thus giving considerable relief to the channel cross-section as some of the schists are fissile and easily eroded. The most prominent joint-set in the area is at right angles to the river direction, and although of low frequency, is strongly developed. A notable trough, 40 feet wide, formed by plucking from between two of these big joints, crosses the bridge site near the right hand bank and the effect of the joint trough and the continuously varying rock types across the site meant that care was necessary in locating the five piers in order to avoid differential settlement.

Bridge Site 3 (Wooroloo Brook) (Plate XIX).

The South Gatta or Wooroloo Brook rises some considerable distance inland, and flows through a fairly steep sided valley, while in the last 1½ miles before the Swan Junction there is a fall of 100 feet, which is much greater than the drop in the Swan Valley itself. The stream finally flows through a deep trench with steep sides, contrasting with the flatter nature of the stream bed higher up the valley. At the junction of the Swan and Wooroloo there is a considerable amount of recent alluvium, and the Swan has been partially diverted with the formation of a steep cliff on the west bank.

The Swan flows in a remarkably straight course above the Wooroloo Junction, and a pool of considerable length remains during the summer. This is obviously in a sheared zone, easily eroded.

Drilling Results.—Four drill holes were put down at pier and abutment positions with a Gemco drill and a further hole was positioned between the Midland abutment and first pier in order to complete the site appraisal. Condensed logs, derived from the driller's log and examination of the core recovered, are given here:—

(a) *Borehole 25.13.1:*

0-10 feet: Boulders and clay (recent stream action).

10-20 feet: Clay, sand gravel.

20-51 feet: Boulders, stone, sand, in old river deposit some boulders highly weathered.

(b) *Borehole 25.13.8:*

0-10 feet: Cobbles, clay and gravel, recent stream deposit.

10-19 feet: Clays, sandy and gravelly.

19-26 feet: Clay sand with weathered stones.

26-30 feet: Clay with sand and gravel.

30-45½ feet: Stones up to 1 ft. 6 in. in clay and sand—old river deposit.

45½-50 feet: Highly weathered granite.

(c) *Borehole 25.14.6:*

0-8 feet: Surface boulders in stream bed.

8-15 feet: Clay.

15-34 feet: Sand with organic fragments.

34-35 feet 9 inches: Schist lens.

35 feet 9 inches-44 feet: Granite, slightly weathered.

(d) *Borehole 25.16.1:*

0-25 feet: Cobbles, sand and clay.

25 feet: Granite shattered near surface, improving immediately to solid rock.

(e) *Borehole 25.17.6:*

0-23 feet: Clay and sands.

23-30 feet: Weathered dolerite.

30 feet: Relatively fresh dolerite.

Foundation Appraisal.—The local geology in relation to the original bridge site is shown on the accompanying sketch plan and section (Plate XIX). The most striking feature is the fact that the shear zone controlling the Swan Valley and the granite/gneiss junction passes through the proposed bridge site. This is reflected in the great depth of alluvium in the bores at the Midland end. Undoubtedly this represents an older buried channel of the Swan, as the Wooroloo is rock bound about 100 yards upstream. The Swan was displaced from this channel by the debris brought down by the Wooroloo, and also the base level of erosion must have been lowered by a depression of the order of 20 feet. This accords with the fact that there is a buried channel at the 1st Bridge site, 17 feet below the existing stream bed.

There would be no particular merit in moving the bridge along the proposed line as heavy cutting costs would be involved to realign the Wooroloo Channel in the dolerite upstream. Shifting the bridge up the Wooroloo was undoubtedly the best solution, and this was adopted. If the bridge had been left on the original alignment, steel H piles would have been necessary to obtain foundation in the old river levels. The possible foundation depth at the new site may vary between 30 feet and surface exposures. Steel H piles would undoubtedly penetrate or turn the weathered granite cobbles as disclosed in the cores, but the dolerite boulders may fill the web or turn the point of the pile.

Debris Slides.

There is an area of substantial cut commencing at the 27m. 01c. and extending through to 27m. 13c., with a maximum cut of 26 feet at 27m. 03c. The sections at the beginning of the cut area show a vertical or overhanging rock cliff above the river channel, then steep debris slopes (35°) which rise to a flat terrace, showing rock exposures 120 feet above the river. From 27 miles 5 chains to 7 chains there are signs of slow movement of the natural soil and rock detritus above granite bedrock of the debris slide type. In determining the stability of this area during and after construction, the critical factor is the depth of debris over granite, as the formation will be stable if the debris is no thicker than 10 feet, but unstable for greater thickness (Figure 8). Probing with hand augers proved ineffectual, and in an attempt to provide some data for design purposes a traverse was made with the Model R117 Seismic Timer. This work indicated a spoon-shaped depression in the granite with a maximum depth of 25 feet at 23 miles 4.5 chains, rising to about 15 feet from the surface, 60 feet on either side of that point. Seismic velocities indicate that there is about 10 feet of weathered granite at the Midland end, but this disappears in the middle of the rock depression. The bulk of the material filling the channel appears to be slide debris and the products of rock weathering under a soil and rubble cover. It would appear likely that the granite rises further, and almost reaches the surface in either direction.

On the basis of this evidence it would appear that only a small section of the cut would require special remedial treatment other than battering back and the provision of a bench in the solid. The area where the downhill part of the cut is entirely in debris, and thus the roadbed formation is liable to movement, may be from 23 miles 2 chains to 23 miles 5 chains. The most suitable form of protection would appear to be the provision of a rock buttress retaining wall, keyed into the solid rock.

Fig. 8. Rock joints at 21m. 17ch., Avon Valley deviation.

Rock Cuttings.

The shape of a cutting in rock is governed by the required depth of cut, the local topography, and the required angle of slope. Soil-mechanics tests will readily give permissable slope angles for unconsolidated materials, whereas it is universal practice for slopes in rock to be decided empirically. The drawback of this procedure is that the inherent stability of the slope, and thus the degree of safety is not known. To keep a cutting absolutely safe, the high cost of flat batters must be faced. On the other hand if money is to be saved by using steep slopes, the risk of some undefinable danger is encountered. The newly developing field of rock-mechanics has now made it possible for rock to be described as a material with nearly the same accuracy that soil-mechanics achieves with clay and sand.

Rock stability and permissable slope angles of open cuts are governed by 9 main considerations:—

(1) Rock type.
(2) Rock strength etc.
(3) Stratification and foliation etc.
(4) Mechanical Fragmentation etc.
(5) Chemical weathering.
(6) Positional relationship between the slope plane and structural elements.
(7) Time.
(8) The presence of water in joints.
(9) Vibrations during construction or from traffic.

The most important element is mechanical fragmentation, such as small joints, big joints, faults and fractured zones, and the mechanical behaviour of the rock is determined largely by the type, size and extent of these small tectonic elements, the condition of their surfaces, the width and filling of gaps, but most of all by their direction and location. The stability of rock formation is largely dependent on their structure, and only to a small extent on their material.

The various major rock cuts along the first and third contract sections have been examined, and an attempt has been made to assess the permissable slope angle. The final consideration of course, will be the engineer's decision on the rock face as exposed, but the estimated angles are applicable for design purposes. A firmer basis of calculation would have entailed the use of cored drill holes to enable an in situ view of the jointing and a detailed examination of fresh rock immediately on removal of overburden and cover. Additionally, the use of a seismic timer would also possibly assist in the determination of the degree of weathering and of joint penetration into the solid.

Two examples of the nature of the assessment involved are given.

(a) Rock cut from 22 miles 6 chains to 22 miles 19 chains. (old chainage) with a maximum cut of 41 feet at 22 miles 13 chains. The rock is characteristically a quartzose granite but some differences will be encountered along the cut, as minor schist and chert bands are locally prominent. Weathering extends largely along the joints which appear to be open well into the rock mass, and as all the vertical joint faces are iron stained, a certain amount of seepage may be expected in a wet season. The joint system as shown in Plate XX is fairly simple as the major joints are vertical or close to vertical. The dominant joint is at 35 degrees to the centre line and this is parallel with the foliation or major trend, while the second major set is at right angles to this direction with the dip ranging from 85 degrees to vertical, i.e., 80 degrees or vertical apparent dip when turned into the excavation. The third joint set is horizontal, and has rather feeble incidence and persistence, in marked contrast to the other two sets.

The degree of disintegration by chemical weathering is not high, but the rock is intensely jointed thus the rock may be classified on the third scale of breakdown. The interaction between the joints is negligible as they are at right angles, and the compound resistance of the rock will be of the steps-of-joints type where most of the breakage will be along the pre-existing 105 degree joint, with short connecting fractures in the solid rock. In effect the permissable angle of slope may be as high as 75 degrees overall, and a factor of safety may be introduced by the cutting of two benches, with the rock slope between the benches near the dip of the main joint into the excavation.

The joint intersections tend to produce tabular blocks of rock nearly face-on to the length of the cutting, and shooting will be necessary for excavation.

When the alignment was altered to eliminate Bridges (1) and (2), a considerable amount of rock cutting was planned, including a new major cutting through the initial scarp, and lengthening and intensification of the cut formerly commencing at 22 miles 6 chains. This new work was not included in the route appraisal, and it was only after construction was well advanced that it was geologically examined in detail. The cutting extends from 21 miles 75 chains to 22 miles 14 chains involving a maximum cut of 85 feet at 22 miles 75 chains.

On opening up it was obvious that rock types other than granite were involved, and as highly jointed and weathered metasediments were revealed in the Midland end of the cut it became apparent that the proposed 1 : 4 batters would be too steep. The geology as exposed in the excavation on 17th December, 1962, revealed that from 21 miles 75 chains to 22 miles 6 chains the cutting would be in highly broken and weathered schists and cherts with granite-gneiss from 22 miles 6 chains to the end of the cut. The granite is in effect the same rock whose properties have been detailed from the abandoned cut 22 miles 6 chains to 22 miles 19 chains (old chainage). Thus the batter slope may be as steep as 75° as the slightly altered direction means practically the same spatial relationship between the joints and the cutting.

The cherts and schists are in places intensely jointed and sheared with breakages resulting from faulting and this, combined with the high degree of chemical weathering, has effectively reduced the rock strength. Against this is the fact that ridges of resistant quartzose rocks form topographic highs or spurs and these provide some measure of added stability. The combined chemical and mechanical breakdown indicates properties of the 5th order, and this in conjunction with the major joint (75°-80° at 45° to the cutting) indicates that the batter slope should be no steeper than 55° or $\frac{3}{4}$: 1.

There are some practical difficulties in having two different slopes in the cutting involving a transition but the appearance of a cutting briefly seen from a train, matters less than considerable economy of construction.

(b) Rock cut from 22 miles 67 chains. to 23 miles (old chainage) with a maximum of 24 feet of cut at 22 miles 78 chains. This cutting is situated on a curve and a considerable portion is traversed by a lens of basic material which lies along the line and then crosses it, over a distance of 5 chains. Otherwise the cut will be in granite-gneiss, and there is a cover of up to 10 feet of rock rubble over both types of rock. The dark coloured basic material has been less affected by weathering than the surrounding granite. The major joints in the basic lens are at 30° and 120° to the direction of the railway, and dip from 80° to 90°, and this would mean joints dipping at about 70° into the cut. In the deepest part of the cut, in granite-gneiss, the main joints are along the line and at right angles to it, while a minor joint at 25° to the line dips towards the river at 75° which would mean a 57° dip into the cut. As the major joint along the line has an angle of between 75° to 90°, it would appear that the limiting factor is the 57° into-the-cut-joint which shows openings of up to $\frac{1}{8}$ inch, is discontinuous, shows faces about 4 feet long and occurs once every 4 feet. There will be no inter-action between this fracture and the major joint at 75° into the cut, as the latter dips away from the river i.e. uphill, while the minor joints dip in the opposite direction. There will be interaction with the major joint at right angles to the line, as it dips 15° along the line and some rock falls are to be expected from wedges of rock of small size. It is considered that the type of fracture to be expected would be steps of fracture between pre-existing joint planes. The resistivity figure of the bonding shows that the permissible slope angle is of the order of 60°.

Abandoned Bridges Nos. 4, 5, 6 and 7.

Bridge Site 4.—Bridge Sites Nos. 4 and 5 are situated across a meander of the Avon in the vicinity of West Toodyay. The existing channel is in the middle of the proposed 700 feet structure of Bridge 4 and this is near the highest point of the bedrock surface, as under the Midland abutment there is a buried channel 50 feet deep and at least 250 feet wide, with boulders and cobbles in clay along with sands and clays filling to the surface. At the Northam end too, there is a former channel, now buried, with a depth of 22 feet and a width of 175 feet.

Bridge Site 5.—Here there are depressions in the granite-gneiss surface that correspond to former river courses—22 feet deep under the Midland Abutment, 50 feet deep in mid-channel, and 30 feet deep under the Northam abutment, although the drillers' log for the latter would fit for a decomposed granite sequence as ambiguous terms such as "clay" and "gravel" are used.

Bridge Site 6.—Four miles east of Toodyay the Avon swings in a large "S" bend round two parallel quartzite spur ends, with the river direction at either end faithfully following the strike direction of easily eroded mica-schist. The section across Bridge Site 6 is shown in Plate XX, and the succession is of soft quartzite, weathered to 40 feet; a band of hard quartzite forming a strike ridge; weathered mica schist; a fault zone; weathered hornblende schist; then soft mica schist followed by quartzite, forming the hill beyond the Northam abutment. Strong weathering in the schists has extended at least as deep as 60 feet, and the high angle of dip of the various layers (60°-80°) means that conditions are varied in the extreme.

Bridge Site 7.—This site exhibits a varied succession of rock types presenting no great foundation problems, however, there is the usual buried channel, 40 feet deep, in the centre of the site.

BALLAST AND BORROW MATERIALS.

Requirements for Railway Ballast.

Ballast is the natural or artificial material that supports the railway sleepers in the permanent way and transfers the train loads to the subgrade. The type and thickness depend on traffic and, of course, on economic considerations. In addition, drainage conditions of the subgrade, climate, and the bearing properties of the subgrade have to be assessed. Ballast must be elastic in order that the ties and rails can return back to true line and grade after the passage of the train. Ballast also has to reduce dust and weed growth, and should permit satisfactory cleaning and repacking, and crushed stone is the best ballast-type from this point of view.

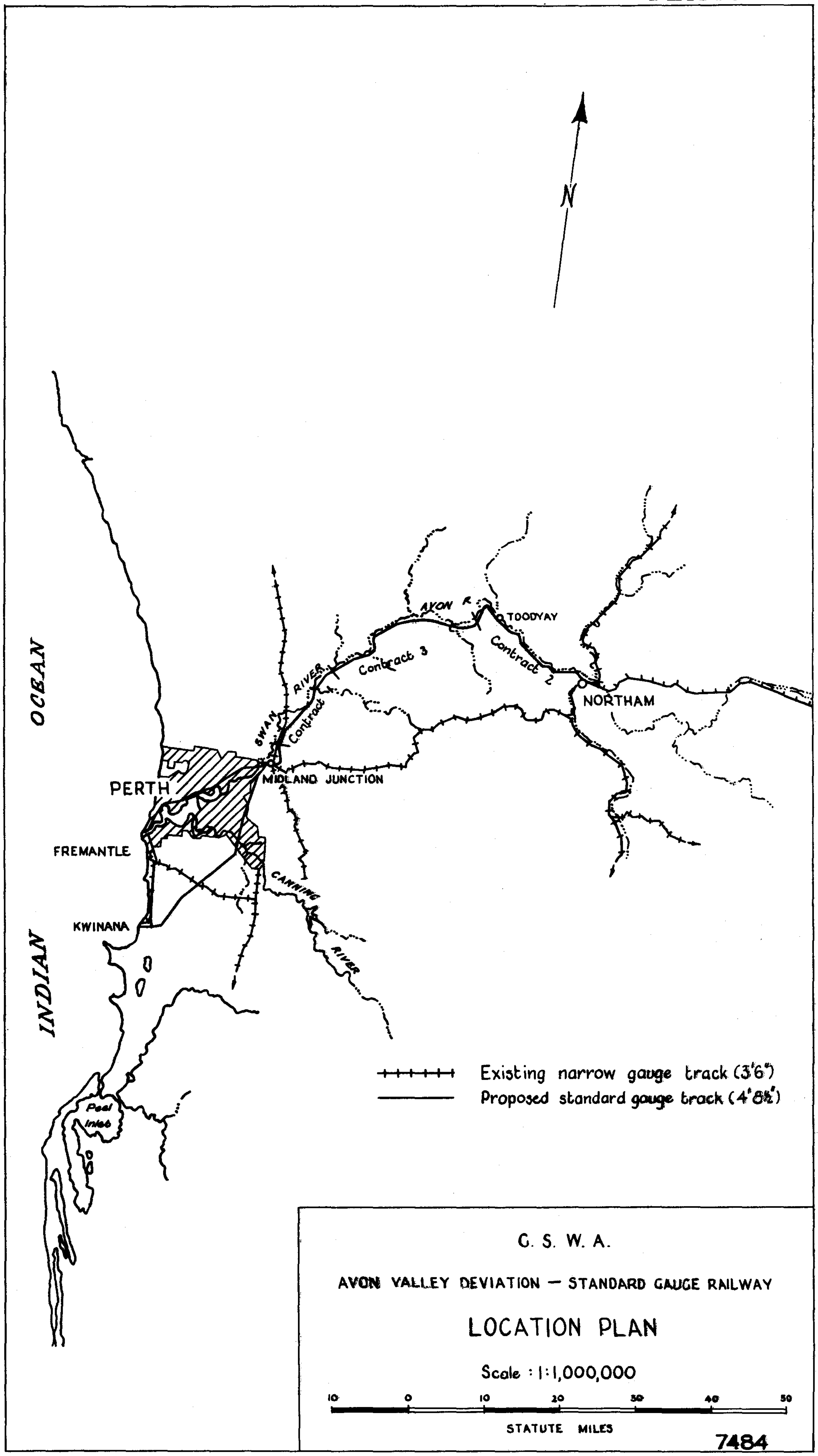
Ballast aggregate must be notably resistant to impact, as railway engines, in particular, impose heavy loads suddenly applied. Furthermore, the ballast particles must have a high resistance to abrasion, as movement induced by a series of cars tends to induce autogenous grinding.

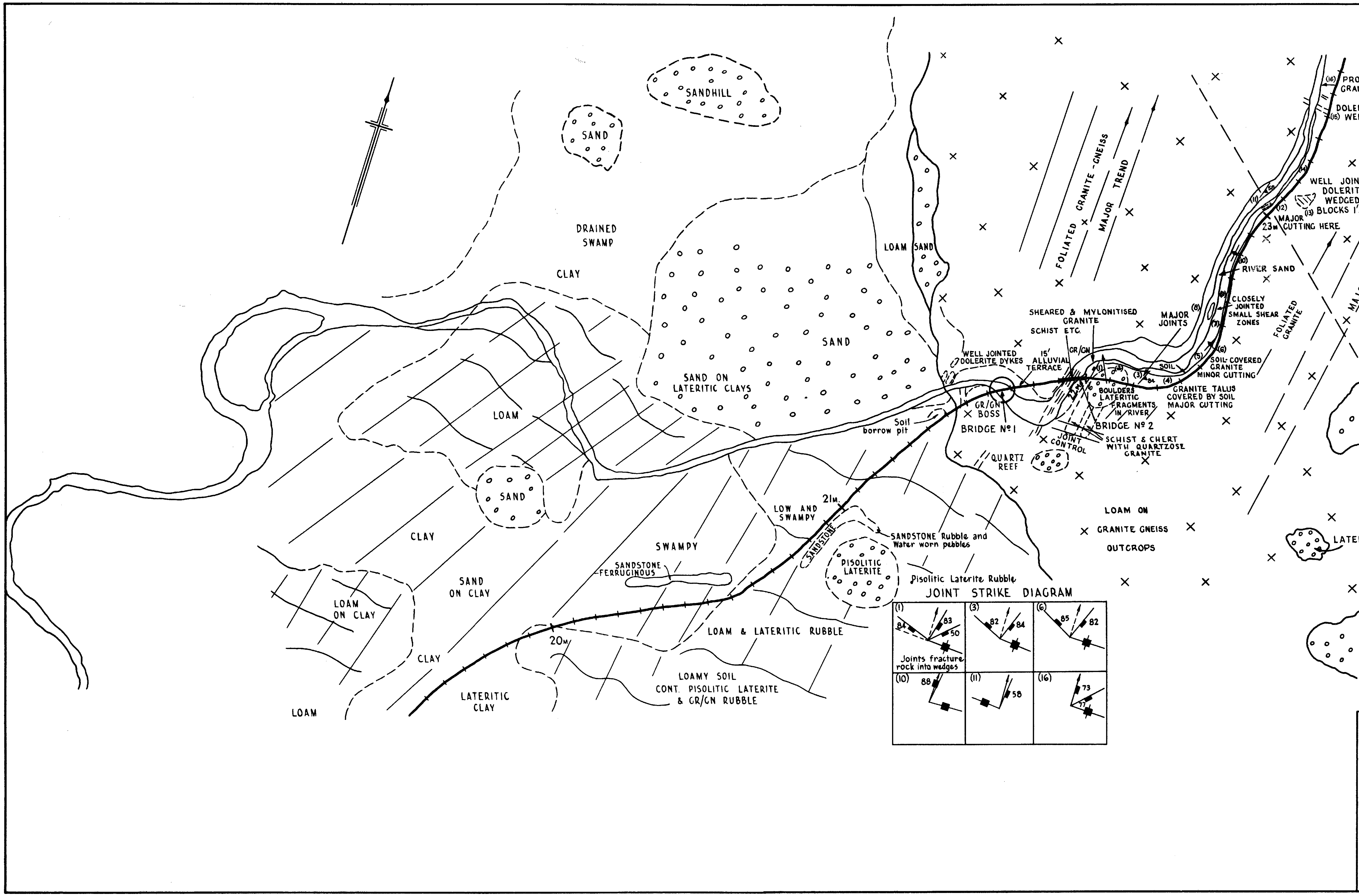
Glassy or brittle rocks, e.g., those containing considerable amounts of quartz or mica, are usually not suitable because of poor impact resistance. The best rocks are those usually known as the "traprocks" or "bluemetal"—basalts, dolerites, diorites, etc. Granites are sometimes not desirable because of interlocking texture causing difficulty in crushing, and sometimes because of a low abrasion resistance. The "traprocks" on the other hand are naturally blocky and brittle enough to crush easily in mechanical crushers; but not under traffic conditions. Quartzites are also excellent sources of ballast if not excessively jointed.

Rock Types.

Dolerites and Epidiorites.—These are dense, dark and fine grained igneous rocks which occur as minor intrusives, usually in the form of dykes, with a width varying from a few inches to over 200 feet and with a length of up to 3 miles. There is no preferred orientation, although many of the dykes in the Perth Metropolitan area lie either in the N.W. or N.E. directions with minor E.W. intrusives generally connecting the major units. Dyke intersections are common, and in some areas the dykes are so numerous and closely spaced as to constitute 80 per cent of the surface outcrop over an

PLATE XVI


N
OCEAN
INDIAN
PERTH
FREMANTLE
KWINANA
MIDLAND JUNCTION
SWAN RIVER
AVON R
TOODYAY
NORTHAM
Contract 1
Contract 3
Contract 2
CANNING RIVER
Peel Inlet
Existing narrow gauge track (3'6")
Proposed standard gauge track (4'8½")
G. S. W. A.
AVON VALLEY DEVIATION — STANDARD GAUGE RAILWAY
LOCATION PLAN
Scale : 1:1,000,000
10 0 10 20 30 40 50
STATUTE MILES
7484



G. S. W. A.

AVON VALLEY DEVIATION - STANDARD GAUGE RAILWAY

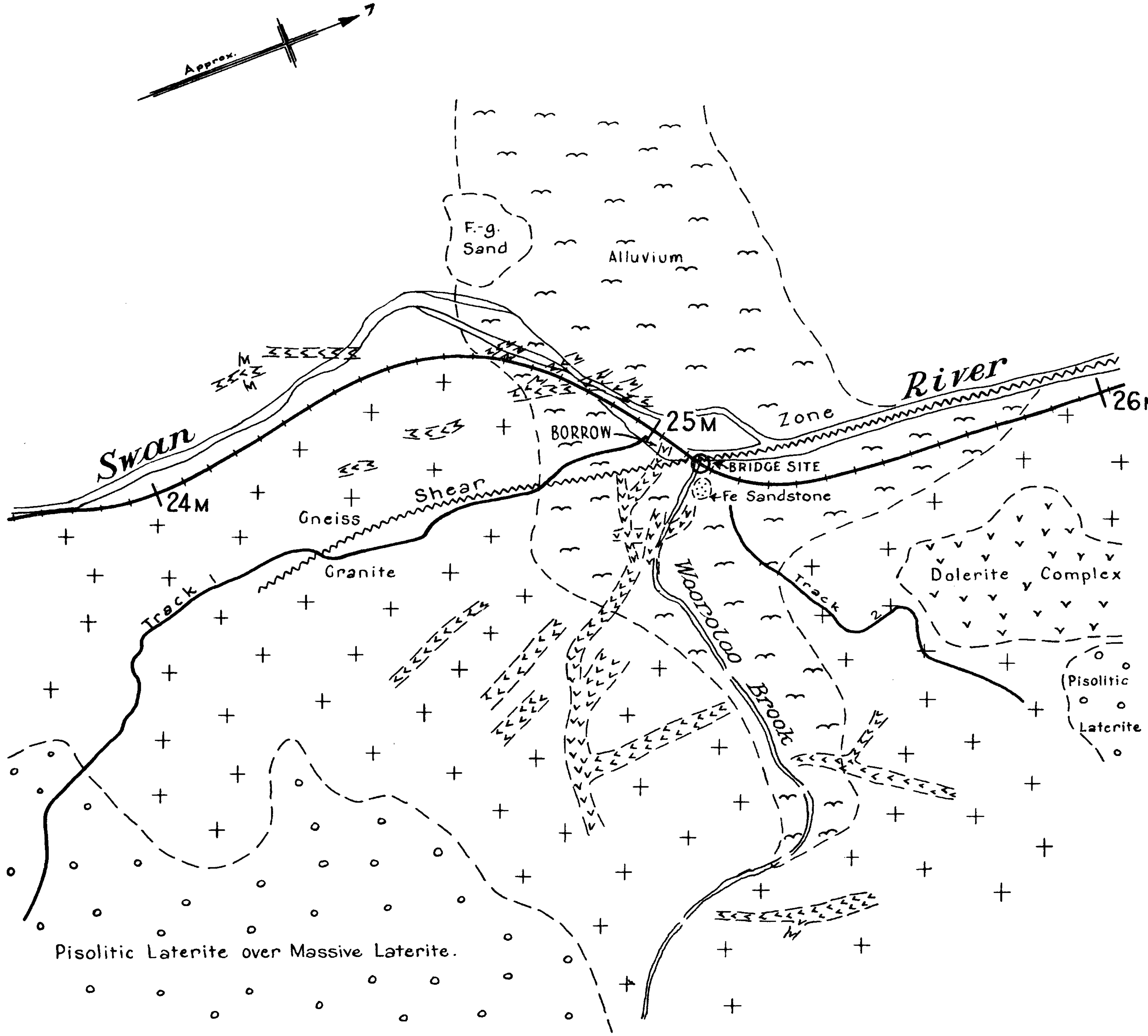
GEOLOGICAL FORMATION
19M 30C to 23M 40C

Scale: approx. 1:15,000

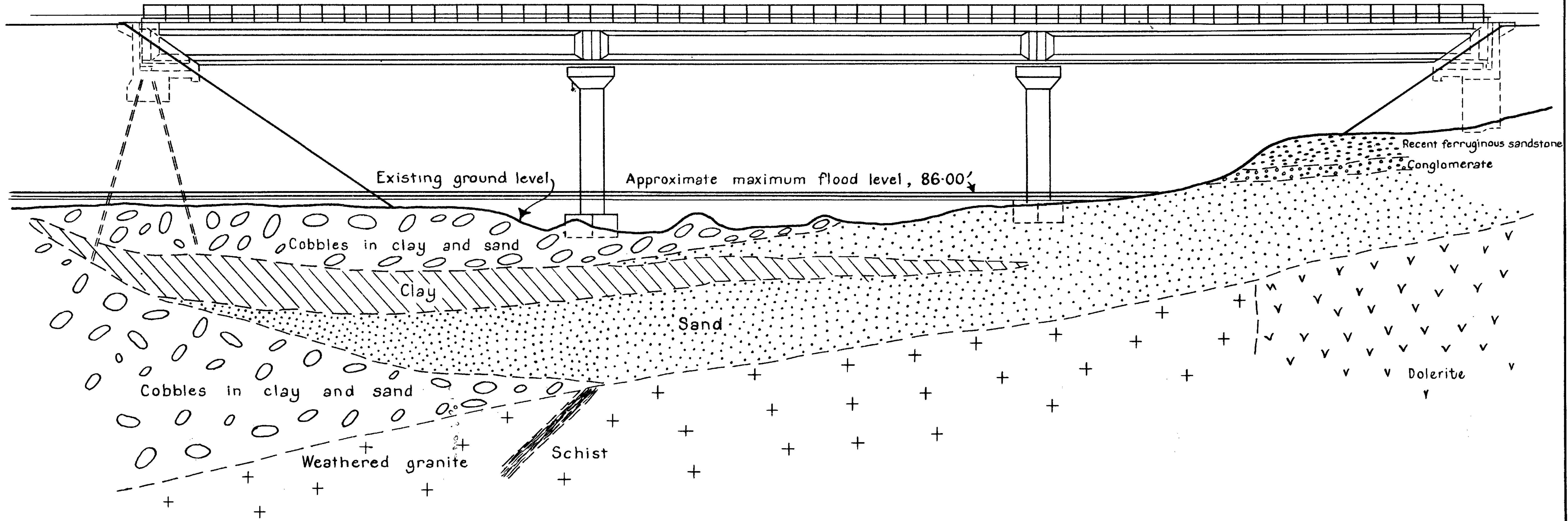
May 1962
F.R.G. & J.D.W.

7485


G.S.W.A.
AVON VALLEY, DEVIATION — STANDARD GAUGE RAILWAY
GEOLOGICAL FORMATION
55M to 63M
Scale: approx 1:15,000
MAY 1962
F.R.G. & J.D.W.
N
CULTIVATED SOIL COVER
55M
GRANITIC RUBBLE AND SOIL
MINOR CUTTING ALONG HILL SLOPE
STRONG FOLIATION LINES
CLAY SOIL
56M
CREEK
MINOR FILL
57M
TOODYAY TOWNSITE
BOUNDARIES
APPROXIMATE BUILT UP
GRANITE GNEISS
MICA SCHIST
58M
MINOR FILL
GRANITE GNEISS
CREEK
SOIL AND GRANITE GNEISS RUBBLE
CULTIVATED SOIL
59M
MINOR CUTTING
MINOR FILL
SOIL AND RUBBLE
CREEK
MICA SCHIST AND QUARTZITE CLAY SOIL
CLAY SOIL OVER MICA SCHIST
LATERITE & ROCK RUBBLE
60M
BRIDGE SITE 6
BRIDGE SITE 7
UNDER ALLUVIAL COVER 20'-30'
RIVER 30' DEEP SAND BOTTOM
LATERITE PIT
WELL JOINTED QUARTZITE
MICA SCHIST
HORNBLENDE SCHIST
RIVER TERRACES
PROBABLE BORROW SOURCE LATERITE UP TO 15' THICK
QUARTZITE
MICA SCHIST
QUARTZITE RUBBLE
JOINTED QUARTZITE
HORNBLENDE SCHIST
WINDMILL HILL
SOIL AND QUARTZITE RUBBLE
MICA SCHIST
GRANITE GNEISS
SOIL COVER
62M (O.C.)
QUARTZITE
HORNBLENDE SCHIST
MICA SCHIST
QUARTZITE
QUARTZITE
GRANITE GNEISS
M/S
63M
JOINT STRIKE DIAGRAM
N
52°
S70E
80°
S80W
N40W
N50E
50
7486



SITE PLAN
Scale : 20 chains to 1 Inch



GEOLOGICAL SECTION ALONG CENTRE LINE
Scale: 20 feet to 1 Inch

G.S.W.A.
AVON VALLEY DEVIATION - STANDARD GAUGE RAILWAY
SITE GEOLOGY - BRIDGE Nº 3 - WOOROLOO BROOK
SCALES { SITE PLAN 20 Chains to 1 Inch; SECTION 20 Feet to 1 Inch }
May, 1962
F.R.G., J.D.W.
7487


60M 45·8c
No 0
456'
Stony Subsoil
Gravel and Cobble in Clay
Boulder
Soft Sandstone
Conglomerate
Soft Sandstone
Gravel in Silty Clay
DRIFT
AND
ALLUVIUM
HIGHLY DECOMPOSED QUARTZITE
No 1
446'
Cobble and Gravel in Clay
Soft Rock in Clay
Clay
Gravel in Clay
Boulder
Soft Brittle Rock
Gravel and Cobble
Bedrock
No 2
435'
Clay
Cobble and Gravel in Clay
Quartzite
STRIKE RIDGE
No 3
431'
Clay
Gravel in Clay
Clayey Sand
Sand
Washed Gravel
Boulder
Quartzite
QUARTZITE
60° Dip
450' ABOVE DATUM, LOW WATER MARK, FREMANTLE
No 4
426'
Sandy Clay
Gravel, Clay and Cobble
Gravel, Cobble and Boulders
Possibly 40 feet of alluvium
ALLUVIUM
No 5
424'
MICA SCHIST
No 6
435'
Clay
Sand
River Grit and Gravel
Gravel, Clay and Cobble
Boulder
Sandy Clay
Silty Sand
Clay
TERRACE
CRUSH ZONE
HORNBLENDE SCHIST
No 7
431'
Sandy Clay
River Sand and Gravel
Sandy Clay
Soft Brown Clay
Soft Grey Clay
Gravel in Green Clay
MICA SCHIST
Dip 60° to Vertical
No 8
443'
Subsoil
Conglomerate
Sandy Clay (Grey)
Soft Clay (Yellow)
Soft Grey-Brown Clay
Soft Sandy Yellow Clay
Firm Grey-Brown Clay
DRIFT AND ALLUVIUM
MICA SCHIST
60M 59·3c
No 9
456'
Subsoil and Stones
Conglomerate
Sandy Grey Clay
Firm Brown Sandy Clay
Soft Rock
Sandy Clay
Soft Grey Clay
Geological Interpretation :- ALLUVIUM
Drillers' Log :- Sandy Gravel
Drill Hole, with Collar R.L.
No 4
426'
G.S.W.A.
AVON VALLEY DEVIATION - STANDARD GAUGE RAILWAY
SITE INVESTIGATION - BRIDGE No 6
60M 45·8c TO 60M 59·3c
SCALES - Horizontal : 30 feet to an Inch
Vertical : 10 feet to an Inch
Prepared by F.R.G.
January, 1963
Based on 6102/P172
G. Maunsell and Partners
7488

area, say, of a mile square. The dykes can usually be identified on airphotos as discontinuous, dark, thick, lines contrasting with the lighter coloured surrounding granite. On the ground the dolerite is often more resistant to weathering than granite and the "backbone" of many spurs and ridges is doleritic. The dykes can be traced in the field by means of pieces of broken rock and by a characteristic dark red colouration of the residual soil lying on top of the basic dyke. Laterite exhibits a brick red colour over dolerite, but caution must be exercised here, as intense heat from a bush fire can cause a similar colouration. Where there is no surface outcrop due to the presence of a residual cover, the dykes can often be traced by the greater growth of larger trees on the richer soil derived from the dolerite.

The larger dykes show fine grained margins with crystal size increasing in towards the centre, in places giving a coarse-grained rock or gabbro, known to local quarrymen as "spotted dick." Some dykes show extensive shearing at the margins, especially so with the epidiorites or lighter hued varieties, and the production of dimension store from these is precluded.

Most of the local working quarries commenced cperating on a dyke or dyke intersection, and the need to maintain an even quarry face has meant that the amount of dolerite has decreased as the face advanced (e.g. Boya).

Granites.—The granites comprise the greater portion of the Darling Range in the Metropolitan area. These acid rocks are usually white to grey in colour and are characteristically coarse grained, but no distinction is usually made between the various types: white granite, grey granite, gneissic granite and banded gneiss. Gneissic material is undesirable in a quarry and should be avoided due to poor particle shape and abrasion loss.

The granite may show weathering to considerable depths, and even in some operating quarries entirely fresh rock has not yet been reached at a distance of 200 feet into the hill. Some granites exhibit no defect in hand specimen, but a high Los Angeles abrasion test result may indicate partial crushing, a condition a petrological examination will quickly confirm. Quite often darker coloured lenses (basic) are encountered within the granite and these are sometimes coarse grained.

Joints are another main consideration in locating a quarry in granite, and massive jointing is necessary for an equidimensional product. Outcrop jointing generally reduces in incidence at depth, leaving usually a major joint parallel to the foliation or grain of the granite and another at right angles to this. Both these joints tend to be vertical, and the next most prominent joint is usually horizontal. Careful consideration of the outcrops is essential to establish if there is a local joint pattern, and if this is intense, further work is probably not warranted.

Many of the working and abandoned quarries in the vicinity of the railway were examined, and details have been reported in the Records of the Geological Survey of Western Australia.

Planning for Ballasting.

A ballast requirement of 2,900 cubic yards of rock to the mile over a distance of 63 miles of track will mean the provision of approximately 190,000 cubic yards of material. The various practical alternatives appear to be:—

(a) Provision of the whole quantity from a quarry near the middle of the run i.e. in the vicinity of the 40-50 mile pegs. This could be achieved from a possible site quarry near the 48 mile peg.

(b) Equal quantities could be provided from either end, from near Midland Junction and from the Northam area. An abandoned quarry on the Spencers Brook road, and Stathams (P.C.C.) abandoned Quarry, appear as the most desirable choices, with the possiblity of opening another quarry on the same dolerite dyke if Stathams is disposed of, before ballasting commences. This scheme would involve then the reopening of two existing quarries and thus the provision of 2 sets of crushing and screening plants.

(c) In order to reduce the capital outlay it may be felt desirable to only open (or reopen) one quarry, say at Northam, and to call for tenders for supply at the Midland end. For this alternative Spencers Brook Quarry, and the most economical price from the Darling Range quarries that produce satisfactory ballast will be preferred.

(d) From the point of view of railway engineering the most conventient situation would probably be the supply of ballast at one of the existing railroad sidings as close as possible to Midland Junction. This would enable ballasting and track laying to proceed up the Swan Avon Valley with the track materials following up the line from Perth. From this aspect a quarry situated between Bellevue and Chidlow, say, on the Great Eastern Railway or in the Darling Range would be in the optimum position. For that reason, a quarry near the railway at Greenmount Block must be considered, However, the fact that Stathams is already developed, and that a temporary track could be quickly laid on the old railway embankment running right into the quarry (a distance of 240 chains) is of major importance.

Borrow Materials.

The material most favoured for use in embankments and formation in the S.W. portion of the State is the weathering product known as laterite. Three forms may be distinguished:—

(i) Pisolitic laterite or "ironstone gravel" which occurs as a thin veneer and in small pockets on top of massive laterite. The reddish brown rock is composed of spherical pebbles loosely cemented together by a lighter coloured earthy matrix.

(ii) Massive laterite or "ironstone" has a wide distribution over the Darling Ranges, usually above the 690 feet contour, and occurs as a superficial layer usually bebetween 10 and 15 feet thick.

(iii) Lateritic gravels are developed on the face of the Darling Scarp and as piedmont deposits at the foot of the scarp. The deposits are limited in extent and lenticular, and have been heavily exploited.

These three lateritic materials are formation-building soils of the highest quality.

WELLS DRILLED FOR PETROLEUM EXPLORATION IN WESTERN AUSTRALIA TO THE END OF 1962.

by P. E. Playford and D. C. Lowry.

INTRODUCTION.

A total of 57 oil-test wells have been completed in Western Australia. Of these, 30 are in the Canning Basin, 21 are in the Carnarvon Basin, five are in the Perth Basin, and one is in the Ord Basin. A further test well is currently being drilled in the Perth Basin. In addition, some 56 wells have been drilled for stratigraphic and structural information in connection with oil exploration in the Canning, Carnarvon, Perth and Eucla Basins, and another is now being drilled in the Perth Basin. No wells have yet been drilled in the Officer Basin, nor in that part of the Bonaparte Gulf Basin lying in Western Australia.

The positions of wells drilled to the end of 1962 are shown on the accompanying map (Plate XXI), and summary information on each well is given in the accompanying table.

HISTORICAL REVIEW.

The first wells drilled for oil in this State were put down in 1902-04 near the Warren River, in the southern part of the Perth Basin. They were drilled following the discovery of small quantities of bitumen washed up on the coast in this area, and because the local residents had noticed that their tea had a strong flavour of "kerosene" when made from water obtained in certain localities. The ensuing "oil boom" was not followed by the discovery of any oil.

In 1919 intense interest was aroused by the report of traces of oil in a water bore being drilled on Gogo Station in the Kimberley District. The report was confirmed by a geologist, and as a result the Freney Kimberley Oil Company was formed. This company drilled a number of wells in the Canning Basin in the years 1922 to 1941, but without success. The interests of the company were taken over by Associated Freney Oilfields N.L. in 1954, and this organization has since drilled three test wells in the Canning Basin.

The first large-scale exploration in this State employing modern geophysical and drilling techniques began in 1952, when West Australian Petroleum Pty. Ltd. (Wapet) commenced operations in the Carnarvon Basin. This company had spectacular success in 1953 with its first well, Rough Range No. 1. This well produced oil at a rate of 500 barrels per day from Lower Cretaceous sands of the Birdrong Formation, at a depth of 3,602 feet. Since then the company has drilled a total of 35 test wells without further success, other than in Rough Range No. 1A, which was drilled a few yards from the discovery well. The company holds exploration permits covering most of the Canning, Carnarvon, and Perth Basins, and it is continuing with active exploration in each.

For more detailed information on the status of oil exploration in Western Australia the reader is referred to publications by Hobson (1936), Playford and Johnstone (1959), Bureau of Mineral Resources (1960), McWhae (1960), and Playford (1962).

EUCLA BASIN.

The only wells drilled for oil exploration in the Eucla Basin were put down in 1960 by Exoil Pty. Ltd. to obtain stratigraphic information. These two wells, Eyre No. 1, and Gambanga No. 1, entered Precambrian basement rocks at shallow depths.

PERTH BASIN.

Five oil-test and seven stratigraphic wells have been completed in the Perth Basin. With the exception of three shallow test wells drilled by the Westralian Mining and Oil Corporation in 1902-04 near the south coast, drilling has been concentrated in the north-central part of the basin. Two test wells and five stratigraphic holes have been drilled by Wapet, and two stratigraphic holes by the Bureau of Mineral Resources. Wapet is currently drilling oil-test and stratigraphic wells at Woolmulla and Eganu respectively, but the greater part of the basin remains untested.

CARNARVON BASIN.

All the test wells drilled to date in the Carnarvon Basin have been put down by Wapet. Most are concentrated in the Exmouth Gulf area, where a total of 17 have been drilled. In addition, several of the Tertiary anticlines outside this area have been tested, but there are no test wells in the central and eastern parts of the basin.

Wapet has completed 30 stratigraphic and structure holes in the Carnarvon Basin, and a further five have been put down by the Bureau of Mineral Resources. Most of the Wapet holes were drilled for structural information on the Rough Range and Dirk Hartog Anticlines.

Although the initial success at Rough Range Nos. 1 and 1A has not been followed by further oil discoveries, some of the other test wells have had showings of oil or gas, especially Cape Range Nos. 1 and 2, which recorded substantial gas showings.

CANNING BASIN.

In the Canning Basin, exploratory drilling has been restricted to the northern part and the coastal strip, where a total of 30 test wells and 8 stratigraphic holes have been drilled. A huge area, covering the central and western parts of the basin, remains untested, mainly because of its inaccessible and inhospitable nature.

Wapet has drilled more holes (14 oil-test and 3 stratigraphic holes) in the Canning Basin than any other organization. The rest have been put down by the Freney Kimberley Oil Company (13 oil-test holes), Associated Freney Oilfields N.L. (3 oil-test holes) and the Bureau of Mineral Resources (5 stratigraphic holes).

Traces of oil and gas have been reported from a number of wells drilled in the Canning Basin, and one, Meda No. 1, produced a few gallons of oil from the Lower Carboniferous sequence.

ORD BASIN

In 1920 bitumen was discovered at two localities in the Ord River area, in jointed and vesicular basalts underlying Lower Cambrian limestones. This discoverey led to the formation of the Okes Durack Kimberley Oil Company, which drilled one dry hole in 1924. Since then there has been no serious oil exploration in the basin.

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WELLS DRILLED FOR PETROLEUM EXPLORATION IN WESTERN AUSTRALA. TO THE END OF 1962.

Name	Type	Location		Depth (feet)	Bottomed in	Drilled for	Year completed	Remarks
		Lat. (S.)	Long. (E.)					
Eucla Basin.								
Eyre No. 1	Strat.	32° 07′	126° 58′	1,718	Precambrian	Exoil	1960	
Gambanga No. 1	Strat.	32° 16′	124° 50′	1,282	Precambrian	Exoil	1960	

WELLS DRILLED FOR PETROLEUM EXPLORATION IN WESTERN AUSTRALIA. TO THE END OF 1962—*continued.*

Name	Type	Location		Depth (feet)	Bottomed in	Drilled for	Year completed	Remarks
		Lat. (S.)	Long. (E.)					
			Perth Basin.					
Abbarwardoo No. 1	Strat.	28° 35′ 10″	115° 09′ 35″	2,000	L. Permian	WAPET	1962	
B.M.R. No. 10 (Beagle Ridge)	Strat.	29° 49′ 38″	114° 58′ 30″	3,910	L. Permian	B.M.R.	1959	Minor oil shows.
B.M.R. No. 10A (Beagle Ridge)	Strat.	29° 49′ 38″	114° 58′ 30″	4,862	Precambrian	B.M.R.	1960	Minor oil shows.
Eganu No. 1	Strat.	29° 59′ 05″	115° 49′ 35″	....	....	WAPET	....	Drilling.
Eneabba No. 1	Oil test	29° 34′ 14″	115° 19′ 56″	13,712	L. Triassic	WAPET	1961	Minor oil and gas shows.
Hill River No. 1	Strat.	30° 16′	115° 18′	1,900	L. Jurassic	WAPET	1962	Five coal seams, 2 to 3 feet thick.
Hill River No. 2	Strat.	30° 11′	115° 14′	1,620	L. Jurassic	WAPET	1962	Minor lignite.
Hill River No. 3	Strat.	30° 00′ 32″	115° 11′ 13″	865	U. Triassic	WAPET	1962	
Hill River No. 4	Strat.	30° 23′ 24″	115° 13′ 49″	1,010	U. Triassic	WAPET	1962	
Jurien No. 1	Oil test	30° 08′ 40″	115° 02′ 54″	3,366	Precambrian	WAPET	1962	Minor gas shows.
Warren River No. 1	Oil test	34° 34′ (app.)	115° 55′ (app.)	81	U. Jurassic	W.M. & O.	1902	Dry.
Warren River No. 2	Oil test	34° 35′ (app.)	115° 54′ (app.)	504	U. Jurassic	W.M. & O.	1902	Dry.
Warren River No. 3	Oil test	34° 37′ (app.)	115° 51′ (app.)	1,719	U. Jurassic	W.M. & O.	1904	Dry.
Woolmulla No. 1	Oil test	30° 01′ 24″	115° 11′ 28″	....	....	WAPET	....	Drilling.
			Carnarvon Basin					
B.M.R. No. 5 (Giralia)	Strat.	22° 39′ 15″	114° 14′ 25″	2,070	L. Permian	B.M.R.	1958	
B.M.R. No. 6 (Muderong)	Strat. & Struct.	24° 05′ 55″	114° 46′ 30″	1,002	L. Permian	B.M.R.	1958	
B.M.R. No. 7 (Muderong)	Strat. & Struct.	24° 05′ 55″	114° 46′ 30″	1,997	L. Permian	B.M.R.	1958	
B.M.R. No. 8 (Mt. Madeline)	Strat. & Struct.	25° 44′ 50″	115° 40′ 40″	3,004	L. Permian	B.M.R.	1959	
B.M.R. No. 9 (Daurie Creek)	Strat. & Struct.	25° 32′ 20″	115° 52′ 50″	2,299	L. Permian	B.M.R.	1959	
Cape Cuvier No. 1	Strat.	24° 13′ 30·3″	113° 23′ 43·6″	1,500	Devonian	WAPET	1955	
Cape Range No. 1	Oil test	22° 05′ 56·5″	114° 00′ 32·5″	8,019	M. Jurassic	WAPET	1954	Minor gas shows.
Cape Range No. 2	Oil test	22° 05′ 50·5″	113° 59′ 41·2″	15,170	L. Jurassic	WAPET	1956	Gas, non-commercia
Cape Range No. 3A	Oil test	22° 08′ 42·9″	113° 59′ 54·2″	3,737	U. Jurassic	WAPET	1956	Dry.
Cape Range No. 4	Oil test	22° 19′ 26·5″	113° 56′ 09·1″	3,858	U. Jurassic	WAPET	1956	Dry.
Dirk Hartog Nos. 1–16	Struct.....	25° 42′ 00″– 25° 57′ 45″	112° 58′ 20″– 113° 09′ 20″	778– 1,500	Eocene	WAPET	1955– 1956	
Dirk Hartog No. 17B	Oil test	25° 51′ 58″	113° 04′ 40·5″	4,998	L. Silurian	WAPET	1957	Dry.
Exmouth No. 1	Struct.....	22° 23′ 01″	114° 06′ 38·5″	1,759	U. Cretaceous	WAPET	1956	
Exmouth No. 2	Struct.....	22° 21′ 25″	114° 08′ 17″	2,029	U. Cretaceous	WAPET	1956	
Giralia No. 1	Oil test	22° 59′ 35″	114° 14′ 20″	4,080	L. Permian	WAPET	1955	Dry.
Grierson No. 1	Strat. & Struct.	24° 12′ 00″	113° 46′ 20″	1,437	Devonian	WAPET	1955	
Grierson No. 2	Strat. & Struct.	24° 12′ 00″	113° 47′ 05″	1,478	Devonian	WAPET	1955	
Grierson No. 3	Strat. & Struct.	24° 12′ 02″	113° 45′ 30″	1,450	Devonian	WAPET	1955	
Learmonth No. 1	Oil test	22° 10′ 58·5″	114° 03′ 31·2″	7,636	L. Permian	WAPET	1958	Minor gas show.
Rough Range No. 1	Oil test	22° 25′ 06·6″	114° 04′ 54·4″	14,607	Devonian	WAPET	1955	Oil saturated 3,602–3,628 feet.
Rough Range No. 1A	Oil test	22° 25′ 06″	114° 04′ 55″	3,657	U. Jurassic-L. Cretaceous	WAPET	1955	Oil saturated 3,604–3,628 feet.
Rough Range No. 2	Oil test	22° 25′ 50″	114° 04′ 05″	4,079	U. Jurassic	WAPET	1954	Dry.
Rough Range No. 3	Oil test	22° 24′ 40″	114° 05′ 09″	3,915	L. Cretaceous	WAPET	1954	Dry.
Rough Range No. 4	Oil test	22° 25′ 23″	114° 04′ 54″	3,760	L. Cretaceous	WAPET	1954	Dry.
Rough Range No. 5	Oil test	22° 25′ 07″	114° 04′ 33″	3,772	L. Cretaceous	WAPET	1954	Dry.
Rough Range No. 6	Oil test	22° 25′ 12·7″	114° 04′ 48·8″	3,697	L. Cretaceous	WAPET	1955	Dry.
Rough Range No. 7	Oil test	22° 26′ 40″	114° 04′ 06″	4,281	U. Jurassic-L. Cretaceous	WAPET	1955	Dry.
Rough Range No. 8	Oil test	22° 26′ 46″	114° 03′ 44″	3,919	L. Cretaceous	WAPET	1955	Dry.
Rough Range No. 9	Oil test	22° 26′ 50″	114° 04′ 22″	3,844	U. Jurassic-L. Cretaceous	WAPET	1955	Dry.
Rough Range No. 10	Oil test	22° 25′ 04·6″	114° 05′ 02·4″	3,739	U. Jurassic-L. Cretaceous	WAPET	1957	Minor oil shows.
Rough Range South No. 1	Struct.....	22° 37′ 17·5″	113° 57′ 37·6″	2,866	L. Cretaceous	WAPET	1956	
Rough Range South No. 2	Struct.....	22° 23′ 48·2″	114° 00′ 20·4″	1,523	L. Cretaceous	WAPET	1956	
Rough Range South No. 3	Struct.....	22° 30′ 08·7″	114° 02′ 29·5″	1,900	U. Cretaceous	WAPET	1956	
Rough Range South No. 4	Struct.....	22° 32′ 00″	114° 01′ 28·4″	2,289	U. Cretaceous	WAPET	1956	
Rough Range South No. 5	Oil test	22° 34′ 24·6″	113° 59′ 16·5″	4,760	L. Permian	WAPET	1956	Dry.
Rough Range South No. 6	Struct.....	22° 32′ 22″	114° 00′ 42·4″	1,594	U. Cretaceous	WAPET	1956	
Wandagee No. 1	Strat.	23° 53′ 15″	114° 23′ 51″	3,520	L. Silurian	WAPET	1962	Minor gas show.
Wandagee No. 2	Strat.	23° 53′ 13″	114° 31′ 38″	1,013	L. Permian	WAPET	1962	
Wandagee No. 3	Strat.	23° 49′ 43″	114° 20′ 03″	730	pre-Cretaceous	WAPET	1962	
Warroora No. 1	Oil test	23° 30′ 30·1″	113° 52′ 48·1″	5,992	Carboniferous	WAPET	1955	Minor oil show.
Yanrey No. 1	Oil test	22° 15′ 15·7″	114° 34′ 56·8″	1,413	Precambrian	WAPET	1957	Dry.
			Canning Basin.					
Babrongan No. 1	Oil test	18° 23′ 23″	123° 35′ 37″	6,395	U. Devonian	WAPET	1962	Dry.
Barlee No. 1	Oil test	17° 48′ 25″	122° 42′ 40″	8,101	U. Carboniferous	WAPET	1960	Minor gas show.
B.M.R. No. 1 (Jurgurra Creek)	Strat.	18° 19′ 49″	123° 42′ 45″	1,680	L. Permian	B.M.R.	1955	
B.M.R. No. 2 (Laurel Downs)	Strat.	18° 07′ 06·1″	125° 20′ 05·1″	4,000	U. Devonian	B.M.R.	1956	
B.M.R. No. 3 (Prices Creek)	Strat.	18° 39′ 40″ (app.)	125° 54′ 05″ (app.)	694	Precambrian	B.M.R.	1956	
B.M.R. No. 4 (Wallal)	Strat.	19° 44′ 12″	120° 44′ 28″	1,410	Jurassic	B.M.R.	1958	
B.M.R. No. 4A (Wallal)	Strat.	19° 44′ 12″	120° 44′ 28″	2,223	Precambrian	B.M.R.	1958	
Dampier Downs No. 1	Strat.	18° 18′ 00″	123° 06′ 00″	3,028	L. Ordovivian	WAPET	1956	
Fraser River No. 1	Oil test	17° 25′ 04″	123° 09′ 39″	10,144	post-Carboniferous gabbro	WAPET	1956	Dry.
Frome Rocks No. 1	Oil test	18° 11′ 48″	123° 38′ 42″	4,003	Rock salt	WAPET	1959	Dry.
Frome Rocks No. 2	Oil test	18° 15′ 15″	123° 39′ 35″	7,504	U. Devonian	WAPET	1959	Minor oil shows.
Goldwyer No. 1	Oil test	18° 22′ 47″	122° 22′ 58″	4,720	Precambrian	WAPET	1958	Minor oil shows.
Grant Range No. 1	Oil test	18° 01′ 00″	124° 00′ 25″	12,915	U. Carboniferous	WAPET	1955	Dry.
Hawkstone Peak No. 1	Oil test	17° 14′ 45″	124° 24′ 26″	3,897	Precambrian	WAPET	1962	Dry.
Langoora No. 1	Oil test	17° 18′ 07″	124° 06′ 48″	5,299	Precambrian	WAPET	1962	Dry.
Meda No. 1	Oil test	17° 24′ 00″	124° 11′ 30″	8,809	Precambrian	WAPET	1958	Oil and gas shows.
Meda No. 2	Oil test	17° 24′ 36″	124° 11′ 23″	7,628	U. Devonian	WAPET	1959	Oil and gas shows.
Mount Wynne No. 1	Oil test	18° 05′ 35″ (app.)	124° 23′ 44″ (app.)	896	L. Permian	F.K.O.	1923	Minor bitumen present.
Mount Wynne No. 3	Oil test	18° 05′ 35″ (app.)	124° 23′ 44″ (app.)	2,154	L. Permian	F.K.O.	1925	Minor oil shows.
Myroodah No. 1	Oil test	18° 16′ 15″	124° 11′ 27″	6,001	L. Permian	A.F.O.	1956	Dry.
Nerrima No. 1 (A.F.O.)	Oil test	18° 26′ 55″	124° 22′ 17″	9,072	U. Carboniferous	A.F.O.	1955	Minor oil shows.

WELLS DRILLED FOR PETROLEUM EXPLORATION IN WESTERN AUSTRALIA TO THE END OF 1962—*continued.*

Name	Type	Location		Depth (feet)	Bottomed in	Drilled for	Year completed	Remarks
		Lat. (S.)	Long. (E.)					
			Canning Basin—continued.					
Nerrima No. 1 (F.K.O.)	Oil test	18° 28′ 16″	124° 24′ 02″	4,271	L. Permian	F.K.O.	1941	Dry.
Poole Range No. 3	Oil test	18° 53′ 06″ (app.)	125° 47′ 20″ (app.)	3,264	L. Permian	F.K.O.	1930	Minor oil shows.
Poole Range No. 5	Oil test	18° 52′ 27″ (app.)	125° 49′ 02″ (app.)	1,545	L. Permian	F.K.O.	1933	Dry.
Prices Creek No. 1	Oil test	18° 40′ 30″ (app.)	125° 55′ 00″ (app.)	1,008	Ordovician	F.K.O.	1922	Minor oil shows.
Prices Creek No. 2	Oil test	18° 40′ 40″ (app.)	125° 55′ 55″ (app.)	340	Ordovician	F.K.O.	1923	Minor oil shows.
Prices Creek No. 3	Oil test	18° 41′ 25″ (app.)	125° 55′ 15″ (app.)	809	Ordovician	F.K.O.	1923	Minor oil shows.
Prices Creek No. 4	Oil test	18° 40′ 55″ (app.)	125° 54′ 05″ (app.)	444	L. Permian	F.K.O.	1923	Dry.
Roebuck Bay No. 1	Strat.	18° 09′ 33·9″	122° 27′ 27·8″	4,000	L. Ordovician	WAPET	1956	
Samphire Marsh No. 1	Oil test	19° 31′ 07·6″	121° 10′ 50·8″	6,664	Precambrian	WAPET	1958	Dry.
Sisters No. 1	Oil test	17° 43′ 31″	124° 25′ 09″	9,828	Devonian	A.F.O.	1957	Dry.
Thangoo No. 1	Oil test	18° 22′ 06″	122° 53′ 22″	3,475	L. Ordovician	WAPET	1959	Minor oil shows.
Thangoo No. 1A	Oil test	18° 21′ 52″	122° 53′ 09″	5,429	Precambrian	WAPET	1960	Minor oil shows.
Wallal No. 1	Strat.	19° 51′ 45·5″	120° 37′ 58·5″	1,014	Jurassic	WAPET	1957	
			Ord Basin.					
Okes Durack	Oil test	17° 16′ (app.)	128° 57′ (app.)	1,196	L. Cambrian basalt	O.D.K.	1924 (app.)	Dry.

Abbreviations :

Strat. = Stratigraphic Hole.
Struct. = Structure Hole.
app. = Approximately.

L. = Lower.
M. = Middle.
U. = Upper.

A.F.O. = Associated Freney Oilfields N.L.
B.M.R. = Bureau of Mineral Resources.
F.K.O. = Freney Kimberley Oil Co.
WAPET = West Australian Petroleum Pty. Limited
W.M. & O. = Westralian Mining and Oil Corporation.
O.D.K. = Okes Durack Kimberley Oil Co.
Exoil = Exoil Pty. Ltd.

THE SEARCH FOR OIL IN WESTERN AUSTRALIA IN 1962.

by P. E. Playford.

INTRODUCTION.

The rate of oil exploration in Western Australia increased considerably during 1962. This was not associated with any new oil discovery in this State, but it followed the Australia-wide trend towards increased exploration resulting from the Moonie discovery in Queensland.

During the year, four oil-test and eight stratigraphic wells were completed, and a further oil-test and a stratigraphic well were still drilling at the end of the year. All were put down by West Australian Petroleum Pty. Ltd. (Wapet) in the Perth, Carnarvon, and Canning Basins.

Geophysical operations totalling some 37 party-months of seismic work, 15 party-months of gravity work and 1½ months of aeromagnetic work, were conducted in the Perth, Carnarvon, Canning, Bonaparte Gulf, and Officer Basins. Surface geological mapping was undertaken by Wapet in the Perth Basin, and by the Geological Survey of Western Australia in the Perth and Canning Basins.

OIL HOLDINGS.

The positions of Permits to Explore and Licenses to Prospect current in Western Australia at the end of 1962 are show on the accompanying map (Plate XXII). Details regarding each permit and license are shown on the following table:

OIL HOLDINGS IN WESTERN AUSTRALIA ON DECEMBER 31st, 1962.

Permits to Explore.

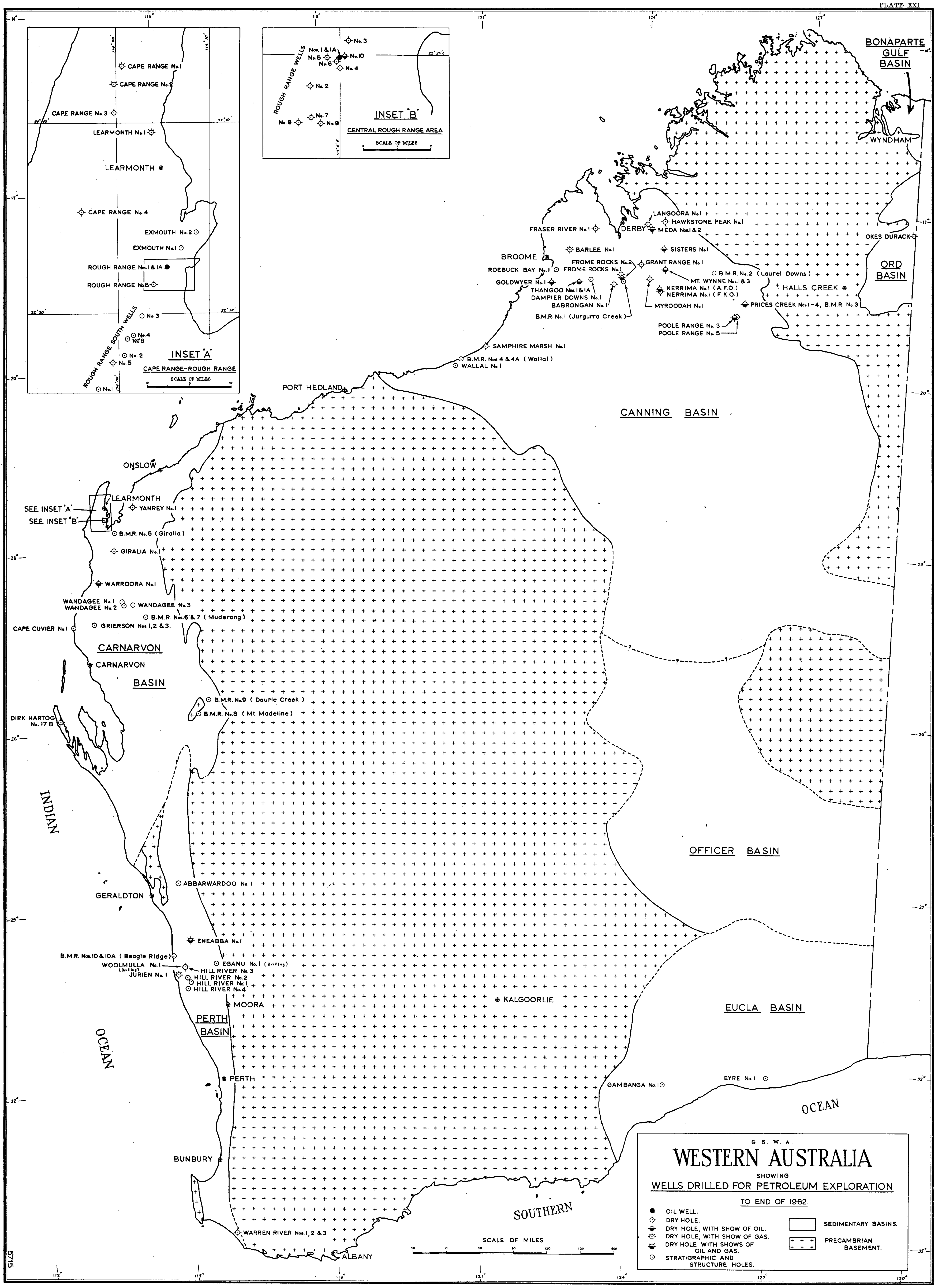
No.	Name of Holder	Area in Square Miles	Date of Expiry of Current Tenure
27H	West Australian Petroleum Pty. Ltd.	52,000	22/10/63
28H	do. do. do.	51,000	22/10/63
29H	do. do. do.	31,100	22/10/63
30H	do. do. do.	151,600	22/10/63
106H	Westralian Oil Ltd.	11,800	28/9/63
127H	Oil Development N.L.	13,800	28/3/63

Permits to Explore—continued.

No.	Name of Holder	Area in Square Miles	Date of Expiry of Current Tenure
133H	Jackson Explorations	15,750	2/9/62 Application for Renewal still under consideration
134H	Exoil Pty. Ltd.	12,600	9/12/63
135H	do.	12,600	9/12/63
136H	do.	12,450	9/12/63
142H	Hawkstone Oil Company Limited	5,200	8/4/63
147H	Hunt Oil Company ; Placid Oil Company	12,850	16/8/63
148H	do. do. do.	12,600	16/8/63
151H	Hackathorn Oils Pty. Ltd.	14,200	7/2/63
152H	do. do.	11,650	7/2/63
153H	do. do.	13,050	7/2/63
156H	Hunt Oil Company ; Placid Oil Company	12,450	10/7/63
157H	do. do. do.	12,600	10/7/63
158H	do. do. do.	12,800	10/7/63
159H	do. do. do.	12,800	10/7/63
161H	do. do. do.	12,900	24/8/63
165H	Vickers, Victor Ivor	13,700	19/12/63
166H	do. do.	5,315	19/12/63
167H	do. do.	13,550	27/12/63
171H	Turnbull, James	8,050	2/8/64
172H	Joice, James Matthew	6,150	30/7/64
173H	do. do.	12,250	30/7/64
174H	do. do.	6,100	30/7/64
175H	do. do.	6,000	30/7/64
177H	do. do.	6,050	30/7/64
178H	Australian Oil Corporation	12,300	29/8/64
179H	Byre Oil Exploration Syndicate	4,850	31/7/64
189H	Kalgoorlie Goldfields Petroleum N.L.	12,950	31/7/64
190H	Textralian Oil Pty. Ltd.	11,300	5/9/64
193H	Hawkstone Oil Company Limited	2,700	5/8/64
197H	Pilbara Exploration N.L.	6,900	15/8/64
199H	do. do.	11,950	15/8/64
203H	Australian Oil Corporation	18,000	29/8/64
209H	do. do.	12,200	30/8/64
210H	do. do.	12,050	29/8/64
211H	do. do.	5,975	28/8/64

Licenses to Prospect.

54H	West Australian Petroleum Pty. Ltd.	197·9	7/5/63
55H	do. do. do.	196·0	14/7/63
56H	do. do. do.	200	22/2/63
57H	Westralian Oil Ltd.	195·9	29/9/63
58H	Associated Freney Oil Fields N.L.	120	27/10/62 Application for Renewal still under consideration
59H	do. do. do.	113·4	do.
60H	do. do. do.	113·2	do.
61H	do. do. do.	112·5	do.
62H	do. do. do.	112·5	do.


G. S. W. A.
WESTERN AUSTRALIA
SHOWING
WELLS DRILLED FOR PETROLEUM EXPLORATION
TO END OF 1962.
OIL WELL.
DRY HOLE.
DRY HOLE, WITH SHOW OF OIL.
DRY HOLE, WITH SHOW OF GAS.
DRY HOLE WITH SHOWS OF OIL AND GAS.
STRATIGRAPHIC AND STRUCTURE HOLES.
SEDIMENTARY BASINS.
PRECAMBRIAN BASEMENT.
SCALE OF MILES
INSET "A"
CAPE RANGE-ROUGH RANGE
CAPE RANGE No.1
CAPE RANGE No.2
CAPE RANGE No.3
LEARMONTH No.1
LEARMONTH
CAPE RANGE No.4
EXMOUTH No.2
EXMOUTH No.1
ROUGH RANGE Nos.1 & 1A
ROUGH RANGE No.8
ROUGH RANGE SOUTH WELLS
INSET "B"
CENTRAL ROUGH RANGE AREA
ROUGH RANGE WELLS
BONAPARTE GULF BASIN
WYNDHAM
ORD BASIN
OKES DURACK
HALLS CREEK
LANGOORA No.1
HAWKSTONE PEAK No.1
DERBY
MEDA No.1 & 2
FRASER RIVER No.1
BROOME
BARLEE No.1
SISTERS No.1
ROEBUCK BAY No.1
FROME ROCKS No.2
FROME ROCKS No.1
GRANT RANGE No.1
B.M.R. No.2 (Laurel Downs)
MT. WYNNE Nos.1 & 3
GOLDWYER No.1
THANGOO Nos.1 & 1A
DAMPIER DOWNS No.1
BABRONGAN No.1
NERRIMA No.1 (A.F.O.)
NERRIMA No.1 (F.K.O.)
MYROODAH No.1
PRICES CREEK Nos.1-4, B.M.R. No.3
B.M.R. No.1 (Jurgurra Creek)
POOLE RANGE No.3
POOLE RANGE No.5
SAMPHIRE MARSH No.1
B.M.R. Nos.4 & 4A (Wallal)
WALLAL No.1
PORT HEDLAND
CANNING BASIN
ONSLOW
LEARMONTH
SEE INSET "A"
SEE INSET "B"
YANREY No.1
B.M.R. No.5 (Giralia)
GIRALIA No.1
WARROORA No.1
WANDAGEE No.1
WANDAGEE No.2
WANDAGEE No.3
B.M.R. Nos.6 & 7 (Muderong)
CAPE CUVIER No.1
GRIERSON Nos.1, 2 & 3.
CARNARVON BASIN
CARNARVON
B.M.R. No.9 (Daurie Creek)
B.M.R. No.8 (Mt. Madeline)
DIRK HARTOG No.17 B
INDIAN OCEAN
OFFICER BASIN
ABBARWARDOO No.1
GERALDTON
ENEABBA No.1
B.M.R. Nos.10 & 10A (Beagle Ridge)
WOOLMULLA No.1 (Drilling)
JURIEN No.1
EGANU No.1 (Drilling)
HILL RIVER No.3
HILL RIVER No.2
HILL RIVER No.1
HILL RIVER No.4
MOORA
KALGOORLIE
EUCLA BASIN
PERTH BASIN
PERTH
GAMBANGA No.1
EYRE No.1
BUNBURY
WARREN RIVER Nos.1, 2 & 3
ALBANY
SOUTHERN OCEAN
5715

Licenses to Prospect—continued.

No.	Name of Holder	Area in Square Miles	Date of Expiry of Current Tenure
63H	West Australian Petroleum Pty. Ltd.	117·7	29/9/63
66H	do. do. do.	200	18/1/63
67H	do. do. do.	199·4	20/4/63
68H	do. do. do.	195·1	17/5/63
69H	do. do. do.	175·1	17/5/63
70H	do. do. do.	192·8	17/5/63
71H	do. do. do.	187·1	17/5/63
72H	do. do. do.	194·7	17/5/63
73H	do. do. do.	188·7	17/5/63
74H	do. do. do.	186·0	17/5/63
75H	do. do. do.	190·8	17/5/63
76H	do. do. do.	192·9	17/5/63
77H	do. do. do.	196·2	17/5/63
78H	do. do. do.	189·7	17/5/63
79H	do. do. do.	198·7	17/5/63
80H	do. do. do.	188·9	17/5/63
81H	do. do. do.	193·3	17/5/63
82H	do. do. do.	198·1	17/5/63
83H	do. do. do.	193·1	17/5/63
84H	do. do. do.	187·4	17/5/63
85H	do. do. do.	187·0	17/5/63
86H	do. do. do.	188·9	17/5/63
87H	do. do. do.	189·0	5/1/63
88H	Hawkstone Oil Company Limited	189	28/2/63
89H	West Australian Petroleum Pty. Ltd.	192	27/2/63
90H	do. do. do.	160·5	27/2/63
91H	do. do. do.	133·8	27/2/63
92H	do. do. do.	180·1	27/2/63
93H	do. do. do.	195·4	27/2/63
94H	do. do. do.	186·5	27/2/63
95H	do. do. do.	200	12/6/63
96H	do. do. do.	100	18/3/64
97H	do. do. do.	196	26/7/64
98H	do. do. do.	200	26/7/64
99H	do. do. do.	190·5	4/12/64
100H	do. do. do.	200	4/12/64
101H	do. do. do.	193·6	17/12/64
102H	do. do. do.	196	13/1/65

DRILLING.

Permit to Explore 27H.

Permit to Explore 27H is held by West Australian Petroleum Pty. Ltd., and covers the Perth Basin. The company completed one oil-test well (Jurien No. 1) and five stratigraphic holes (Hill River Nos. 1-4, and Abbarwardoo No. 1) in the permit area during 1962, and a further test well (Woolmulla No. 1) and a stratigraphic hole (Eganu No. 1) were still being drilled at the end of the year. Details of each are as follows:—

Jurien No. 1:

Type: Oil-test.
License to Prospect: 98H.
Latitude and Longitude: 30° 8′ 40″ S., 115° 2′ 54″ E.
Elevation: Ground = 30 feet, derrick floor = 39 feet.
Date commenced: July 9th, 1962.
Date completed: August 28th, 1962.
Total depth: 3,366 feet.
Bottomed in: Precambrian gneiss.
Remarks: Minor showing of gas and traces of fluorescence present in the Lower Triassic sequence.

Woolmulla No. 1:

Type: Oil-test.
Latitude and Longitude: 30° 1′ 24″ S., 115° 11′ 28″ E.
Elevation: Ground = 382 feet, derrick floor = 394 feet.
Date commenced: November 3rd, 1962. Drilling ahead on December 31st, 1962, at 5,400 feet.
Remarks: Minor showings of oil and gas recorded in the Lower Cretaceous sequence.

Hill River No. 1:

Type: Stratigraphic.
Latitude and Longitude: 30° 16′ S., 115°18′ E.
Elevation: Ground=363 feet, Kelly bushing=368 feet.
Date commenced: April 2nd, 1962.
Date completed: April 25th, 1962.
Total depth: 1,900 feet.
Bottomed in: Lower Jurassic.
Remarks: Thin coal seams present in the lower Jurassic sequence.

Hill River No. 2:

Type: Stratigraphic.
Latitude and Longitude: 30° 11′ S., 115° 14′ E.
Elevation: Ground=620 feet, Kelly bushing= 625 feet.
Date commenced: May 6th, 1962.
Date completed: May 24th, 1962.
Total depth: 1,620 feet.
Bottomed in: Lower Jurassic.

Hill River No. 3.

Type: Stratigraphic.
Latitude and Longitude: 30° 00′ 32″ S., 115° 11′ 13″ E.
Elevation: Ground=408 feet, Kelly bushing=413 feet.
Date commenced: August 12th, 1962.
Date completed: August 27th, 1962.
Total depth: 865 feet.
Bottomed in: Upper Triassic.

Hill River No. 4:

Type: Stratigraphic.
Latitude and Longitude: 30° 23′ 24″ S., 115° 13′ 49″ E.
Elevation: Ground=305 feet, Kelly bushing=309 feet.
Date commenced: 19th June, 1962.
Date completed: 30th June, 1962.
Total depth: 1,010 feet.
Bottomed in: Upper Triassic.
Remarks: Four additional shallow holes were drilled in the vicinity of Hill River No. 4, to obtain structural information. They are—

Hill River No. 4/1, drilled at a shot-point AD-102 to 500 feet, bottoming in Lower Jurassic;
Hill River No. 4/2, drilled at shot-point AD-104 to 510 feet, bottoming in Upper Triassic;
Hill River No. 4/3, drilled at shot-point V-106 to 510 feet, bottoming in Upper Triassic; and
Hill River 4/4, drilled to 510 feet at shot-point Q-89, bottoming in Upper Triassic.

Abbarwardoo No. 1:

Type: Stratigraphic.
Latitude and Longitude: 28° 35′ 10″ S., 115° 09′ 35″ E.
Elevation: Ground=720 feet, Kelly bushing=725 feet.
Date commenced: December 12th, 1962.
Date completed: December 22nd, 1962.
Total depth: 2,000 feet.
Bottomed in: Lower Permian.

Eganu No. 1:

Type: Stratigraphic.
Latitude and Longitude: 29° 59′ 05″ S., 115° 49′ 35″ E.
Elevation: Ground=772 feet, Kelly bushing=777 feet.
Date commenced: December 30th, 1962. Preparing to drill ahead at 67 feet on December 31st, 1962.

Permit to Explore 28H.

Permit to Explore 28H is held by West Australian Petroleum Pty. Ltd., and covers the Carnarvon Basin. Three stratigraphic holes (Wandagee Nos. 1, 2, and 3) were drilled in this permit area during 1962. Details of each are as follows:—

Wandagee No. 1:

Type: Stratigraphic.
Latitude and Longitude: 23° 53′ 15″ S., 114° 23′ 51″ E.
Elevation: Ground=225 feet, derrick floor=234 feet.

Date commenced: 25th April, 1962.

Date completed: 17th June, 1962.

Total depth: 3,521 feet.

Bottomed in: Lower Silurian.

Remarks: Completed as a water bore. This well was put down on the site of the earlier Wandagee corehole No. 1, which was drilled to a depth of 721 feet from 6th January 1962 to 14th January, 1962, bottoming in Upper Devonian strata.

Wandagee No. 2:

Type: Stratigraphic.

Latitude and Longitude: 23° 53′ 13″ S., 114° 31′ 38″ E.

Elevation: Ground=338 feet.

Date commenced: 16th January, 1962.

Date completed: 25th January, 1962.

Total depth: 1,013 feet.

Bottomed in: Lower Permian.

Wandagee No. 3:

Type: Stratigraphic.

Latitude and Longitude: 23° 49′ 43″ S., 114° 20′ 03″ E.

Elevation: Ground = 183 feet.

Date commenced: 30th January, 1962.

Date completed: 2nd February, 1962.

Total depth: 730 feet.

Bottomed in: Pre-Cretaceous rocks.

Permit to Explore 30H.

Permit to explore 30H is held by West Australian Petroleum Pty. Ltd., and covers the Canning Basin. Three oil-test wells (Babrongan No. 1, Langoora No. 1, and Hawkstone Peak No. 1) were drilled in this permit area during 1962. Details of each are as follows:—

Babrongan No. 1:

Type: Oil-test.

License to Prospect: 96H.

Latitude and Longitude: 18° 23′ 23″ S., 123° 35′ 37″ E.

Elevation: Ground = 350 feet, derrick floor = 360 feet.

Date commenced: 29th May, 1962.

Date completed: 6th August, 1962.

Total depth: 6,395 feet.

Bottomed in: Upper Devonian.

Remarks: No signs of oil or gas were encountered. The well was abandoned because of stuck drill-pipe, following the collapse of the mast.

Langoora No. 1:

Type: Oil-test.

Latitude and Longitude: 17° 18′ 7″ S., 124° 6′ 48″ E.

Elevation: Ground = 69 feet, derrick floor = 80 feet.

Date commenced: 25th August, 1962.

Date completed: 6th October, 1962.

Total depth: 5,279 feet.

Bottomed in: Precambrian schist.

Remarks: No significant signs of oil or gas were encountered.

Hawkstone Peak No. 1:

Type: Oil-test.

License to Prospect: 101H.

Latitude and Longitude: 17° 14′ 45″ S., 124° 24′ 26″ E.

Elevation: Ground = 161 feet, derrick floor = 170 feet.

Date commenced: 17th October, 1962.

Date completed: 2nd December, 1962.

Total depth: 3,897 feet.

Bottomed in: Precambrian quartzite.

Remarks: No signs of oil or gas were encountered.

GEOPHYSICAL OPERATIONS.

Seismic.

During the year seismic operations were conducted in the Perth, Carnarvon, Canning, Bonaparte Gulf, and Officer Basins.

West Australian Petroleum Pty. Ltd. carried out operations totalling some 13 party-months in the Perth Basin (Permit 27H), 6½ party-months in the Carnarvon Basin (Permit 28H), and seven party-months in the Canning Basin (Permit 30H).

Associated Freney Oil Fields N.L., conducted a seismic survey of The Sisters Licenses to Prospect (61-62H) in the Canning Basin, which occupied about two weeks.

In the Bonaparte Gulf Basin (Permit 127H), Oil Development N.L., conducted some two party-months of seismic work.

Exoil Pty. Ltd., ran a regional seismic line along the Officer Basin extending from the South Australian part into Western Australia (Permit 135H), nearly one party-month being spent in this State.

The Bureau of Mineral Resources continued a regional seismic survey, commenced in 1961, between Giles weather station and Carnegie homestead, in the south-eastern part of the Canning Basin. This work occupied approximately two party-months. A contract seismic crew engaged by the Bureau carried out a seismic survey of the Poole Range Anticline, in the Canning Basin, over a period of nearly five months.

Gravity.

Gravity surveys were carried out during the year in the Perth, Carnarvon, and Canning Basins. Wapet conducted surveys amounting to some four party-months in the northern Perth Basin (Permit 27H), and some six party-months in the northern Canning Basin (Permit 30H). A brief reconnaissance gravity survey was also carried out by this company on Barrow Island (Part of Permit 29H), in the Carnarvon Basin.

The Hawkstone Oil Co. Ltd., and Oil Development N.L., conducted gravity surveys, each amounting to about one party-month, on Permits 142H and 106H, respectively near the northern margin of the Canning Basin.

A regional gravity survey of the south-eastern part of the Canning Basin was carried out by the Bureau of Mineral Resources, a total area of some 55,000 square miles being covered. Helicopters were utilized in this work, which occupied about three months. Additional gravity readings were made along the Bureau of Mineral Resources' seismic line between Giles and Carnegie.

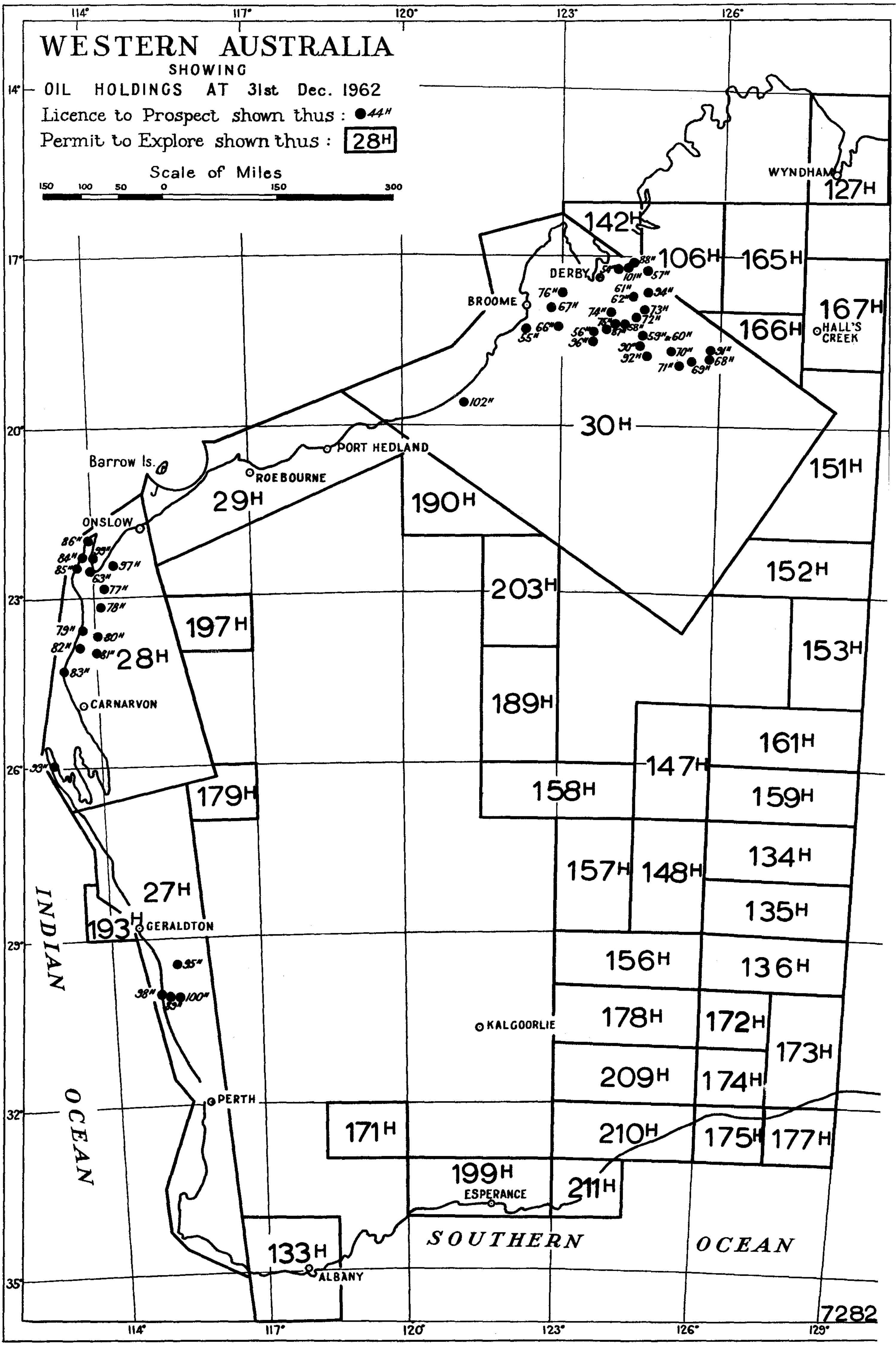
Aeromagnetic.

The only aeromagnetic work done in Western Australia during 1962 was in the Canning Basin, where Wapet conducted a survey extending previous aeromagnetic coverage to include about 160,000 square miles of the southern and eastern parts of the basin. This work occupied some 1½ months, and was incomplete at the end of the year.

GEOLOGICAL OPERATIONS.

Geological field investigations played only a small part in the exploration programmes of the various companies searching for oil in Western Australia. Wapet employed two geologists for two weeks in field work in the Hill River area of the Perth Basin, and other companies carried out even briefer field studies. Most geological activity was concerned with the collation of previously gathered information with the results of exploratory wells and geophysical investigations.

The Geological Survey of Western Australia conducted field studies, which are still incomplete, amounting to three months for two geologists on the Devonian reef complexes of the Canning Basin, and two months for one geologist in regional mapping of the southern part of the Perth Basin.


WESTERN AUSTRALIA
SHOWING
OIL HOLDINGS AT 31st Dec. 1962
Licence to Prospect shown thus : ●44H
Permit to Explore shown thus : 28H
Scale of Miles
150 100 50 0 150 300
114° 117° 120° 123° 126° 129°
14° 17° 20° 23° 26° 29° 32° 35°
WYNDHAM
127H
142H
106H
165H
167H
HALL'S CREEK
166H
DERBY
BROOME
30H
151H
152H
153H
PORT HEDLAND
ROEBOURNE
Barrow Is.
29H
190H
203H
ONSLOW
197H
28H
CARNARVON
189H
161H
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GERALDTON
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KALGOORLIE
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PERTH
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INDIAN OCEAN
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7282

FACIES CHANGES IN THE ARCHAEAN OF THE ROEBOURNE AREA, WEST PILBARA GOLDFIELD.

by R. C. Horwitz.

Based on field work by W. Bock and the author early in 1962, the following conclusions on facies equivalence are presented.

In the Archaean rocks of the Nickol River area, north-west of Roebourne, coarse clastic rocks rest disconformably upon basic volcanic rocks. A dolerite which intrudes the volcanic rocks is truncated at this contact. This break in sedimentation does not persist along strike as the clastic and volcanic rocks pass laterally into an unbroken sequence of jaspilites and calcareous sediments. Still further along the strike, the jaspilites and calcareous sediments change facies to a sequence of bedded amphibolites with rare jaspilites. All these beds are overlain by basic volcanic rocks, which together with the volcanic rocks already mentioned, elsewhere form an apparently unbroken sequence consisting mainly of pillow lavas.

It is thus concluded that, in this region, in a part of this Archaean succession, basic lavas, an intrusive dolerite and sediments are all roughly contemporaneous. All these rocks form the lower part of the Archaean succession. The upper part, recently established by Ryan and Kriewaldt (1963), consists of banded iron, chert and shale with no record of lavas.

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THE STRATIGRAPHIC SEQUENCE IN THE WARBURTON RANGE, EASTERN DIVISION.

by R. C. Horwitz and J. Sofoulis.

During a short visit to the Warburton Range, a traverse was made across all the rocks that occur below the Permian glacials. This paper deals with these rocks on the Talbot One-Mile Military Sheet.

Talbot and Clarke (1917) gave an account of these rocks. They recognised a break in sedimentation, thus subdividing this sequence into two units—a complex lower unit, overlain by the Townsend Range "Series." They equated the basic rocks in the lower unit with the greenstones of the Kalgoorlie area, and the upper unit with the "Nullagine Series" which they tentatively assigned to the Ordovician.

F. G. Forman (1937) gave a summary of his previous investigations in the area (1932, 1933). He first recognised the presence of Nullagine-type rocks in the Warburton Ranges and suggested that:—"pending further investigations, the basal rocks of the Nullagine series in this area should be regarded as being the little altered sediments immediately underlying the Warburton Range Porphyries and that some, at least, of the greenstones and the altered sediments beneath the porphyries should be referred to the older Pre-Cambrian" (The older Pre-Cambrian here referred to the Kalgoorlie greenstones).

After a reconnaissance trip to the area, Sofoulis (1962) came to conclusions that agreed with Wilson, Compton and Jeffery (1961): that the oldest rocks exposed in the Warburton Ranges are younger than the greenstones of the Kalgoorlie region. He proposed a Lower Proterozoic age for all the Precambrian rocks of the Warburton Ranges and the Nullagine "System" and equated them with what is known as the "Archaean" in South Australia; one of the criteria used is the similarity between the acid igneous rocks in these three provinces. Because of a misinterpretation in structure, these igneous rocks were believed to be the youngest of all the rocks below the Permian in the Warburton Ranges.

Some of the conclusions reached in every one of the papers cited are considered correct and these are summarized below:—

(1) The Archaean (rocks broadly equivalent to the Kalgoorlie greenstones) is not represented in the Warburton Range, as suggested by Wilson, Compton and Jeffery (1961), and by Sofoulis (1962).

(2) The break in sedimentation established by Talbot and Clarke (1917) is considered valid: as noted by these authors, the base of the Townsend Range "Series" contains abundant reworked elements of the acid igneous rocks.

(3) The lower part of the Townsend Range "Series" (The Ainslie Volcanics of Sofoulis, 1962) is composed of basic volcanics, conglomerates, quartzites, and calcareous beds, which show copper mineralization. They rest on a unit with a characteristic acid igneous suite which is widespread in the "Archaean" of South Australian geologists. All the facies and characteristics of the lower part of the Townsend Range "Series" thus apply to the Willouran Series (basal unit of the Adelaide System, Mawson, 1927; Sprigg, 1949).

(4) The upper part of the Townsend Range "Series" (Townsend Quartzite of Sofoulis, 1962) is mainly composed of felspathic quartzite which is locally pebbly. Its lithology and distribution, as shown by Sofoulis (1962), suggest that it is unconformable on the Ainslie Volcanics. In a creek section nine miles south-east of Warburton Mission, felspathic gypsiferous silts, shales and limestones with quartzites are exposed. They are the highest beds observed in the Townsend Range "Series" and overlie the felspathic quartzites. The sediments of the upper half of the Townsend Range "Series" strongly resemble the beds of the passage from the Marinoan Series (upper part of the Adelaide System) to Lower Cambrian in South Australia.

(5) All these rocks are part of a south-west facing limb on the Talbot One-Mile Sheet as already recognised by Talbot and Clarke.

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ARCHAEAN STRATIGRAPHY IN THE ROEBOURNE AREA, WEST PILBARA GOLDFIELD.

by G. R. Ryan and M. Kriewaldt.

Regional mapping of the Roebourne and Dampier 1:250,000 Sheets in the West Pilbara Goldfield, although not complete, has disclosed a definite succession in the Archaean rocks of the area.

Broadly, ignoring for the moment the many facies changes, the succession from top to bottom consists of five main units, as follows:—

(5) Banded iron, chert, and shale; fine grained purple and green clastic rocks; manganese staining.

(4) Basic volcanic rocks including pillow lavas.

(3) Chert and calcareous sediments; prase, fuchsite. Arenaceous sediments.

(2) Amphibolites, ultrabasic rocks, acid lavas; severely metasomatised.

(1) Gneiss, granite.

Granite has been seen to intrude all but the highest unit.

These rocks are folded into a series of generally broad anticlines and tight synclines, with gneiss in the cores of anticlines and the uppermost beds restricted in outcrop to the axes of the synclines. Foliation in the gneiss is in most cases parallel to the overlying strata.

The beds immediately above the gneiss have been severely metasomatised, with the production of a wide range of hybrid rocks ranging from ultrabasic to gabbroic and granitic in composition. Sporadic copper mineralization is found in this zone, and deposits of corundum, asbestos, and titaniferous magnetite are known.

This lower unit (2) includes calcareous rocks, and there is a gradation to the overlying unit (3) where calcareous and arenaceous sediments are now represented by amphibole schist and quartz-mica-schist. Above these rocks, banded chert and thin siltstone beds are interbedded with calcareous sediments; prase, fuchsite, and nickeliferous dolomite are developed locally. This horizon has been used with some success as a marker. Copper and gold mineralisation is also found in this succession.

Tough blue volcanic rocks and pillow lavas (4) overlie the chert horizon but are also present lower in the Archaean succession. Near the mouth of the Nickol River, chert and calcareous sediments pass laterally to volcanic rocks; arkose, conglomerate, and felspathic sandstone are found overlying a local disconformity (Horwitz, 1963). South of Roebourne the volcanic rocks, chert, and calcareous sediments (3 & 4) are represented by a very thick succession of red and green clastic rocks, massive chert beds, and volcanic rocks in which turbidites have been recognised.

A distinct change in environment is indicated by the beds of the uppermost unit (5), which consists of banded jaspilite, hematite, and chert with interlaminated shale, some thicker beds of red shale and siltstone, and sporadic manganese staining. This unit is well defined and consistent, and represents a marked change from the instability which prevailed during deposition of the lower units. Nowhere has granite been seen to intrude these upper beds.

The progression from basal gneiss in the anticlinal domes to manganiferous iron beds in the synclinal troughs provides a reliable facing throughout the area. This has greatly facilitated interpretation of the structure of the area.

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THE OCCURRENCE AND HYDROLOGICAL SIGNIFICANCE OF CALCRETE DEPOSITS IN WESTERN AUSTRALIA.

by J. Sofoulis.

INTRODUCTION.

The calcrete deposits are here referred to as an assemblage of surface limestone and opaline silica deposits that are generally associated with fine gravel beds of riverine origin. These formations occur in broad fossil valleys that still serve as trunk valleys for the present drainage systems.

The valley locations and physical characteristics presented by the calcrete deposits provide excellent conditions for ground water storage and aquifer recharge. Their distribution in the lower rainfall regions and utilization as shallow aquifers has been of valuable assistance to the State's pastoral development.

RECORDED DISTRIBUTION IN WESTERN AUSTRALIA.

Calcrete deposits are known in most trunk valleys of the major drainage systems in the North-West and Eastern Land Divisions. Those in the Oakover valley are referred to by Maitland (1904) and by Traves and others (1956) as the Oakover Beds. Similar deposits from this and other drainage systems of the North-West Division are described by Noldart and Wyatt (1963) and by de la Hunty (1960) as the Oakover Formation. Talbot (1920 and 1926) has referred to further deposits in the Ashburton drainage system as the Brumby Creek Beds.

Extensive developments of calcrete formations also occur throughout the Murchison District. Those of the Wiluna-Meekatharra area are described by C.S.I.R.O. Land Research Division as the Cunyu and Mileura Land Systems (Mabbutt and others, in press). The major occurrences known at Wiluna and at Lorna Glen have previously been referred to by Brookfield (in press), Chapman (1962), Morgan (1962), de la Hunty (1959), and by Ellis (1953).

Many of the deposits locally recorded in other parts of the State as kunkar, travertine, tufa, creek limestone, caliche, etc., are believed to be calcrete deposits. Traves and others (1956) consider that the Oakover Beds of the Pilbara area closely resemble the Tertiary deposits of the East Kimberley and Northern Territory. Recent investigations have also confirmed the presence of similar calcrete formations in the Eastern Division and in the Central Aborigines Reserve (Sofoulis, 1962a and 1962b).

Formations of this nature appear to be absent in the South-West and Eucla Land Divisions. A dissected remnant is recorded near Boorabbin (Sofoulis and Bock, 1962) but in general the trunk valleys in the southern part of the State are cut to basement or else they contain kunkarised earths. The kunkarised earths are believed to be unrelated to the calcrete deposits and rest directly on weathered basement without detrital fill.

The approximate area in which calcrete deposits are known to occur are shown on the accompanying sketch map (figure 9).

LITHOLOGY AND GENERAL DESCRIPTION.

The upper part of the calcrete deposits consists of limestones that contain thin detrital bands and cellular opaline silica layers. These form sequences that range from several feet to 100 feet thick but are usually of the order of 15 feet to 30 feet thick. The lower part of the deposit rarely exceeds a thickness of 50 feet and consists of gravels, sands and silts overlying an eroded surface of weathered rock. These detrital beds (subsequently referred to as fine gravels) are mainly unconsolidated although some sections show lime, silica and iron oxide indurations. Small pockets or bands of cellular opaline silica up to 10 feet or more thick

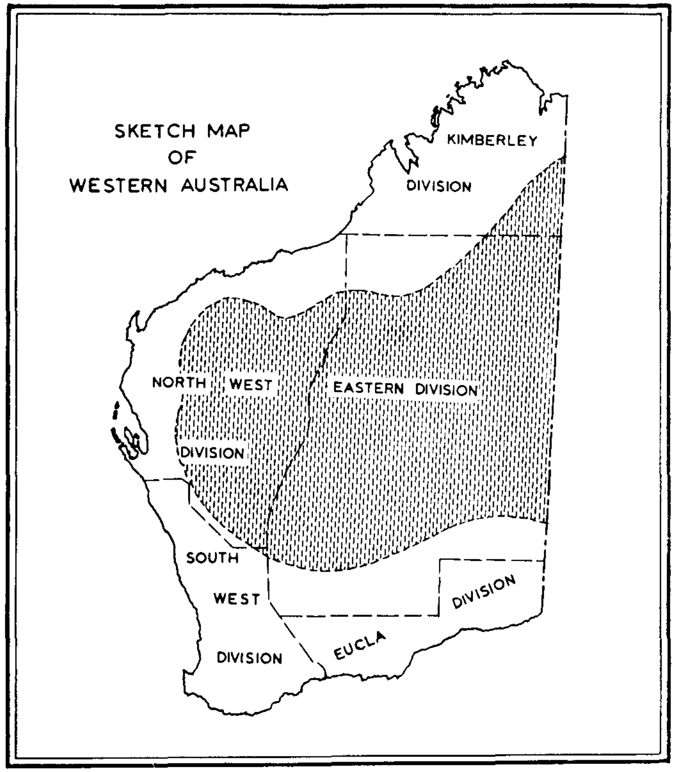

Fig. 9 (above). Sketch map of Western Australia showing the approximate area (shaded) within which calcrete deposits are known to occur.

Fig. 10 (right). Aerial photograph showing characteristic photo-pattern of calcrete deposits, Weeli Wolli Creek, North West Division. Photo illustrates low limestone platforms and kunkarised mounds (white pattern), alluviated trunk and tributary drainages and flanking outwash plains. Lands Dept. photo W.A.373 Roy Hill run 18, No. 5123. Approximate Scale: 50 chains to an inch.

are characteristically developed at the interface of fine gravels and limestone and often mark the present water table.

Opaline silica bands and fine gravels are exposed only in areas of greater dissection. Thus surface exposures are usually kunkarised limestone and consist of secondary lime cements, cappings, concretionary nodules, and powdery calcareous earths. Karst and sub-karst features are locally associated with these surfaces.

Extensive valley tracts of calcrete deposits are often continuous for distances up to 10 miles or more. These are usually of the order of 1 mile wide but locally may broaden to 4 miles or more, particularly in the larger drainage systems or in areas above stream constrictions or below confluent valleys. Smaller limestone developments usually appear as discontinuous valley trains separated by alluvium. Others occur as isolated pockets occupying restricted or perched basins eroded in weathered rock.

Valley side benches, breakaways, and flat-topped mesas (up to 80 feet high), composed of calcrete deposits are observed in some drainage systems of the North-West Division where the base level has been lowered (e.g. Oakover River, Weeli Wolli Creek). Most other drainages contain calcrete limestones at valley floor level where they appear as low limestone platforms, or kunkarised mounds, separated by a network of narrow alluviated channels (See figure 10). These are usually flanked or overlapped by extensive deposits of alluvium and fine outwash or are locally buried by aeolian sands.

In some instances, buried calcrete deposits are reflected by the vegetation and their extensions can be traced below soil covered areas. Calcrete deposits that locally appear in the desert areas are interpreted as relics of buried systems that drained internally or were tributary to major salt lake basins.

ORIGIN OF CALCRETE DEPOSITS.

Various authors have suggested that the limestone and opaline silica layers represent primary chemical deposits that were precipitated from solution in ground and surface waters. The nature and appearance of calcrete formations at different elevations along the same drainage system, together with broadening above valley constrictions or at confluent drainages, suggests that these formations could have been deposited in ponded sections of drainages following the cessation of a past period of higher rainfall.

Correlation between discontinuous outcrops in one or separate drainage systems is difficult as no fossils have been found. (These were probably inhibited by the concentration of salts.) However, it is assumed that the calcrete deposits are more or less contemporaneous and that their formation was governed by the same widespread climatic conditions. Since the calcrete deposits are locally underlain by a ferruginised layer and contain lateritic gravel bands, their formation is believed to date back to the period of lateritisation (Tertiary).

HYDROLOGICAL SIGNIFICANCE.

The calcrete deposits constitute important aquifers that are capable of providing a high density of watering points and are capable of yielding ground water of quantity and quality suitable for stock use and locally suitable for domestic, irrigation and town supply use.

The distinctive photo pattern (see figure 10) and pattern consistency over wide areas could provide a rapid means of assessing areas of possible aquifer potential. Their delineation could also assist in planning permanent watering points for pastoral extension as well as assist in the strategic selection of further watering points in remote regions.

Various factors influencing the economic usefulness of calcrete deposits in the Wiluna and Lorna Glen areas have been studied in detail by Chapman (1962) and by Brookfield (in press). These studies have included such aspects as porosity, permeability, storage capacity, flow rate, run off, recharge, yield, salinity, etc., and their resultant findings should be applicable to calcrete deposits of other parts of the State. Other aspects of regional significance are discussed below.

Formation Factors.

In addition to other factors, the aquifer potential of a calcrete deposit is influenced by its areal extent, thickness and state of dissection. The formations contain assemblages of varying porosities that in turn influence salinities and yields. Reductions in porosity are also effected by lime, silica and iron oxide indurations. In general the layers of greater aquifer potential are the unconsolidated coarse sands and gravel beds, cellular opaline silica bands, cavernous limestone, or basement rocks with high effective porosity.

Depth to Groundwater.

In most areas the water table in calcrete formations generally lies between 20 feet and 60 feet below the surface. Locally it can be as shallow as 5 feet or as deep as 100 feet or more. Low pressure waters, where present, are generally restricted to deeper aquifers. In some instances stream dissection or karstic phenomena may extend to water table level to provide a permanent spring, soak, or natural well. (e.g. Millstream Homestead, Weeli Wolli Spring, Wort Native Well.)

Quality and Yield.

The waters currently supplied from calcrete deposits are generally of good quality and excellent for stock purposes. Higher salinities are often associated with formations of lower effective porosity. In these areas the quality may show improvement towards the outer margins of the calcrete deposit particularly where these are flanked by extensive areas of alluvium or outwash. Highly saline sectors are generally restricted to the lower parts of valleys or to lower drainage reaches that are in close proximity to salt lakes. At Cue, Wiluna and Lorna Glen some calcrete aquifers yield good quality waters in amounts sufficient for irrigation and town supply use.

From a tabulation by Brookfield (in press), 74 per cent. of the watering points in calcrete formations of the Wiluna-Meekatharra area have salinities of less than 250 grains of sodium chloride per gallon. The tabulation also shows that 58 out of 124 watering points have yields greater than 4,000 gallons per day and that, of these, five have yields greater than 5,000 gallons per hour. In such pastoral areas, it is considered that the current supplies are mainly governed by equipment used and reflect demand rather than potential.

From these data, the quality and quantity of water available from calcrete deposits in other areas can be expected to show considerable fluctuations. It is also likely that some large untested deposits may be capable of providing good quality waters in amounts sufficient for restricted irrigation and town supply use.

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REPORT ON DIAMOND DRILLING ON THE PINNACLES GROUP OF LEASES, NEAR CUE, MURCHISON GOLDFIELD.

by J. H. Lord.

LOCALITY.

The Pinnacles leases are situated in the Murchison Goldfield, about 12 miles south-east of Cue. The distance is slightly longer by a graded gravel road.

Cue is connected to the ports at Geraldton and Perth by rail at distances of 263 and 533 miles respectively. The distances by road are 268 and 408 miles respectively.

HISTORY.

Gold was discovered at The Pinnacles or Jasper Hill and the first leases, the Comet (now Gold Mining Lease 676D) and the Eclipse (now G.M.L. 664D) were granted in November, 1913.

The Comet and adjoining leases were taken over by the Black Range Pinnacles Co. N.L. from the original owners Messrs. Phillips and Campbell. This company erected a small treatment plant, which operated until 1918. Over 90 per cent of the ore produced from the Comet lease was treated during this period.

As the only production, since that period, came from stripping the existing workings and from old dumps, the grade has been low.

The Eclipse lease, originally owned by Messrs, Harrison and Kelly, was investigated in 1914 by the Great Fingall Company, who apparently abandoned it. During the 1930s, a Mr. H. L. McGee, formerly of Bewick Moreing & Co. and the Great Fingall Company, operated the Eclipse, and an unsuccessful attempt was made to form a public company. Since World War II the only production has been low grade material from old dumps which have been treated at the State battery at Cue by the leaseholder.

The other leases on the line of mineralisation have been worked only on a small scale by prospectors.

In 1958, New Consolidated Gold Fields (Australia) Pty. Ltd., obtained an option over the area and put down five diamond drill holes (numbered 1 to 5 on Plates XXIII and XXIV). The three holes on the Comet leases (G.M.L. 676 and 670) showed interesting values, while the two holes on the Eclipse lease (G.M.L. 664) were disappointing. The company abandoned its option.

In 1959, a syndicate put down diamond drill hole No. 6 to intersect the lode on the Comet leases at a great depth, but the results were poor.

In 1961, another syndicate approached the Department of Mines and negotiated a subsidy on a pound-for-pound basis to carry out further drilling at Pinnacles. The location of the drill holes and examination of the core were undertaken by the Geological Survey.

The three drilling programmes were carried out by K. and W. H. McCallum, drilling contractors of Cue, in an efficient manner. Core recovery throughout was excellent. The author planned and examined the results of each programme.

PRODUCTION.

The Department of Mines' records show that prior to 1950, the Pinnacles group of leases now under consideration had produced 11,967 tons of ore for 5,715 fine ounces of gold (9.5 dwt. per ton). About 85 per cent. of this production occurred between 1913 and 1918 and it is doubtful whether all of the gold won from the tailings has been included in these figures.

The production from the Comet Lease (G.M.L. 676D) is as follows:—

Years	Tonnage	Grade	Grade
		fine oz.	dwts./ton
1913–1918	9,225	3,929·6	8·5
1932–1935	1,057	138·5	2·6
Total	10,282	4,068·1	8·0

The ore treated during the period 1932-1935 was obtained from old dumps and by stripping old workings. Some similar material has been treated in recent years, and no ore has been drawn from underground.

The production from the Eclipse lease (G.M.L. 664D) according to the Department of Mines is as follows:

Years	Tonnage	Grade	Grade
		fine oz.	dwts./ton
1913–1915	75	58·6	15·6
1935–1938	583	193·8	6·7
Total	658	252·4	7·7

MINE WORKINGS.

The most extensive underground workings, on the Comet lease, were done by the original Black Range Mining Co. The company sank a three-compartment inclined (45 degrees) shaft to a depth of 230 feet (vertical depth 160 feet), drove on the lode for nearly 800 feet, and some stoping was done.

On the Eclipse lease the chief workings are two inclined shafts (60 degrees), connected on the 71 foot level, and stoped above.

The line of lode can be traced for the full length of the leases and has been prospected at numerous points with small shafts, costeans and potholes.

GEOLOGY.

The regional geology of this area has been described fully by F. R. Feldtman in Bulletin 80, of the Geological Survey of Western Australia. A regional map and report of the Cue district by J. C. McMath appear in the Annual Report of the Geological Survey for 1950.

The leases are situated on an island or roof pendant of the Archaean greenstone series, surrounded by granite and granite-gneiss. The gold mineralization occurs along lines of weakness or shear lines. There are two major lines—the Comet and the Pinnacle. The former occurs within the area being considered (See Plates XXIII and XXIV).

The "greenstones" consist of basic lavas and dolerites, which have been subjected to low grade regional metamorphism producing hornblende and chlorite schists. Some massive epidiorites occur.

The country rock, for the sake of logging, has been termed "hornblende schist." The degree of alteration is variable and produces a rock which varies from quartz-actinolite schist to a chlorite-talc schist. The latter occurs on the hanging wall of the lode formation.

The Comet line can be traced for 2¼ miles and gold has been produced along the northern half. The general strike of this Comet lode formation is N. 30° E. and it dips at 40 to 60 degrees east at the northern end, steepening to 60 to 80 degrees east in the centre and southwards. On the Comet lease the lode formation is up to 20 feet in width with a footwall and hanging wall lode. The mining was done on the footwall lode, whereas on the adjoining lease (G.M.L. 670D) to the north, the hanging wall lode is said to have been worked, but this is doubtful. These lodes were supposed to vary in width up to 5 feet, being separated by a varying thickness of formation, consisting mainly of hornblende schist.

The drilling has been concentrated near the Comet mine (leases 676 and 670) and shows that the zone of shearing, which is silicified and mineralised in places, varies in width up to about 25 feet. Within this zone there are sections of unaltered hornblende schist. The gold mineralisation, shown on the core assays, occurs in the silicified zone of shearing, mainly near the footwall.

Although the Eclipse mine is on the same Comet line of lode formation about 50 chains to the south, there is no record of the existence of the hanging wall lode. The lode formation is said to be 12 feet wide.

The lode formation is oxidised to nearly 100 feet at the Comet mine but only to 71 feet at the Eclipse. The ore shoots, according to Feldtman, are erratic but at the Comet mine they appear to pitch at about 55 degrees to the north-east. From the drilling results the pitch appears to be much steeper. The ore shoots do not appear to be associated with any well-defined structural control along the shear line. They may be related to changes in dip of the lode formation.

DRILLING.

During these programmes five inclined and eleven vertical diamond drill holes were drilled. Nos. 1 to 3 and 6 to 15 were near the Comet Mine (leases 676 and 670), while Nos. 4, 5 and 16 were near the Eclipse Mine on lease 664. The position of the drill holes are shown on Plates XXIII and XXIV.

The detailed log of each hole, together with the full assay results of samples submitted to the Kalgoorlie School of Mines are on file at the Geological Survey. The summarized results of each hole are shown in the accompanying table.

It is interesting to note that the lode formation, with gold values, was encountered in all holes; however, the grade in many was low.

The earlier drilling (holes Nos. 1, 2 and 3) had shown that reasonable gold values occurred over a length of 900 feet at a vertical depth of about 250 feet. The continuation of these values to the north was tested with drill holes No. 7 and 8, which showed that, although mineralisation continued, values over a workable width were between only 2 and 3 pennyweights per ton.

Testing to the south showed values in drill hole No. 9 of 10.1 dwt./ton over 68 inches but further south in holes No. 11 and 14 the grade fell to 2 to 3 dwt./ton.

Three holes, Nos. 10, 11 and 13, were drilled to test the lode at a vertical depth of 500 to 600 feet. One hole, No. 10, showed two sections of good values, namely, 13.4 dwt./ton over 45 inches and 7.8 dwt./ton over 28 inches, but the remaining two holes Nos. 12 and 13 showed only low values. Hole No. 6, drilled by another syndicate to this depth, failed also to locate values of interest. It would appear that the possibility of workable values occurring at this depth are remote.

Hole No. 16 was drilled on the Eclipse Lease 664 but, as in earlier holes Nos. 4 and 5, it showed only low values.

ORE POTENTIAL.

Accurate ore reserves can not be assessed on this drilling programme, but some idea of the ore reserve potential can be gained.

Five holes have intersected values at a vertical depth of 200 to 250 feet which, when considered, represent a possible ore body. They are:—

	inches	dwts./long ton
D.D.H. No. 3	60	11.0
D.D.H. No. 1	90	13.0
D.D.H. No. 15	42	3.1
D.D.H. No. 2	48	6.7
D.D.H. No. 9	68	10.1

This is over a length of 800 feet and it is fair to assume that the ore body may extend beyond the holes at either end and result in an approximate length of 1,000 feet. It would indicate an ore potential of 620 tons per vertical foot averaging 9.9 dwt./long ton at this depth. This probably extends upwards to the old workings but apparently decreases with depth because, at a vertical depth of 550 to 600 feet, only one hole out of four intersected values. It is unknown whether this is only a barren horizon with values improving with depth or not.

TREATMENT.

It has been alleged that this ore is difficult to treat, but investigations by the Kalgoorlie Metallurgical Laboratory show that a 92 per cent extraction can be achieved with the normal amalgamation and agitation cynanidation method. Their report is Ore Dressing Investigation, Report No. 718.

CONCLUSION.

The drilling programmes were not entirely successful. They show an ore body at a vertical depth of 250 feet in the Comet leases of 620 tons per vertical foot averaging 9.9 pennyweights per long ton which, apparently, decreases in value with depth as only one hole located values at a vertical depth of 600 feet.

The values on the Eclipse lease were poor.

A considerable tonnage of ore may exist about the 500 feet vertical level, which should be tested further by underground development.

SUMMARISED DRILLING RESULTS AT PINNACLES, NEAR CUE, WESTERN AUSTRALIA.

Hole No.	Position	Bearing	Angle of Depression (degrees)	Total Depth (feet)	Assays of Interest				Remarks
					Depth (feet)		Estimated true width (inches)	Average Grade dwts./long ton	
					From	To			
1	200 feet on bearing 296° 40′ from N.E. corner G.M.L. 676D	N. 58° W.	50°	375	321	332	36	6·80	90″. 13·0 dwts./ton
					332	336½	54	17·00	
2	373 feet on bearing 244° from N.E. corner G.M.L. 676D	N. 58° W.	50°	375	314½	316½	24	4·10	48″. 6·65 dwts./ton
					316½	318½	24	9·20	
3	352 feet on bearing 356° from N.E. corner G.M.L. 676D	N. 58° W.	50°	397	366½	369	30	11·62	60″. 10·95 dwts./ton
					369	371½	30	10·28	
4	542 feet on bearing 146° from N.W. corner G.M.L. 664D	N. 51° W.	50°	350	294¾	298¾	48	1·17	
5	536 feet on bearing 114° from N.W. corner G.M.L. 667D	N. 51° W.	50°	320	297	300	36	0·21	
6	298 feet on bearing 010° from N.E. corner G.M.L. 676D	....	Vertical	648	....	....	....	....	Some low values
7	730 feet on bearing 355° from S.E. corner of G.M.L. 670D	....	Vertical	283	248	250	24	1·79	
					250	252	24	3·81	68″. 2·0 dwts./ton
					252	254	24	1·34	
					254	256	24	1·06	
8	985 feet on bearing 006° from S.E. corner G.M.L. 670D	....	Vertical	255	239	241	24	2·74	
					241	243	24	3·64	51″. 2·5 dwts./ton
					243	245	24	1·12	
9	692 feet on bearing 254° from N.E. corner G.M.L. 676D	....	Vertical	251	187	191	48	3·08	
					191	194½	42	7·22	102″. 7·7 dwts./ton
					194½	196	18	0·50	or
					196	199	36	18·20	68″. 10·1 dwts./ton
10	35 feet on bearing 254° from N.E. corner of G.M.L. 676D	....	Vertical	625	544	548	48	13·44	
					548	551	36	0·28	
					551	555	48	0·28	189″. 4·9 dwts./ton
					555	558	36	1·12	
					558	560½	30	7·78	
11	850 feet on bearing 245° 15′ from N.E. corner G.M.L. 676D	....	Vertical	225	178	180	24	2·69	48″. 3·0 dwts./ton
					180	183½	42	3·14	
					183½	186½	36	1·90	
					186½	190	42	0·62	
					196	201	60	2·13	68″. 2·7 dwts./ton
					201	204	36	3·70	
12	320 feet on bearing 213° 30′ from corner G.M.L. 676D	....	Vertical	642	584½	590	66	0·50	57″. 1·1 dwts./ton
					590	595½	66	1·12	
13	576 feet on bearing 031° from S.E. corner G.M.L. 670D	....	Vertical	701	610½	612½	24	1·34	
14	1,025 feet on bearing 239° 30′ from N.E. corner G.M.L. 676D	....	Vertical	271	211	215	48	1·29	68″. 2·5 dwts./ton
					215	219	48	3·92	
15	482 feet on bearing 281° 30′ from N.E. corner of G.M.L. 676D	....	Vertical	247	207	212	60	3·08	
16	515 feet on bearing 173° 15′ from N.W. corner G.M.L. 664D	....	Vertical	269	215	220	60	2·18	

A PRELIMINARY REPORT ON THE HAMERSLEY IRON PROVINCE, NORTH-WEST DIVISION.

by W. N. MacLeod, L. E. de la Hunty, W. R. Jones and R. Halligan.

INTRODUCTION.

A regional investigation of the newly discovered iron ore deposits of the Hamersley and Ophthalmia Ranges was commenced by the Geological Survey in May, 1962. The field team comprised Geologists L. E. de la Hunty, W. R. Jones and R. Halligan under the supervision of W. N. MacLeod, Senior Geologist. The field season was concluded at the end of October.

The investigation involved the resolution of the principal stratigraphic units of the region, the study of the relationship of the iron ore to the stratigraphic column and the examination and sampling of individual deposits. Approximately 11,000 square miles of the iron province has been mapped on a scale of 50 chains to the inch by ground traversing and photo interpretation and a further 10,000 square miles has been examined photogeologically. It is planned to complete the mapping of the province during the 1963 field season. The present report outlines the progress to date and is accompanied by a progress regional map on a scale of 15 miles to the inch (Plate XXV). A more detailed map is also being compiled and will be published when the investigation of the Iron Province is completed after the 1963 field season.

These deposits have been referred to as the "Pilbara Iron Ores". Investigation has shown that the deposits of the Hamersley and Ophthalmia Ranges constitute an integral mineral province related to a group of Proterozoic sediments. These deposits are quite distinct from those related to the Archaean jaspilites in the northern part of the Pilbara Goldfield, e.g., Mt. Goldsworthy. The term Hamersley Iron Province is accordingly introduced to cover the deposits associated with the Proterozoic sediments of the Hamersley and Ophthalmia Ranges. The deposits in the Archaean Jaspilites are referred to as the "North Pilbara Iron Province."

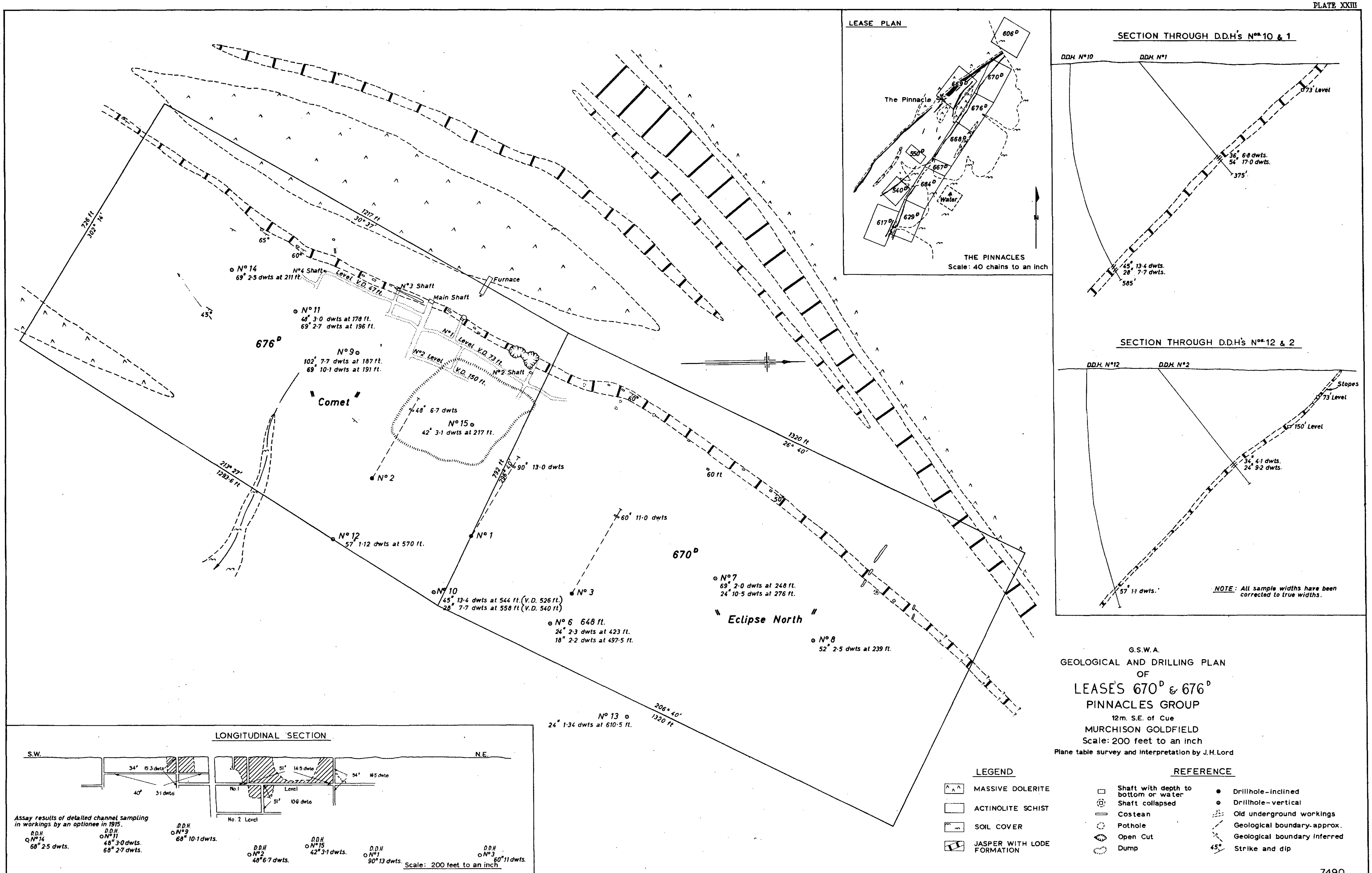
Close liaison has been maintained with prospectors and mining companies, who have been actively exploring for iron deposits in the Province since early 1961, and their confidential reports to the Department have been consulted. The courteous and wholehearted co-operation of the geologists of Conzinc Riotinto Australia Ltd., Broken Hill Pty. Co. Ltd. and Basic Materials Pty. Ltd. is gratefully acknowledged.

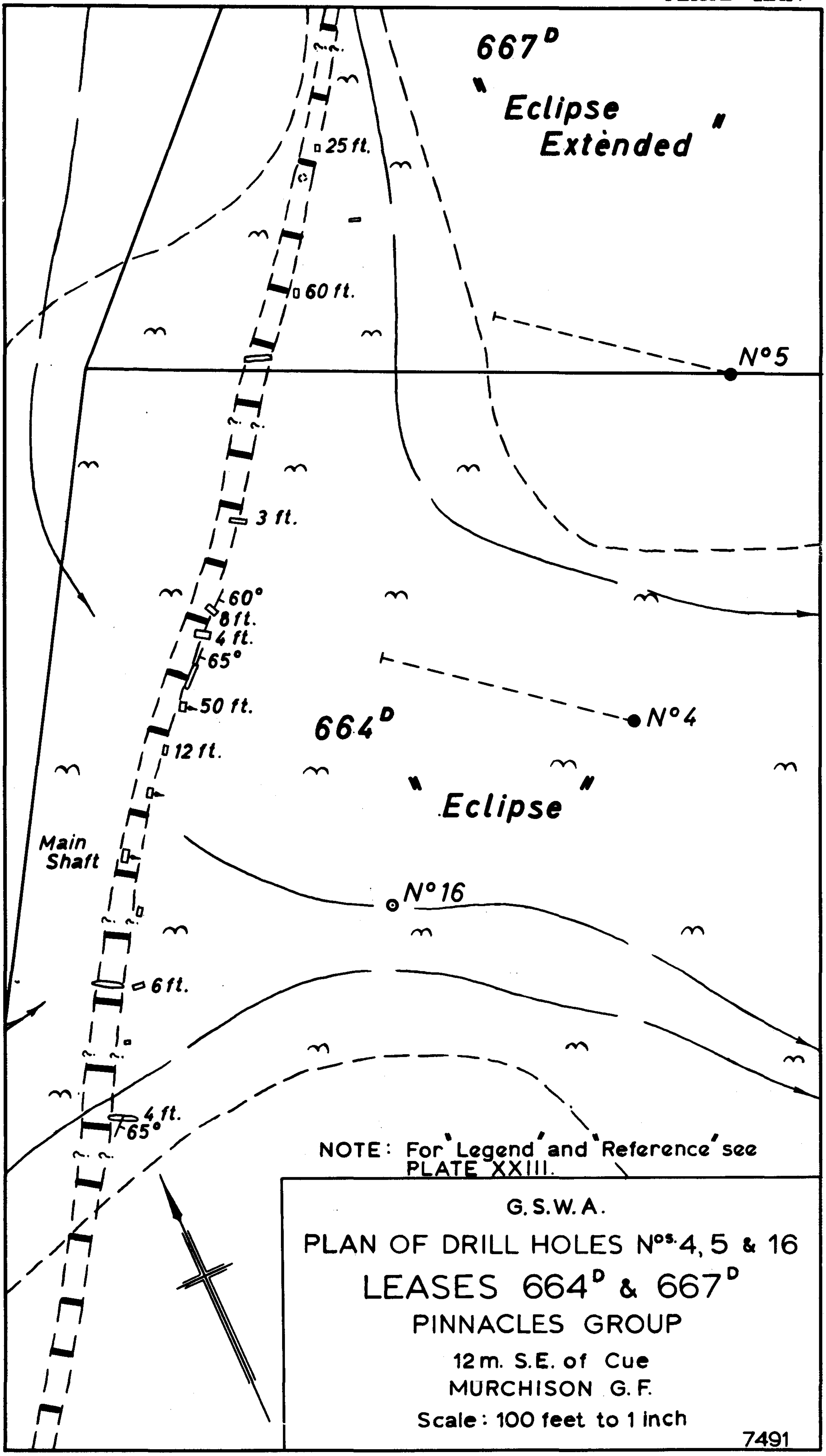
PHYSICAL FEATURES.

The Hamersley Iron Province covers an area of approximately 25,000 square miles between Latitude 21° S. and 23° 30′ S. and Longitude 116° E. and 120° E. This region of Western Australia includes the highest mountains of the State with many summits approaching 4,000 feet above sea level. The ranges lie astride the watershed of the important Fortescue and Ashburton drainage systems.

The region is semi-arid and sparsely inhabited. Owing to the rugged and deeply dissected nature of much of the terrain and the paucity of vegetation, large areas are unsuitable for grazing. Average temperatures during the summer months are the highest recorded throughout the entire conti-

PLATE XXIII


LEASE PLAN
The Pinnacle
606D
669D
670D
676D
668D
550D
667D
540D
684D
Water
617D
629D
THE PINNACLES
Scale: 40 chains to an inch
SECTION THROUGH D.D.H's Nos. 10 & 1
D.D.H. No 10
D.D.H. No 1
73' Level
36" 6·8 dwts.
54" 17·0 dwts.
375'
45" 13·4 dwts.
28" 7·7 dwts.
585'
SECTION THROUGH D.D.H's Nos. 12 & 2
D.D.H. No 12
D.D.H. No 2
Stopes
73' Level
150' Level
34" 4·1 dwts.
24" 9·2 dwts.
57" 1·1 dwts.
NOTE: All sample widths have been corrected to true widths.
726 ft
302° 14'
1217 ft
30° 37'
1320 ft
26° 40'
213° 27'
1293·6 ft
792 ft
206° 40'
206° 40'
1320 ft
65°
60°
45°
60°
60 ft
50
No 14
69" 2·5 dwts at 211 ft.
No 4 Shaft
Level V.D. 47 ft.
No 3 Shaft
Main Shaft
Furnace
No 11
48" 3·0 dwts at 178 ft.
69" 2·7 dwts at 196 ft.
676D
No 9
102" 7·7 dwts at 187 ft.
69" 10·1 dwts at 191 ft.
No 1 Level V.D. 73 ft.
No 2 Level V.D. 150 ft.
No 2 Shaft
"Comet"
48" 6·7 dwts
No 15
42" 3·1 dwts at 217 ft.
90" 13·0 dwts
No 2
60" 11·0 dwts
No 12
57" 1·12 dwts at 570 ft.
No 1
670D
No 7
69" 2·0 dwts at 248 ft.
24" 10·5 dwts at 276 ft.
No 10
45" 13·4 dwts at 544 ft. (V.D. 526 ft.)
28" 7·7 dwts at 558 ft (V.D. 540 ft.)
No 3
No 6 648 ft.
24" 2·3 dwts at 423 ft.
18" 2·2 dwts at 497·5 ft.
"Eclipse North"
No 8
52" 2·5 dwts at 239 ft.
No 13
24" 1·34 dwts at 610·5 ft.
LONGITUDINAL SECTION
S.W.
N.E.
34" 6·3 dwts
40"
3·1 dwts
51" 14·5 dwts
54" 14·5 dwts
No. 1 Level
51" 10·6 dwts
No. 2 Level
Assay results of detailed channel sampling in workings by an optionee in 1915.
D.D.H. No 14 68" 2·5 dwts.
D.D.H. No 11 48" 3·0 dwts. 68" 2·7 dwts.
D.D.H. No 9 68" 10·1 dwts.
D.D.H. No 2 48" 6·7 dwts.
D.D.H. No 15 42" 3·1 dwts.
D.D.H. No 1 90" 13 dwts.
D.D.H. No 3 60" 11 dwts.
Scale: 200 feet to an inch
G.S.W.A.
GEOLOGICAL AND DRILLING PLAN
OF
LEASES 670D & 676D
PINNACLES GROUP
12m. S.E. of Cue
MURCHISON GOLDFIELD
Scale: 200 feet to an inch
Plane table survey and interpretation by J.H. Lord
LEGEND
MASSIVE DOLERITE
ACTINOLITE SCHIST
SOIL COVER
JASPER WITH LODE FORMATION
REFERENCE
Shaft with depth to bottom or water
Shaft collapsed
Costean
Pothole
Open Cut
Dump
Drillhole-inclined
Drillhole-vertical
Old underground workings
Geological boundary-approx.
Geological boundary inferred
Strike and dip
7490



NOTE: For 'Legend' and 'Reference' see PLATE XXIII.

G.S.W.A.

PLAN OF DRILL HOLES Nos. 4, 5 & 16

LEASES 664D & 667D

PINNACLES GROUP

12 m. S.E. of Cue

MURCHISON G.F.

Scale: 100 feet to 1 inch

7491

nent, but the winter months are mild and equable. The average annual rainfall amounts to about 10 inches, but there is a high variability and as most of the rain falls during the hot summer months its effectiveness is greatly reduced by excessive evaporation. Most of the watercourses are dry throughout the greater part of the year and flow briefly only after heavy summer thunderstorms.

In few areas of the State is the close correlation between geology and topography more strikingly demonstrated. The Hamersley and Ophthalmia Ranges both owe their existence and form to the presence of three thick, resistant jaspilite iron formations of wide lateral extent. These units are separated by dolomite, shale and volcanic rocks of much lower resistance to erosion and, in consequence, the stratigraphic and structural features of the region have been boldly outlined by erosion. The clear topographic expression of the major stratigraphic units has permitted accurate photogeological interpretation and the recognition of potential ore-bearing zones in the jaspilite. The northern escarpment of the Hamersley Range, which in places rises 2,000 feet above the Fortescue River plain, can be followed almost continuously for nearly 250 miles. It faithfully demarcates the northern limit of the Brockman Iron Formation which is the major jaspilite unit of the Hamersley succession.

In the northern zone of the Hamersley Range the rocks are almost flat lying with a gentle regional dip to the south. The topographic forms reflect these low dips with the development of broad plateaux, mesas, buttes and cuestaform ridges. In the central and southern sections of the ranges the rocks are much more strongly folded; in places with near vertical dips. Here the resistant jaspilites form bold and persistent hog backs in the limbs of the major folds and clearly define the broad geological structure of the region.

The majority of hill summits in the region, particularly those formed of the Brockman Iron Formation, have a gently domed form. The slopes of the domes are transgressive to the bedding of the jaspilite. These domes and cappings represent remnants of an older land surface, possibly of early Tertiary age, which has been strongly incised by more recent erosion. Recognition of this ancient surface is of paramount economic significance. Most of the major hematite ore bodies in the region are to be found immediately below this surface.

In the eastern section of the province, south and south-east of Wittenoom, this old surface is most extensively preserved in a terrain of low, domed hills separated by broad and shallow valleys in which there are thick detrital accumulations.

Elsewhere the old surface has been deeply eroded and in cross section most of the valleys have a characteristic "valley in valley" shape testifying to a vigorous cycle of erosion following stream rejuvenation. Active headward erosion by the rivers continues at the present time and most of the scenic attractions of the region such as Wittenoom Gorge, Joffre Falls and Dale's Gorge are products of this renewed erosion cycle.

STRATIGRAPHY.

Previous reconnaissance mapping has correlated the rocks of the Hamersley and Ophthalmia Ranges with those of the Proterozoic Nullagine Series which is widely distributed in the north-western portion of the State. (Maitland, 1909; Talbot, 1920b and Forman, 1938). There has been no systematic mapping or subdivision of these sediments prior to the present investigation.

The Proterozoic rocks of this region form a conformable succession which has been divided into three groups. The total thickness is about 33,000 feet. The upper part of the succession has not yet been completely examined and the total thickness could be much greater.

At the base, arkosic grits, sandstone and conglomerate unconformably overlie the Archaean basement. These sediments are followed by a thick and widespread succession of basaltic lava flows in which pillow lavas are abundantly represented. There are numerous sedimentary and pyroclastic intercalations within the lava sequence and these increase in thickness and proportion towards the upper part of the succession. This lowermost group of lavas and clastic sediments is termed the *Fortescue Group* and has a total thickness of about 14,000 feet.

The Fortescue Group is conformably overlain by a thick sequence of sediments which appear to be mainly of chemical origin. These comprise jaspilite, chert and dolomite with siltstone and shale. No coarse clastic sediments have been recorded in this part of the succession. These are interbedded with acid lavas and have been intruded by thick dolerite sills over a wide adea. This group is termed the *Hamersley Group*. Most of the iron ore deposits of the region occur within, or have been derived from, the thick jaspilite formations within this group. A striking feature of the group is the remarkable lateral persistence of the individual sedimentary units. The Hamersley Group is about 8,000 feet thick. The highly resistant jaspilite formations form most of the prominent topographic features of the Hamersley and Ophthalmia Ranges.

The chemical and fine clastic sediments of the Hamersley Group are conformably overlain by a thick sequence of sediments which are predominantly of clastic origin. These include greywacke, quartzite, conglomerate, phyllite, shale and interbedded vesicular basalt. A strong dolomite unit towards the upper part of the succession, the Duck Creek Dolomite, has been followed for over 200 miles. These later sediments have been termed the *Wyloo Group*. The upper limit of the group has not yet been determined but it is known to be at least 11,000 feet thick. Formal definition of the group and its component formations cannot be made at present. Some of the sediments which were formerly included within the Ashburton beds and correlated with the Mosquito Creek Series of the Archaean (Maitland, 1909) have been shown to belong to the Wyloo Group.

The Archaean basement rocks are exposed in the cores of structural domes at Rocklea, Milli Milli Spring and south of Mt. Newman. These include granite and granite gneiss, greenstone, schist and jaspilite and appear to be typical of the Warrawoona Series.

Superficial deposits in the iron province include thick deposits of valley fill of both Tertiary and Quaternary age, limestone and opaline silica of the Oakover Formation, limonitic iron ore deposits, thick river gravels, alluvium and soil cover. Much of the thick valley fill of Tertiary age has been dissected and redistributed in the present drainage system. Areas underlain by dolomite are sites of thick calcrete accumulations along the drainage channels.

The stratigraphic column is summarized in the following table:—

Stratigraphic Column of the Hamersley Iron Province.

Era	Period	Group	Formation	Lithology	Thickness
					Feet
CAINOZOIC	Recent			Soil cover	
				River gravel and alluvium	20
				Outwash	50
	Tertiary		Oakover Formation	Fill	100+
				Limestone and opaline silica	70
				Limonitic deposits	50av.
				Chert breccia	20
MESOZOIC	Jurassic		Yarraloola Conglomerate	Conglomerate, sandstone with fossil leaves and marine fossils	20
PROTEROZOIC		Wyloo		Greywacke	2,000
			Duck Creek Dolomite	Dolomite and chert	1,000
				Conglomerate (1)	1,300
				Dark shale	100
			Cheela Springs Basalt	Vesicular basalt	5,000
			Mt. McGrath Beds	Dark siltstone, quartzite and conglomerate	100
			Beasley River Quartzite	White quartzite	300
			Turee Creek Formation	Greywacke, conglomerate, shale and basalt	1,000
		Hamersley	Boolgeeda Iron Formation	Jaspilite, ferruginous shale....	700
			Woongarra Dacite	Dacite	1,900
			Weeli Wolli Formation	Jaspilite, dolerite and basalt	1,600
			Brockman Iron Formation....	Jaspilite, shale, chert	2,200
			Mt. McRae Shale	Shale, siltstone, dolomite, dolomitic shale, chert	300
			Mt. Sylvia Formation	Thin jaspilite with shale	110
			Wittenoom Dolomite	Dolomite and dolomitic shale	500
			Marra Mamba Iron Formation	Jaspilite, chert	600
		Fortescue	Jeerinah Formation	Jaspilite and shale with dolerite and basalt	3,000
			Mt. Jope Basalt	Pillow lavas and pyroclastics	7,000
			Hardey Sandstone	Sandstone, arkose, conglomerate, basalt, quartzite and dolerite	4,000
ARCHAEAN	....	....	....	Talc-chlorite schist, volcanics, jaspilite and granite	

(1) Conglomerate may be equivalent to dark siltstone, quartzite and conglomerate of Mt. McGrath Beds.

THE PROTEROZOIC ROCKS.

Fortescue Group.

The Fortescue Group embraces the lower formations of the Proterozoic succession. These are most extensively exposed along the valley of the Fortescue River between Roy Hill in the east and the watershed between the Robe and Fortescue Rivers in the west. A large area of the Mt. Bruce Sheet is underlain by this group and it also appears in the extreme south-eastern section of the iron province, south of Mt. Newman.

The upper limit of the group is arbitrarily placed at the base of the Marra Mamba Iron Formation. The appearance of this thick and persistent iron formation marks the change from the initial volcanic activity and clastic sedimentation to the phase of chemically precipitated sediments of the Hamersley Group.

The type locality of the Fortescue Group is in the vicinity of Moonah Well (Lat. 22° 49′ S., Long. 117° 27′ E.) on the southern limb of the Rocklea Anticline.

The Hardey Sandstone is the basal formation of the Proterozoic succession and is about 4,000 feet thick. In the type area in the core of the Rocklea Anticline (see above) it dips radially off the Archaean nucleus with an average dip of about 60 degrees and is excellently exposed. The formation reappears in a similar fashion in the Milli Milli Anticline further to the east and in the core of the Wyloo Anticline near the western boundary of the province.

The Hardey Sandstone is a white to reddish brown and green quartz sandstone. It is commonly arkosic and in places rather calcareous. Basalt and volcanic agglomerate are interbedded with the sandstone, especially near the eastern side of the Rocklea Anticline near Rocklea Homestead. The Hardey Sandstone is conformably overlain by the pillow lavas of the Mt. Jope Basalt.

Mt. Jope Basalt.—This formation is of wide areal extent in the Hamersley Iron Province. It has been best studied in the central and southern areas of the Mt. Bruce Sheet, and is known to extend along the entire northern arc of the province from the Robe River to near Roy Hill, a distance of 300 miles. Basaltic lavas south of the Ophthalmia Range are also correlated with this formation.

In the type locality around Mt. Jope (Lat. 22° 57′ S., Long. 117° 29′ E.), three principal members have been distinguished and mapped. These include two thick pillow lava units separated by a zone of pyroclastics and sediments. The pillow lavas cover a wide area in the southern half of the Mt. Bruce Sheet and form prominent rugged hills. The best exposures occur around the Rocklea Dome.

The lower pillow lava member conformably overlies the Hardey Sandstone and is about 2,500 feet thick. The pillows are best exposed in the watercourses where the weathering products are being constantly removed. The lower pillow lava contains intercalations of blue-grey carbonate rocks and soft grey chlorite rocks with dark elongated pellets. These rocks have a peculiar fish scale weathering pattern and, on a larger scale, weather like flattened and sheared pillows.

The intervening pyroclastic unit which separates the two pillow lava flows includes finely banded grey ash beds with agglomerate and volcanic bombs. Minor amounts of chert, shale and jaspilite have been noted and there is some coarse-grained dolerite and pillow lava. The pyroclastic unit is about 2,000 feet thick. It has a marked topographic expression and can be readily identified from its photo pattern. The pyroclastic member has also been recognized in the Jeerinah anticline, where it outcrops over an area of about 14 square miles.

The upper pillow lava member is the most widely distributed unit of the formation due to lower dips at greater distances from the centres of the domes. There are extensive exposures in the Jeerinah Anticline and the pillow structure can be seen at Jeerinah Rockhole (Lat. 22° 23′ S., Long. 117° 7′ E.), at Fish Pool on the Beasley River and at Bunjinah Spring (Lat. 22° 23′ S., Long. 117° 51′ E.). Pillows are also well-exposed on the south side of the Hardey River, 8 miles south-west of Rocklea Homestead. This unit contains vesicular basalt and volcanic breccia and these components are often seen in zones where pillows are not developed. Such a zone is at Stinking Pool on the Beasley River, about 17 miles north-north-west of Mt. Turner. The upper pillow lava member is about 2,500 feet thick.

The Jeerinah Formation includes the sediments and doleritic sills and flows in the upper section of the Fortescue Group. The formation comprises shale, chert, jaspilite, mudstone, quartzite and dolerite. The softer sedimentary members are rarely well-exposed; the harder dolerite and jaspilite outcrop more frequently.

The formation has been named from its wide exposure within the Jeerinah Anticline around Jeerinah Rockhole and this may be regarded as the type locality. A type section has been measured about 1 mile south of Mt. Turner (Lat. 22° 43′ S., Long. 117° 26′ E.) where the formation dips steeply to the north. The section is as follows:—

		Feet,
Top—	Coarse-grained dolerite	620
	Chert, shale, mudstone	280
	Coarse-grained dolerite	400
	Shale and jaspilite	110
	Coarse-grained dolerite	510
	Chert and calcareous shale	320
	Coarse-grained dolerite	250
Base—	Chert, shale, mudstone and quartzite	510
	Total	3,000

The Jeerinah Formation conformably overlies the Mt. Jope Basalt and is overlain by the Marra Mamba Iron Formation of the Hamersley Group.

In the Jeerinah Anticline the lowermost sedimentary member forms a prominent scarp about 400 feet high. A thick white quartzite bed has controlled the formation of this escarpment. Here the sediments dip to the east at about 10 degrees. In some parts of the province, basalt flows are interbedded with the shale and chert, and dolerite intrusions are poorly developed. In the Robe River area, white shale and chert are the principal rock types. A persistent white shale unit, between 50 and 100 feet thick, is the uppermost member of the formation in the Fortescue valley and can be followed continuously from the Robe River to Roy Hill, a distance of 300 miles. Near Roy Hill the shale is interbedded with dolomite and chert. This member is a useful marker bed for the upper limit of the Fortescue Group.

The Hamersley Group.

The sediments of the Hamersley Group are predominantly of chemical origin. Chert, jaspilite and dolomite are the principal rock type. Thin lutites are interbedded with jaspilite and dolomite, and coarse clastics have not been recorded. The lithology of the lower part of the group indicates a prolonged period of alternating phases of precipitation of iron, silica, lime and magnesia under still water conditions. The acid lavas in the upper section of the group were probably extruded under sub-aerial conditions. The uppermost sedimentary unit, the Boolgeeda Iron Formation, contains a higher proportion of clastic material than the two lower iron formations. The Hamersley Group is conformably overlain by the coarser sediments of the Wyloo Group.

Over three-quarters of the total area of the iron province is underlain by rocks of the Hamersley Group. It has been subdivided into eight formations whose total thickness amounts to about 8,000 feet.

Marra Mamba Iron Formation.—The wide distribution of this formation is clearly shown on the map of the iron province which accompanies this report. It extends, with almost continuous outcrop, along the entire northern front of the Hamersley Range for a distance of over 300 miles. In the central and southern sections of the province, where folding is more intense, the Marra Mamba Iron Formation faithfully outlines the principal structural elements of the region and serves as an invaluable marker bed.

The Marra Mamba Formation is 600 feet thick. The type locality is at Marra Mamba (Lat. 22° 20′ S., Long. 117° 15′ E.). The thickness has been measured in the northern limb of the Hardey Syncline, where the beds dip steeply to the south. It is conformably overlain by the Wittenoom Dolomite.

Chert and jaspilite are the principal lithological components. The chert bands are generally yellow to yellowish brown and have a distinctive "pinch and swell" structure, which is often sufficiently pronounced to separate the chert into individual lenses within the jaspilitic matrix. These chert lenses are rarely more than two inches thick but are up to 2 feet across. Many are elongated at right angles to the elliptical section. Magnetite concentrations are common on the surfaces of these chert lenses and these can be veined by thin seams of crocidolite.

The jaspilite is similar to that of the other iron formations. Thin bands of chert and iron minerals rapidly alternate and are sharply demarcated. Magnetite and hematite as martite are the principal iron minerals.

Numerous hematite deposits have been recorded in the Marra Mamba Iron Formation but these are smaller and of lower grade than those of the Brockman Iron Formation. Broken Hill Pty. Co. Ltd. are currently drilling and mapping hematite zones in this formation at Roy Hill and in the Chichester Range.

At Marra Mamba the formation contains seams of crocidolite. These were the first to be worked in the State and some 49 tons of fibre were extracted in 1941. Here the crocidolite occurs at the top of the iron formation, close to the contact with the overlying Wittenoom Dolomite. The deposits have been mined in four localities along the northern flank of the Jeerinah Anticline and are scattered over a length of 12 miles.

Small showings of crocidolite have been seen on the eastern end of the Mt. Brockman Syncline and on the northern side of the Mt. Turner Syncline. In both localities the asbestos appeared in the upper section of the iron formation.

The Marra Mamba Iron Formation is also characterized by the common appearance of skins of manganese dioxide. This is rare in other iron formations. Most of these deposits are too small to be of any economic significance but it is possible that some would merit development if large scale exploitation of the iron resources of the region was commenced.

At the eastern end of the Mt. Turner Syncline a manganese deposit has originated by replacement of jaspilite. The manganese body is 2 to 5 feet thick, dips at 40 degrees and is clear of overburden. It is at least three chains long and more than 50 feet high. The grade is possibly better than 40 per cent. manganese.

Wittenoom Dolomite.—The Marra Mamba Iron Formation is conformably overlain by 500 feet of dolomite, chert and dolomitic shale. The formation is named from its type locality in the hills south of Wittenoom township (Lat. 22° 15′ S., Long. 118° 20′ E.). Sections of the formation have been examined in many localities but the base is rarely exposed as it is usually covered with heavy detritus from the surrounding jaspilite hills. In most sections the lower part of the formation is composed of well-bedded grey to bluish grey crystalline dolomite. Chert and shaly intercalations are more abundant towards the upper part. At Mt. Sylvia and the Robe River, shales and dolomitic shales form the uppermost 200 feet of the formation. At Wittenoom Gorge, chert is more abundant than dolomite in most of the exposed sections.

The best exposures of the Wittenoom Dolomite are along the northern escarpment of the Hamersley Range. The dolomite forms most of the spurs and isolated hillocks at the edge of the plain of the Fortescue Valley. Most of this broad, alluvium-filled valley is believed to be underlain by dolomite. The Goodiadarrie Hills, north-east of Wittenoom are composed of the Wittenoom Dolomite.

The formation is thin in the Hardey Syncline near the southern boundary of the iron province. Thin and limited exposures of calcareous and cherty shale between the Brockman and Marra Mamba Iron Formations in this area probably represent the formation.

Minor folding is a common feature of the Wittenoom Dolomite. This is particularly well seen in the Robe River sections and at Weeli Wolli. The minor folds are tight and randomly orientated and are thought to be drag folds resulting from the relative incompetence of the dolomite during the broad warping and gentle folding of the more competent jaspilite beds between which the dolomite is confined.

Mt. Sylvia Formation.—This formation includes three thin, but remarkably persistent, beds of jaspilite with interbedded dolomitic shales. The three jaspilite members outcrop prominently along the escarpments of the Hamersley Range and can be followed continuously for many miles. These are excellent marker beds and serve to clearly define the base of the Brockman Iron Formation where most of the large hematite deposits of the region have been found.

The type locality and measured section of the formation are at Mt. Sylvia (Lat. 22° 18′ S., Long. 117° 37′ E.). This is a few miles south-west of Hamersley Homestead, close to the road and easily accessible. The formation is 110 feet thick at this locality and is seen to conformably overlie the Wittenoom Dolomite.

The uppermost jaspilite bed is 18 feet thick and defines the top of the Mt. Sylvia Formation. It is a finely banded, light green and brown to maroon jaspilite with many highly ferruginous bands. Despite the small thickness of this unit it has been seen to persist from the Buckland Hills on the Robe River to the eastern end of the Ophthalmia Range, a distance of over 300 miles, with little change either in thickness or lithology.

The two lower jaspilite members are thinner and contain a higher proportion of greenish white banded chert than the uppermost unit. The chert and jaspilite beds are separated by blocky calcareous shale and thinly bedded fissile shale with dolomitic intercalations. These sediments weather rapidly to give smoothly concave slopes from which the jaspilite beds stand out as prominent low cliffs.

The upper shale unit has been seen to range between 15 and 50 feet in thickness and the lowermost units between 8 and 15 feet.

Mt. McRae Shale.—This formation conformably overlies the Mt. Sylvia Formation and its type locality is also at Mt. Sylvia. The formation takes its name from its similar mode of occurrence on the nearby Mt. McRae, 3 miles to the north-west.

The Mt. McRae Shale is about 300 feet thick. Its upper and lower limits are sharply defined by the overlying Brockman Iron Formation and the uppermost jaspilite of the Mt. Sylvia Formation at the base. The formation includes shale, siltstone and dolomitic shale with thin beds of jaspilite and chert. At Wittenoom Gorge the formation contains a high proportion of chert and dolomite and closely resembles the lower Wittenoom Dolomite. In this area it is necessary to identify the Mt. Sylvia jaspilite beds before the Mt. McRae Shale can be recognised.

The shaley sediments have low resistance to erosion and in cliff sections weather to concave slopes with white outcrops. Exposures are rare and the formation is often masked with a veneer of jaspilite scree from the overlying Brockman Iron Formation.

Brockman Iron Formation.—This iron formation is the thickest and most widely exposed formation of the Hamersley Group. It conformably overlies the Mt. McRae Shale and is conformable with, or grades into the overlying Weeli Wolli Formation.

The type locality for the formation is at Mt. Brockman (Lat. 22° 28′ S., Long. 117° 18′ E.) but the thickness cannot be reliably measured in this area because of much minor folding and faulting in the limbs of the Mt. Brockman Syncline. The thickness has been measured in the steeply dipping northern limb of the Hardey Syncline where it is seen to be about 2,200 feet. In the northern area of the province, where folding is gentle, the upper part of the formation has usually been removed by erosion and measurement of total thickness cannot be made. An excellent section is exposed at Mt. Bruce where the uppermost 1,500 feet of the mountain is composed of flat-lying Brockman Iron Formation.

The high resistance to erosion of the jaspilite of this formation is the dominant topographic control of the region. Most of the prominent hills of the Hamersley and Ophthalmia Range, many of which approach 4,000 feet above sea level, are composed of Brockman Iron Formation. The elevated hogback ridges in the limbs of the major folds have controlled the regional drainage patterns at least since Mesozoic time.

The Brockman Iron Formation consists mainly of jaspilite and chert. The jaspilite is usually very finely banded with alternating laminae of iron ore minerals and quartz. The bedding ranges from fissile and flaggy to medium and is normally regular and well defined. In the Robe River headwater region the lowermost beds are medium-bedded and cherty with well marked red, green, black and white colour bands. The greater part of the formation, however, has bedding within the range of 2 to 6 inches and the individual beds are finely laminated to impart a monotonous dark blue-grey colour to the outcrop. The upper part of the formation contains more fissile varieties which weather to a reddish brown shaley outcrop. Bedding is normally regular and laterally persistent but pinching and lensing of beds has been observed. Chert "rolls" are also seen but are less common and on a smaller scale than those of the Marra Mamba Formation. Interbedded shales have been recorded on the southern side of the Mt. Brockman Syncline and thin interbedded tuffs and acid lavas occur near Yerra Bluff on the Robe River.

A dolerite sill has been intruded into the upper part of the formation in the limbs of the Mt. Brockman Syncline. The sill is about 50 feet thick and because of its lower resistance to erosion has weathered out to a steep-walled gully. This gully is a prominent and useful feature on aerial photographs and serves as a useful structural and stratigraphic indicator. On the south side of the syncline the dolerite is overlain by 400 feet of jaspilite and underlain by 250 feet of ferruginous shale.

Thin section examination reveals that the banding of the jaspilite is due to alternating zones of magnetite, hematite, martite or limonite with a very fine-grained quartz mosaic. Carbonate minerals are commonly present in the quartz-rich bands. The boundaries between the laminae may be sharp or diffuse and there is some degree of replacement of the iron minerals by silica. Riebeckite occurs in bands, veins, or cavity fillings and as bundles of fine acicular and curved crystals. The overall iron content of the Brockman Iron Formation is estimated to be between 20 and 25 per cent., and the silica content within the range of 40 to 60 per cent.

The Brockman Iron Formation is the locus for most of the large hematite deposits in the region. The ore appears to have formed as a result of selective leaching of the silica from the jaspilite by meteoric and ground waters. The ore only forms close to the old land surface, and particularly in synclinal troughs where residuals of the Brockman Iron Formation have been preserved by infolding.

The Brockman Iron Formation also carries the important deposits of crocidolite near Wittenoom. The crocidolite seams occur near the base of the formation close to the contact with the underlying Mt. McRae Shale. Here the shale formation is mainly dolomitic in composition. A similar close relation between the asbestos and dolomite has been noted in the Marra Mamba Formation near its contact with the Wittenoom Dolomite.

Weeli Wolli Formation.—In the central and eastern half of the iron province the Brockman Iron Formation is overlain by a thick succession of interbedded dolerite and jaspilite. This formation is extensively developed in the Ophthalmia Range and particularly so to the north of Weeli Wolli Spring where it occupies the troughs of two long and gentle synclinal folds. This area is taken as the type locality for the formation. A type section has been measured in the northern limb of the Hardey Syncline at Lat. 22° 53′ S., Long. 117° 6′ E. This is as follows:—

	Feet
Top—Dolerite	350
Jaspilite	60
Dolerite	250
Jaspilite	30
Dolerite	260
Jaspilite	50
Base—Dolerite	600
Total	1,600

A similar succession has been noted in the Ophthalmia Range along the valley of the Fortescue River where many beds of jaspilite, some only a few feet in width, occur in the dolerite between the thicker jaspilite members.

It is not yet established whether the dolerite of this formation is extrusive or intrusive. If it is intrusive, there has been a remarkable degree of confinement to one horizon in the stratigraphic column, viz., the junction of the Brockman Iron Formation and the Woongarra Dacite. In some areas the dolerite is vesicular but if the rock is extrusive it is difficult to account for the wide lateral extent of individual thin jaspilite beds.

Woongarra Dacite.—The acid lavas are conspicuous and widespread throughout the iron province and excellently exposed in many localities. The dacite was first recognised in the Mt. Brockman Syncline where it forms low bouldery hills on either side of the valley. In the southern limb the lava is 2,000 feet thick and in the northern limb about 1,600 feet. At the type locality, Woongarra Pool on the Beasley River (Lat, 22° 53′ S., Long. 117° 6′ E.), the dacite is about 1,900 feet thick, and dips south at 60 degrees where it overlies the Weeli Wolli Formation. West of Palra Spring, in the north-western corner of the Mt. Bruce Sheet, the Weeli Wolli Formation is missing, and the Woongarra Dacite directly overlies the Brockman Iron Formation. The dacite is thinner in the Ophthalmia Range; generally less than 1,000 feet.

Textural variations in the dacite suggest that separate flows are represented. Some varieties are eucrystalline and equigranular but the most common type is a grey to black porphyritic rock with abundant phenocrysts of quartz and white felspar. Dark aphanitic lava with flow banding is common. Perlitic cracks, indicative of devitrification of originally glassy material, have been recognised in thin sections. Autobrecciation of the acid lava is commonly observed.

Another variant, classified in the field as a "green quartzite," has been recorded in many localities. This contains rounded quartz grains like a sedimentary rock. There is some obvious banding and cavities are infilled with calcite and iron carbonate. Thin section examination has established that the rock is actually a silicified lava and that the green colour is due to an abundance of chlorite. Despite the distinctive appearance of this rock it is neither continuous in outcrop nor constant in stratigraphical position, and, accordingly is of little value as a marker.

Boolgeeda Iron Formation.—The youngest formation of the Hamersley Group is exposed only in the cores of synclines in the central and southern parts of the iron province. It has been recognised in the Mt. Brockman, Mt. Turner and Hardey Synclines on the Mt. Bruce Sheet in the Turee Creek Syncline further to the south and in the Duck Creek area. Extensive exposures are found in the eastern section of the Ophthalmia Range.

The type locality of the Boolgeeda Iron Formation is on the south side of Boolgeeda Creek, about 18 miles west-south-west of Mt. Brockman (Lat. 22° 36′ S., Long. 117° 4′ E.). Here it dips to the north at 45 degrees, conformably overlies the Woongarra Dacite with a sharp and well-exposed contact, and is about 700 feet thick.

The formation is composed of purplish red, flaggy siltstone and ferruginous shale with some jaspilite. Pale creamy shale and siltstone occur near the base of the formation in the Ophthalmia Range. Boulders of ferruginous shale containing riebeckite have been found in Boolgeeda Creek and these are believed to have been derived from this formation.

Jaspilite is more common towards the eastern end of the province, where many large hematite deposits are developed within the formation. No hematite deposits have been recorded in the Boolgeeda Iron Formation in the Mt. Bruce, Wyloo and Yarraloola Sheets. The formation is capped with limonite deposits up to 20 feet thick along the limbs of the Mt. Brockman Syncline. Some limonite also caps the iron formation where it is steeply dipping in the northern limb of the Hardey Syncline.

Wyloo Group.

The rocks of the Wyloo Group are the youngest within the Hamersley Iron Province. They conformably overly the Hamersley Group in the Mt. Brockman Syncline, the Turee Creek Syncline and the Hardey Syncline, and are well exposed in the Hardey River valley and in the Duck Creek area.

This part of the Proterozoic succession was only briefly examined during the 1962 field season and detailed subdivision of the group is not yet possible. However, several formations have been recognised and the general characteristics of the group have been studied.

The total measured thickness of the Wyloo Group is of the order of 11,000 feet. Coarse clastic sediments are thick and abundant in contrast to the underlying Hamersley Group, and rapid thinning and lensing of formations along the strike is common. Basic volcanic rocks are interbedded with the sediments and the whole sequence is strongly folded and much disturbed by faulting. The group has been followed for over 200 miles around the western and southern periphery of the Hamersley Range and, although the general assemblage of formations remains much the same, the lithology of the succession undergoes wide variations as members thicken and thin and sometimes disappear entirely. Facies changes and lensing of the beds raise difficulties in correlation of sections in different localities.

The group has been provisionally subdivided as follows:—

Top—Greywacke;
Duck Creek Dolomite;
Conglomerate;
Dark Shale;
Cheela Springs Basalt;
Mt. McGrath Beds;
Beasley River Quartzite;
Base—Turee Creek Formation.

Formal definition and naming of the formations is deferred pending further field work during the 1963 field season.

The Turee Creek Formation, which consists mainly of greywacke and shale, conformably overlies the Boolgeeda Iron Formation and was first recognised in the Mt. Brockman Syncline. It is well exposed in the Hardey Syncline where it is protected from erosion by a capping of the resistant Beasley River Quartzite. The greywacke is greenish, thinly bedded and schistose and in places grades into a conglomerate. Near Meteorite Bore it carries quartzite boulders up to two feet in diameter and is interbedded with dolomite, siltstone and basalt. The thickness of the greywacke is of the order of 1,000 feet.

The Beasley River Quartzite conformably overlies the greywacke of the Turee Creek Formation. In some places where folding has been strong, tectonic dislocation has occurred resulting from the greatly differing competencies of the resistant quartzite and the underlying greywacke, and locally the two formations appear to be in angular unconformity.

It is a white, medium to coarse-grained quartzite with occasional current bedding and ripple marks. Conglomeratic zones have been noted. It ranges between 300 and 550 feet in thickness and because of its highly resistant character, weathers into bold ridges.

The Mt. McGrath Beds are incompletely known but have been seen to include conglomerate, sandstone, greywacke and shale. The unit is characterised by very rapid changes in thickness and lithology along the strike. In the western areas it underlies the Cheela Springs Basalt but further east, at a point two miles south of Meteorite Bore, some 1,300 feet of coarse pebbly sandstone overlies basalt. These beds are thought to be equivalents of the Mt. McGrath Beds. In both areas the succession is directly overlain by the Duck Creek Dolomite.

An important feature of the Mt. McGrath Beds is the presence of highly ferruginized conglomerates. Locally, within these beds, the chert and jaspilite pebbles have been completely replaced by hematite and magnetite. A high-grade iron ore body, about 9,000 feet long and 20 feet thick, occurs in this formation about two miles south of Medalla Bore in the Duck Creek valley. Replacement of the conglomerate has been complete throughout most of the body, and the deposit is estimated to contain about 10 million tons of high grade ore.

The Cheela Springs Basalt overlies the Beasley River Quartzite near Meteorite Bore and it is estimated to be about 5,000 feet thick. Similar basalt overlies the quartzite in the Duck Creek valley. The basalt is epidotized and amygdaloidal with quartz, chlorite and pyrite in the amygdules. There are extensive exposures of the basalt along the southern flank of the Hamersley Range between Wyloo Homestead and the Beasley River.

The Duck Creek Dolomite is one of the most persistent units of the Wyloo Group and can be traced from the Beasley River to the lower Robe River, a distance of 200 miles. The dolomite is about 1,000 feet thick. It is a tough, light grey to buff, crystalline dolomitic limestone with medium to thick bedding. The lower part of the formation includes grey and buff coloured, thinly bedded limestone with interbedded shale. The rock is often silicified and interbedded cherts are common. Chert breccia often forms a capping on the dolomite. Skins of manganese minerals have formed on the dolomite in many localities but none of these appear to be of any economic value.

Stylolites have been recorded in the dolomite at Duck Creek Gorge, and "collenia" have been collected south of Mt. June, further west in the Duck Creek valley and also near Cheela Springs.

The Duck Creek Dolomite is overlain by greywacke and younger basalt flows and agglomerates of unknown thickness.

STRUCTURAL GEOLOGY.

In terms of structure the Hamersley Iron Province may be broadly divided into three main zones. These zones are aligned parallel to the long axis of the province and reflect an increasing intensity of folding and faulting on passing from north to south.

The northern zone includes the greater part of the Hamersley Range. Here the rocks have a gentle regional dip of generally less than 5 degrees to the south. This regional attitude is punctuated by occasional block faulting and narrow zones of strong flexuring; some of which serve as loci for ore. In the north-western sector, near Silver Grass Peak, and in the central and eastern sectors near Wittenoom, a gentle basin and swell structure is apparent. Most of the northern zone is underlain by the thick and resistant Brockman Iron Formation and, accordingly, the most extensive areas of high plateau country are found within this northern zone of the province. Younger members of the Hamersley Group are preserved in some of the deeper basin structures.

The central zone of the province is much more strongly folded and the topographic forms faithfully reflect the major structural units. Two superimposed fold trends are apparent and these have combined to produce a regular pattern of large domes and basins en echelon. The Mt. Brockman Syncline, the Jeerinah Anticline, the Mt. Turner Syncline, the Rocklea Anticline, the Milli Milli Anticine and the Turee Creek Syncline are the major structural units of the central zone. The limbs of the major structures dip at about 30 degrees, but minor folding and drag on the numerous fault planes cause local steepening. The minor folds within the limbs of the large synclines are the most favourable loci for hematite ore as is strikingly demonstrated in the case of the Mt. Brockman Syncline.

The southern structural zone is the narrowest, but extends with variable width along the entire southern and south-western boundary of the iron province. Here the folding is particularly strong with near vertical dips and accompanied by strong faulting with large displacements. The south-western corner of the province is the most violently disturbed portion of the region. In the Ophthalmia Range, at the eastern extremity of the province, folding is almost isoclinal in places. The east-west trending folds have been transected by a system of north-east-trending faults, one of which appears to have controlled the course of the upper Fortescue River. Between Duck Creek and the Robe River, the western boundary of the Hamersley Group is largely controlled by a north to north-west-trending fault pattern of great complexity.

The Brockman Iron Formation has a persistent regional joint pattern with the dominant system trending about 30 degrees west of north and with a secondary system at right angles. In the western section of the province, the major joint system and trend of the fault planes are clearly closely related. Minor movements on the north-west joint system are common but not always easy to detect.

THE IRON ORE DEPOSITS.

Although exploration is far from complete it is now apparent that the Hamersley Iron Province is one of the largest in the world. From mid-1961 to the end of 1962, intensive exploration has disclosed the existence of iron ore resources amounting to about 8,000 million tons of material of grade exceeding 50 per cent. iron. Of this total, inferred reserves of high-grade hematite-goethite ore of at least 60 per cent. grade amount to about 3,000 million tons. Lower grade pisolitic limonite-goethite ores, which contain between 50 and 60 per cent. iron, constitute the balance.

THE HEMATITE-GOETHITE ORES.

General Characteristics.

The hematite-goethite ores are of the Lake Superior type and occur within the jaspilite of the Brockman, Marra Mamba and Boolgeeda Iron Formations of the Hamersley Group. Over 100 ore zones have so far been located within the province and further exploration appears certain to reveal many more. In these ore zones all gradations in size and quality of ore have been observed. In some there is a sporadic development of small zones of porous, platy ore with abundant chert and jaspilite intercalations. Others are large bodies, extending continuously for several miles, composed of high-grade massive hematite in which remnants of unaltered jaspilite are rare or absent over large areas.

Considerable textural variations are to be observed within any one ore zone. In the most common occurrence bands of massive hematite up to several feet in width are intermingled with strongly banded and porous, platy material containing a high content of goethitic cement. The porous ore, locally termed "biscuit ore," forms the greater part of many ore zones and has an iron content within the range of 56 to 62 per cent. The more massive ore ranges between 63 and 68 per cent. iron. The overall grade of any particular ore zone is determined by the relative content of the two types.

The ore bodies appear to have originated as a result of selective leaching of silica and other impurities from the jaspilite. There has been some degree of concurrent mobilization and reprecipitation of the iron in the form of hydrated oxides. The unaltered banded iron formation contains between 20 and 30 per cent. iron and usually at least 50 per cent. silica. The process of enrichment has reduced the silica content of the ore to less than 4 per cent. It is believed that this enrichment has been achieved through the agency of ground and meteoric waters.

Examination of many ore bodies has revealed a dependence on certain structural and geomorphological conditions. Firstly, ore formation occurs only in vertical proximity to the old land surface and is rarely found at depths greater than 200 feet below this surface. Secondly, the ore is usually restricted to the basal sections of the Brockman Iron Formation, where the jaspilite has been infolded into structural traps, flanked and underlain by the relatively impermeable Mt. McRae Shale.

The formation of a large ore body appears to involve the wholesale transformation of the iron formation roughly in concordance with the profile of the ancient surface. When viewed in vertical scale the ore bodies appear as crusts and cappings on the unaltered jaspilite where a favourable combination of structural controls has permitted the leaching of silica by supergene waters.

The Marra Mamba Iron Formation is similarly underlain by a white shale and ore enrichment occurs in structural troughs as in the case of the Brockman Iron Formation. The lowermost member of the Boolgeeda Iron Formation is of similar lithology and ore is abundant in this formation, in the strongly folded sections of the Ophthalmia Range.

Ore bodies are most abundant and extensive along the troughs of minor synclinal folds on the limbs of the major domes and basins in the central and southern sections of the iron province. These conditions are best exemplified in the limbs of the Mt. Brockman and Mt. Turner Synclines and in many places in the Ophthalmia Range. Zones in the jaspilite which have been closely faulted are also favourable loci for hematite enrichment.

The age of the hematite ore bodies is unknown. It is clear that they were formed prior to the rejuvenation of the rivers which has produced the deeply dissected terrain of the present day. Their dependence upon proximity to the remnants of the old land surface could indicate that enrichment occurred concurrently with the development of this surface.

Distribution of the Hematite Ores.

The largest hematite ore bodies are located within the Brockman Iron Formation in the central and south-eastern sections of the iron province. There the rocks are more strongly folded into major domes and basins and favourable loci for hematite enrichment are abundantly presented in the limbs of these major structures. The Mt. Brockman and Mt. Turner Synclines have been carefully explored by geologists of Conzinc Riotinto Australia Ltd. and many large and high-grade ore bodies have been located. Drilling and assessment of these zones is now in progress.

Of the areas so far examined, the Ophthalmia Range appears to be the richest in ore. There the rocks are strongly folded on east-west axes and the Brockman Iron Formation forms long ridges as erosion residuals in the cores of synclines. Many large and high-grade deposits have been found in this region which, as yet, is but partially explored. The north-western limb of the Turee Creek Syncline appears to be another promising area for ore as is the country around and to the west of Weeli Wolli Spring.

Along the northern front of the Hamersley Range the jaspilite has a gentle regional dip to the south and there are no persistent major folds as in the central and southern areas of the province. Nevertheless narrow zones of strong flexuring are common and these commonly serve as sites of hematite enrichment. The most significant of these ore-bearing structures occur at Mt. Pyrton, Mt. Lockyer, Mt. Farquhar and in the hills north of Hamersley Station homestead. Some of these deposits have been drilled and assessed by Conzinc Riotinto Australia Ltd. These flexure belt ore bodies are individually smaller than those in the limbs of the Mt. Brockman Syncline, but the grade of ore is generally similar. These smaller deposits clearly illustrate the structural importance of synclinal troughs as a prerequisite for iron enrichment.

Numerous hematite ore zones have been found in the Marra Mamba and Boolgeeda Iron Formations. The richest area in the Marra Mamba Iron Formation appears to be at Roy Hill, and in the Chichester Range to the west of Roy Hill. In general these superficial deposits are thinner than those of the Brockman Iron Formation and deteriorate in grade at shallow depths below the surface. Chert bands are common and persistent.

Some large and high-grade ore zones have been found in the Boolgeeda Iron Formation in the Ophthalmia Range. None of these has as yet been tested in depth and it is possible that they may suffer the same deterioration at shallow depths as those of the Marra Mamba Iron Formation. Both formations are underlain by impermeable shaley beds and iron enrichment seems to have been controlled by the same structural and geomorphological conditions as apply to the Brockman Iron Formation.

Mineralogical and Chemical Composition.

Hematite, in the form of martite octahedra, and goethite are the principal mineral constituents of the ore. The proportion of the two varies widely in any one ore zone. The ore is usually banded in appearance and cavities, parallel to the banding, are a common feature. The cavities are often lined with coarse specular hematite and sometimes with goethite. In the "biscuits ore" the cavities are commonly infilled with black vitreous goethite or yellow ochreous material. Clusters and strings of fine quartz crystals are occasionally noted in thin section. Most of the ore in non-magnetic but specimens which are highly magnetic are not uncommon, and small magnetite octahedra have been recorded in thin section examination. In the massive recrystallised ore the grain size of the hematite is larger and the proportion of goethite much reduced. The banding in the ore is still detectable even in massive material of the highest grade and is presumably inherited from the protore jaspilite. Rhombohedral pseudomorphs, presumably derived by complete replacement of carbonate mineral in the protore, have been occasionally noted.

A vast amount of chemical data is now available concerning the hematite ores. The range in iron content is usually within the limits of 56 to 68 per cent., with the bulk of the material grading 60 to 64 per cent. The silica content is usually less than 4 per cent., alumina averages about 1.5 per cent., sulphur ranges between 0.03 and 0.06 per cent., titanium is less than 0.1 per cent. and the combined water content is generally less than 1 per cent. The phosphorus content averages about 0.12 per cent. with an extreme range between 0.05 and 0.17 per cent. This is a rather higher figure than that of ores for Yampi Sound and the Middleback Ranges. In all, the hematite of the Hamersley Range compares very favourably in composition and texture with other major deposits in the world.

THE PISOLITIC IRON ORES.

General Characteristics.

The pisolitic iron ores are widely distributed throughout the Hamersley Iron Province, but are most abundant in the ancient drainage channels of the Robe River, Duck Creek and the Beasley River. The ore forms the cappings of mesas and elongated ridges which are aligned along the courses of the original drainage channels, and is readily recognisable both on the ground and on aerial photographs. These ores represent an unusual variety of sedimentary iron deposit and the mode of origin is not completely understood. Very large reserves of this type of ore are available. In the Robe River valley alone the deposits cover a total area of about 30 square miles with the ore ranging in thickness from a few feet to nearly 200 feet.

The ore is usually pisolitic in texture and the iron content of the highest grade material is within the limits of 52 to 60 per cent. Silica and alumina are the main impurities, but collectively amount to less than 10 per cent. The content of combined water is of the order of 10 per cent., sulphur and phophorus are low and the ore is remarkably free of other metallic impurities.

Limonite, goethite and hematite are the principal mineral constituents of the pisolitic ore. The material is resistant to erosion, as is evidenced by its preservation as mesa cappings, but is friable and easily crushed and could be mined relatively cheaply from steep natural faces.

Distribution of the Pisolitic Ores.

The limonitic ore is found in all drainage systems radiating from the Hamersley Range which rise on the Brockman and Marra Mamba Iron Formations. There can be little doubt that these highly ferruginous formations are the ultimate source of the iron in the secondary pisolitic accumulations. The ore characteristically appears as elongated deposits along the low-gradient river valleys immediately below the steep hills and ranges composed of the Brockman Iron Formation.

The most important pisolitic deposits are to be found in the western section of the iron province in the drainage systems of the Robe River and Duck Creek. There appears to be a rough proportionality between the amount of ore within each drainage system and the area of Brockman Iron Formation drained by that system. The Robe River system, which has changed little since the ores were deposited, drains almost the entire northwestern sector of the Hamersley Range and contains by far the largest deposits of limonite ore in the province. The deposits can be followed almost continuously for 100 miles from Warramboo Station on the North-West Coastal Highway to the upper reaches of the Robe River near Silver Grass Peak. The largest individual deposits are in the downstream section between Deepdale and Warramboo and these are now being exhaustively examined and assessed by Broken Hill Pty. Co. Ltd. Total indicated reserves are measurable in thousands of millions of tons of ore in excess of 50 per cent. iron content.

The limonite deposits in the middle and upper reaches of the Robe River are held under Temporary Reserves by Basic Materials Pty. Ltd. In the middle reach of the river the mesas are generally smaller and narrower than those further downstream, but there is little difference in the grade of the ore and several hundreds of millions of tons have been indicated by face sampling and measurement of the mesaform deposits.

In the upper section of the Robe River, within the Hamersley Range, there are extensive terrace deposits of ore along the walls of the narrow gorges. These deposits have been deeply dissected following rejuvenation of the Robe and its numerous headwater tributaries. The gorge deposits tend to be more variable in texture and mineralogical composition than those downstream. In some sections the ore is of higher grade due to admixture with hematite-goethite conglomerate and assays of better than 60 per cent. iron are commonly recorded. Reserves of ore in the gorges are rather more difficult to assess due to the highly irregular base of the deposits on the valley walls. In some places the ore is up to 120 feet thick, but abrupt variations are common both in the direction of the river and across the valley. To all appearances the gorge deposits represent remnants of thick valley fill, which has been deeply incised and much of it scoured downstream by river action. The gorge deposits have been mapped and partially sampled. Reserves must be well in excess of 100 million tons. The value of this iron ore is rather offset by the difficulties of access within this rugged area.

There are numerous limonite deposits along the valley of Duck Creek and its tributary, Boolgeeda Creek. The ore-capped mesas are similar to those in the Robe River, but the ore layers are generally thinner and the overall grade is lower. Many of the mesas are deeply eroded and only thin residual cappings of ore remain. Estimated reserves of ore of grade exceeding 50 per cent. iron amount to about 800 million tons. These deposits have been mapped and sampled by Conzinc Riotinto Australia Ltd. and the Geological Survey. Duck Creek and Boolgeeda Creek are the main drainage units of the centre and northern limb of the important Mt. Brockman Syncline.

The Beasley River is the main southerly drainage unit from the southern limb of the Mt. Brockman Syncline. Extensive limonite deposits have formed along its valley for a distance of 15 miles. The ore is generally between 30 and 50 feet thick and the upper pisolitic layer assays between 53 and 57 per cent. iron. Reserves of the order of 250 million tons have been inferred.

Other large deposits of limonite have been found along the southern branch of the Fortescue River, where it traverses the Hamersley Range west of Wittenoom and at Dale's Gorge, which is situated in the plateau country to the south-east of Wittenoom. In the Dale's Gorge area the ancient land surface is preserved over a wider area than anywhere else in the province and it seems likely that further deposits may be located in the broad, alluvium-filled valleys beneath the more recent detrital veneer. Other pisolitic deposits, some quite extensive, occur along Yandicoogina Creek and Weeli Wolli Creek in the eastern section of the Hamersley Range. The remoteness of this area from the coast renders such ore of little immediate value in view of the abundant, nearby deposits of higher grade hematite ore.

Mineralogical and Chemical Composition.

The ore is characteristically pisolitic in texture with most of the pisoliths between 1 and 3 mm. in diameter. Examination, even in hand specimens, discloses great variation in the nature of the pisoliths. Many are composed of red, ochreous iron oxide, some of vitreous black and dark brown goethite and others of hematite with metallic lustre. Thin section examination shows that many are complex in composition with concentric layers of limonite and hematite. Some pisoliths provide evidence of fracturing followed by recementation and further growth. Fragments of fossil wood, randomly orientated and generally less than 1 cm. in length, are abundant in some horizons.

The pisolitic ore is usually porous. Vuggy cavities partially infilled with black vitreous goethite are common. Some sections of ore are less obviously pisolitic and appear to be composed of brown vitreous limonite. This type of ore is often sharply demarcated from the pisolitic ore. In the Robe River sections the vitreous ore weathers to well-defined benches interbedded with pisolitic ore and it has been possible to correlate some of these separate beds over short distances.

Intercalations of fluviatile sediments are rare in the ore. Clay lenses have been recorded from drill holes together with zones of lower grade clayey limonite.

In the middle section of the Robe River the pisolitic ore overlies with a knife edge contact an old surface of lateritized basalt. In other zones the ore is separated from the basalt by a zone of low grade, porous ore with large cavities and an abundance of yellow ochreous clay. In the lower Robe River the ore is underlain by clay, sandstone and fluviatile grits.

Cavities within the ore are occasionally lined with opaline silica and veins of travertine have been detected in drill core.

Angular fragments of hematite are abundant in the material in the gorges of the upper Robe River. Most of these fragments are less than 1 cm. across and they are set in a pisolitic groundmass, similar to the common ore type seen downstream. Fluctuations in the grade of ore are presumably influenced by the relative proportion of goethite, limonite and hematite. Ore of lower grade is usually recognisable by a high content of yellow ochreous limonite in large cavities and pipes, while ore of high grade has a sub-metallic lustre and numerous pisoliths of red ochre.

Many hundreds of chemical assays of the limonitic ores are available from Company and Geological Survey records. The ore in the Robe River may be regarded as fairly representative of the entire region and the results of over 100 face sample assays are summarised in the following table:—

	Lower Robe River		Middle Robe River	
	Average	Range	Average	Range
	%		%	
Fe	56·0	50·2–60·5	57·0	53·8–59·5
SiO_2	5·0	2·3–9·2	5·0	4·2–6·0
Al_2O_3	2·9	1·3–6·6	3·0	2·2–4·1
P	0·06	0·025–0·11	0·06	0·05–0·08
S	0·11	0·02–0·15	0·07	0·05–0·11
Ignition Loss	10·8	7·6–12·7	10·0	9·5–11·0
TiO_2	0·19	0·07–0·40	....	....
Mn	0·10	0·05–0·20	....	....

Genesis of the Pisolitic Ores.

As mentioned earlier the most significant occurrences of this type of ore are confined to long established drainage channels which rise on the Brockman and Marra Mamba Iron Formations. The upper drainage basin of the Robe River is almost entirely underlain by the Brockman Iron Formation over an area of nearly 2,000 square miles in the north-western sector of the Hamersley Range. Duck Creek, Boolgeeda Creek and the Beasley River drain from the same formation in the limbs of the Mt. Brockman Syncline, and at Dale's Gorge the limonite has accumulated within an internal drainage basin on the high plateau which is mainly underlain by the Brockman Iron Formation.

It is suggested that the pisolitic ores represent the end product of a protracted cycle of weathering and desilicification of transported jaspilite detritus. This detritus accumulated in most of the valleys within and around the Hamersley Range during the long period of erosion which culminated in a mature subdued landscape of broad valleys and domed, gently sloping hills. Remnants of this old surface are abundantly preserved throughout the Hamersley Range. The flat-topped mesas in the present river channels are regarded as remnants of this profile in the lowland areas.

Following the establishment of this mature surface climatic conditions were apparently favourable for the process of iron enrichment within the jaspilite. Silica was dissolved and retained sufficiently long in solution to be removed entirely. Iron was dissolved to a lesser extent and quickly reprecipitated. Where structural conditions were favourable, zones of hematite enrichment were developed on the slopes of the jaspilite hills to depths of up to 200 feet below the surface.

At the same time, in the river channels, similar processes of desilicification and iron enrichment are believed to have occurred within the thick detrital deposits which were mainly composed of the same jaspilite as that of the surrounding hills. In the river channels, where there was free and continuous movement of water through this unconsolidated detritus, desilicification apparently proceeded rapidly and almost completely. In the Robe River channel field evidence indicates that the old channel was almost entirely infilled with detritus which has now been transformed to pisolitic ore, in places over a width of four miles.

The first stage in the transformation of jaspilite detritus led to the formation of hematite-goethite conglomerate or "canga." Remnants of this conglomerate are found in the terraces which flank the ancient drainage channels. In the central zones of the channels, where water was more abundant the hematite conglomerate was progressively transformed to pisolitic limonite-goethite. Careful examination of the material in the gorges of the upper Robe River and along the northern flank of the Buckland Hills provides examples of all stages of progressive desilicification and transformation of hematite-goethite conglomerate into pisolitic ore.

In summation, this theory proposes a common mode of origin for both the hematite-goethite ores and the lower grade pisolitic limonite ores. Both are products of supergene enrichment of jaspilite by selective removal of silica. In the case of the limonitic ores hydration of the iron oxides has been more extensive due to their concentration at lower levels in well watered drainage channels. Hydration has been accompanied by the growth of pisoliths, and remnants of hematite are rare.

Following the rejuvenation of the rivers, probably in late Tertiary times, both the gorge and riverine deposits were deeply dissected and are preserved as terraces or mesa cappings.

The distribution of the limonitic ores in the Robe River has apparently been influenced by the resistant bar of Brockman Iron Formation at the northern end of the Buckland Hills. Large and thick deposits occur immediately upstream from this bar which appears to have dammed the transported material. Downstream, below the bar, the river followed a meandering course with a low gradient of the order of 10 feet per mile. It cut directly across the general strike of the sediments of the Hardey Group and older sediments further to the west. These conditions must have been favourable for the accumulation of the large deposits between Yerra Bluff and Warramboo. At Warramboo drilling has shown that the deposits continue below the more recent alluvium and are split into channels. This area may have been delta at the time of deposition.

It has been postulated that the limonite was deposited as bog ore. This would necessitate the transport of vast quantities of iron in solution and its subsequent precipitation in swampy reaches of the rivers. The most serious objection to this concept is the fact that environmental conditions appear to have been more in favour of the solution and transport of silica rather than iron. As the hematite ore bodies and the "canga" terraces have originated as a result of selective leaching of silica and consequent enrichment of iron in the parent jaspilite, it seems logical to believe that the pisolitic ores originated under a similar chemical regime.

Furthermore the grade of the ores is much higher than any recorded bog iron deposits in the world, and there is an absence of the common impurities such as manganese, lime, magnesia, sulphur, and heavy metals which normally contaminate bog iron deposits. Most of the deposits are curvilinear in surface plan and can be reasonably assumed to mirror the pattern of the old drainage system. It is clear that they have been deposited in well-defined river channels rather than in swampy areas of broad and ill-defined drainage such as are favourable to bog iron accumulation.

CONCLUSIONS.

A great deal of work remains to be done before a reliable estimation of the iron ore reserves of the Hamersley Iron Province can be made. It is unlikely that further major deposits of the pisolitic ore will be discovered except in areas far from the coast. However, it appears certain that further exploration will disclose more extensive deposits of hematite, particularly in the western section of the Ophthalmia Range and in the Turee Creek Syncline. These areas are far from the coast, but seem to offer better prospects for the occurrence of the highest grade of hematite ores containing more than 65 per cent. iron.

Photogeological examination of the eastern and southern section of the province has revealed ideal structural conditions for ore formation in many localities. These will be examined during the 1963 field season.

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THE IRON ORE DEPOSITS OF THE WELD RANGE, MURCHISON GOLDFIELD.

by W. R. Jones.

INTRODUCTION.

General.

The Weld Range, centred approximately at latitude 26° 50′ S., longitude 117° 40′ E., is a prominent line of hills 35 miles long by 2 miles wide. It rises from 200 feet to 800 feet above the surrounding plain. It is most widely known because of Wilgie Mia, the aboriginal red ochre mine, which was worked for centuries before the advent of the whites. Consequently the iron ore of the Range was known by whites at an early date but the distance from seaboard has discouraged its detailed examination. The Range is 40 road miles from Cue which is 264 miles by a 3 foot 6 inch gauge railway to the port of Geraldton, capable of handling ships of safe loaded draught of 27 feet and length of 525 feet.

As part of its plan to stimulate the search for iron ore the Western Australian Government, late in 1959, proposed to diamond drill the six known iron ore lenses of the Weld Range as listed by Johnson (1950). Drilling commenced in January, 1961, and was completed in September, 1962. The Range was mapped on a scale of 50 chains to the inch in March and April, 1962, by W. R. Jones and I. Gemuts.

Seven new lenses of probably economic size were found. In May and June lenses W1 to W6 were mapped on contour plans at 100 feet to 1 inch prepared from aerial photographs by the Photogrammetry Section of the Department of Lands and Surveys. Lenses W7 to W13 were measured by pacing and tape.

Plans accompanying this report are a geological map at 1 mile to 1 inch (Plate **XXVI**) and five plans, with sections, of each of lenses W1 to W6 at 200 feet to an inch (Plates **XXVII** to **XXXI**).

Previous Work.

Weld Range has been visited by many geologists but little detailed work has been done. Aspects of the geology have been mentioned by Gibson (1904), Woodward (1914), Johnson (1950), Miles (1953) and Ellis (1955) who describes the investigation of slight anomalous radioactivity found at Wilgie Mia in 1952. The original drilling programme of the present investigation was designed by R. R. Connolly.

GEOLOGY.

General.

The Weld Range is a series of steeply dipping jaspilite beds interlayered with dolerite, some of which may be extrusive. Less important are porphyry, sandstone, breccia and granite. Apart from superficial deposits the rocks are probably of Archaean age.

Jaspilite.

The jaspilite beds are typical banded iron formations ranging in width from 1 foot to 400 feet. Most of them contain between 20 and 60 per cent. magnetite interbedded with chert in distinct alternating bands of 1 inch maximum width. The grain size is in the order of 0.01 mm.-0.03 mm.

Some jaspilite has a prominent lensing structure. All lenses are chert and in the hand specimen magnetite has the appearance of flowing around each lens. Two groups of jaspilite (Madoonga beds and

Yarraloola
Warramboo
NORTH WEST COASTAL HIGHWAY
ROBE RIVER
BHP Camp
Deepdale
MT. ENID
BUCKLAND HILLS
MT. PYRTON
HAMERSLEY
RANGE
SILVER GRASS PEAK
FORTESCUE
RIVER
TO ROEBOURNE
TO PORT HEDLAND
MT. FARQUHAR
Marra Mamba
MT. SYLVIA
Hamersley
Wittenoom
Blue Asbestos Mine
Goodiadarrie Hills
River
indefinite
TO ONSLOW
MT Stuart
Boolgeeda Camp
C.R.A.
MT. BROCKMAN
DALES GORGE
MT. LOCKYER
MT. BRUCE
Marillana
Roy Hill
Boolgeeda Creek
BEASLEY RIVER
MT. TURNER
Wyloo
Rocklea
MT JOPE
HARDEY RIVER
Weeli Wolli Creek
NORTHERN HIGHWAY
OPHTHALMIA RANGE
MT. NEWMAN
Seven Mile Creek
Turee Creek
LOCATION MAP
MILES
INDIAN OCEAN
BROOME
PORT HEDLAND
DEPUCH IS.
C. PRESTON
ROEBOURNE
NORTH-WEST CAPE
ONSLOW
HAMERSLEY IRON PROVINCE
WESTERN AUSTRALIA
INDEX OF 1:250,000 MAP SHEETS
YARRALOOLA
PYRAMID
MARBLE BAR
WYLOO
MT BRUCE
ROY HILL
EDMUND
TUREE CREEK
NEWMAN
AREA COVERED BY MAP
LEGEND
CAINOZOIC
Valley Fill, Scree, Alluvium.
PROTEROZOIC
WYLOO GROUP
Quartzite, Conglomerate, Greywacke, Dolomite.
HAMERSLEY GROUP
Boolgeeda Iron Formation. Woongarra Dacite Weeli Wolli Formation.
Brockman Iron Formation.
MT. McRae Shale, MT. Sylvia Formation, Wittenoom Dolomite.
Marra Mamba Iron Formation.
FORTESCUE GROUP
Basalt and Sediments.
ARCHAEAN
Granite, Gneiss, Greenstone.
Iron Deposits – Pisolitic
– Hematite
REFERENCE
Geological boundary.
Fault.
Synclinal axis.
Anticlinal axis.
Watercourse.
Road.
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
GEOLOGICAL MAP
OF THE
HAMERSLEY IRON PROVINCE
WESTERN AUSTRALIA
SHOWING DISTRIBUTION OF IRON DEPOSITS
SCALE : 15 MILES TO AN INCH
Geology by W.N. Macleod, L.E. de la Hunty, W.R. Jones and R. Halligan.
1962
7492

Lulworth beds) near the northern side of the range have characteristic structures and although similar they are easily distinguishable and remarkably consistent along the strike (Figs. 11 and 12). Occasional zones of slumping and minor contemporaneous brecciation are the only additional variations in the uniform appearance of the jaspilite.

The search for iron ore was concentrated in jaspilite sufficiently wide to carry ore in large quantities. The iron ore-bodies are anomalous concentrations of magnetite, hematite and goethite confined, so far as is known, to the Madoonga and Wilgie Mia beds. Of these the Wilgie Mia bed is by far the more important.

Dolerite.

The dolerite is fine to medium-grained and rarely porphyritic. It makes up the major part of the range as a number of intrusions, with possibly some flows. It is normal dolerite except near the margins of the range. Thin sections cut from bore core of DDH No. 10 have been examined by Dr. Trendall, (Petrologist of the Geological Survey) who reports: "These rocks together suggest a steady metasomatic breakdown of original dolerite, consisting of quartz, sericite and limonite. The whole process would be expected to involve relative enrichment in silica and potash and relative impoverishment in soda and lime." This metasomatism is undoubtedly associated with the intrusion of porphyry and granite.

Porphyry.

Fine to medium-grained quartz-plagioclase porphyry, typical of the goldfields, is widespread but outcrops infrequently. The maximum exposed development is near the western end of the range, on its northern fringes. The largest outcrop within the range proper is a plug-like mass near the northern end. The formation of the porphyry was associated with the end stages of the granite intrusion which was also responsible for the quartz veins in the faults and the metasomatism of the dolerite.

Granite.

A coarse-grained gneissic biotite-granite forms prominent outcrops flanking the range closely at its northern end.

Breccia.

There is a distinct band of breccia of doubtful origin within the Madoonga jaspilite. It is best exposed in the vicinity of the yellow ochre mine.

Sandstone.

There are a few small outcrops of coarse-grained, clayey sandstone southwest of Little Wilgie Mia. This sandstone is in the stratigraphic position of the Wilgie Mia jaspilite which is not seen for several miles to the southwest.

STRUCTURAL GEOLOGY.

Folds.

Johnson (1950) has published a structural sketch map of a wide area near Weld Range. This map shows that the Range is probably on the southern limb of a northeasterly plunging anticlinal segment of a large granite intrusive. The range may be an almost complete syncline but this is not clear. On any interpretation parts of the southern beds are overturned.

Minor folds are not numerous but there is a widespread monoclinal flexure plunging 15°-25° northeasterly. There are occasional drag folds associated with movement along the faults. Chevron folds with axial planes usually parallel with the joint-fault system are common, particularly near the faults.

Faults.

The Weld Range is segmented by a well-developed fault system, the pattern of which is clearly shown on the accompanying geological map. Strong jointing parallels the fault system. The strike of the faults is resolved into three main directions each of which has two directions of dip. The observed range of dips is 25°-90° but numerous strong joints dipping at less than 25° suggest that the range is wider. At the Weld Hercules gold mine the dip of the fault containing the gold-quartz vein changes from 70° to 35° in about half a mile.

The large faults which displace the Range northeast of lens W1 and elsewhere are the resultants of groups of small faults en echelon (Fig. 13).

The numerous faults have strongly affected the iron ore bodies, considerably reducing the potential of some and adding the complication of mullock horses in others. Separation by as much as 100 feet of parallel fault planes has produced strike blanks in jaspilite and ore. Plate XXVII shows at least one such separation in Lens W2. The rock in these blanks is highly decomposed but it is probably dolerite.

DIAMOND DRILLING.

The drilling was done by private contractors using equipment hired from the Mines Department. Drilling conditions were bad and the core recovery was poor. Table 1 summarises the results:—

TABLE 1.

SUMMARY OF DIAMOND DRILLING RESULTS 1961-62.

Hole No.	Lens No.	Angle of Depression	Depth of Hole	Iron Formation	Estimated True width	Core Recovery in Iron Formation	Acid-soluble Iron	Sludge samples	Acid-soluble Iron
		Degrees	feet	feet	feet	%	%	feet	%
1	W. 1	50	812	143–168 244–322	18 60	9 65	57·5 57·5	....	....
2	W. 1	50	647	Nil	....	....	....	....	....
3	W. 6	45	808	440–522 522–637 715–760	70 90 40	91 100 100	52·3 approx. 40 53·5	....	....
4	W. 3	45	802	399–429	26	88	68	....	....
5	W. 3	45	605	196–241	35	52	44	....	....
6	W. 3	45	429	199–312	90	30	64	....	....
7	W. 6	40	383	206–383	130 Hole abandoned	9	60	....	....
8	W. 3	40	411	248–390	110	6	66	....	....
9	W. 4	50	650	Nil	....	....	....	....	....
10	W. 5	40	472	469–472	.... Hole abandoned	....	....	....	....

TABLE 1—*continued.*

Summary of diamond drilling results 1961-62—*continued.*

Hole No.	Lens No.	Angle of Depression	Depth of Hole	Iron Formation	Estimated True Width	Core Recovery in Iron Formation	Acid-soluble Iron	Sludge Samples	Acid-soluble Iron
		Degrees	feet	feet	feet	%	%	feet	%
11	W. 1	30	362	182–330	135	50	56	182–330	51 (*a*)
12	W. 1	50	334	228–297	40	15	59	231–303	56·2
13	W. 2	40	313	174–313	110	11	59	177–270	52
14	W. 5	40	417	262–378	85	29	64	265–375	56·5 (*b*)

Total Footage Drilled: 7,247.

(*a*) Includes two assays of less than 40 per cent. The sludge was probably contaminated in casing operations.

(*b*) Includes three assays of less than 40 per cent. There was no casing operation comparable to that of " a " and the sludge probably in part came from the mullock band shown on the plan of Lens W. 5.

IRON OREBODIES.

General.

The iron ore is boldly exposed in hills which rise to about 200 feet above the surrounding plain. All lenses are almost vertical and only Lens W2 has any overburden. The removal of wallrock waste is a minor problem to the depths listed in Table 2.

The hematite bodies are largely of specularite with bands of red and yellow ochre and of earthy and botryoidal goethite. They would produce a large proportion of fines in any mining operations. The magnetite ore is more massive.

Details of the orebodies are summarised in Table 2. Plates XVII to XXXI show the shapes, mostly arbitrary, of the blocks used to estimate the tonnages of ore in Lenses W1 to W6. Poor recovery of core and incomplete surface sampling preclude stating an exact ore grade but the estimates given are restricted to those blocks with a reasonable chance of containing 60 per cent. iron. A factor of 8 cubic feet of ore to a long ton has been used in the calculations.

TABLE 2.

SUMMARY OF THE DETAILS OF THE IRON OREBODIES.

Lens No.	Length	Width	Depth	Long Tons	Main Minerals	Remarks
	feet	feet	feet	millions		
W. 1	1,800	96	400/2	4·3	Hematite, Goethite	Includes the old native ochre mine the desired preservation of which would reduce the estimate to about 4 million tons.
W. 2	1,200 less 60	60 60	260/2 20	1·2	Goethite, Hematite Mullock	Has a maxmium of 80 feet of overburden at its N.E. end. Fault block.
W. 3	1,000 less 80	72 72	400/2 250	1·6	Hematite .... Mullock	A block of 500,000 tons at the western end is not included as numerous mullock seams would probably lower the mined grade.
W. 4	600 less 30	80 80	260/2 200	0·7	Hematite .... Mullock	Plunge of the eastern end is not known. Block shape may be uneconomic. Possible fault blank.
W. 5	700 +1,600 +560	48 56 50	210/2 230 240/2	3·4	Magnetite, Hematite and a little Goethite	Continuously mineable. Divided in places by 10 feet of mullock. Width is conservative.
W. 6	Two of 400 +880	60 60	300/2 300	2·9	Magnetite, *Goethite some Hematite	Probably continuously mineable. Estimate conservative.
W. 7	500 700	65 50	200 200	0·8 0·8	Magnetite and a little Goethite	There are other small blocks. Lens may total 4,000 feet by 100 feet of > 45% Fe, i.e., 10,000,000 tons to 200 feet.
W. 8	a 950 b 600	80 36	200 100	1·9 0·3	Magnetite and a little Goethite	a and b are separated by 75 feet of low grade jaspilite. Lens may total 4,600 feet by 100 feet of > 45% Fe, i.e., 12,000,000 tons to 200 feet.
W. 9	900	80	200	1·8	Magnetite	Has several smaller bodies from 200 feet by 20 feet to 300 feet by 80 feet. Lens may total 3,500 feet by 100 feet of > 45% Fe, i.e., 9,000,000 tons to 200 feet.
W. 10	3,500 700	72 56+	200 100	6·3 1·0	Magnetite Goethite	Lateritic crust. Low poor outcrop.
W. 11	2,300	60	200	3·4	Magnetite and some Hematite	Lateritised at its eastern end. Full width of iron formation is not exposed.
W. 12	1,000	32	100	0·4	Magnetite	Low comparatively poor outcrop.
W. 13	2,000	32	100	0·8	Magnetite	Least well examined.

* A complex association of minerals in core from D.D.H. No. 3 is recorded by the Government Chemical Laboratories in the Annual Report of the Mines Department for 1961, p. 158. Minnesotaite and an iron manganese phosphate were among the minerals identified. They are of mineralogical interest only.

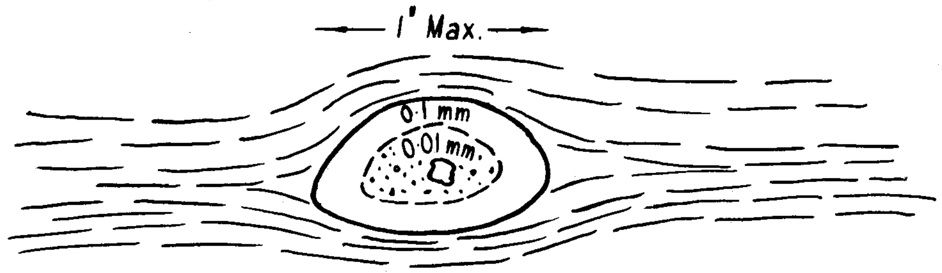

Fig. 11 Quartz eyes of the Madoonga jaspilite

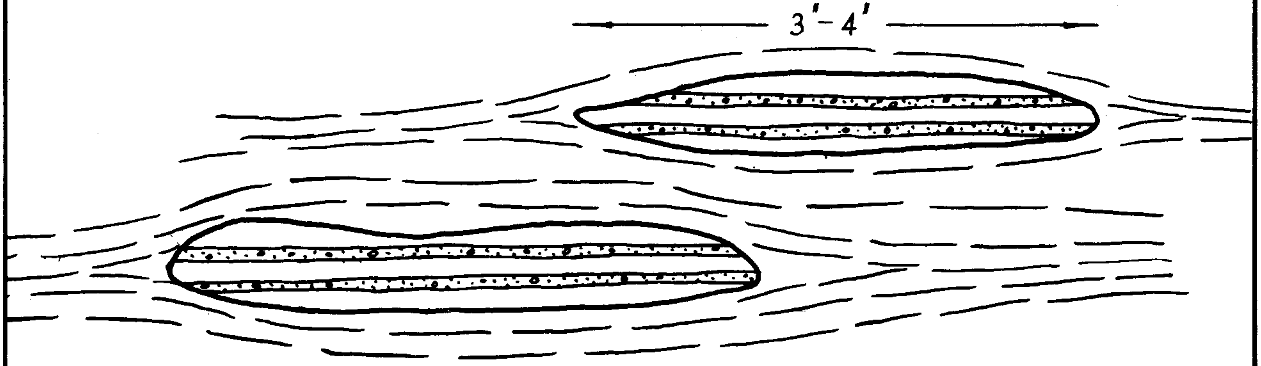

Fig. 12 Chert discs of the Lulworth jaspilite

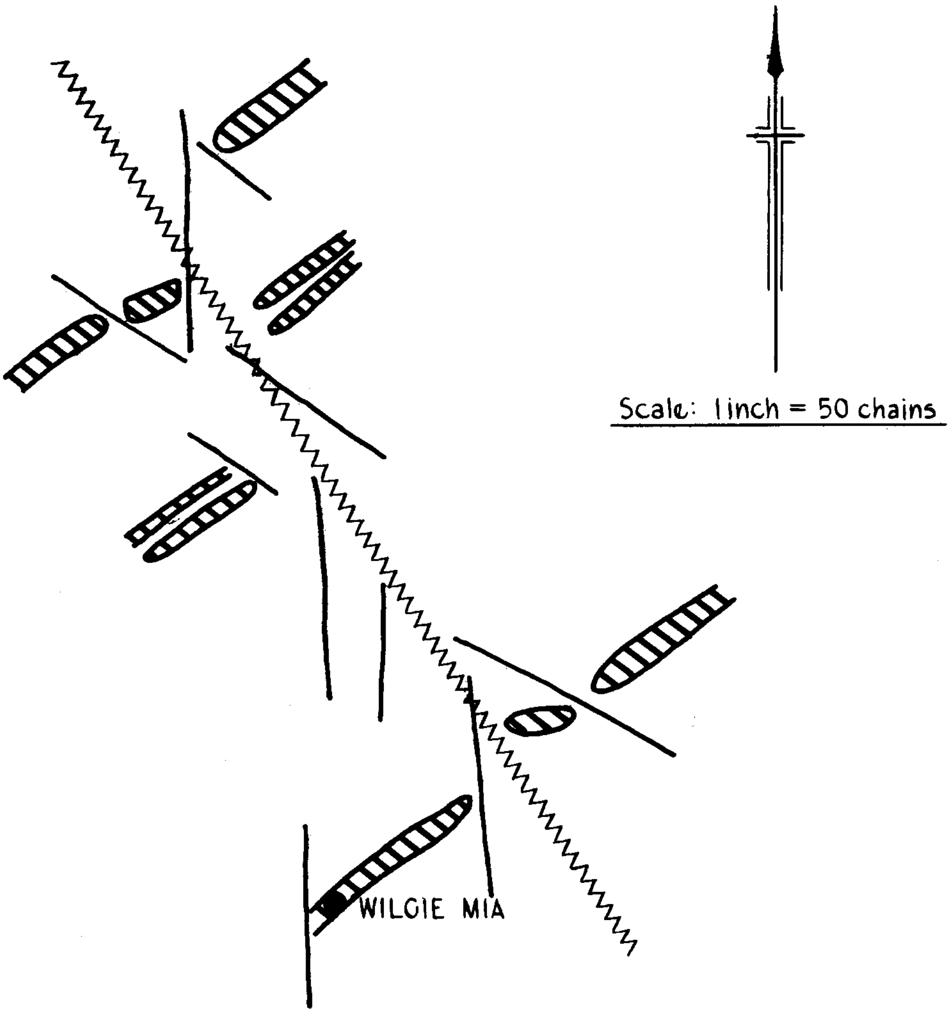

Fig. 13 Complex faulting near Wilgie Mia. The resultant break is normal to the strike of the Range

No estimates are given for ore in talus or in the 10 to 30-foot jaspilite associated with the Wilgie Mia bed. This jaspilite has a number of hematite-goethite bodies particularly near lenses W5 to W11, but they are probably not of economic width.

Impurities.

All samples which assayed better than 56 per cent. iron had a low impurity content. Ores of a lower iron percentage are high in silica but other deleterious elements are within the generally accepted limits and remain so, probably to a depth of 400 feet below the outcrops. Sulphur as pyrite might be a problem at depth. Core from 522 feet-637 feet in D.D.H. No. 3 had fine pyrite. This core assayed 40 per cent. iron and 1.4 per cent. sulphur.

Ore from lenses W1 and W2 has a consistently high water content which would probably prevent attaining a 60 per cent. grade for direct shipping. Table 3 lists the analyses of a number of composite samples.

TABLE 3.

ANALYSES OF A NUMBER OF COMPOSITE SAMPLES.

Lens	Sample Locality	ANALYSIS										
		Fe Total	Fe Acid Soluble	SiO_2	S	P	Ti	Mn	MgO	CaO	Al_2O_3	Ignition Loss
W. 1	DDH No. 1— 143–168 ft. .... 244–320 ft.	57·5 57·5	57·2 57·3	3·34 4·33	0·07 0·02	0·14 0·09	0·14 0·19	0·06 0·04	Tr. Tr.	0·16 0·07	2·14 2·61	11·2 10·0
	DDH No. 11— 182–330 ft.	58·4	58·4	3·16	0·02	0·13	0·05	1·0	Tr.	Nil	2·9	9·22
	Johnson (1950)— Sample M115 .... Sample M116	....	63·69 62·7	1·78 2·35	0·08 0·06	0·27 0·18	TiO_2 0·02 0·02	....	....	....	....	5·17 5·98
W. 2	DDH No. 13— 173–313 ft.	58·9	58·9	4·22	Tr.	0·06	0·02	0·42	0·3	0·11	2·35	9·48
	Johnson (1950)— Sample M120	....	57·5	4·58	0·02	0·09	TiO_2 0·02	....	....	....	....	10·35
W. 3	DDH No. 6— 198–299 ft. .... DDH No. 4— 399–429 ft.	64·1 68·3	63·9 68·1	3·63 1·94	Tr. Nil	0·02 0·01	0·03 0·02	0·02 0·01	Tr. Nil	Tr. Nil	2·9 Nil	1·64 0·43
W. 4	Johnson (1950)— Centre of Orebody M123	....	60·7	6·07	0·14	0·2	TiO_2 0·1	....	....	....	....	....
W. 5	DDH No. 14— 262–378 ft.	64·1	64·1	4·8	0·01	0·05	0·05	0·19	0·19	0·07	1·69	1·35
	Johnson (1950)— Sample M140	....	66·4	1·89	Tr.	0·08	TiO_2 0·03	....	....	....	....	1·17
W. 6	DDH No. 3— 440–522 ft. .... 715–760 ft.	51·6 54·1	51·6 53·2	23·0 12·9	0·46 0·24	0·07 0·08	Tr. 0·02	0·12 0·56	1·23 1·54	0·17 0·16	1·6 0·6	0·66 6·66
	Johnson (1950)— Sample M143	....	64·38	2·11	0·02	0·12	Tr.	....	....	....	....	4·32
W. 9	Chip across 105 ft. width	61·1	61·1	4·31	0·04	0·1	0·02	0·04	Tr.	Tr.	1·8	6·15

Origin.

The orebodies have a complex geological history and the relative importance of each process involved in their formation can only be surmised. They may be—

(1) mainly as they were originally deposited;

(2) altered supergene enrichments of the jaspilite;

(3) predominantly of metamorphic origin.

There is abundant evidence throughout the Weld Range to show that the iron has been mobilised in part. This probably took place at the same time as the quartz injection and silica bleaching along some of the faults. The effects are quite localised and the largest altered mass observed is west of the yellow ochre mine where the jaspilite is altered to specular hematite quartzite for about 400 feet along the bedding from a cross fault.

It is not known to what extent mobilisation has contributed to the establishment of an economic grade. It has clearly modified the shape and limits of some orebodies, in places sufficiently to complicate a mining operation. An example is in lens W8 where blocks a and b (Table 2) are separated by a 75 foot wide zone of bleached jaspilite.

Later modification by intense weathering has produced the hematite-goethite bodies of lenses W1 to W4 in a part of the range cut by numerous large faults.

CONCLUSION.

Total indicated and inferred reserves of iron ore in the 13 orebodies of the Weld Range are 30 million tons of about 60 per cent. grade.

Lenses W5, W10 and W11, which are considered to be the best three orebodies, together contain about 13 million tons. Lens W1, the best known of the orebodies, has a high proportion of goethite and run-of-mine ore probably would not maintain a 60 per cent. grade.

A further 25-30 million tons of iron formation adjacent to lenses W7, W8, W9 and W12 might contain 45 per cent. iron. The Madoonga jaspilite is comparatively rich in iron and careful sampling might outline several tens of millions of tons of material suitable for beneficiation.

Most of the 30 million tons of ore listed in Table 2 could be mined cheaply with a low initial capital outlay. High transport costs over 40 miles of road and 264 miles of lightly ballasted railway of 3 ft. 6 in. gauge reduce its prospects for development in the near future.

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SOME PROTEROZOIC VOLCANIC ROCKS FROM THE NORTH WEST DIVISION.

by A. F. Trendall.

ABSTRACT.

The presence of perlitic, eutaxitic and quartz-felspar intergrowth textures (including spherulitic and micrographic) is noted in some acid volcanic rocks of the Western Australian Precambrian. The association of high-temperature albite and probable quartz paramorphs after tridymite suggest that many of the textural features described were formed during devitrification shortly after emplacement. Slow devitrification at normal temperatures is probably an unusual phenomenon.

INTRODUCTION.

In this paper selected textures and minerals of some acid intrusive, extrusive and pyroclastic rocks of the Nullagine successions of the Hamersley Range area (22-23° S.; 117-119° E.) and the Dampier Archipelago (centre 20° 30′ S.; 116° 50′ E.) are briefly described, and their possible significance discussed; systematic descriptions of the rocks are not given in this preliminary account.

DISTRIBUTION, RELATIONSHIPS, CLASSIFICATION AND APPEARANCE.

For information used in the following summary I am grateful to Drs. R. C. Horwitz and W. N. MacLeod and to Messrs. R. Halligan, L. E. de la Hunty, M. Kriewaldt and R. Ryan. The Hamersley rocks are mainly from the Woongarra Dacite, which includes tuffs as well as lavas. It is a thick and laterally extensive formation whose base is some 20,000 feet above the base of the Nullagine succession in which it occurs. Some come also from thinner bands of similar volcanic rocks which occur impersistently at other levels in the same succession and also from a few small plugs. In the Dampier Archipelago the rocks concerned crop out on several islands at and near the base of the succession; field evidence shows that most are intrusive.

For present convenience of reference these rocks may be grouped as follows:—

(1) Hamersley Area:
- (a) Homogeneous dacite.
- (b) Lava-breccia (stratiform and intrusive).
- (c) "Green quartzite" lava (MacLeod and others, 1963).
- (d) Tuff.

(2) Dampier Archipelago:
- (a) Granophyres.
- (b) Aphanitic and porphyritic rocks.

The field appearance is frequently misleading. Many of the quartz-rich aphanitic rocks are as dark as basalts, and tuffs are not distinguishable from lavas. A blotchiness in colour often gives a false impression of granularity, especially in the granophyres, and "green quartzite" is an apt, but erroneous name for the lower part of the Woongarra Dacite.

TEXTURES.

Quartz-Felspar Textures.

The "green quartzite" (R95, R96—numbers refer to rocks and thin sections in the registered collection of the Geological Survey of Western Australia) and the matrix of the porphyritic dacites (R207) are largely composed of an equidimensional quartz-felspar mosaic, of average grain diameter 0.02-0.1 mm., in which the boundaries are so grotesquely intercrenulated that it is impossible in a section of standard thickness to define the limits of any one grain. Irregular quartz-felspar boundaries of this type pass gradationally through fine brush-like (R 220) or myrmekite-like (R 94, R 222) intergrowths which produce irregular extinction effects into micrographic textures best displayed by the granophyres (R 152).

Spherulites formed of similar irregularly radiate linear quartz-felspar intergrowths are common in the aphanitic rocks of both the Hamersley and Dampier areas. They vary in excellence of development from a crudely radiate pattern imposed over a well crystallised mosaic (R 226) to feathery aggregates with sharp edges completely lacking granularity (R 153), and they vary in size from 0.3 mm. (R 223) to 3 mm. (R 153). They may be conspicuous or indistinguishable in hand specimen. Another type of spherulite often occurs in association with perlitic breccias. Each grain of what at first appears to be a fine quartz mosaic is a radiate (chalcedonic?) aggregate extinguishing with a black cross (R 104). Both these and the larger spherulites are radially fast. They may be closely packed in the rock (R 206) or widely spaced.

A common textural feature of the "green quartzite" and of the Dampier granophyres is the presence of interlocking laths or needles of quartz which are clearly defined under ordinary light by their complete freedom from turbidity. Under crossed nicols these laths extinguish in several parts, each part together with the quartz of the immediately adjacent matrix. They vary in length (maxima in individual thin sections from 0.1 mm. (R 89) to 2 mm. (R 152)) and have elongations as great as 100 : 1. They have no obvious preferred orientation, except that several needles often occur in acutely radiate and loosely aggregated bundles; such bundles are common in the Dampier granophyres, where they tend to form the central part of optically consistent areas of micrographic intergrowth (R 154).

Perlitic Texture.

Textbook examples of perlitic cracking occur frequently in the constituent fragments of lava-breccias in the Hamersley area (R 88, R 106, R 107, R 108, R 109). The cracks themselves are marked either simply by the grain boundaries of the plagioclase which is the main devitrification product of the original glass, by dark lines running through plagioclase crystals, or by thin chlorite bands. This plagioclase is arranged concentrically, together with some quartz and chlorite, around an irregular core of cryptocrystalline and effectively isotropic green chlorite. It is described more fully below.

Eutaxitic Texture.

Tuffs in which closely packed shards have been deformed into a crudely parallel arrangement have been collected from two localities in the Hamersley area; one is within the Woongarra Dacite proper (R 214) and another from a similar stratiform volcanic band lower in the succession (R 216, R 217). The shards are devitrified to quartz and plagioclose aggregates and average 0.5 mm. in greatest diameter.

MINERALS.

Plagioclase.

Plagioclase was noted above as a devitrification product of rocks with perlitic texture. A similar plagioclase is also the felspar of the quartz-felspar intergrowth textures described in both the Hamersley and Dampier areas. Its usual characteristics are as follows:—

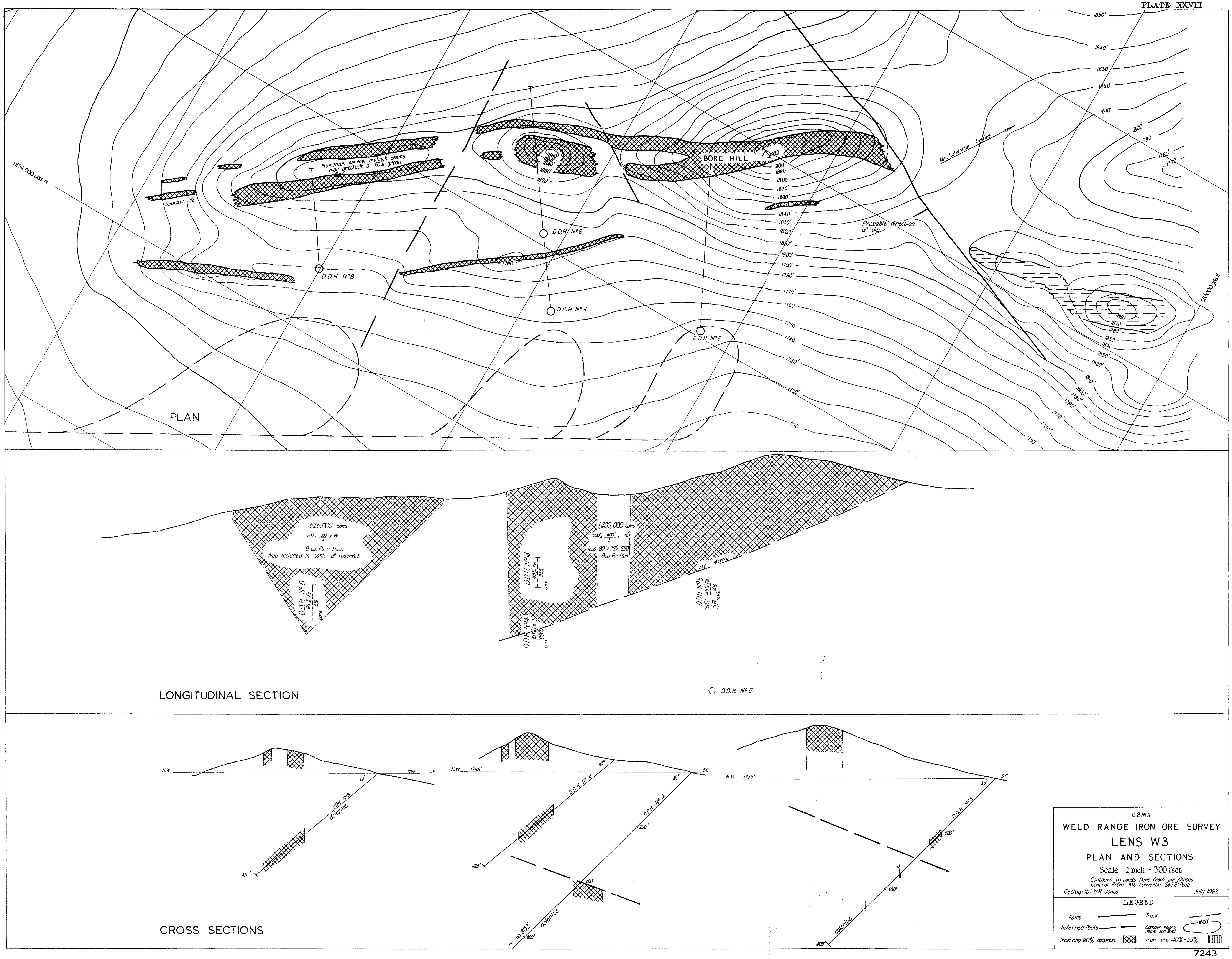
(1) It never forms large or euhedral crystals.
(2) The extinction is often irregular (radiate or feathery).
(3) It is always cloudy with inclusions about 0.2 mm. across.
(4) The only twinning is of an unusual type, described below.
(5) One or two cleavages are defined by thin inclusion-free planes rather than by cracks. The strongest is (001).
(6) It is usually elongate parallel to (100).

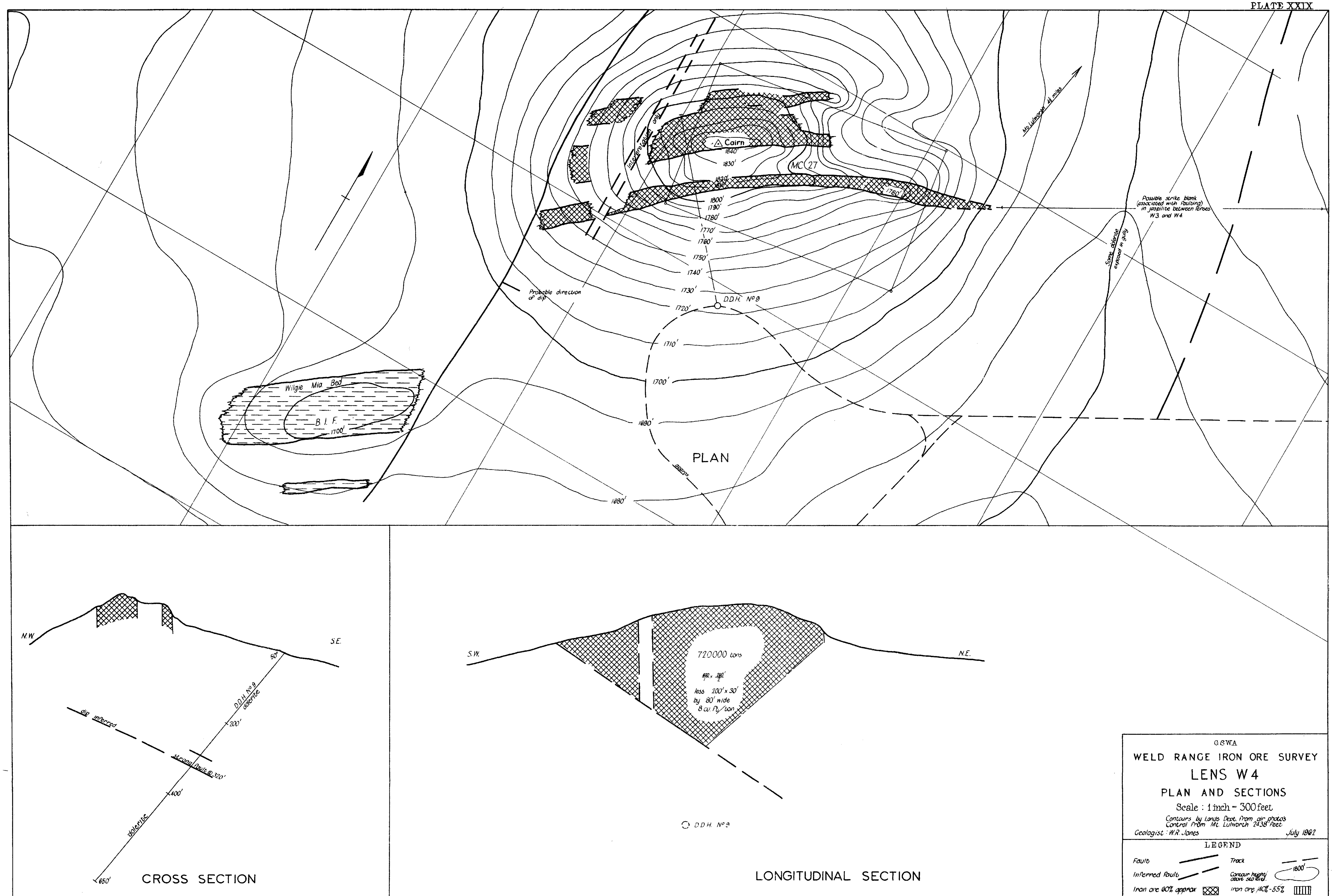
This plagioclase was tentatively identified as zeolite or orthoclase when first encountered. The twinning mentioned above, of which only a few examples have been seen, gives a lozenge-shaped


PLATE XXVI
LEGEND
LATERITE: Includes canga.
CONGLOMERATE: Pebble sandstone, breccia.
IRON ORE: Hematite, magnetite & limonite
DOLERITE: Fine-to medium-grained rarely porphyritic, may include some flows.
JASPILITE: Wilgie Mia beds, Strongly banded chert & magnetite.
JASPILITE: Madoonga beds. Strongly banded chert & magnetite with characteristic chert eyes ½"-1" diam.
JASPILITE: Lulworth beds. Strongly banded chert & magnetite. with distinctive chert lenses 1"-5" long.
PORPHYRY: Aphanitic to medium-grained quartz-plagioclase porphyry.
GRANITE: Medium-to coarse-grained gneissic. Strongly jointed.
Fault
Inferred fault
Quartz vein
Strike & dip
Track
Ochre workings
LOCATION MAP
Weld Range
Cue
Geraldton
Perth
G.S.W.A.
WELD RANGE
GEOLOGICAL MAP
Scale 1" = 1 mile
Geological mapping W.R. Jones & I. Gemuts
1962
7242
Squatters Well
Mindoolah Well
soil covered flats
YELLOW OCHRE MINE
Four Mile Well
Range Well
Madoonga Homestead
Stock Well
House Well
Ram Well
W E L D
R A N G E
MT LULWORTH
THE GAP
HERCULES GOLD MINE
LITTLE WILGIE MIA
WILGIE MIA
Thin Jaspilites
W1
W2
W3
W4
W5
W6
W7
W8
W9
W10
W11
W12
W13
Mill
to Cue
Uncertain
soil covered flats

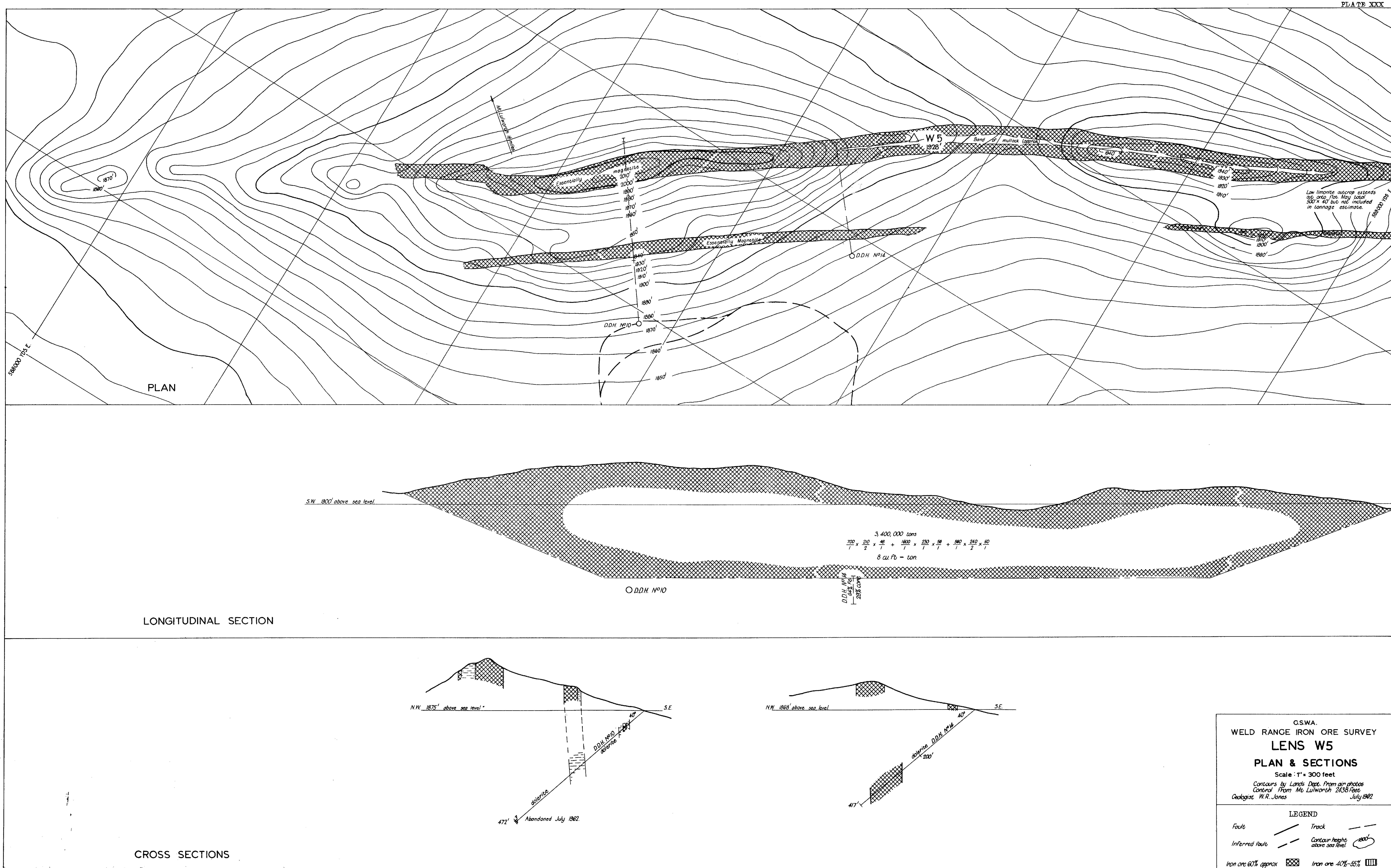

PLAN
OCHRE HILL
Ochre Mine
Essentially hematite with narrow bands of siliceous limonite
LENS W1
LENS W2 Gossanous limonite with hematite
Gossan with hematite (not included in reserve)
Mullock dump
D.D.H. No 13
D.D.H. No 1
D.D.H. No 2
D.D.H. No 11, 12
Mt. Lulworth 5½ miles
1840'
1830'
1820'
1810'
1800'
1790'
1780'
1770'
1760'
LONGITUDINAL SECTION
S.W.
1800' above sea level
N.E.
W1 4,300,000 tons
8 cu. ft. = 1 ton
W2 1,200,000 tons
8 cu. ft. = 1 ton
Adit
Ochre mine
Profile on W2
D.D.H. No 2
CROSS SECTIONS
1771' above sea level
S.E.
N.W.
1782' above sea level
1775' above sea level
1775' S.E.
Adit
D.D.H.
D.D.H. No 13
D.D.H. No 11
D.D.H. No 2
dolerite
Thin jaspilites
200'
400'
600'
812'
313'
334'
342'
G.S.W.A.
WELD RANGE IRON ORE SURVEY
LENS W1 & LENS W2
PLAN & SECTIONS
Scale: 1" = 300 feet
Contours by Lands Dept. from air photos
Control from Mt. Lulworth 2438 feet.
Geologist W.R. Jones
July 1962
LEGEND
Fault
Track
Inferred fault
Contour height above sea level
Iron ore 60% approx.
Iron ore 40-55%

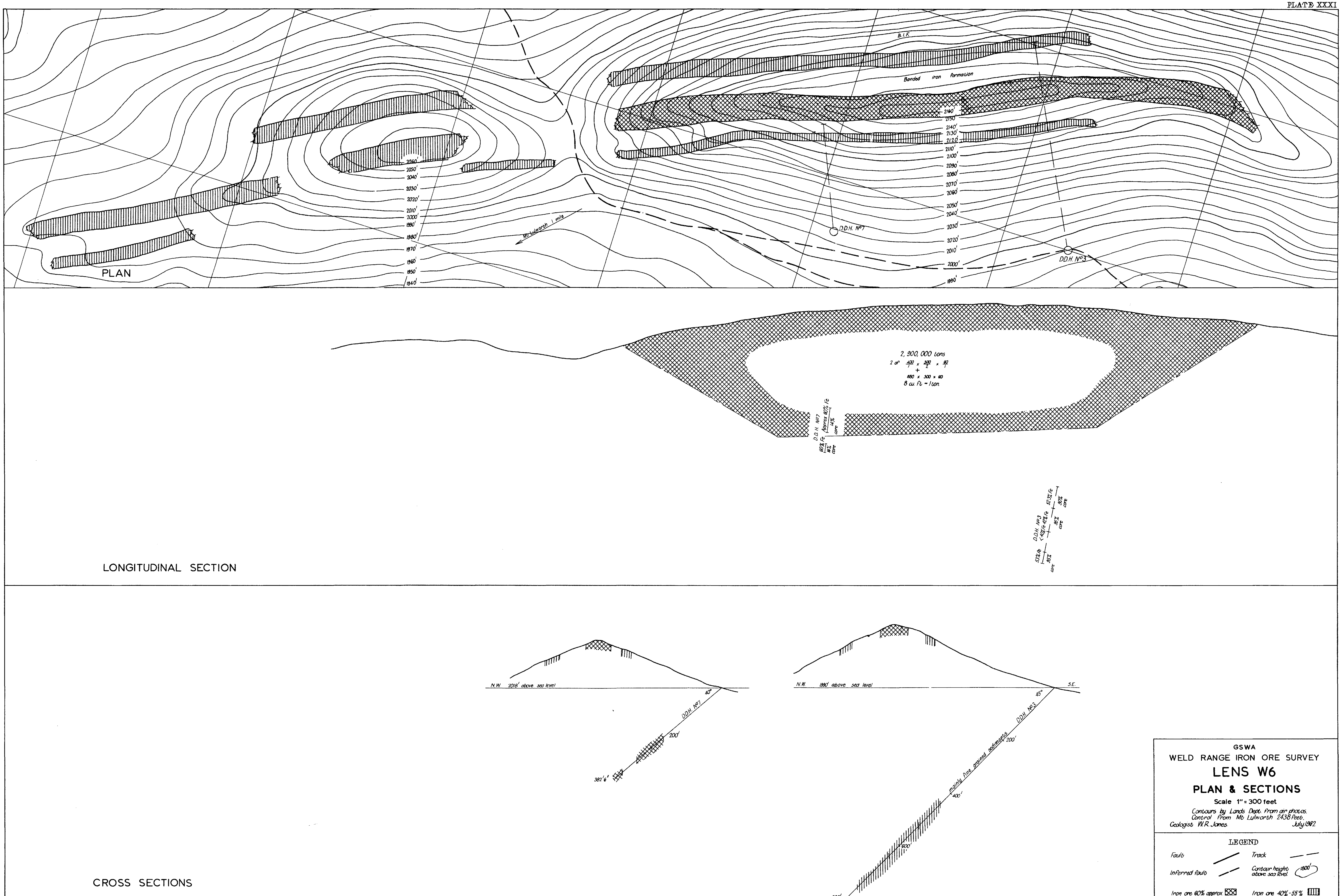
7244


PLAN
BORE HILL
Numerous narrow mullock seams may preclude a 60% grade.
Sporadic %
1654,000 yds N
D.D.H. Nº 4
D.D.H. Nº 5
D.D.H. Nº 6
D.D.H. Nº 8
Probable direction of dip
Mt. Lulworth 4 miles
LONGITUDINAL SECTION
525,000 tons
8 cu. ft. = 1 ton
Not included in table of reserves
1,600,000 tons
less 80' x 72' x 250'
8 cu. ft. = 1 ton
dip inferred
CROSS SECTIONS
N.W.
S.E.
dolerite
G.S.W.A.
WELD RANGE IRON ORE SURVEY
LENS W3
PLAN AND SECTIONS
Scale 1 inch - 300 feet
Contours by Lands Dept. from air photos
Control from Mt. Lulworth 2438' Peak
Geologist W.R. Jones
July 1962
LEGEND
Fault
Inferred Fault
Track
Contour height above sea level
Iron ore 60% approx.
Iron ore 40%-55%
7243



Mt. Lulworth 4 miles
Cairn
1840'
1830'
1800'
1790'
1780'
1770'
1760'
1750'
1740'
1730'
1720'
1710'
1700'
1690'
1680'
MC 27
Interpretation only
Possible strike blank (associated with faulting) in jaspilite between lenses W3 and W4
Some dolerite exposed in gully
Probable direction of dip
D.D.H. No 9
Wilgie Mia Bed
B.I.F.
PLAN
N.W.
S.E.
50°
D.D.H. No 9
dolerite
200'
dip inferred
strong fault @ 320'
400'
dolerite
650'
CROSS SECTION
S.W.
N.E.
720000 tons
less 200' x 30' by 80' wide
8 cu. ft/ton
DDH No 9
LONGITUDINAL SECTION
GSWA
WELD RANGE IRON ORE SURVEY
LENS W4
PLAN AND SECTIONS
Scale : 1 inch = 300 feet
Contours by Lands Dept. From air photos
Control from Mt. Lulworth 2438 feet
Geologist : W.R. Jones
July 1962
LEGEND
Faults
Track
Inferred Faults
Contour height above sea level
1800'
Iron ore 60% approx
Iron ore 40%-55%


PLAN
588000 YDS E.
W5
1928'
Band of mullock (approx)
Essentially magnetite
Essentially Magnetite
D.D.H. No14
D.D.H. No10
Low limonite outcrop extends out onto flat. May total 500' x 40' but not included in tonnage estimate.
LONGITUDINAL SECTION
S.W. 1800' above sea level
3,400,000 tons
8 cu.ft = ton
O D.D.H. No10
CROSS SECTIONS
N.W. 1875' above sea level
S.E.
doleritе
472' Abandoned July 1962.
N.W. 1868' above sea level
S.E.
200'
417'
G.S.W.A.
WELD RANGE IRON ORE SURVEY
LENS W5
PLAN & SECTIONS
Scale : 1" = 300 feet
Contours by Lands Dept. from air photos
Control from Mt Lulworth 2438 feet
Geologist W.R. Jones
July 1962
LEGEND
Fault
Track
Inferred fault
Contour height above sea level.
Iron ore 60% approx
Iron ore 40%-55%


PLAN
B.I.F.
Banded iron formation
Mt Lulworth 1 mile
D.D.H. No 7
D.D.H. No 3
LONGITUDINAL SECTION
2, 900, 000 tons
8 cu. ft = 1 ton
CROSS SECTIONS
N.W. 2018' above sea level
N.W. 1980' above sea level
S.E.
mainly fine grained sediments
GSWA
WELD RANGE IRON ORE SURVEY
LENS W6
PLAN & SECTIONS
Scale 1" = 300 feet
Contours by Lands Dept. from air photos.
Control from Mt Lulworth 2438 feet.
Geologist W.R. Jones.
July 1962
LEGEND
Fault
Track
Inferred fault
Contour height above sea level.
1800'
Iron ore 60% approx.
Iron ore 40%-55%

7247

cross-section with opposite quadrants extinguishing together. It appears to be similar to that described by Klein (1939) and Rogers (1911) from microcline and orthoclase respectively.

The irregular extinction and small size of the crystals make optical measurements inaccurate. Twenty-six grains from 14 rocks from both Hamersley and Dampier areas were measured with the following results:—

	mean	maximum	minimum
2V	−67°	−83°	−54°
$\alpha \wedge \perp (001)$	82°	86°	76°
$\beta \wedge \perp (001)$	11°	23°	6°
$\gamma \wedge \perp (001)$	84°	90°	72°

Allowing for a high experimental error these optics could fit either orthoclase or high-temperature albite-oligoclase. However, there is independent evidence that this felspar is a plagioclase. In some rocks (R 154, R 159), the usually cloudy felspar is patchy with clear areas free of inclusions, in some of which there is lamellar albite twinning. These areas are of low-temperature albite. In some devitrified perlites (R 108) finely twinned low-temperature albite occupies the same textural position in relationship to the perlitic cracking that the cloudy felspar does in other parts of the same thin section. There is every appearance of inversion in place, and the mean values given above fit well with a high-temperature albite.

Quartz After Tridymite.

Wager and others (1953, Pl. XIII C) have described and figured a granophyre from Skye which is almost indistinguishable from some of the Dampier granophyres (R 152) which bear high-temperature albite. On the basis of comparison of the chilled edge of the Skye granophyre, in which tridymite was identified by shape and orientation of the replacing quartz (Ray, 1947), the acicular quartz of the body of the granophyre was thought to be after tridymite. Parts of the Skye granophyre (Wager, and others, 1953, fig. 2B) bear quartz "laths" with the same patchy extinction as has been described from both granophyre and "green quartzite" above. There is a high probability that many of the quartz "laths" in the rocks discussed represent tridymite, and it is hoped to carry out further work on this point.

DISCUSSION.

For clarity the principal propositions which are developed, and where possible justified, in the succeeding discussion are set out first:—

(1) Some of these rocks are devitrified glasses.

(2) The devitrification textures are closely associated with the development of high-temperature albite.

(3) High-temperature albite, closely similar in many ways, is also associated in both granophyres and lavas with quartz after tridymite.

(4) The Dampier granophyres may represent devitrified rocks.

(5) Most devitrification of glassy rocks takes place at high temperature within a comparatively short period after emplacement.

Although devitrification was proposed as a cause of some textures in igneous rock over a century ago (Ludwig, 1861) relict perlitic cracking in crystalline rocks, first suggested by Allport (1877), remains the only unequivocal criterion for post-solidification crystallisation. Later workers familiar with the textural complexities of volcanic rocks associated with lavas thus shown to be devitrified (Bascom, 1896; Bonney and Parkinson, 1903) accepted other features; while Iddings (1899, p. 420) argued against a devitrification origin for spherulites formed later than perlitic cracks, Harker (1909, p. 275) accepted some spherulites as resultant from devitrification. Subsequent work has not produced general agreement, or a clear distinction between immediate post-consolidation devitrification, subsequent slow devitrification at ordinary near-surface temperatures, and devitrification consequent upon later (metamorphic) stress and heat. Although glass is increasingly rare in older rocks (Marshall, 1961) it is uncertain whether this is mainly a result of the slowness of the devitrification or whether the likelihood of any rock escaping subjection to high temperatures and pressures also decreases with age.

The high-temperature albite associated with the perlitic rocks of the Hamersley lava-breccias shows that these rocks probably devitrified at a temperature below the transformation range of the material, but before complete cooling. Certainty is precluded partly by current doubts of the temperature significance of plagioclase optics and partly by the possibility of later metamorphism. On the second point the general metamorphic level of the Hamersley Nullagine rocks makes it unlikely that a temperature rise of the necessary severity ever took place after cooling. The actual temperature required for the formation of the albite is not known. Although Sandran (1959) succeeding in synthesising low-temperature albite at 900° C., it is not known at how low a temperature high-temperature albite can crystallise. If it is accepted, on the similarity of the felspars of the perlitic fragments and the "green quartzite," in which the felspar is associated with tridymite needles, that the two rocks have had similar cooling histories, then the devitrification probably occurred above 870° C., although Larsen (1929) has cast doubt on the validity of tridymite as a temperature indicator. The extreme elongation, and consequent fragility, of the tridymite crystals makes it certain that no relative internal movement of the rock took place after their crystallisation. Accurate information on the transformation ranges of natural lavas is non-existent, but what viscosity and temperature data exist suggest that 900° C. would be an unexpectedly high temperature to be below the transformation range.

Granophyre, and its micrographic texture, were suggested to result from devitrification by Bonney (1885; 1903) and Judd (1889) for different reasons, and Reynolds (1959) has more recently made the same suggestion on other grounds again. The common association in the Tertiary volcanic centres of Scotland (e.g., Bailey and others, 1924, pp. 334-336) between granophyres and felsites, which are there accepted as devitrified rocks, supports this view. In the Dampier Archipelago granophyres the intercrystallisation of tridymite and high-temperature albite in textures similar to those of the Hamersley lavas, strongly suggests a similar thermal history for these rocks, with cooling below the transformation range before crystallisation. As in the Hamersley area, immediately after emplacement is the only time in the history of the Dampier rocks that the granophyres are likely to have attained the high temperatures believed to be necessary for rapid and complete devitrification to tridymite and albite. Devitrification is envisaged as an integral part of the cooling histories of these rocks.

The textural similarity is so striking between many of these Nullagine rocks, Bascom's (1896) Precambrian "aporhyolites" of South Mountain and the Tertiary volcanic rocks of Scotland and the Yellowstone Park (Iddings, 1899) that it is difficult to accept devitrification as a gradual process acting over immense periods of time, an early concept still implicit in recent text-books (e.g. Jung, 1959, p. 232; Turner and Verhoogen, 1960, p. 64). Walker (1962) has described a Tertiary welded tuff from Iceland, most of which is felsitic and devitrified. Careful study of modern acid volcanoes should reveal devitrification textures.

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Geological Survey Section Index

DIVISION V

School of Mines, Western Australia Annual Report — 1962

The Under Secretary for Mines:

I have the honour to submit for the information of the Honourable the Minister for Mines my report for the year 1962. The report covers the work done in Kalgoorlie, in Norseman, in Bullfinch, and for part of the year in Wittenoom. It is with regret that I record the closing down of two Branch Schools—one at Bullfinch and the other at Wittenoom. The Bullfinch School closed at the end of the year because it was likely that the operating Company would cease operations early in 1963. The School at Wittenoom closed because of an almost complete lack of interest by the people of Wittenoom and by the operating Company.

KALGOORLIE.

Enrolments.

The number of students enrolled in 1962 was 352—an increase of 42 by comparison with the previous year. For some years the numbers of students enrolled has been decreasing each year and it is hoped that the increase noted this year will continue next year and that it represents an increased interest in the School by the young people of Kalgoorlie.

Table I gives the individual and class enrolments for 1962 and for the four previous years; Table II, the enrolments in the various subjects; and Table III, the students enrolled for the various courses. A word of explanation so far as Table III is concerned is necessary. A major change in the arrangement of subjects in the Associateship Courses was made in 1962. Most of the subjects previously included in the first years of full-time study or the first and second years of part-time study were taken out of the Courses and grouped together as Qualifying or "Q" subjects. Thus some students who would previously have been enrolled for Associateship Courses were in 1962 enrolled for "Q" subjects. This more than accounts for the apparent decrease in the numbers of students enrolled for Associateship Courses.

TABLE I.

Enrolments, Kalgoorlie.

1958-1962.

Year	Individual	Class
1958	380	928
1959	365	916
1960	332	967
1961	310	804
1962	352	945

TABLE II.

Class Enrolments, Kalgoorlie, 1962.

Subject	First Term	Second Term
Chemistry P	23	17
Chemistry Q	23	17
Chemistry 1	11	10
Chemistry 2	8	8
Analytical Chemistry 1	6	6
Analytical Chemistry 2	3	3
Chemical Metallurgy 1	6	6
Mineral Dressing 1	15	13
Mineral Dressing 3	2	2
Assaying	4	4
Metallurgy A	15	10
Mathematics P	65	50
Mathematics Q	52	34
Mathematics 1	45	36
Mathematics 2	14	13
Applied Mathematics 1	10	10
Physics Q	28	21
Physics 1.1	37	31
Physics 1.2	16	15
Physics 2	13	13
Engineering Drawing P	33	21
Engineering Drawing Q	37	32
Engineering Drawing 1	22	12
Mechanical Engineering 1	12	10
Mechanical Engineering 2	3	3
Practical Electricity	19	14
Electrical Engineering 1	32	32
Electrical Engineering 2.1	6	5
Electrical Engineering 2.2	2	2
Structural Engineering 1	18	17
Structural Engineering 2.1	6	6
Structural Engineering 2.2	5	4
Machine Design 1.1	14	14
Machine Design 1.2	9	7
Hydraulics 1	7	7
Materials of Construction 1	4	4
Workshop Practice 1	10	9
Workshop Practice A	17	12
Workshop Practice B	3	2
Workshop Practice C	4	3
Workshop Practice D	1	1
Steam Engine Driving	1	1
Welding A	31	21
Welding B	10	7
Internal Combustion Engines	12	11
Geology Q	22	15
Geology 1.1	13	10
Geology 1.2	15	14
Geology 2.1	5	5
Geology 2.2	5	5
Geology 2.3	3	3
Geology 3.2	7	7
Geology 3.3	6	6
Mining 1	14	9
Mining 2.1	12	12
Mining 2.2	6	3
Mining 3	5	4
Mining 3.1	4	4
Mining 3.2	2	2
Mine Ventilation 1	6	6
Surveying 1	21	17
Surveying 2.1	11	8
Surveying 2.2	11	4
English Q	15	13
Leaving English	9	8
English 1	24	24
Totals	930	755
Totals, 1961	787	656

TABLE III.

Number of Students Enrolled for Various Courses at Kalgoorlie.

Course	Number Enrolled 1958	1959	1960	1961	1962
Associateship Courses—					
Mining	29	35	37	24	27
Metallurgy	21	21	13	17	15
Engineering	43	43	49	49	44
Mining Geology	13	13	15	19	11
Total	106	112	114	109	97
Certificate Courses—					
Assayer's	2	5	3	3	6
Mine Surveyor's	18	23	25	30	27
Mine Manager's	....	....	....	4	3
Engineering Draughtsman's	8	9	4	6	8
Electrical Engineering	4	7	2	2	....
Mechanical Engineering	....	....	4	1	1
Total	32	44	38	46	45
Technician Courses—					
Engine Operation and Maintenance	3	1	2	1	1
Workshop Foreman's	8	6	7	6	2
Welding	14	7	10	16	24
Total	25	14	19	23	27
No Set Course—					
Preparatory Subjects	52	61	47	44	38
Qualifying Subjects	....	....	....	....	22
External Students	....	3	6	3	....
Junior and Leaving	....	2	12	9	28
University	....	10	7	4	3
Others	165	119	89	72	92
Total	217	195	161	132	183
Total for Year	380	365	332	310	352

Revenue.

The revenue for the year was £6,031 4s. 7d. This was made up as shown in Table IV, which also shows the revenue for the two previous years.

Table V shows age groups of the students and the types of fees paid. It also shows that increase in the numbers enrolled occurred mainly in the under 18 and 18-21 age groups.

Staff.

The following staff changes occurred during the year:

- Brinsden, W. K., Laboratory Assistant, 2/3/62—Resigned.
- Cairnduff, D. J., Junior Clerk, 30/11/62—Transferred.
- Carroll, L. J., Registrar, 18/7/62—Transferred.
- Crew, R. J., Laboratory Assistant, 17/9/62—Appointed.
- Cundill, M. I., Librarian, 30/11/62—Resigned.
- Forrest, A., Cadet, 12/3/62—Appointed.
- George, T. J. F., Assayer, 8/6/62—Resigned.
- Goergenyi, G. J., Cadet, 6/3/62—Appointed; 7/12/62—Resigned.
- Hardy, R. J., Lecturer, 12/2/62—Appointed.
- Hollett, J., Junior Clerk, 28/11/62—Appointed.
- McKenzie, J. H., Laboratory Assistant, 5/6/62—Appointed.
- Mason, C. S., Registrar, 18/7/62—Appointed.
- Reece, G. D., Fitter and Turner, 19/2/62—Appointed.
- Renton, K. J., Laboratory Assistant, 2/5/62—Appointed.
- Stewart, W., Fitter and Turner, 19/1/62—Resigned.

Courses of Study.

The revised Courses referred to in last year's Report were introduced in 1962. The major changes were in the Associateship Courses and these changes bring the School of Mines' Courses more into line with similar courses being taught elsewhere in Australia.

Further changes were made to the Certificate Courses during the year. The Engineering Draughtsman's Certificate Course was revised and made more attractive to students who do not wish to do the longer Associateship Course. The new Course will be available in 1963.

TABLE IV.

Revenue, 1960-1962.

	1960	1961	1962
	£	£	£
Class Fees	1,339 9 6	1,232 3 6	1,419 0 0
Registration Fees	85 10 0	79 10 0	97 0 0
Lecture Notes	57 17 6	56 2 6	62 15 0
Laboratory Deposits	114 7 0	121 0 0	115 0 0
Supplementary Examinations	21 0 0	31 0 0	37 0 0
Student's Association	....	132 10 0	149 10 0
Apparatus and Equipment Trust Fund	1,000 0 0	1,000 0 0	....
Metallurgical Laboratory Trust Fund	1,056 5 1	1,258 14 0	1,268 14 0
Commonwealth Grant Fund	2,500 0 0	2,700 0 0	2,703 0 0
Mine Managers and Underground Supervisors	32 0 6	42 19 0	47 5 0
Sundries	42 5 0	55 6 0	132 0 7
Total	£6,248 14 7	£6,709 5 0	£6,031 4 7

TABLE V.

Numbers of Students Paying Fees at Kalgoorlie.

Group No.	Description	1962 Full Time	Part Time	External	Totals	1961 Totals
1	Students under 18. Lecture notes plus Students' Association	14	86	....	100	77
2	Students 18-21 years. Registration plus Lecture Notes plus Students' Association	12	85	....	97	82
3	Students over 21. Class plus Lecture Notes plus Students' Association	7	111	2	120	117
4	Returned Servicemen. Exempt Class Fees	....	27	....	27	27
5	Staff. Exempt Registration or Class Fees	....	6	....	6	6
6	Scholarship Holders. Exempt Registration or Class Fees	2	....	....	2	1
	Total	35	315	2	352	310

The Technician Courses were also revised and a new Second Class Mine Manager's Course was prepared. This new Course was made necessary by changes made to the Mines Regulation Act.

Annual and Supplementary Examinations.

The examination results are summarized in Tables VI and VII, which are based on class enrolments and individual enrolments respectively. Generally, the results were similar to those obtained in previous years.

The results for individual subjects are given in Appendix 1.

Scholarships and Prizes.

Three students held Mines Department Senior Scholarships during 1962.

Name	Scholarship Year	Associateship Course	Notes
Black, N. C.	2nd	Metallurgy	Year's work satisfactory. Scholarship available for two years.
Karczub, L. M.	1st.	Engineering	Years' work satisfactory. Scholarship renewed for 1963.
....	1st.	Metallurgy	Year's work unsatisfactory. Scholarship cancelled.

Thirteen students held Chamber of Mines Scholarships. With two exceptions these students completed a satisfactory year's work. The two students whose work was disappointing were senior students, who for various reasons, did not make the effort necessary to pass the required subjects and to complete the requirements of the courses for which they were enrolled. They will need to make a special effort in 1963.

The usual awards were made at the end of the year and are listed in Appendix 2.

Diplomas and Certificates.

During the year, 10 students completed Associateship Courses; 17, Certificate Courses; and 2, Technican Courses. The numbers of students completing Courses during the past five years are given in Table VIII.

TABLE VI.

Results of Annual and of Supplementary Examinations Based on Class Enrolments, 1958-1962, Kalgoorlie.

	1958	1959	1960	1961	1962
Class enrolments = A.	928	916	939	804	945
Number of entries for Annual Examinations = B.	577	605	596	544	609
B/A per cent.	62	68	63	68	64
Number of passes at Annual Examinations as a per cent of A.	52	52	54	51	49
Number of passes at Annual Examinations as a per cent. of B.	84	79	85	76	75
Number of passes at Annual Examinations and Supplementary Examinations as a per cent of A.	53	54	55	53	52
Number of passes at Annual Examinations and Supplementary Examinations as a per cent of B.	85	80	87	79	81

TABLE VII.

Students Sitting for Annual Examinations 1960, 1961, 1962.

Course	1960		1961		1962	
	Number Enrolled	Per cent. Sitting	Number Enrolled	Per cent. Sitting	Number Enrolled	Per cent. Sitting
Associateship	114	85	109	93	95	93
Certificate	38	84	46	83	45	78
Technician....	19	58	23	57	27	88
No set Course	161	43	132	38	182	49
Total	332	63	310	65	349	67

TABLES VIII.

Courses Completed, 1958-1962.

	1958	1959	1960	1961	1962
Associateship Courses—					
Mining	7	6	3	2	1
Metallurgy	2	11	5	5	2
Engineering	3	4	4	10	3
Mining Geology	1	1	....	....	4
Total	13	22	12	17	10
Certificate Courses—					
Assayer's	3	3	2	1	6
Mine Manager's	....	3	1	1	1
Mine Surveyor's	9	5	....	11	6
Engineering Draughtsman's	....	1	2	2	2
Electrical Engineering	1	1	3	1	1
Mechanical Engineering	1	2	4	....	1
Total	14	15	12	16	17
Technician Courses					
Engine Operation and Maintenance	2	4	2	1	1
Workshop Foreman's	1	1	1	1	1
Welding	3	5	2	1	....
Total	6	10	5	3	2

On Monday, May 28th, the Annual Graduation Ceremony was held in the Kalgoorlie Town Hall, and Diplomas, Certificates, and Prizes awarded at the close of 1961 were presented to the successful students, by the Honourable the Minister for Mines, Mr. A. F. Griffith. After an address by the Minister the new Associates were welcomed by the Vice-President of the Associates Association, Mr. A. Y. Wilson. The Guest Speaker was Mr. L. E. Elvey, President of the Chamber of Mines of Western Australia (Inc.) and General Manager of Great Boulder Proprietary Gold Mines Ltd. Mr. Elvey referred to the past and the future of the gold mining industry and to the opportunities it offered to students of the School of Mines. A vote of thanks to the Minister and to Mr. Elvey was proposed by the President of the Students' Association, Mr. A. J. Murphy.

Library.

During 1962 the central reading room and reference section was open for the use of students and mining personnel. General reference material is housed in the reading room, and three sets of encyclopaedias have been added to the stock, and give a fairly comprehensive cover of borderline material.

During the year a service to the mining industry was also initiated in the issue of a monthly library bulletin consisting of an index to selected articles from periodical literature on mining and mineral dressing. Loans to mining companies have increased since the issue of this bulletin, the circulation of each new number being almost immediately followed by requests for some of the articles listed.

The number of new books added to the library in 1962 was 527 and the total number of items catalogued at December 31st, was 7,728. There is still quite a backlog of uncatalogued old material. With the extra work involved in shifting into new buildings it has not been possible to do much with this in 1962.

Services to the Public.

The School continued to provide the usual services to the Public in addition to its teaching activities. The number of samples submitted for assay or mineral determination increased considerably from 341 in 1961 to 561 in 1962—the increase was mainly in the number of samples submitted for gold assay. Details are given in Table IX.

TABLE IX.

Work done on Samples Received from Prospectors and others, Kalgoorlie.

	1958	1959	1960	1961	1962
Assay—Gold	105	220	263	177	325
Assay—Gold and other constituents	0	4	1	2	11
Assay—Metals other than gold	18	16	35	23	46
Assay plus mineral determination	3	5	3	16	11
Mineral examination	130	140	94	117	138
Rejected or transferred to Metallurgical Laboratory pay	5	13	8	6	30
Total	261	398	404	341	561

Buildings.

Additions and alterations to the Kalgoorlie Metallurgical Laboratory which were commenced in late 1961 dragged on throughout 1962 and were still not complete at the end of the year.

During the year no other work was done on the buildings, which are generally in good condition.

Requirements of the School.

Generally, these remain as set out in the 1961 Report.

Advisory Committee.

This Committee met on ten occasions and attendances were as follows: Mr. Kay, 6; Mr. Blown, 6; Mr. Field, 10; Mr. Golding, 7; Mr. Collard, 1 (possible 1); Mr. Havlin, 4 (possible 9); Mr. Hobson, 10; Mr. Mundle, 5.

Equipment to the approximate value of £6,100 was approved for purchase.

Kalgoorlie Metallurgical Laboratory.

Five reports of investigations and 391 certificates of testing or analyses were issued during the year. In addition numerous free assays were made for prospectors and others, and many enquiries were answered by the Senior Research Metallurgist and by members of the Laboratory Staff. Five investigations were in progress at the end of the year. More details are given in Appendix 3, which has been prepared by the Senior Research Metallurgist.

The Senior Research Metallurgist continued during the year as a member of the Chamber of Mines Metallurgical Committee and the Laboratory continued to do work for this Committee in association with mine laboratories.

Although the alterations and additions to the Laboratory buildings were not completed by the end of the year some new sections were in use. Satisfactory office accommodation and a special apparatus room are available, and when work is completed an air conditioned balance room and new assay laboratory will be available. Some delay has been occasioned by the proposed change from 40 to 50 cycle current.

Students' Association.

The President of the Students' Association was Mr. A. J. Murphy and the Association was active throughout the year. The usual functions were held.

TABLE X.

Kalgoorlie Metallurgical Laboratory. Summary of Work.

	1958	1959	1960	1961	1962
Investigations outstanding (January 1)	7	3	3	2	6
Investigations asked for (721-725 inclusive)	7	3	....	7	5
	14	6	3	9	11
Investigations completed	11	3	1	3	5
Investigations outstanding (December 31)	3	3	2	6	5
Investigation cancelled (712)	....	....	....	....	1
Total	14	6	3	9	11
Certificates issued (assays, analyses, etc.)	106	481	395	469	391

NORSEMAN.

Enrolments.

The number of students enrolled during the year was 69—an increase of four by comparison with the previous year. Table XI sets out the individual and class enrolments during the year and in the four previous years; Table XII, the enrolments in individual subjects; and Table XIII, the numbers enrolled for the various courses.

Revenue.

The revenue received was £237.

Staff.

There were no changes in the fulltime staff. Six part-time lecturers were employed.

Subjects Taught.

Eighteen subjects were taught at Norseman and as in previous years use was made of mine workshops for practical work in Workshop Practice and in Welding.

Examinations.

The results of the Annual Examinations are summarized in Tables XIV and XV—Table XIV is based on class enrolments and Table XV on individual enrolments. Table XVI makes a comparison of Kalgoorlie, Norseman, and Bullfinch results and is based on class enrolments. The results are similar to those obtained in previous years.

The results for individual subjects are given in Appendix 1.

Scholarships and Prizes.

The Reg Dowson Scholarships for 1962 were awarded to G. L. Rasmussen and to K. W. Giles. The two students who received Reg Dowson Scholarships in 1961 both completed a satisfactory year's work in 1962.

TABLE XI.

Enrolments, Norseman, 1958-1962.

Year	Individual	Class
1958	67	180
1959	55	140
1960	61	146
1961	65	139
1962	69	160

TABLE XII.

Class Enrolments, Norseman, 1962.

Subject	First Term	Second Term
Chemistry P	8	6
Metallurgy A	16	15
Mathematics P	10	9
Mathematics Q	10	9
Mathematics 1	4	5
Engineering Drawing P	6	5
Engineering Drawing Q	13	11
Engineering Drawing 1	3	1
Workshop Practice A	12	9
Welding A	12	12
Welding B	5	5
Geology 1.2	7	7
Mining 3	5	5
Surveying 1	7	5
English 1	9	9
Physics P	9	6
Electrical Theory A	9	6
Electrical Drawing A	10	8
TOTALS:	155	133
TOTALS, 1961:	135	127

TABLE XIII.

Number of Students Enrolled for Various Courses at Norseman.

Course	Number Enrolled				
	1958	1959	1960	1961	1962
Associateship Courses—					
Mining	6	....	2	3	6
Metallurgy	....	....	....	....	....
Engineering	2	3	2	2	3
Mining Geology	1	....	....	....	1
Total	9	3	4	5	10
Certificate Courses—					
Assayer's	....	....	....	....	....
Surveyor's	7	8	10	13	11
Mine Manager's	....	....	....	....	....
Engineering Draughtsman's	....	1	2	2	....
Electrical Engineering	1	....	1	1	1
Mechanical Engineering	....	....	....	1	....
Total	8	9	13	17	12
Technician Courses—					
Engine Operation and Maintenance	18	14	6	17	12
Workshop Foreman's	4	3	8	3	6
Welding	6	4	5	4	6
Total	28	21	19	24	24
No Set Course—					
Preparatory Subjects	13	9	3	3	11
Others	9	13	22	16	12
Total	22	22	25	19	23
Total for Year	67	55	61	65	69

TABLE XIV.

Results of Annual and of Supplementary Examinations Based on Class Enrolments, 1958-1962, Norseman.

	1958	1959	1960	1961	1962
Class enrolments = A.	180	140	146	139	160
Numbers of entries for Annual Examinations = B.	95	93	123	96	118
B/A per cent.	52	66	84	70	74
Number of passes at Annual Examinations as a per cent. of A.	37	53	65	48	51
Number of passes at Annual Examinations as a per cent. of B.	70	80	77	70	69
Number of passes at Annual Examinations and Supplementary Examinations as a per cent. of A.	38	57	66	54	53
Number of passes at Annual Examinations and Supplementary Examinations as a per cent. of B.	73	86	78	78	71

TABLE XV.

Students Sitting at Annual Examinations, 1960-1962, Norseman.

Course	1960		1961		1962	
	Number Enrolled	Per cent Sitting	Number Enrolled	Per cent Sitting	Number Enrolled	Per cent Sitting
Associateship	4	100	5	100	10	100
Certificate	13	93	17	82	12	67
Technician....	19	95	24	83	24	96
No set Course	25	76	19	26	23	52
Total	61	87	65	69	69	77
Kalgoorlie for Comparison	332	63	310	65	349	67

TABLE XVI.

Examination Results, Kalgoorlie, Norseman, Bullfinch.

Notes:

1. Information based on class enrolments.
2. The letters "A" and "B" have the same meaning as in Table XIV.

	1958	1959	1960	1961	9162
B/A per cent.—					
Kalgoorlie	62	68	63	68	64
Norseman	52	66	84	70	74
Bullfinch	63	65	51	57	50
Total passes as a per cent of A.—					
Kalgoorlie	53	52	55	53	52
Norseman	38	53	66	54	53
Bullfinch	54	46	41	48	44
Total passes as a per cent of B.—					
Kalgoorlie	85	79	87	79	81
Norseman	73	80	78	78	71
Bullfinch	85	71	80	84	88

Buildings.

The buildings were painted during the year and are generally in good condition.

Advisory Committee.

The Committee met twice during the year with Mr. Dutton as Chairman. The only new member of the Committee was Mr. J. A. Richards, the Headmaster of the Junior High School at Norseman.

BULLFINCH

Enrolments.

The number of students enrolled was 27—a decrease of 33 by comparison with the previous year. This decrease in enrolments was expected as it was known early in the year that Great Western Consolidated would close down at the end of the year or thereabouts. The School was kept open during the year to enable a few of the better students to complete some additional subjects. Information about the numbers of students enrolled, the numbers in the various classes, and the numbers in the various courses is given in Tables XVII, XVIII and XIX.

Revenue.

The revenue received was £57 2s. 0d.

Staff.

Mr. Browne continued as Acting Officer-in-Charge and Registrar. Four part-time lecturers were employed.

Subjects Taught.

Nine subjects were taught at Bullfinch and in addition three subjects were made available to Bullfinch students as external students from Kalgoorlie.

Examinations.

The examination results are summarized in Tables XX and XXI—Table XX is based on class enrolments and Table XXI on individual enrolments. The results are generally similar to those obtained in previous years.

The results for individual subjects are given in Appendix 1.

Scholarships and Prizes.

No awards were made to Bullfinch students.

Buildings.

The School buildings and the quarters are in fair condition. As the School was not likely to continue beyond 1962 only minor repairs were done during the year.

Advisory Committee.

The Committee did not meet during the year.

TABLE XVII.

Enrolments, Bullfinch, 1958-1962.

Year	Individual	Class
1958	47	87
1959	48	85
1960	63	98
1961	60	89
1962	27	34

TABLE XVIII.

Class Enrolments, Bullfinch, 1962.

Subjects	Number students enrolled
Mathematics 1 (external, Kalgoorlie)	2
Physics Q (external, Kalgoorlie)	1
Engineering Drawing P	2
Engineering Drawing Q	2
Engineering Drawing 1	4
Workshop Practice A	4
Workshop Practice B	3
Welding A	4
Welding B	5
Geology 1.2	4
Mining 1 (external, Kalgoorlie)	1
Surveying 2.2	2
Totals	34

TABLE XIX.

Number of Students Enrolled for Various Courses at Bullfinch.

Course	Number Enrolled				
	1958	1959	1960	1961	1962
Associateship Courses—					
Mining	....	....	....	....	....
Metallurgy	2	1	1	1	1
Engineering	....	....	....	1	....
Mining Geology	2	1	....	....	....
Total	4	2	1	2	1
Certificate Courses—					
Assayer's	....	....	....	....	....
Mine Surveyor's	7	3	2	3	3
Mine Managers'....	....	1	....	....	....
Engineering Draughtsman's	....	1	1	....	....
Electrical Engineering	....	1	1	....	....
Mechanical Engineering	....	....	1	1	....
Total	7	6	5	4	3
Technician Courses					
Engine Operation and Maintenance	....	....	....	....	....
Workshop Foreman's	4	2	....	....	....
Welding	....	1	....	....	....
Total	4	3	....	....	....
No Set Course					
Preparatory Subjects	4	8	16	5	1
Others	28	29	41	49	22
Total	32	37	57	54	23
Total for Year	47	48	63	60	27

TABLE XX.

Results of Annual and of Supplementary Examinations Based on Class Enrolments, 1958-1962, Bullfinch.

	1958	1959	1960	1961	1962
Class enrolments = A.	87	85	98	89	34
Number of entries for Annual Examinations = B.	55	55	50	51	17
B/A per cent.	63	65	51	57	50
Number of passes at Annual Examinations as a per cent of A.	54	46	36	48	38
Number of passes at Annual Examinations as a per cent. of B.	85	71	70	84	77
Number of passes at Annual and Supplementary Examinations as a per cent. of A.	54	46	41	48	44
Number of passes at Annual and Supplementary Examinations as a per cent. of B.	85	71	80	84	88

TABLE XXI.

Students Sitting at Annual Examinations, 1960-1962, Bullfinch.

Course	1960		1961		1962	
	Number Enrolled	Per cent Sitting	Number Enrolled	Per cent Sitting	Number Enrolled	Per cent Sitting
Associateship	1	100	2	100	1	100
Certificate	5	100	4	75	3	67
Technician....	....	....	....	....	....	....
No set Course	57	61	54	57	23	43
Total	63	65	60	58	27	48
Kalgoorlie for Comparison	332	63	310	65	349	67
Norseman	61	87	66	68	69	77

Summary of Activities at Bullfinch.

1. Towards the end of 1962 it was known that Great Western Consolidated would close down early in 1963, and it was therefore decided to close the School at the end of 1962. A brief closing-down function was held on Thursday, December 13, 1962. I would like to record here a few facts concerning Bullfinch, which may be of value if a Branch School is being considered in a new locality.

2. The School opened in February, 1953 and continued to the close of 1962. It was therefore in existence for ten school years.

3. The Staff of the School has been mainly part-time. The intention was to appoint a full-time Officer-in-Charge after the School had been going for one year, but difficulty was experienced in obtaining and retaining a suitable person. Mr. V. J. Tie was full-time Officer-in-Charge from February, 1955 to December, 1956 and Mr. M. H. Lloyd from February, 1959 to April, 1961, when he was transferred to Kalgoorlie. Mr. J. C. Browne has been associated with the School as part-time Registrar over the whole of its period of existence and as Acting Officer-in-Charge for much of the time.

4. Useful statistical information concerning the School is as follows:

Maximum population of Bullfinch (1955-59)		1,400
Total number of students enrolled		239
Average students per year		51
Total number of subjects taught (most subjects more than once and many each year)		32
Average number of subjects taught each year		14
Total individual enrolments		511
Total class enrolments		876
Total number of passes at Annual and Supplementary Examinations		343
Total income received (approximately)		£750
Total cost of School:	£	
Full-time staff	6,070	
Part-time staff	11,520	
Cleaner and gardener	3,470	
Equipment and incidentals	3,650	
Buildings	6,400	£31,110

5. One student completed the Mine Surveyor's Certificate Course and obtained his Certificate of Competency as a Mine Surveyor from the Mines Department. Two other students almost completed the same Course.

6. There was at Bullfinch—as at most Schools—a nucleus of good students, but there were many who were not keen and who failed to take advantage of the facilities offered by the School. Two reasons account for many of the not-so-good students. First of all, many of the young people were too concerned with making money. In the early days of the Mine many opportunities for overtime work were available and these not only reduced the time available for study but made it appear to be unnecessary. Furthermore, many young lads had not reached the standard of education necessary for School of Mines classes and found it impossible to bridge the gap between the normal School work at Bullfinch and that required at the School of Mines.

7. Every assistance was received from the Company and without this it would have been difficult and probably impossible to establish and continue the School. The building first used was provided by the Company, which also made available some of its staff members to help in the intitial stages. The Company provided assistance and co-operation during the ten years of the School's life.

WITTENOOM.

Although the results of the work done in 1961 were very disappointing indeed, it was decided to continue classes in 1962 in the hope that interest in the School would grow. This did not happen and all classes were discontinued in May, 1962, and equipment was returned to Kalgoorlie.

The position in 1962 was as follows:—

Subject	Number Enrolled March, 1962	Number Active May, 1962
Mining 1	5	1
Mathematics P	4	0
Welding A	13	8
Engineering Drawing P .... } Engineering Drawing Q .... }	4	5
Geology Q	4	2

There was some interest in the Welding and Drawing classes, but none in the other classes. Furthermore, the Company desired to take over the house being used by the School, but did not offer any satisfactory alternative accommodation. Neither the Company nor the people of Wittenoom appeared to have a real interest in the work of the School.

ACKNOWLEDGMENTS.

Appreciation is due to all members of the staff, who have assisted students in every way and who have also provided information when this has been required by members of the public. Thanks are also due to the Registrar and to members of the Office Staff for assistance in compiling this Report.

As the Branch School at Bullfinch was closed down at the end of 1962 it is appropriate to record here the co-operation and assistance of the two Officers-in-Charge at different times—Messrs. Tie and Lloyd—and also of the part-time staff. Of the part-time staff mention must be made of Mr. J. C. Browne, Registrar and sometime acting Officer-in-Charge, who was associated with the School throughout its life at Bullfinch.

At Wittenoom thanks are due to the part-time Officer-in-Charge, Mr. J. P. Shanahan, who endeavoured under difficult conditions to keep the School operating at Wittenoom, and also to other members of the part-time staff.

Assistance and co-operation have also been received from Advisory Committees, Mining Companies, Head Office Staff and all sections of the Mines Department, and other Government Departments e.g. Public Works Department and Government Stores.

R. A. HOBSON,
Director, School of Mines.

June 25th, 1963.

School of Mines of Western Australia.

APPENDIX I.

ANNUAL EXAMINATIONS.
1962.

PASS LIST.

Passes are in order of merit.

Bracket denotes equal marks.
(*) Denotes year fee scholarship.

Chemistry P.

Credit:
*Miller, T. D.

Pass:
{Curran, B. G.
{Livingstone, G.
Chamberlain, E. H.
Walker, M. C.
Jones, G. J. F.
Golding, P. D.
Forrest, A.
Hicks, D. C.

Supp. Exam. Granted:
Baldwin, N. G.
Moriarty, M. E.

Exemption Granted from Practical Work for 1963.
Baldwin, N. G.
Moriarty, M. E.

Chemistry Q.

Credit:
*Green, E. D.

Pass:
McNally, R. T.
Sloan, R. B.
Woolhouse, M. L.
Smurthwaite, A. J.
Ralph, G. M.
Fong, K. H.
{Erbe, J. D.
{Flanagan, K. J.
Bayly, J. G.

Supp. Exam. Granted:
Lindfield, N. W.

Exemption Granted from Practical Work for 1963.
Lindfield, N. W.

Chemistry 1.

Pass:
Absolon, V. J.
King, R. M.
Head, D. J.

Supp. Exam. Granted:
Sands, D. J.

Exemption Granted from Practical Work for 1963.
Sands, D. J.

Chemistry 2.

Pass:
Gray, D. J.
Willcocks, P. W.

Supp. Exam. Granted:
Black, N. C.

Analytical Chemistry 1.

Credit:
*Tonkin, D.
Wills, M. F.

Pass:
Willcocks, P. W.
{Black, N. C.
{Thornton, W. F.

Analytical Chemistry 2.

Credit:
*Klose, W. F.

Mineral Dressing 1.

Credit:
*Absolon, V. J.

Pass:
Head, D. J.
Ritchie, H. G.
Willcocks, P. W.
Crew, W. J.
Shugg, P. J.
Sloan, R. B.
Black, N. C.
Banks, F. R.

Supp. Exam. Granted:
Flanagan, K. J.
Kozuh, D.

Mineral Dressing 3.

Pass:
Sceresini, B. J. S.
Kops, J. N.

Chemical Metallurgy 1.

Pass:
Willcocks, P. W.
Gray, D. J.
Black, N. C.

Supp. Exam. Granted:
Klose, W. F.

Assaying 1.

Credit:
*Lewis, C. J. B.
Cruickshank, A. C.

Pass:
Hooker, N. R.
Moriarty, M. T.

Metallurgy A.

Credit:
*Hall, R.
Reece, G. D.

Pass:
Williams, P. I.
Jose, N. W.
Fry, B. G.
Joyce, G. D.
Pinkerton, J. M.

Mathematics P.

Credit:
*Bowman, J.
Miller, T. D.
Chamberlain, E. H.
Walker, M. C.

Pass:
{Forrest, A.
{Moon, J.
Taylor, D.
McInerney, E.
Baldwin, N. G.
Fisher, J. A. S.
Farrell, R. T.
{Arjunan, G.
{Hewitt, G. P.
{Tasker, H. E.
{Terrell, J. W.
{Collins, D. H.
{Cowin, A. B.
{Smith, D. L.
Drazic, K. W.
Livingstone, G.

Supp. Exam. Granted:
Argus, A. A.
Delbridge, A. G.

Mathematics Q.

Credit:
*Tonkin, D.
Green, E. D.

Pass:
Mason, R. E.
Golding, P. D.
{Hill, J. W.
{Ridley, R. H.
Gould, R.
Amos, R. J.

Mathematics 1.

Credit:
*Brinsden, W. K.

Pass:
Absolon, V. J.
Woolhouse, M. L.
Head, D. J.
{King, R. M.
{Marshall, D. A.
Bain, W. B.
Karczub, L. M.
{Fong, K. H.
{George-Kennedy, R. J.
Patterson, B. S.
Maley, W. S.
{Kilderry, T. J.
{McGushin, G.
McRostie, B. L.
McKenzie, J. H.
McNally, B. T.
Magnus, E. R.

Mathematics 2.

Credit:
*Fraser, B. J.

Pass:
{Pearson, C. A. L.
{Willis, R. J.
Blurton, L. N.
Ghor, A.
Softley, M. D.
Kelly, J. P.
Baldwin, W. E.

Supp. Exam. granted:
Cumming, G. M.
Egan, H. P.
Leslie, W. E.
Currie, E. G.

Applied Mathematics 1.

Credit:
*Fraser, B. J.

Pass:
Blurton, L. N.
Willis, R. J.
Miller, J. J.
Ghor, A.
Softley, M. D.
Baldwin, W. E.
Donovan, R. J.

Physics Q.

Credit:
*Flanagan, K. J.

Pass:
Brinsden, W. K.
Amos, R. J.
Mason, R. E.
Judges, J. E.
Gould, R. J.
McNally, B. T.
{Goergenyi, G. J.
{Smurthwaite, A. J.

Supp. Exam. Granted:
Golding, P. D.

Exemption Granted from Practical Work for 1963.
Golding, P. D.

Physics 1.1.

Credit:
*Gard, L. A.

Pass:
Marshall, D. A.
Absolon, V. J.
Willcocks, P. W.
{Leyland, E. C.
{Sands, D. J.
Head, D. J.
King, R. M.
{Kilderry, T. J.
{Woolhouse, M. L.
Cunneen, P. J.
{Black, N. C.
{Kelly, J. P.
{Karczub, L. M.
{Dykstra, F. D.
Magnus, E. R.

Supp. Exam. Granted:
Fong, K. H.
Maley, W. S.
McRostie, B. L.
Argus, J. C.

Exemption Granted from Practical Work for 1963.
Fong, K. H.
Maley, W. S.
McRostie, B. L.
Argus, J. C.

Physics 1.2.

Credit:
*Maley, W. S.

Pass:
Woolhouse, M. L.
King, R. M.
{Lewis, C. J. B.
{McRostie, B. L.
Dykstra, F. D.
{Karczub, L. M.
{Sands, D. J.
Magnus, E. R.

Supp. Exam. Granted:
Lindfield, N. W.
Argus. J. C.

Physics P.

Credit:

*Rasmussen, G. L.

Pass:

Skinner, K. J.
Rose, F. W.
Murphy, F. J.
Murphy, R. J.

Exemption Granted from Practical Work for 1963:

Giles, T. E.

Engineering Drawing P.

Pass:

Taylor, R. L.
Foote, S. P.
Green, T. D.
Fleay, J. R.

Engineering Drawing Q.

Credit:

*Skinner, K. J.

Pass:

Horne, R. H.
May, C. F.
Prime, G. G.
Giles, T. E.
Underwood, W. J.
Goodwin, H.
Dowsett, D. W.
Coles, J. E.

Engineering Drawing 1.

Credit:

*Campbell, R. D.

Workshop Practice A.

Credit:

*Skinner, K. J.

Pass:

Reher, R.
Swain, G. B.
Giles, T. E.
Freeman, P. G.
Delamotte, R. C.
Cappa, W. F.
Murrie, A. W.

Exemption Granted from Attendance at Lectures for 1963:

McEwan, J.

Welding A.

Credit:

*Barnes, D. A. J.

Pass:

Brouwer, J. H.
Temple, E. D.
Giles, K. W.
McEwan, J.
Goodwin, H.

Exemption Granted from Practical Work for 1963:

Hayes, R. C.
Pope, D. A.
Smith, T. L.
Taylor, R. L.
Watson, R. H.

Welding B.

Pass:

Conte, A. L.
Underwood, W. J.
Benoit, A. L.
Jones, E. J.
Dowsett, D. W.

Electrical Theory A.

Credit:

*Rasmussen, G. L.

Pass:

Murphy, R. J.
Freeman, P. G.
Prime, G. G.
Jenkins, L. K.

Electrical Drawing A.

Credit:

*Bottegal, J.
Demarteau, H. J.
Hill, A. J.
Rasmussen, G. L.
Freeman, P. G.

Pass:

Johnson, R. A.
Murphy, R. J.
Rose, F. W.
Jenkins, L. K.

Geology 1.2.

Pass:

Lea, R. J.

Supp. Exam. Granted:

Moffat, B.

Exemption Granted from Practical Work for 1963:

Moffat, B.

Mining 3 (Section A only).

Pass:

Lea, R. J.
Hug, R. L.
Powell, P.
Brouwer, J. H.

Surveying 1.

Pass:

Cook, G. J. S.
Cooper, A. W.
Swain, G. B.
Kerr, P. H.

Supp. Exam. Granted in Paper "B":

O'Connor, G.
Hill, A. J.

Exemption Granted from Practical Work for 1963:

O'Connor, G.
Hill, A. J.

English 1.

Pass:

Lea, E. J.
Powell, P.

School of Mines—Bullfinch

ANNUAL EXAMINATIONS.

PASS LIST.

Mathematics 1.

No Passes.

Physics Q.

Pass:

Annear, E. J.

Engineering Drawing P.

Credit:

*Wickham, R.
Goode P. R. A.

Pass:

Zappelli, C. D.

Engineering Drawing Q.

Pass:

de Vries, T.

Engineering Drawing 1.

Pass:

de Vries, T.
Annear, E. J.

Workshop Practice A.

Pass:

Wickham, R. A. R.

Workshop Practice B.

No Passes.

Exemption Granted from Practical Work for 1963:

Lanfranchi, J. J.
Sawyer, D. J.

Welding A.

Credit:

*Quadrio, B.

Exemption Granted from Practical Work for 1963:

Reid, F. A. R.

Welding B.

Pass:

Della Bosca, R.
Capitanio, R.

Exemption Granted from Practical Work for 1963:

Armanasco, D.
Armanasco, F.

Geology, 1.2.

Pass:

Harken, R. M.

Supp. Exam. Granted:

Blackley, T.

Exemption Granted from Practical Work for 1963:

Blackley, T.

Surveying 2.2.

Credit:

*Harken, R. M.

Pass:

Blackley, T.

SUPPLEMENTARY EXAMINATIONS.

FEBRUARY, 1962.

The following students passed in the subjects listed below:—

KALGOORLIE.

Chemistry IB.
Wills, M. F.

Mineral Dressing I.
Hennessy, R. M.
Morel, F. R.

Mathematics I.
Taaffe, L. D.

Mathematics II.
Falls, G. W.

Physics II.
Leslie, W. E.
Hobson, J. C.

Mechanical Engineering I.
Dodge, G. J.

Welding I.
Bryndzej, T.

Preparatory Geology.
Moriarty, M. T.

Geology IIA.
Sloan, R. B.
Morel, F. R.

Surveying I.
Turner, B. C.

Surveying II.
Connelly, M. A.
Crew, W. J.
Kozuh, D.

NORSEMAN.

Trade Mathematics II.
Murphy, R. J.
Goodwin, H.
Coles, E. J.

Mathematics I.
Skinner, K. J.

Materials of Construction.
Swain, G. B.

Practical Electricity.
May, R. I.

Surveying II.
Stewart, B. A.
Denison, J. L.

SCHOOL OF MINES OF WESTERN AUSTRALIA.

APPENDIX 2.

SCHOLARSHIPS AND PRIZES, 1962.

MINES DEPARTMENT.

Entrance Scholarship: No award made.
Senior Scholarship: No award made.

CHAMBER OF MINES PRIZES.

Metallurgy: No award.
Mining: A. M. Pivac.
Engineering: J. H. Slocomb.
Mining Geology: No award.

SCHOOL OF MINES STUDENTS' ASSOCIATION SCHOLARSHIPS.

Metallurgy: D. J. Gray.
Mining: I. R. Letts.
Engineering: R. N. Forrest.
Mining Geology: J. M. Fogarty.

INSTITUTE OF MINING SURVEYORS' PRIZE.

£10: L. D. Taaffe.
£5: J. M. Fogarty.

SOCIETY OF W.A. SCHOOL OF MINES ASSOCIATES' PRIZE.

E. D. Green.

REG. DOWSON SCHOLARSHIPS.

G. L. Rasmussen.
K. W. Giles.

ROBERT FALCONER PRIZES.

First Prize: M. C. Walker.
Second Prize: No award.

C. A. HENDRY PRIZE.

W. K. Brinsden.

WESLEY LADIES' GUILD PRIZE.

J. A. Collins.

APPENDIX 3.

Kalgoorlie Metallurgical Laboratory

By E. Tasker, A.W.A.S.M. (Met.), A.M. Aust.I.M.M., Senior Research Metallurgist.

INTRODUCTION.

Five reports of investigation and three hundred and ninety-one certificates of testing or analyses were issued during the year. Brief descriptions of the investigations are included in this report.

For further information regarding these reports apply to:—

The Secretary,
Commonwealth Scientific and Industrial Research Organization,
314 Albert Street,
East Melbourne, C.2.,
Victoria.

from whom copies of the reports can be obtained, usually six months after date of issue.

In addition to the reports issued, five other investigations were approved and test work was in progress.

Numerous inquiries dealing with the technical problems of people engaged in the mining industry were handled during the year, and visits were made to various treatment plants by members of the Laboratory staff following requests for assistance.

COMPLETED INVESTIGATIONS.

Report No. 717.

Batch and pilot scale test-work was carried out on a spodumene bearing pegmatite ore from Mt. Marion, Western Australia.

Spodumene concentrates containing a high percentage of lithia were produced by means of flotation.

Report No. 718.

Treatment tests were carried out on diamond drill core samples from the Pinnacles Lease, in the Cue district.

A high percentage of the gold was recoverable by amalgamation and agitation cyanidation.

Report No. 719.

Treatment tests were carried out on a sulphide copper-gold ore from Ravensthorpe. The ore contained a large percentage of pyrrhotite, with which chalcopyrite was very intimately associated. It was necessary to grind the ore very fine before selective flotation of the chalcopyrite was possible.

Report No. 720.

Examination of plant residues from the Sons of Gwalia Gold Mine were carried out to determine the relationship between the high gold values and the sulphide minerals.

The presence of auriferous arsenopyrite appeared to be the cause of the high residue values.

Report No. 722.

Treatment tests were carried out on a high-grade gold ore from "The Trump" Gold Mine, Wymans' Well. The ore was extremely refractory and roasting followed by agitation cyanidation appeared to be the most satisfactory method of treatment.

INCOMPLETE INVESTIGATIONS.

Report No. 716.

Further test-work was in progress on a sulphide gold ore from Fimiston, W.A.

Report No. 721.

Beneficiation tests were being carried out on an iron ore from the Tallering deposit, W.A.

Report No. 723.

Treatment tests were carried out on a cupiferous gold tailing from Gabanintha, W.A.

Report No. 724.

Beneficiation tests were in progress on a Manganese ore from Woodie Woodie, W.A.

Report No. 725.

Test-work had commenced on beneficiation of low-grade cement limerock from Fremantle, W.A.

Kalgoorlie Metallurgical Laboratory.

Summary of Year's Work, 1962.

Report No.	Owner	State	Locality	Ore Type	Type of Investigation	Confidential Until	Number of Metallurgical Tests	Number of Assays	
								Gold	Other
712	Warman Equipment Company, Perth	W.A.	Capel	Zircon	Concentration	CANCELLED		....	....
717	Western Mining Corporation, Kalgoorlie	W.A.	Mt. Marion	Spodumene	Beneficiation Tests Pilot scale production	6/12/62	15	....	60
718	Government Geologist, Perth	W.A.	Cue	Gold	Treatment Tests	21/8/62	2	10	2
719	Ravensthorpe Copper Mines, N. L., Ravensthorpe	W.A.	Ravensthorpe	Copper-Gold	Treatment Tests	10/10/62	20	35	133
720	Sons of Gwalia G. M., Gwalia	W.A.	Gwalia....	Gold	Examination of Treatment plant residue	2/9/62	4	24	8
722	L. Miller, Trump Gold Mine, Marble Bar	W.A.	Wyman's Well via Marble Bar	Gold	Treatment Tests	7/5/63	11	21	30
....	Certificates Nos. 1705–1726, 1728–2096	....	....	....	....	....	....	1,171	751
....	Free Assays	....	....	....	....	....	....	357	72
....	School of Mines	....	....	....	....	....	....	....	32
						Totals	52	1,618	1,088
THE FOLLOWING INVESTIGATIONS WERE INCOMPLETE OR PENDING AT DECEMBER 31, 1962									
716	Gold Mines of Kalgoorlie, Fimiston	W.A.	Fimiston	Gold	Treatment Tests	....	38	212	173
721	Western Mining Corporation, Kalgoorlie	W.A.	Tallering	Iron-ore	Beneficiation Tests	....	20	....	175
723	Gaban Syndicate, Perth	W.A.	Gabanintha	Gold-Copper Tailings	Treatment Tests	....	20	65	100
724	Northern Minerals Syndicate, Perth	W.A.	Woodie Woodie	Manganese	Beneficiation	....	5	....	22
725	Cockburn Cement Pty. Ltd., Perth	W.A.	Fremantle	Cement Limerock	Beneficiation	....	6	....	38
						Totals	141	1,895	1,596

DIVISION VI

Annual Report of the Inspection of Machinery Branch of the Mines Department for the Year 1962

The Under Secretary for Mines:

For the information of the Hon. Minister for Mines I submit the report of the Deputy Chief Inspector of Machinery in the administration of the Inspection of Machinery Act, 1921-1958, for the year ending 1962.

E. E. BRISBANE,
Chief Inspector of Machinery.

Section 1.

INSPECTION OF BOILERS, MAINTENANCE, ETC.

(See Returns Nos. 1, 2 and 3.)

Under the Act "Boilers" means and includes—

(a) any boiler or vessel in which steam is generated above atmospheric pressure for working any kind of machinery, or for any manufacturing or other like purpose;

(b) any vessel used as a receiver for compressed air or gas, the pressure of which exceeds 30 lb. to the square inch, and having a capacity exceeding five cubic feet; but does not include containers used for transport;

(c) any vessel used under steam pressure as a digester; and

(d) any steam jacketed vessel used under steam for boiling, heating, or disinfection purposes.

It also includes the setting, smoke stack, and all fittings and mountings, steam or or other pipes; feed pumps and injectors and other equipment necessary to maintain the safety of the boiler.

Return No. 1.

In this return is recorded the number of boilers of the various types added to our registrations during the year: those of Western Australian origin exceed by 242 the number of pressure vessels imported.

Return No. 2.

This return shows the number of each type, and overall total, in the register of useful boilers. Of the total, 1926 were not in service.

Return No. 3.

This contains a summary of operations for the year. Once again the manufacture of boilers in this state for export continued and numbers increased approximately 20 per cent. on 1961. For other Australian states 107 boilers were constructed and six were sent to countries outside Australia. There has also been an increase in the number of boilers imported from other Australian States, due in some part to firms with Eastern States headquarters opening branches in this State, and also a number of Eastern States construction firms obtaining contracts in Western Australia.

Return No. 1.

Showing the Number of Boilers of Each Type, and Country of Origin of New Registrations for the Year ended 31/12/62.

	U.S.A.	Japan	United Kingdom	Belgium	Eastern States	Western Australia	Unknown Sources	Total
Ret. Multi Stat. Int. Fired	....	....	....	....	....	112	....	112
Digester	....	....	....	....	2	9	....	11
Vulcanizer	....	....	....	....	4	8	....	12
Steam Jacket Vessels	....	....	....	....	4	24	....	28
Sterilizer	....	....	....	....	30	36	....	66
Air Receiver	1	....	17	2	28	91	12	151
Gas Receiver	....	....	2	....	14	74	....	90
Autoclave	....	1	1	....	19	3	....	24
Vert. Stat.	....	....	....	....	2	....	....	2
Ret. Multi. Stat. U/fired	....	....	....	....	....	2	....	2
Cornish	....	....	....	....	....	6	....	6
Water Tube	....	....	1	....	....	3	....	4
Waste Heat	....	....	....	....	....	1	....	1
Cylindrical Ext. Fired	....	....	....	....	....	1	....	1
Total	1	1	21	2	103	370	12	510

Return No. 2.

Showing Classification of Various Types of Useful Boilers in Proclaimed Districts on 31/12/62.

Types of Boilers	Districts Worked from Perth	Districts Worked from Kalgoorlie	Total
Lancashire	44	23	67
Cornish	228	60	288
Semi Cornish	14	1	15
Vert. Stationary	406	41	447
Vert. Port	34	10	44
Vert. Multi. Stat.	46	4	50
Vert. Multi. Port.	8	1	9
Vert. Pat. Tubular	49	....	49
Loco. Rect. F/Box Stat.	74	17	91
Loco. Rect. F/Box Port.	155	20	175
Loco. Circ. F/Box. Port.	91	2	93
Locomotive	83	11	94
Water Tube	556	61	617
Ret. Multi. U/fired Stat.	260	7	267
Ret. Multi. U/fired Port.	....	5	5
Ret. Multi. Int. Fired Stat.	171	6	177
Sterilizers	562	38	600
Autoclaves	90	2	92
Digesters	303	7	310
Gas Receivers	459	....	459
Air Receivers	2,059	601	2,660
Vulcanizers	451	9	460
Steam Jacketed Vessels	669	15	684
Not Elsewhere Specified	199	5	204
Total Registration Useful Boilers	7,011	946	7,957
Total Boilers out of use, 31/12/62	1,418	558	1,926

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Return No. 3.

Showing Operations in Proclaimed Districts During Year Ended 31/12/62.

Boilers	Districts Worked from Perth	Districts Worked from Kalgoorlie	Total 1962	Total 1961
Total number of useful boilers registered	7,011	946	7,957	7,634
New boilers registered during year	501	9	510	434
Boilers inspected thorough	4,540	360	4,900	4,465
Vessels exempt under Act constructed for export, thorough	....	....	....	2
Boilers inspected working	1,053	22	1,075	919
Boilers condemned during year temporarily	1	....	1	10
Boilers condemned during year permanently	75	3	78	58
Boilers sent to other States during year	107	....	107	90
Boilers sent from other States during year	103	....	103	96
Boilers sent from other countries during year	20	5	25	38
Boilers sent to other countries during year	6	....	6	3
Transferred to other Departments	....	....	....	....
Transferred from other Departments	3	....	3	10
Re-instated	2	2	4	....
Converted	2	....	2	....
Number of notices of repairs issued during year	497	31	528	580
Number of certificates issued, including those issued under Section 30 during year	4,515	360	4,875	4,460

MAINTENANCE AND MISCELLANEOUS.

Boiler maintenance has in the main continued to be of high standard, particularly in larger installations and where they are in the charge of staff with an appreciation of the care required and the knowledge necessary to keep the boilers in good condition. Unfortunately this is not the case with numbers of small boilers which get scant attention except for supplying water and fuel to the boiler, as long as the required amount of steam for the process continues to be generated. In these cases particularly the advantages of snap working inspections cannot be overstressed but it is regretted that staff numbers have not permitted more to be made during the year. It is hoped to educate these latter boiler owners in time but it is a difficult assignment.

There has been some decline in the number of boilers in use both in the timber mills and on the goldfields. The former due to availability of State Electricity Commission power encouraging change to electric motor drive. The latter due to conversion of mine haulage to electric power instead of steam for reasons of economy. However, any drop in boiler numbers in these spheres has been more than balanced by new installations in the metropolitan and near country areas.

The establishment of a carbon dioxide plant in Western Australia and a large increase in the use of refrigeration has increased the numbers of low temperature vessels both manufactured in this State and imported, necessitating the application of additional testing during manufacture.

Section 2.

EXPLOSIONS AND INTERESTING DEFECTS.

I am pleased to report that there was no explosion of any pressure vessel during 1962 but several occurrences during the year are considered worthy of note, one unfortunately resulting in a fatality.

A.

This mishap occurred on an oxygen warm evaporation unit installed at the premises of a large engineering firm. The unit consists of a warm evaporator and nine gas storage bottles. Six of these bottles are in one bank and are the main supply, three are reserve supply. The whole unit is housed in a shed located some distance from the main workshop and isolated from any other buildings.

There were no witnesses to the accident and the injured man was unable to give a statement before he died. From investigation after the accident the following points have been discovered.

The liquid evaporator had been refilled during the morning prior to the mishap and it is thought that the victim who had operated the plant for the previous nine months, was changing over the valves to equalise the pressure in the main, and reserve bottles, and the evaporator. Procedure then was to shut off the draw from the bottles and use any gas left in the warm evaporator first before changing over again to the main supply bottles.

There was an explosion in the evaporator shed heard by a number of the workmen and the victim was seen coming from the shed with his clothes in flames. Unfortunately he died a week later.

Inspection showed that the fire had occurred in and around the bank of control valves. One valve had melted out and there were holes burnt through the junction and the back had been almost melted away. A second valve was loose and broke away when attempts were made to move it. The third valve of the set up was intact.

No apparent cause of the fire could be found and although the whole valve assembly was sent to the oxygen supplier's laboratory for tests and checking we have been unable to pin-point the cause of the fire.

B.

During 1960 three similar return multi tubular internally fired boilers were installed at a brewery in this state. After approximately six months work and within a few weeks of each other it was discovered that a number of plain fire tubes in the second pass back end were leaking in all three boilers. No evidence of water shortage could be found and the tubes were re-expanded. The same fault occurred in all boilers at intervals of approximately two months, which led to the replacement of a number of second pass plain tubes in two boilers and re-expansion of the others. Again leakage occurred in a matter of weeks and after further re-expansions when the trouble occurred again all plain tubes in the second pass were renewed.

For approximately three months all was well then the leakage began again. Re-expansion was again tried on several occasions without success. Eventually all second pass tubes were welded to the tube plate at the back end. It is now twelve months since this was done and no further trouble has been experienced in more than twelve months of operation since.

The duty of boilers in a Brewery is rather unusual being subject to high peak load conditions at very short notice. While the preceding tube leakages were occurring and recurring the cause of same was the subject of much thought and investigation both by this Department, the owners and the boiler manufacturers.

The following possible causes were considered:—

(1) Low water condition. Not present as in addition to automatic control were supervised by reliable certificated boiler attendants.

(2) Heavy deposits of scale on heating surfaces causing overheating. Proved wrong by visual inspection.

(3) Automatic Control too severe in bringing boilers onto high fire in answer to sudden steam demand. Exhaustive tests and cutting out of auto firing and trying on hand control were tried. Fault still occurred.

In addition water treatment was changed in case this was in some way responsible. Temperatures in the back end were checked with thermo couples and proved to be within reasonable limits. Conditions of firing and purging were exhaustively examined and experimented with to no avail.

I feel that the initial trouble is the high steaming rate of this type of boiler and the comparatively small amount of water and steam space which does not have the reserve steam for the sudden high peak demands made on them. This leads to heavy firing in the initial stage of the sudden demand until the boilers settle down to carry the load. In this period the second pass tubes at the back end, the hottest part of the boiler could very likely be subject to insulation by steam bubbles being generated, and therefore some overheating occurring each time maximum demand was made, eventually causing leakage.

C.

During the year a small electrically heated boiler attached to a sterilizer was found to be leaking slightly. When stripped of sheathing and lagging, cracks were apparent near the longitudinal seam extending in a circumferential direction and also adjacent to baffles which had been welded to the shell. The cracking was in the parent plate in the heat affected zone which again emphasises the necessity for stress relieving any vessel of cusilman bronze fabricated by welding.

D.

Once again that villain and bane of boiler owners, inspectors and manufacturers, the automatically controlled boiler which is not correctly treated has featured in a mishap.

This boiler, a small water tube type, was fitted with a float control operating the feed pump and burner, also had a timing device which started the boiler at 4.30 a.m. to heat water ready for bottle washing at 7.30 a.m. When workmen arrived at 7.30 a.m. on the day in question no steam was showing in the boiler gauge. The float control reset was pushed and the feed pump started. When water showed in the gauge glass the burner came into action but operated intermittently and water was seen to be issuing from the bottom of the furnace.

Investigation showed leakage from all tubes which had been overheated, distorted and holed through. When the float control was opened up a considerable amount of mud was present in the float chamber and additionally the float control bellows was found to be holed through. Either or both of these caused the failure of the control to operate satisfactorily and again point out the necessity of frequent regular blow down of float control chambers and regular checks and maintenance of all components.

Section 3.

INSPECTION OF MACHINERY.

(See returns Nos. 4, 5 and 6.)

At the expiration of the year 45,582 groups of machinery were in the register. This indicates an increase of 342 groups in comparison with the figure for the previous year. Lift figures reveal an increase of 36 installations.

Return No. 4.

Showing Classification according to Motive Power of Groups of Machinery in use or likely to be used by Proclaimed Districts and which were on the Register during the Year ended 31st December, 1962.

Classification	Districts Worked from Perth	Districts Worked from Kalgoorlie	Totals 1962	Totals 1961
Number of groups driven by Steam Engines	122	373	495	500
Number of Groups driven by Oil Engines	3,291	842	4,133	4,052
Number of Groups driven by other power	77	63	140	154
Number of Groups driven by Electric Motor	37,689	3,055	40,744	40,464
Total	41,179	4,333	45,512	45,170

Return No. 5.

Showing Operations in Proclaimed Districts during Year ended 31st December, 1962.

(Machinery Only.)

——	Districts Worked from Perth	Districts Worked from Kalgoorlie	Totals 1962	Totals 1961
Total Registrations Useful Machinery	41,179	4,333	45,512	45,170
Total Inspections made	26,346	4,300	30,646	29,363
Certificates (Bearing Fees)	5,665	588	6,253	6,198
Number of Extension Certificates issued under Section 42 of Act	....	....	....	....
Notices issued (Machinery Dangerous)	733	39	772	892

Return No. 6.

Showing Classification of Lifts on 31st December, 1962.

Types	How Driven	Total 1962	Total 1961
Passenger	Electrically driven	291	266
Goods	Electrically driven	124	122
Goods	Hydraulically driven	1	1
Goods	Belt driven	3	3
Service	Electrically driven	106	100
Service	Hydraulically driven	1	1
Escalators	Electrically driven	28	24
		554	518

Accidents to Machinery.

Four accidents in this category are considered worthy of some detailed description but as they all involve persons, reports are contained in references to cases A, B, C, D and E under Accidents to persons, Section 5 hereafter.

Section 4.

PROSECUTIONS FOR BREACHES OF THE ACT.

No prosecutions to report.

Section 5.

ACCIDENTS TO PERSONS.

(See Returns Nos. 7, 7a and 7b.)

Returns 7 and 7a record accidents to persons with which machinery subject to the Act was involved, the former relating to those of a serious nature and the latter to incidents classified as being of minor character.

Return 7b shows accidents caused by machinery not subject to registration by this Department but investigated under provisions of Section 50 of the Act. The overall total of occurrences shown in the three returns numbers 83.

It is regretted that I have to report seven (7) accidents resulted in fatalities. Five (5) in the former category and two (2) in the latter.

Case A.

The machinery involved in this mishap was a conveyor belt system consisting of two 3 ft. wide endless belts which transport ore from various loading points in the main shaft to a tipping point into a bin at the shaft entrance. Each belt is approximately 600 ft. long. The one nearest the shaft entrance is designated No. 1 and the other one No. 2. Number 2 belt was raised at the end to discharge down a chute onto No. 1 belt thus giving continuous flow. The system was also arranged so that No. 2 belt could not be started up unless No. 1 belt was already operating.

On the day of the accident maintenance work was being carried out during afternoon shift on No. 1 belt so that the belt attendants, in which category the deceased was employed, were to put their time in clearing up spillage, etc. Deceased was allotted the section around the transfer point between the two belts and was also instructed to clean off accumulated fibre from the bottom jockey roller. This roller together with a top jockey roller maintains belt tension round the belt drive roller. It was stated that the deceased was instructed not to attempt to clean the roller while the belt was in motion.

From statements of other men engaged in cleaning up the spillage at various points along the No. 2 belt and a pipe fitter, who was walking past the position when the mishap occurred, No. 2 belt had been running for approximately two to three minutes intermittently prior to the accident.

As the pipe fitter approached the point where deceased was working he could see his miner's cap lamp moving about under the belt near the drive and jockey rollers, and as he came close saw that he was in a stooped position and appeared to be poking and scraping something with a scraper held in both hands. As the pipe fitter was about to speak the victim seemed to turn slightly towards the fitter as if to speak also. At this moment the deceased's right arm was jerked upward into the lower side of the return belt and he was pulled in between the upper jockey roller and the belt, fatal crushing resulting.

Inquiries did not reveal positively who had started the belt but it appears likely that deceased did so himself. While work was in progress on No. 1 belt the main power supply to the belt motors was switched off. However work on No. 1 belt had been completed prior to the accident and although power was switched on again the fitters stated that they did not run No. 1 belt.

From the above, two points are apparent which could have prevented the mishap:—

(1) A thorough check down the length of both belts to see that all men were clear and warning that power was to be switched on again.

(2) The dangers involved in attempting to clean off or otherwise work on moving conveyor belts and pulleys and the folly of ignoring instructions.

Case B.

The machinery concerned in this accident was a diesel engine driving a stamp battery from a pulley on the main shaft and from two other pulleys a line shaft and a circulating pump. All were flat belt drives.

The particular drive on which the accident occurred was the latter where the 3 in. flat belt drove from a $14\frac{1}{2}$ in. diameter pulley on the drive shaft to the $4\frac{1}{2}$ in. pulley on a 1 in. ajax centrifugal pump.

Inquiries revealed that prior to the accident it had been noticed that the belt in question, which was twisted to give correct direction of rotation to the pump, had been put on the wrong way. Not directionally wrong but so that the belt tended to run over against a grease nipple on the pump. Normally it was twisted so that it ran towards the outside edge of the pulley and was clear of the grease nipple. It did not prevent the pump operating satisfactorily.

An instruction was given by the foreman to the engine driver coming on shift that next time the engine was stopped the twist in the belt was to be corrected. Whether the instruction was misunderstood due to the noise of the engine and the battery stamps or whether the driver had changed belts before with the machinery in motion and intended to do it again is not known. However, in front of the foreman the driver picked up a hammer handle, ran the belt off the pulleys and then attempted to replace the belt correctly without stopping the engine. Owing to shock and the speed with which the accident happened the foreman's account is not very definite. Suffice to say that the engine driver's hand was caught by the belt as he attempted to feed it onto the larger pulley. He was pulled against the concrete pedestal bearing block, his arm was torn off and his body thrown back towards the pump. As a result of his injuries he died before he could be transported to medical attention.

This unfortunate fatality emphasises the dangers, mentioned in item (2) of accident "A" foregoing, of attempting to work on, change or shift drive belts without stopping the machinery.

Case C.

This accident, regretably also fatal, occurred when the victim, a turner was filing the square thread on a steel spindle which was held in the lathe chuck at one end and centred at the other.

No one actually witnessed the accident and the first evidence was when the victim fell to the ground bleeding profusely from head injuries. Investigations showed that the spindle being filed had broken. One piece was still held in the chuck but at an angle and the other portion was found on the floor near the operator. The file he had been using was broken in half. The handle and one-half were still in the victim's hand, the other section was found approximately 30 ft. away.

The report of the Inspector who investigated this accident was as follows:—

> **The foreman informed me to the best of his knowledge the machine was as it was when the accident occurred. I found that it was set for maximum spindle speed of 800 r.m.p. Tailstock nuts only finger tight and the saddle back against the Tailstock. The nut being fitted was on spindle for approximately a third length of the spindle thread, and the spindle centre hole showed signs of having been used.**
>
> **From the appearance of the spindle at the break it had been cracked for some time and was "crystallized," also the next two pitches from the break showed cracks at the base of the thread.**
>
> **As the nut was on the spindle and the tailstock locking nuts only finger tight after the accident it is my opinion that the live centre was not in the spindle centre hole. After starting the machine, the spindle "whipped," struck the lathe saddle, broke off and hit the deceased.**

The operation of a lathe is generally considered as a safe job and certainly not one where a fatality is likely to occur. However, this mishap should dispel the false sense of security into which we can be lulled and shows that care must be exercised at all times in every vocation in which machinery is used.

Case D.

This accident, again resulting in a fatality, occurred on board a ship discharging phosphate from the ship's hold by means of a wharf luffing crane fitted with a grab. The report of the Inspector who investigated the mishap reads as follows:—

> **It was the duty of the hatchman to signal the movements required of the grab to the crane driver and in order to be seen by the crane driver he was on the deck at the starboard after corner of the hatch. He signalled the crane driver to commence discharging. Once this signal is given the driver begins a cycle of operations, luffs out and lowers the grab to the phosphate, lifts the grab and once clear of the hold luffs in to bring the grab over the discharging bin, opens the grab allowing the phosphate to fall into the bin then begins the cycle over again does not stop until signalled to do so by the hatchman.**
>
> **The grab had made two trips into and out of the hold and the accident occurred on the third trip down. It appears that deceased, who was employed as foreman stevedore had come along unnoticed by the hatchman and was standing on the deck at approximately the midlength of the hatch on the starboard side bending over the coaming calling out to the men below.**
>
> **The hatchman was watching the grab being luffed out and lowered, as he watched it lowering he noticed that it had drifted over the outer edge of the starboard coaming and at the same instant saw the foreman. He cried out to him but he did not appear to hear and the grab being lowered and swinging back into the centre of the hatch struck the deceased on the back of the head.**
>
> **The weight of the grab is 3 tons 12 cwt. and when opened, the width across the grab is 18 ft. and when closed 7 ft. 6 in., the width of the hatch was 31 ft. It is normal practice in all**

ports when working this type of cargo and where the hatch opening will permit to keep the grab open from the time it leaves the bin until it is closed on the cargo.

It would be impossible for the crane driver to have seen the foreman as that portion of the hatch would be blotted out by the open grab.

During investigations of this accident the supervising stevedore for the company employing the victim stated that instructions were given to all their men to work cargo from the corners of the hatches. It is most unfortunate that deceased was standing mid length of the hatch instead of at either end and emphasises the need for constant vigilance by driver, hatchman or dogman, and anyone having occasion to come within the working range of cranes.

Case E.

This accident occurred on a large single roller steam ironing machine which was in use in a hospital laundry. The machine was being operated by two female personnel who were putting through theatre gowns. These gowns are laid on the tapes feeding into the rolls with the bottom hem of the gown leading. The injured person noticed a crease in one of the sleeves of the gown and put her hand into the sleeve to straighten it out before it entered the roll. Unfortunately she appears to have misjudged the speed and did not withdraw her hand before it hit the safety fence and entered the nip between the roller and the steam heated bed. The safety fence tripped the power to the motor but the run on of the rolls pulled the girl's hand into the nip and jammed it between the safety fence, the roller and the bed. The machine could not be reversed and it took three to four minutes to remove the safety fence, during which time the victim's hand as well as being crushed was also suffering burns.

This accident revealed the shortcomings of the safety devices provided which operated satisfactorily within their limitations. The points noted were:—

(1) Failure of the machine to stop instantly before contact was made with rolls.

(2) Inability to reverse the machine and free the injured person quickly.

(3) Time lapse in lifting safety fence which acted as a hindrance after accomplishing its initial duty of cutting power off the machine.

Following the accident, investigations were made by this department and the engineering staff attached to the hospital. During tests it was found that the roller ran an approximate three feet after the power was cut off. After consideration and experimentation the following modifications were made which seem to be satisfactory.

The safety fence was moved approximately 12 in. further back from the nip point and fitted with two switches operated by movement of the fence. The first movement of the fence cut the power off the machine. Further pressure on the fence operated a reverse current switch which reversed the direction of rotation of the motor and thus the roller. A mesh cover was placed over the top of the extra space between the safety fence and the roller so that hands could not be inserted behind the safety fence. The safety fence was modified so that it could be quickly removed from its working position if necessary.

This accident underlies the difficulties in guarding machinery in trying to foresee all the possibilities and hazards which may arise. It is unfortunate that, in many instances, somebody has to suffer injuries before many of them become apparent.

Case F.

This accident occurred with a front end loader hydraulically operated, which unless used as a crane is not subject to the jurisdiction of this department. In this instance it was being used to transport a 6 ft. length of 6 in. diameter cast iron concrete lined pipe from where it had been delivered to the required site for installation. To do this the pipe had to be laid across arms supporting the bucket and during most of the trip the arms were below horizontal so that the pipe was cradled between the arms and the bucket. However, the installation site was in a private front yard and the front fence, approximately 2 ft. 6 in. high, had to be negotiated. To do this the driver raised the bucket and in so doing the arms were moved above the horizontal causing the pipe to roll back where the operator's head was sandwiched between it and the concrete ballast block on the back of the machine.

The possibility of the hydraulic system malfunctioning and causing the arms to rise independently of control was investigated but could not be supported. It therefore seems that the driver forgot that the pipe was not secured and operated the arms himself. The injuries suffered by the operator were such that he could not be interviewed and eventually proved fatal.

This mishap illustrates the hazard of using a machine for a purpose for which it is not designed and additionally the risk of not securing a load during transport.

Case G.

A saw gulleting emery wheel was the machine involved in this further fatality and as it was erected on a farming property operated only by the owner, is not subject to the Inspection of Machinery Act.

The accident was investigated by this Department under section 50 of the Act and the results are as follows—

The gulleting head was manufactured but had apparently been installed by the victim. A number of unsatisfactory and contributory factors to the accident were found.

At the time of the accident the deceased was gulleting a 30 in. diameter circular saw when the wheel burst and a piece of it approximately ½ in. x ¾ in. x 2¼ in. long struck him on the forehead causing severe injuries from which he died approximately a fortnight later.

Contributing factors were:—

(1) The gulleting head was mounted on an old dry mallee stump approximately 7 in. to 7½ in. in diameter as was the frame for holding the saw although the stump did not appear to be loose in the ground the whole head could be easily shaken by hand. It is safe to say there would have been excessive vibration when the machine was working.

(2) Although the gulleting head was a manufactured article and the washers supplied with the spindle properly designed as far as being recessed on the face they were too small in diameter for the size wheel being used. The washers supplied were 1¾ in. diameter the wheel being 10 in. x ½ in. t. Apparently the owner realised this and to increase the support of the wheel had two extra washers 4 in. diameter made. However they were only made of ⅛ in. t. plate with a recess 1-9/32nd in. diameter 1/32nd in. bare in depth. These were worse than useless as they were probably directly responsible for the failure of the wheel. The outside diameter of the lead centre of the stone was 1-5/16th in. and the washers were not dead flat and being so light easily distorted. It therefore follows that when these washers were tightened onto the stone undue pressure was most likely applied to the centre of the stone tending to burst it.

(3) The gulleting wheel was supplied with square face and had been used without rounding it off. It is felt that used in this manner cutting square gullets in the saw that extra stress and vibration would be applied to the stone.

(4) A further factor which could be contributory to the failure may have been the speed of the stone. It was tractor driven by the power take-off but the tractor had been shifted prior to our investigation so that the speed could not be checked.

(5) The guard supplied with the machine was of the usual type being semi-circular in shape, made from steel flat 2 in. wide x 3/32 in. thick and attached to the machine by two short lengths of $\frac{3}{8}$ in. round one at each end of the guard and tack welded onto the bar frame of the machine. The guard had broken away at the attachment of the flat to the $\frac{3}{8}$ in. bars. The father of the deceased revealed that approximately two months previously another wheel had been fitted which burst when being adjusted for speed, and had knocked the guard off without injury to anyone. The guard had not been replaced prior to this accident.

The conclusions reached by the Inspector are as follows:—

> From the evidence available I am of the opinion that the stone which caused the accident, burst from a combination of conditions, namely badly designed washers, excessive vibration and stress and possibly overspeeding, but I consider the faulty washers could have been the main factor. Had the guard been replaced before the second stone burst it could have been the means of saving the life of the deceased.

I agree with these findings and also consider that the risks taken in ignorance with this type of installation cannot be too greatly emphasised.

Return No. 7

Showing Number of Serious Accidents, both Fatal and Non-fatal, which Occurred in Proclaimed District during the Year ended 31st December, 1962

" F " denotes Fatal

Industry	Circular Saw	Buzzer (Planer)	Thicknesser	Spindle Moulder (Shaper)	Belts and Shafting	Gearing	Hoist (Coal)	Conveyor	Elevator (Bucket)	Wiredrawing	Abrasive Wheels	Buffing Spindle	Guillotine	Lathe	Rolls	Press (Metal)	Press (Other)	Gib Cutter	Printing Machine	Winding Engine	Gas Engine	Crane	Vacuum Pump	Lift	Mincer	Boiler Fuel (Gas) Explosion	Oxygen Storage Plant Explosion	Ironing Machine (Laundry)	Totals per Industry
Woodworking and Furniture	1	8	1	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	11
Metalwork and Engineering	....	....	....	....	....	....	....	....	1	1	1	1	1	1 (F)	2	5	....	1	....	....	....	1	....	....	....	1	1 (F)	....	17 (2F)
Printing and Allied Industries	2	....	....	....	....	....	....	....	....	....	....	....	2	....	1	....	....	....	2	....	....	....	....	....	....	....	....	....	7
Food and Drink Processing	1	....	....	....	....	1	....	1	....	....	....	....	1	....	1	....	....	....	....	....	....	....	....	....	1	....	....	....	6
Building Materials and Building	....	....	....	....	2	....	....	1	....	....	....	....	....	....	....	....	1	....	....	....	....	1	....	....	....	....	....	....	5
Mining	....	....	....	....	1 (F)	....	....	1 (F)	....	....	....	....	....	....	....	....	....	....	....	1	1	....	1	....	....	....	....	....	5 (2F)
Glassmaking	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	....	1
Other	....	....	....	....	1	....	1	....	....	....	....	....	....	....	2	....	1	....	....	....	....	1 (F)	....	2	....	....	....	1	9 (1F)
Totals per Type of Machine	4	8	1	1	4 (1F)	1	1	3 (1F)	1	1	1	1	4	1 (F)	7	5	2	1	2	1	1	3 (1F)	1	2	1	1	1 (F)	1	61 (5F)

Return No. 7a

MINOR ACCIDENTS

Showing No. of Accidents not classed as serious under the Act and not included in Return No. 7 but were reported and investigated during the year ended 31st December, 1962

Industry	Circular Saw	Buzzer	Spindle Moulder (Shaper)	Belts and Shafting	Conveyer	Elevator (Tray)	Abrasive Wheels	Slotting Machine	Rolls	Press (Other)	Creasing Machine	Crane	Lift	Beaters	Pneumatic Ram	Totals per Industry
Woodworking and Furniture	....	2	2	....	....	....	....	....	....	....	....	....	....	....	....	4
Metalworking and Engineering	....	....	....	....	....	....	1	1	....	....	....	1	....	....	1	4
Printing and Allied Industries....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	....	1
Food and Drink Processing	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	1
Building Materials and Building	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	1
Mining	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	1
Glassmaking	1	....	....	....	....	....	....	....	1	....	....	....	....	....	....	2
Other	....	....	....	1	....	....	....	....	....	1	....	....	1	....	....	3
Totals per type of Machine....	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	17

Return No. 7b

Accidents involving Machinery not subject to the provision of the Inspection of Machinery Act, reported to and investigated by the Department in compliance with Section 50 of the Act during the Year ended 31st December, 1962

Industry	Abrasive Wheels	Drilling Machine	Press	Front End Loader	Total per Industry
Metalworking and Engineering	1	1	....	....	2
Leather Working	....	....	1	....	1
Agriculture	1 (F)	....	....	....	1 (F)
Other	....	....	....	1 (F)	1 (F)
Totals per type of machine	2 (1 F)	1	1	1 (F)	5 (2 F)

Section 6.

EXAMINATION OF ENGINE DRIVERS, CRANE DRIVERS AND BOILER ATTENDANTS.

The Board of Examiners granted 87 engine drivers, 228 crane drivers, and 79 boiler attendants' certificates during the year.

Compared with the previous year these figures constitute a decrease of 22, increase of 29 and increase of five respectively in the number of certificates granted.

Section 7.

AMENDMENTS TO ACT.

No amendments to be reported.

Section 8.

STAFF.

Again this year the inspectorial staff has been under allowable strength for a large portion of the time. The extra position created at the end of last year was filled in February as was the vacancy caused by the resignation of Mr. Remkes. The filling of the Senior Inspector's position was delayed by an appeal which was dismissed in March. This allowed the advertising of the vacancy Inspector-in-Charge, Kalgoorlie, created by Mr. Harris' promotion to Senior Inspector.

The Kalgoorlie vacancy was filled in June the position being taken up by Mr. Shaw that month and Mr. Harris came to Perth to assume duty as Senior Inspector of Machinery. The further vacancy caused by Inspector Shaw's promotion was filled in September by the appointment of Mr. Jagger to the item.

The delay in the Senior Inspector's position being filled threw considerably more work on himself and Inspector Kennedy who acted in the position. The effect of the additional item created has actually been lost in the almost continuous shortage of one Inspector during the year due to the circumstances set out above.

Towards the end of the year a further new item, Inspector of Machinery was created which will be filled early in 1963. Additionally Mr. McAllister applied for and was successful in getting a transfer to Harbour and Lights Branch, where he will take up duty early in January. This of course creates another vacancy which it is hoped to fill at the same time as the new item.

Despite the fact that two new items have been created I do not think this will cope with the amount of work to be done at present nor foreseeable. The expansion of industry, erection of new factories and buildings both in the city, suburban and country districts continues to increase. The manufacture and erection of cranes, which require a great deal of time continues unabated. This staff position is being watched and could be the subject of further submissions next year.

The clerical staff numbers have remained unchanged although there were three changes in the actual personnel due to one resignation and two transfers.

In both sections there has been wholehearted co-operation and response by all officers to the demands made upon them. I wish to thank all staff members for their loyalty and willingness which has been unstinting during the year.

To the Police Department our appreciation for continued co-operation by its officers in reporting of accidents to persons involving machinery, their assistance during investigations and in several instances the supply of photographs of scenes of and machinery involved in such mishaps.

In conclusion and on behalf of the members of my staff and myself I wish to express appreciation of the assistance readily forthcoming from yourself and other officers and branches of the Mines Department when requested.

E. J. McMANIS,
Deputy Chief Inspector of Machinery.

RETURN No. 9.

Revenue and Expenditure for year ended 31st December, 1962, and Comparison with Preceding Year.

——	Revenue 1962	Revenue 1961
	£ s. d.	£ s. d.
Fees from Boiler Inspections	5,886 1 3	5,570 0 5
Fees from Machinery Inspections	9,229 2 4	9,468 0 0
Fees from Engine Drivers	788 4 3	753 6 0
Incidentals	223 11 1	109 18 7
Total	£16,126 18 11	£15,901 5 0

Increase in Revenue compared with 1961—£225 13s. 11d.

——	Expenditure 1962	Expenditure 1961
	£ s. d.	£ s. d.
Salaries	31,761 14 1	33,787 15 10
Incidentals	6,433 8 6	5,041 16 5
Engine Drivers' Examinations	402 19 7	140 19 7
Total	£38,598 2 4	£38,970 11 10

Decrease in Expenditure compared with 1961—£372 9s. 6d.

RETURN No. 10

Showing Distances Travelled, Number Inspections made and average Miles Travelled for Inspections for the year ended 31st December, 1962

——	Road Miles	Air Miles	Rail Miles	Water Miles	Collective Mileage all Transport Services	Number of Inspections	Average Miles per Inspection
Districts operated from Perth	98,114	200	*Nil*	*Nil*	98,314	31,939	3·75
Comparison with 1961	Inc. 7,089	Dec. 5,850	*Nil*	*Nil*	Inc. 1,239	Inc. 1,688	Inc. 0·54
Districts operated from Boulder	12,189	....	....	....	12,189	4,682	2·60
Comparison with 1961	Dec. 3,737	....	....	....	Dec. 3,737	Inc. 186	Dec. 0·76
Totals	110,303	200	*Nil*	*Nil*	110,503	36,621	....
Comparison with 1961	Inc. 3,352	Dec. 5,850	*Nil*	*Nil*	Dec. 2,498	Inc. 1,874	3·01

Average Miles per inspection all districts, 1962 .... 3·01
Average Miles per inspection all districts, 1961 .... 3·25
Increase per inspection compared with 1961 .... Dec. 0·24
Note Abbreviations :—Inc. = Increase ; Dec. = Decrease.

DIVISION VII

Government Chemical Laboratories Annual Report—1962

The Under Secretary for Mines:

I have the honour to present to the Hon. Minister for Mines a summarised Annual Report on the operations of the Government Chemical Laboratories for the year ended 31st December, 1962.

Administration.

The Laboratories consist of six Divisions, a Physics and Pyrometry Section, a central office and a library all under the control of the Director (Government Mineralogist, Analyst and Chemist) as follows:—

Director—L. W. Samuel, B.Sc., Ph.D., M.A.I.A.S., F.R.A.C.I., F.R.I.C.

Agriculture, Forestry & Water Supply Division—R. C. Gorman, B.Sc., A.R.A.C.I., M.A.I.A.S., Deputy Government Agricultural Chemist.

Engineering Chemistry Division—S. Uusna, Dr. Ing., A.M.I.E. (Aust.), M. Inst.F., Chief Chemical Engineer.

Food, Drugs, Toxicology & Industrial Hygiene Division—N. R. Houghton, B.Sc., A.R.A.C.I., Deputy Government Analyst.

Fuel Technology Division—R. P. Donnelly, M.A., B.Sc., M.I. Gas Eng., A.M.I. Chem Eng., M.Inst.F., Fuel Technologist.

Industrial Chemistry Division—A. Reid, M.A., B.Sc., A.R.I.C., Chief Industrial Chemist.

Mineralogy, Mineral Technology & Geochemistry Division—G. H. Payne, M.Sc., A.W.A. S.M., A.R.A.C.I., Deputy Government Mineralogist.

Physics & Pyrometry Section—N. L. Marsh, B.Sc., Physicist and Pyrometry Officer.

Librarian—Miss H. Duffield.

Office—Miss D. E. Henderson, Senior Clerk.

At 31st December 1962 the staff numbered 76, being

Professional	45
General	16
Clerical	9
Wages	6
	76

It is with great regret that I have again to report a very difficult year for staff requirements. We have not been able to maintain a full professional staff and in addition to the 45 listed above we had at the end of the year 7 vacancies spread over 4 of the 6 Divisions. Fortunately we had less difficulties on the clerical side and the office staff remained relatively stable throughout 1962.

The close association of these Laboratories with other Government Departments and with kindred associations was maintained during 1962 and various members of the staff are members of the folowing Committees.

Air Pollution Committee.
Food and Drugs Advisory Committee.
National Association of Testing Authorities, State Committee.
Oils Committee of the Government Tender Board.
Paints Advisory Committee of the Government Tender Board.
Pesticides Registration Committee.
Phytochemical and Toxic Plants Committee.
Rivers and Waters Technical Advisory Committee.
Swan River Conservation Board.
Veterinary Medicines Advisory Committee.
Water Purity Advisory Committee.

In addition the Director was a member of an interdepartmental Committee to advise the Department of Industrial Development on the feasibility and economics of producing salt from sea water by solar evaporation at Shark Bay.

Most of these Committees meet regularly and are very active and occupy considerable time of the officers concerned, not only for the meetings but also for inspections, preparation of material and analysis of samples. This has been particularly so for (1) the Air Pollution Committee for which we have commenced a preliminary survey of "dust" precipitation in the metropolitan area (2) the Swan River Conservation Board which requires considerable time and thought and for which a large number of analyses are made in connection with possible pollution of the Swan River (3) the Phytochemical and Toxic Plants Committee for which a search of our records for the past 40 years was undertaken and abstracts made of all work done on indigenous plants, as a first step in the production of a Phytochemical Register. The Pesticides Registration Committee dealt with 122 applications for registration of new pesticide formulations. The total number of applications received by this Committee to the 31st December, 1962 is 1,366. A matter of great concern to this Committee is the poisonous nature of most of the newer pesticides, particularly as many of them can be absorbed through the skin.

In connection with the Water Purity Committee the Director attended a Melbourne meeting of the chief chemists to the water supply authorities of the capital cities of Australia. At this meeting was finalised a set of chemical and bacteriological standards for water supplies to capital cities.

The Veterinary Medicines Advisory Committee re-registered 732 products, dealt with 165 applications for new registration and 23 applications for alterations to registered products. Of the 165 new applications, 117 were approved, 22 rejected, 16 deferred for further information and 10 did not require registration.

Equipment.

Major items of equipment added to our facilities in 1962 include (1) a Leitz Dialux-Pol microscope with a full set of accessories (2) a Roller particle size analyser (3) pilot-plant scale equipment for the removal of dust and smuts from air streams and (4) an oil fired high temperature furnace (to 1700° C).

Accommodation.

It is a great pleasure to record that the building of extensions to these Laboratories commenced in October, 1962. Three portions of the extensions are now under construction (1) to join the Assay Block to the Fuel Technology building, mainly to house sample storage and preparation for the Agriculture, Forestry and Water Supply Division (2) to join the Assay Block wing to the Agriculture, Forestry, and Water Supply—Food and Drug wing. This will expand slightly the laboratories of these two Divisions, will provide amenities rooms on the West side and four more air-conditioned instrument rooms on the East side (3) extending our office block some 85 feet to the West, which will approximately double the area available to our office staff, records room and general store room. In addition a modern amenities block has been constructed at our Engineering Chemistry Division, Bently, but it is a matter of great regret that our major difference of opinion with the architects is still unresolved. It is to be hoped that it will not be long before the architects accept our wishes for the sites of our new rooms since it is now (31 December, 1962) nearly 4 years since my first formal request for additional accommodation and is some 5 months since discussions at Ministerial level.

The need for these extensions was again emphasised in 1962 when requests for work exceeded those of 1961 by one-eighth.

General.

The total number of registrations during 1962 was 3,793, an increase of 12½ per cent. over the number for 1961 (3,372). The number of samples accepted in 1962 was 10,658, a reduction of 10 per cent. on the number received in 1961 (11,921). This lower acceptance of samples in 1962 enabled us to pick up some of the back-log of samples; the samples in hand (received but not reported) was 880 at the 1st January, 1963 compared with 2,124 at the 1st January, 1962. Thus samples dealt with in 1962 were practically the same as in 1961.

The number of registrations and of samples gives some measure of our activities but does not completely describe our work. A major factor in this is the enormous variation in the amount of work associated with different samples, but also it is not possible to give a statistical account of the time and effort devoted to the various Committees previously mentioned, advice to Government Departments and the public, attendance at Courts, visits to industrial establishments and so on.

In previous Annual Reports I have referred to the large number of Government Departments for which we do work as an indication of the influence exerted by these Laboratories on Government expenditure. In my Annual Report for 1961 I furnished a Table showing the State Government Departments for which our individual Divisions did work; 1962 showed a similar pattern, samples were received from 15 of the 28 Government Departments shown in the Public Service List 1962. In the reports of the Divisions which follow are included Tables 2 and 27 for the Agriculture, Forestry and Water Supply and for the Food and Drug Divisions respectively showing the source and type of samples received. These Tables have been compressed for publication purposes, the original Tables show 107 types of samples from 21 different sources for the Agriculture, Forestry and Water Supply Division, and 97 types of samples from 23 sources for the Food and Drug Division.

The samples accepted were allocated to the various Divisions of these Laboratories according to the specialised work undertaken by each Division. In a number of cases work was done on the same sample(s) by more than one Division and this applies particularly to the Physicist whose X-ray examination of minerals is usually on samples registered to the Mineral Division. Such samples are not usually doubly registered but others are, so the total shown in Table 1 is greater than the total of samples given earlier in this report.

Other examples of the co-ordination between Divisions will be found in (a) dust separation and particle sizing with the Engineering Chemistry Division and the Fuel Technology Division (b) clays, shales and dust identification with Fuel Technology Division and Mineral Division (c) ores and product analyses between Engineering Chemistry Division and Mineral Division.

This co-operation between Divisions helps to foster the policy that we are one Government Chemical Laboratories, not six separate Divisions as separate entities, that problems in one Division may be assisted by specialists from another Division. It is also further support for the value of one centralised chemical laboratory instead of chemical sections in various Government Departments.

Table 1 shows the source of the samples received during 1962 and their allocation to the separate Divisions.

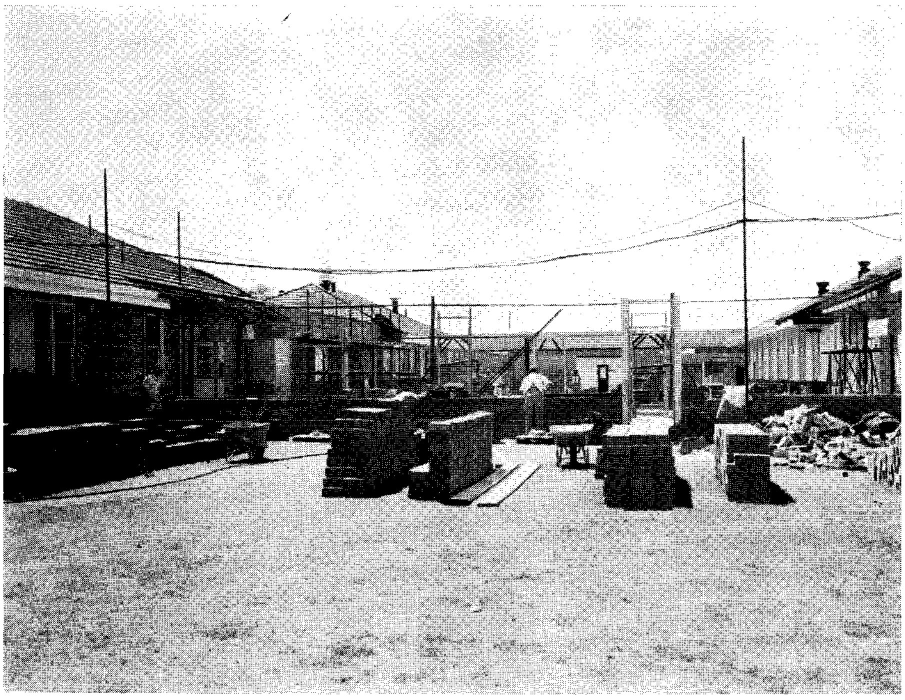
TABLE I.

Source and Allocation of Samples Received During 1962.

Source	Division						Total
	Agriculture	Engineering Chemistry	Food and Drug	Fuel Technology	Industrial Chemistry	Mineralogy	
State—							
Agriculture Department	2,670	....	417	1	1	18	3,107
Departmental	4	2	33	44	9	129	221
Hospitals	2	....	92	....	....	....	94
Main Roads Department	....	....	....	....	11	....	11
Metropolitan Water Supply	303	....	....	....	....	6	309
Milk Board	....	....	574	....	....	....	574
Mines Department	71	3	53	5	....	518	650
Police	....	....	993	....	....	2	995
Public Health Department	22	....	451	3	....	47	523
Public Works Department	474	....	196	....	133	44	847
Swan River Conservation Board	....	....	128	....	....	1	129
Tender Board	....	....	76	....	....	....	76
University	106	....	7	....	....	....	113
War Service Land Settlement	10	....	....	....	....	....	10
Other	14	....	18	1	....	10	43
Commonwealth—							
Department of Air	....	....	39	....	....	....	39
Other	2	....	5	....	....	8	15
Public—							
Free	6	....	6	2	....	1,009	1,023
Pay	1,073	3	89	117	29	724	2,035
	4,757	8	3,177	173	183	2,516	10,814

Fees were charged for work undertaken for some Government Departments, for Commonwealth Government Departments, Hospitals, Milk Board and the general public but the greater part of our work is done free for State Government Departments, together with an appreciable amount of free mineral identification and assay to assist prospectors.

The summarised reports of the individual Divisions which follow show the very wide range of subjects dealt with by these Laboratories. Comparing 1962 with 1961 there were some marked alterations in the numbers of various types of samples received. These were:



Building Extensions, November, 1962.

Marked Increase—

	1961	1962
Animal toxicology	32	87
Fertilisers	54	110
Human toxicology	388	611
Industrial Hygiene	335	446
Iron ore	380	451
Milk—bovine	437	574
Pastures	247	402
Pesticides	160	231
Tantalite-columbite	93	126
Tin	41	131
Water	1318	1786
Wheat	203	388

Marked Decrease—

Cheese	140	71
Clover	595	204
Oats	231	57
Oil seeds	817	466
Soil	366	254
Tobacco	1441	162

L. W. SAMUEL,
Director.

AGRICULTURE, FORESTRY AND WATER SUPPLY DIVISION

The main function of this Division in 1962 has again been the examination of a wide variety of material for the advisory and research sections of the Department of Agriculture, the examination of waters and problems associated with water supply and the recommendation for treatment of water supplies for Government Departments, primary producers, private industry and the general public.

Compared with 1961 there was a decrease of just over 1,300 samples received attributed to an almost corresponding decrease in the number of tobacco samples received. The large decrease in tobacco samples was no doubt due to the suspension of nearly all research on tobacco because of the almost total collapse of the industry in this State.

Because the type of work undertaken by the Division has slowly changed over the years, it has been recommended that from the 1963 reclassification the Division be retitled the Agriculture and Water Supply Division as work on Forestry has been of minor significance over the past several years. Another recent change in the character of the work has been the increase of work performed for sources other than the Department of Agriculture. In 1961 this represented only 28 per cent. of the samples received compared with 43 per cent. in 1962. Within the Department of Agriculture there has also been a shift of emphasis in the samples submitted, from predominantly plant nutrition samples to a balance with animal nutrition samples, which has required a larger number and wider variety of trace element determinations, which are more difficult and more time consuming.

The commencement of building extensions has been a welcome step forward in 1962. It is hoped that soon we will have completed adequate sample receival, preparation and storage space, which will greatly assist our overall efficiency. However not until the proposed laboratory extensions are completed can we hope to give the full service that is asked of us.

During the year the Deputy Government Agricultural Chemist was able to attend the Third Australian Soil Science Conference at Canberra. Amongst the many topics discussed there was considerable debate on the pros and cons of soil testing for advisory service. Additional benefit was gained from the conference in that attending the conference also were the agricultural chemists occupying similar positions with the New South Wales, Queensland, South Australian and Victorian Governments. Several informal extra-conference discussions were held on related work, which was of considerable value to each State representative.

Details of the Divisional work for 1962 are included under the appropriate headings below and the types, sources and number of samples received are listed in Table 2.

TABLE 2.
Agriculture, Forestry and Water Supply Division, 1962.

—	Agriculture	Commonwealth	Government Departments	Hospital	Metropolitan Water Supply	Mines	Public Free	Public Health Department	Public Pay	Public Works Department	University	War Service Land Settlement	Total
Animal—													
Bone	51	....	....	....	....	....	....	....	8	....	....	....	59
Faeces	....	....	....	....	....	....	....	....		....	19	....	19
Hair	17	....	....	....	....	....	....	....	....	....		....	17
Liver	109	....	....	....	....	....	....	....	....	....	....	....	109
Urine	29	....	....	....	....	....	....	....	....	....	9	....	38
Other	18	....	....	....	....	....	....	....	2	....	....	....	20
Cereals—													
Oat plants	45	....	....	....	....	....	....	....	....	....	....	....	45
other	10	....	....	....	....	....	....	....	2	....	....	....	12
Wheat ears	36	....	....	....	....	....	....	....	....	....	....	....	36
plants	236	....	....	....	....	....	....	....	....	....	....	....	236
straw	36	....	....	....	....	....	....	....	....	....	....	....	36
other	....	....	....	....	....	....	....	....	2	....	1	....	3
Various	12	....	....	....	....	....	....	....	....	....	6	....	18
Fertilisers—													
Fertilisers	17	....	....	....	....	....	....	....	7	....	....	....	24
Fertilisers (Act)	15	....	....	....	....	....	....	....	....	....	....	....	15
Lime-sand and stone	6	....	....	....	....	....	....	....	59	....	....	....	65
Trace elements	5	....	....	....	....	....	....	....	1	....	....	....	6
Horticulture—													
Apples fruit	17	....	....	....	....	....	....	....	....	....	....	....	17
leaves	73	....	....	....	....	....	....	....	....	....	....	....	73
Cucumber leaves	10	....	....	....	....	....	....	....	....	....	....	....	10
Potato	52	....	....	....	....	....	....	....	....	....	....	....	52
foliage	14	....	....	....	....	....	....	....	....	....	....	....	14
Tobacco	162	....	....	....	....	....	....	....	....	....	....	....	162
Various	18	....	....	....	....	....	....	....	....	....	....	....	18
Miscellaneous—													
Oil bearing seeds	466	....	....	....	....	....	....	....	....	....	....	....	466
Various	10	....	5	2	5	16	4	....	12	27	9	....	90
Pastures and Fodders—													
Animal feed	....	....	....	....	....	....	....	....	....	....	57	....	57
Bromis gusonii	13	....	....	....	....	....	....	....	....	....	....	....	13
Clover	203	1	....	....	....	....	....	....	....	....	....	....	204
Hay	16	....	....	....	....	....	....	....	....	....	....	....	16
Lucerne	11	....	....	....	....	....	....	....	3	....	....	....	14
Lupins	106	....	....	....	....	....	....	....	....	....	....	....	106
Pastures	401	....	....	....	....	....	....	....	1	....	....	....	402
Silage	106	....	....	....	....	....	....	....	3	....	....	....	109
Stock foods	14	....	....	....	....	....	....	....	7	....	....	....	21
Feeding Stuffs (Act)	56	....	....	....	....	....	....	....	....	....	....	....	56
Various	35	....	....	....	....	....	....	....	....	....	12	....	47
Soil	200	....	....	....	....	....	....	....	47	7	....	....	254
Water	45	1	6	....	298	55	2	22	919	440	....	10	1,798
Total	2,670	2	11	2	303	71	6	22	1,073	474	113	10	4,757

Soils.

1. Aluminium in soils. Suspected aluminium toxicity of clover was investigated on five soils from Denbarker. Aluminium in the leaves and petioles and in the roots of clover was compared with aluminium extracted from the soil on which the clover was grown. The aluminium was extracted with normal ammonium acetate at pH 7.0 (exchangeable aluminium) and at pH 4.8. The results given in Table 3 show no relationship between soil and clover aluminium.

TABLE 3.

Aluminium in Clover and Soil.

Sample	Aluminium, Al			
	Clover, p.p.m.		Soil, m.eq. per 100 g.	
	Leaves and petioles	Roots	pH 4·8	pH 7·0
R. Wass—				
Poor clover	830	1500	5·6	0·04
Good clover	380	830	8·3	0·06
W. G. O'Connor—				
Poor clover	430	1000	5·0	0·03
Good clover	250	1200	6·3	0·03
Good clover	280	2000	5·0	0·06

2. 18 soils typical of soils 50-60 miles east of Esperance in the Condingup-Mt. Howick area and 50-60 miles west of Esperance in the Muglinup-Oldfield River area, were analysed in detail to give fundamental information about the soils being developed in these areas.

3. From an experiment on Esperance Downs Research Station comparing the carrying capacity of lucerne and sub-clover based pastures, 36 soils were analysed for exchangeable cations, carbon and nitrogen.

4. From a long term rotation experiment at Wongan Hills Research Station 29 samples of Wongan loamy sand were analysed in triplicate for nitrogen to test the analytical sub-sampling of a sandy soil and to find the effect on fertility build-up to date. The analytical sub-sampling was found satisfactory and the results of treatments up to 1961 are given in Table 4.

TABLE 4.

Treatment	Soil nitrogen N
	per cent. (average)
Fallow	0·030
1 wheat crop	0·033
2 wheat crops	0·032
2 wheat crops, 1 year of clover pasture	0·033
2 wheat crops, 2 years of clover pasture	0·031
2 wheat crops, 3 years of clover pasture	0·041

5. Owingup Swamp.—14 samples of soil from a soil survey of this swamp between Denmark and Nornalup were analysed to assess the potential of this and similar swamp soils in the area for vegetable growing in relation to the possible establishment of a canning industry.

6. Ground Water Research Station, Wiluna and Albion Downs Station, Wiluna.—A number of soil profiles characteristic of soils on these stations were analysed in detail to provide essential information on the initial status of these soils prior to the commencement of irrigation and fertiliser trials.

7. 16 soils from Wongan Hills and Avondale Research Stations from the commencement of an experiment on the effect of various rates of three sources of nitrogenous fertiliser on grain yield, under continuous cropping, were analysed for total nitrogen mineralised after 21 days' incubation at 25°C. On the heavier more fertile Avondale soils, the increase in mineral nitrogen in the surface soil averaged 10 p.p.m. and in the lighter Wongan soil averaged 26 p.p.m.

8. From another experiment at Wongan Hills 40 soils were analysed for organic carbon for correlation with water stable aggregates. The results of statistical treatment are not yet available.

Waters.

The main aspect of this part of the Division's work has been the examination of waters with the view to determining their suitability for human consumption, industrial use, irrigation and domestic use and to make recommendations for treatment where necessary. Waters were examined from all over the State from Kununurra to Esperance and from Rottnest to Kalgoorlie. During the year our joint Bulletin with the Department of Agriculture on "Waters for Agricultural Purposes in Western Australia" was rewritten in the light of many years experience to make it more readily useful to farmers. A further bulletin on "Clearing of Cloudy Waters on Farms" was also written. Of the 1,786 waters examined the following are of more interest.

1. Balcatta Artesian Bore No. 1.—The Metropolitan Water Supply Department put down a new bore to 2,500 ft. in 10 in. and 12 in. casing on Lot 2 Albert Street, Balcatta, to supplement the metropolitan supply. The water from this bore, about 2¼ million gallons per day, is now added to Mt. Yokine Reservoir for distribution. In the drilling of the bore several artesian aquifers were passed through. The first of these with any supply of consequence was at 980 ft. This water had 4 p.p.m. of iron in solution and would have required treatment before use and was therefore sealed off. The next aquifer was at 1,600-1,700 ft. The water from this was a particularly good water, unusually low in total dissolved solids and total hardness, but not of sufficient supply. Further aquifers were passed through each one gradually decreasing in quality to a depth of 2,500 ft., where the water had a total dissolved solids of 900 p.p.m. The lower aquifers were sealed off and the bore casing slotted at various aquifers to give a mixed water of sufficient quantity and reasonable quality. The analysis below shows the results of the good quality supply at 1,700 ft. and the final mixture which is still of excellent quality by comparison with other Metropolitan Water Supply artesian bores.

TABLE 5.

Balcatta Artesian Bore No. 1.

—	1,700 ft.	Final mixed supply
Specific conductivity 20° C. (micromhos)	237	356
Turbidity, APHA units	less than 5	less than 5
Colour, APHA units	less than 5	less than 5
Odour	*nil*	*nil*
pH	8·2	7·8
Saturation index, 20° C.	—1·1	—0·8
	p.p.m.	p.p.m.
Free carbon dioxide, CO_2	1·5	5·2
Total dissolved solids (by evaporation)	290	570
Total hardness (as $CaCO_3$)	9	32
Total alkalinity	130	156
Calcium, Ca	2	8
Magnesium, Mg	1	3
Sodium, Na	104	191
Potassium, K	5	8
Bicarbonate, HCO_3	165	190
Carbonate, CO_3	*nil*	*nil*
Sulphate, SO_4	12	16
Chloride, Cl	66	201
Nitrate, NO_3	less than 1	2
Silica, SiO_2	18	21
Iron, Fe	less than 0·1	less than 0·1
Aluminium, Al	3	3

2. Regular fortnightly samples from Dombakup and Carey Brook have been examined for over 12 months now for a variety of characteristics, to determine their suitability for the possible establishment of a paper pulp industry.

3. Canning and Serpentine Dams Stratification Investigations:—Because of discoloured water troubles in various parts of the metropolitan distribution and the finding of high amounts of up to 20 per cent. manganese in the material causing the discolouration, an investigation was undertaken into the possible stratification in Serpentine Dam. The complaints of discoloured water have increased since the introduction of water from the recently completed Serpentine Dam, but this is apparently coincidental as identical discolouration and mains deposits, perhaps not as prounounced, have been found in areas receiving only Canning Dam water. As Serpentine Dam is a new dam, it

was anticipated that because of an accumulation of organic matter in the bottom and in the mud there would be anaerobic conditions on the bottom of the dam which would lead to, amongst other things, increased iron and manganese in the water. For comparison purposes a similar investigation was started at Canning Dam. Canning Dam is more than 20 years older than Serpentine Dam and it was expected therefore that more stable conditions in the biochemical activity at the bottom would have been reached.

Initial depth sampling in April and early May at Serpentine Main Dam showed a depletion of dissolved oxygen with depth from 78 per cent. saturation at the surface to 1 per cent. saturation at the bottom. The bottom water had also decreased 0.3 pH units compared with the surface and had increased in free carbon dioxide, iron, manganese, and colour by 2.6, 2.6, 0.44 and 100 p.p.m. respectively. The bottom sample taken in March also smelled strongly of hydrogen sulphide indicating the presence of strong reducing conditions.

As the water from the main dam is run out through a channel, then 2-3 miles into the upper reaches of a pipehead dam before entering the reticulation, it was found that even bottom water 20 yards down stream from the dam became well aerated and the free carbon dioxide was reduced to the same as that of top water. Because of possible turnover in the main dam and difficulty in removing iron and manganese by aeration and settling in the pipehead dam, it was recommended to the Metropolitan Water Supply Department that hydrolime be added to the water to raise the pH to about 8.4. The quantity required was only of the order of 10-20 lbs per million gallons, which would not be very expensive. By adding the lime just down stream from the main dam there would be excellent conditions for thorough mixing without additional equipment. The retention time provided by the pipehead dam would be sufficient to allow for deposition of the precipitated iron and manganese. The main intention behind the lime addition however was not primarily iron and manganese removal, but to raise the pH and remove the free carbon dioxide so that corrosion in the reticulation would be decreased, and to prevent a proliferation of iron and manganese bacteria in the reticulation by providing an unfavourable environment.

Since October regular monthly samples from both Canning and Serpentine Dam have been taken to obtain additional information about the stored water. Results to date have shown that somewhat similar conditions exist in both dams. A steady decrease of dissolved oxygen with depth was noted in both dams. This decrease became greater as the surface temperatures increased with the advance of summer. Bottom samples at Canning Dam were reduced to 2-3 p.p.m. dissolved oxygen compared with 0.5-2 p.p.m. at Serpentine. These results taking into consideration greater depth of water at Canning Dam, 200 ft. compared with 100 ft. at Serpentine, emphasises the more stable biochemical conditions in the former.

The thermal conditions down to 100 ft. in both dams have so far been very similar. Very slight to no increase in iron and manganese has been found at Canning Dam with depth, but some large increases have been found occasionally at Serpentine Dam. A slight mineral stratification amounting to an increase of 20-25 p.p.m. in the total dissolved solids in the 0-25 ft. epilimnion, compared with the thermocline and hypolimnion, was also observed in both dams as summer progressed. This is probably due to evaporation from the surface.

Further sampling throughout the autumn, winter and spring is hoped to give information on which is the best level from which to draw water and also what time of the year "turnover" and consequent troubles are likely to occur. Similar sampling at Mundaring Weir is also proposed when a boat becomes available.

4. An unusual natural water, by Western Australian conditions, was received from a bore in limestone, on the West Coast Highway at Mt. Claremont. The water from this bore which is over 30 years old had almost blocked the reticulation and had completely lined a galvanised tank with calcium carbonate. Analysis of the water, which had a total dissolved solids content of 740 p.p.m., showed it to have a positive saturation index of + 0.3, indicating super saturation with calcium carbonate and explaining the deposition in the reticulation and tank.

Fertilisers.

1. Fertiliser Act.—Again this year the Act has been sensibly policed by the Department of Agriculture. 21 samples were analysed and reported, and as Table 6 shows, indicated no abuses of the Act.

TABLE 6.

Fertiliser Act Samples Reported, 1962.

Constituent	Samples analysed	Complied	Deficient
Nitrogen, N	19	18	1
Water soluble potash, K_2O	9	9	....
Phosphoric anhydride, P_2O_5—			
Water soluble	11	11	....
Citrate soluble	19	19	....
Acid soluble	19	17	2
Total	19	19	....
Fine material (a)	5	5	....
(b)	5	4	1

2. Limesand and Limestone.—Interest in the use of limesand and ground limestone with superphosphate on certain soils involved the analysis of 65 samples.

3. A sample of copper-zinc superphosphate suspected of being indirectly involved in the heavy metal accumulation, that occurs in the livers of sheep affected by lupinosis was analysed for a number of heavy metals. The result is given below:—

COPPER-ZINC SUPERPHOSPHATE

	per cent.
Cobalt, Co	0·0010
Copper, Cu	1·26
Iron, Fe	1·28
Manganese, Mn	0·012
Molybdenum, Mo	less than 0·00001
Lead, Pb	0·03
Zinc, Zn	0·95

Because of the suspected association of lead accumulation in the liver with lupinosis, two samples of super phosphate made from Christmas Island rock phosphate were analysed for lead, to find out how much of the above lead figure in the copper-zinc superphosphate was due to the added copper ore and zinc oxide. The results of 0.002 and 0.006 per cent lead in straight superphosphate show that the superphosphate is not the source of the lead in the copper-zinc superphosphate.

4. A sample of rock phosphate from the recently discovered deposit at Rum Jungle in the Northern Territory was found to contain 37.4 per cent. P_2O_5. A high fluorine figure of 3.46 per cent., similar to North African and American rock phosphate rules out the possibility of using it as a phosphate supplement for stock.

5. A number of miscellaneous fertilisers were analysed to assess their value or to provide information about responses obtained in various trials.

Pastures Fodders and Stock Foods.

1. Feeding Stuffs Act.—Sensible policing by the Department of Agriculture Inspectors, resulted in the receival of 56 samples stock foods registered under the Feeding Stuffs Act. Departmental policy of maintaining stock-foods manufacturer's co-operation rather than bureaucratic enforcement of regulations, has resulted in the intention of the Act being carried out, as shown in Table 7, by the compliance of the majority of the samples analysed. In no case of a deficiency or excess was there any appreciable deviation from the registered analysis.

TABLE 7.

Feeding Stuffs Act Samples Reported 1962.

Constituent	Samples analysed	Complied	Deficient	Excess
Crude protein	56	44	12	....
Crude fat	56	51	5	....
Crude fibre	56	51	....	5
Sodium chloride	52	43	....	9
Phosphoric anhydride	52	47	5	....
Calcium	52	48	4	....

2. From an experiment at Quairading and Badgingarra on the response of pasture grasses to nitrogen fertiliser, marked increases in yield were obtained with added nitrogen. There was no increase in quality as indicated by the nitrogen uptake except in the higher rates of application of 224 and 448 lbs. of ammonium sulphate per acre.

3. From an experiment at Bramley Research Station on the persistence of cobalt fertiliser applied in 1961 on gravelly sloping soil with ironstone outcrops a series of replicated pastures were received for cobalt analysis. The average results of four samplings over two seasons, Table 8, show the definite uptake of cobalt in the first year of application and some persistence at the higher rates into the second year.

TABLE 8.

Cobalt in Pasture.

Date of Sampling	24/10/61	20/12/61	14/6/62	31/10/62
Material	Lush green pasture	Dry mature pasture	Firstly grown pasture	Mature green pasture
Treatment	Cobalt Co p.p.m. dry basis			
Aerophos (76 lb.) and gypsum	0·03	0·09	0·03	....
Superphosphate 180 lb./acre	0·02	0·09	0·03	0·05
Superphosphate 180 lb./acre + 1 oz. Cobalt Sulphate per acre	0·08	0·13	0·02	0·06
Superphosphate 180 lb./acre + 3 oz. Cobalt Sulphate per acre	0·06	0·25	0·03	0·07
Superphosphate 180 lb./acre + 9 oz. Cobalt Sulphate per acre	0·15	0·43	0·03	0·16
Superphosphate 180 lb./acre + 18 oz. Cobalt Sulphate per acre	0·31	0·45	0·06	....

4. A further cobalt fertiliser trial was conducted at Mayanup. The results of the average of replicate samples, at a mature stage analysed for cobalt, are given in Table 9. These also indicate the uptake of cobalt in pasture from fertiliser application.

TABLE 9.

Cobalt in Pasture.

Treatment	Cobalt Co p.p.m. dry basis (sampled 12/10/62)
Control	0·03
1 oz. Cobalt sulphate per acre	0·02
3 oz. Cobalt sulphate per acre	0·08
9 oz. Cobalt sulphate per acre	0·12

Because of the remarkable response of stock to cobalt in marginal areas the present recommendation is that one-third of the superphosphate used should be cobalt super containing 5 lb. of cobalt sulphate per ton. The additional cost of 44s. per ton or 3s. 8d. per bag for cobalt super is not excessive.

5. The effect of lime on superphosphate uptake in pasture was investigated in a Department of Agriculture experiment at Bridgetown. This land had previously had a considerable amount of superphosphate applied. The results of bulked replicates in Table 10 show that the addition of limestone slightly increased the uptake of phosphorus for all levels of added superphosphate, but added superphosphate had little effect on phosphorus uptake.

TABLE 10.

Phosphorus Content of Pasture.

Treatment	Limestone, cwts. per acre				
	0	1¼	5	20	80
Superphosphate lb. per acre	Phosphorus P per cent, dry basis				
0	0·24	0·24	0·26	0·28	0·26
60	0·26	0·25	0·28	0·30	0·29
180	0·24	0·26	0·26	0·29	0·29

6. A sample of salt bush from a fairly heavy growth on the river frontage at Guildford was found to contain 12.2 per cent. oxalates. Lambs and ewes on this property had been showing symptoms of acute calcium deficiency and of renal calcification.

7. 106 silage samples were analysed for moisture and protein. These came mostly from the Australian Dairy Products Board's silage competition.

8. From a trial on a property near Northam a series of pasture samples was analysed to find the effect of elemental sulphur on nitrogen, phosphorus, sulphur and suphate sulphur uptake. Grass on this trial responded to superphosphate alone but clover only grew when elemental sulphur had been applied in addition. The averages of the analytical results are shown in Table 11.

TABLE 11.

Effect of Sulphur Fertiliser on Pasture Composition.

Treatment	Nitrogen N	Phosphorus P	Total Sulphur S	Sulphate Sulphur S
	per cent., dry basis			
Nil	2·24	0·18	0·20	0·01
Superphosphate 150 lb./acre	2·02	0·22	0·20	0·02
Superphosphate 750 lb./acre	1·88	0·34	0·22	0·06
Superphosphate 150 lb./acre + sulphur 300 lb./acre	2·28	0·20	0·32	0·16
Superphosphate 150 lb./acre + sulphur 600 lb./acre	2·44	0·20	0·45	0·28
Superphosphate 150 lb./acre + sulphur 1,200 lb./acre	2·18	0·24	0·52	0·34
Superphosphate 150 lb./acre + trace elements	2·24	0·20	0·22	0·02

The results show that the sulphur fertiliser has no effect on the nitrogen and phosphorus but has considerably increased the uptake of total sulphur and sulphate sulphur. Further, the increase in total sulphur is due entirely to the increase in sulphate sulphur, the non sulphate sulphur in the pasture has remained constant at about 0.18 per cent.

9. Selenium in Pasture.—The increased interest in White Muscle Disease by the Chief Veterinary Pathologist has resulted in over 100 samples of pasture being received for selenium determinations. This determination is both time consuming and involved. To obtain reproducible and accurate results a considerable amount of skill and experience is required.

(a) Pasture survey for selenium. A survey of pastures from light and heavy soils from various parts of the State has shown that generally pastures on heavy soil have ample selenium. Pastures on lighter soils are low in selenium and may have less than the 0.02-0.03 p.p.m. considered likely to be associated with White Muscle Disease, especially on soils from the high rainfall areas.

The selenium content of pastures from various parts of the agricultural areas of Western Australia is shown in Table 12, which also indicates the soil texture, when this was available.

TABLE 12.

Selenium Content of Pastures.

Locality	Selenium, Se p.p.m. dry basis
Arthur River	0·05
	0·06
Bokerup	0·04
Boyup Brook	0·04
	0·05
	0·02
	0·04
	0·05
	0·05
	0·03
	0·05
	0·02
Bramley	
Research Station	0·02
Burracoppin—	
Light soil	0·33
Heavy soil	0·08
	0·50
Chapman	
Research Station—	
Loamy sand	0·05
Red loam	0·12
Chowerup	0·02
Dandaragan—	
Loam	0·08
Sand	0·08
Denmark	0·03
	0·04
	0·04
	0·03
Esperance—	
Light soil	0·02
Light soil	0·02
Light soil	0·02
Research Station	
Light soil	0·04
Hyden—	
Light soil	0·19
Heavy soil	0·21
Jingalup	0·02
	0·05
Kellerberrin (South)	0·20
Kojonup	0·03
	0·03
	0·02
	0·13
	0·02
	0·04
	0·05
	0·06
	0·03
	0·05

Locality	Selenium, Se p.p.m. dry basis
Koorda—	
Light soil	0·14
Light soil	0·09
Heavy soil	0·62
Kulin—	
Light soil	0·08
Heavy soil	0·79
Manjimup	0·09
Mayanup	0·04
	0·04
	0·08
Mendel—	
Red loam	0·42
Merredin	
Research Station	0·36
Middlesex	0·04
	0·08
Miling—	
Light soil	0·04
Heavy soil	0·02
Mingenew (East)—	
Clay loam	0·15
Sand plain	0·09
Moore River	0·01
	0·03
Northampton—	
Grey sand	0·02
Red loam	0·12
Pemberton	0·02
Tenterden	0·03
	0·01
	0·02
	0·02
	0·02
	0·02
	0·03
Wagin	0·02
	0·05
	0·06
Wickepin—	
Light soil	0·24
Heavy soil	0·02
Wongan Hills	
Research Station —	
Light soil	0·05
Heavy soil	0·26
Woogenellup	0·04
	0·05

(b) A series of cuts of pasture from a selenium fertiliser spray trial from a property at Darkan was analysed for selenium to determine the uptake from the spray. The results are given in Table 13.

TABLE 13.

Selenium Fertiliser and Selenium Content of Pasture.

Treatment	Sampling Time			
	Early July	Late July	September	Late October
	Selenium Se—p.p.m. dry basis			
Control	0·02	0·02	0·02	0·02
36 mgm. Se per acre	0·03	0·08	0·02	0·03
100 mgm. Se per acre	0·03	0·12	0·02	0·03
200 mgm. Se per acre	0·03	0·03	0·02	0·02
400 mgm. Se per acre	0·17	0·21	0·03	0·01
600 mgm. Se per acre	0·13	0·16	0·04	0·03
800 mgm. Se per acre	0·13	0·22	0·04	0·14

These results show an early uptake of selenium in young pasture, but no increase in the selenium content of fully matured pasture, except for the anomalous results for the 800 mgm. per acre application for the late October cut.

10. A large number of miscellaneous pastures, stock foods, meatmeals, etc., were analysed for a variety of purposes, usually to assess their food value for stock.

Cereals.

1. Barley.—Four samples of barley plants from cereal grazing trials on Agriculture Department Research Stations were analysed for feeding stuff value.

2. Maize.—Six samples of grain representative of maize growing districts in Queensland were analysed for zinc. This concluded an investigation into the zinc content of Australian poultry feeds commenced by the University Institute of Agriculture and reported in our 1961 Annual Report. The average of these samples was 22 p.p.m. zinc.

3. Oats.—(a) From five Department of Agriculture experiments at Esperance Downs Research Station 161 samples of plants were analysed for phosphorus from experiments designed to test various rates of application of superphosphate and rock phosphate.

(i) Experiment 51EC consisted of 5 replicates of 7 treatments of 3 rates of rock phosphate, 2 of superphosphate and 1 of gypsum in various combinations. The treatments were applied in 1951-2-3-4 and 1958; the land was cropped to oats in 1951 and was under clover pasture till cropped to oats in 1960. Phosphorus uptake was found to increase in the following order of treatment:—(1) rock phosphate 56 lb. plus gypsum, (2) rock phosphate 112 lb. plus gypsum, (3) rock phosphate 56 lb. plus super 112 lb. plus gypsum, and super 168 lb., (4) rock phosphate 112 lb. plus super 112 lb. plus gypsum and (5) rock phosphate 224 lb. with and without gypsum.

(ii) Experiment 51EA, C, comparing 4 rates of superphosphate with and without 3 rates of gypsum and with and without ammonium sulphate applied in 1951-2-3-4-5-6 and 1958-9, on land under clover from 1951 till cropped to oats in 1960 showed phosphorus uptake to be increased by added superphosphate, slightly suppressed by sulphate of ammonia and unaffected by gypsum.

(iii) Experiment 51EA, O, consisted of 5 replicates of 7 treatments of 4 rates of superphosphate and 3 rates of superphosphate with 3 rates of gypsum applied in 1951-2-3-4 and 1958 on land sown to oats in 1951 and then under clover pasture till cropped in 1960. Phosphorus uptake was found to increase with added superphosphate and was unaffected by gypsum.

(iv) Experiment 51EC, C, consisted of duplicates of 14 treatments of combinations of 2 rates of superphosphate, 3 rates of rock phosphate, 2 rates of gypsum and 1 rate of ammonium sulphate applied in 1951-2-3-4-5-6 and 1958-59 to land which had been under clover since 1951 till cropped to oats in 1960. Phosphorus uptake was found to increase with added phosphorus, was unaffected by gypsum and increased with ammonium sulphate at the highest level of application of rock phosphate.

(v) Experiment 51EC, O, consisted of 5 replicates of 7 treatments of superphosphate, rock phosphate and gypsum applied in 1951-2-3, and 7 to land cropped to oats in 1951 and under clover till cropped to oats again in 1960. Phosphorus uptake was found to be lowest with rock phosphate 56 lb. next highest with rock phosphate 112 lb. or super 168 lb. and highest with rock phosphate 56 lb. plus super 112 lb., rock phosphate 112 lb. plus super 112 lb., rock phosphate 224 lb. plus super 112 lb. or rock phosphate 224 lb.

(b) Twenty samples of Ballidu oat plants from Mayanup, sorted into various plant parts, from manganese deficient and adjacent healthy areas, were analysed for manganese to find the most suitable plant part for confirming manganese deficiency symptoms. Table 14 indicates either the youngest leaf or the 2/3 leaf as being the best part.

(14)—70240

TABLE 14.

Distribution of Manganese in Oat Plants.

Plant Part	Healthy Plants	Unhealthy Plants
	Manganese, Mn p.p.m. dry basis average	
Oldest leaf blade	20	12
Youngest leaf blade	18	8
2/3 leaf blade showing symptoms	16	6
Stems	14	7
Roots	12	10

(c) 20 samples of grain and hay were analysed for cobalt and/or selenium and copper in connection with outbreaks of White Muscle Disease or of ill-thrift in flocks of sheep. Oat grain was found to contain 0.01-0.10 p.p.m. selenium.

(d) 10 samples of plants from Research Station cereal grazing trials were analysed for feeding stuff value.

4. Wheat.—(a) From a Department of Agriculture glasshouse experiment investigating the translocation of nitrogen from wheat roots after anthesis in Gabo wheat plants, 108 samples of ears, roots and straw were analysed for nitrogen. The treatments consisted of three rates, low, medium and high nitrogen nutrient solution applied at three stages (i) no more nitrogen after anthesis (ii) nitrogen continued after anthesis and (iii) plants harvested at anthesis.

Ears, roots and straw nitrogen were found to increase with increasing nitrogen nutrient level at all stages except for a decrease in root and straw when the nitrogen nutrient solution was continued after anthesis, Ear, root and straw nitrogen were found to decrease when no more nitrogen was applied after anthesis for all levels of nitrogen application. Ear nitrogen at all levels of applied nitrogen and roots and straw nitrogen at the low level of applied nitrogen, increased when nitrogen application was continued after anthesis. Root and straw nitrogen for the medium and high levels of nitrogen nutrient solution were found to decrease when the nitrogen application was continued after anthesis.

(b) 128 samples of wheat tops from a differential response of wheat varieties to nitrogenous fertilisers experiment at Wongan Hills Research Station were analysed for nitrogen. The experiment consisted of four varieties, Charter, Gabo, Gluclub and Insignia, four rates of application of ammonium sulphate, 0, 100, 200 and 400 lb. per acre and two times of application, at seeding and at earing, replicated four times.

The results showed that 100 and 200 lb. per acre of ammonium sulphate at seeding depressed plant nitrogen for all varieties and 400 lb. per acre at seeding increased plant nitrogen for all varieties, Gabo and Gluclub showing the greatest increase. 100 and 200 lb. per acre of ammonium sulphate applied at earing had little effect on plant nitrogen, 400 lb. per acre at earing increased plant nitrogen for all varieties except Charter. The increase of plant nitrogen with 400 lb. per acre of ammonium sulphate was greater when applied at seeding than at earing.

(c) 11 samples of Kondut wheat from Brookton were analysed for manganese to find which part of the plant was the most suitable for confirming manganese deficiency symptoms. This was a similar experiment to that reported above for oats. The results showed that the roots had the greatest difference between healthy and unhealthy plants, but because of possible soil contamination, the youngest or the 2/3 leaf blade as with oats would be best for sampling.

(d) From an experiment at Woogenellup designed to investigate the availability of copper from various sources and degrees of fineness of copper ore, 73 samples of tops and roots were analysed for copper. The results of copper uptake for various treatments are given in Table 15.

TABLE 15.

Uptake of Copper by Wheat from Various Copper Fertilisers.

Treatment	Grain Yield	Straw		Roots		Whole Plant
	bus./ acre	Average Copper, Cu—				
		p.p.m.	μg*	p.p.m.	μg*	μg*
Aerophos and Gypsum + Zinc oxide	0	2·0	104	6·5	47	151
Zinc oxide	0	1·6	104	6·8	41	145
Copper sulphate	9·9	2·6	216	24	168	384
C.S.M.L. Carbonate ore	8·1	2·6	243	22	156	396
Stubbs No. 2 Roasted ore, fineness I, II, and III	7·7	2·2	147	17	133	290
Stubbs No. 2 Roasted ore, fineness III	9·1	2·2	163	15	112	275
New Surprise carbonate ore No. 1, fineness I, II, and III	8·0	2·3	184	13	97	281
New Surprise carbonate ore No. 1, fineness III	8·9	2·3	141	20	162	303
New Surprise sulphide ore No. 3, fineness I, II, and III....	2·3	1·8	171	7·3	51	222
New Surprise sulphide ore No. 3, fineness III	4·2	2·1	153	7·6	67	220
New Surprise carbonate and sulphide ore No. 1 and No. 3, fineness I, II, and III	5·0	2·3	193	8·3	76	269
New Surprise carbonate and sulphide ore No. 1 and No. 3, fineness III	6·9	2·2	176	8·9	65	241

* Total copper in micrograms.

All treatments except the first had 150 lb./acre of superphosphate and all copper treatments are equivalent to 9 lb./acre of copper sulphate. Fineness I = — 50 + 100 B.S., Fineness II = — 100 + 200 B.S., Fineness III = — 200 B.S.

Plant Nutrition.

1. Apples.—(a) Leaves: 49 samples of apple leaves from Granny Smith trees were analysed for nitrogen, phosphorus and potassium to supply information on the fertiliser requirements of Western Australian apple orchards.

(b) Whole Apples:—17 whole apples were analysed for nitrogen to confirm the relationship found in 1961 between increasing green colour of mature Granny Smith apples and the nitrogen content. The results from this series were not consistent with previous results; though there was a general trend, there were many anomalies.

2. Citrus.—60 samples of citrus leaf, wood and root material were analysed for sodium, from a Department of Agriculture experiment involving the intermittent spray irrigation of trees with water containing 0, 20, 40, 60 and 80 grains per gallon of total dissolved solids. Increasing salinity of the water had no effect on the sodium content of any of the material. The leaves averaged 0.08 per cent. sodium, the wood 0.02 per cent. and the roots 0.08 per cent.

3. Clover.—(a) From a Department of Agriculture experiment at Harvey a series of Mt. Barker sub-clover samples were analysed for phosphorus, boron and copper. This species of sub-clover had not grown as well on plots receiving super and molybdenum, as those receiving super alone. Other species on adjacent plots had responded to molybdenum. The analytical results indicated that the non responding plots were still too low in phosphorus.

(b) Samples of clover from a further experiment at Harvey were analysed for copper, manganese and zinc, to determine the trace elements supplied by superphosphate as compared with a zinc free mixture of aerophos and gypsum. The results of the average of replicates are given in Table 16.

TABLE 16.

Trace Elements from Superphosphate.

Treatment	Mt. Barker Sub-clover		
	Copper, Cu	Manganese, Mn	Zinc, Zn
	p.p.m. dry basis		
Aerophos and gypsum only, added 1960 and 1961	2·4	77	11
Superphosphate only, added in 1960 and 1961	4·4	84	16
Superphosphate only, added in 1960 and 1961, plus copper and zinc in 1960	9·7	83	70

(c) Samples from an application of lime trial, on new land at Mayanup were analysed for boron, copper, iron, manganese and zinc. The addition of lime had had a detrimental effect on growth, and visual symptoms of the unhealthy clover did not indicate the cause. Comparing the analyses from healthy unlimed and unhealthy limed areas, the only nutrient that was affected was the considerable increase in zinc, from 28 p.p.m. in the unlimed areas to 130 p.p.m. in the limed areas. Further samples were forwarded from other replicates and these had even higher zinc contents of 280 and 400 p.p.m. The cause was subsequently found to be due to a contaminated batch of ground limestone used. This limestone was found to have had accidentally added about 1 per cent. of zinc.

(d) A subterranean clover strain trial conducted at Muradup showed that the Bacchus Marsh strain gave the lowest loss of dry weight and protein per acre over the summer, on ungrazed pasture. The results of the nine strains included in the trial are given in Table 17.

TABLE 17.

Loss of Dry Weight and of Protein from Clover.

Sub-clover Strain	December cut			February cut			April cut		
	Yield	Protein		Yield	Protein		Yield	Protein	
	Cwts. per acre	Per cent.	Cwts. per acre	Cwts. per acre	Per cent.	Cwts. per acre	Cwts. per acre	Per cent.	Cwts. per acre
Dwalganup	21·0	9·8	2·06	18·6	11·0	2·05	16·6	10·2	1·69
Geraldton	20·1	12·9	2·59	10·6	13·2	1·40	12·0	12·8	1·54
Yarloop	27·9	9·2	2·57	22·5	10·6	2·38	18·2	10·5	1·91
Dinninup	34·4	10·0	3·44	24·1	12·1	2·92	24·9	11·2	2·79
Marrar	39·9	10·8	4·31	31·3	12·2	3·82	28·3	11·4	3·23
Bacchus Marsh	45·1	13·8	6·22	37·8	15·1	5·71	34·5	12·9	4·45
Clare	31·9	9·9	3·16	29·8	11·2	3·34	22·4	10·9	2·44
Woogenellup	38·9	12·4	4·82	27·6	12·4	3·42	31·6	11·3	3·57
Mt. Barker	39·3	15·0	5·90	29·9	16·8	5·02	29·7	15·0	4·45

(e) Interest in the sodium-potassium balance in sheep in relation to clover-disease resulted in a number of samples of clover being submitted for sodium analysis. A search of our records was also made for sodium in subclover for the benefit of the Chief Veterinary Pathologist. The results summarised are as follows:—

40 samples from glass house trials: 0.76-2.31 per cent. sodium.

32 samples from acid peaty sand at Pingrup: 0.64-1.67 per cent. sodium.

24 samples from Denmark Research Station: 0.57-1.33 per cent. sodium.

(f) 39 samples of clover from Esperance Downs Research Station and from the Geraldton district were analysed for copper, in a copper in clover survey.

4. Cucumber Leaves.—The application of molybdenum in the form of molybdenum oxide or sodium molybdate, applied either as a spray or direct to the soil, was studied by the Department of Agriculture with the aid of analysis of 10 samples of leaves. Soil application was found to give the highest uptake of molybdenum, there being little difference between the two forms applied. The molybdenum was increased from 1 p.p.m. in the control, to about 12 p.p.m with the spray and 22 p.p.m by soil applicaton. Potassium and manganese uptake were unaffected by the molybdenum applications.

5. Lupins.—Because the problem of toxicity of lupins in lupinosis is considered related to heavy metal metabolism further work on the mineral composition of lupins was undertaken. The considerable number of analytical results determined during the year are given in Table 18. This table is a supplement to the table published in the Annual Report of 1961 of results up to the end of 1961.

TABLE 18.

Composition of Lupins.

Supplementary Table of 1962 Results to be Added to the 1961 Composition of Lupins Table.
Analyses on Dry Basis.

	Leaves			Pods			Stalks			Whole tops			Seeds		
	No.	Range %	Average %	No.	Range %	Average %	No.	Range %	Average %	No.	Range %	Average %	No.	Range %	Average %
Protein	9	9·7 –13·8	11·7	9	3·5 –4·3	4·0	9	3·8 – 6·9	5·1	1	....	3·6	9	29·0 –41·1	32·0
Fat	9	1·5 – 2·3	1·9	9	0·1 – 0·9	0·6	9	0·6 – 1·5	0·9	1	....	1·4	9	2·3 – 6·7	3·9
Fibre	9	21·3 –25·9	23·0	9	33·6 –41·3	36·5	9	45·1 –54·6	50·9	1	....	51·2	9	16·6 –20·6	19·2
Ash	9	12·1 –19·7*	14·3	9	3·0 – 4·0	3·7	9	4·3 – 6·8	5·0	1	....	3·3	9	2·9 – 3·8	3·3
Nitrogen free extract	9	45·0 –52·2	49·1	9	50·3 –58·4	55·3	9	35·2 –41·5	38·3	1	....	40·5	9	31·8 –45·2	41·9
Calcium, Ca	9	1·05– 2·63	1·48	9	0·19– 0·36	0·27	9	0·40– 0·58	0·50	4	0·23– 0·39	0·30	9	0·11– 0·29	0·20
Magnesium, Mg	....	....	....	....	....	....	....	....	....	1	....	0·20	....	....	....
Phosphorus, P	9	0·08– 0·12	0·10	9	0·01– 0·03	0·02	9	0·02– 0·08	0·06	4	0·03– 0·74	0·47	9	0·24– 0·40	0·33
Silicon, Si	10	0·23– 0·70	0·48	....	....	....	....	....	....	....	....	....		....	....
		p.p.m.			p.p.m.			p.p.m.			p.p.m.			p.p.m.	
Cobalt, Co	9	0·12– 0·60	0·28	9<	0·01– 0·05	0·04	9	0·01– 0·18	0·10	8<	0·02– 0·10	0·05	9<	0·01– 0·11	0·05
Copper, Cu	9	2·9 – 6·7	4·8	9	1·1 – 3·5	2·1	9	1·4 – 4·6	2·7	11	0·8 –10·0	4·7	9	3·3– 8·3	5·3
Iron, Fe	9	1200*–4400*	2180	9	62–270	166	9	72–1100*	322	1	....	260	9	61–230	90
Lead, Pb	9	0·5 – 1·6	1·0	9	0·2 – 0·7	0·3	9	0·2 – 0·8	0·5	1	....	1·2	9<	0·2– 0·9	0·4
Manganese, Mn	9	180–790*	382	9	20–66	41	9	20–140*	66	1	....	74	9	22–51	35
Molybdenum, Mo	8	0·18– 0·52	0·30	....	....	....	....	....	....	....	....	....	....	....	....
Selenium, Se	....	....	....	....	....	....	....	....	....	3	0·03– 0·05	0·04	....	....	....
Zinc, Zn	9	12–84	35	9	3–10	6	9	5–27	14	4	13–33	20	9	30–52	38

*Soil contamination.

6. Miscellaneous Leaves.—Samples of beetroot, cabbage, carrot, lettuce, orange, parsnip, potato and rose leaves were analysed for confirmation of visual symptoms of nutrient deficiencies.

7. Potatoes.—A further 52 samples of potato tubers were analysed for specific gravity and moisture in a survey of potato growing districts.

8. Tobacco.—Although only 162 samples of tobacco were received in 1962, 788 were analysed because of samples received late in 1961. Because of the almost complete collapse of the tobacco industry in Western Australia, due to the lack of interest of buyers in local leaf, this part of the Division's work is expected to be very small in future.

Of the samples reported the following are of interest.

(a) From an experiment at Manjimup Tobacco Research Station on old and new land, 144 samples were analysed for phophorus and sulphate. Previous analyses for potassium, chloride and nitrogen suggested that phosphorus and sulphate results could be useful. The trial consisted of a factorial combination of four rates of application of ammonium sulphate, three rates of superphosphate and three rates of potassium sulphate.

On the old land, added potassium had no effect on phosphorus or sulphate uptake. Phosphorus uptake increased with added superphosphate only at the lowest level of added nitrogen, i.e., 48 lb. per acre of ammonium sulphate. High levels of ammonium sulphate slightly suppressed phosphorus uptake at all levels of added superphosphate. Sulphate uptake was not affected by added superphosphate or potassium sulphate, but was slightly suppressed by the highest level of ammonium sulphate, i.e., 270 lb. per acre.

On the new land added potassium also had no effect on phosphorus or sulphate uptake. Only the highest level of superphosphate, i.e., 800 lb. per acre, gave a slight increase in phosphorus. Added nitrogen generally suppressed the phosphorus. Sulphate uptake was variable and not affected to any extent by the fertiliser treatments.

(b) Seventy-two samples were received from another experiment on old land at Manjimup Tobacco Research Station that was designed to find the effect on nitrogen, nicotine, potassium, phosphorus and chloride of high rates of fertiliser application. The fertiliser treatment consisted of four rates of nitrogen, 100, 200 and 300 lb. per acre of ammonium sulphate and 300 lb. of ammonium sulphate plus 300 lb. of blood and bone, three rates of phosphorus, nil, 600 and 2,200 lb. per acre superphosphate applied as pretreatment plus 200, 400 and 800 lb. per acre applied at planting and three rates of potassium, nil, 700 and 2,400 lb. per acre of potassium sulphate applied as pretreatment plus 150, 300 and 600 lb. per acre applied at planting.

Nitrogen was found to increase with added nitrogen fertiliser and was unaffected by all other fertiliser treatments.

Nicotine was found generally to increase slightly with added nitrogen for all levels of added potassium and phosphorus and slightly decrease with added potassium for all levels of added nitrogen and phosphorus.

Phosphorus uptake generally showed a slight increase with added phosphorus, a slight decrease with added potassium and a slight decrease with added nitrogen except for the highest level of added phosphorus.

Potassium uptake was found generally to increase with added potassium and was unaffected by added phosphorus or nitrogen.

Chloride uptake was found generally to slightly decrease with added potassium for all levels of added phosphorus or nitrogen and slightly increase with added nitrogen, for all levels of added potassium and phosphorus.

(c) Forty-five samples of growers' crops sampled just prior to the tobacco sales were analysed for nicotine, total sugars and chlorides, to assess the value of the leaf and to find what effect the recommended management changes had in bringing the tobacco nearer the quality required by the manufacturers. The changed management practices consisted of increased topping to produce higher nicotine contents and the introduction of clover cover crops for a similar purpose. The nicotine results average 3.33 per cent. ranging from 1.40-5.24 per cent. The chlorides were variable and independent of the nicotine content; they averaged 2.37 per cent. ranging from 1.10-4.62 per cent.

(d) From another experiment at Manjimup Tobacco Research Station, 360 samples were received for analysis of nicotine, total sugars chloride and nitrogen. The experiment consisted of 5 replications of 72 treatments involving factorial combinations of: (i) Topped and not topped; (ii) low and high rate of nitrogen fertiliser; (iii) 42 in. x 18 in., 48 in. x 21 in. and 48 in. x 17 in. spacings; (iv) no cover crop, sub-clover cover crop, oats and vetches cover crop; and (v) stalks removed and stalks not removed.

The results showed that:—

Chloride was generally slightly lower in the topped than the not topped, in the 42 in. x 18 in. spacing than the other 2 spacings, and in the no cover crop than either in the sub clover or oats and vetches cover crops. Chloride was not affected by nitrogen fertiliser and was slightly higher in the stalks not removed than in the stalks removed.

Total sugars were generally higher in the topped than not topped, slightly higher with the lower nitrogen level, highest in the no cover crop and lowest with a sub clover cover crop, and higher with the stalks removed than without the stalks removed. Spacing had little effect on the total sugars.

Nicotine was higher in the topped than not topped, higher with the higher nitrogen level, higher with a sub clover cover crop and lower with no cover crop, slightly higher with the stalks removed than without the stalks removed. The 48 in. x 17 in. spacing had the highest nicotine and the 42 in. x 18 in. spacing the lowest, for both topped and not topped samples with the low nitrogen level, and for the not topped samples with the high nitrogen level.

Nitrogen was unaffected by topping, increased with added nitrogen, highest in 48 in. x 17 in. spacing and lowest in 42 in. x 18 in. spacing, slightly higher with a sub clover cover crop and lowest with no cover crop, and very slightly higher with the stalks removed than without the stalks removed.

(e) Because of the collapse of the tobacco industry in Western Australia, the detailed analysis given below of representative samples of 5 grades of leaf from possibly the last tobacco sale in this State, is of interest. The samples were made by taking leaf from every second bale offered for sale and then grouping them into their respective grades.

TABLE 19.

Composition of Western Australian Tobacco Leaf 1962.

	Lugs	Cutters	Sub-leaf	Leaf	Tops
	Per cent. dry basis				
Starch	0·96	1·29	0·87	2·10	1·24
Sugars before inversion	17·0	20·5	19·5	20·5	19·3
Total sugars	24·5	30·8	26·6	29·4	27·4
Resins	5·6	6·0	5·9	5·7	6·1
Total nitrogen, N	1·29	1·40	1·29	1·54	1·70
Protein nitrogen, N	0·75	0·74	0·74	0·77	0·84
Total alkaloid as nicotine	1·90	2·73	2·16	3·56	3·67
Nicotine	1·79	2·62	2·04	3·21	3·41
Nor-nicotine	0·10	0·11	0·11	0·32	0·24
Total volatile bases	0·28	0·33	0·30	0·42	0·47
Ash	15·5	12·1	14·1	9·99	10·2
Chloride, Cl	4·54	2·57	3·07	2·25	2·25
Calcium, Ca	3·85	2·96	3·44	2·46	2·34
Potassium, K	1·69	1·60	1·73	1·15	0·96
Sodium, Na	0·14	0·10	0·12	0·10	0·11
Phosphorus, P	0·15	0·18	0·18	0·17	0·18

9. Tomato Leaves.—(a) 4 samples from Hope Valley and Balcatta were analysed for calcium, magnesium, phosphorus, potassium, iron, manganese, copper and zinc without finding the cause of the "iron chlorosis" symptoms.

(b) Samples from the Vegetable Research Station at Wembley investigating the effect of iron chelate on "iron chlorosis" showed no effect on the uptake of elements listed in 9 (a).

(c) Leaf samples from a farmer's property where there had been excessive application of sodium molybdate, 6 lb. per acre instead of 6 oz. per acre, were found to have more than 6 p.p.m of molybdenum. Mature fruit from the same plants had 0.8 p.p.m of molybdenum on dry basis, which in no way affects their quality.

Animal Nutrition.

1. A series of samples of hair from Hereford cattle from a property at Keysbrook were examined spectrographically and analysed chemically for selenium and copper to see if any relationship existed between the mineral content of the hair and the degree of fading of the hair. The samples were separated into three groups, controls, slight fading and marked fading. Spectrographic analysis showed no relationship between mineral content of the hairs and fading. There was no significant differences in the copper figures, the average copper being 5.5 p.p.m. The controls showed slightly but not significantly more selenium 0.33 p.p.m against 0.24 p.p.m in the markedly faded samples and 0.14 in the slightly faded samples.

2. Urinary Calculi.—A number of urinary calculi were analysed from a renewed investigation into the causes of urinary calculi. Samples from the wheatbelt areas were found to be mainly amorphous silica with some containing a considerable amount of calcium oxalate. One sample from Mayanup containing only silica in the inorganic fraction had 60 per cent. of unidentified organic matter, probably a complex muco-protein; sample size prevented further identification.

3. A sample of thyroid gland from a spastic calf at Katanning contained 3.42 per cent. iodine ruling out the diagnosis of a possible iodine deficiency. Analysis for selenium on the liver of the calf showed it to contain 0.58 p.p.m selenium, which also eliminated a suspected selenium toxicity.

4. A sample of sheep kidney from a property at Darkan where the sheep had had repeated doses of selenium over 12 months and when killed was in a moribund condition, contained 5.8 p.p.m. of selenium.

5. Over 60 liver samples were received for copper and cobalt analysis for confirmation of diagnosis of causes of ill-thrift.

6. The urinary fluorine of three cows showing progressive stiffness of gait and lameness indicative of fluorosis was 40-70 p.p.m. These cows were the most affected of a herd receiving 4 ozs. per day per head of ground rock phosphate of unknown origin.

7. Lupinosis Experiments:

(a) From an Animal Health Laboratory experiment investigating the effects of the sodium salt of E.D.T.A. on heavy metal absorption and excretion on sheep fed from three sources of "toxic" lupins, 18 samples of urine and 14 samples of liver were received for analysis for cobalt, copper, iron, lead, manganese, zinc and potassium. 24 hours urine samples were collected after a period of prefeeding, then after 14 days and after 21 days on lupins. There was a marked decrease in the excretion of urinary cobalt in both chelate and non-chelate sheep with the feeding of lupins. Urinary copper excretion increased very markedly in both groups, being more pronounced in the chelate fed sheep. Iron excretion increased 13 fold in the chelate fed sheep compared with the non-chelate sheep. The low excretion of iron from the latter indicates the iron storage aspect of lupinosis. There was increased excretion of lead in the chelate fed group and increased excretion of manganese in both groups but more pronounced in the chelate fed sheep. There was a marked increase in excretion of zinc in the chelate fed group and a fall in zinc excretion in the non-chelate group. There was a very pronounced drop in urinary potassium in both groups and this was related to potassium intake.

Liver samples taken at the conclusion of the experiment showed no consistant differences between chelate and non-chelate fed sheep.

(b) Lead in Bones.—From an Animal Health Laboratory experiment on six properties in the Gingin, Dandaragan and Bolgart disticts investigating lupinosis, the lead in the bones of the sheep in the experiment was determined to ascertain any relationship to the degree of lupinosis. The degree of lupinosis was assessed by taking an average of the degree of lupinosis in each of the 10 sheep in each paddock of the experiment, the individual degree of lupinosis being on a scale of 0-5; for nil, slight, mild, moderate, marked and severe lupinosis. In each paddock there were five sheep which had had previous experience of lupin grazing and five sheep without previous experience of lupin grazing.

Table 20 shows a general increase in bone lead with severity of lupinosis, and also that the sheep with a previous history of lupin grazing have a generally higher bone lead.

TABLE 20.
Lead in Sheep Bones.

Paddock	Degree of Lupinosis	Previous lupin experience	No previous lupin experience	All sheep
		Bone lead—p.p.m. in ash		
Dandaragan B	4·2	7·2	6·6	6·9
Dandaragan No. 4 G	3·1	7·1	4·0	5·9
Dandaragan No. 1 G	3·7	5·6	3·0	4·8
Dandaragan C	4·1	3·5	3·0	3·3
Dandaragan No. 3 G	1·7	1·9	2·0	1·9
Gingin E	0·7	1·4	3·0	2·2
Bolgart C	0·3	3·7	2·7	3·2

Analysis of the lupin feed did not indicate that the increased lead with lupinosis, was coming from that source. The accumuation is apparently due to increased absorption in the gut.

Although no published figures for sheep bone leads could be found, the above figures do not appear to be abnormally high. Previous analyses of sheep bone in these Laboratories have shown 0.5-3.2 p.p.m. lead in fresh bone. Monier-Williams in "Trace Elements in Food" suggest an apparently healthy man can have 15-140 p.p.m. lead in fresh bone and suggests an average of 50 p.p.m. for a middle-aged man. Browning in "Toxicity of Industrial Metals" gives 2-30 p.p.m. lead in adult bone and Sundemann in "Normal Values in Clinical Medicine" gives 5-20 p.p.m as normal for human bones.

(c) Analysis of copper and cobalt in the lupin leaves from the experiment in 7 (b) above showed that there was generally a decrease in the severity of lupinosis with increased copper and cobalt in the lupin leaves. It was also observed that despite low levels of copper in the lupin pasture in the experiment, high normal to toxic levels of copper were found in the livers, but there was no correlation with lupinosis.

Miscellaneous.

1. Spectrography.—(a) Semi-quantitative emission spectrographic analysis was carried out on samples of aluminium alloy, silver, silver and copper bromides, tungsten carbide, iron oxide, potassium chloride, urines, liver ash and a number of miscellaneous minerals.

(b) Atomic Absorption Spectroscopy.—This technique is now standard for all zinc determinations. Investigations have been made into the use of the technique for lead in urine and for manganese in water. In the case of lead in urine the recently published method by J. B. Willis (Anal. Chem. 1962 p. 614) was not found applicable under our conditions. The sensitivity claimed by Willis could not be obtained due to the high noise level in the amplifier, due to emission from the flame. Also the practical difficulty of shaking and separating 1.5 ml. of solvent with 50 ml. of urine and aspirating this small volume proved to be a handicap. The sensitivity of manganese by atomic absorption is not sufficient for determination of manganese down to levels of 0.01 p.p.m. in water. Investigations have commenced into the ketone extraction of the hydroxy-quinaldine manganese complex. It is hoped that the increased sensitivity due to concentration by solvent extraction and enhancement by the solvent in the flame as occurs with copper, will be sufficient to make the method satisfactory.

One of the faults wth present available equipment for atomic-absorption spectroscopy is the lack of an amplifier with a suitable filter circuit to pass only the 50 cycle signal from the hollow cathode source and not any signal from the flame.

2. Oil Seeds.—The 541 samples of safflower, linseed and castor oil seed analysed for oil and iodine value from the Kimberley, Avondale and Esperance Research Stations is almost identical with the number received in 1961.

3. Blood Alcohol.—Because of disputed results in Court of blood alcohol analyses, a further 43 samples representing about 1 in 5 of post mortem

samples received by the Food and Drug Division were independently checked by the Kozelka and Hine method and good agreement was obtained.

4. A preliminary investigation into the cause of growths and deposits in clear aerated waters of a soft drink manufacturer was undertaken. This problem was brought to us as it was suspected that the water supply was at fault and further treatment was required. Investigation showed that the problem was common to a number of soft drink manufacturers and was certainly not due to the water in this case as the deposit was found to be all organic, of biological origin, and the water had been superchlorinated with 10 p.p.m. of free chlorine and then dechlorinated before use. Acting on our suggestions the firm was able to trace the trouble to one of the ingredients. This was rectified when complaints were made to the supplier.

This problem of deposits and growths in aerated water seems to occur each year at the commencement of summer. This is probably due to the fact that the shelf life of aerated water is much longer over winter and with the advent of a few warm days the contents rise sufficiently in temperature to accelerate the microbiological spoilage of the drinks. The effect this summer was more pronounced because of a contaminated ingredient.

5. Corrosion, Scales and Deposits.—(a) An investigation was made on the behalf of an air-conditioning firm into the rapid corrosion of the cooling circuit of an air-conditioning plant they had supplied. The cooling circuit was being cleaned with a proprietary brand of inhibited sulphamic acid and in fifteen hours overnight, a 2 inch galvanised iron elbow had been completely corroded through, allowing 2-300 gallons of acid to run out into the building and on to stores and equipment below. Our examination showed that the sulphamic acid contained an inhibitor, that was effective with iron or steel but accelerated the attack on copper 3-16 fold. This however was not the prime cause of the trouble. The design of the plant was basically wrong in having galvanised elbows in an otherwise all copper system. This bad design was aggravated by cleaning the system with an acid not inhibited to copper and which would rapidly dissolve any copper corrosion deposits and rapidly deposit the copper by galvanic action causing concentrated attack on the galvanised elbow.

Recommendations were made on preventing a recurrence and on the treatment of the cooling water to minimise the future cleaning of the cooling water circuit.

(b) A number of miscellaneous boiler scales and water formed deposits from Kununurra, Wooroloo, Mt. Hawthorn, Home of Peace Subiaco, Albany Hospital, Port Hedland Hospital and the Metropolitan Water Supply were examined to find the cause of their formation, and recommendations were made to prevent their recurrence or to alleviate the trouble they were causing.

(c) The corrosion of galvanised water pipes at Donnybrook and Northampton was investigated. Pipes from Donnybrook were being corroded by the slight acidity of the water and the pipes from Northampton were being affected by the small amount of copper in the water.

During this work the lack of a standard for galvanised water pipes was again brought to our attention. The Standards Association of Australia would be performing a worthwhile service if they investigated the establishment of a standard for galvanised wrought iron pipes for water supply. This is of importance to all industry and the general public yet no Australian, American or British Standard exists.

6. Selenium in Human Urine.—Investigations by the University Department of Medicine into an outbreak of hepatitis at Norseman, involving a high rate of relapse, suggested that because of the amount of selenium containing pyrite ore mined and roasted in the area, that the susceptibility of Norseman sufferers to the hepatitis virus may be related to selenium damaged livers. In this connection urine samples were taken from a comprehensive range of patients involving recent sufferers both towns people and underground workers and also similar people who have had frequent relapses. Analysis of the urines for selenium showed no pattern amongst the patients. The figures of 0.011-0.045 mgm. per litre of selenium found are well within the normal range of 0-0.15 mgm. per litre as suggested by Sterner and Ledfelt (1941 J. Pharm. Exp. Ther 73, 205) indicating little likelihood of selenium being involved in the hepatitis outbreak.

7. University Physics Department Chilled Water Circuit.—The rapid blocking of filters on the cooling water circuit of the new Physics Department building was investigated. The cooling water which is derived from a bore in the University grounds is chilled and stored in a large tank in the top of the new building.

It gravitates to various pieces of equipment such as X-ray tubes, each protected with a filter to prevent any possibility of a blockage within the apparatus. These felt filters were found to block with deposits of rust after a few days use. Initial design of the circuit was based on the bore water having only 0.1 p.p.m. of iron in solution and further checks showed the water had not changed. After every other possible source of iron in the system had been eliminated further investigation of the bore water showed that although it only contained 0.1 p.p.m. iron, the oxidation potential of the water and the efficiency of the filters were such that the iron could be reduced to less than 0.02 p.p.m. Checking the volume of the water that had passed a filter and weighing the deposit on the filter, confirmed that the deposit was all coming from the iron in the bore water.

Recommendations were made to install a single backwash filter after the storage tank or else to use only a coarse filter on each piece of apparatus. The velocity of the water through each piece of apparatus was sufficient to keep any fine material in suspension. The whole problem was really due to over efficient filters.

ENGINEERING CHEMISTRY DIVISION.

As in the previous year, three original research projects were undertaken by the Division during the year. Two of the projects, viz. the recovery of sulphur from Kalgoorlie gold ore concentrate, and the calcination of calcareous beach sand, were continued from the previous years, whereas the third, the benefication of Robe River (Pilbara) iron ore, was initiated during the year at the request of the Geological Survey Branch.

Additional investigations were also carried out into the upgrading of ilmenite, mainly to clarify problems arising from the pilot plant work at Capel.

Apart from the above, work was also undertaken on behalf of private interests.

Sulphur Recovery from Kalgoorlie Gold Ore Concentrate.

As stated in the Annual Report for 1961, two possible processes were formulated, viz.:—

(1) One stage process involving roasting of gold concentrate in conditions controlled by the admission of air and steam to yield sulphur vapour, sulphur dioxide and hydrogen sulphide. Sulphur vapour is condensed, and the sulphur dioxide and hydrogen sulphide are reacted over a catalyst to yield elemental sulphur:

$$30FeS_2 + 18H_2O + 21O_2 = 10Fe_3O_4 + 18H_2S + 9SO_2 + 33S$$

(2) Two stage process involving the conversion of pyrite in the concentrate to pyrrhotite by roasting in the absence of oxygen

$$FeS_2 + heat = 2FeS + S$$

in the first stage, and oxidation of pyrrhotite under pressure in water, in the second stage

$$2FeS + O + H_2O = Fe(OH)_2 + 2S$$

The locking up of gold was considered the most important factor to be considered when working on both processes. Consequently, conditions for a maximum recovery of gold had to be found first, the maximum yield of sulphur being a secondary consideration at this stage.

Investigations, started in the previous year, were continued in 1962.

Two Stage Process.—Two batches of pyrrhotite were produced by roasting the concentrate in a closed crucible at 700°C. Analyses are set out below:—

	Original concentrate	Pyrrhotite (1)	Pyrrhotite (2)
	%	%	%
Total iron	27.2	31.8	31.3
Total sulphur	27.9	21.9	21.5
Oxidised sulphur	0.41	1.53	1.31
Pyrite Sulphur	27.5	0.12	0.32
Pyrrhotite sulphur	0.05	20.2	19.9

These results would indicate that only about 34 per cent. of the labile sulphur was removed, well below the theoretical 50 per cent. One of the possible explanations for this is that during roasting, the excess iron present in pyrite had captured some sulphur, being converted to pyrrhotite.

Some pyrrhotite for further treatment was made by roasting the concentrate in an entrained bed at a temperature of about 800°C, nitrogen being used as entraining gas. Superficial velocity of the gas at this temperature was 4-5 ft/sec. At this velocity the apparent residence time of the material in the unit was around one and one-third seconds.

The results would indicate that, provided that solids after roasting are separated from gases at a temperature above 740°C, the conversion of pyrite to pyrrhotite is virtually complete in this time. The yield of sulphur was not determined in these experiments.

The hydrometallurgical treatment of the pyrrhotite formed was carried out in a 3-litre laboratory pressure vessel lined with stainless steel, by blowing air at 100 lb./in^2 pressure through the agitated suspension of treated concentrate (pyrrhotite) (800 g. in 2,000 ml.) at about 115°C for a period of about 4 hours. Several such runs were made to obtain sufficient material for extraction of gold and for other assay work.

The rust, formed during the hydrometallurgical treatment, is easily separable from the residual ore by decantation. The gold assay of these fractions showed:—

	per ton oz.	dwt.	grains
Fine Rust	1	17	19
Coarse Residue	4	15	3

As the gold occurred in both fractions there was no point in separating them.

In view of the above, the solids from several runs were bulked and extracted with carbon disulphide, a recovery of sulphur of about 85 per cent. being obtained.

The sulphur occurs in the form of balls from about one-eighth in. down to very fine crystals. This would probably present a problem for commercial recovery requiring further investigations.

One Stage Process.—Since the treatment of concentrate in pelletised form was ruled out (see Annual Report for 1961) it was decided as the next step to investigate the roasting of pyrite concentrate in a fluidised bed using steam and air mixture as fluidising medium.

Before designing a suitable unit, some tests were made in a glass model for the evaluation of gas velocities required for fluidisation and entrainment of the material. As a result it was proposed to build a fluid bed unit incorporating a dip-leg around which the solids are entrained and through which they would regularly be recycled from the fluid bed formed at the top of the leg.

This idea was first tested in the glass model before building an operational bench scale unit.

By the end of the year, seven exploratory runs had been made in this unit at bed temperatures of 700° and 800°C.

The results may be summarised as follows:—

(a) In the batchwise operation at 800°C. using steam as fluidising medium, sulphur was steadily distilled off, mainly as H_2S. Indications were that a retention time of about 6 hours would be required to convert pyrite in the concentrate to magnetite under these conditions.

(b) In the batchwise operation at 800°C. using steam and air mixture (50:50 by volume) as fluidising medium, pyrite was converted to magnetite in about 1 hour and to hematite in a total of around 2 hours.

(c) Continuous operation at 700° and 800°C. using steam and air in proportion just sufficient to produce H_2S and SO_2 in the ratio of 2:1, i.e. in the ratio required for the subsequent sulphur recovery, was successful. However, a high proportion of fines was carried out of the system.

This treatment was followed by an oxidising roast in the same furnace, to convert magnetite to hematite. An attempt to treat the entrained fines in the same way was, however, unsuccessful.

(d) In a continuous treatment of fines in the entrained bed using air diluted by steam or sulphur dioxide so as to reduce its oxygen content to about 10 per cent., no flashing occurred and the pyrites was oxidised to hematite without fusion.

The work in the unit is being continued.

Beneficiation of Robe River (Pilbara) Iron Ore.

On the request of the Government Geologist, investigation of the beneficiation of Pilbara iron ore from the Robe River district, was initiated and a series of exploratory tests carried out.

Three samples of the ore were received and were analysed by the Mineral Division, Table 21.

TABLE 21.

	Upper section of the face	Lower section of the face	Full face
	per cent. on dry basis		
Total iron, Fe	60·1	50·8	55·8
Acid soluble iron, Fe	59·7	50·8	55·3
Alumina, Al_2O_3	1·27	4·49	1·57
Silica, SiO_2	4·03	11·5	8·27
Sulphur, S	0·06	0·15	0·04
Phosphorus, P	0·03	0·07	0·04
Titanium, Ti	0·07	0·31	0·16
Manganese, Mn	0·03	0·01	0·03
Loss on ignition	8·35	11·2	10·1
Calcium oxide, CaO	0·03	0·05	0·14
Magnesium oxide, MgO	trace	0·03	0·02
Mineral identification	concretions of hematite strongly cemented with goethite and opaline silica with little quartz and clay	mainly goethite with little limonite, clay, hematite, quartz and opaline silica	concretions of hematite cemented with goethite with little limonite, clay, silica and quartz

A sample of the lower Section ore was crushed and screened and the size fractions analysed for total iron content.

Size fraction, mesh, Tyler screen	Analysis Total Fe	Distribution of Fe
	per cent.	per cent.
+ 3	48·1	26·3
— 3 + 6	50·2	20·3
— 6 + 20	50·6	33·0
—20 + 90	51·2	14·6
—90 + 200	50·3	2·6
— 200	46·1	3·2

This indicates that no enrichment of iron occurred in size fractions.

Several lumps of lower section ore were leached with hydrochloric acid. The acid insoluble residue was screened in order to ascertain the grain size. The result was as follows:—

Size fraction, mesh, Tyler screen	Per cent. by weight
+ 65	25·2
— 65 + 110	16·7
— 110 + 150	9·9
— 150 + 200	9·4
— 200 + 270	1·1
— 270	37·7

Although almost 42 per cent. of the silica was in the plus 110 mesh size, these larger particles, when viewed under the microscope, appeared to be composed of aggregates of fine grains.

Further samples of the upper and lower section ore were examined under the microscope by the Mineral Division for the determination of the grain size of silica.

Upper Section.—Quartz grains average approximately 50 μ in diameter (about 300 mesh B.S.S.) with numerous grains as large as 100 μ in diameter (150 mesh B.S.S.).

Lower Section.—Quartz grains mainly less than 50 μ with only an occasional grain as large as 100 μ. A test with a screen showed only a trace of 250 mesh B.S.S. (60 μ) quartz.

A sample of the lower section ore was crushed to pass a 20 mesh Tyler screen. The sample was then divided into three size fractions, each fraction being individually fed through a laboratory induced-roll magnetic separator.

Though some separation of the particles was observed, the analyses showed little difference in the total iron content of the magnetic and non-magnetic portions.

A sample of the full face ore, crushed to minus 8 mesh (Tyler) and separated into two fractions of minus 8 mesh plus 48 mesh and minus 48 mesh, was tested for the elimination of moisture and condensed water. Each fraction was subjected to various temperatures in the electric oven and then cooled in one of the following ways:—(a) in a desiccator followed by weighing when cool, and (b) in an open dish in the air, allowed to come to equilibrium overnight and weighed next day. The following results were recorded, Tables 22, 23.

TABLE 22.

Loss in Weight on Heating, Minus 8 Plus 48 Mesh Material.

(Predried at 125°C. for 3 hours (loss 1.79 per cent.).)

Temperature	Time of heating	Per cent. weight loss	
		Desiccator cooled	Air cooled
°C.	hours		
200	1	1·02	no loss
200	1	1·08	no loss
250	1	3·52	2·4
250	1	3·70	2·5
300	1	8·18	4·99
300	1	8·3	4·97
350	1	8·6	5·32
350	1	8·5	5·29
400	1	8·77	5·58
400	1	8·76	5·63
500	1	9·45	6·06
500	1	9·45	5·97
650	1	9·93	8·4
650	1	9·70	8·5
800	1	10·20	9·83
800	1	10·40	....

TABLE 23.

Loss in Weight on Heating, Minus 48 Mesh Material.

Temperature	Time of heating	Per cent. loss in weight	
		Desiccator cooled	Air cooled
°C.	hours		
115	1	0·99	0·40
115	1	0·98	0·41
115	2	1·44	0·45
115	2	1·52	0·55
225	1	3·73	1·82
225	1	3·32	1·50
225	2	3·50	....
225	2	3·65	1·70
315	1	9·45	....
315	1	9·45	5·18
315	2	9·53	....
315	2	9·50	5·45
420	1	9·68	5·64
420	1	9·75	6·25
420	2	9·97	6·15
420	2	9·92	6·40
500	1	10·30	7·93
500	1	10·35	7·76
500	2	10·3	8·20
500	2	10·3	8·27
700	2	11·2	10·2
700	2	11·1	10·1

Summary.—The exploratory tests carried out so far would indicate that—

(a) from the two main contaminants in the ore—silica and water—silica is in a finely divided state and may prove difficult to remove for economic beneficiation;

(b) the elimination of water should give an easier upgrading. To achieve a degree of beneficiation resulting in a product with more than 60 per cent. total iron, the ore has to be heated to between 600° and 700°C., if the product was to be cooled under atmospheric conditions. The tests so far are of an exploratory nature only and more detailed work remains still to be carried out.

Calcination of Beneficiated Calcareous Sand.

As reported previously, considerable difficulties were experienced with blockages in the lime recovery system of the entrained bed calcining pilot kiln during a prolonged run, indicating that the design of this portion of the kiln required modification.

Among the theories advanced, is that one of the main reasons for these blockages might be the decrepitation of lime sand particles when the sand at ambient temperature was introduced directly into the hot zone at the bottom of the calcining shaft. Very fine particles are created by decrepitation which, calcined to lime, cause trouble in the way of blockages in the settling chamber and the product cyclone.

It was considered possible that the heating of sand gradually to the calcining temperature of around 1050°C., or heating in temperature steps not exceeding certain limits, would greatly minimise the decrepitation and hence the danger of blockages.

In order to verify this, a separate two-stage preheating system for sand, consisting of a furnace and two cyclones, was erected utilising the drier furnace of the existing coal carbonising retort.

In two exploratory runs with this unit, a sand temperature of 410° and 460°C. respectively was attained. However, the presence of fine particles in the gas exhaust system of the unit was still evident, suggesting that the temperature difference between the incoming gas and incoming sand in one or both of the stages may still have been too great.

Although no trouble was experienced during the following two calcinations runs, where the above sand preheating system was used in conjunction with the calciner proper, the results of the second, longer, run of three days duration indicated that the continuous operation of the calciner for a prolonged period would not have been possible, and further modifications of the plant are required before the lime collecting portion of the calciner can operate efficiently. These modifications were in progress by the end of the year.

Below are the analyses of the material used and the product made in the last mentioned run:—

Lime Sand.

	Raw Sand Per Cent.	Beneficiated Sand Per Cent.
$CaCO_3$	75.7	91.5
$MgCO_3$	5.65	6.24
R_2O_3	0.5	0.45
Acid insoluble	17.1	0.55

Lime Produced.

	Per Cent.
Total CaO	89.5
Sucrose soluble CaO	87.3
MgO	4.93
S	0.13

Additional Investigations Into Upgrading of Ilmenite.

Though the work on upgrading of local ilmenite, which was commenced in 1959 and led to a patent application, was successfully finalised by the end of 1961, the activities of the Division as consultants to a local company, which erected a pilot plant based on the process developed required some additional investigations contributing to the general knowledge of the actual technology of the process.

(1) Aeration under Elevated Pressure.—Some work on aeration of reduced ilmenite under elevated pressure was carried out in the early stages of investigations into upgrading of ilmenite. It was considered desirable to repeat the above experiments in the light of experience gained in the meantime with the aeration under atmospheric pressure.

The experiments were carried out in the 3-litre capacity laboratory pressure vessel using as feedstock reduced ilmenite containing 29.6 per cent. of metallic iron. The results, of the tests carried out at 90 to 100 lb/in^2 pressure showed that the average aeration efficiency (a) expressed as the ratio of metallic iron converted to ferric oxide to oxygen admitted, was 52.8 per cent. and (b) expressed as the ratio of oxygen absorbed to oxygen admitted, was 37.1 per cent.

Compared with aeration under atmospheric pressure, these figures are 6 to 7 times higher. The oxidation under pressure also proceeded more than five times as fast as under atmospheric pressure within the limits of 50° and 150°C. The temperature of aeration appeared to have little effect on the rate of oxidation.

Since all the iron was oxidised, the results suggest that hydrogen must have been evolved according to the reaction:

$$2Fe + 3H_2O = Fe_2O_3 + 3H_2$$

This was verified by agitating reduced ilmenite suspended in water at 150°C in the vessel pressurised with nitrogen.

(2) Conditions Governing the Rate of Ilmenite Reduction.—In connection with irregularities encountered in the reduction stage of the pilot plant at Capel, some work was carried out by the Division for a better understanding of conditions governing the rate of reduction of iron oxides in ilmenite.

In the first series of experiments, the mixture of ilmenite and carbon from various sources, was placed in crucibles and the crucibles exposed to a temperature of 900°C in a muffle furnace for varying periods. After treatment, the crucibles were cooled in nitrogen. Some 60 reduction tests were carried out in this way and the results can be summarised as follows:—

(a) The origin of the carbon, and the method of its preparation, have an effect on the time required for reduction. Sawdust, or char prepared from it, was found to be inferior to Collie coal or char prepared from it at 700°C. These results are in accordance with the results obtained elsewhere.

(b) Within certain limits, the size of carbon used appeared to have little effect on the rate of reduction.

(c) The addition of other materials to the ilmenite-carbon mixture has some effect on the quantity of metallic iron formed in a given time, the acidification of the carbon prior to reduction being particularly harmful. The addition of basic materials, e.g. $CaCO_3$, resulted in a slight improvement.

(d) Oxidation of ilmenite prior to reduction appeared to promote the reduction.

(e) Under the conditions applied a 94 per cent. reduction of iron oxides in ilmenite to the metallic state was attained in 80 minutes. A prolonged heating for 240 minutes increased this to about 97 per cent.

In the second series of experiments, the rate of gas evolution was measured for observing the reduction reaction. The experiments were carried out in a small stainless steel crucible with a gas outlet to an Orsat apparatus. Provisions were made for vibrating the apparatus while in the furnace.

The indications are that under these conditions the reduction was completed much faster than in the stationary crucible as used in the first series of tests. Though altogether 38 lots of ilmenite of an average weight of 10 grammes were reduced, still more experimentation is required to clarify the influence of several factors.

The results up to date would indicate the following:—

(a) Sawdust and its char again proved to be inferior to Collie coal char as a reducing agent.

(b) Preoxidation of ilmenite reduced the temperature at which rapid reduction takes place as indicated by the comparison of the following two results:—

	Temperature	Time of Reduction Minutes	Metallic Iron Per Cent.
Ilmenite	1000°C	23	23.6
Preoxidised ilmenite	1000°C	23	30.5

(c) Increasing the temperature of reduction from 900°C to 1100°C increased the rate of reaction by a factor of at least three.

(d) On using the char a second time, the rate of reduction at 1100°C appeared to be only a half as fast as with fresh char produced at 700°C.

(e) Sodium carbonate added to the char as a solution, appeared to have a slight beneficial effect on the reduction reaction. Sodium chloride and calcium chloride addition had a detrimental effect, reducing the degree of reduction at 1100°C in a given time by a factor of two for calcium chloride and by a factor of four for sodium chloride.

(3) Reduction of Ilmenite in Fluidised Bed.—Consideration was given to the possibility of the reduction of ilmenite in fluidised bed, and some exploratory tests were carried out in the bench scale equipment.

The results of the U.S. Bureau of Mines Investigation No. 3869, dealing with the selective reduction of iron oxides in ilmenite, indicate that neither hydrogen nor carbon monoxide is a practical agent for reduction, as the theoretical maximum utilisation of the reductant is only 20 per cent. and 8.5 per cent. respectively at the temperature just below the melting point of ilmenite. According to the same report, solid carbon, to the contrary, is very effective, requiring a temperature of around 1100°C to obtain a practical rate of reduction. Consequently, the reduction of ilmenite has to be carried out in the presence of solid carbon, which makes the application of fluid bed technique more complicated.

Tests were made in a glass model to ascertain whether and under what conditions the mixture of ilmenite and suitably sized char would segregate in a fluidised bed. Later the process was studied in the stainless steel unit used in the investigations for the recovery of elemental sulphur from gold ore concentrate.

Seven exploratory runs were made, operating the unit batch wise. Despite difficulties encountered because the unit was designed for a quite different purpose, results showed that:—

(a) it is possible to reduce ilmenite in fluidised bed in the presence of solid carbon; and

(b) preoxidised ilmenite responded much better to the treatment than ilmenite as received, the use of lower reduction temperatures, well below the sintering temperature of ilmenite being possible.

In order to illustrate the latter point, the results of two runs are compared below. In both runs 1500 g. of ilmenite were fluidised with nitrogen, and 1000 g. of Collie coal char added to the bed after the temperature reached 900°C.

TABLE 24.
Reduction of Ilmenite in Fluidised Bed.

	Ilmenite as received		Preoxidised ilmenite	
	Per cent.	Per cent. of theoretical maximum	Per cent.	Per cent. of theoretical maximum
Metallic iron after treatment for :				
15 minutes	14·5	44·9	....	....
20 ,, ...	....	....	24·9	75·0
30 ,, ...	19·7	56·3	....	....
35 ,, ...	....	....	31·0	93·4
45 ,, ...	22·4	67·5	....	....
50 ,, ...	....	....	32·0	96·4
60 ,, ...	25·3	75·7	....	....

(4) Miscellaneous.—(a) The effect of hot air on the reduced ilmenite was briefly studied. It was found that in slowly moving air, the reoxidation of reduced ilmenite set in at about 140°C. At 400°C. the rate of reoxidation was still comparatively low—around 0.3 per cent. Fe per minute. The moisture content of the air appeared to influence the reoxidation to a marked degree.

When reduced ilmenite at 180°C. was wetted and redried at 110°C. with agitation its metallic iron content was reduced from 30 per cent. to 27.5 per cent.

(b) It was shown that the ilmenite, as delivered by Western Titanium N.L. starts to be entrained in the air at a superficial velocity of the air of 3.7 ft./sec. and is completely entrained by the time the superficial velocity reaches 7.5 ft./sec. The screen analysis of the ilmenite was:—

Size Fraction, Mesh, Tyler Screen.	Per Cent. by Weight.
+ 48	0.15
- 48 + 65	5.15
- 65 + 110	37.95
-110 + 200	55.0
-200	0.8

and the bulk weight: 154 lb./cu. ft.

(c) Some experiments were carried out to determine whether and how the metallic iron content of reduced ilmenite could be determined by measuring either the electric resistivity or the magnetic properties of a flowing stream of material. This was considered important in connection with the control of operation of the reduction kiln.

A scheme, based on measuring the electric resistivity, which appeared to work reasonably well, was recommended to the interested party for further evaluation and development.

(d) Laboratory work designed for clarification of the factors causing reduced ilmenite to "rust in situ" during aeration, was continued intermittently. Certain theories were advanced as to the likely causes, and the effect of various factors was investigated.

The results of the work up-to-date failed, however, to positively identify the causes of this undesirable process.

(5) Utilisation of Iron Oxide Produced in the Process.—Investigations were initiated into the possible utilisation of the iron oxide produced as a by-product in the process for upgrading ilmenite.

From previous investigations it was known that the material is in an extremely fine state, only about 0.5 per cent. of it being coarser than 300 mesh B.S.S. Depending on separation efficiency after aeration, the iron oxide contains varying amounts of titanium oxide the minimum being about 4 per cent.

According to the work carried out by the Kalgoorlie Metallurgical Laboratory (Report No. 715—26/9/61), it is possible to reduce TiO_2—content of the product to around 2 per cent. by flotation using Aeromine 3037 as collector.

The first efforts were directed towards determination of the usefulness of the oxide as pigment, comparing it with the natural and synthetic iron oxides marketed in this State.

A study of the relevant literature was made followed by laboratory tests designed to vary and to control the colour and shades of the oxide.

Two samples of calcined oxide were analysed as having an average iron content of 61.2 per cent. which compares very favourably for instance, with the oxide occurring naturally in the Weld Range (iron content approx. 45 per cent.) which finds some use as pigment.

A comparison of the size distribution of the oxide with a pigment grade oxide imported from Germany, showed the following results (sizing in water suspension using the standard sedimentometer).

TABLE 25.
Size Distribution of Iron Oxide Pigment.

Nominal size range	Oxide from ilmenite	Imported pigment
microns	Per cent.	Per cent.
90–64	4·8	1·5
64–45	....	....
45–32	1·5	0·1
32–23	6·2	0·1
23–16	7·8	....
16–11	6·4	2·3
11– 8	4·4	10·4
8–5·7	3·9	13·0
5·7–4·0	3·5	6·6
4·0–2·8	3·6	5·3
under 2·8	57·9	60·7

The manufacturers of paint, concrete tiles, masonry blocks, and lime-sand bricks were approached, and asked to test the oxide as pigment in their coloured products.

From the reports received, it appears that the oxide may be considered as technically satisfactory for colouring lime-sand bricks and masonry blocks giving a colour approaching "salmon pink". However a measure of "colour fastness" was still required.

A number of concrete slabs, coloured with iron oxide from upgrading of ilmenite, were then prepared and submitted to the Industrial Chemistry Division for testing under ultra-violet light in a special machine. The test revealed no significant change in colour after exposing the slabs to the light for a long period.

Upgrading of Leucoxene.

Some work on upgrading leucoxene by the process developed for upgrading ilmenite, was carried out by the Division on the request of a local company. The aim was to repeat on a large scale the work done in the previous year in bench scale equipment, and at the same time to produce a quantity of upgraded leucoxene for dispatch for trial purposes.

Beneficiation of Calcareous Beach Sand.

Approximately 5 tons of calcareous beach sand were beneficiated at the request of a local firm. Using the high tension separation method the sand containing 8.3 per cent. acid insolubles was beneficiated to a product containing 0.8 per cent. acid insolubles.

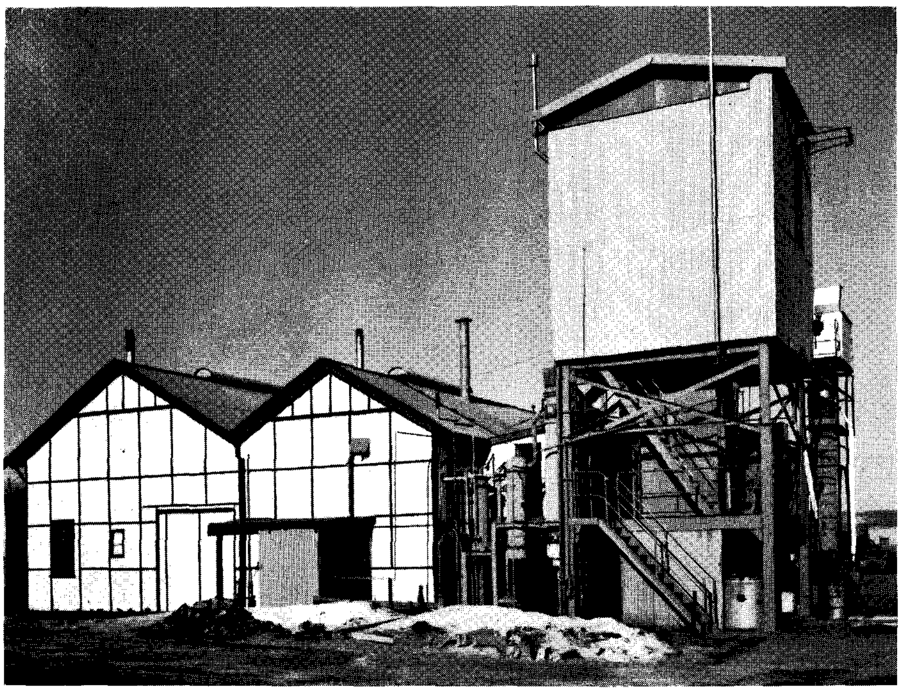
Magnetic Separation of Laterite and Gravel.

Two parcels of laterite containing ferruginous particles, one parcel of bauxite and one parcel of gravel were subjected to magnetic separation using a magnetic head pulley. The purpose of the test was to ascertain whether some enrichment of the material in Al_2O_3 can be achieved in this simple way. The work was done for a local firm.

Advisory Service.

The Division continued to provide advisory service to industry and other government Departments. Most intensive activity in this field was centred around the consultative service to a local industry in connection with the operation of their semi-commercial (or large scale pilot) plant for upgrading of ilmenite based on the process developed by this Division.

Besides numerous discussions and meetings held in Perth, the members of the staff of the Division spent during the year 49 man-days (including travelling time) at the plant.



Pilot Plant.

General.

(1) Chief Chemical Engineer, Dr. S. Uusna, took an active part in the preparation of the paper to the 6th Plenary Meeting of the World Power Conference entitled "Production of Metallurgical Fuel from Sub-Bituminous Coal (in Western Australia)" which summarises the work done by this Division (and Fuel Technology Division). He was also a delegate to this conference held in Melbourne from 20th to 27th of October and took part in discussions.

(2) During the week following the conference in Melbourne, the Chief Chemical Engineer visited research establishments (B.H.P. Central Research Laboratories, Atomic Energy Commission's Establishments, etc.) and some industries in New South Wales.

(3) Among the interstate and overseas visitors to the Division, with whom fruitful discussions were held, were:—

Mr. F. Olmsted, Cabot Corp., U.S.A.

Mr. P. M. Rinaldo and Mr. S. Smith, W. R. Grace & Co., U.S.A.

Mr. G. W. Leckey, Chemical Plant & Engineering Co. Pty, Ltd., West Footscray, Victoria.

Mr. O. Wiseapple, American Potash & Chemical Corp., U.S.A.

Mr. Tui-Mei Wu, Mr. Sun-Dah-Chang and Mr. J. J. Chao, Formosa Plastic Corp., Taiwan (Formosa).

Mr. W. A. Fullarton, Coke & Carbon Development Division, F.M.C. Corporation, U.S.A.

Dr. A. Parker, International Executive Council, World Power Conference, Great Britain.

FOOD, DRUGS, TOXICOLOGY AND INDUSTRIAL HYGIENE DIVISION.

The greater proportion of the work carried out by this Division consisted of chemical examinations for the Departments of Public Health, Police, Agriculture and Public Works, as well as for the Milk Board of Western Australia and the Swan River Conservation Board, but the usual variety of miscellaneous work was also performed for other Government Departments and for the general public.

The personnel of the Division comprised, nominally, twelve officers, but owing to staff shortages the Division was at its full nominal strength for only one month during the year.

3177 samples were received during 1962, being an increase of 9 per cent. on the number received in 1961, and an increase of 34 per cent. on the corresponding 1960 figures. The chief increases occurred in the number of samples of milk analysed, and in the number of samples classified under industrial hygiene and human toxicology.

A broad outline of the variations in numbers of samples over recent years is indicated in the following classification, Table 26.

Class	1958	1959	1960	1961	1962
Milks	189	281	194	437	574
Cheese	54	113	84	140	71
Exhibits—Alcohol	229	316	358	315	331
Human toxicology	284	290	421	388	611
Industrial hygiene	86	305	327	335	446
Pesticides	34	34	24	160	231
Pollution surveys—					
Swan River	205	128	204	178	128
Bunbury	48	48	48	50	50
Total, general samples	2,604	2,639	2,436	2,901	3,177

Table 27 shows the source and description of samples received during 1962.

TABLE 27.

Food and Drug Division, 1962.

	Agriculture Department	Departmental	Mines Department	Police Department	Public Free	Public Health Department	Public Works Department	Swan River Conservation Board	Tender Board	University	Other Government Departments	Pay: Department of Air	Pay: Hospitals	Pay: Milk Board of W.A.	Pay: Public	Pay: Other Government Departments	Total
Foods—																	
Apples	16	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	16
Cheese	71	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	71
Food Dyes	....	....	....	....	....	10	....	....	....	....	....	....	....	....	....	....	10
Milk—Bovine	....	....	....	....	....	....	....	....	....	....	....	....	....	574	....	....	574
Oranges	80	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	80
Vinegar	....	....	....	....	....	14	....	....	....	....	....	....	....	....	....	....	14
Wine	12	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	12
Various	5	....	....	....	....	21	....	....	6	....	4	1	....	....	....	....	37
Industrial Hygiene—																	
Air	....	....	38	....	....	189	....	....	....	....	....	....	....	....	....	....	227
Hair and Nails	....	....	....	....	....	10	....	....	....	....	....	....	3	....	3	....	16
Urine	....	....	....	....	....	113	....	....	....	....	5	....	6	....	54	2	180
Various	....	....	....	....	....	21	....	....	....	....	1	....	1	....	....	....	23
Miscellaneous—																	
Building Materials	....	....	....	....	....	16	....	....	....	....	....	....	....	....	....	....	16
Criminal Cases	....	....	4	45	....	....	....	....	....	....	....	....	....	....	....	....	49
Detergents	....	....	....	....	....	....	1	....	57	....	....	....	3	....	....	....	61
Oxygen	....	....	....	....	....	....	....	....	....	....	....	32	....	....	....	....	32
Paint	....	....	....	....	....	....	25	....	....	....	....	....	....	....	....	....	25
Pesticide	117	....	....	....	....	1	111	....	....	....	....	....	....	....	2	....	231
Resin	....	17	....	....	....	....	....	....	....	....	....	....	....	....	....	....	17
Sheep Sera	18	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	18
Water	3	12	....	2	....	14	....	....	....	....	....	4	....	....	....	....	35
Various	18	4	10	3	4	19	9	....	13	7	7	1	3	....	22	4	124
Pollution—																	
Effluent	....	....	....	....	2	....	2	19	....	....	....	....	....	....	2	....	25
Maritime	....	....	....	5	....	....	....	....	....	....	....	....	....	....	....	....	5
Sewage	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	1
Water—Bunbury	....	....	....	....	....	....	48	....	....	....	....	....	....	....	....	....	48
Water—Swan River	....	....	....	....	....	....	....	109	....	....	....	....	....	....	....	....	109
Toxicology—																	
Human :																	
Alcohol—Sobriety	....	....	....	150	....	1	....	....	....	....	....	....	....	....	1	1	153
Alcohol — Traffic Death	....	....	....	180	....	....	....	....	....	....	....	....	....	....	....	....	180
Toxicology	....	....	....	601	....	1	....	....	....	....	....	....	7	....	....	....	609
Specimens Patients	....	....	....	....	....	19	....	....	....	....	....	1	69	....	3	....	92
Animal	77	....	....	7	....	2	....	....	....	....	....	....	....	....	1	....	87
	417	33	52	993	6	451	196	128	76	7	17	39	92	574	89	7	3,177

Foods.

(1) A total of 815 samples of foods was received and examined during the year. 574 of these were samples of cows milk submitted by the Milk Board of Western Australia. Of this number 537 were milks suspected of being adulterated or of failing to comply with the standards required by the Regulations under the Milk Act. 5.6 per cent. of these samples contained less than the legal minimum of milk fat (3.2 per cent.), and 48.6 per cent. contained less than the legal minimum of solids not fat (8.5 per cent.), while 79.4 per cent. of the samples failed to comply with the legal standard for freezing point of milk (0.540 degrees Centigrade below zero). The proportion which failed to comply wtih the standards for fat and freezing point is much the same as in 1960 and 1961, but in respect of solids not fat the figure of 48.6 per cent., while an improvement on that for 1960 (57.5 per cent.) is a decline on the 1961 figure of 34.5 per cent. The distribution of analytical figures is shown in the following table:—

Milk Fat.

Per Cent. in Sample.	Per Cent. of Total Samples.
Less than 3.00	1.5
3.00-3.19	4.1
3.20-3.49	16.7
3.50-3.74	21.0
3.75-3.99	11.1
More than 3.99	45.6
	100.0

Milk Solids Not Fat.

Per Cent. in Sample.	Per Cent. of Total Samples.
Less than 8.00	2.0
8.00-8.24	16.2
8.25-8.49	30.4
8.50-8.74	31.1
8.75-8.99	16.4
More than 8.99	3.9
	100.0

Freezing Point.

Degrees C below Zero.	Per Cent. of Total Samples.
Less than 0.500	0.2
0.500-0.509	1.0
0.510-0.519	2.4
0.520-0.529	19.8
0.530-0.539	56.0
0.540-0.550	17.6
More than 0.550	3.0*
	100.0

In presenting the above figures it is emphasised that they were in respect of samples for which there was prima facie evidence of their not complying with legal standards.

An investigation by the Milk Board into factors affecting animal nutrition and milk quality was continued in 1962, and in this connection 37 samples of selected milks were analysed more fully for the Board.

(2) 71 samples of cheese were analysed for the Dairying Division of the Department of Agriculture as a check on the quality of cheese produced by factories in this State. Of this number 87 per cent. contained more than 50 per cent. of fat calculated on the moisture-free basis.

(3) Only 6 samples of food were submitted by the Government Tender Board. These consisted of sweetened and unsweetened condensed milks which were examined to determine their suitability for use in Government institutions.

(4) 5 samples of grapes were analysed for the Department of Agriculture in a continuation of their investigation of the seasonal variation in sugar and acid content of certain varieties of grapes.

* In more than half these samples with a freezing point depression exceeding 0.550°C, the acidity was greater than normal.

(5) 80 samples of oranges were examined for the Department of Agriculture as part of a study of the effects of spray treatment on the maturity of the fruit.

(6) The work of the Department of Agriculture on the use of diphenylamine to control "scald" in apples was continued in 1962, and 15 samples of apples were analysed to determine surface residues of diphenylamine and its concentration in the pulp of the fruit.

(7) 14 samples of vinegar were analysed for the Public Health Department. Although only one was incorrectly described on its label, there were numerous minor infringments of the labelling requirements of the Food and Drug Regulations.

(8) Following the detection of a non-permitted artificial colouring in a sample of concentrated fruit cordial, a number of samples of dyes, concentrates, etc., used in its preparation were examined in an endeavour to locate the source of the particular colouring. It was finally concluded that the colouring in question was produced by chemical action of a preservative on one of the permitted colourings used in the cordial.

(9) 12 samples of wine were received from the Department of Agriculture in connection with problems encountered in manufacture or storage. These were examined variously for iron, copper, albumen, sulphur dioxide and traces of insecticide.

(10) 40 samples of canned meats which had been deferred from 1961 were also analysed. These had been submitted by the Public Health Department in a survey of the products of this nature being sold on the local market. Analysis indicated that nearly half of these samples did not strictly comply with the present requirements of the Food and Drug Regulations.

(11) Miscellaneous foods examined during the year included sausages, mince and sausage meats, fish, olive oil and pineapple juice which were examined for compliance with specific requirements of the Food and Drug Regulations.

Human Toxicology.

Samples were received from approximately 330 cases of sudden death which were the subject of police investigation. Over 100 cases were as a result of "traffic accident," while 161 cases, comprising 535 exhibits, were examined for the presence of poison or other physiologically active drug.

In 46 cases no poison or drug was detected, while in 115 cases a poisonous substance or other drug was identified on analysis.

In a small number of cases more than one poison or drug was detected. Details are listed in Table 28.

TABLE 28.

Poison or Drug	No. of Cases
Carbon monoxide	29
Pentobarbitone	19
Amylobarbitone	8
Butobarbitone	3
Phenobarbitone	2
Bartiturate (unidentified)	15
Carbromal	8
Alcohol	8
Strychnine	8
Arsenic	2
Aspirin	2
A.P.C.	2
Cresol	2
Malathion	2
Nicotine	2
Chlorpromazine	2
Ergot	2
Thallium	2
Succinic acid	2
*Various (one of each)	11
Negative	**46**

In 57 of the 120 cases where a sample of blood was available, alcohol was found to be present. The concentration of alcohol in the blood was 0.15 per cent. or greater in 37 of these cases.

* Quinalbarbitone, Cyanide, D.D.T., Chloral, Mercury, Methanol, Toluol, Impramine, (Tofranil), Methedrine, Glutethimide, Sulphonamide.

From another 52 cases of sudden death other than "traffic accident," blood samples were examined for alcohol, making a total of 172 such cases of sudden death where the blood-alcohol figure was determined as a routine procedure. The distribution of the blood-alcohol figures is indicated in the following table:—

Alcohol Per Cent.	No. of Cases.
Negative	81
Less than 0.05	15
0.05-0.09	10
0.10-0.14	9
0.15-0.20	19
0.21-0.30	29
More than 0.30	9
	172

From the table it will be observed that in 57 cases, i.e., 33 per cent. of the total, the blood-alcohol figure was 0.15 per cent. or greater.

Blood-Alcohol (Traffic).

One hundred and eighty samples of blood and/or urine were received in connection with investigations into fatal traffic accidents. One hundred and two of these consisted of "post-mortem" blood samples which were analysed for alcohol content as a routine procedure.

The distribution of the analytical figures for the various categories of persons involved in these accidents is shown in the following table:—

Alcohol (per cent.)	Number Involved		
	Drivers	Passengers	Pedestrians
Negative	13	10	15
Less than 0·05	4	3	....
0·05–0·09	7	4	....
0·10–0·14	7	3	3
0·15–0·20	7	3	2
More than 0·20	13	5	3
	51	28	23

The above table indicates that 39 per cent. of fatally injured drivers had a blood-alcohol figure of 0.15 per cent. or more, while the corresponding figures for passengers and pedestrians was 29 per cent. and 22 per cent., respectively.

Voluntary Blood-Alcohol Tests.

One hundred and fifty samples of blood were submitted by the Police Department and one by a local Government Authority in connection with charges of "driving while under the influence of intoxicating liquor". These samples were taken from persons who on being charged with such offence, had exercised the right provided by the Traffic Act to offer a blood sample for chemical analysis.

This Act states that if the alcohol content of the blood at the time of the alleged offence is 0.15 per cent. or greater it shall be prima facie evidence that the accused was under the influence of intoxicating liquor at that time. The results of these analyses are set out in the following table, the figures being the alcohol content of the blood at the time of the alleged offence, calculated by the formula prescribed in the Blood Alcohol Test Regulations 1958:

Alcohol Per Cent.	No. of Cases.
Less than 0.15	3
0.15-0.20	29
0.21-0.25	55
0.26-0.30	48
0.31-0.35	15
More than 0.35	1
	151

Animal Toxicology.

(1) There was a distinct increase in the number of samples received in connection with suspected poisoning of animals. Of the 30 cases which were examined 17 were found to be negative, while there were 7 cases of poisoning due to strychnine, 5 due to arsenic, and one due to metaldehyde.

Only four samples were received of meat "baits" suspected of containing poison; three of these were found to contain strychnine.

(2) Ten samples comprising variously teeth, bones and tissues were analysed, principally for fluorine, in continuation of the experiments on supplementary diet conducted by the Department of Agriculture.

(3) The Animal Health Branch of this Department commenced an investigation into Vitamin A deficiency, particulary of sheep, and in this connection analyses for Vitamin A were carried out on 17 samples of animal liver, 19 of blood serum and one of whole blood.

Industrial Hygiene.

Samples received in connection with industrial hygiene investigations again showed an increase in 1962, numbering 446 as compared with 335 in 1961.

(1) One hundred and sixty-seven of these were specimens of urine from persons exposed to actual or potential lead hazard, and which were submitted for chemical analysis in order to assist the clinical diagnosis. 80.8 per cent. of these specimens contained less than 0.08 parts per million (milligram per litre) of lead, which is generally accepted as the normal upper limit. The distribution of the figures obtained in these analyses is shown in the following table:—

Lead (Pb) Parts per Million	Per Cent. on Total Samples
Less than 0.08	80.8
0.09-0.15	17.4
0.16-0.20	1.2
0.21-0.30	0.6
	100.0

The 19.2 per cent. of samples which contained more than 0.08 parts per million of lead included a number of repeat analyses carried out for supervisory purposes.

(2) One hundred and fourteen analyses of urine and 24 of hair and nails were also carried out with a view to detecting the presence of toxic metals, although not all of these were necessarily associated with industrial hygiene. These consisted of analyses for arsenic 58, copper 38, lead 30, thallium 7 and mercury 5.

(3) Eight samples of urine from workers using benzene were examined to determine the ratio of inorganic to organic sulphate, as a measure of their exposure to benzene during working operations.

(4) Similarly 3 samples of urine were analysed for trichloroacetic acid as a measure of exposure of workers to trichloroethylene, and 5 samples of urine were analysed for para-nitrophenol to assess the possible hazard in a specific enquiry regarding the use of organic phosphate insecticides.

(5) Two hundred and twenty-seven samples of air were analysed during the year. Ten of these were samples from assay offices which were examined for hazardous concentrations of lead fume or dust. Twenty-eight samples of mine air were analysed for oxygen, carbon dioxide, carbon monoxide and oxides of nitrogen in connection with investigations by the Mines Department into the gaseous products of explosive mixtures.

(6) Investigations into the use of phosphine and cyanogas as fumigants in bulk wheat installations were continued by the Public Health Department in collaboration with commercial authorities, and 24 samples of air were analysed for phosphine content and 139 for cyanide. Most of the examinations were made at the Geraldton wheat silo, but samples from Fremantle were also tested.

Tests of air for cyanide were also made in the hold of a cargo ship in order to check that conditions were safe for unloading the cargo of cyanide.

The possible absorption of sodium fluoroacetate as a fine dust during the formulation of poisoned oats was investigated by the Public Health Department, and samples of air collected by means of a Greenberg-Smith Impinger. Two such samples were examined for sodium fluoroacetate late in the year, and investigations into this problem are being continued.

Dust cartridges from respirators being worn by workers were also examined, four for sodium fluoroacetate and two for mercury which in the form of organic fungicide was being used for the treatment of seed grain.

(7) Miscellaneous samples which were examined included a surface hardening preparation analysed for traces of arsenical contamination, paints which were tested for the presence of lead, a liquid hardener submitted for identification of its nature, and a sample of water alleged to be causing dermatitis which was analysed for traces of petroleum products.

Pollution Surveys.

(1) Swan River.—The regular quarterly surveys of the Swan River were continued in 1962 when 128 samples were analysed for the Swan River Conservation Board. 111 of these were samples of river water from selected points of possible pollution, while 17 were samples of trade effluents examined to determine their suitability for discharge into the river.

(2) Leschenault Inlet Bunbury.—The normal summer and winter surveys were carried out in January and June, when 50 samples were collected and analysed. In accord with previous surveys the degree of pollution was greater in the winter, but in general the position has improved following the diversion to sea of much of the effluent which had formerly discharged into the inlet.

(3) Maritime.—5 samples of oily fluids alleged to have been discharged from ships into the waters of Fremantle Harbour were analysed to provide supporting evidence as to the nature of the fluid.

Miscellaneous.

(1) Thirty-two samples of "high altitude" oxygen were received and examined for the Department of Air. This oxygen is prepared to exacting specifications, and a laboratory check is performed on each batch, in addition to the normal factory inspection tests.

(2) Sixteen samples of varied materials were tested for fire resistance by means of the standard "fire test cabinet", in order to assist the Public Health Department in determining their suitability for use in public buildings.

(3) Twenty-four samples of paint were examined for the Public Works Department, chiefly to determine the nature of the vehicle present in the sample. Seventeen samples of resins for use in paints were also examined departmentally to determine their identity.

(4) Fifty-seven samples of detergent materials were the subject of extensive consideration in order to advise the Government Tender Board as to those which were most suitable for use in Government institutions.

(5) Waters.—35 samples were received and examined in connection with the actual or suspected contamination of water.

Thirteen were samples of water from wells adjacent to industrial establishments; these were analysed to determine if contamination from trade effluents was reaching the wells.

Investigations which commenced in 1960 concerning an unusual chemical contamination of water, were continued in 1962 when 11 further samples of water were analysed for phenolic substances and for chloro derivatives of phenoxyacetic acid.

Four samples were examined in connection with the unpleasant flavour imparted to water stored in a certain type of canister. The cause of the trouble was found to be the type of protective coating used on the internal surface of the canister.

Miscellaneous samples of water were analysed to determine the identity of a dyestuff added to an ornamental pool, and in another case to check the possible source of toxic symptoms in animals. An unusual case of illness from drinking water from a household tank was considered to be due to contamination by the toxic droppings from a nearby tree.

(6) The number of pesticides received in 1962 was much greater than in the previous years. Nearly half of these were diluted aldrin emulsions used by the Architectural Division, Public Works Department in white ant preventive treatments, and nearly one quarter were weedicides of the 2:4D type which were subject to check analysis for the Weeds and Seeds Branch of the Department of Agriculture. The number and variety of pesticides received is shown in Table 29:—

TABLE 29.

Pesticide.	Number of Samples.
Aldrin (diluted)	111
Chlordane (pure)	2
Chlordane concentrate	4
Dieldrin concentrate	26
Dieldrin (solid)	6
Malathion concentrate	3
Malathion (diluted)	21
Thiodan	2
Weedicides (2:4D type)	54
Various	2
	231

There was a marked decrease in the number of samples received from the Agriculture Protection Board, only three samples of poisoned oats being analysed for sodium fluoroacetate.

The use of malathion to combat weevil infestation of stored wheat was the subject of investigation by the Public Health Department, and samples of wheat were analysed to determine the extent of the residual malathion after an appropriate interval.

(7) Grocery items submitted by the Government Tender Board were few in number, 6 samples of floor polish and 7 samples of soap being the only items received. These were examined to determine their relative suitability for the purposes required by the board.

(8) Only four samples of drugs were received in 1962, apart from those examined in connection with toxicological work. These comprised opium tincture and "mother-liquor", dextrose-saline solution, and traces (1/32nd grain) of a powder which was identified as the remains of a methedrine tablet.

(9) Forty-nine exhibits were submitted in connection with criminal investigations or other police enquiries. Sixteen varied exhibits were analysed following the illness of a group of people after drinking tea, 13 exhibits were examined in connection with charges of breaking and entering, nine exhibits were submitted in an endeavour to ascertain the cause of several fires, and miscellaneous exhibits were received from alleged "hit-run" cases and from suspected adulteration of food.

(10) Samples examined for the Explosives Branch included the routine analysis of commercial explosives, the identification of the solid propellant material used in pyrotechnic rockets, and of an exudate from a plug of gelignite, and exhibits in connection with the illegal possession of explosives.

(11) Nine samples of tallow were received from various sources and analysed to determine their quality in terms of normal trade requirements.

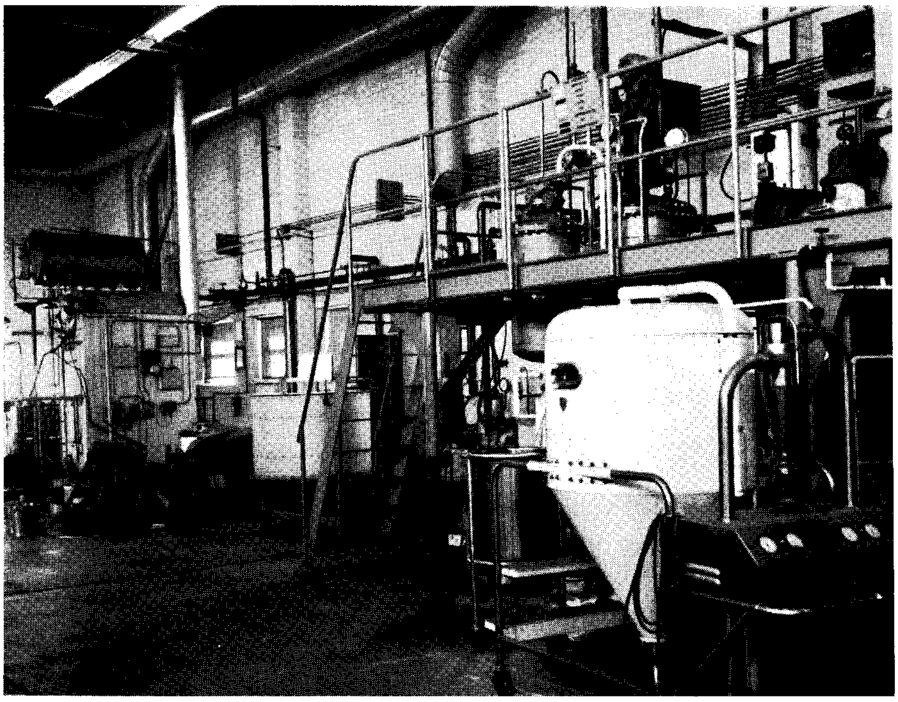
(12) Six samples of varied fuel and lubricating oils and two samples of kerosene were examined, in some cases to prescribed specifications, and in others to determine the degree of dilution which had occurred in a crankcase oil.

(13) Several samples of dusts and deposits, and of substances found on beaches, were received for identification. None of the latter proved to be ambergris, and a deposit thought to have originated from an aircraft exhaust was identified as a gum similar to that exuded by trees.

(14) A sample of brine used for the storage of cheese was submitted because of a belief that it contained some preservative substance. Extensive examination failed to detect the presence of any preservatives in the sample.

(15) An investigation into the cause of rapid deterioration of a hospital's trolley covers and dressing towels disclosed that hydrogen peroxide was the responsible agent, the damage becoming apparent on subsequent laundering.

General Laboratory.



Pilot Plant.

(16) A bundle of wage sheets alleged to have been written up in chronological order was submitted for examination. Inspection under ultraviolet light indicated that there were two different types of paper in the bundle of sheets and gave a lead as to the subsequent line of inquiry by the proper authorities.

(17) Miscellaneous samples examined during the year included liquors for the information of the Police Department, disinfectants for relative chlorine content, overalls for test of flameproofing treatment, and pine and whale oils for examination to trade specifications.

The usual enquiries for technical information and advice were received during the year, generally by telephone, and endeavours were always made to give the required assistance.

Expert evidence at Criminal, Coroner's and other Courts was tendered as required by Messrs. Wood, Sedgman, Uren, Katnic, Double, Jago and McLinden in connection with their official duties.

The acquisition late in 1961 of a new infra-red spectrophotometer of modern design added considerably to the analytical facilities available to the Laboratories. While it has not been possible, because of lack of staff, to make full use of the potentialities of this instrument, it has nevertheless proved to be an invaluable asset and has enabled results to be achieved which had hitherto been impossible. The conflict still exists however, between the pressure of "routine" type activities, and the need to investigate problems raised by post-war technological advances, especially in the fields of foodstuffs, synthetic drugs and pesticides. The existing facilities and staff numbers are not adequate to meet both demands fully.

FUEL TECHNOLOGY DIVISION

Introduction.

One hundred and seventy-three samples and investigations were allotted to Fuel Technology during 1962. These have included coals, clays, dusts, sulphide ores, gases, an investigation into production of light weight aggregates and a commencement with assessment of air pollution.

The figure of 173 samples does not give an accurate assessment of the amount of work done in the Division since a single sample may involve work occupying several weeks or even months, and require many separate experiments. Work on sulphide ores continued over six months and three samples required over 100 experiments. Fourteen clays and shales examined in the work on light weight aggregates have required so far 106 experiments occupying almost a day each.

The Division has been short staffed over the whole year and also there have been absences through long service leave, illness and staff changes. It has only been possible to keep research and routine work moving forward together by fitting in research and development projects as time and opportunity permitted.

The scope of the work on fine particle size analysis has been extended by the acquisition of an air elutriation apparatus and we now have sufficient variety in our apparatus for sub-sieve particle size analysis to be able to assist in the many industrial processes and problems which involve small particles.

We are currently setting up with the Engineering Chemistry Division dust arrestment plant to investigate and demonstrate the scope and effectiveness of a variety of dust catching devices with special emphasis on those which operate with a low pressure loss. This work does not however progress as fast as it should, partly through lack of staff, partly through delays in obtaining the various plant items required.

The World Power Conference in Melbourne in October was attended and the visit was extended to Sydney mainly to discuss air pollution measurement and prevention with those engaged on this work in New South Wales.

Our own association with air pollution is that we represent the Laboratories on a Government Committee examining the need and scope for "Clean Air" legislation in this State.

A scientific and technical unit of the Division of Occupational Health under the Public Health Department of New South Wales is established with its headquarters in Sydney to combat and reduce the considerable industrial air pollution which exists in New South Wales. The ultimate annual cost of this unit will be in the region of £50,000-£100,000 per annum.

Here, in Western Australia, there is no air pollution on the scale which occurs in New South Wales. Existing conditions are good and it should be possible to safeguard them from deterioration through the Government Departments which are at present concerned with prevention of nuisances, if use is made of the facilities which we possess in the Fuel Technology Division and its access to the specialist chemists, apparatus and techniques available in other Divisions. The considerable scale of expenditure anticipated in New South Wales is thus in a sense obviated and already provided for by our general laboratory organisation.

It must however be commented that, as part of the "Clean Air" programme in New South Wales, the group of fuel technologists, chemists and chemical engineers which is being created to deal with air pollution will also provide advice and services for the associated work of improved industrial fuel efficiency.

Our Fuel Technology Division here has no such approach to industry. It is possible that under "Clean Air" legislation a means of approach could be created. This would be valuable since this year with the solitary exception of one plant visit to measure and advise on dust arrestment we have otherwise remained almost entirely in our laboratories and have given no field assistance to industry or to institutions in the important field of applied Fuel Technology.

Coal Survey, Sampling and Analysis.

1. Development of the Muja Open Cut continues and Diana, Eos, Flora and Galatea seams are now exposed above Hebe. Samples of Diana and Eos have been taken and of the Northward development of Hebe. The samples show that the low ash content of the Muja coals is being maintained and, near the surface, they still show the characteristic white ash of near-surface, open-cut coal at Collie. The ash of the Hebe North coal is very white indeed and shows an alumina:silica ratio of about 5.7:1 and has, correspondingly, an ash fusion point which is in excess of 1500°C. These white, infusible ashes, have the drawback that they deposit in brick kilns and make the work of discharge of the kilns dusty and unpleasant.

Associated with these coal seams are some excellent white clays which should be valuable for "cream" bricks. It is possible too that there are some good fireclays as well.

Coals from the Western Collieries which have been sampled are satisfactory. The Western No. 4 coal is however high in ash content by present Collie standards.

Samples of deliveries of Collie coal to industrial users show that the quality of coal received by industry agrees with that shown in our samples. The only complaint which now reaches us about Collie coal is the foregoing one about the lightness of the ash in brick kilns. So far however coal holds its own against oil on existing brick kilns both in regard to price and to ease of operation. This position may be changed by the adoption of tunnel kilns for brick making.

TABLE 30.

Fuel Laboratory Survey Samples.

Origin of sample— Seam	Wyvern	Bottom seam	Top seam	Diana—south	Eos—south	Hebe—north
Locality	Western No. 2	Western No. 4	Western No. 4	Muja open cut	Muja open cut	Muja open cut
Laboratory No. 1962	*4815–4817	†501–502	503	7343	7342	7341
			Per cent.			
Proximate analysis—						
Moisture	28·4	25·7	29·6	31·4	30·9	26·5
Ash	3·1	7·5	6·0	4·4	2·7	2·8
Volatile matter	26·4	20·4	19·3	24·4	26·3	29·2
Fixed carbon	42·1	46·4	45·1	39·8	40·1	41·5
	100·0	100·0	100·0	100·0	100·0	100·0
			B.t.u. per lb.			
Calorific value	8700	8900	8400	8220	8500	9030

* Mean of three samples. † Mean of two samples.

Average analyses of Collie coal samples submitted by private industries :—

	Per cent.
Moisture	27·4
Ash	3·8
	B.t.u. per lb.
Calorific value	8800

2. Samples of coal seams encountered in drilling for oil north of Perth have not been as interesting as those from the 100 ft. Eneabba seam encountered last year. Nevertheless three samples from Jurien Bay caked; unfortunately their ash content is high. Analyses are shown in Table 31.

The opinion is advanced that some of these coals now being encountered are suitable for underground gasification in situ. Although this technique has had limited success the possibility should not be overlooked as providing a source of power alternative to Collie since the latter is limited as a source of cheap coal.

TABLE 31.

Coals Encountered in Oil Exploration.

Locality	Hill River							Jurien			Mintaja		Collie	
Hole No.	1	1	1	2A	2A	2A	2A	1	1	1	7B	8C	78	78
Lab. No.	*3750	4227	4228	5279	5280	9649	9650	†7027	7028	7029	9651	9708	9485	9486
							Per cent.							
Proximate Analysis :—														
Moisture	24·7	10·2	9·3	18·1	20·8	**20·0	**20·0	1·2	2·4	3·8	**20·0	**20·0	**20·0	**20·0
Ash	13·9	33·1	22·9	12·4	13·8	9·8	6·8	13·8	22·7	20·6	11·1	15·8	6·7	8·2
Volatile matter	27·2	26·6	31·9	30·7	29·3	31·9	37·3	18·4	17·6	15·1	32·3	31·4	30·1	28·6
Fixed carbon	34·2	30·1	35·9	38·8	36·1	38·3	35·9	66·6	57·3	60·5	36·6	32·8	43·2	43·2
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0
							B.t.u. per lb.							
Calorific value	7760	....	....	8650	8270	8890	9190	13215	11360	11825	8390	9240	9460	9140
Caking Properties	No	No	No	No	No	No	No	Yes	Yes	Yes	No	No	No	No

* This core was received in two portions and the analysis is that of the lower ash portion constituting 55·4 per cent. by weight of the sample.
† This sample is portion (22·3 per cent.) of a larger quantity of core received and was separated as the fraction with specific gravity less than 1·5.
** These analyses are reported on an arbitrary basis of 20 per cent. moisture.

Roasting of Sulphide Ores.

Roasted copper ores are used as a source of agricultural copper fertiliser for addition to superphosphate. Work has been done on chalcopyrite ore containing 22-25 per cent. of copper to determine the temperature and conditions required to obtain the maximum amount of copper as the water soluble copper sulphate and the dilute acid soluble basic sulphate. This implies that as little as possible of the copper is converted to the insoluble cupric oxide.

The conditions found are to keep the temperature in the region of 450-500°C with limited access of air. This will give over 60 per cent. of the copper as sulphate and up to 35 per cent. as the basic sulphate so that 95 per cent. of the copper is readily available.

Suitable conditions could most readily be provided by fluid bed roasting particularly if recirculation of tail gases containing sulphur dioxide is used to control the reaction. Work done on disperse beds approaching conveying velocities shows that ready oxidation of chalcopyrite can be secured under these conditions but the oxidation is carried too far without recirculation of tail gases. The work was not extended to try the effect of tail gas recirculation.

It would appear from the work done that fluid bed roasted chalcopyrite of 22 per cent. copper content or more would be a satisfactory and cheaper replacement for imported copper sulphate as the price per unit of copper from chalcopyrite is only half that from copper sulphate at similar percentages of copper.

Work was also done to determine the temperature of rapid reaction approaching burning of gold bearing iron pyrite and pyrrhotite. Here again a temperature of about 450°C marked the commencement of combustion in air and this could be controlled by addition of sulphur dioxide indicating that tail gas recirculation could control the rate of roasting and, possibly, decrease the gold which is locked up in pyritic ores which are rabble roasted.

Clays and Refractories.

A number of interesting clays have been examined mainly for brick making purposes and two tests have been made for thermal conductivity in refractory insulating materials.

A white clay from Katanning Lab. No. 8651/62, of composition 65 per cent. kaolinite, 10 per cent. illite, 25 per cent. quartz was of considerable interest since it gave a strong white brick at 1100°C with refractory qualities which would commend it for use as a good firebrick.

Another white clay from Brookton, Lab. No. 6175/62, commenced to vitrify at 1100°C and continued vitrification in a controlled manner which suggested its use for manufacture of sanitary whiteware and pottery.

Three clays from Geraldton, Lab. No. 6087-9/62, were submitted as coming from three different levels in a clay pit. One burnt to a good cream brick at 1,000°C, the second at 1,100°C and the third was a highly siliceous material which showed no vitrification up to 1,400°C and was therefore unsuitable for brickmaking. The information provided has been of value in successful ventures in brick production at Geraldton.

Three clays were picked up out of the clay bands in the Muja open cut from above Diana coal seam. All three are admirable white clays suitable for cream brick, pottery or whiteware manufacture. This suggests that Collie could become an important producer of both firebricks and good quality housebricks at a relatively low cost from clay at present dumped as overburden.

The thermal conductivity of a sample of spongolite was determined using our own conductivity method. A sample of insulating concrete was also examined as the user considered it overdense and of high conductivity. His opinion was confirmed.

Work on refractories this year has advanced considerably by a combination of the facilities and experience of our Mineral Division and Physics Section with our own work. Clays and shales can be characterised accurately and their best uses determined. We have a large number of clay samples reserved from past work of the Laboratories and a re-examination of them using our present methods would be fruitful and should be undertaken when the necessary staff becomes available.

Dusts and Sub-Sieve Particle Size Analysis.

The Division now has three methods of size analysis for fine dusts and particles in the size range 50 to 1 micron. For general examinations by air elutriation a Roller size analysis apparatus has been purchased. Alternatively dusts and other fine material can be suspended in water or other liquid dispersant and size analysis can be made by sedimentation using either gravimetric or photometric methods of measurement. The results obtained are reasonably self consistent and in fair agreement with the results of other workers on our own or on standard dusts.

Analyses have been made on dusts from asbestos mining and on iron oxide pigment samples produced by the Engineering Chemistry Division in benefication of ilmenite by removal of iron. Most of this latter material was less than 2.8 microns diameter and was the type of material for which photometric sedimentation is best suited.

Earlier work and recommendations on dust evolved in flash calcining of gypsum have now shown successful results and dust carried away in the tail gases of this process appears negligible in amount. The method adopted is to scrub the tail gases with ingoing gypsum and to pass the cooled gases through a fan which agglomerates any dust which remains. Our final connection with this has been to measure the gas flow in the plant to confirm that this remained at a satisfactory figure.

Light Weight Aggregates.

The research discussed in last year's report into the production of light weight aggregates has been developed throughout the year. Fourteen clays and shales have been examined and over one hundred tests of these materials or formulations prepared from them have been made. Amongst the materials examined have been shales sent us by C.S.I.R.O. Building Research Section from which light weight aggregates can be made. Sedimentary brick clays from the Swan River Plain which are the materials used for brick making in this State do not give light aggregates without the use of additives

Light aggregates are produced from clays or shales which soften at about 1050°C-1200°C. If by some means the constituents of the clay can react to form a gas while the clay or shale is in a soft, plastic condition an expanded pumice like material is produced of considerable strength and of a specific gravity which may be as low as 0.5. An aggregate is thus produced which is as light as wood but of greater crushing strength. The aggregate is suitable for use in concrete members to produce structures of low total mass which therefore call for lighter sections in the members than if normal bluemetal aggregate is used.

The expansion of the fluid clay matrix by gases is called bloating. The most easily produced gas is carbon monoxide or carbon dioxide through reaction of carbon in the clay with iron oxide. Surprisingly little carbon is required and calculation shows that 0.02 per cent. of carbon will produce enough gas to bloat out a clay to five times its original volume.

There is however no systematic connection between the percentage carbon in clays and their bloatability. This is shown in Table 32 comparing three Eastern States bloatable materials and three West Australian brick clays without much bloatable character.

TABLE 32.

Comparison of Bloatable and Non-bloatable Materials.

	Carbon Per Cent.
Eastern States Bloatables (Shales):	
A	1.09
B	1.30
C	0.13
West Australian Non-bloatables (Clays):	
1	0.04
2	0.18
3	0.29

The behaviour of bloating and non-bloating materials in our refractoriness under light load test is shown in Figure 1. The Eastern States shales A, B and C show a definite cusp in which a sharp expansion follows the normal gradual shrinkage of a clay. Shale C also shows a continuation of collapse after a sharp initial rise. The two Western Australian brick clays show no such cusp.

The comparable analyses of some of these materials are given in Table 33. It is difficult to find any marked difference of a chemical nature between bloating and non-bloating materials and it is concluded that the difference must be physical.

TABLE 33.

Analyses of Non-bloatable and Bloatable Materials.

Lab. No. (1962)	1868	1869	3463	4477	1975
Material	Brown clay 1	Brown clay 2	Armadale shale	Brown clay 3	Eastern States Shale—4 ex C.S.I.R.O.
	%	%	%	%	%
SiO_2	60·1	61·0	69·9	65·6	59·25
Al_2O_3....	19·2	19·8	15·2	17·0	19·26
Fe_2O_3	7·2	7·11	6·13	6·62	9·46
TiO_2	1·12	1·18	0·64	....	0·84
CaO	0·82	0·54	0·11	nil	0·12
MgO	0·88	0·89	0·51	0·87	0·76
Na_2O	1·39	1·17	0·24	1·29	0·34
K_2O	1·77	1·89	2·41	1·82	2·24
Carbon, C	0·04	0·18	....	0·29	1·09
Ignition loss	....	....	....	....	7·99

(15)—70240

Western Australian clays can however be bloated quite easily by addition of carbonaceous materials such as finely ground coal. Oil is a better and more easily incorporated additive. One per cent. of diesel oil added to any of the standard brick making clays used in Western Australia gives an excellent bloat. It appears from determinations made that 0.3 per cent. of the oil remains in the clay at bloating temperature to produce the necessary amount of expansion gas.

It is not thought that these artificially bloated clays are suitable for concrete manufacture as they are so light that they are difficult to mix in with cement and sand. Further, they are rather smooth pellets since to make them the clay is first ground with oil and water and then pelleted or glomerulised before firing. The product tends to be smooth skinned and round without any of the random binding corners which are desirable in a sharp aggregate. They are however most suitable for making light weight insulating building bricks and their use for this purpose would resolve difficulties which hinder production of such bricks by incorporating sawdust.

The work continues and it is expected that it will be successfully finalised during 1963.

INDUSTRIAL CHEMISTRY DIVISION.

Staff.

At the end of the year the staff consisted of four chemists (including the Chief Industrial Chemist), one technician and two laboratory assistants.

Mr. A. Reid, Chief Industrial Chemist, was in Victor Harbour and Adelaide for a fortnight in June to attend the Conference of the Oil & Colour Chemists' Association and a Technical Symposium of the Plastics Institute of Australia. Considerable benefit was derived from the visit, both from the point of renewing old, and making new contacts and the gathering of useful information.

Classification of Work.

The work may be classified as—

(a) routine;
(b) consultative practice;
(c) developmental research.

The three categories are not mutually exclusive as will be apparent later.

Routine.

Of the 183 samples examined by the Division, 166 fall under the general heading of building materials. This heading includes paints, concrete additives, floor tiles and miscellaneous materials used in the construction and fitting out of structural and civil engineering undertakings. The examinations were carried out for three main reasons:—

(a) To compare the relative merits of a range of products.
(b) To ascertain whether specifications are being adhered to.
(c) To determine the cause of failure and recommend suitable methods of rectifying faults and preventing their recurrence.

For sources of samples and their nature see Table 34.

TABLE: 34.

Industrial Chemistry Division, 1962.

	Agriculture Department	Departmental	Main Roads Department	Public Pay	Public Works Department	Total
Construction materials :—						
Concrete additives	....	....	....	10	23	33
Tiles	....	4	....	....	14	18
Various	....	....	....	8	18	26
Goldfields Water Supply Pipeline	....	....	....	....	6	6
Paints :—						
Paint	....	3	11	11	47	72
Primer	....	....	....	....	8	8
Shelves	....	....	....	....	14	14
Various	1	2	....	....	3	6
	1	9	11	29	133	183

(1) Paints.—Sixty-five samples of paint were examined during the year for compliance with specifications and for use as a guide to the choice of suitable paints for specific purposes.

(2) Paint Flakes.—Examination of paint scrapings from the stained fibrous plaster ceilings of three houses showed that the stains originated from the reaction of traces of iron with atmospheric hydrogen sulphide. A successful means of removing the stain was suggested.

(3) Painted Shelves.—Fourteen samples of steel locker shelves painted with seven different brands of enamel were examined for their suitability for use as high school students' lockers. The examination included paint adhesion, surface hardness, abrasion resistance and impact resistance.

(4) *Plastic Effluent Pipeline.*—Seven samples of rigid polyvinyl chloride pipe wrapped with fibre glass reinforced polyester were examined to determine the most suitable one to carry a corrosive, abrasive liquid waste from a titanium dioxide works near Bunbury. The unusual nature of the samples entailed devising new test methods and fabrication of new equipment. The relative qualities of the various types of pipe were discussed, and recommendations for improvement of the selected type were made. A contract for supply and installation of the pipeline was let to a local firm for more than £130,000.

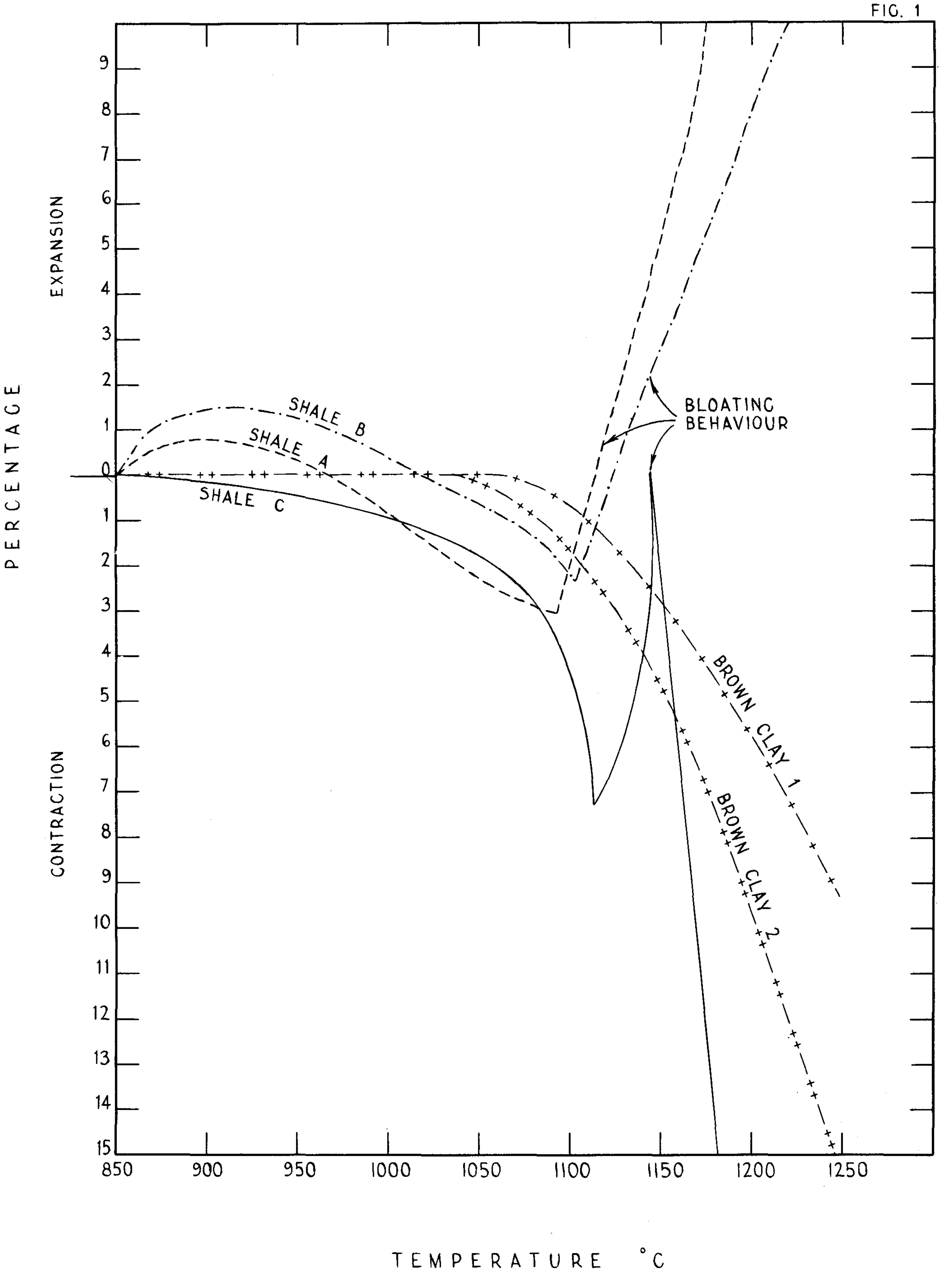
(5) Cement Additives.—Of the 33 samples of cement additives, five were plastic membrane curing compounds and 28 were calcium lignosulphonate based plasticiser and retarding agents. Ten of the calcium lignosulphonate type were "pay public," eight for Public Works Department, Architectural Division and the remaining ten were examined in connection with the Ord River Diversion Dam. There was considerable variation in the active ingredient content of the latter ten, and the analytical results correlated well with the setting rate observations made on the dam site.

(6) Oil Injection in Water Pipes.—In collaboration with the Country Towns Water Supply, an investigation was begun into methods of improving the throughput of the 36 in. water mains. At the beginning of the summer samples of scrapings from a known area on the inside of the pipe were taken and examined for oil content. During the summer it is intended to inject small quantities of oil into the pipeline, and then re-sample the areas when the pipeline can be re-opened (at the end of the summer) to ascertain whether any oil film has built up on the interior of the pipe.

(7) Lupinosis Investigation.—A large sample of lupin stalks was received from the Chief Veterinary Pathologist, Department of Agriculture for preparation of a concentrated alcoholic extract to be used in feeding trials on ruminants. The preparation of this extract necessitated fitting up a vacuum evaporator from existing equipment and the use of a special heat exchanger to avoid super heating of the liquid being concentrated.

REFRACTORINESS UNDER LOAD OF BLOATING AND NON-BLOATING MATERIAL

FIG. 1



Consultative Practice.

Since the Division first began operation, work of a consultative nature has been an important feature and consultant practice has increased more rapidly than any other phase of the Division's activities. It has changed, however, in character. In the early stages, manufacturers in a small way, and intending manufacturers formed the major part of enquiries. In 1962 there were more enquiries from established manufacturers (including a number of Australia-wide enterprises) than from "small" men, and many more from Government Departments than heretofore.

Attempts have been made in previous reports to classify the subjects dealt with in consultative work but such a classification can be misleading. Quite a number of questions can be answered "off the cuff" and could not be rated important, except of course to the enquirer. Others require investigation and occasionally experimental work before an answer can be given.

Broadly speaking, building materials have been the source of more enquiries than any other subject. Cements and cement additives, concrete, timber, metals and metal treatments, paints and plastics are some of the topics covered. Of enquiries in this class most emanate from the Architectural Division of the Public Works Department, but an increasing number of private architects and builders is to be found among our clients.

The question of cement additives remains a difficult one. Competition in the sale of such additives is keen, and although the preparations on offer have mostly a laboratory blessing and a background of practical use, over-enthusiastic claims by competing representatives at times end up in failures, or mis-use of some of the various proprietary products. This was basically the probable explanation for example of the "drummy" plaster on the risers in the public stand at Perry Lakes Stadium. There have been cases of failure of floor tiles due to the ill-advised use of cement additives. Broadly speaking cement additives do have a place in building construction but their indiscriminate use may lead to failures, and to additional and unnecessary construction costs.

Treatments for timber and metal are often asked for by clients and at times we have been called on to arbitrate between the conflicting claims of rival proprietaries. In the timber field the painting of karri, wandoo and blackbutt is often the subject of queries. Our research on the painting of karri, referred to under "developmental research" has made it easier to answer such queries.

In the painting of metals it is pleasing to record that a greater interest is being taken in surface preparation, but equally displeasing to record that in about seven out of ten paint failures the basic cause is still inadequate preparation of surfaces.

Quite a few queries on the correct selection of a painting system can be referred to the technical staff of the various companies but we are occasionally called on, particularly by Government Departments, to help resolve the rival claims and suggestions of paint firms

New paint introductions by the various firms bring their quota of enquiries. A suggestion that the enquirer refer to the technical staff of the paint firm concerned is generally met with the riposte "They want to sell it to us; we would like an unbiased view." Partly to solve this difficulty, paint firms generally advise us of a forthcoming new line some time before the advertising campaign gets under way and provide technical literature together with samples if called for.

In the building field plastics are playing an increasing part and this is particularly to be found in the applications of rigid P.V.C. In the United Kingdom, Europe and the United States of America this material is often favoured in rain and soil systems. Its introduction into Australian building has been slower but some States now recognise its potential importance to the extent of including plastic plumbing in the syllabus of plumbing courses at technical schools. In this respect Western Australia is a little behind other States but will undoubtedly catch up. The Plastics Institute of Australia, of which body the writer is a member of the Federal Technical Committee, has done much to promote the sane and successful use of P.V.C. in the building industry.

Reinforced plastics, particularly polyester panels with a plastic foam "sandwich," are being increasingly made and used in this State. Because of the relatively low costs of equipment required for the making of this type of product the manufacture of reinforced plastic materials in Western Australia is going ahead rapidly and has brought in its train enquiries on formulations, processes, sources of raw materials, and the occasional anatomy of failures.

The plastics industry as a whole is flourishing in this State; from a total value of some £30,000 annually of locally-made products ten years ago, production has gone to an estimated £250,000 in 1962. Such expansion has inevitably brought with it a crop of problems of a technical nature. Solutions to most of these problems have been found, with the very full co-operation of the Technical Secretary of the Plastics Institute of Australia.

Probably the most asked questions by clients coming to this Division take the form of:

"Have you ever heard of ....?"
"What can I use instead of ....?"
"Who are the agents for ....?"
"Who sells ....?"

To answer such enquiries requires a very comprehensive "library" of technical literature, ready access to "specialists", in the various fields, and the full co-operation of manufacturers, retailers, representatives and agents. Much still remains to be done to improve our technical literature collection but its deficiencies are somewhat covered by the very excellent co-operation of "specialists" and the suppliers of the literature. The writer is very grateful to these people who make his part in the daily "quiz programmes" both pleasant and rewarding.

There is every indication that the consultant practice in this Division will continue to grow and thought is continually being given to making it more efficient.

Developmental Research.

Now that the Divisional staff is at a higher numerical level it should be possible to give attention to topics of developmental research. At the moment a start has been made on two projects:—

(i) The correlation of testing methods on P.V.C. tiles.

(ii) The measurement of anti-slip and the evaluation of materials used for this purpose.

A third project, the painting of karri timber, has reached a stage at which a report can be made and this is included as an Appendix.

(1) Testing Methods for P.V.C. Tiles.—There exist British and Australian Specifications for Vinyl Floor Tiles but each is subject to the criticism that neither is a very good guide to the architect in his choice of tiles for a particular job, nor do they give any methods which will enable a comparison of the potential wear resistance of the various types of tile available. There are also other tests which can be carried out on plastic materials such as vinyls but there is no indication of their relative value in assessing the suitability of tiles for specific purposes.

In order to resolve this problem and to attempt to arrive at data which an architect can specify with the assurance that he will get the sort of material he wants, an investigation of the measurable physical properties of tiles has begun. It is hoped that test results will show some degree of correlation and also point to significant differences.

At this early stage in the work it would be unwise to comment except perhaps to indicate that prospects of securing correlations are perhaps a little brighter than they were.

(2) Measurement of Anti-Slip.—As with P.V.C. tiles there are methods of determining the resistance to slip of flooring materials but there is no apparently sound correlation between machines used for the purpose, and no indication of their relation to actual practice. From time to time anti-slip materials come forward for assessment but no definite standard methods have been so far devised in these Laboratories to do this. The work now in prospect is intended to provide suitable testing methods, to evaluate existing anti-slip systems and to suggest improved ones.

An examination of the problem mathematically has begun and it would seem that there are factors other than the co-efficient of sliding friction which must be considered in determining the value of an anti-slip material.

(3) Painting of Karri Timber.—This work is described in detail in the Appendix and it will be sufficient to say here that two, possibly three, paint systems have been found, which are expected to solve the problem. There is however, much still to do in improving the successful basic systems and this work should be begun early in 1963.

MINERALOGY, MINERAL TECHNOLOGY AND GEOCHEMISTRY DIVISION.

General.

The total number of samples examined during the year was 2,463 compared with 2,653 in the previous year.

With the completion early in the year of the basic survey of dust conditions associated with foundry work, the number of dust samples dealt with fell off considerably from 372 (1961) to 44 (1962).

The most marked increase in sample numbers occurred in the cases of tin (from 41 in 1961 to 131 in 1962), iron (380 to 451) and tantalite—columbite (93 to 126), a fairly accurate reflection of the increased interest in these ores.

The main sources of samples were:—

General public (free)	1,009
General public (pay)	717
Geological Survey Branch	280
State Batteries Branch	201

Table 35 details the nature and source of samples received during 1962.

TABLE 35.

Mineral Division, 1962.

——	Public		Government Geologist	State Batteries	Public Health Department	Internal	Public Works Department	State Mining Engineer	Other State Government Departments	Commonwealth	Total
	Pay	Free									
Aggregates	13	....	....	....	....	2	30	....	....	4	49
Burnt Lime	11	....	....	7	....	1	....	....	5	....	24
Clays	7	15	1	....	....	....	....	....	2	....	25
Dusts	....	....	....	....	44	....	....	....	....	....	44
Minerals and Ores—											
Beryl	61	14	....	....	....	....	....	....	1	....	76
Copper	42	98	4	....	....	3	....	....	2	....	149
Gold ores	103	136	1	....	....	6	....	6	....	....	252
Gold tailings	....	....	....	168	....	....	....	....	....	....	168
Gold umpires	....	....	....	25	....	....	....	....	....	....	25
Heavy sands	16	14	....	....	....	....	....	....	....	....	30
Iron	96	153	201	....	....	1	....	....	....	....	451
Limestone and limesand	15	4	6	....	....	6	....	....	....	....	31
Manganese	16	9	....	....	....	....	....	....	....	....	25
Pyrite	....	2	....	....	....	21	....	....	....	....	23
Tantalite	104	11	1	....	....	4	....	6	....	....	126
Tin	107	7	16	....	....	1	....	....	....	....	131
Titanium	3	9	....	....	....	29	....	....	....	....	41
Miscellaneous mineral identification	64	528	32	....	....	26	....	5	10	....	665
Miscellaneous mineral analyses	39	7	16	....	....	2	....	2	....	....	66
Miscellaneous investigations	20	2	2	1	2	12	8	....	11	4	62
Total	717	1,009	280	201	46	114	38	19	31	8	2,463

During the year the Deputy Government Mineralogist visited the Greenbushes and Smithfield tin fields where commercial exploratory work is in hand aimed at assessing the large scale dredging potential of the area. A visit was also made to the Northampton mineral field and the opportunity taken to visit the salt deposits at Hutt Lagoon, the iron deposits of Tallering and Koolanooka and the talc mine at Three Springs. In May, Mr. R. Lindsey accompanied staff from the Geological Survey on an inspection of the Dalgaranga pegmatite deposits and the Weld Range iron ore.

The helpful co-operation of the companies exploiting the various deposits visited, and of the Government Geologist, is deeply appreciated and adds greatly to the benefits arising from these field trips.

Mineral Collections.

One hundred and sixty seven specimens were added to the Mineral Division Collection during the year, bringing the total to 3,367. The big majority originated from within the State and included specimens of minerals recorded for the first time from a Western Australian locality.

Opal and gypsum from Coober Pedy, South Australia, and apatite from Rum Jungle, Northern Territory were the only Australian specimens added from outside Western Australia. Additions from overseas included osarizawaite from the type locality in the Akita prefecture of Japan, high-grade commercial amosite and chrysotile from South Africa, and fourteen specimens from Scandinavia resulting from an exchange requested by the Swedish Museum of Natural History. The latter included yttrotantalite from the type locality of Ytterby in Sweden, native lead from Langban, Sweden, viridin or manganandalusite from Ultrevis, Sweden and the uncommon radioactive rare-earth niobate-titanate blomstrandine from the island of Hittero, Norway.

The re-housing and re-classifying of the Simpson Collection of between four and five thousand specimens has been completed and work continues on the indexing and registration of all specimens.

Twenty-three requests were received for collections of Western Australian mineral specimens. Five originated from teachers, eight from students, six from prospectors and four from private collectors. Collections were sent for teaching purposes to a School of Mines in West Germany and to the School of Mines and Industry at Ballarat, Victoria.

These collections are prepared and despatched when time is available without interfering with the normal work of the Division and it is felt that they serve a very useful purpose, not only in encouraging the study of minerals and in assisting prospectors, but also in the equally important field of public relations.

Building Materials.

1. Cement and Concrete: (a) Aggregates.—One of the most interesting aspects of the work carried out on the potential reactivity of aggregates with cement was the amount of sulphide minerals in some of the aggregates examined.

These particular aggregates originated from Kalgoorlie and Norseman. The worst of them, from the point of view of the sulphide mineral content, was from Norseman and consisted of stone fragments composed of feldspar, amphibole and pyroxene, quartz, pyrite, pyrrhotite, magnetite, chlorite and graphite. The sulphur content was 8.72 per cent., equivalent to a figure of the order of 20 per cent. for the sulphide minerals.

Tested by the standard chemical method for assessing the potential reactivity of an aggregate towards the alkali of cement, the sample gave results classifying it as innocuous. From the mineral nature of the rock, such results were to be expected.

However, the high pyrite content and particularly the presence of pyrrhotite suggest that such material could be deleterious due to a set of reactions other than alkali reactivity, namely the oxidation of the sulphide minerals to hydrated oxides, iron sulphate and sulphuric acid. These reactions are known to cause "popouts" and surface staining of concrete particularly under conditions of warmth and high humidity.

Though much has been written on alkali reactivity, very little seems to have been done to study and measure the possible effects of sulphide minerals. The iron sulphide minerals can occur in forms designated reactive and non-reactive depending on their behaviour when immersed in limewater and this test seems the only one available for assessing their potential reactions when present in concrete aggregates. This test is better than nothing, but it must not be overlooked that a sulphide mineral may be non-reactive in freshly broken aggregate but may become reactive with increasing oxidation.

As there is always a degree of uncertainty about the behaviour of the sulphides it is felt that the use for first class concrete of aggregates containing appreciable percentages of these minerals should be avoided if at all practicable.

Preliminary work on seven concrete aggregates (four coarse and three fine) from the Dimond Gorge damsite on the Fitzroy River has been completed for the Public Works Department.

In the case of the coarse aggregates, somewhat anomalous results were obtained regarding their potential reactivities. All four were similar rock types, consisting of rounded quartz grains strongly interlocking and cemented together by later crystal growth. No petrographic evidence could be found of cryptocrystalline or colloidal silica nor were any other minerals found that are normally suspected of alkali reactivity.

However, chemical tests gave figures for dissolved silica in excess of that accepted by ASTM standards. In two cases, these figures were considerably in excess, in one border line and the fourth gave an acceptable figure. As these figures were confirmed by repeat tests, it was recommended that mortar-bar expansion tests were necessary to fully assess the suitability of such aggregates.

These tests are now in hand, and expansion readings will be taken at monthly intervals over a six to twelve month period. Mortar bars made up from a standard pure quartz sand and from a highly opaline sand are being tested for comparison at the same time.

Four highly calcareous aggregates were examined for the Department of Works, two being rock fragments and two consisting of sands. The rocks were composed of calcite enclosing numerous rounded quartz grains and the sands of calcite with a little quartz and clay.

When tested for reactivity, high figures were obtained for reduction in alkalinity but dissolved silica figures were extremely low and the aggregates proved acceptable as regards alkali reactivity. Because of its unusual structure, the coarse agregate was tested for soundness by submitting to five cycles of immerson in sodium sulphate solution following by drying. Here again, it easily complied with specification requirements.

Lightweight artificial aggregates being developed by a commercial concern were subjected to the ASTM standard test for potential alkali reactivity. Figures obtained were interesting and, to a degree, informative but as they were obtained by a method not specifically designed for this type of aggregate, caution is necessary in interpreting the results.

A number of sands were examined, both for Government departments and private interests. These were subjected to microscopic examination, and to tests for size distribution, organic matter, reactivity and water soluble salts.

(b) Hardened Concrete.—Only a limited amount of work was requested on hardened concrete and cement products.

Four cement water pipes were examined. The internal deposit, suspected of being a corrosion product, was shown to have originated from the settling of iron-rich compounds and suspensions rather than any undue corrosion of the pipe surface.

Crumbling cement segments from a well lining were suspected of having deteriorated due to their soil environment or from the attack of acid waters. Analysis of the segments suggested that the cause of deterioration was more probably due to a lean cement-sand mixture having been used in their manufacture.

2. Lime.—Five industrial lime samples from current buildings sites were tested at the request of the State Housing Commission. Some had been manufactured from the residues from acetylene generators and not by direct burning of carbonate material. Their properties appeared essentially the same.

The mineral composition and bulk density of two commercial lime products were determined, and a number of analyses carried out on a commercial lime putty.

Only seven samples were tested for State Batteries Branch but six of these did not show the preferred minimum CaO figure (86 per cent.) on the ignited sample. The lowest was 76.4 per cent., with two others greater than 84 but below 86 per cent. A penalty clause applies to all samples falling below 86 per cent.

Samples resulting from the experimental burning of Mullaloo beach sands were analysed for the Engineering Chemistry Division.

3. Limestone and Limesand.—Limestone samples were examined both as raw material for burnt lime and as building material. The highest grade stone came from the Yanchep area, containing lime equivalent to 96 per cent. calcium carbonate, Three limestones from the South-West were submitted for testing as to suitablility for building purposes. Chemical composition does not help much in assessing stone for this purpose but it is nevertheless surprising that no tests, either chemical, or physical, are specified for building stone by building authorities. It is felt that at least minimum figures for compressive strength, and perhaps maximum figures for porosity, are necessary as a form of quality control of such material.

That these two properties are quite variable in stone of similar chemical composition, and yet bear no relationship to each other, is indicated in results obtained on the three stones mentioned above. Each stone contained 94 per cent. (± 1 per cent.) of calcium carbonate and each contained about 1 per cent. of silica, but the percentage porosities were 42, 52 and 44 respectively and the compressive strengths (measured at Western Australian University) were 1,180, 110, 210 lb/sq. in. respectively. It has been stated by Fletcher (J. Roy. Soc. W.A., Vol. 20, 1933-34) that for foundations, porosities from 40 to 55 per cent. are favoured and that the approximate average compressive strength, based on building stone as commonly used, is 388 lb./sq. in. (25 tons/sq. ft.). The silica content he quotes as varying from 5 to 66 per cent. with an average about 23 per cent.

Lime sands from the Ravensthorpe-Esperance area were examined at the request of the Government Geologist for evaluation of their use as agricultural soil dressing. Lime content varied from a trace to 57 per cent. Other sands, from Mullaloo, Dongara and Geraldton were subjected to partial analysis, both at the request of private firms and in connection with up-grading experiments being conducted by Engineering Chemistry Division.

4.—Masonry.—A limited amount of work was carried out on stains disfiguring both cement blocks and fired clay bricks.

White stains on concrete masonry blocks were found to be essentially calcium carbonate with the calcium originating from the cement and not, as thought possible, from the synthetic additive used in the mix.

Two cases of vanadium staining of fired bricks were encountered, one on bricks from a near-metropolitan clay, the other from Geraldton. Methods of control were recommended.

Analysis of a kiln scum on fired bricks suggested the origin of the scum as being in the soluble salts either of the original clay or of the water used for mixing.

Health Hazards.

1. Foundry Dust Survey.—The survey of industrial dust hazards commenced in 1961 was continued.

The foundry industry, with emphasis on the silicosis hazard, had been selected by the Public Health Department as the first industry to be surveyed. Initial work was carried out at the Western Australian Government Railway Workshop's foundry, Midland Junction.

It was hoped that results obtained here would give figures that would serve as a basis for comparison with other foundries as the survey extended.

In March a report was issued on this work, covering in considerable detail the three main objectives:—

(1) To determine the airborne dust concentration of the air throughout the foundry away from any particular process. This was to give an indication of any possible hazard to all foundry workers and establish a basic dust level.

(2) To determine the airborne dust concentration encountered by workers in particular processes with particular attention to machines and methods used in this foundry. A number of dusty processes, machines and methods were selected for particular study.

(3) To determine the airborne dust concentration encountered in a day in a particular job by any worker carrying out the duties which constitute the job. Fifteen jobs considered to expose the worker to the highest total daily airborne dust levels in the foundry were selected for the survey.

This report should serve a useful purpose as an aid to correlating the nature and concentration of dusts with clinical findings and hence as a quide to the Public Health Department on setting up standards for dust conditions.

2. Other.—A larger number of samples than usual was received in connection with asbestosis hazards compared with silicosis dangers.

These samples originated from both the mine producing this mineral and from the sites of factories using it. Settled dusts from the Wittenoom blue asbestos mines were examined and found to consist mainly of quartz, hematite, chalybite, dolomite, magnetite and crocidolite (blue asbestos). As to be expected in such dusts the particles covered a wide size range and also varied considerably in the weight distribution of the various minerals present.

Three batches of airborne dusts, taken at monthly intervals from the plant of a firm manufacturing asbestos fibre board were examined for particle size and density and mineral composition. The respirators used were found to be very efficient in trapping asbestos dust in the significant size ranges.

A sample of lung tissue was submitted for examination for the presence of crocidolite asbestos. The ash prepared from the tissue showed a combined silica to free silica ratio of about 4 to 3. Quartz was identified mineralogically, as was a mineral in the form of fine needles and having optical properties suggesting an amphibole. Unfortunately the latter could not be isolated in a condition pure enough to allow of its certain classification within the amphibole family of which crocidolite is a member.

Ten airborne dusts from a plant manufacturing clay products were examined to determine particle count and the proportion of quartz to total dust. A settled sample from the same locality was analysed chemically to determine both free and combined silica.

Dusts from Collie coal mines were received and were studied in conjunction with the ash of the originating coal. The main minerals present in both were quartz, kaolinite and calcite.

A deposit from a roof was tested to determine if it could have originated from a nearby fertiliser plant. Phosphorus and sulphur figures suggested that such a plant could have contributed significantly to this deposit.

A fluorescent tube, broken near the face of an infant, was examined for any toxic beryllium compounds but none were detected.

Sand from an old battery and cyanidation plant that had ceased operation over 30 years ago was submitted to ascertain its safety for use in a kindergarten sand pit. The CN^1 content was found to be 0.6 p.p.m.

CYANIDATION TESTS.

A project in hand at the Engineering Chemistry Division is aimed at the recovery of elemental sulphur from Kalgoorlie flotation concentrates. The recovery of gold from such concentrates remains of course the prime consideration and so cyanidation tests were run in the Mineral Division on various products obtained throughout the course of this work.

The recovery process involves, in part, the removal of one element of sulphur from the pyrite, leaving a highly pyrrhotitic product with many cyanidation problems. A typical chemical analysis of this product is shown below, expressed as percentages on a dry basis:—

	Per Cent.
Total iron, Fe	32.7
Total sulphur, S	24.5
Pyrrhotite sulphur, S	15.5
Pyrite sulphur, S	6.4
Oxidised sulphur, S	2.25
Free sulphur, S	0.35

These figures suggest the presence in the sample of:—

	Per Cent.
Pyrrhotite, Fe_5S_6	38
Pyrite, FeS_2	12
Ferrous sulphate, $FeSO_4$	10.7

The gold content was 54.3 dwt./short ton.

Unfortunately, the scale of the original experiment was not large enough to enable the accumulation of sufficient material for exhaustive cyanidation tests. The procedure finally adopted consisted of a copious wash, followed by pre-liming and filtration before cyanidation. Owing to the extremely high oxygen demand, the tests were carried out in open bottles.

The filtrate from the water wash contained sulphides, sulphates and ferrous iron, while the first pregnant solution from a two-stage cyanidation showed thiocyanates and traces of soluble sulphides. There was no sulphide in the solution from the second stage though it still gave positive tests for thiocyanate.

As was to be expected under these conditions, the gold recovery was poor (83.2 per cent. with a residue of 9.1 dwt./ton) and the reagent consumption excessive (potassium cyanide 31 lb./ton, lime 33 lb./ton).

It is generally accepted that in cyanidation, pyrrhotite is by far the most troublesome of the iron sulphide minerals. It acts both as a cyanicide and as a reducing agent. It consumes cyanide by formation of thiocyanates, while the ferrous sulphide which is also produced absorbs oxygen to given ferrous sulphate which in turn destroys cyanide by combination as ferrocyanide. Though a protective lime alkalinity is required for the efficient solution of gold, any undue excess of lime in the presence of pyrrhotite leads to the formation of undesirable calcium polysulphides.

A further stage in the Engineering Chemistry Division treatment involved the calcination under oxidising conditions of the pyrhotitic product discussed above. The resulting product still contained 3.18 per cent. of sulphur (a big proportion of which was water-soluble). Cyanide tests on this material gave much cleaner pregnant solutions and left a gold residue of the order of 4 dwt./ton with much lower reagent consumptions.

A number of other products connected with this project were tested and for the most part proved more amenable to cyanidation than the materials described above.

Minerals and Ores.

1. Beryl.—The increased interest in beryl shown in the previous year continued into the middle of this year after which a drop in price led to a slackening of interest.

Early in the year the Australian Atomic Energy Commission increased its unit price for beryl ore from £13 10s. to £15 10s. with the result that production began to increase, particularly from the Yalgoo field and, to a lesser extent, from the Pilbara. Half way through the year, with production at its peak, the Commission ceased buying and the only available market was in the United States. Here the market value was lower than had been prevailing in Australia and was falling still further. A subsequent decline of over 10 per cent. in the unit value has led to a marked falling off in production of beryl in this State.

More than fifty commercial parcels assayed gave an average beryllium oxide (BeO) content of 10.7 per cent. The highest, from the Nullagine area, assayed 12.2 per cent. Eleven parcels assayed below the commercial minimum of 10 per cent. but most were sufficiently close to this figure to be mixed with cleaner material to give the required grade.

A sample received from Strelley emphasised the difficulties of identifying beryl in the field. Though assaying over 10 per cent. BeO it was so heavily stained throughout by manganese as to be almost black. Some alteration was evident and X-ray results suggested the presence of bityite, the hydrated alumino-silicate of calcium, beryllium and alkalis. The black staining mineral was partially isolated by electromagnetic separation, the concentrate assaying 32.5 per cent. MnO_2 and 0.02 per cent. sulphur. This sulphur figure was too low to confirm the suspected presence of helvine.

Perhaps the most interesting beryllium-bearing mineral encountered during the year was euclase ($2BeOAl_2O_3.2SiO_2.H_2O$). It was identified for the first time in this State in the heavy mineral fraction isolated from a Dalgaranga ore, together with pyrite, microlite and tantalite. It is hoped to purify sufficient of the mineral to allow of a complete chemical analysis. Its X-ray diffraction pattern compares closely with that of a Brazilian euclase from the Simpson collection.

2. Clay.—A clay from the Yardarino area consisted of approximately 45 per cent. clay mica, 30 per cent. kaolinite, 10 per cent. quartz and 15 per cent. montmorillonoid. This latter gave it limited bentonitic properties, with a Sadler figure of 25 per cent.

A sample from Widgiemooltha containing about 15 per cent. of clay minerals was composed chiefly of extremly fine-grained white mica. Though not in itself a ceramic raw material, the use of its mica content to act as an added flux to more refractory clays is worthy of consideration.

A clay-like material from Calcarra reported to ooze from the ground and then form a hard crust over an area six feet in diameter was examined and found to consist of 80 per cent. sand and 20 per cent. of clay and silt. The clay and silt fraction was made up of 40 per cent. kaolinite, 40 per cent. montmorillonoid and 10 per cent. quartz.

In connection with the formation of kiln scum on fired bricks the water-soluble sulphate content of three raw clays was determined. Figures varied from 0.01 to 0.03 per cent. SO_4.

Virtually complete analyses were made of about a dozen clays. Three were to supply data for a University research project. Three were made at the request of a company manufacturing porcelain.

Complete firing tests were carried out on clays from Katanning, Brookton, Donnybrook, Kalamunda, Glen Forrest and Widgiemooltha. Sets of specimen briquettes were supplied to the interested persons.

3. Copper.—The steady demand for copper ores continued and the number of samples submitted was the same as the record high of the previous year (149).

The urgent demand was for the carbonate and oxide ores for fertiliser use where 8 per cent. copper is the minimum grade acceptable. To help meet this demand a commercial company is producing a saleable product from low-grade carbonate ore at Thaduna after concentration by flotation. This product is supplementing that obtained by controlled calcination of sulphide ores from the Marble Bar area.

An attempt was made to identify optically and by X-ray diffraction the minerals resulting from this calcination of chalcopyrite. Positive indentification was not possible of all minerals present due in part of the masking effect of hematite, but the probable composition was hematite, the anhyrous copper sulphate hydrocyanite, quartz and the copper oxide tenorite.

Ores containing both sulphide and oxidised minerals are assayed for their content of acetic-soluble copper as well as total copper. The former is considered to be a measure of the copper readily available to plant life and excludes the sulphide minerals, though there is some evidence that the copper of chalcopyrite becomes sufficiently available if very finely ground. However, such fine grinding may not prove economically practicable.

As in previous years, check assays were carried out at the request of producers who normally do their own assay work. Gold and silver-bearing copper flotation concentrates were also assayed.

An unusual number of specimens, mostly high-grade, were received from the Kimberley area. A limonite-malachite-cuprite intergrowth from Hall's Creek assayed over 30 per cent. Copper ore from the Negri River contained over 50 per cent. copper and was composed of malachite, bornite, chalcopyrite and chalcocite. Napier Downs and Leopold Downs were two other sources of good quality specimens.

From the North West Division the most impressive specimens came from Mt. Blair, Abydos, Marble Bar, Range Station, Croydon, Roebourne and Mulgul areas with the Roebourne district perhaps being the most actively prospected.

Three samples received were of particular mineralogical interest. One from Jerramungup assayed 10.2 per cent. of copper, all in the form of atacamite, associated with quartz, clay, feldspar and limonite. Another, from Westonia, contained the basic sulphate brochantite associated with clay minerals only. A hand specimen assayed 32.8 per cent. copper: the occurrence of brochantite was the first recorded from the area. The third specimen was a limestone from Hall's Creek containing residuals of chalcocite altering to malachite.

4. Gold and Silver.—Gold assaying continues to be an important function of the Division, particularly as there is no other metropolitan laboratory available to the public for this type of work.

The number of samples assayed was essentially the same as the previous year, 436 (1962) compared with 445 (1961) though the distribution showed a decrease in the number handled for the public balanced by an increased number of both check and umpire samples from State Batteries Branch.

Thirty samples from Wilson's Patch were assayed in connection with the possible re-opening of an old mine. A number of high-grade copper ores from the Ashburton Station were assayed for both silver and gold, and an appreciable number of samples from the Forrestonia area showed high values.

Sand from around an old battery in the North West assayed over 20 oz. per ton. Vanadium ore from Coates Siding was assayed for gold at the request of the State Mining Engineer but values were less than 2 grains per ton.

Copper flotation concentrates were assayed for gold and silver while batches of samples were received from exploration mining companies, public laboratories, tributers and operating mines.

5. Heavy Sands.—Most samples of heavy sands originated from the South West from such localities as Nannup, Denmark, Margaret River, Greenbushes and Kirup.

Perhaps the most interesting though, came from more northerly areas. One from Shaw River was a fine sand carrying 10 to 15 per cent. copper-stained bismutite and minor amounts of malachite and calcite. A sample from the Gascoyne River at Carnarvon contained 31 per cent. of an unusually wide range of heavy minerals, including ilmenite, magnetite, garnet, hornblende, zircon, monazite, epidote, staurolite, tourmaline, kyanite, andalusite, rutile, leucoxene and xenotime. A sand from the Broome area contained 12 per cent. zircon, 31 per cent. tourmaline and a little topaz, together with hematite, quartz and titanium minerals.

It was found that a commercial parcel of coarse heavy sand could be up-graded from 15 per cent. Ta_2O_5 and 19 per cent Nb_2O_5 to 32 per cent. and 42 per cent. respectively by screening through 20 mesh with a recovery of 90 per cent. of the columbite. The minus 20 mesh fraction was mainly ilmenite, iron oxides and silicate minerals.

An ilmenite sand from Kelmscott was found to be sufficiently intergrown with magnetite to render it magnetic at exceptionally low intensities.

Eleven sands from Greenbushes were examined quantitatively for their content of ilmenite, zircon, rutile, monazite, and leucoxene. Also present were traces of xenotime, gold and corundum.

6. Iron.—An increase of 70 in the number of iron ore samples received compared with the previous year was due almost entirely to an increase in sampling activities of the Geological Survey of Western Australia. These samples originated mainly from the survey's drilling programme at Weld Range, and were mainly bore cores, though some sludge and surface samples were examined.

All were assayed for acid-soluble iron and composites made from appropriate groupings were further analysed for total iron, silica, sulphur, phosphorus, titanium, manganese, magnesia, lime and alumina. Five such composites examined spectrographically showed copper present in the range 0.01 to 0.1 per cent. and tin in the range 0.001 to 0.01 per cent.

In addition, the Survey submitted 35 surface samples from the Pilbara fields and four from near James Point. The latter were mainly hematite, though in one sample goethite was the predominant iron mineral.

A sample from Mallina station in the North-West, consisting of hematite with some magnetite, assayed 70.2 per cent. iron. Others assaying in excess of 68 per cent. originated from Mt. Fraser, Wagga Wagga and Whim Creek areas.

A number of iron ore samples contained appreciable percentages of vanadium. One from Mt. Broome in the Kimberleys assayed 1.2 per cent. vanadium contained in a magnetite-ilmenite intergrowth; another, from Ord River station, showed 57.9 per cent. iron, 8.3 per cent. titanium and 0.8 per cent. vanadium.

An exceptionally fine crystal of magnetite came from Mt. Phillip, and an unusual specimen of martite from the Geraldton area.

Complete analyses were made of three ores from Robe River in connection with up-grading tests being carried out on that ore at Engineering Chemistry Division while a number of check and umpire assays were carried out for commercial laboratories.

7. Manganese.—Only a few samples of manganese were received. The largest batch, consisting of twelve samples, was submitted by Japanese interests for manganese, iron and silica determinations.

Nodules received from Hall's Creek were found to assay 56.5 per cent. manganese and a still higher grade sample from Wallangie contained 59.0 per cent. manganese. From the Youanmi area a pyrolusite-cryptomelane specimen assayed 55.0 per cent. manganese.

8. Tantalo-columbate Minerals.—The exceptionally high prices offered for high-grade tantalite ores during the latter half of 1961 were not maintained during 1962. However, the slump during the earlier months of 1962 was only comparative and the price level gradually improved towards the end of the year. This applied to both the American and European markets with prices on offer being slightly better in America than in Europe.

Production in Western Australia has remained fairly steady except in the lower grades below 30 per cent. Ta_2O_5 where the realisable value dropped to about 10s. per lb. of material.

The relatively new Yalgoo (Dalgaranga) finds contributed a significant proportion of the State's production: during the first three-quarters of the year this contribution was of the order of 30 per cent. of the total, expressed in units of Ta_2O_5. The Greenbushes field still continues to produce tin-tantalite concentrates which are forwarded to Sydney for magnetic separation, the resultant tin fraction being bought within Australia, and the tantalite fraction marketed overseas.

This continued interest in tantalite resulted in an increased demand on the services of the Division for both analytical and determinative work. The number of samples handled was much greater than in any previous year. In fact, since the renewal of interest in these minerals and the exploiting of the new Dalgaranga fields, the Division in the past two years has dealt with twice as many samples as in the previous four years. Both chemically and mineralogically the tantalum and niobium-bearing minerals are unusually complex and it has been found necessary for an additional chemist to specialise in this work.

Much of the work consisted of the examination of samples from commercial parcels submitted by buyers to determine the grade and nature of the material. In most cases, chemical determinations of tin and titanium were also involved as both are common impurities carrying penalties.

As in previous years, assay figures for tin dioxide were in some cases in excess of the amount of cassiterite present due mainly to tin partially replacing tantalum in the columbo-tantalite molecule. Though no cassiterite at all could be isolated from a Pilbara parcel, chemical analysis showed the presence of 3.47 per cent. SnO_2.

The grades of commercial parcels submitted through buyers varied over a very wide range. One from Dalgaranga assayed 76.9 per cent. Ta_2O_5, whereas one originating from the Gascoyne consisted of 98 per cent. martite with columbite equivalent to less than 1 per cent. Ta_2O_5. Among the higher grade samples was one composed of 58 per cent. tantalite and 37 per cent. of a tantalite-microlite intergrowth.

A specimen from the Dalgaranga fields submitted by the Government Geologist was found to be a metamict fergusonite. It is of interest that a metamict columbite had previously been collected from the same area.

A commercial parcel from the Shaw River was found to be predominantly formanite, another metamict tantalo-columbate mineral which is the tantalum-rich end of the fergusonite-formanite series. A hand-picked typical fragment of the formanite assayed:—

	Per Cent.
Tantalic oxide, Ta_2O_5	49.3
Niobic oxide, Nb_2O_5	8.16
Total rare-earths including thoria	31.6

An unusual specimen from an undisclosed locality had properties resembling, but not identical with, those of calciosamarskite. It was essentially a uranium-bearing rare-earth columbo-tantalate, containing 38.8 per cent Ta_2O_5 suggesting that it was either an intergrowth or a tantalum equivalent of the niobium-rich calcio-samarskite.

9. Tin.—Much of the work involving tin assays and determinations was closely allied with similar work on tantalo-columbate minerals. Commercial parcels of either of these minerals almost invariably carry a proportion of the other as impurities. As the presence of titanium minerals with tin minerals can involve penalty payments titanium is also determined on such parcels.

Cassiterite fragments or concentrates were received from a number of localities, mainly in the North-West and Murchison Divisions. A sample of pegamatite lode material from Dalgaranga assayed 4.85 per cent. tin.

The renewed interest in the Greenbushes tin field has resulted in a big increase in the demand for specialized chemical and mineralogical work on tin—tantalite products. These products originate from the intensive drilling programme being undertaken by a mining company with a view to the establishment of large scale dredging in that locality. Concentrates, middlings and tailings from gravity concentrations as well as products depending on magnetic properties and sizings have been examined.

Mineralogically, many of the samples have been complex and estimates of ilmenite, leucoxene, zircon, tourmaline, staurolite, rutile, monazite, spinel, sillimanite, sphene and garnet have been made in addition to the main products cassiterite and tantalite. It is of interest that particles of native copper and gold were identified in a few of the bore core samples.

In all, 114 samples have been received in connection with this project. They have raised interesting problems in that the determination of trace amounts of tin, tantalum and niobium were required in addition to the more commonly required macro determinations.

A number of methods for determining trace amounts of tin was examined, including both volumetric and colorimetric, before the decision was made to use the method involving separation of the tin by distillation followed by its determination colorimetrically using dithiol as reagent. This method is a little longer than straight colorimetric methods but, particularly in the possible presence of both bismuth and antimony as bismutho-and stibio-tantalites, was considered more reliable.

Tantalum in milligram quantities is determined by density of the colour produced by its complex with phenyl fluorone while micro quantities of niobium have been measured by paper chromatography.

10. Titanium.—Much of the work under this head is included under heavy sands.

Analyses were carried out for the Engineering Chemistry Division for the determination of titanium, total iron, metallic iron, carbon and insolubles on the various products associated with that Division's research work on the up-grading of leucoxene. The original head sample and final upgraded product were analysed for titanium dioxide, titanium sesquioxide, ferric and ferrous iron, alumina, silica, manganese, zircon, chromium and water.

In addition to the numerous heavy sands containing ilmenite, massive specimens of this mineral were received from Bullara, Mooloo Downs, Hillside and Yinnietharra Stations in the North-West, from Wydgee Station and Mt. Magnet on the Murchison and from Smithfield in the South-West.

A mineral isolated by the Government Geologist from the red Archaean shale of the Roebourne area proved to be rutile. Specimens of the same mineral were identified from Payne's Find, Calingiri, Bullara Stations and Yarlarweelor Station.

Miscellaneous Analyses.

1. Minerals.—Ninteen *bauxitic laterites* were examined but no prospector samples assayed better than 33 per cent. soda-soluble alumina. Pay samples submitted by commercial organisations showed contents as high as 51 per cent. Assessment of bauxite grade is based in part on the content of soda-soluble alumina, the method used being arbitrarily standardised and accepted by commercial laboratories.

Bismuth minerals were received from Moolyella, Shaw River, Mt. Francisco, Lockier Range and Yinnietharra. The two Shaw River samples were in the form of coarse heavy sand comprised largely of iron oxides, pyrite and copper-stained bismutite with smaller amounts of calcite and malachite. The richer assayed 12.4 per cent, bismuth. The Moolyella and Lockier Range specimens were carbonates, those from Mt. Francisco and Yinnietharra were predominantly metalic. The latter, a 43g. fragment, showed peripheral alteration to carbonate.

A number of *chromite* specimens were received but none proved to be of commercial grade. The best material came from Trilbar station in the Murchison. It assayed 41.4 per cent. chromium oxide (Cr_2O_3) and the chromium-iron ratio was 1.1 to 1. In all others, iron was present in greater proportion than chromium.

The half dozen *gypsum* samples came from widely separated areas and varied in nature from a clear selenite from Mt. Panton in the Kimberleys to a flour-fine 97 per cent. pure powder from Dongara.

Of the *lithium minerals* submitted, only one was found to contain more Li_2O than the generally accepted commercial minimum of 3.5 per cent. This was a lepidolite ore from 11 miles north of Warda Warra. It assayed 4.35 per cent. of lithia. A number of lepidolite samples, received from Hall's Creek, Yalgoo and Poona areas, assayed only between 2 and 2.5 per cent. Li_2O and in addition carried amounts of iron, up to 0.5 per cent., in excess of the required minima for some specialised uses.

Other lithium minerals examined included petalite from a new locality 15 miles East-North-East of Dalgaranga Homestead, spodumene from Ravensthorpe and lithiophilite from Wodgina. Associated with the latter was a small amount of the manganese phosphate mineral hureaulite.

A market exists for lithium minerals provided they assay at least 3.5 per cent. Li_2O, Price on offer was £5 per long ton unit of Li_2O f.o.b. Fremantle with buyers interested in 20 to 100 ton lots for domestic sale and in much larger tonnages for export.

To encourage the replacement of imported *mineral pigments* by local products, comparative tests were made to determine the essential difference between imported German ochres and the best at present available from local sources. German yellow ochre contained 60.4 per cent. iron Fe, present as limonite and the red ochre 67.8 per cent. iron Fe, as hematite whereas the corresponding local product though containing the same minerals assayed 46.0 and 59.4 per cent. respectively. As regards particle size, the percentage of particles less than 10 microns was considerably higher in the German than in the Australian samples. Though the colour and brillance of a mineral pigment does not depend entirely on the above variables, the work does at least suggest two lines along which attempts could be made to improve the West Australian product.

Eleven *phosphate-bearing* rocks from Mingenew, Williamburg and Wandagee areas were assayed for phosphorus content at the request of the Government Geologist.

A fine-grained mineral of the *jarosite* group was received from the Mt. Vernon area. A pure mineral could not be isolated but X-ray work on a cleaned portion suggested jarosite mixed possibly with alunite.

Partial analysis of this portion showed 8.89 per per cent. K_2O and 0.27 per cent. Na_2O.

Monazite concentrates were assayed for rare-earths, thoria and phosphorus.

Wolframite from 14 miles east of Brookton assayed 69.8 per cent. tungstic oxide (WO_3); a specimen of ferberite, from Dalgaranga carried 70.3

per cent. WO_3. Other tungsten-bearing minerals came from an unidentified locality in the Kimberleys and consisted of both scheelite and wolframite associated with biotite, sericite and limonite. A cream to yellow non-radioactive mineral associated with one of these specimens gave an X-ray pattern that did not compare with any recorded in the A.S.T.M. index and its identity remains unknown.

Elements identified spectrographically in this unknown material included aluminium, arsenic, bismuth, lead and tin as well as tungsten.

Two titanium-bearing magnetic iron oxide specimens from the Ord River area showed significant *vanadium* contents, the richer assaying 0.8 per cent. of this metal. Samples from Coate's Siding, analysed at the request of the State Mining Engineer, contained vanadium in percentages ranging from 0.64 to 0.77. The sample showing the highest figure for the year assayed 1.21 per cent. vanadium and consisted essentially of magnetite intergrown with a little ilmenite. It came from the Mt. Broome area in the Kimberley Division.

No specific vanadium mineral was isolated from the above samples. Vanadinite, occurring as an encrustration of hexagonal prisms on a specimen of cerussite from the Dixon Range area was the only actual vanadium mineral recorded.

Interesting specimens of *water-soluble minerals* were received from the Mt. Vernon area. These were fibrous in structure, for the most part white in colour though portions were stained blue-green. X-ray and optical properties suggested a mixture of pickeringite (a hydrated magnesium aluminium sulphate), and epsomite (hydrated magnesium sulphate), while chemical analysis indicated that these two minerals were present in the approximate percentages of 70 pickeringite and 30 epsomite.

Chemical analysis showed:—

	Per Cent.
Alumina, Al_2O_3	8.32
Magnesia, MgO	8.84
Sulphur trioxide, SO_3	37.0
Water, H_2O	the remainder

The blue-green stains were found to be due to traces of cobalt and nickel.

These minerals are not common and because of their ready solubility in water can be expected to occur mainly as an efflorescence in sheltered localities or in very arid regions.

No records can be found of their industrial application, due probably to their rarity, but if reasonable amounts were available such aluminium-bearing sulphates could possibly find application in water treatment in the same way as manufactured alums are used.

Somewhat similar material was received from a lead mine at Galena but here epsomite predominated over the natural alum (which was again probably pickeringite).

Five samples of commercial rock salt were analysed to determine the potash content.

Two other samples contained an excessive amount of gypsum, and on a third sample from the same source an attempt was made to remove or reduce this gypsum content. Though the finer fractions assayed higher in gypsum than the coarse, screening did not result in sufficient beneficiation. Washing with concentrated brine for two hours reduced the gypsum concentration by about 55 per cent. but it is doubtful if such treatment would in this case be economically feasible.

Zircon concentrates from commercial production were assayed for zirconium, iron, titanium, total and free silica and alumina. The determination of trace amounts of the latter in the presence of large amounts of zirconium is a difficult analytical procedure but a method based on that of H. Freund and F. J. Miner (Anal. Chem. 25 : 564, 1953) involving the use of ion exchange resins to separate the aluminium was found satisfactory.

2. Complete Analyses.—Complete mineral analyses were made as a contribution to research work being carried out at the Department of Geology at the University of Western Australia.

One analysis was of a new mineral occurring in the Wolgidite rock from Wolgidee Hills, Fitzroy Basin, West Kimberley. It was somewhat similar to a new mineral, batisite, reported recently from Russia but different in a number of significant respects. Major elements present were silica, titanium, barium and potassium.

A sample of perovskite, a calcium titanate, which had been isolated from the same Wolgidite rock was also analysed. In addition to the main elements calcium and titanium the sample contained small amounts of iron, zirconium, barium, sodium, potassium, aluminium and silica.

A complete analysis was carried out on a specimen of black glassy mineral recovered at depth from a bore core in the Mt. Jackson area. Optically and by X-ray it was identified as opal carrying as inclusions minor amounts of anatase and graphite. Aside from titania (2.21 per cent.) and carbon (1.6 per cent.), both almost certainly deriving entirely from these two inseparable inclusions, only silica and water are present in amounts in excess of 0.6 per cent.

Complete analytical figures were as follows:—

	Per Cent.
Silica, SiO_2	85.62
Alumina, Al_2O_3	0.56
Ferric oxide, Fe_2O_3	0.10
Magnesia, MgO	0.03
Lime, CaO	Nil
Soda, Na_2O	0.20
Potash, K_2O	0.05
Combined water, H_2O + ...	2.99
Free water, H_2O —	6.25
Titania, TiO_2	2.21
Carbon dioxide, CO_2	Nil
Phosphorus pentoxide, P_2O_5	0.02
Sulphur trioxide, SO_3	0.10
Chlorine, Cl	0.07
Manganese oxide, MnO	trace
Carbon, C	1.60
	99.80
Less O = Cl	0.01
	99.79

Analyst: J. R. Gamble.

3. Others.—An aluminium alloy was analysed at the request of the Public Works Department for zinc, iron and silicon while four samples of lead being used by Metropolitan Water Supply, Sewerage and Drainage Department as a jointing material were analysed for tin, arsenic, antimony, aluminium, iron and zinc.

One of the most complex analyses of the year resulted from a quantitative examination of a soldering flux made up of borates and fluorides of lithium, sodium and potassium.

An ash from Collie coal was analysed for silica, alumina, lime, magnesia, soda, potash, manganese, chromium, iron, titanium, vanadium, phosphorus and sulphur.

Three commercial explosives were submitted by the Inspector of Explosives for microscopic examination, sizing, and determination of bulk density, water-insoluble material and the nature of the insoluble filler. The explosive was essentially ammonium nitrate in each case and the filler was diatomite in two of the samples and kaolin in the third.

Three barium sulphate powders for use in radiological work when examined microscopically were found to be comprised of particle of varying physical characteristics. One sample, an imported product which gives entirely satisfactory results clinically, was made up of spherical aggregates of crystals, each less than 1 micron in diameter. A second sample was composed of discrete angular particles up to 45 microns in diameter. This was an Australian product which did not give the desired freedom of flow in suspensions or the even adhesion to linings of the alimentary system so necessary in radiological work.

It was apparent that the imported powder is prepared by controlled chemical precipitation, whereas the local product is apparently prepared by fine-grinding of natural baryte.

A sludge from a storm water sump at Welshpool industrial area was analysed for the Swan River Conservation Board.

A deposit formed on the anodes (and on supporting steelwork) of the cathodic protection system on the Wyndham jetty was analysed for the Public Works Department and found to be predominantly magnesium and calcium carbonates with some iron and silica but traces only of zinc.

Two sand samples were submitted by the Metropolitan Water Supply, Sewerage and Drainage Department for an explanation of the tendency of the sand to cake after wetting and compaction. Examination showed insufficient clay or water-soluble salts to cause caking, but microscopic and chemical tests suggested the presence of very finely divided calcite as the likely cause. Though calcite is soluble in cold water only to the extent of about 15 parts per million, the presence of carbon dioxide greatly increases its solubility. The mineral goes into solution as bicarbonate which on evaporation of the water or loss of carbon dioxide comes out of solution as the carbonate which would produce a weak calcium carbonate bond between individual sand grains.

Further sand samples from a different locality showing the same property of caking contained no calcite but had a fairly high clay content of 5 per cent.

Mineral Identifications.

1. New Species.—In the report for 1961 a brief description was given of a basic lead aluminium copper sulphate mineral under the name edgarite. This mineral was believed to be new to science and a paper on its properties submitted to the American Mineralogist had been accepted for publication. At the same time a paper appeared in a Mineralogical Journal (Japan) decribing a new mineral from the Osarizawa mine in Japan and named osarizawaite after its locality of origin. This mineral proved to be identical with the edgarite from the Marble Bar district and so the Western Australian occurrence lost by a small margin the distinction of being the first ever described. However, the description of the local occurrence duly appeared in the American Mineralogist for Sept.-Oct., 1962 under the title "Osarizawaite from Western Australia" and the name edgarite became stillborn.

2. Russellite.—A most interesting specimen mineralogically was received from a prospector in the Poona area. Though it was essentially quartz with some muscovite, there was associated with it a yellow bismuth mineral that could not readily be identified.

An impure concentrate of the yellow mineral was assayed and found to contain 57.0 per cent. bismuth oxide (Bi_2O_3) and 25.6 per cent. tungstic oxide (WO_3).

An X-ray powder photograph gave a picture corresponding with that of russellite, but with a few extra lines which may have been due to impurities. Spectrographic work indicated the presence of appreciable molybdenum, in addition to tungsten and bismuth.

Russellite was first discovered in 1934 as a pale yellow, heavy, soft mineral which appeared occasionally along with the wolfram in jig concentrates from the Castle-an-Dinas wolfram mine in Cornwall. All attempts to find it in situ underground in the sedimentary host rock of the wolfram failed, and as far as can be ascertained it has not since been recorded elsewhere in the world.

Work by its original discoverers suggests a mineral of composition Bi_2O_3. WO_3 and by nature an isomorphous mixture of oxides rather than a bismuth tungstate.

The probable occurrence of this mineral in Western Australia would obviously repay study and work is in hand to isolate sufficient of the pure material to carry out further work.

3. New Localities.—Among the minerals recorded during the year for the first time from certain localities within the State, a number represented the first reported occurrence in Western Australia. One at least, russellite was the first in Australia and, as far as available published literature shows, only the second in the world.

As some of these have been discussed under headings appropriate to their composition, a list only is given here.

Mineral.	New Locality.
	(a) Kimberley Division.
Anthophyllite	25 miles North-West of Hall's Creek.
Chromite	Rose's bore, Dixon Range.
Vanadinite	Wilson's mine, Dixon Range.
	(b) North-West Division.
Baryte	5 miles West of Prairie Downs Homestead.
Chromite	4 miles South-East of Roebourne.
Hureaulite	Wodgina.
Diaspore	Starr's find, Comet.
Pyrophyllite	Starr's find, Comet.
Mimetite	Koonong Pool, Ashburton Downs.
Arseno-bismite	Koonong Pool, Ashburton Downs.
Duftite	Koonong Pool, Ashburton Downs.
	(c) Murchison Division.
Anthophyllite	15 miles East-North-East of Dalgaranga.
Beryl	3 miles South-East of Windsor Homestead.
Chromite	Trilbar Station.
Chromite	30 miles West of Wooleen Homestead.
Corundum	12 miles North-North-East of Dalgaranga.
Cryptomelan-pyrolusite	Youangarra Station.
Columbite	3 miles South-East of Windsor Homestead.
Petalite	15 miles East-North-East of Dalgaranga.
Rutile	10 miles North of Yarlarweelor Station.
Russellite	2 miles South - East Poona.
	(d) South-West Division.
Brochantite	Westonia.
Copper (Native)	Greenbushes.
Beryl	1 mile North of Rothsay.
Manganotantalite	Mt. Edon.
Columbite	Mt. Edon.

4. Miscellaneous.—Many mineral identifications are described elsewhere, under appropriate headings in the sections Minerals and Ores. This section refers to a selection not elsewhere described.

The hydrous aluminium phosphate *variscite* associated with iron oxides, clay and quartz was identified in a specimen originating from a locality between Mt. Vernon and Teano Range. Though an interesting mineral with an appreciable phosphate content it would be a refractory mineral to treat and is unlikely to occur in deposits of commercial significance.

Another interesting phosphate mineral, identified for the first time in this State, was hureaulite, a hydrated manganese phosphate found associated with a lithiophilite specimen from Wodgina.

Of ten *baryte* specimens examined, only one (from Mooloo Downs) crushed to a powder sufficiently white to be of possible interest to the paint and paper trades: the others all carried iron stains of varying intensities.

Diatomaceous earth samples were received from Dandaragan, Dongara and Jandakot. Material from the latter source, after calcination at 900°C, showed filtering properties which compared favourably with imported filter-aids.

A number of *quartz crystals* were examined but none was of a quality suitable for use in the radio industry. The property of becoming luminescent when rubbed or scratched (triboluminescence) was strongly developed in a quartz specimen from Lake Darlot area.

No high quality *asbestos* specimens were received. The only *chrysotile* specimen examined came from the vicinity of Mt. Alexander in the Ashburton district. It was intergrown with calcite and other minerals associated with it included magnesite, magnetite, chlorite and quartz.

A number of *anthophyllite* specimens were weathered and heavily iron stained. One from Roebourne, was extensively altered to sericite and talc; the fibres of all asbestiform varieties were brittle.

Fibrous *actinolite* samples came from Ninghan Station and Roebourne. An asbestiform *tremolite* from Warriedar Station had exceptionally long fibres but these were too brittle to be of commercial value.

Samples of commercial grade South African *chrysotile* and *amosite* were examined and X-ray diffraction photographs were recorded for reference.

The localities from which *talc* samples were received included the Roebourne area, Mt. Seabrook, Wiluna and Armadale. It is difficult to assess the commercial potential of a talc sample in view of the wide variations in specifications from one industry to another and often within the same industry. The tests are far from standardised and are often designed by buyers to fit their own particular needs. Another difficulty of course is the fairly wide range of industrial applications of talc. Fairly universal requirements are a good colour, freedom from grit, a minimum iron content (particularly of water-soluble iron) and a reasonably low ignition loss.

A talc from Armadale, submitted by the Government Geologist for general examination, ground to a smooth pale yellow-brown powder containing no water-soluble iron but having an ignition loss of 4.1 per cent. Its colour precluded its use in the paint or cosmetic industries and its loss on ignition was in excess of that allowed in some rubber industry specifications. A possible application could be as a filler in roofing products.

The best quality talc specimen came from 40 miles South-West of Roebourne. It was a fine-grained material which crushed to a good white powder free from grit. When fired slowly in a muffle, a cube cut from the sample showed no distortion and retained both its strength and orginal dimensions up to a temperature of 1250°C. A second sample also from the vicinity of Roebourne, gave a gritty, creamy-buff powder but in the massive form had an attractive mottled appearance which suggested some ornamental value.

A platy mineral occurring in a pisolitic limonite from Robe River was identified as well-crystallised *gibbsite*.

A mineral of the *scapolite* group was recorded for the first time in the State, associated with a green pyroxene from Kurrenkutten. The group is composed of complex alumino-silicates of calcium and sodium with the chloride and carbonate radicles also present in small amounts.

A saussuritised *feldspar* from Roebourne area was composed of epidote, zoisite, chlorite and fine-grained mica while from the same area a specimen of *zorsite* was received in the form of radiating bunches of crystals associated wth quartz, feldspar and calcite.

A spectacular specimen from the Kimberleys was portion of a vug composed of an outside casing of quartz and limonite. The internal surface was made up of well-formed hexagonal quartz crystals with small spherical blebs of hematite on the crystal faces, and also limonite pseudomorphs, probably after hematite scalenohedrons, with well-marked natural etching figures on the crystals.

Other minerals received during the year, with approximate locality, included celestite (Kalgoorlie), rutile (Cue), prehnite (Osmond R, Kimberley and Roebourne), selenite (Mt. Panton) corundum and dudleyite (Warda Warra, Roebourne and Derby), pyrophyllite, and diaspore (Comet), pumpellyite, sphene (Roebourne), arsenopyrite (Warriedar), black calcite and graphite (Uaroo), cryptomelane (Dalgaranga), nontronite (Bullfinch, Ninghan and Trilbar), scorodite (Warriedar), magnetite (Peninsula and Dalgaranga), dolomite (Kununoppin and Peninsula), opal (Pindar).

Miscellaneous.

A steel ball suspected of being a meteorite and steel chips hopefully identified by a prospector as osmiridium were among the spurious minerals received. Others of artificial origin submitted included speiss and silicon.

Australites were received from the Nullarbor Plain near Haig and from the Ord River Station in the Kimberleys. The latter is of particular interest as it represents the most northerly occurrence of these tektities recorded at these laboratories and is well north of the generally accepted northerly limit defined by a line joining Derby with Kyogle in N.S.W.

Among fossilised material received was a sample of silicified wood from Cranbrook and one of wood replaced by calcite and pyrite from about 500 feet below the surface in an Allanooka water bore hole.

A meteorite found North East of Loongana and forwarded by the Government Geologist was identified as a medium-grained octahedrite composed largely of kamacite with a little plessite and some fine intergranular taenite. A portion assayed 90.0 per cent. iron and 7.4 per cent. nickel.

A white powder stated to occur as a surface deposit (under an inch or so of soil) over an area of 40 to 50 acres was identified as wheat flour.

PHYSICS AND PYROMETRY SECTION.

Pyrometry.

National Association Testing Authorities certificates covering the calibration of 11 mercury in glass thermometers were issued during the year. The majority of these were total immersion thermometers. The distribution of accuracy required was as follows:—three were calibrated to ± 0.05°C., five were to ± 0.1°C. and two to ± 0.5°C. The total range of calibrations was from 0°C. to 400°C.

Differential Thermal Analysis.

A total of 19 samples was examined using this method in conjunction with X-ray diffraction. Of these, eight were clay samples of mostly simple composition, whose identification was thus straightforward. Two of the clays, from beds underlying coal seams, showed large exothermal reactions between 500°C. and 600°C. characteristic of organic matter, which was removed only after prolonged treatment with hydrogen peroxide.

Some metamict samples previously identified by means of X-ray diffraction were studied by differential thermal analysis. The recrystallisation temperatures so deduced agreed approximately with those reported in the literature.

X-Ray Diffraction.

The number of samples identified or confirmed by this method was 160, involving 500 exposures. This represents a twofold increase over the number of samples so treated in the previous year. Of the total, 19 were clays and 16 were rare earth or radioactive minerals.

The clay samples were generally straightforward and identification presented no problems.

The rare earth and radioactive minerals, including metamicts, can generally be classed into series with some facility, and this is usually sufficient identification. Precise identification of series members will in general have to await further study.

Some interesting and unusual mineral identifications by the X-ray diffraction method are quoted below.

The X-ray pattern of a black glassy material from Mt. Jackson, thought to be a pseudotachylite, resembled a mixture of high cristobalite and low tridymite, an unlikely combination. (Quartz and anatase lines were also present, and anatase was confirmed in the HF insoluble residue.) This however is often the case with opals, in which the apparent high cristobalite is in reality a disordered low cristobalite. According to Dana Vol.

III, low tridymite lines appear and increase in intensity as the disorder increases. Hence the sample apparently is an impure common opal, a conclusion strengthened by exposing an opal from one of the mineral collections which gave a pattern almost identical but for the impurities. The black hue may be contributed by the anatase known to be present and by graphite, as 2 per cent. carbon was determined chemically.

Two examples of identification of organic crystalline material were a urinary calculus and a lung tissue deposit. The urinary calculi tested here in the past contained only a small proportion of crystalline matter but this sample gave quite a clear diffraction pattern easily identified as Weddellite $CaC_2O_4.2H_2O$, a common constituent of such calculi. The other example, a crystalline lung tissue deposit, was available only in very small quantity from a microscope slide. The resultant patterns were very poor but showed good resemblance to Whewellite $CaC_2O_4.H_2O$.

A pattern taken to identify a manganese and iron oxide mineral proved to be predominantly that of Bityite, the Mn, Fe mineral being presumably amorphous. This case is interesting both from a mineralogical point of view, it being a beryllium mica formed as an alteration product of beryl, and the fact that Bityite was not suspected before the X-ray.

A first occurrence in Western Australia to be reported from these Laboratories was the rare mineral Euclase, a hydrated beryllium aluminium silicate. This occurred in small quantities associated with muscovite schist containing a small percentage of tantalum minerals, chiefly microlite. No pattern was available in the American Society for Testing Materials powder data file, but the X-ray pattern, taken to confirm the optical and chemical diagnosis, was identified by comparison with patterns from a Brazilian Euclase in the Simpson Collection and from other literature.

A mica like mineral found in pisolitic laterite was submitted for diagnosis by the Geological Survey. The mineral proved to be the uncommon crystallised variety of Gibbsite.

A forensic investigation was carried out for the Police Department in conjunction with the Food and Drug Division. A single small grain of material from the trouser cuff of a suspect was shown by both optical and X-ray methods to be identical with material described as "safe ballast". Final diagnosis of ammonium alum was confirmed by comparing X-ray patterns of the samples and that of prepared alum.

A mineral with the optical properties of Lotrite was found in a sample from Roebourne. Lotrite has been classified as a variety of Pumpellyite (hydrated calcium alum iron silicate) and comparison of x-ray patterns with American Society for Testing Materials powder data, and of Pumpellyite from Ubini has confirmed this.

APPENDIX.

THE PAINTING OF KARRI TIMBER.

Abstract.

The frequency of failures in the painting of Karri timber has had a very adverse effect on its usage. The work described in this report covers attempts to determine the cause of paint failures on karri and to devise suitable paint systems.

Results of 3-year exposure tests indicate that there is a general type of primer suitable for painting karri. As long as this primer coat remains intact the karri surface does not appear to show the longitudinal cracking characteristic of the timber on exposure.

It appears that best results will accrue if the karri is painted whilst still green.

Introduction.

Work on the painting of karri timbers was first suggested by the State Housing Commission in 1957 when they experienced trouble with paint flaking off karri weatherboards. At the time the laboratories were just beginning work on surface coatings suitable for Western Australian conditions and the painting of karri was necessarily a part of this wide programme. The Timber Development Association was also deeply interested in the karri problem and in view of its importance it was decided to focus attention on painting karri, leaving other aspects of surface coatings to such time as opportunity and staff conditions permitted their investigation.

Thus began almost a seven-year investigation. If this seems a long time it has to be remembered that much of the work involved exposure testing and that the results of such tests may not be available for a year or two, at least not for some months.

Test Programme.

In December 1957, 42 test panels of karri were exposed on an exposure frame at South Fremantle Power Station, to the Superintendent of which, Mr. Brackenridge, our thanks are due for his cooperation. The panels faced north and were inclined at 32 deg. to the horizontal.

Previous work on karri painting in other laboratories had shown that green timber gave better results than dry. There was probably, therefore, a range of moisture contents between which karri might successfully be painted. This range has, incidentally, not yet been fully established but it is now known that only green karri can be painted with reasonable chances of success.

These preliminary tests were not intended primarily to find a successful sealer or primer but rather to study some theories that had been developed in considering the past history of karri painting. It seemed that a successful sealer would require to have—

(i) high elacticity to cope with movement in the timber;

(ii) high resistance to chemical attack;

(iii) an aqueous base since the solvents present in oil-based paints might dissolve out substances from the karri which would be harmful to paint films.

Subsequent work adequately established the correctness of the first assumption. The other two have not been proved and the work which followed on these preliminary investigations showed that, whilst karri did yield some soluble material on treatment with solvents the extract did not apparently affect paints applied to karri to any marked extent.

This later work also indicated that paint failures in karri were largely due to superficial cracks in the timber allowing moisture penetration beneath the film. Treatment of the timber with solutions of various chemicals did not appear to improve the durability of the primer.

It must be mentioned here that the work just reviewed was on primers with no subsequent undercoat or top coat. It is to be regarded as an accelerated weathering test for primers, the results of which might not necessarily be applicable to a 3-coat system. Nevertheless it could be argued that those primers which resisted the test conditions best would be the most likely to provide the best primers for a 3-coat system.

Of all the primers used one gave most promising results. This was a micaceous iron oxide type with aluminium. At the end of the test this paint could still be scatched with a finger nail. The film was, therefore, pliable and therefore sufficiently elastic to withstand movement in the timber without cracking.

A pink primer used in the tests gave better results than two red leads. In earlier work a red lead primer below conventional undercoat and top coat had, on exposure, given reasonably good results. Presumably when the primer was undercoated a week after it was applied the red lead primer had not completely hardened and the subsequent hardening was either greatly decelerated or stopped by the under and top coats.

At this stage of the work—1959—it was clear that the best chances of success of painting karri seemed to rest on—

(i) choice of a primer which would remain elastic indefinitely;

(ii) use of timber with about 25 per cent. moisture content (indications were that 35 per cent. was too high and 15 per cent. too low).

A series of karri panels was accordingly painted with selected primers, undercoats and top coats and by February 1960 were on exposure at South Fremantle Power Station. Subsequently in June 1961 the test samples were removed to Woodman's Point since it had been found that fly ash from the chimney stacks at the Power Station had fallen on samples causing deterioration and thereby making accurate assessment of exposure results almost impossible.

In the work, 72 painting systems were applied to 144 karri panels. The karri was quarter-sawn, had a moisture content of 20-30 per cent. and was dressed at the mill. Before painting, the surface was smoothed with a rotary sander and all edges rounded.

The primers, undercoats and topcoats were applied to one face and all sides of the panels; the reverse side was left unpainted.

A general description of the primers, etc., used is as follows:—

Primers.

Mark	Pigments.	Vehicle.
A.	Aluminium, micaceous iron oxide.	Raw and boiled linseed oil.
B.	Titanium dioxide, carbon black (trace).	Oil modified chlorinated rubber.
C.	Aluminium, micaceous iron oxide.	Raw and boiled linseed oil.
D.	Micaceous iron oxide, red iron oxide.	Raw and boiled linseed oil.
E.	Aluminium	Oil modified chlorinated rubber.
F.	Aluminium, micaceous iron oxide, lead cyanamide.	Long oil alkyd, phenolic tung varnish.
G.	Red Lead.	Not known.
H.	Zinc oxide, aluminium, talc.	Linseed oil, tung oil.

Undercoats.

Mark	Type.
1.	White exterior, oil based.
2.	White interior, oil based.
3.	White, water based.

Topcoats.

Mark.	Type.
1.	White exterior alkyd gloss enamel.
2.	White interior alkyd gloss enamel.
3.	White polyurethane (2 can) gloss.
4.	Grey chlorinated rubber.

Each panel was identified by painting on the reverse side a letter indicating the primer used, and numbers indicating the undercoat and top coat thus A.1.1. would have primer A, undercoat 1 and topcoat mark 1. Each primer was overcoated with the following systems:—

Marks.	Description.
1.1	Exterior undercoat and exterior alkyd gloss enamel.
1.1.U.V.	As 1.1. but with 1.0 per cent. phenyl salicylate ("Salol") added as an ultra-violet absorbent.
2.2.	Interior undercoat and interior alkyd gloss enamel.
2.2.U.V.	As 2.2. but with ultra-violet absorbent as in 1.1.U.V.
3.3.	Waterbased undercoat and polyurethane topcoat.
3.1.	Waterbased undercoat and exterior alkyd gloss enamel.
0.4.	No undercoat and grey chlorinated rubber topcoat.
0.0.	No undercoat nor topcoat.
1.1. (4 weeks)	As 1.1. but overcoated four weeks after applying primer.

Two panels were painted with each system.

The exposed panels were examined periodically and an assessment of performance was made. Originally this was based on points lost for—

cracking;
flaking;
checking;
colour;
gloss.

Later, colour and gloss were omitted for a number of reasons, one being that we had no standard instrument for such measurements. After 18 months' exposure a tabulation of points lost in respect of the first 3 items was made and forms Table 1. of this report.

The essential features of this table are—

(i) the painting systems applied over primer H failed completely in 3 months;

(ii) painting systems over primer G were very poor after 18 months;

(iii) painting systems based on primers A, C, and E were in very good condition.

TABLE 1.

Points Lost in Exposure Test.

Topcoats	Primers								Total
	A	B	C	D	E	F	G	H	
1·1	0	0	0	0	0	0	Complete failure after 1 year	Complete failure after 3 months	0
1·1 U.V.	0	0	0	0	0	0			0
2·2	4	6	8	11	3	2			34
2·2 U.V.	4	6	8	11	6	5			40
3·3	0	0	0	0	0	3			3
3·1	0	0	0	0	0	0			0
0·4	0	1	0	0	2	5			8
0·0	7	9	5	4	8	14			47
1·1 (4 weeks)	2	4	0	0	2	7			15
Total	17	26	21	26	21	36	....	....	....

At this stage in the investigation it seemed reasonably certain that failure of karri painting systems was not due to an attack on the paint film by a compound of the wood, but was much more likely to be caused by movement of the timber brought about by changes in moisture content. Two observations supported the premise that inter-grain splitting was responsible for paint failures:—

(i) Quarter-sawn timber, which "moves" much less than backsawn timber had the better paint-holding qualities.

(ii) Visual examination of paint failures indicated that inter-grain splitting had ruptured the paint film.

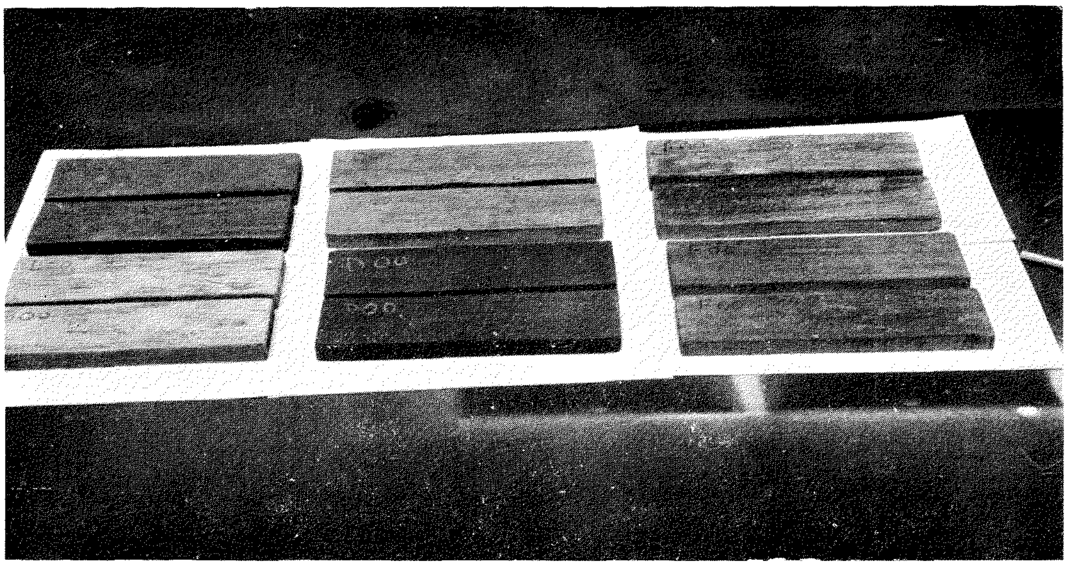
On this basis it was considered that the two desiderata in a primer for painting karri would be permanent flexibility and resistance to the passage of water or water vapour. It might be added that most decorative type paints used as undercoats and gloss coats are reasonably permeable to water vapour.

Exposure tests of samples were continued to February 1963, when 3 years had elapsed since their first painting. And the assessment was made on the same lines as in Table 1 and the figures arrived at are collected in Table 2.

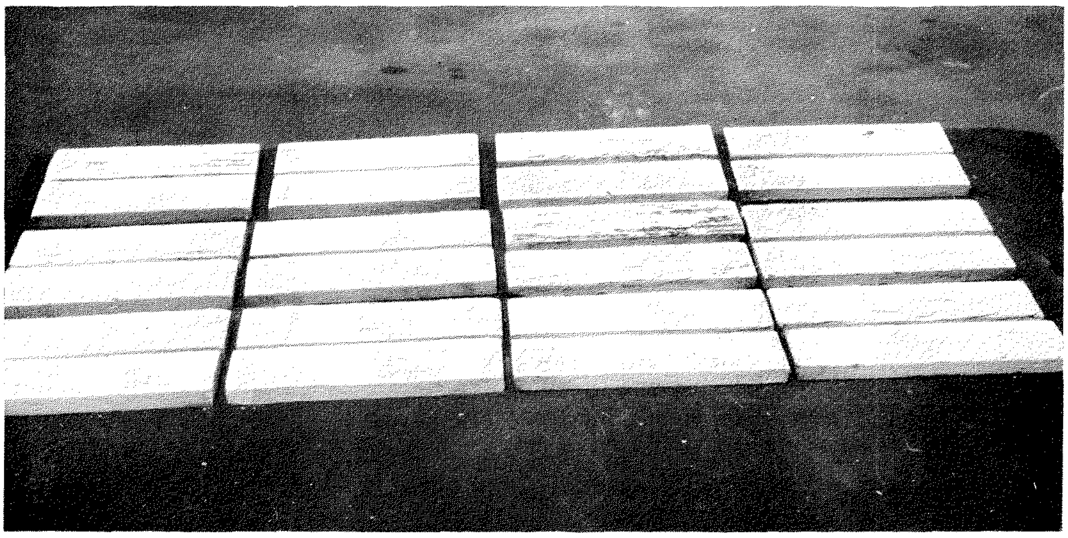
TABLE 2.

Points Lost in Exposure Test.

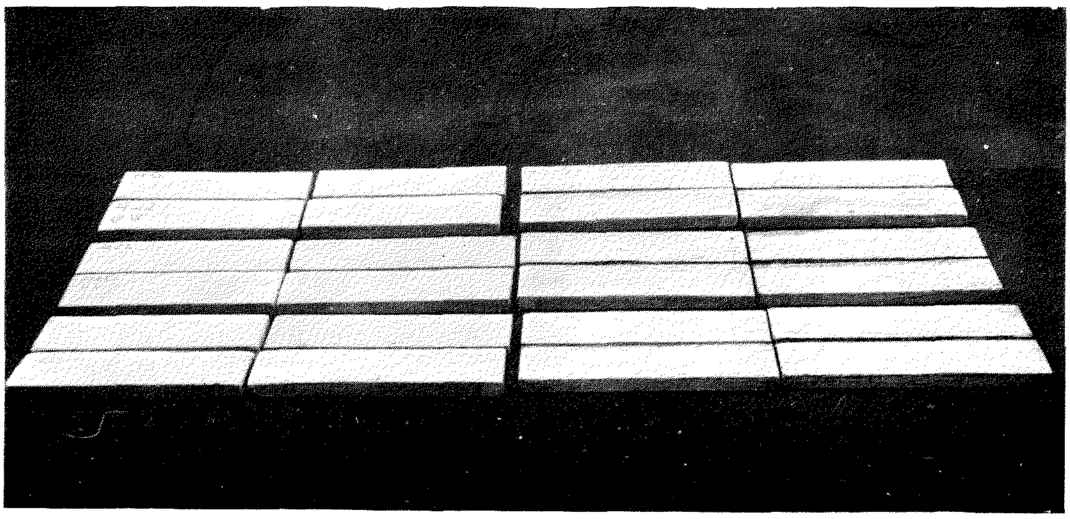
Topcoats	Primers								Total
	A	B	C	D	E	F	G	H	
1·1	5	6	8	16	3	7	See Table 1		45
1·1 U.V.	6	3	12	21	8	7			57
2·2	13	10	12	15	11	15			76
2·2 U.V.	8	12	10	20	15	13	....		78
3·3	2	0	1	7	5	6	....		21
3·1	1	1	2	10	5	3	....		22
0·4	10	7	12	8	7	14	....		58
0·0	10	22	25	8	25	30	....		120
1·1 (4 weeks)	19	20	17	20	17	23	....		116
Total	74	81	99	125	96	118	....		....
Excluding 0·0 totals are	64	59	74	117	71	88	....		....



Plates 1 and 2.—Primers exposed without overcoating. All have failed.



Plates 4 and 5.—Two identical painting series except that for the series on the left, and second from the right, the undercoat and top coat were not applied till two weeks after the primer.



Plates 13 and 14.—Panels with and without ultra-violet absorbent showing no appreciable benefit from the absorbent.

The evaluations in Table 1 were made by Mr. B. J. O'Leary who was largely responsible for the planning and working of the karri painting test scheme. Before the exposures had passed the 3-year period Mr. O'Leary had been transferred to the Department of Industrial Development. In order to reduce the personal error to the minimum Mr. O'Leary kindly arranged to make the evaluations which are now given in Table 2 above. In this connection Mr. O'Leary wrote:—

> Table 2 gives points lost out of 10 for each of the factors cracking, flaking, and checking for each system (not each panel). It is therefore possible to lose 30 points representing complete failure in or by all 3 factors.
>
> There are probable discrepancies in actual points lost between evaluations, i.e.; a system may have shown an apparent improvement between evaluations. This is unlikely and is undoubtedly due to the empirical method of evaluations. A comparision of systems at each evaluation, however, is reasonably accurate. For comparison purposes it is suggested that the panels be independently evaluated at this stage.
>
> The panels have been exposed for about 3 years. They have had rough treatment, e.g.; exposure to flue dust at power house, dropped from panel holders due to wind, etc.
>
> The main change since last evaluated is that the 1.1 system has deteriorated due to flaking of the top coat which has allowed the bottom coats to check and flake. An outstanding feature is that the systems 3.3. and 3.1., both undercoated with water based formulation have over three years shown marked superiority over the other top coat systems. Of the primers, primer D is inferior to the others. It is noted that this is the only primer tested not containing aluminium pigment.
>
> Based on this evaluation the primers A, B or C overcoated with systems 3.3. or 3.1. appear to have the best weathering characteristics.
>
> It is suggested that the test programme be continued, using the most favourable of the formulations tested. The other requirements, moisture content and, quarter sawn timber could be more closely evaluated to determine the extent of control necessary over these properties.

On the basis of all the work now reported it is considered that a successful scheme for the painting of karri timber can be set forward now, but it will doubtless improve with further testing. Much thought is being devoted to the continuance of the exposure testing and it is intended to consult both paint companies and the timber organisations freely in the course of planning. Meantime the rules for the successful painting of karri would seem to be:—

(i) Use quarter sawn timber where possible.

(ii) Paint only green timber, moisture content between 20 and 30 per cent.

(iii) Use a primer giving a permanently flexible film with low permeability to water or water vapour—micaceous iron oxide type with a linseed oil vehicle.

(iv) A water-based, P.V.A. co-polymer type latex paint is best as an undercoat. Paints based on Monsanto's "Lytron" 680 were used in the test. This base is used in commercially available latex paints; an intending user should consult the technical officers of any paint company.

(v) If a matt finish is required the paint used as the undercoat above is suitable; paint companies can suggest alternatives. For a satin finish it is belived that conventional water based latex paints would suit. For top coats with a gloss a well-pigmented 2-can polyurethane coating would seem best.

On the basis of the saying that a picture is worth a thousand words some photographs of the exposed panels have been taken and are to be found in the text. Their captions should make it quite clear how they are intended to illustrate the text of the report.

A. REID,
Chief Industrial Chemist.

CONTENTS

DIVISION VIII

•

Annual Report of the Chief Inspector of Explosives for the Year 1962

•

The Under Secretary for Mines:

For information of the Hon. Minister for Mines, I am privileged to report on the operation and functioning of the Explosives Branch during 1962.

Staff.

Although the year's work was carried out with the same small staff, recent developments and implementation of the potentially large field of Dangerous Goods control will necessarily demand augmented inspectional and clerical assistance. Apart from this expected future expansion, a mounting throughput of technical duties ushered in by the blasting agent era and linked also with explosives requirements of large government and private undertakings has detracted from time formerly spent at Head Office. Notwithstanding a curtailed program of distant magazine and licensed explosives storage inspections, occasions have arisen where neither man can be at his post in Perth.

Accommodation.

In its ultimate functioning, the Branch must obviously acquire space for additional staff. Of immediate urgency, however, is an office for the Inspector who since appointment in 1958 has shared a room and telephone with the clerk, whose duties also cover the interviewing of applicants for prospecting assistance.

At Woodman's Point Explosives Reserve, staff quarters and storage facilities are adequate, but a small semi-isolated structure for deteriorated explosive awaiting destruction is wanted. The practice of holding these residues in the room used for sensitive heat-testing determination is undesirable. Similarly, chemical apparatus and a few reagents also housed therein as the nucleus of a small laboratory will require other accommodation when available.

Equipment.

The last mentioned facilities were provided for qualitative examination of firework and explosive compositions. Incursion into the formal quantitative analytical field is neither intended nor at present possible, but self-sufficiency in the means for rapid on-the-spot identification has become an essential and time-saving adjunct to the Branch's work.

Importation of Explosives.

As in 1961, the State's nitro-explosive and blasting powder requirements were substantially met by consignments shipped and railed from Nobel's factory near Melbourne. Approximately the same tonnage arrived by each method of conveyance until a significantly lower consumption later in the year reflected the wide inroads made by blasting agents into the conventional explosives domain, particularly as applied to gold mining. Ammonium nitrate, the preponderating component, also imported from the Eastern States, was supplemented by supplies of a special grade prilled product from U.S.A. Several tons of French explosives were lightered from a vessel at roadstead for magazining in Woodman's Point Reserve whilst awaiting despatch to the oil-drilling industry. Koolan and Cockatoo Islands continued to receive explosives loaded into north-bound iron-ore ships at Kwinana.

About 1950, long before transcontinental railage of explosives was envisaged, suggested importation through Esperance came under investigation. It was proved, however, that the high costs of establishing and maintaining such a project would annul any freight advantages accruing from the shorter haul to the Golden Mile. A recent resurgence of interest in the port's potentialities was directed not to explosives but to ammonium nitrate —and justifiably so, because it may be discharged in limited quantity over a non-isolated jetty, and handled, transported and stored under less rigorous conditions than with explosives. Already a small shipment to Esperance has occurred, with indications of future larger ones.

Types of Explosives.

No new or unknown compositions appeared during the year. It is true that certain gelignites manufactured in October and November, though conforming to type, contained ammonium sulphate in which an impurity caused deterioration in quality, as described later under that heading. Weights and dimensions of explosives underwent no change except for re-introduction of the once-familiar 4 in. x $\frac{7}{8}$ in. cartridges—a handy size for small jobs, but now mainly used as primers for blasting agents.

Types of Blasting Agents.

Chemically there is nothing new to report; the only blasting agents used in Western Australia consist of hydrocarbon oils of defined flashpoint in admixture with almost pure ammonium nitrate. The latter, however, has undergone considerable physical change compared with the prototype material which even as a fine powder proved poorly absorptive, taking up only about 4.5% oil and leaving the remainder as a film on the crystals. Intimacy of contact being essential, a more porous and permeable variety was developed under the trade name of Nitrex. This was superseded by a better physical form known as Nitrolite which is now in use along with a prilled nitrate of American manufacture. An Australian plant for making a similar or even further improved ammonium nitrate prill should be able to cope with the rapidly increasing consumption by 1964.

Use of Explosives and Blasting Agents.

Explosives.—Goldmining accounted for 57.7% of total usage, coal 10.7, geoseismic firing 6.7, quarrying and non auriferous mining 13.7, construction 7.0, State public works 1.4, local government works 0.5 and miscellaneous purposes 2.3.

(16)—70240

Blasting Agents.—Ammonium nitrate, the principal component, comprised 17% of total commercial explosives importations. Taking into account the fuel oil, the figure becomes about 18%. The impact of blasting agents on conventional explosives was heavy toward the close of the year, especially in gold mining, quarrying and dry-hole seismic operations, but no precise information as to the extent of its application in the various industries was available.

The Quality of Explosives.

During bulk inspection of explosives on arrival, vigilance is exercised for externally stained packages as possibly indicative of wetting or decomposition of the contents. Greasy patches on several cases from M.V. Falie's shipment of February 21st, however, were simply a superficial soiling. Oiliness among 65 cases from M.V. Blythe Star's holds last April had partly dissolved the protective wax and messed the contents of 80 plugs, which were rejected. More serious trouble was encountered at the Kalgoorlie Reserve about mid-December with dark stains on Semigel boxes, shown later by chemical analysis to be concentrations of nitrated glycerol-glycol up to 9.6 per cent by weight of the affected fibreboard areas. The liners were similarly permeated and although the composition and immediate wrappers lacked the characteristics of exudation, some kind of mass migration was inferred. Results of further analyses, still in progress, are awaited with interest. Other samples of Semigel, also from Kalgoorlie, were cleared when suspected exudate was found to be merely surplus adhesive from the liner seal. One minor instance of wetting in transit came to notice. "Blebbing", or the occurrance of relatively large gelatinous particles of probable over-sensitivity by comparison with the matrix, was of almost negligible incidence this year.

The usual 2,000-2,500 samples submitted to heat-test determination complied with requirement except that gelignites manufactured during October and November were reactive below the standard minimum ten minutes at 160°F. The heat-test being regarded as a criterion of stability, these findings were most disturbing, especially as several tons of the low-reacting explosive had been forwarded direct from South Australia to Loongana within the Western Australian border. However, by the good offices of the Chief Inspector at Adelaide, this side of the problem was satisfactorily handled. Briefly explained, the depressed values were established as related to an impurity in ammonium sulphate, an additive claimed by factory chemists as not detrimental to stability. On this assurance and results of the Branch's continued laboratory investigations, explosives technically out of compliance with regulation but showing no dangerously low heat tests were released for early consumption. All States struck the same trouble—one was considering the destruction of 6,000 cases reacting in some samples down to three minutes—and each reported normal values from December onward after ammonium sulphate was no longer added.

Explosive accessories maintained high quality and suitability for specified purpose. In the new field of blasting agent technology, however, deviations were often observed in the burning rate of safety fuse passing through the oil-impregnated charge for bottom firing. No doubt a more heavily countered or otherwise fortified Australian product will eventually displace the American fuse known as Orange Sequoia, at present under trial on at least one Kalgoorlie mine. Other accessories of which the quality was challenged comprised slow and fast igniter cord of alleged undue impact-sensitivity. Percussion testing to somewhat drastic limits failed to substantiate this assertion, but following a rare mishap of ignition by falling rock, the manufacturers advised covering the cord where heavy mechanical damage might be expected.

To conclude these remarks on quality, practically all explosives, blasting agents, accessories and packaging materials reached here in satisfactory condition conforming with definition or specification. Anything of defective nature was but a small fraction of total importations, and except for two obvious instances to the contrary, nothing of sub-standard or deteriorated quality left the factory for Western Australia.

Packaging of Explosives.

Success attendant on the bagging of fuse in polythene and use of the same fabric as liners in powder-type explosives containers encouraged application to carton wrapping as replacement for waxed paper. Samples recently received created favourable impression without of course permitting final assessment until long-run observations are completed. Cartridges thus packed have so far been end-waxed only, whereas full waxing is recommended because the small user or reseller is generally saddled with residual material once the 5 lb. carton is opened. For the standard 80 lb. ammonium nitrate packages, six-ply paper bags plastic-varnished internally were found preferable to polythene which, even at 0.01 inch thickness, showed certain mechanical weakness at the stitched tops and heat-sealed seams. Steel drums, whether bulk filled or used to hold several bags, have been frequently used; indeed this type of outer package, or its equivalent in the form of sea containers, is insisted on by most shipping and railage authorities.

Nine tons of foreign explosive lightered from an American research vessel for temporary storage at the coastal reserve were poorly packed, but as the entire quantity was returned a few days later and could not therefore be regarded as importation, no departmental action followed. The oil drilling explosive already mentioned bore French inscriptions and labelling; its release was sanctioned after stencilling the word "Explosives" on all sides.

Disposal of Unwanted Explosives.

The generally satisfactory state of explosives on arrival practically restricted destruction to residual sample composition and deteriorated materials either picked up during inspections or submitted by the police. From the latter body came an unusually large quantity of detonators, mostly serviceable. They were destroyed by detonating, sometimes on a pre-arranged plan which furnished information as to sensitivity, action at given distance, etc.

Magazine and Store Inspections.

Coverage of this field, though perhaps less comprehensive than formerly, actually demanded attention at more inspectional points consequent on the rapid ascendancy of blasting agent use. In 1961 only one sizeable new magazine appeared, whereas during the current period dozens of inquiries and considerable activity concerning ammonium nitrate storage were recorded. Whether intended for nitro-explosive or blasting agent component, most buildings complied with requirements. A drive towards greater security by installing recessed magazine doors and locks resistant to hacksaw and jemmy was continued, with good results.

As to conditions of explosives under storage, moisture absorption again proved to be the main deteriorant. Various small amounts ranging from the soggy to the dripping stage were condemned, and instruction given where necessary for decontamination of the receptacle or magazine.

Ordnance and Services Explosives Movements.

Inspectional function under Fremantle Harbour Trust regulations called for attendance at North Wharf, the Naval Jetty and Woodman's Point Reserve jetty during transhipping, loading and discharge of munitions. All such operations, including conveyance to or from the vessel, were controlled by rigid codes and performed with high regard for safety. Though not ordinarily concerned with the composition and properties of ordnance, Explosives Branch inspection has paid off by detection of occasional risky and foolhardy acts on the part of workmen and others not associated with the main job. Among such breaches may be mentioned the attempted or actual use within the danger area of blowlamps, welding equipment and even a diesel compressor not fitted with spark and flame-trapped exhaust.

Accidents with Explosives and Dangerous Goods.

Where fire or injury may possibly be related to sub-standard explosives and dangerously reactive chemicals, the Branch investigates. A few of the more interesting such problems may be briefly described.

At a new Doubleview house, a contractor liberally doused an unsatisfactory tile underlay with mineral turpentine to facilitate spading from a concrete floor. Almost the first stroke fired the mass, causing disastrous damage. Attempted reconstruction aimed at producing spark ignition actually failed, probably because under a prevailing strong cool breeze the former conditions of heat and restricted ventilation could not be reproduced. However, the experiment demonstrated the flame sensitivity of bituminous tile material and solvent —and this applied also to certain adhesives used in the laying process.

Fire in a parked caravan defied positive explanation, notwithstanding evidence that a pressure pack of hair lacquer had burst alongside a lighted electric globe. Liquid from a new can of the same material was shown to be flammable.

A former miner familiar with explosives lost several finger joints by alleged premature explosion when removing sawdust from a detonator at a Willagee well-sinking job on October 6th. Fortunately the residual metal shell and several unused detonators, all of the same purchase, were kept. Percussion testing established normal sensitivity. The detonator blamed for injury, however, presented an unusual stubbed appearance, quite different from the splaying characteristic of explosion unconfined or under light manual pressure. As the victim and two witnesses all abided by evidence so difficult to reconcile with observation, the detonator remnant in due course was sent to the manufacturer for expert opinion as to prevailing conditions at the moment of explosion. A report is expected early next year.

A 13 year old boy at Bolgart was injured by a bomb made at home from cordite and blasting powder. How he came by such dangerous playthings, or what action followed, was not disclosed.

Explosives Found.

Two cases of gelignite recovered from under a slab on a grave at Karrakatta were thought to have been cached by a criminal, since deceased. Police attached importance to the age of this explosive, but the dates stencilled on the boxes were at first quite illegible. Laboratory examination by ultraviolet light proved of little avail until the wood had thoroughly dried, when one date showed up distinctly and that on the other box sufficiently for the purpose in mind.

Attendance at Conferences and Meetings.

The sub-committee comprising Harbour Masters and heads of Government Explosives Departments met in Melbourne on February 8th and 9th for discussion and analysis of a model code on handling, labelling, shipping and storage of dangerous goods. Being covered by other regulations, explosives were not primarily considered, but the main subject encompassed much of the Branch's past advisory work which, under the Act of 1961, will become one of its essential functions.

At the seventh Australasian and New Zealand Explosives Conference at Adelaide from April 3rd to 11th, progress on earlier decisions and resolutions was reported before dealing with 88 items under 11 headings. Prominent topics such as blasting agent technology and the modification of firework sizes and types received special attention. At Brukunga, Messrs, Nairne Pyrites Ltd. demonstrated all phases of ammonium-nitrate-molasses usage from the drilling of the shotholes to final explosion. Unique information, seldom available from textbook sources, was obtained from vibrographic measurements and extent of damage resulting from increasing explosive charges in an unwanted house on the Myponga Reservoir Reserve. The effect of each shot was recorded until intentional complete demolition under a heavy charge, which provided additional detail such as radius of projected debris. Visits to the Explosives Reserve and Saltfields at Dry Creek completed a most interesting program of field work.

By courtesy of the Chamber of Mines at Kalgoorlie, Mr. Greaves and the writer attended several meetings during the year.

Explosives and Dangerous Goods Act, 1961.

Following practice adopted with the Act when in draft form, intended Explosives and Fireworks Regulations were circulated among all concerned. Criticism, mostly constructive and seldom at variance with the basic safety factor aspect of control, was acted upon wherever practicable. The fireworks section has been operative since gazettal in October, but the explosives regulations, comprehensive and in step with changing technology, may not be ready for official sanction until mid-1963. Preparation of dangerous goods regulations was by no means completed although, as for years past, the Branch freely advised in matters relevant thereto.

Fireworks—Class 1, Division 3, Shopgoods.

On a reduced scale compared with past years, fireworks importations comprised smaller and simpler types. The season was a quiet one almost devoid of mishap except for a reported instance of burns from a home-made bomb. Carry-over stock accounted for occasional appearance of plastic-tipped rockets and other banned lines, but all pyrotechnics entering the State during 1962 were authorised for sale only if complying with the new more restrictive regulations. In the inspection of samples, the usual attention to incendiary and exploding compositions was extended to analytical determination of arsenical or other toxic compounds in streamer bombs and like articles for indoor use. Especially when purporting to differentiate between fireworks suitable or otherwise for holding by hand, labelling received attention. Pursuant to clauses j, k, and l of Regulation 12, firing tests were applied to all lines to detect erratic projection and to ensure ready ignition, safe delay and freedom from incandescent material reaching ground level.

Actually very few fireworks were condemned. Whenever contactable, manufacturers were apprised in advance of requirements so that modification or adjustment to their wares could be effected. Several border-line instances of defect brought under notice were well received and rectified prior to further despatches.

Firework Displays.

Before gazettal of controls last October, occasional unsatisfactory or even dangerous practices at public exhibitions came under notice. However, two displays earlier in the year, one by a noted English pyrotechnist, were conducted without incident.

Fireworks—General.

A parcel of clothing sent from Germany to a North-West mission was declared also to contain "firecrackers for the children." Perhaps confusion arose in translation, for the "firecrackers" turned out to be parachute flares, encased in metal and containing propellant and igniting explosive charges. For firing, a pistol, which had to be licensed under Western Australian law, was required. Obvious danger, especially in attempted launching without proper equipment, was the deciding factor in ordering destruction of the flares.

Acknowledgments.

Ready co-operation from organisations and individuals in formulating regulations proved helpful during a year in which the impact of blasting agents on the former nitro-explosives field brought about problems and extra duty. To my colleague Mr. G. A. Greaves gratitude is expressed for zeal and aptitude in all phases of the Branch's functions. The clerical side was well carried out, and satisfaction is also recorded as to the management and staffing of the two major explosives reserves. Cordial relationships both with various departments and non-governmental contacts were well maintained.

F. F. ALLSOP,
Chief Inspection of Explosives.

DIVISION IX

Report of Chairman, Miner's Phthisis Board and Superintendent Mine Workers' Relief Act, 1962

Under Secretary for Mines:

I have the honour to submit for the information of the Honourable Minister for Mines, my report on this Branch of the Mines Department for the year 1962.

General.

The State Public Health Department, under arrangements made with this Department, continued the periodical examination of mine workers, the work being carried on throughout the year at the Kalgoorlie Laboratory and a mobile x-ray unit visited the Coolgardie, North Coolgardie, Yilgarn, Dundas, Mt. Margaret, Murchison, East Murchison, Pilbara, West Pilbara and the Phillips River Goldfields and the South West Mineral Field.

Mine Workers' Relief Act.

Total Examinations.—The examinations under the Mine Workers' Relief Act during the year totalled 5,760 as compared with 5,753 for the previous year, an increase of seven. The results of the examinations are as follows:—

Normal	5,183
Silicosis early previously normal	50
Silicosis early previously silicosis early	499
Silicosis advanced previously normal	1
Silicosis advanced previously silicosis early	10
Silicosis advanced previously silicosis advanced	Nil
Silicosis plus tuberculosis previously normal	1
Silicosis plus tuberculosis previously silicosis early	5
Silicosis plus tuberculosis previously silicosis advanced	Nil
Tuberculosis previously normal	1
Asbestosis early previously normal	2
Asbestosis early previously asbestosis early	3
Asbestosis advanced previously asbestosis early	1
Asbestosis plus silicosis previously silicosis early	2
Asbestosis plus silicosis previously asbestosis plus silicosis	2
Total	5,760

These 1962 figures, but not in such detailed analysis, together with the figures for the previous years, are shown in the Table annexed hereto. Graphs are also attached illustrating the trend of examinations since 1940.

Analyses of Examinations.—In explanation of the examination figures I desire to make the following comments:—

Normal Etc.—These numbered 5,183 or 89.98% of the men examined and include men having first class lives or suffering from fibrosis only. The figures for the previous year being 5,188 or 90.18%.

Early Silicosis.—These numbered 549 of which 50 were new cases and 499 had been previously reported, the figures for 1961 being 54 and 479 respectively. Early silicotics represents 9.53 per cent of the men examined, the percentage for the previous year being 9.26 per cent.

Advanced Silicosis.—There were 11 cases reported of which one was previously reported as normal, and 10 advanced from early silicosis during the year. Advanced silicotics represent 0.19 per cent. of the men examined, the percentage for the previous year being 0.23 per cent.

Silicosis Plus Tuberculosis.—Six cases were reported compared with five in 1961.

Tuberculosis Only.—One case was reported compared with three in 1961.

Asbestosis.—One case of advanced asbestosis and nine cases of early asbestosis were reported. Of the early cases two were new and seven had been previously reported. Cases of asbestosis represented 0.18 per cent. of the total examinations.

Mines Regulation Act.

Total Examinations.—Examinations under the Mines Regulation Act totalled 1,812. These were in addition to the 5,760 examinations under the Mine Workers' Relief Act. There was a decrease of 321 examinations under this Act in 1962 as compared with those in 1961. Of the total of 1,812 men examined, 1,454 were new applicants and 358 were re-examinees.

Analyses of Examinations.—Particulars of the examinations are as follows:—

New Applicants.

Normal	1,433
Pneumoconiosis or increased fibrosis	4
Silicosis early	Nil
Silicosis advanced	Nil
Silicosis plus tuberculosis	Nil
Query tuberculosis	5
Tuberculosis	Nil
Other conditions	12
Total	1,454

Of the above applicants for admission into the industry 1,423 received the Initial Certificate (Form 2), five received the Temporary Rejection Certificate (Form 3), 15 received the Rejection Certificate (Form 4) and in 11 cases no certificate was issued. Thus of the 1,454 applicants, 1,423 or 97.87 per cent. were eligible for employment anywhere on a mine.

Re-examinees.

Normal	304
Pneumoconiosis or increased fibrosis	28
Silicosis early	14
Silicosis advanced	Nil
Silicosis plus tuberculosis	Nil
Query tuberculosis	5
Tuberculosis	Nil
Other conditions	7
Total	358

These men had been previously examined and scme were in the industry prior to this examination. 302 received the Initial Certificate (Form 2), four received the Temporary Rejection Certificate (Form 3), three received the Rejection Certificate (Form 4), 15 received the Re-admission Certificate (Form 5), 17 received the Special Certificate (Form 9) and in 17 cases no certificate was issued.

Grouping of Examinations—New Applicants and Re-Examinees.—Grouping the two sets of figures discloses that the following certificates were issued under the Mines Regulation Act:—

Initial Certificates (Form 2)	1,725
Temporary Rejection Certificates (Form 3)	9
Rejection Certificates (Form 4)	18
Re-admission Certificates (Form 5)	15
Special Certificates (Form 9)	17
No certificate	28
Total	1,812

The percentage of men of normal health (Initial Certificates) to the number examined was 95.20 per cent. compared with 96.53 per cent. in 1961.

Miner's Phthisis Act.

The amount of compensation paid during the year totalled £10,696 11s. 8d. compared with £11,683 1s. 3d. for the previous year.

The number of beneficiaries under the Act on the 31st December, 1962, was 98, being eight ex-miners and 90 widows.

Administrative.

During the year the regulations under the Mine Workers' Relief Act were extensively amended but in the main these were consequential upon the 1961 amendments to the Act.

Dr. P. F. Maguire, M.B.Ch.B., D.P.H., was appointed to the medical staff of the Kalgoorlie Laboratory in October, 1962.

W. Y. R. GANNON,
Superintendent Mine Workers' Relief Act,
and Chairman Miner's Phthisis Board.

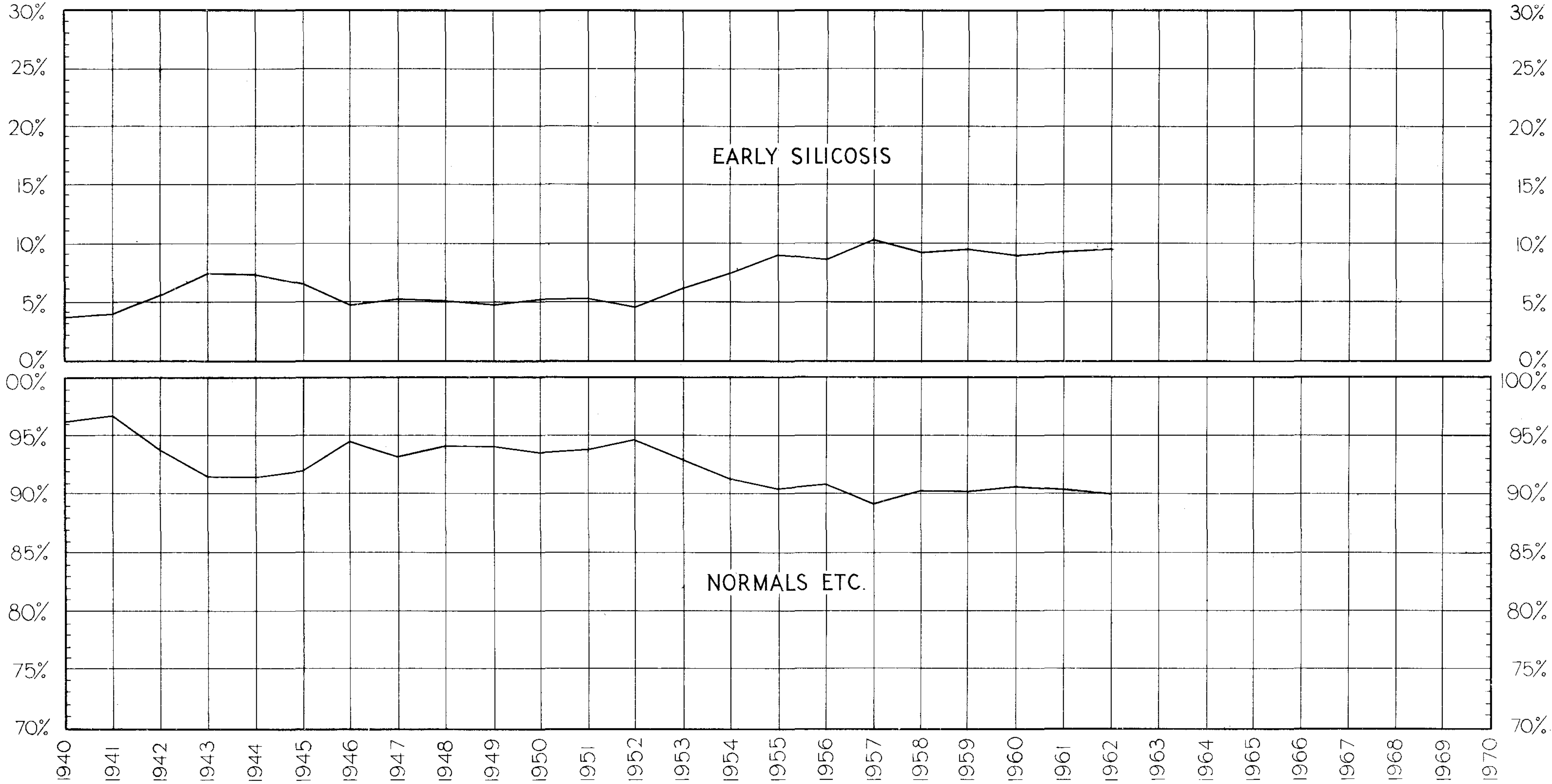
Table Showing Results of Periodical Examination of Mine Workers from Inception of Examinations (1925).

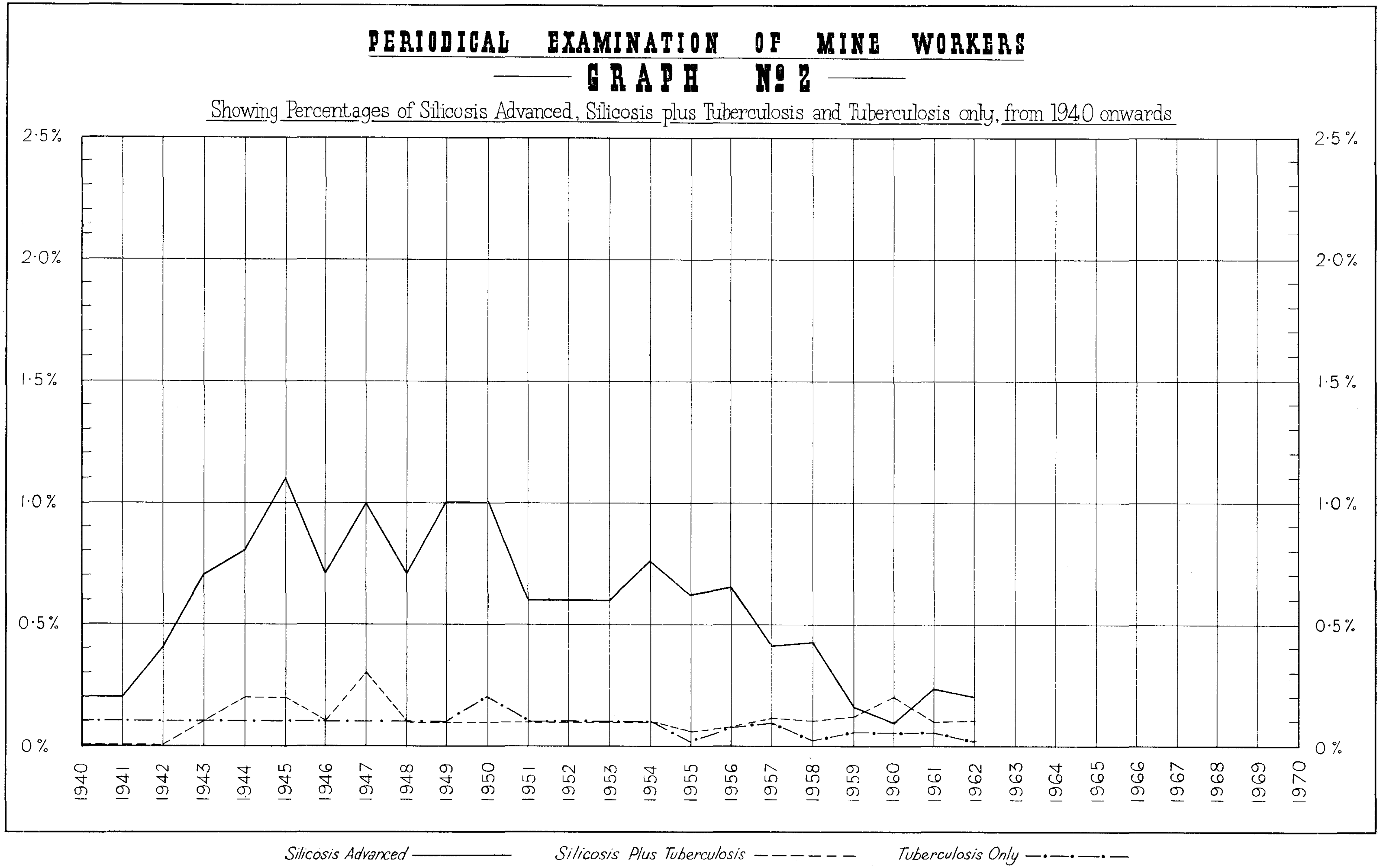
Year	Normal		Silicosis Early				Silicosis Advanced					Silicosis plus Tuberculosis					Tuberculosis Only		Asbestosis									Total
	Total	Per Cent.	Previously reported as Normal etc.	Previously reported as Silicosis Early	Total	Per Cent.	Previously reported as Normal etc.	Previously reported as Silicosis Early	Previously reported as Silicosis Advanced	Total	Per Cent.	Previously reported as Normal etc.	Previously reported as Silicosis Early	Previously reported as Silicosis Advanced	Total	Per Cent.	Total	Per Cent.	Asbestosis early previously normal	Asbestosis early previously asbestosis early	Asbestosis advanced previously normal	Asbestosis advanced previously asbestosis early	Asbestosis advanced previously asbestosis advanced	Asbestosis plus tuberculosis previously normal	Asbestosis plus tuberculosis previously asbestosis	Total	Per Cent.	
1925 } 1926 }	3,239	80·5	....	....	459	11·4	....	....	....	183	4·5	....	....	....	131	3·3	11	0·3	....	....	....	....	....	....	....	....	....	4,023
1927	3,116	83·6	33	348	381	10·2	8	....	85	93	2·5	39	27	62	128	3·4	10	0·3	....	....	....	....	....	....	....	....	....	3,728
1928	2,977	85·5	59	303	362	10·4	3	16	79	98	2·8	18	14	10	42	1·2	4	0·1	....	....	....	....	....	....	....	....	....	3,483
1929	2,120	81·9	102	224	326	12·6	....	34	60	94	3·6	8	14	19	41	1·6	7	0·3	....	....	....	....	....	....	....	....	....	2,588
1930	2,785	81·9	136	247	383	11·3	2	22	43	67	2·0	8	60	46	114	3·3	50	1·5	....	....	....	....	....	....	....	....	....	3,399
1931	2,530	84·0	94	252	346	11·5	....	18	35	53	1·8	4	35	19	58	1·9	25	·8	....	....	....	....	....	....	....	....	....	3,012
1932	3,835	89·5	35	338	373	8·7	....	6	47	53	1·2	3	9	4	16	·4	8	·2	....	....	....	....	....	....	....	....	....	4,285
1933	2,920	86·5	57	322	379	11·2	1	15	44	60	1·8	2	9	4	15	·4	3	·1	....	....	....	....	....	....	....	....	....	3,377
1934	5,140	92·4	54	315	369	6·6	1	24	12	37	·7	6	6	....	12	·2	5	·1	....	....	....	....	....	....	....	....	....	5,563
1935	4,437	92·3	35	303	338	7·0	....	24	2	26	·6	....	5	....	5	·1	2	·0	....	....	....	....	....	....	....	....	....	4,808
1936	6,972	94·7	29	323	352	4·8	1	15	4	20	·3	3	8	....	11	·1	8	·1	....	....	....	....	....	....	....	....	....	7,363
1937	7,487	95·4	15	319	334	4·3	....	14	4	18	·2	1	10	....	11	·1	2	·0	....	....	....	....	....	....	....	....	....	7,852
1938	6,833	95·7	13	266	279	3·9	....	15	2	17	·2	1	8	....	9	·1	3	·0	....	....	....	....	....	....	....	....	....	7,141
1939	6,670	95·6	18	264	282	4·0	....	7	3	10	·1	1	9	1	11	·2	2	·0	....	....	....	....	....	....	....	....	....	6,975
1940	7,023	96·2	12	245	257	3·5	....	10	1	11	·2	....	4	....	4	·0	4	·0	....	....	....	....	....	....	....	....	....	7,299
1941	6,840	95·8	32	248	280	3·9	....	11	3	14	·2	....	....	....	....	....	7	·1	....	....	....	....	....	....	....	....	....	7,141
1942	5,469	93·9	61	264	325	5·6	....	20	5	25	·4	....	2	....	2	·0	3	·1	....	....	....	....	....	....	....	....	....	5,824
1943	3,932	91·5	63	262	325	7·6	....	25	7	32	·7	....	5	....	5	·1	4	·1	....	....	....	....	....	....	....	....	....	4,298
1944	4,079	91·5	70	270	340	7·5	....	21	14	35	·8	1	7	....	8	·2	6	·1	....	....	....	....	....	....	....	....	....	4,468
1945	3,071	92·1	54	166	220	6·6	....	26	10	36	1·1	3	2	....	5	·2	2	·1	....	....	....	....	....	....	....	....	....	3,334
1946	5,294	94·4	89	172	261	4·7	1	36	2	39	·7	3	1	2	6	·1	6	·1	....	....	....	....	....	....	....	....	....	5,606
1947	6,021	93·3	101	237	338	5·2	....	49	9	58	1·0	13	11	1	25	·3	8	·1	....	....	....	....	....	....	....	....	....	6,450
1948	4,827	94·0	24	239	263	5·1	....	18	17	35	·7	1	3	....	4	·1	5	·1	....	....	....	....	....	....	....	....	....	5,134
1949	5,162	94·0	24	239	263	4·8	....	20	31	51	1·0	3	2	1	6	·1	7	·1	....	....	....	....	....	....	....	....	....	5,489
1950	5,077	93·6	14	269	283	5·2	....	14	41	55	1·0	....	1	2	3	·1	8	·2	....	....	....	....	....	....	....	....	....	5,426
1951	4,642	93·9	13	248	261	5·3	....	9	20	29	·6	....	4	2	6	·1	4	·1	....	....	....	....	....	....	....	....	....	4,942
1952	5,073	94·6	8	234	242	4·5	....	4	31	35	·6	....	2	....	2	·1	7	·1	....	....	....	....	....	....	....	....	....	5,359
1953	4,474	93·03	74	225	299	6·22	....	8	24	32	·6	....	2	....	2	·1	2	·1	....	....	....	....	....	....	....	....	....	4,809
1954	5,142	91·33	154	275	429	7·62	....	22	21	43	·76	1	6	2	9	·1	7	·1	Segregation of asbestosis diagnoses commenced in 1959									5,630
1955	4,559	90·40	63	386	449	8·90	....	9	22	31	·62	1	1	1	3	·06	1	·02	....	....	....	....	....	....	....	....	....	5,043
1956	4,600	90·78	25	401	426	8·41	....	8	25	33	·65	1	3	....	4	·08	4	·08	....	....	....	....	....	....	....	....	....	5,067
1957	3,925	89·08	30	424	454	10·30	....	8	10	18	·41	1	4	....	5	·12	4	·09	....	....	....	....	....	....	....	....	....	4,406
1958	5,154	90·20	46	483	529	9·26	....	15	9	24	·42	....	6	....	6	·10	1	·02	....	....	....	....	....	....	....	....	....	5,714
1959	5,242	90·10	66	485	551	9·47	....	9	....	....	·15	1	5	1	7	·12	3	·05	6	....	....	....	....	....	....	6	....	5,818
1960	5,214	90·54	50	473	523	9·08	....	5	....	5	·09	2	9	....	11	·19	3	·05	2	....	....	....	....	1	....	3	....	5,759
1961	5,188	90·18	54	479	533	9·26	....	13	....	13	·23	2	3	....	5	·09	3	·05	5	5	....	1	....	....	....	11	·19	5,753
1962	5,183	89·98	50	499	549	9·53	1	10	....	11	·19	1	5	....	6	·10	1	·02	2	7	....	1	....	....	....	10	·18	5,760

PERIODICAL EXAMINATION OF MINE WORKERS

GRAPH Nº 1

Showing Percentages of Normals and Early Silicotics from 1940 onwards




PERIODICAL EXAMINATION OF MINE WORKERS
GRAPH No. 2
Showing Percentages of Silicosis Advanced, Silicosis plus Tuberculosis and Tuberculosis only, from 1940 onwards
2·5%
2·0%
1·5%
1·0%
0·5%
0%
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
Silicosis Advanced
Silicosis Plus Tuberculosis
Tuberculosis Only

DIVISION X

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Report of the Chief Draftsman for the Year 1962

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Under Secretary for Mines:

I have the honour to submit, for the information of the Hon. Minister for Mines, my report on the operations of the Survey and Mapping Branch for the year ended 31st December, 1962.

Staff.

The staff of the Branch totals 34. Considerable increases in the amount of work of the different sections was brought about by the added interest shown in the development of the iron and mineral resources of the State. Due to the keen demand, a large number of our maps required re-printing to replenish stocks, and new issues were produced.

Our cadets continued to make good progress and some of them gained valuable field experience from excursions with licensed surveyors, while others worked under the guidance of departmental geologists.

Close liaison with various Government and Local Government Departments was maintained in connection with the problems arising from the increased mineral activity.

Thanks are due to the staff for their excellent co-operation in coping with the increased work during the year.

Reports in summarised form of the sections of the Branch are appended hereto.

L. A. JONES,
Chief Draftsman.

Surveys.

Contract surveys in accordance with Mines Department regulations to the value of £2,266 15s. 3d. were carried out during 1962 at the following centres:—

South West Mineral Field:
- Marmion
- Forrestfield
- Bolgart
- Wanneroo
- Kelmscott
- Capel
- Irwin
- Kojonup
- Forrestdale

East Murchison Goldfield:
- Goanna Patch

Gascoyne Goldfield:
- Mangaroo
- Yinnietharra
- Dalgety Downs

North Coolgardie Goldfield:
- Menzies

Mt. Margaret Goldfield:
- Leonora

Northampton Mineral Field:
- Northampton

Pilbara Goldfield:
- Moolyella

West Kimberley Goldfield:
- Hawkstone Peak

West Pilbara Goldfield:
- Mons Cupri

During the year special requests for surveys were received and attended to. The details are as follows:—

Whim Creek (Mons Cupri): On the instruction of the Hon. Minister, certain surveys were carried out at this centre to enable him to reach a decision regarding Mineral Claims in dispute between Depuch Shipping and Mining Co. and Hancock Prospecting Co.

Northampton: The applicants for certain Mineral Claims at this centre requested an identification with verification of the corner of their claims. This was done.

Goanna Patch (Wildara Station): Surveys at this centre were carried out at the request of the Warden to enable him to resolve a dispute regarding pegging of leases in this area.

Hawkstone Peak: This called for the establishment by survey of the common corner of Licenses to Prospect Nos. 57H and 88H and the corresponding point on the northern boundary of P.E. 30H. This is the first survey of its kind in this State under the Petroleum legislation and could quite well form a precedent for similar surveys.

Survey Examination.

Diagrams of surveys were drawn and examined, duplicate and original plans were prepared on lease instruments and diagrams of surrender and resumption were prepared as required.

Geodetic.

Computations for the laying down and cadastral plotting control for plans on the Transverse Mercator Projection were completed for 15 sheets.

Mapping.

The main mapping carried out was as follows:—

(1) Corunna Downs 1 mile map published. Wodgina 1 mile map completed.

(2) 1 : 50,000 series. Garden Creek, Mondana and Coogan Belt published. Twelve other maps in progress.

(3) Several 20-chain lithographs of areas in the Pilbara region drawn on Transverse Mercator Projection, also 20-chain lithographs of old series re-drawn where required.

(4) Ten new Standard Plans compiled and surveys from field notes plotted on Standard system.

(5) Two hundred and eighty-three plans prepared for Geological Surveys together with 2,083 prints.

Nullagine 4 mile geological map printed.

Boorabbin 1 : 250,000 map completed with colour masks and ready for publication.

Balfour Downs 1 : 150,000 map commenced and also four maps in the 1 : 50,000 series.

(6) State general information map and Mineral Resources map re-printed.

(7) Miscellaneous reproductions for Chemical Laboratories, Explosives and Inspection of Machinery Branches. Certificates and diagrams for School of Mines, Kalgoorlie.

(8) Prints and copy-rapid orders fulfilled during the year comprised 3,123 dyelines and 4,792 copy-rapids representing an increase of 54% in this sphere alone.

Public Plans.

Number of Applications dealt with	992
Number of Public Plans in use	717
Number of existing tenements maintained on Public Plans	4,489
Number of Maps, Plans Sketches, Underground Plans, etc., supplied to the public, outstations and other Departments	965
Number of Temporary Reserves applied for	170
Number of Temporary Reserves in force	371
Number of Petroleum Tenements in force	98

MINING STATISTICS
to 31st December, 1962

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Table of Contents

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TABLE 1.

PRODUCTION OF GOLD AND SILVER FROM ALL SOURCES, SHOWING IN FINE OUNCES THE OUTPUT AS REPORTED TO THE MINES DEPARTMENT DURING 1962, AND THE TOTAL PRODUCTION TO DATE.

(*Note*.—Lease numbers in brackets indicate that the holding was *voided* during the year.)

(*Note*.—* Denotes mainly derived from treatment of tailings. † Denotes mainly derived from Lead Ore. ‡ Denotes mainly derived from Copper Ore. § Concentrates. || Tantalum.

Kimberley Goldfield.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
Brockman	....	Voided leases	....	....	....	....	....	....	....	1,545·75	1,455·34	....
		Sundry claims	....	....	....	....	....	7·62	7·62	2,484·00	1,871·92	....
Halls Creek	....	Voided leases	....	....	....	....	....	....	....	423·00	477·76	....
		Sundry claims	....	....	....	....	....	27·73	....	217·05	179·57	12·64
Mary	....	Voided leases	....	....	....	....	....	82·66	951·52	399·00	210·03	....
		Sundry claims	....	....	....	....	....	....	14·36	46·85	53·66	....
Mt. Dockrell	....	Voided leases	....	....	....	....	....	9·17	13·66	1,173·70	1,206·09	93·00
		Sundry claims	....	....	....	....	....	18·89	31·31	160·00	89·64	....
Panton	....	Voided leases	....	....	....	....	....	....	....	42·95	140·47	....
		Sundry claims	....	....	....	....	....	....	6·28	6·15	18·01	....
Ruby Creek	G.M.L. 97	Ruby Queen	....	....	....	....	....	....	....	3,069·25	1,726·56	2·14
		Voided leases	....	....	....	....	....	....	16·05	12,902·20	9,619·82	....
		Sundry claims	....	....	....	....	....	12·71	....	281·25	183·30	....
	From District generally :—											
	Sundry claims		....	....	....	....	....	....	....	....	....	†20·98
	Reported by Banks and Gold Dealers		31·01	....	....	....	....	8,868·70	1,894·04	·75	8·15	....
		Total	**31·01**	....	....	....	....	**9,027·48**	**2,934·84**	**22,751·90**	**17,240·32**	**128·76**

West Kimberley Goldfield.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
Napier Range	M.C. 29	Devonian Silver Lead Mine	....	....	....	....	....	....	....	....	....	†13,575·29
	From District generally :—											
	Sundry claims		....	....	....	....	....	1·30	24·68	1·00	2·49	....
		Total	....	....	....	....	....	**1·30**	**24·68**	**1·00**	**2·49**	**13,575·29**

Pilbara Goldfield.

MARBLE BAR DISTRICT.

Bamboo Creek	G.M.L. 1120	Bamboo Queen	....	....	....	....	....	....	....	88·50	30·99	·34
	1107	Bulletin	....	....	....	....	....	....	....	995·25	446·03	2·02
	1118	Kitchener	....	....	....	....	....	....	....	261·00	61·44	3·53
	(1096), 1095, (1097)	Mt. Prophecy Leases	....	....	....	....	....	....	24·50	3,053·00	1,096·72	49·63
	817	Prince Charlie	....	....	478·75	128·24	....	....	3·68	8,854·75	6,131·47	269·16
	1072	Princess May	....	....	....	....	....	....	....	92·50	24·27	....
	924	True Blue	·62	....	1,235·00	2·73	·01	·62	....	4,357·75	114·64	·22
		Voided leases	....	....	....	....	....	13·54	568·41	49,263·85	55,709·29	8·97
		Sundry claims	....	....	....	....	....	8·97	307·83	5,208·85	3,034·45	7·21
Boodalyerrie	....	Voided leases	....	....	....	....	....	....	292·07	120·25	587·86	....
		Sundry claims	....	....	....	....	....	....	7·16	....	....	....
Braeside	....	Sundry claims and producers	....	....	....	....	....	....	....	....	....	†21,960·80
		Braeside Lead Claims	....	....	....	....	....	....	....	....	....	†3,892·95
Lalla Rookh	....	Voided leases	....	....	....	....	....	....	4·78	3,612·00	4,696·33	574·01
		Sundry claims	....	....	....	....	....	....	....	7,943·00	7,675·09	....
Marble Bar	G.M.L. 930 (956)	Alexander Leases	....	....	....	....	....	....	....	354·50	120·94	·81
	930	Alexander	....	....	....	....	....	....	....	640·00	114·59	....
	1094	Blue Bar	....	....	....	....	....	....	....	1,187·50	167·19	·48
	927, etc.	Halley's Comet	....	....	....	....	....	....	....	6,360·00	6,390·33	680·36
	1121	Little Portree	....	....	....	....	....	....	....	103·00	66·88	6·93
		Voided leases	....	....	....	....	....	45·98	199·09	165,957·49	151,729·10	595·61
		Sundry claims	....	....	....	....	....	67·08	255·30	21,488·54	12,846·92	9·43
North Pole	1122 (1123) (1124)	Normay Leases	....	....	....	....	....	....	....	1,685·00	1,435·98	1,755·28
		Voided leases	....	....	....	....	....	....	....	4,339·00	1,930·51	260·08
		Sundry claims	....	....	....	....	....	....	....	669·75	298·62	15·82
North Shaw	....	Voided leases	....	....	....	....	....	7·53	....	1,072·45	996·29	....
		Sundry claims	....	....	....	....	....	2·84	579·91	179·75	121·72	....
Pilgangoora	M.C. 291	Northern Territory Prospecting & Development Co. Ltd.	....	....	....	....	....	....	2·12	....	§39·54	....
		Voided leases	....	....	....	....	....	16·65	....	2,255·00	403·60	....
		Sundry claims	....	....	....	....	....	161·08	45·64	483·60	150·15	....
Sharks	G.M.L. 1082 (1085)	Table Top Leases	....	....	....	....	....	....	....	1,082·75	594·97	17·28
		Voided leases	....	....	....	....	....	1·43	....	1,739·50	1,969·65	1·16
		Sundry claims	....	....	....	....	....	163·14	47·93	1,159·50	1,675·34	·97
Talga Talga	....	Voided leases	....	....	....	....	....	....	93·15	1,799·00	1,760·68	....
		Sundry claims	....	....	....	....	....	76·17	85·18	2,013·65	1,509·26	·70
Tambourah	....	Voided leases	....	....	....	....	....	....	73·90	1,603·50	1,886·22	....
		Sundry claims	....	....	....	....	....	89·52	294·75	3,742·25	2,689·78	....
Warrawoona	1193	Trump	....	....	....	....	....	....	....	228·50	16·70	·96
		Voided leases	....	....	....	....	....	....	16·99	17,749·30	19,645·44	23·70
		Sundry claims	....	....	....	....	....	70·98	623·67	6,632·79	4,247·38	·08

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
		PILBARA GOLDFIELD—continued.										
		MARBLE BAR DISTRICT—*continued.*										
Western Shaw	....	Voided leases	....	....	....	....	....	....	....	1,222·50	957·80	....
		Sundry claims	....	....	....	....	....	22·34	67·47	71·50	81·49	....
Wodgina	....	Sundry claims	....	....	....	....	....	....	43·37	·50	....	3·25
Wyman's Well	1084	New Copenhagen	....	....	....	....	....	....	....	770·55	165·52	4·34
		Voided leases	....	....	....	....	....	....	42·86	2,977·29	1,258·44	....
		Sundry claims	....	....	....	....	....	4·47	51·52	2,732·71	1,324·64	1·47
Yandicoogina	....	Voided leases	....	....	....	....	....	....	140·76	3,159·20	6,218·83	....
		Sundry claims	....	....	....	....	....	4·32	239·89	622·25	682·47	45·96
	From District generally :—											
	Sundry Parcels treated at :											
		H. B. & C. L. Dorrington (L.T.T. 1451H)	....	....	....	....	....	....	....	94·00	3·47	·42
		H. N. Flagg (L.T.T. 1439H)	....	....	....	....	....	....	....	....	1·04	....
		State Battery, Bamboo Creek	....	....	....	*243·47	39·38	....	....	40·00	*11,929·47	336·33
		State Battery, Marble Bar	....	....	....	....	....	....	....	12·00	*12,083·07	63·36
		Various Works	....	....	....	....	....	....	....	286·95	1,919·97	5·54
	Reported by Banks and Gold Dealers		·86	....	....	....	....	14,509·36	457·01	....	15·41	2,224·53
		Total	**1·48**	....	**1,713·75**	**374·44**	**39·39**	**15,266·02**	**4,568·94**	**340,366·47**	**329,057·98**	**32,823·69**
		NULLAGINE DISTRICT.										
Eastern Creek	....	Voided leases	....	....	....	....	....	8·96	8·19	5,594·00	9,854·21	14·76
		Sundry claims	....	....	39·00	20·44	·12	....	12·74	1,448·10	1,621·15	17·02
Elsie	....	Voided leases	....	....	....	....	....	....	....	586·25	1,675·91	....
		Sundry claims	....	....	....	....	....	....	8·28	58·00	188·08	....
McPhee's Creek	....	Voided leases	....	....	....	....	....	....	....	113·00	137·92	....
		Sundry claims	....	....	....	....	....	....	....	134·00	197·09	....
Middle Creek	G.M.L. 229L	Barton	....	....	697·00	74·02	2·60	1·22	....	9,186·75	4,547·10	37·88
	231L, etc.	North West Mining N.L.	....	....	1,538·50	950·54	....	....	....	9,782·07	6,174·22	....
	231L, etc.	Prior to transfer to present holders	....	....	....	....	....	....	....	53,391·41	32,009·01	10·99
		Voided leases	....	....	....	....	....	....	1·02	18,813·15	11,745·73	8·37
		Sundry claims	....	....	380·00	144·71	2·38	....	18·69	6,497·60	2,582·11	2·38
Mosquito Creek	331L	Ard Patrick	....	....	....	....	....	10·80	....	78·00	19·75	....
		Voided leases	....	....	....	....	....	1·07	30·12	8,392·30	12,839·13	....
		Sundry claims	....	....	....	....	....	....	181·64	3,707·44	3,789·21	....

Nullagine	292L	Alice	....	....	....	....	....	3·85	1,159·85	138·85	331·29	63·45
	336L	Happy Wanderer	....	....	....	....	....	....	....	201·00	80·54	4·15
		Voided leases	....	....	....	....	....	....	599·59	9,192·75	13,376·46	36·92
		Sundry claims	....	5·04	....	....	·26	321·36	689·71	6,629·45	10,552·87	17·57
Spinaway Well	314L Copper Hills Copper Mine		....		....	....	....	....	....	....	‡15·44	‡483·78
Twenty Mile Sandy	M.C. 112L	J. C. & G. M. Baker	....	....	....	....	....	....	....	....	·93	‡51·20
		Voided leases	....	....	....	....	....	....	16·97	7,243·70	9,007·72	320·50
		Sundry claims	....	....	....	....	....	33·10	30·50	7,793·85	6,283·29	2·76
	From District generally :											
	Sundry Parcels treated at :											
	Barton's Battery		....	....	....	....	....	....	....	....	*45·19	....
	McKinnon's Sluicing Plant (D.C.s 10L, 14L, 15L)		....	....	....	....	....	3·89	2·23	....	7·20	....
	Various Works		....	....	....	....	....	....	....	124·50	*8,110·35	1·37
	Reported by Banks and Gold Dealers		13·77	....	....	18·22	·15	10,057·36	147·52	....	48·03	5·95
		Total	**13·77**	**5·04**	**2,654·50**	**1,207·93**	**5·51**	**10,441·61**	**2,907·05**	**149,106·17**	**135,239·93**	**1,079·05**

West Pilbara Goldfield.

Croydon	....	Voided Leases	....	....	....	....	....	....	....	8·00	5·44	....
Hong Kong	....	Voided Leases	....	....	....	....	....	....	....	331·00	442·45	....
		Sundry claims	....	....	....	....	....	21·40	·02	9·00	3·15	....
Lower Nicol	G.M.L. 177	Swelpme	....	....	95·00	2·70	·17	....	....	119·00	7·02	·60
		Voided leases	....	....	....	....	....	....	1·10	653·20	402·22	....
		Sundry claims	....	....	....	....	....	10·44	2·71	99·00	35·16	·40
Mallina	....	Voided leases	....	....	....	....	....	....	....	141·60	128·44	....
Nicol	....	Voided leases	....	....	....	....	....	....	....	30·00	11·47	....
Pilbara	....	Voided leases	....	....	....	....	....	9·90	48·12	267·00	432·84	....
		Sundry claims	....	....	....	....	....	1·11	86·24	163·00	255·42	....
Roebourne	....	Voided leases	....	....	....	....	....	....	....	2,396·86	1,424·04	385·15
		Sundry claims	....	....	12·00	6·03	....	15·47	3·29	1,946·85	817·89	130·21
Station Peak	....	Voided leases	....	....	....	....	....	177·74	41·37	11,016·00	11,388·18	·08
		Sundry claims	....	....	....	....	....	·69	....	86·50	77·23	....
Towranna	....	Voided leases	....	....	....	....	....	....	2·62	3,965·80	5,187·51	....
		Sundry claims	....	....	....	....	....	....	....	22·00	12·35	....
Upper Nicol	....	Sundry claims	....	....	....	....	....	....	....	6·50	2·57	....
Weerianna	....	Voided leases	....	....	....	....	....	....	....	3,200·15	3,214·45	....
		Sundry claims	....	....	....	....	....	....	....	336·00	135·26	1·29
Whim Creek	....	Voided leases	....	....	....	....	....	....	....	....	....	‡883·80

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
		WEST PILBARA GOLDFIELD—continued.										
		From Goldfield generally :—										
		Sundry Parcels treated at :										
		Various Works	....	....	....	....	....	....	....	....	102·39	4·90
		Sundry claims and leases	....	....	....	....	....	....	11·77	....	....	†503·36
		Reported by Banks and Gold Dealers	....	....	....	....	....	6,102·62	177·50	103·50	231·54	·87
		Total	....	....	**107·00**	**8·73**	**·17**	**6,339·37**	**374·74**	**24,900·96**	**24,317·02**	**1,910·66**
		Ashburton Goldfield.										
Belvedere	....	Voided leases	....	....	....	....	....	....	9·88	1,560·00	435·86	176·48
Dead Finish	....	Voided leases	....	....	....	....	....	....	....	1,699·00	874·60	·03
		Sundry claims	....	....	....	....	....	....	11·89	104·25	245·08	....
Linden Station	....	Sundry claims	....	....	....	....	....	....	....	128·35	203·51	....
Melrose	....	Voided leases	....	....	....	....	....	....	....	2,704·00	840·26	213·11
		Sundry claims	....	....	....	....	....	12·41	21·88	562·00	262·78	6·40
Mt. Edith	....	Sundry claims	....	....	....	....	....	....	....	5·00	3·97	....
Mt. Mortimer	....	Sundry claims	....	....	....	....	....	364·63	315·64	44·50	40·25	74·47
Uaroo	....	Voided leases	....	....	....	....	....	....	....	....	....	†7,713·22
		From Goldfield generally :—										
		Sundry claims (Silver Lead)	....	....	....	....	....	....	....	....	....	†33,787·67
		Reported by Banks and Gold Dealers	....	....	....	....	....	8,890·33	123·17	....	7·12	....
		Total	....	....	....	....	....	**9,267·37**	**482·46**	**6,807·10**	**2,913·43**	**41,971·38**
		Gascoyne Goldfield.										
Bangemall	....	Voided leases	....	....	....	....	....	....	6·22	350·70	313·82	....
		Sundry claims	....	....	....	....	....	88·97	33·55	36·30	203·47	....
Carnarvon	M.C. 4	Allen McDonald	....	....	....	....	....	....	49·09	....	....	†26·92
	G.M.L. 46	Star Mangaroon	....	·77	104·50	271·92	9·62	....	·77	181·50	477·81	9·62
		Sundry claims	....	....	....	....	....	....	....	97·00	376·12	....
		From Goldfield generally :—										
		Reported by Banks and Gold Dealers	1·26	....	....	....		609·16	28·97	....	2·56	....
		Total	**1·26**	**·77**	**104·50**	**271·92**	**9·62**	**698·13**	**118·60**	**665·50**	**1,373·78**	**36·54**

Peak Hill Goldfield.

Bulloo Downs	....	Voided leases	....	....	....	....	....	....	....	....	....	†50·09
Egerton	....	Voided leases	....	....	....	....	....	62·31	224·68	7,292·25	6,604·91	....
		Sundry claims	....	....	....	....	....	235·35	23·51	1,501·77	791·34	....
Horseshoe	G.M.L. 568P	Horseshoe Lights	....	....	....	....	....	....	....	9,549·00	1,255·34	·34
	568P, etc.	Anglo-Westralian Mining Pty. Ltd.	....	....	....	....	....	....	....	135,872·00	22,870·80	1,407·05
	568P	Horseshoe Lights (Prior to transfer)	....	....	....	....	....	....	....	3,914·00	894·44	....
		Voided leases	....	....	....	....	....	15·57	1,975·37	5,654·38	2,818·56	2·00
		Sundry claims	....	....	....	....	....	20·12	829·58	2,201·35	792·31	·05
Jimblebar	....	Voided leases	....	....	....	....	....	....	172·75	7,526·25	2,561·95	·58
		Sundry claims	....	....	....	....	....	13·79	65·95	1,048·05	574·16	....
Mt. Fraser	602P	Duffer	....	....	....	....	....	....	....	9·50	15·32	....
		Voided leases	....	....	....	....	....	....	....	389·50	320·96	....
		Sundry claims	....	....	....	....	....	88·28	40·61	480·75	460·12	....
Mt. Seabrook	....	Voided leases	....	....	....	....	....	....	5·05	620·25	428·26	....
		Sundry claims	....	....	....	....	....	....	....	1,089·35	803·12	....
Peak Hill	512P	Atlantic	....	....	....	....	....	1·69	2·87	5,399·75	628·42	1·52
	511P	Commercial	....	....	316·00	21·06	·84	....	....	4,281·25	634·40	1·70
	584P	Dazzle Star	....	....	....	....	....	....	....	329·00	99·97	·50
	567P	Miner Bird	....	....	157·00	29·73	1·41	....	....	2,213·00	967·52	1·68
	553	Morning Star	....	....	1,314·00	160·26	6·79	....	4·43	4,505·75	597·55	6·79
	587P	Murray Heath	....	....	....	....	....	....	....	41·00	6·17	....
	506P	No. 1 North	....	....	456·00	37·76	1·44	....	86·47	8,840·70	1,789·81	3·08
	492P	North Star	....	....	....	....	....	23·20	69·63	13,371·50	2,091·89	....
		Voided leases	....	....	....	....	....	7·39	920·21	523,227·33	247,155·42	2,285·73
		Sundry claims	....	....	189·00	17·02	·70	61·51	306·63	34,968·35	8,999·13	1·90
Ravelstone	....	Voided leases	....	....	....	....	....	....	101·64	4,219·85	3,117·68	....
		Sundry claims	....	....	....	....	....	....	....	553·60	283·17	....
Wilgeena	....	Voided leases	....	....	....	....	....	....	23·54	230·50	156·25	....
Wilthorpe	....	Voided leases	....	....	....	....	....	....	....	47·00	20·93	....
		Sundry claims	....	....	....	....	....	....	....	89·00	25·71	....
Yowereena	....	Voided leases	....	....	....	....	....	....	....	19·50	36·46	....
		Sundry claims	....	....	....	....	....	....	....	117·25	203·16	....
	From Goldfield generally :											
	Sundry Parcels treated at :											
	Australian Machinery & Investment Co. Plant				....	....	....	....	....	....	*1,686·20	....
	State Battery Peak Hill		....	....	....	....	....	....	3·05	15·00	7,171·41	....
	Various Works		....	....	....	....	....	....	....	1,332·00	5,723·81	23·12
	Reported by Banks and Gold Dealers		3·44	....	....	....	·14	2,858·58	444·91	....	15·88	·14
		Total	**3·44**	....	**2,432·00**	**265·83**	**11·32**	**3,387·79**	**5,300·88**	**780,949·73**	**322,602·53**	**3,786·27**

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962: Alluvial	Total for 1962: Dollied and Specimens	Total for 1962: Ore treated	Total for 1962: Gold therefrom	Total for 1962: Silver	Total Production: Alluvial	Total Production: Dollied and Specimens	Total Production: Ore treated	Total Production: Gold therefrom	Total Production: Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.

East Murchison Goldfield.

LAWLERS DISTRICT.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
Kathleen Valley	G.M.L. 1369	Kathleen Development Syndicate	....	....	95·00	7·36	·63	....	....	400·00	25·45	1·57
		Voided leases	....	....	....	....	....	....	144·85	80,563·66	49,028·87	....
		Sundry claims	....	....	....	....	....	14·37	526·03	5,836·75	2,662·74	‡893·45
Lawlers	1363, etc.	Kim Prospecting & Development Syndicate	....	....	....	....	....	....	....	290·00	25·64	....
	(1236), 1356, etc.	Waroonga	....	....	....	....	....	....	....	....	99·40	·50
		Voided leases	....	....	....	....	....	25·51	692·45	1,622,917·40	575,150·65	14,803·08
		Sundry claims	....	....	69·50	44·14	2·74	401·71	451·61	17,707·48	9,779·27	274·09
Sir Samuel	....	Voided leases	....	....	....	....	....	....	359·03	275,417·55	141,829·52	10,234·80
		Sundry claims	....	....	....	....	....	57·64	64·96	7,851·00	4,585·10	·02
Wildara Station	1367	Tahmoo	....	....	157·00	62·16	·28	....	....	690·00	274·60	·28
		Sundry claims	....	....	208·25	96·94	3·86	143·23	....	208·25	96·94	3·86
	From District generally :—											
	Sundry Parcels treated at :											
	State Battery, Sir Samuel	....	....	....	....	....	....	....	....	53·50	*2,356·81	....
	Vanguard Cyanide Plant	....	....	....	....	....	....	....	....	4·00	*1,014·04	3·18
	Western Machinery Co. Pty. Ltd.	....	....	....	....	....	....	....	....	5·00	*4,291·25	29·00
	Prior to transfer to present holders	....	....	....	....	....	....	....	....	....	*1,371·33	15·64
	Various Works	....	....	....	....	....	....	2·12	2·35	1,711·53	*30,788·76	936·21
	Reported by Banks and Gold Dealers	....	6·92	....	....	....	....	6,458·80	101·91	·05	10·00	....
		Total	**6·92**	....	**529·75**	**210·60**	**7·51**	**7,103·38**	**2,343·19**	**2,013,656·17**	**823,390·37**	**27,195·68**

WILUNA DISTRICT.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
Coles	....	Voided leases	....	....	....	....	....	....	....	2,765·50	1,240·40	....
		Sundry claims	....	....	20·00	3·31	·32	....	21·03	3,864·50	1,510·54	·32
Corboys	....	Voided leases	....	....	....	....	....	5·24	1·25	14,946·29	11,036·71	5·00
		Sundry claims	....	....	....	....	....	21·58	....	9,082·35	5,210·79	....
Gum Creek	....	Voided leases	....	....	....	....	....	20·75	....	1,380·00	595·73	....
		Sundry claims	....	....	....	....	....	....	1·36	407·25	131·08	....
Mt. Eureka	....	Voided leases	....	....	....	....	....	....	....	142·25	96·36	....
		Sundry claims	....	....	....	....	....	....	....	783·75	548·56	....
Mt. Keith	....	Voided leases	....	....	....	....	....	....	44·54	20,259·50	13,551·08	....
		Sundry claims	....	....	6·00	5·03	·99	4·81	227·29	3,868·50	2,485·06	·99

New England	....	Voided leases	....	....	....	....	....	5·74	95·70	5,364·25	3,490·87	....
		Sundry claims	....	....	....	....	....	9·31	5·78	4,534·75	3,111·97	....
Wiluna	....	Voided leases	....	....	....	....	....	....	574·76	8,777,986·65	1,789,127·12	10,049·13
		Sundry claims	....	....	....	....	....	105·39	225·82	27,442·65	10,897·38	·33
	From District generally :—											
	Sundry Parcels treated at :											
	T. J. Jones (L.T.T. 1J/61)		....	....	....	2·56	·12	....	....	....	*5·43	·18
	State Battery, Wiluna		....	....	....	....	....	....	....	637·00	*23,679·00	219·70
	Various Works		....	....	....	....	....	....	....	139·00	*5,322·12	12·72
	Reported by Banks and Gold Dealers		1·75	....	....	....	....	63·66	56·58	....	158·54	12·02
		Total	**1·75**	....	**26·00**	**10·90**	**1·43**	**236·48**	**1,254·11**	**8,873,604·19**	**1,872,198·74**	**10,300·39**

BLACK RANGE DISTRICT.

Barrambie	G.M.L. 1116B	Dingo	....	....	....	....	....	....	....	1·00	201·93	....
	1117B	Scheelite Leases	....	....	120·50	113·85	6·35	....	....	866·75	531·73	8·57
		Voided leases	....	....	....	....	....	....	22·49	18,554·67	17,363·81	125·60
		Sundry claims	....	....	....	....	....	5·07	170·20	978·55	1,062·22	216·73
Bellchambers	....	Voided leases	....	....	....	....	....	....	111·80	4,349·27	3,130·56	....
		Sundry claims	....	....	....	....	....	....	....	1,182·80	557·95	....
Birrigrin	....	Voided leases	....	....	....	....	....	....	820·68	12,042·93	15,086·09	....
		Sundry claims	....	....	....	....	....	....	179·92	2,487·55	1,238·22	....
Currans	....	Voided leases	....	....	....	....	....	18·24	222·89	7,252·25	3,116·68	....
		Sundry claims	....	....	....	....	....	....	29·38	2,158·75	827·18	....
Erroll's	....	Voided leases	....	....	....	....	....	14·17	152·29	14,170·50	9,328·92	....
		Sundry claims	....	....	29·00	6·88	·25	6·53	399·11	993·75	602·33	·25
Hancocks	....	Voided leases	....	....	....	....	....	....	6,968·16	33,726·00	36,664·76	55·72
		Sundry claims	....	....	....	....	....	4·21	142·89	8,608·10	3,228·18	....
Maninga Marley	....	Voided leases	....	....	....	....	....	....	195·20	60,833·48	48,494·40	22·55
		Sundry claims	....	....	....	....	....	....	158·16	3,079·65	1,768·16	....
Montague	....	Voided leases	....	....	....	....	....	....	100·17	79,550·60	23,444·82	....
		Sundry claims	....	....	....	....	....	....	71·09	5,041·35	3,171·19	....
Nunngarra	....	Voided leases	....	....	....	....	....	25·94	952·34	9,509·00	3,655·49	....
		Sundry claims	....	....	....	....	....	50·27	1,458·98	7,682·40	2,960·27	....
Sandstone	958B	Lady Mary	....	....	....	....	....	....	383·35	7,165·75	7,119·35	2·35
		Voided leases	....	....	....	....	....	4·75	4,449·73	696,625·32	448,299·76	11,754·22
		Sundry claims	....	....	....	....	....	44·95	1,421·07	15,998·95	6,928·81	....
Youanmi	....	Voided leases	....	....	....	....	....	·36	126·92	731,497·55	273,884·97	10,474·10
		Sundry claims	....	....	....	....	....	1·07	18·79	6,258·55	1,814·66	....

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
EAST MURCHISON GOLDFIELD—continued.												
BLACK RANGE DISTRICT—continued.												
		From District generally :										
		Sundry Parcels treated at :										
		State Battery Sandstone	....	....	....	....	....	....	....	290·50	*23,575·34	61·02
		State Battery Youanmi	....	....	....	....	....	....	....	40·00	*5,504·08	....
		Various Works	....	....	....	....	....	....	....	104·50	*11,496·73	....
		Reported by Banks and Gold Dealers	....	2·13	....	....	·15	1,494·98	54·36	....	20·38	·15
		Total	....	**2·13**	**149·50**	**120·73**	**6·75**	**1,670·54**	**18,609·97**	**1,731,050·47**	**955,078·97**	**22,721·26**

Murchison Goldfield.

CUE DISTRICT.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Alluvial (1962)	Dollied and Specimens (1962)	Ore treated (1962)	Gold therefrom (1962)	Silver (1962)	Alluvial (Total)	Dollied and Specimens (Total)	Ore treated (Total)	Gold therefrom (Total)	Silver (Total)
Big Bell	G.M.L. (2282)	Orange Bell	....	....	29·50	4·33	·66	....	....	741·50	100·17	3·00
		Voided leases	....	....	....	....	....	....	4·49	5,540,131·00	731,031·48	251,813·67
		Sundry claims	....	....	....	....	....	·39	6·32	577·50	482·19	6·61
Cuddingwarra	....	Voided leases	....	....	....	....	....	10·59	132·46	102,115·91	56,152·11	100·71
		Sundry claims	....	....	62·75	8·24	·83	18·46	384·38	10,398·64	5,751·99	17·68
Cue	....	Voided leases	....	....	....	....	....	202·71	911·60	292,424·49	222,335·12	73·03
		Sundry claims	....	....	....	....	....	252·92	894·70	47,411·74	20,545·18	4·64
Eelya	G.M.L. 2286	Eagle Hawk	....	....	150·25	25·44	·73	....	....	150·25	25·44	·73
		Voided leases	....	....	....	....	....	....	8·78	2,477·75	2,228·56	....
		Sundry claims	....	....	....	....	....	6·20	143·81	2,309·90	1,099·24	1·31
Mindoolah	....	Voided leases	....	....	....	....	....	3·07	2·54	9,380·28	5,672·31	42·97
		Sundry claims	....	....	....	....	....	....	29·30	3,309·85	2,347·36	....
Reedy	....	Voided leases	....	....	....	....	....	2·82	219·70	729,693·43	240,349·10	20,467·28
		Sundry claims	....	....	....	....	....	170·71	137·16	7,295·00	2,690·88	1·24
Tuckabianna	2237	Gidgie	....	....	160·25	48·02	1·87	....	297·73	2,950·15	2,156·81	35·44
		Voided leases	....	....	....	....	....	649·70	996·22	13,968·23	7,833·32	4·05
		Sundry claims	....	....	....	....	....	154·26	489·40	5,567·85	2,790·63	·35
Tuckanarra	....	Voided leases	....	....	....	....	....	85·37	3,511·10	19,490·00	22,828·99	172·77
		Sundry claims	....	....	....	3·14	·13	115·23	797·89	10,190·82	10,311·39	·13
Weld Range	....	Voided leases	....	....	....	....	....	....	23·64	2,169·75	1,137·11	....
		Sundry claims	....	....	....	....	....	....	3·90	1,438·50	1,136·41	....

		From District generally :—										
		Sundry Parcels treated at :										
		J. & V. Hronsky & Son (L.T.T. 1467H)	....	....	....	*37·24	49·01	....	....	....	*37·24	49·01
		A. L. Armstrong (L.T.T. 1450H)	....	....	....	....	....	....	....	....	*78·01	2·60
		A. L. Armstrong (L.T.T. 1425H)	....	....	....	....	....	....	....	....	*109·35	....
		A. L. Armstrong (L.T.T. 1427H)	....	....	....	....	....	....	....	....	*107·79	23·02
		State Battery, Cue	....	....	....	....	....	....	....	76·25	*26,792·60	123·99
		State Battery, Tuckanarra	....	....	....	....	....	....	....	518·50	*5,535·57	....
		Various Works	....	....	....	....	....	....	....	8,097·02	*30,177·79	1,206·50
		Reported by Banks and Gold Dealers	6·69	....	....	....	·56	3,435·76	109·87	....	22·62	·63
		Total	**6·69**	....	**402·75**	**126·41**	**53·79**	**5,108·19**	**9,104·99**	**6,812,884·31**	**1,401,866·76**	**274,151·36**
		MEEKATHARRA DISTRICT.										
Abbotts	....	Voided leases	....	....	....	....	....	....	26·45	36,841·35	38,775·28	....
		Sundry claims	....	....	....	....	....	....	5·29	3,951·57	2,357·54	....
Burnakurra	....	Voided leases	....	....	....	....	....	....	3,247·59	39,387·45	30,920·76	26·90
		Sundry claims	....	....	....	....	....	17·03	129·24	2,486·55	1,310·84	1·54
Chesterfield	....	Voided leases	....	....	....	....	....	29·02	420·32	11,987·26	8,656·61	25·84
		Sundry claims	....	....	....	....	....	....	42·19	1,069·05	776·69	....
Gabanintha	G.M.L. 1990N	Tumbulgum	....	....	....	....	....	....	....	188·25	49·09	4·72
	1986N	Tumbulgum North	....	....	108·50	45·83	9·92	....	....	161·00	92·18	9·92
		Voided leases	....	....	....	....	....	11·79	38·14	32,995·35	22,204·79	815·57
		Sundry claims	....	....	58·00	20·36	1·14	16·78	159·05	5,279·00	2,999·95	2·12
Golden Gully	....	Voided leases	....	....	....	....	....	26·36	74·91	30,272·07	21,864·74	1,102·59
		Sundry claims	....	....	43·50	4·22	·36	....	18·74	3,023·69	1,725·84	·38
Gum Creek	....	Voided leases	....	....	....	....	....	25·27	91·96	3,893·08	3,819·91	....
		Sundry claims	....	....	....	....	....	4·37	84·86	735·05	656·05	....
Holdens	....	Voided leases	....	....	....	....	....	....	18·99	18,061·00	7,320·42	....
		Sundry claims	....	....	....	....	....	164·95	49·07	425·15	279·25	....
Jillawarra	....	Voided leases	....	....	....	....	....	....	1,263·53	1,999·80	3,565·40	....
		Sundry claims	....	....	....	....	....	173·02	150·04	443·75	404·77	....
Meeka Pools	....	Voided leases	....	....	....	....	....	....	....	111·58	82·27	....
		Sundry claims	....	....	....	....	....	....	2·84	233·57	205·38	....
Meekatharra	G.M.L. 1991N	Commodore	....	....	....	....	....	....	....	20·00	40·11	....
	(1998N)	Fenian West	....	....	151·00	12·95	·27	....	....	151·00	12·95	·27
	1559N	Ingliston	....	....	....	....	....	....	498·32	3,167·85	1,885·91	....
	1999N	Ingliston South	....	....	82·50	11·88	·58	....	....	82·50	11·88	·58
	1985N	Lady Central	....	....	....	....	....	....	....	327·75	39·19	....
	1529N	Prohibition	....	....	588·00	75·97	1·93	....	....	7,013·25	2,235·51	7·42
	1529N	Prohibition Gold Mining Co. N.L.	....	....	....	....	....	....	....	24,844·25	4,978·31	11·83
		Prior to transfer to present holders	....	....	....	....	....	....	....	29,422·00	4,971·30	....
	R.C. 75N	C. J. S. White & W. E. Fisher	....	....	....	....	....	173·82	43·80	372·50	131·88	....
		Voided leases	....	....	....	....	....	7·57	1,664·22	1,716,920·32	929,129·02	2,472·57
		Sundry claims	....	....	238·50	29·05	1·06	279·84	1,009·74	31,585·45	11,624·48	4·09

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
		MURCHISON GOLDFIELD—continued. MEEKATHARRA DISTRICT—*continued.*										
Mistletoe	....	Voided leases	....	....	....	....	....	4·15	1,000·24	417·00	486·21	....
		Sundry claims	....	....	....	....	....	119·14	71·85	19·75	2·03	....
Mt. Maitland	....	Voided leases	....	....	....	....	....	....	....	88·00	80·11	....
		Sundry claims	....	....	....	....	....	....	....	420·75	240·86	....
Munara Gulley	....	Voided leases	....	....	....	....	....	....	....	13,283·50	6,559·93	....
		Sundry claims	....	....	....	....	....	....	34·23	1,009·75	373·74	....
Nannine	....	Voided leases	....	....	....	....	....	47·31	844·02	129,492·88	76,482·78	167·45
		Sundry claims	....	....	....	....	....	138·95	1,301·28	6,752·68	4,728·61	·12
Quinns	....	Voided leases	....	....	....	....	....	7·30	1,186·50	33,356·91	13,464·37	90·70
		Sundry claims	....	....	....	....	....	15·07	1,289·65	3,841·67	2,718·33	....
Ruby Well	....	Voided leases	....	....	....	....	....	....	43·46	7,461·00	4,046·70	....
		Sundry claims	....	....	....	....	....	1,015·87	409·39	520·25	629·60	....
Stakewell	....	Voided leases	....	....	....	....	....	....	200·12	21,362·00	9,566·18	....
		Sundry claims	....	....	....	....	....	31·91	34·73	1,003·60	584·54	....
Star of the East	....	Voided leases	....	....	....	....	....	....	....	27,244·00	20,305·40	....
		Sundry claims	....	....	....	....	....	....	....	127·62	94·97	....
Yaloginda	G.M.L. 1853N	Bluebird	....	....	253·50	26·09	·95	....	....	10,331·00	3,026·80	2·04
		Voided leases	....	....	....	....	....	19·03	1,972·23	28,175·54	14,609·36	8·68
		Sundry claims	....	....	172·75	51·40	·71	61·89	647·51	11,613·17	5,111·33	·71
	From District generally :											
	Sundry Parcels treated at :											
	Hanley & Christie (L.T.T. 1N/60)		....	....	....	....	....	....	....	234·00	9·69	....
	P. Polletti (L.T.T. 2N/59)		....	....	....	....	....	....	....	13·50	4·82	....
	State Battery, Meekatharra		....	....	....	....	....	....	....	130·00	*27,938·13	24·34
	Various Works		....	....	....	....	....	....	....	3,699·80	*13,948·46	391·20
	Reported by Banks and Gold Dealers		6·66	....	....	....	·55	12,247·79	185·53	451·50	97·71	1·33
		Total	**6·66**	....	**1,696·25**	**277·75**	**17·47**	**14,638·23**	**18,260·03**	**2,308,502·31**	**1,308,238·96**	**5,172·91**
		DAY DAWN DISTRICT.										
Day Dawn	G.M.L. 573D, etc	Mountain View Gold N.L.	....	....	....	....	....	....	....	13,612·10	17,376·85	217·60
		Prior to transfer to present holders	....	....	....	....	....	....	94·05	10,060·78	32,623·97	....
	(576D)	New Fingall	....	....	....	....	....	6·12	6·84	3,230·00	1,226·01	....

		Voided leases	....	....	....	....	....	160·64	826·65	1,922,088·36	1,225,599·75	169,210·44
		Sundry claims	....	....	....	....	....	96·42	523·56	13,660·51	6,773·85	2·89
Lake Austin	....	Voided leases	....	....	....	....	....	613·00	3,079·62	36,872·20	51,050·49	....
		Sundry claims	....	....	58·00	12·98	·16	59·07	965·49	3,603·19	1,354·13	4·76
Mainland	....	Voided leases	....	....	....	....	....	·41	3,296·77	7,575·62	25,026·07	....
		Sundry Claims	....	....	....	....	....	17·85	771·56	1,337·95	701·31	....
Pinnacles	664D	Eclipse	....	....	....	....	....	....	....	282·75	29·73	....
	676D	Eclipse Amalgamated North	....	....	....	....	....	....	....	187·50	17·68	....
	670D	Eclipse North	....	....	....	....	....	....	....	840·00	47·62	....
		Voided leases	....	....	....	....	....	4·90	1,213·68	18,280·00	9,915·71	....
		Sundry claims	....	....	....	....	....	62·93	509·50	4,678·17	1,801·29	....
	From District generally :											
	Sundry Parcels treated at :											
	V. Hronsky (L.T.T. 1441H)		....	....	....	....	....	....	....	....	*1·51	·59
	F. W. Turner (L.T.T. 1418H)		....	....	....	....	....	....	....	....	*7·13	....
	Various Works		....	....	....	....	....	....	16·61	988·00	*1,988·33	....
	Reported by Banks and Gold Dealers		....	·17	....	....	....	2,223·83	37·47	....	12·57	·01
		Total	....	·17	58·00	12·98	·16	3,245·17	11,341·80	2,037,297·13	1,375,554·00	169,436·29

MOUNT MAGNET DISTRICT.

Jumbulyer	G.M.L. 1410M	Gold Bug	....	....	....	....	....	....	2·20	927·35	277·15	....
		Voided leases	....	....	....	....	....	....	13·37	680·10	361·74	....
		Sundry claims	....	....	....	....	....	20·32	116·27	1,216·70	886·47	....
Lennonville	1566M	Empress	....	....	....	....	....	....	....	....	*9·51	....
	1637M	Long Reef South	....	....	....	....	....	....	....	224·75	230·27	9·69
	1651M	Nodoe	....	....	84·50	96·96	2·63	....	....	84·50	96·96	2·63
	1596M	Wheel of Fortune South	....	....	....	....	....	....	....	18·00	51·37	....
		Voided leases	....	....	....	....	....	....	3,226·91	151,502·55	128,568·28	459·62
		Sundry claims	·14	....	98·50	28·14	1·73	26·00	108·82	15,235·52	5,974·06	8·25
Mt. Magnet	1527M	Eclipse Gold Mine N.L.	....	....	6,086·00	6,757·16	967·77	....	....	31,959·00	37,296·92	3,876·19
	1527M	Eclipse	....	....	....	....	....	....	....	272·10	141·41	1·34
	1255M (1415M)	Edward Carson Leases	....	....	....	....	....	1·82	....	18,042·75	12,899·55	7·76
	1455M	Evening Star	....	....	....	....	....	....	....	1,083·25	124·35	....
	1581M	Exchange	....	....	....	....	....	....	....	22·00	29·36	....
	1287M	Havelock	....	....	....	....	....	....	11·05	4,332·50	840·14	....
	1282M, etc.	Hill 50 Gold Mine N.L.	....	....	165,698·00	87,195·99	6,242·04	....	....	1,857,523·40	944,047·55	37,787·30
	1246M	(Neptune)	....	....	....	....	....	....	829·41	8,787·65	4,122·61	·21
	1361M	Jupiter	....	....	....	....	....	....	·83	658·05	261·71	....
	1444M	Late Comer	....	....	....	....	....	....	2·53	511·00	391·31	....
	1447M	Morning Star	....	....	....	....	....	....	....	2,135·40	483·54	1·53
	1475M	Morning Star North	....	....	....	....	....	....	....	11·75	8·13	....
	1536M	Pat O'Meara	....	....	....	....	....	....	....	34·00	·68	....
	1505M	Perseverance	....	....	....	....	....	....	....	107·25	11·40	....
	1588M	Three Boys	....	....	....	....	....	....	....	48·00	2·47	....
		Voided leases	....	....	....	....	....	29·26	9,811·54	834,437·81	312,786·26	851·39
		Sundry claims	....	....	78·25	18·22	·93	157·95	2,626·24	61,147·92	30,004·30	14·52

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
MURCHISON GOLDFIELD—continued. MOUNT MAGNET DISTRICT—*continued.*												
Mt. Magnet East	....	Voided leases	....	....	....	....	....	63·29	764·53	5,522·28	2,811·75	....
		Sundry claims	....	....	....	....	....	....	37·22	418·25	428·29	....
Moyagee	1538M	Moyagee	....	....	....	....	....	....	....	33·75	34·88	....
		Voided leases	....	....	....	....	....	....	23·59	12,439·10	18,299·16	757·77
		Sundry claims	....	....	....	....	....	14·44	176·21	1,550·75	1,752·39	....
Paynesville	....	Voided leases	....	....	....	....	....	....	1,613·34	449·77	1,116·15	....
		Sundry claims	....	....	....	....	....	3·36	540·21	882·57	1,372·00	....
Winjangoo	1653M	Old Granites	....	10·28	294·25	29·10	1·51	....	10·28	294·25	29·10	1·51
		Voided leases	....	....	....	....	....	·99	191·88	72·00	69·98	....
		Sundry claims	....	....	....	....	....	....	223·32	237·53	71·58	....
	From District generally :—											
	Sundry Parcels treated at :											
	P. Sciarisa (L.T.T. 1477H)		....	....	·25	109·56	7·65	....	....	·25	*109·56	7·65
	R. Johns & D. Budge (L.T.T. 1M/1961)		....	....	....	....	....	....	....	37·25	*27·41	2·28
	R. G. Giles (L.T.T. 1486M)		....	....	7·00	1·82	·16	....	....	7·00	1·82	·16
	State Battery, Boogardie		....	....	....	....	....	....	....	348·26	*35,102·45	15·62
	Various Works		....	....	....	....	....	....	....	56·06	*18,949·24	10·04
	Reported by Banks and Gold Dealers		1·40	....	....	....	·04	2,317·52	114·69	8·00	113·15	·26
		Total	**1·54**	**10·28**	**172,346·75**	**94,236·95**	**7,224·46**	**2,634·95**	**20,444·44**	**3,013,360·37**	**1,560,196·41**	**43,815·72**
Yalgoo Goldfield.												
Bilberatha	....	Voided leases	....	....	....	....	....	1·27	90·94	3,384·50	1,845·05	....
		Sundry claims	....	....	....	....	....	....	6·64	3,075·05	1,401·56	....
Carlaminda	....	Voided leases	....	....	....	....	....	1·28	3·39	2,056·57	862·42	3·30
		Sundry claims	....	....	....	....	....	....	....	1,368·50	600·68	....
Fields Find	G.M.L. 1207	Rose Marie	....	....	....	....	....	....	....	418·67	254·46	1·59
		Voided leases	....	....	....	....	....	....	226·72	50,316·71	33,692·51	58·08
		Sundry Claims	....	....	100·00	5·22	·15	5·77	188·67	5,558·85	1,783·13	·15
Goodingnow	1063	Ark	....	....	....	....	....	....	12·49	2,270·50	1,927·29	....
	(1238)	Carnation	....	....	121·00	16·74	·68	....	....	121·00	16·74	·68
		Voided leases	....	....	....	....	....	146·70	299·28	81,692·71	66,350·01	....
		Sundry claims	....	....	63·00	10·82	·14	152·96	169·70	10,433·05	5,136·08	·14
Gullewa	....	Voided leases	....	....	....	....	....	....	19·05	39,913·60	20,966·51	113·70
		Sundry claims	....	....	....	....	....	....	170·45	4,391·25	1,918·24	....

Kirkalucka	....	....	Voided leases	....	....	....	....	....	....	....	61·25	45·10	....
			Sundry claims	....	....	....	....	....	....	17·79	257·30	126·29	....
Messengers Patch	....	....	Voided leases	....	....	....	....	....	8·64	349·71	39,836·51	28,564·95	1,083·01
			Sundry claims	....	....	....	....	....	463·12	333·98	1,595·10	588·36	·07
Mt. Farmer	....	....	Voided leases	....	....	....	....	....	....	....	64·00	40·19	....
			Sundry claims	....	....	....	....	....	....	....	462·90	145·06	....
Mt. Gibson	....	....	Voided leases	....	....	....	....	....	....	6·44	526·50	888·70	....
			Sundry claims	....	....	....	....	....	3·95	44·72	1,152·60	502·15	1·00
Ninghan	....	....	Voided leases	....	....	....	....	....	....	....	10·00	1·41	....
			Sundry claims	....	....	....	....	....	....	....	324·75	123·28	....
Noongal	1201	....	Hard to Find	....	....	....	....	....	....	....	114·00	111·83	....
			Voided leases	....	....	....	....	....	7·88	31·96	11,149·75	5,659·83	4·04
			Sundry claims	....	....	....	....	....	39·32	310·31	8,506·55	3,590·35	1·16
Nyounda	....	....	Voided leases	....	....	....	....	....	....	217·63	416·00	183·91	....
			Sundry claims	....	....	194·00	11·44	·54	....	30·88	1,229·00	240·38	·54
Pinyalling	....	....	Voided leases	....	....	....	....	....	....	313·79	2,318·90	1,146·19	....
			Sundry claims	....	....	....	....	....	3·27	134·09	1,500·00	959·31	....
Retaliation	....	....	Voided leases	....	....	....	....	....	....	....	5,089·25	1,872·98	....
			Sundry claims	....	....	....	....	....	....	....	913·25	321·52	....
Rothsay	....	....	Voided leases	....	....	....	....	....	....	24·06	40,680·75	10,777·98	....
			Sundry claims	....	....	....	....	....	....	·73	6,469·50	2,562·03	....
Wadgingarra	....	....	Voided leases	....	....	....	....	....	....	....	691·11	650·63	....
			Sundry claims	....	....	16·00	36·37	2·65	....	....	2,147·30	596·20	2·65
Warda Warra	....	....	Voided leases	....	....	....	....	....	....	....	10,760·50	5,862·04	....
			Sundry claims	....	....	6·50	7·41	....	....	....	947·25	428·41	2·31
Warriedar	....	....	Voided leases	....	....	....	....	....	....	....	13,661·50	4,607·88	7·30
			Sundry claims	....	....	85·00	57·91	4·52	....	2·84	8,867·85	1,950·37	4·52
Yalgoo	....	....	Voided leases	....	....	....	....	....	....	3·23	6,314·50	9,965·18	....
			Sundry claims	....	....	....	....	....	....	23·56	2,622·75	1,010·02	....
Yuin	....	....	Voided leases	....	....	....	....	....	....	127·12	68,139·50	27,908·57	130·13
			Sundry claims	....	....	....	....	....	....	4·70	335·50	67·53	....
	From Goldfield generally :—												
	Sundry Parcels treated at :												
	Francis & Latham (L.T.T. 1463H)			....	....	....	*·98	·17	....	....	....	*·98	·17
	State Battery, Payne's Find			....	....	....	....	....	....	....	156·50	*4,548·42	....
	State Battery, Warriedar			....	....	....	....	....	....	....	....	*6,545·96	·90
	State Battery, Yalgoo			....	....	....	....	....	....	....	....	*1,200·51	....
	Various Works			....	....	....	....	....	9·42	....	865·00	*3,337·19	99·84
	Reported by Banks and Gold Dealers			6·12	....	....	....	·69	964·44	58·32	....	48·90	·89
			Total	**6·12**	....	**585·50**	**146·89**	**9·54**	**1,808·02**	**3,223·19**	**443,188·08**	**263,935·27**	**1,516·17**

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mt. Margaret Goldfield.

MOUNT MORGANS DISTRICT.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962: Alluvial (Fine ozs.)	Total for 1962: Dollied and Specimens (Fine ozs.)	Total for 1962: Ore treated (Tons (2,240 lb.))	Total for 1962: Gold therefrom (Fine ozs.)	Total for 1962: Silver (Fine ozs.)	Total Production: Alluvial (Fine ozs.)	Total Production: Dollied and Specimens (Fine ozs.)	Total Production: Ore treated (Tons (2,240 lb.))	Total Production: Gold therefrom (Fine ozs.)	Total Production: Silver (Fine ozs.)
Australia United	....	Voided leases	....	....	....	....	....	....	1,911·63	15,913·69	23,305·76	1·76
		Sundry claims	....	....	....	....	....	....	580·98	1,307·50	2,227·65	....
Eucalyptus	....	Voided leases	....	....	....	....	....	....	2,878·56	1,603·85	3,251·01	....
		Sundry claims	....	....	....	....	....	....	591·62	2,160·30	2,011·78	....
Linden	....	Voided leases	....	....	....	....	....	7·53	566·97	72,919·81	66,208·35	·68
		Sundry claims	....	....	....	....	....	132·11	244·96	19,575·35	13,822·37	....
Mt. Margaret	....	Voided leases	....	....	....	....	....	12·13	1·89	8,900·39	5,291·51	12·55
		Sundry claims	....	....	....	....	....	25·22	111·18	1,790·10	661·42	....
Mt. Morgans	G.M.L. 399F, etc.	Morgans Gold Mines Ltd.	....	....	....	....	....	....	....	5,070·05	13,981·69	....
		Prior to transfer to present holders	....	....	....	....	....	....	16·66	779,578·43	354,225·86	5,552·63
		Voided leases	....	....	....	....	....	17·95	148·79	61,354·50	34,786·53	77·86
		Sundry claims	....	....	....	....	....	36·41	398·78	5,104·07	3,396·77	....
Murrin Murrin	....	Voided leases	....	....	....	....	....	10·43	231·35	136,940·22	104,029·97	29·60
		Sundry claims	....	....	49·00	47·00	1·25	51·15	557·24	6,691·68	4,708·32	9·29
Redcastle	....	Voided leases	....	....	....	....	....	4·49	491·33	4,284·95	4,111·85	....
		Sundry claims	....	....	....	....	....	....	113·84	1,183·57	642·45	....
Yundamindera	....	Voided leases	....	....	....	....	....	....	110·93	84,523·85	52,042·94	36·50
		Sundry claims	....	....	....	....	....	3·01	271·93	6,674·35	4,789·46	....
	From District generally :—											
	Sundry Parcels treated at :											
		Crocker's Anniversary Battery	....	....	....	....	....	....	....	10·00	26·96	....
		United Aborigines Mission	....	....	....	....	....	113·08	18·87	403·00	135·50	·09
		State Battery, Linden	....	....	....	....	....	....	9·16	299·54	*15,502·97	....
		Various Works	....	....	....	....	....	....	....	1,257·81	*8,561·39	99·97
	Reported by Banks and Gold Dealers	....	17·07	....	....	....	....	3,147·83	141·84	10·30	95·75	·68
		Total	**17·07**	....	**49·00**	**47·00**	**1·25**	**3,561·34**	**9,398·51**	**1,217,557·31**	**717,818·26**	**5,821·61**

MOUNT MALCOLM DISTRICT.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962: Alluvial (Fine ozs.)	Total for 1962: Dollied and Specimens (Fine ozs.)	Total for 1962: Ore treated (Tons (2,240 lb.))	Total for 1962: Gold therefrom (Fine ozs.)	Total for 1962: Silver (Fine ozs.)	Total Production: Alluvial (Fine ozs.)	Total Production: Dollied and Specimens (Fine ozs.)	Total Production: Ore treated (Tons (2,240 lb.))	Total Production: Gold therefrom (Fine ozs.)	Total Production: Silver (Fine ozs.)
Cardinia	....	Voided leases	....	....	....	....	....	13·87	1,598·15	5,531·74	4,238·57	....
		Sundry claims	....	....	52·00	22·94	2·21	4·25	121·91	1,948·25	643·86	2·87
Diorite	....	Voided leases	....	....	....	....	....	....	945·65	38,879·03	35,144·28	33·18
		Sundry claims	....	....	....	....	....	11·21	332·13	4,655·85	4,514·02	....

Dodgers Well	....	Voided leases	....	....	....	....	....	....	57·90	1,373·30	1,936·52	....
		Sundry claims	....	....	....	....	....	·95	28·32	1,440·25	904·23	....
Lake Darlot	G.M.L. 1845C	Monte Christo	....	....	1,709·50	130·85	1·35	....	....	5,020·00	412·10	2·66
		Voided leases	....	....	....	....	....	....	4,482·18	74,717·46	52,293·77	7·56
		Sundry claims	....	....	178·50	127·05	6·16	129·92	906·52	11,670·62	6,298·15	9·19
Leonora	1829	Jessia Alma	....	....	....	....	....	....	582·87	727·25	1,920·53	....
	1849C	Puzzle	....	....	27·00	53·30	·35	....	....	27·00	53·30	·35
	1579C, etc.	Sons of Gwalia Ltd.	....	....	121,773·00	25,950·35	2,453·67	....	....	6,871,089·53	2,549,067·49	185,878·28
		Prior to transfer to present holders	....	....	....	....	....	....	....	109,081·00	55,989·21	8·66
	1848C	Tower Hill	....	....	807·00	89·23	3·87	....	....	1,119·75	129·89	5·34
	1847C	Victor	....	2·34	....	....	·04	....	2·34	16·50	33·73	·09
		Voided leases	....	....	....	....	....	....	1,866·86	176,575·00	91,197·84	94·57
		Sundry claims	....	....	720·00	268·92	13·97	37·73	377·26	21,621·95	12,603·80	18·64
Malcolm	....	Voided leases	....	....	....	....	....	11·65	47·07	62,656·53	47,563·43	....
		Sundry claims	....	....	....	....	....	5·75	35·60	4,948·47	2,728·98	1·59
Merton Dale	....	Voided leases	....	....	....	....	....	....	....	89,024·75	60,935·32	1,497·58
		Sundry claims	....	....	....	....	....	5·42	85·74	3,216·41	2,295·52	....
Mt. Clifford	....	Voided leases	....	....	....	....	....	....	1,786·51	9,588·96	16,640·81	....
		Sundry claims	....	....	....	....	....	53·98	1,860·00	5,602·70	3,494·04	·24
Pigwell	....	Voided leases	....	....	....	....	....	....	....	13,587·32	14,676·58	63·68
		Sundry claims	....	....	....	....	....	....	34·61	2,896·65	1,225·46	....
Randwick	....	Voided leases	....	....	....	....	....	....	246·76	10,912·65	9,736·57	....
		Sundry claims	....	....	....	....	....	66·57	164·02	2,551·64	1,320·66	....
Webster's Find	....	Voided leases	....	....	....	....	....	30·30	....	22,167·50	14,377·65	....
		Sundry claims	....	....	....	....	....	36·84	695·68	2,356·15	1,530·56	....
Wilson's Creek	....	Voided leases	....	....	....	....	....	....	....	333·50	168·27	....
		Sundry claims	....	....	....	....	....	·70	4·24	316·00	261·12	....
Wilson's Patch	....	Voided leases	....	....	....	....	....	....	99·38	28,863·35	13,050·19	1·05
		Sundry claims	....	....	55·00	6·30	·93	4·68	54·46	1,700·16	1,433·20	·96
		From District generally:										
		Sundry Parcels treated at:										
		State Battery, Darlot	....	....	....	*467·81	2·07	....	....	18·00	*2,514·77	4·98
		Reefer Cyanide Plant	....	....	....	....	....	....	....	20·00	*3,125·37	22·38
		Various Works	....	....	....	....	....	....	....	789·50	*22,175·93	135·97
		Reported by Banks and Gold Dealers	2·58	....	....	....	....	3,646·05	252·83	46·50	57·80	....
		Total	**2·58**	**2·34**	**125,322·00**	**27,116·75**	**2,484·62**	**4,059·87**	**16,668·99**	**7,587,091·22**	**3,036,693·52**	**187,789·82**

MOUNT MARGARET DISTRICT.

Burtville	G.M.L. 2567T	Boomerang	....	....	....	....	....	....	....	578·00	34·08	3·67
		Voided leases	....	....	....	....	....	4·89	419·10	74,268 45	122,454·22	948·27
		Sundry claims	....	....	....	....	....	2·65	208·27	8,677·66	5,673·60	....

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

MOUNT MARGARET GOLDFIELD—continued.

MOUNT MARGARET DISTRICT.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962: Alluvial	Total for 1962: Dollied and Specimens	Total for 1962: Ore treated	Total for 1962: Gold therefrom	Total for 1962: Silver	Total Production: Alluvial	Total Production: Dollied and Specimens	Total Production: Ore treated	Total Production: Gold therefrom	Total Production: Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
Duketon	....	Voided leases	....	....	....	....	....	5·35	3,216·10	31,889·42	22,542·63	....
		Sundry claims	....	....	....	....	....	85·07	528·26	2,442·65	2,196·49	29·76
Eagle's Nest	....	Voided leases	....	....	....	....	....	....	145·34	534·50	1,238·22	....
		Sundry claims	....	....	....	....	....	24·07	487·05	1,046·35	360·11	....
Erlistoun	....	Voided leases	....	....	....	....	....	10·07	393·41	156,731·00	101,641·56	4,327·81
		Sundry claims	....	....	....	....	....	1,181·65	165·05	5,716·59	3,888·89	....
Euro	....	Voided leases	....	....	....	....	....	....	65·14	91,821·50	37,678·25	....
		Sundry claims	....	....	....	....	....	4·87	73·04	1,507·00	835·30	....
Laverton	....	Voided leases	....	....	....	....	....	28·59	2,028·85	2,131,121·12	820,120·06	56,945·78
		Sundry claims	....	....	....	....	....	215·58	1,492·90	17,552·50	9,256·80	....
Mt. Barnicoat	....	Voided leases	....	....	....	....	....	....	23·08	2,370·00	2,251·99	....
		Sundry claims	....	....	....	....	....	....	·68	1,309·75	1,087·77	....
Mt. Shenton	....	Voided leases	....	....	....	....	....	....	....	15·00	26·65	....
		Sundry claims	....	....	....	....	....	....	....	279·25	209·67	....
	From District generally :—											
	Sundry Parcels treated at :											
		United Gold Recoveries Pty. Ltd.	....	....	....	....	....	....	....	·25	*3,786·44	3,374·06
		State Battery, Laverton	....	....	....	....	....	....	....	97·50	*19,327·97	561·11
		Various Works	....	....	....	....	....	....	....	214·75	*19,403·68	·24
	Reported by Banks and Gold Dealers	....	....	....	....	....	....	2,580·75	108·08	....	29·18	....
		Total	....	....	....	....	....	**4,143·54**	**9,354·35**	**2,528,173·24**	**1,174,043·56**	**66,190·70**

North Coolgardie Goldfield.

MENZIES DISTRICT.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962: Alluvial	Total for 1962: Dollied and Specimens	Total for 1962: Ore treated	Total for 1962: Gold therefrom	Total for 1962: Silver	Total Production: Alluvial	Total Production: Dollied and Specimens	Total Production: Ore treated	Total Production: Gold therefrom	Total Production: Silver
Comet Vale	G.M.L. 5766Z....	Coonega Extended	....	....	....	....	....	....	....	100·25	35·55	....
		Voided leases	....	....	....	....	....	....	419·74	267,668·97	193,272·82	5,355·33
		Sundry claims	....	....	61·75	12·91	....	....	40·19	2,236·96	1,176·14	....
Goongarrie	5740Z	Gulls Blow	....	....	....	....	....	....	164·75	357·50	257·47	....
		Voided leases	....	....	....	....	....	·94	1,385·26	29,897·79	18,124·83	....
		Sundry claims	....	....	24·00	12·01	....	46·46	2,140·81	2,877·85	3,374·74	....

Menzies	(5543Z)	Black Swan	....	....	276·50	38·82	....	....	....	1,532·13	1,721·04	9·08
	5736Z	Bodington	....	....	25·00	10·11	....	....	134·83	175·50	191·26	....
	5511Z	First Hit	....	....	481·25	167·19	....	....	....	6,445·75	7,653·62	22·37
	5511Z	First Hit Gold Mines (1934) Ltd.	....	....	....	....	....	....	....	68,473·70	49,060·96	6,676·23
	5788Z	Flying Fish	....	....	180·50	36·48	....	....	....	180·50	36·48	....
	5542Z	Good Block Lease	....	....	138·75	33·49	....	....	7·32	3,500·40	3,076·92	....
	5780Z	Good Enough	....	....	1,719·75	497·83	1·54	....	....	3,243·45	982·47	1·54
	5520Z	Mignonette	....	....	....	....	....	....	....	808·50	404·43	....
		Voided leases	....	....	....	....	....	45·42	1,125·41	937,698·50	727,099·60	13,586·39
		Sundry claims	....	....	896·25	134·57	....	56·87	624·33	39,041·09	26,185·18	812·86
Mt. Ida	5701Z, etc.	Moonlight Wiluna Gold Mine Ltd.	....	....	24,493·00	13,704·80	....	....	40·77	340,557·86	177,694·76	912·22
		Prior to transfers to present holders	....	....	....	....	....	....	....	31,833·25	16,021·98	891·37
		Voided leases	....	....	....	....	....	....	92·21	68,748·92	72,681·44	106·63
		Sundry claims	....	....	....	....	....	48·14	436·08	16,117·41	8,280·58	·12
Twin Hills	....	Voided leases	....	....	....	....	....	....	....	582·30	574·93	....
		Sundry claims	....	....	....	....	....	....	....	97·80	86·69	....
	From District generally :											
	Sundry Parcels treated at :											
	R. McPherson Plant (L.T.T. 3Z/59)		....	....	....	....	....	....	....	....	*15·20	....
	R. H. Bennetts (L.T.T. 1423H)		....	....	....	....	....	....	....	79·50	31·83	....
	State Battery, Mt. Ida		....	....	....	....	....	....	....	1,866·25	*7,556·16	2·04
	State Battery, Menzies		....	....	....	*345·12	78·74	....	....	....	*3,379·05	727·31
	Various Works		....	....	....	....	....	....	....	3,136·55	*58,757·09	3,062·11
	Reported by Banks and Gold Dealers		....	....	....	....	....	1,489·87	403·22	100·00	48·49	....
		Total	....	....	**28,296·75**	**14,993·33**	**80·28**	**1,687·70**	**7,014·92**	**1,827,358·68**	**1,377,781·71**	**32,165·60**

ULARRING DISTRICT.

Davyhurst	....	Voided leases	....	....	....	....	....	2·93	152·64	304,354·62	195,751·92	21,336·15
		Sundry claims	....	....	....	....	....	....	208·48	14,160·19	5,787·29	....
	G.M.L. 1094U	First Hit	....	....	219·75	212·43	9·62	....	....	5,002·00	7,016·89	9·75
	1168U	Hazel Dawn	....	....	....	....	....	....	....	51·25	104·97	....
	1081U	Mabel Gertrude	....	....	....	....	....	....	17·19	1,692·75	1,998·06	....
	1089U	Paramount	....	....	....	....	....	....	1·49	4,547·50	3,812·36	....
	1163U	Two Chinamen	....	....	....	....	....	....	....	9·25	15·28	....
Morleys	....	Voided leases	....	....	....	....	....	....	3,881·18	7,349·00	8,409·85	10·54
		Sundry claims	....	....	....	....	....	2·16	932·23	1,983·75	2,648·51	....
Mulline	1107U	Ajax West	....	....	....	....	....	....	1·37	8,355·50	6,653·34	....
	(1170U)	Golden Wonder	....	....	180·00	139·79	....	....	....	720·75	2,211·25	....
	1173U	Riverina	....	....	....	....	....	....	....	29·50	23·51	....
	1070U	(Riverina)	....	....	....	....	....	....	....	283·00	75·30	....
	1068U, etc.	Riverina Gold Mines Pty. Ltd.	....	....	....	....	....	....	....	32,085·50	11,669·45	·07
	1176U	Wildcat	....	....	84·75	47·43	....	....	....	218·25	180·42	....
		Voided leases	....	....	....	....	....	....	274·09	102,720·82	103,438·26	530·75
		Sundry claims	....	....	7·25	14·38	....	10·82	296·42	11,155·89	9,768·32	1·10
Mulwarrie	1153U	Fourmile	....	....	....	....	....	....	....	89·00	498·92	....
	1113U	Oakley	....	....	174·00	576·03	36·59	....	....	4,420·00	6,530·49	47·29
		Voided leases	....	....	....	....	....	....	165·29	19,480·68	26,369·21	38·47
		Sundry claims	....	....	....	....	....	·80	282·29	3,106·33	2,722·13	....

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962: Alluvial	Total for 1962: Dollied and Specimens	Total for 1962: Ore treated	Total for 1962: Gold therefrom	Total for 1962: Silver	Total Production: Alluvial	Total Production: Dollied and Specimens	Total Production: Ore treated	Total Production: Gold therefrom	Total Production: Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
		NORTH COOLGARDIE GOLDFIELD—continued.										
		ULARRING DISTRICT—*continued.*										
Ularring	....	Voided leases	....	....	....	....	....	....	563·34	9,771·60	13,907·76	....
		Sundry claims	....	....	....	....	....	....	....	671·50	309·48	....
		From District generally :—										
		Sundry Parcels treated at :										
		State Battery, Mulline	....	....	....	....	....	....	....	639·99	*16,459·89	....
		State Battery, Mulwarrie	....	....	....	....	....	....	....	613·18	*6,564·16	....
		Linnett & Hawkins (L.T.T. 1252U)	....	....	....	....	....	....	....	....	*229·52	1·53
		Riverina South Battery	....	....	....	....	....	....	....	....	*900·46	....
		Various Works	....	....	....	....	....	....	15·82	268·15	*9,639·15	11·15
		Reported by Banks and Gold Dealers	....	12·99	....	....	....	112·81	424·28	100·00	106·34	....
		Total	....	**12·99**	**665·75**	**990·06**	**46·21**	**129·52**	**7,216·11**	**533,879·95**	**443,802·49**	**21,986·80**
		NIAGARA DISTRICT.										
Desdemona	....	Voided leases	....	....	....	....	....	....	7·12	9,809·00	7,555·81	12·04
		Sundry claims	....	....	....	....	....	....	10·35	2,225·45	892·48	....
Kookynie	G.M.L. 928G	Altona	....	....	626·00	181·06	9·45	....	....	12,176·75	7,219·71	16·74
	940G	New Gladstone Syndicate	....	....	326·25	61·44	·08	....	....	326·25	61·44	·08
		Voided leases	....	....	....	....	....	3·35	347·30	748,602·71	396,353·94	5,376·87
		Sundry claims	....	....	17·50	7·20	....	60·92	106·60	9,437·05	6,944·40	3·90
Niagara	....	Voided leases	....	....	....	....	....	....	104·54	85,876·50	52,365·05	....
		Sundry claims	....	....	....	....	....	28·10	97·22	14,687·91	8,265·87	....
Tampa	....	Voided leases	....	....	....	....	....	....	41·58	50,477·57	23,287·71	174·24
		Sundry claims	....	....	....	....	....	32·60	283·40	8,041·33	4,113·02	....
		From District generally :—										
		Sundry Parcels treated at :										
		Various Works	....	....	....	....	....	....	....	1,220·50	*20,884·22	120·98
		Reported by Banks and Gold Dealers	....	....	....	....	....	1,593·39	823·66	....	63·53	....
		Total	....	....	**969·75**	**249·70**	**9·53**	**1,718·36**	**1,821·77**	**942,881·02**	**528,007·23**	**5,704·85**
		YERILLA DISTRICT.										
Ejudina	....	Voided leases	....	....	....	....	....	....	18·44	35,523·70	43,374·79	37·79
		Sundry claims	....	....	....	....	....	....	28·52	6,967·58	4,829·77	·69
Patricia	....	Voided leases	....	....	....	....	....	....	....	4,158·50	5,396·40	25·40
		Sundry claims	....	....	....	....	....	....	....	47·00	20·78	....

Pingin	....	Voided leases	....	....	....	....	....	....	48·34	17,463·30	10,742·77	....
		Sundry claims	....	....	....	....	....	....	154·86	5,642·59	3,475·75	....
Yarri	G.M.L. 1346R	Dawn	....	....	6·50	2·96	....	....	....	6·50	2·96	....
	1320R	Margaret	....	....	335·00	49·29	....	....	....	4,371·00	1,302·61	·32
	1126R, etc.	Porphyry (1939) Gold Mines Ltd.	....	....	....	....	....	....	....	66,939·00	9,893·51	261·95
	1136R, etc.	(Edjudina Goldmining Co. N.L.)	....	....	....	....	....	....	....	30,220·00	5,409·93	507·51
		Prior to transfer to present holders	....	....	....	....	....	....	....	124·50	38·89	....
	1345R	Wallaby Extended	....	....	56·00	7·06	....	....	....	56·00	7·06	....
	1339R	Yilgangie	....	....	126·00	28·29	·46	....	....	589·00	236·22	·46
		Voided leases	....	....	....	....	....	6·30	87·08	45,427·75	21,392·94	2·00
		Sundry claims	....	....	48·00	7·44	....	·87	5·93	18,013·05	6,309·23	1·27
Yerilla	....	Voided leases	....	....	....	....	....	....	3,107·25	16,481·43	12,925·74	13·93
		Sundry claims	....	....	....	....	....	19·30	97·63	2,752·83	1,590·03	....
Yilgangie	1176R, etc.	Western Mining Corporation	....	....	1,801·75	1,223·02	159·46	....	....	29,688·50	27,409·12	4,058·73
		Prior to transfer to present holders	....	....	....	....	....	....	·85	1,244·75	1,830·28	....
		Voided leases	....	....	....	....	....	....	9·94	2,432·75	1,500·80	....
		Sundry claims	....	....	14·00	3·34	....	121·67	98·20	3,381·30	2,070·84	·63
		From District generally :—										
		Sundry Parcels treated at :										
		State Battery, Yarri	....	....	....	....	....	....	....	276·50	*9,060·18	11·65
		State Battery, Yerilla	....	....	....	....	....	....	....	....	*43·52	....
		Various Works	....	....	....	....	....	2·17	....	642·25	*6,049·24	....
		Reported by Banks and Gold Dealers	....	....	....	....	....	1,161·60	160·08	....	27·36	....
		Total	....	....	**2,387·25**	**1,321·40**	**159·92**	**1,311·91**	**3,817·12**	**292,449·78**	**174,940·72**	**4,922·33**

Broad Arrow Goldfield.

Bardoc	....	Voided leases	....	....	....	....	....	....	2,335·41	85,370·59	55,699·50	203·60
		Sundry claims	....	....	6·00	1·10	....	54·95	1,218·09	17,783·78	8,333·97	....
Black Flag	G.M.L. 2229W	Bellevue	....	....	84·50	39·08	2·58	....	212·68	4,069·23	3,230·85	9·76
	2291W	Bellevue South	....	....	51·00	3·29	·07	....	....	51·00	3·29	·07
		Voided leases	....	....	....	....	....	27·81	405·90	48,277·79	28,175·08	....
		Sundry claims	....	....	....	....	....	712·92	251·59	8,337·01	5,020·54	....
Broad Arrow	....	Voided leases	....	....	....	....	....	70·32	10,453·81	155,895·94	120,088·05	20·23
		Sundry claims	....	....	273·25	86·47	....	1,007·72	3,046·26	35,440·15	17,182·24	·48
Canegrass	....	Voided leases	....	....	....	....	....	....	27·77	669·82	460·72	....
		Sundry claims	....	....	....	....	....	....	227·55	717·45	505·06	....
Carnage	....	Voided leases	....	....	....	....	....	176·04	659·31	2,402·00	2,170·67	....
		Sundry claims	....	....	....	....	....	....	6·61	2,340·33	921·90	....
Cashmans	....	Voided leases	....	....	....	....	....	67·51	813·76	8,172·15	7,090·91	....
		Sundry claims	....	....	32·75	6·54	....	....	40·31	1,237·87	368·28	·05
Christmas Reef	2279W	New Mexico	....	....	20·25	8·64	....	....	....	623·75	475·99	6·99
	2253W	New Mexico South	....	....	97·25	65·58	·35	....	....	3,264·75	3,517·83	·57
		Voided leases	....	....	....	....	....	....	55·49	1,865·12	3,606·65	....
		Sundry claims	....	....	15·50	2·46	....	....	441·85	3,327·64	3,248·02	....

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
		BROAD ARROW GOLDFIELD—continued.										
Fenbark	....	Voided leases	....	....	....	....	....	....	4·42	6,771·00	2,711·68	....
		Sundry claims	....	....	....	....	....	....	51·96	3,031·52	1,000·47	....
Grant's Patch	G.M.L. 2311W	Bent Tree	....	....	128·00	75·17	....	....	....	128·00	75·17	....
	2277W....	Coronation	....	....	19·50	19·88	....	....	....	535·75	448·28	1·39
	2299W....	Jeanie May	....	....	....	....	....	....	....	362·85	91·03	....
	2278W....	Prince of Wales Syndicate	....	....	....	....	....	....	....	702·75	1,246·34	40·88
	2277W, 2278W	(Ora Banda Amalgamated Mines N.L.)	....	....	....	....	....	....	....	961·00	1,148·58	....
		Voided leases	....	....	....	....	....	....	274·13	203,675·74	80,047·31	175·00
		Sundry claims	....	....	95·50	10·82	....	....	356·66	7,264·34	3,216·70	....
Ora Banda	2270W, 2290W	Gimlet South Leases	....	....	1,529·50	332·24	....	....	....	11,904·25	2,338·37	·06
	(2303W)	Old Victoria	....	....	135·25	13·10	....	....	....	201·75	25·55	....
	2300W....	Sleeping Beauty	....	....	439·50	65·67	....	....	....	2,130·50	756·16	1·14
		Voided leases	....	....	....	....	....	....	846·13	423,464·77	151,188·55	1,685·77
		Sundry claims	....	....	125·25	12·30	....	....	467·18	15,397·80	4,878·06	....
Paddington	2298W....	Rona Lucille	....	....	....	....	....	....	....	227·50	40·46	....
		Voided leases	....	....	....	....	....	5,566·30	463·31	196,486·56	86,485·99	32·15
		Sundry claims	....	....	37·50	4·18	....	1,714·16	291·43	17,479·68	9,310·47	....
Riche's Find	2306W....	Cave Hill	....	....	14·60	3·70	....	....	238·15	46·60	100·57	....
		Voided leases	....	....	....	....	....	....	21·64	7,643·09	6,095·69	71·36
		Sundry claims	....	....	16·00	7·87	....	....	549·09	1,979·50	2,493·93	·13
Siberia	....	Voided leases	....	....	....	....	....	1·07	2,649·28	28,995·47	31,776·06	....
		Sundry claims	....	....	6·30	4·86	....	289·06	1,261·72	21,314·59	12,891·93	....
Smithfield	2296W....	Timewell	....	12·51	29·28	42·46	....	....	12·51	53·78	63·12	....
		Voided leases	....	....	....	....	....	....	19·19	11,717·71	2,068·58	....
		Sundry claims	....	....	53·50	2·34	....	....	124·29	3,969·59	1,400·01	·11
	From Goldfield generally :											
	Sundry Parcels treated at :											
	H. Seaton & H. Edwards Plant (L.T.T. 1W/62)		....	....	....	*12·00	....	....	....	....	*12·00	....
	W. J. Ferguson Plant (L.T.T. 1455H)		....	....	....	....	....	....	....	·50	·52	....
	H. T. Kingdon (M.A. 4W)		....	....	....	....	....	....	1·53	12·55	*6·49	·18
	State Battery, Ora Banda		....	....	....	*102·61	....	....	....	128·05	*26,626·76	73·53
	Golden Arrow Battery		....	....	....	....	....	....	....	80·75	*4,333·07	2·30
	Various Works		....	....	....	....	....	2,275·66	1·24	16,967·02	49,504·77	3,103·45
	Reported by Banks and Gold Dealers		·04	....	....	....	....	10,018·34	165·70	61·68	95·83	·15
		Total	**·04**	**12·51**	**3,210·18**	**922·36**	**3·00**	**21,981·86**	**27,995·95**	**1,363,543·01**	**742,578·05**	**5,429·35**

North-East Coolgardie Goldfield.

KANOWNA DISTRICT.

Gindalbie	G.M.L. 1583X	S.H.E.	....	....	....	....	....	....	....	243·00	163·25	....
		Voided leases	....	....	....	....	....	....	1,151·99	46,180·53	41,748·13	38·31
		Sundry claims	....	....	10·50	3·49	....	....	716·52	5,857·27	3,309·40	·01
Gordon	....	Voided leases	....	....	....	....	....	....	682·54	53,900·58	20,072·51	517·61
		Sundry claims	....	....	....	....	....	....	177·38	2,265·95	1,229·87	....
Kalpini	....	Voided leases	....	....	....	....	....	....	38·73	13,543·50	6,753·78	·07
		Sundry claims	....	....	....	....	....	24·70	269·72	1,492·50	1,026·37	....
Kanowna	1572X	Kanowna Red Hill	....	....	170·00	80·01	1·83	....	2·38	3,508·75	1,156·35	4·60
		Voided leases	....	....	....	....	....	24·94	4,516·76	685,625·60	380,504·87	2,482·24
		Sundry claims	....	....	371·30	43·40	....	125·32	2,169·07	28,267·07	12,093·35	1·71
Mulgarrie	....	Voided leases	....	....	....	....	....	....	1,216·63	6,902·26	4,197·98	....
		Sundry claims	....	....	....	....	....	....	16·78	1,290·00	646·60	....
Six Mile	....	Voided leases	....	....	....	....	....	....	1,603·72	559·00	767·72	....
		Sundry claims	....	....	....	....	....	....	56·51	771·75	232·66	....
	From District generally :— Sundry Parcels treated at :											
		Various Works	....	....	....	....	....	330·42	867·52	158,935·05	153,209·41	....
		Reported by Banks and Gold Dealers	·55	....	....	....	....	106,030·94	40·42	·50	109·73	....
		Total	**·55**	....	**551·80**	**126·90**	**1·83**	**106,536·32**	**13,526·67**	**1,009,343·31**	**627,221·98**	**3,044·55**

KURNALPI DISTRICT.

Jubilee	....	Voided leases	....	....	....	....	....	....	145·13	2,122·50	1,465·16	....
		Sundry claims	....	....	....	....	....	25·57	13·52	1,246·25	522·21	....
Kurnalpi	....	Voided leases	....	....	....	....	....	371·18	3,166·80	4,130·76	4,022·13	6·27
		Sundry claims	....	....	19·00	3·03	....	324·12	727·39	4,558·11	2,356·23	....
Mulgabbie	G.M.L. 457K	Mulgabbie Lucknow	....	....	70·00	6·72	....	....	....	70·00	6·72	....
		Voided leases	....	....	....	....	....	....	1,402·66	226·75	7,845·87	4·95
		Sundry claims	....	....	....	....	....	8·06	2,772·71	1,327·45	2,241·18	....
	From District generally :— Sundry Parcels treated at :											
		Various Works	....	....	....	....	....	....	....	101·50	388·63	....
		Reported by Banks and Gold Dealers	1·15	....	....	....	....	12,107·71	70·70	....	2·35	1·49
		Total	**1·15**	....	**89·00**	**9·75**	....	**12,836·64**	**8,298·91**	**13,783·32**	**18,850·48**	**12·71**

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
East Coolgardie Goldfield.												
EAST COOLGARDIE DISTRICT.												
Binduli	....	Voided leases	....	....	....	....	....	....	....	1,904·60	495·36	....
		Sundry claims	....	....	93·50	13·26	·02	....	13·01	5,697·37	1,731·28	·08
Boorara	....	Voided leases	....	....	....	....	....	....	459·07	309,467·82	172,861·95	411·37
		Sundry claims	....	....	7·75	1·17	....	·49	145·56	4,251·34	1,570·80	·05
Boulder	G.M.L. 6145E	Boomerang	....	....	....	....	....	....	....	77·00	8·00	....
	5531E	Cassidy's Hill	....	....	52·50	10·63	....	....	....	1,365·75	115·95	....
	5964E	Croesus Extended	....	....	....	....	....	....	....	192·75	16·57	....
	6537E	Golden Key	....	....	....	....	....	....	58·22	767·10	828·68	....
	5692E, etc.	Gold Mines of Kalgoorlie (Aust.) Ltd.	....	....	502,064·00	135,013·20	41,526·48	....	....	3,015,559·00	802,960·22	173,249·36
		Prior to transfer to present holders	....	....	....	....	....	....	791·73	15916155·97	6,415,881·49	819,123·27
	5696E, etc.	Great Boulder Gold Mines Ltd.	....	....	450,192·00	121,627·97	35,535·29	....	1·53	14576614·97	6,521,650·19	1,603,675·52
	5478E, etc.	Lake View and Star Ltd.	....	....	694,054·00	181,094·78	22,071·88	....	....	17192980·30	5,006,809·55	553,221·98
		Prior to transfer to present holders	....	....	....	....	....	....	8·49	15792500·38	9,149,223·80	1,348,055·28
	5431E, etc.	North Kalgurli (1912) Ltd.	....	....	368,350·00	84,558·77	34,209·67	....	127·55	6,460,093·24	1,736,344·03	401,463·60
	5405E, etc.	North Kalgurli (1912) Ltd. (Croesus Pty. Group)	....	....	....	....	....	....	51·20	90,159·00	19,261·22	....
	5891E	New Croesus	....	....	....	....	....	....	....	193·00	48·74	....
		Prior to transfer to present holders	....	....	....	....	....	43·99	....	4,018,436·01	2,815,911·21	97,625·03
		Voided leases	....	....	....	....	....	129·24	12,023·37	1,822,556·06	761,933·46	24,046·96
		Sundry claims	....	....	....	....	....	24·58	212·32	11,649·99	4,300·62	....
Cutters Luck	....	Voided leases	....	....	....	....	....	45·87	133·58	74·50	239·19	....
		Sundry claims	....	....	....	....	....	8·11	501·65	922·90	384·71	....
Feysville	6591E	Kalgoorlie Star	....	....	....	....	....	....	....	24·75	12·01	·57
		Voided leases	....	....	....	....	....	....	110·93	863·30	425·16	....
		Sundry claims	....	....	....	....	....	....	199·00	1,264·75	655·20	....
Hampton Plains	P.P. 1	Hampton Boulder	....	....	196·00	20·11	....	....	....	361·75	38·81	·08
	P.P. 1, etc.	Consolidated Gold Areas N.L.	....	....	....	....	....	....	....	142,565·73	37,249·15	5,835·85
	P.P. 10	F. C. Schoppe	....	....	....	....	....	....	....	891·50	42·05	....
	P.P. 12	Junction Extended	....	....	14·50	6·49	....	....	....	3,675·00	545·35	....
	P.P. 86	Golden Hope N.L.	....	....	....	....	....	....	....	5,964·00	2,006·14	....
	P.P. 50	A. McKay	....	....	....	....	....	....	....	80·25	5·46	....
	P.P. 23	Mutooroo	....	....	....	....	....	....	....	1,747·50	134·82	....
	P.P. 202	P. E. Dolling	....	....	5·25	·29	....	....	....	5·25	·29	....
	P.P. 280	W. J. White	....	....	167·75	31·62	....	....	....	167·75	31·62	....
	P.P. 48	E. Doherty	....	....	....	....	....	....	....	....	34·65	....
	P.P. 175	S. Shackleton	....	....	....	....	....	....	....	121·25	7·40	....
	P.P. 175	F. C. Shoppe	....	....	....	....	....	....	....	6,708·00	906·81	....
	P.P. 192	Golden Hope North	....	....	....	....	....	....	....	353·00	201·02	....

	P.P. 222	Hampton Jubilee	....	....	1,090·00	81·40	·16	....	....	1,247·75	99·96	·50
	P.P. 252	Hampton Properties Ltd.—Mount Martin	....	....	....	....	....	....	....	14,953·75	5,574·11	....
	P.P. 227	Parker & Africh	....	....	630·00	37·28	....	....	....	630·00	37·28	....
	P.P. 277	M. Africh	....	....	3,559·00	212·51	....	....	....	7,540·00	609·99	....
	P.P. 277	Pernatty	....	....	....	....	....	....	....	7,247·75	866·88	·01
	P.P. 277	New Hope	....	....	....	....	....	....	17·23	61,468·55	11,175·94	....
	P.P. 460	Hampton Xmas Gift	....	....	....	....	....	6·72	37·57	107·00	89·44	....
	P.P. 471	Cullen & Renton	....	....	....	....	....	....	....	7·05	126·78	....
	P.P. 474	L. Rowell	....	....	....	....	....	....	....	20·75	3·96	....
	P.P. 476	Ivy Rose	....	....	7·50	58·85	....	....	7·75	99·55	238·81	·72
	P.P. 478	L. Bracegirdle	....	....	....	....	....	....	....	2·75	5·25	....
	P.P. 480	A. Brokenshire	....	....	13·50	3·65	....	....	....	26·50	7·73	....
		Cancelled leases	....	....	....	....	....	4,578·52	203·94	126,877·34	39,711·84	69·83
		Sundry claims and leases	....	....	190·75	24·08	....	2·68	70·85	46,681·91	8,547·12	·13
Kalgoorlie	G.M.L. 6562E	Bretvic	....	....	....	....	....	....	....	326·50	26·09	....
	6563E, 6564E	Champagne Syndicate N.L.	....	....	....	....	....	....	....	12,287·75	1,348·10	61·41
	4547E, etc.	Mount Charlotte (Kalgoorlie) Gold Mine Ltd.	....	....	....	....	....	....	....	25,143·25	2,888·32	110·15
		Prior to transfer to present holders	....	....	....	....	....	....	5·72	48,292·60	13,930·79	....
	6503E	Coronation	....	....	....	....	....	....	....	20·50	2·52	....
	5510E	Golden Dream	....	....	....	....	....	....	....	207·75	19·29	....
	6589E	Gray's Central	....	....	81·00	47·82	....	....	....	822·75	153·15	....
	6502E	Gold Mines of Kalgoorlie (Aust.) Ltd.	....	....	3,425·75	920·85	2·42	....	....	4,740·25	1,243·65	4·31
	6502E	Western Mining Corporation Ltd.	....	....	....	....	....	....	....	256·00	65·07	4·28
	6091E	Lesanben	....	....	64·00	65·96	·52	....	193·96	1,103·80	701·79	2·45
	6485E	Maritana Hill	....	....	....	....	....	....	....	3,138·50	394·23	....
	6535E	Mary A	....	....	377·25	32·04	....	....	....	5,487·25	511·80	·14
	(6321E)	North End Extended	....	....	24·25	2·79	....	....	69·28	2,149·25	517·08	....
	5852E (6024E)	Pedestal Leases	....	....	....	....	....	....	....	1,828·50	490·37	....
	(6024E)	Trident	....	....	....	....	....	....	....	58·75	36·67	....
	5852E	Pedestal	....	....	....	....	....	....	....	1,608·75	444·93	....
		Voided leases	....	....	....	....	....	242·48	10,733·00	1,472,999·01	582,188·37	45,975·97
		Sundry claims	....	....	642·75	57·27	....	232·41	1,124·61	62,858·53	23,347·36	·18
Wombola	(6595E)	Big Bull	....	5·86	....	....	....	....	5·86	....	....	....
	5688E (5967E)	Caledonian Leases	....	....	....	....	....	....	....	970·00	659·67	....
	5688E	Caledonian	....	....	....	....	....	....	....	4,275·00	3,632·98	....
	(5967E)	North Caledonian	....	....	....	....	....	....	1·27	22·25	8·15	....
	5497E, 5500E	Daisy Leases	....	....	1,067·75	891·46	35·99	....	....	18,129·95	13,214·59	145·75
	5497E	Daisy	....	....	....	....	....	....	....	6,282·25	5,031·93	....
	5500E	Happy-Go-Lucky	....	....	....	....	....	....	....	2,075·25	1,675·85	....
	G.M.L. 5689E, etc.	Mt. Monger Mining Syndicate	....	....	97·00	10·26	....	....	....	5,013·75	3,225·88	41·72
	5689E	(Haoma Gold Mines N.L.)	....	....	....	....	....	....	....	9,233·00	7,239·42	269·03
	5689E	(Haoma Leases)	....	....	....	....	....	....	....	27,396·50	25,445·40	79·15
	5689E	(Haoma)	....	....	....	....	....	....	....	2,168·00	1,948·36	·54
	5525E	(Xmas Flat)	....	....	....	....	....	....	....	330·25	264·74	....
	5798E	(Maranoa)	....	....	....	....	....	....	32·17	3,183·50	1,633·27	....
	5493E	(New Milano N.L.)	....	....	....	....	....	....	·25	17,390·75	11,622·24	479·00
	5493E	(Milano)	....	....	....	....	....	....	....	4,012·75	11,676·72	....
	5616E	(Leslie)	....	....	....	....	....	....	....	602·00	939·10	....
	6312E	Inverness	....	....	207·00	36·04	....	....	....	3,269·50	583·86	....
	6487E	Leslie	....	....	....	....	....	....	....	343·75	343·85	·49
	6533E	Rosemary	....	....	1,056·00	761·22	21·54	....	....	6,200·10	8,550·22	78·28
		Voided leases	....	....	....	....	....	3·80	2,491·44	34,368·84	43,609·38	1·18
		Sundry claims	....	....	116·50	60·09	....	....	711·10	25,529·68	14,476·65	·20

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
EAST COOLGARDIE GOLDFIELD—continued.												
EAST COOLGARDIE DISTRICT—*continued.*												
		From District generally :										
		Sundry Parcels treated at :										
		Golden Horseshoe (New) Ltd. Plant	....	....	....	....	....	....	....	....	*350,028·15	354,192·20
		Bagworth & Parker (L.T.T. 1415H)	....	....	....	....	....	....	....	....	*3·57	....
		Northern Mineral Sands Plant	....	....	....	....	....	....	....	532·25	*216·88	....
		State Battery, Kalgoorlie	....	....	....	*769·88	59·75	....	....	390·70	*36,489·40	233·81
		Sundry claims	....	....	....	....	....	11,014·57	465·61	5,440·46	2,541·10	....
		Various Works	....	....	....	....	....	384·36	64·70	41,135·02	*270,756·33	14,114·46
		Reported by Banks and Gold Dealers	4·80	2·85	....	....	....	16,994·94	10,073·32	392·43	7,498·53	....
		Total	**4·80**	**8·71**	**2,027,847·25**	**526,451·74**	**133,463·72**	**33,712·76**	**41,146·84**	**81,515,341·10**	**34973593·85**	**5,442,574·89**
BULONG DISTRICT.												
Balagundi	....	Voided leases	....	....	....	....	....	....	2,408·98	1,115·93	1,488·91	12·92
		Sundry claims	....	....	....	....	....	3·51	293·52	806·01	505·93	....
Bulong	G.M.L. 1311Y	Blue Quartz....	....	....	....	....	....	....	....	2,031·25	701·61	....
	1337Y	Rainbow	....	....	....	....	....	....	....	288·50	39·37	....
		Voided leases	....	....	....	....	....	107·54	8,526·12	108,515·05	85,819·62	....
		Sundry claims	....	....	8·00	1·39	....	1,655·86	1,611·58	18,061·73	17,972·11	....
Majestic	....	Voided leases	....	....	....	....	....	19·45	63·91	1,317·94	647·62	....
		Sundry claims	....	....	·03	11·72	....	42·88	154·58	1,926·58	959·78	....
Morelands	....	Sundry claims	....	....	....	....	....	....	·13	308·75	81·84	....
Mount Monger	....	Voided leases	....	....	....	....	....	....	2,771·39	1,437·85	1,256·10	....
		Sundry claims	....	....	....	....	....	215·60	....	379·05	308·48	....
Randalls	....	Voided leases	....	....	....	....	....	....	60·04	33,180·35	11,100·46	....
		Sundry claims	....	....	....	....	....	20·70	9·79	4,842·56	1,216·07	....
Taurus	....	Voided leases	....	....	....	....	....	2·06	3·70	1,765·10	909·84	....
		Sundry claims	....	....	....	....	....	112·69	51·88	2,656·60	1,049·81	....
Hampton Plains (Trans Find)	....	P.P.L. 308A	....	....	....	....	....	....	2·87	1,145·75	330·33	....
		Voided leases	....	....	....	....	....	....	....	1,098·42	876·22	....
		Sundry claims	....	....	....	....	....	....	5·93	808·25	335·33	....

		From District generally :									
		Sundry Parcels treated at :									
		Various Works	....	....	....	....	....	....	6,102·15	6,675·38	....
		Reported by Banks and Gold Dealers	....	....	....	....	25,224·93	70·15	·01	28·44	....
		Total	....	8·03	13·11	....	27,405·22	16,034·57	187,787·83	132,303·25	12·92

Coolgardie Goldfield.

COOLGARDIE DISTRICT.

Bonnievale	G.M.L. 5986	Jenny Wren	....	64·75	41·80	·29	....	....	245·00	120·59	·29
	5622	Lucky Hit	....	20·00	23·84	....	....	3·28	1,128·10	622·77	....
	5890	Rayjax	....	50·00	58·64	1·81	....	....	558·25	968·96	3·61
	6007	Sabrina	....	9·75	13·66	....	....	....	9·75	13·66	....
		Voided leases	....	....	....	....	....	212·48	362,696·87	196,412·90	19·86
		Sundry claims	75·72	80·00	26·10	·45	....	238·91	8,421·88	5,462·77	·87
Bulla Bulling	6003	Worked Out	....	70·00	85·09	....	....	....	124·50	139·99	....
		Voided leases	....	....	....	....	....	....	1,410·56	968·52	....
		Sundry claims	....	....	....	....	5·21	15·98	2,068·76	819·66	....
Burbanks	....	Voided leases	....	....	....	....	14·90	376·98	420,591·86	306,446·31	521·06
		Sundry claims	....	333·25	88·32	·87	55·05	497·55	17,304·85	9,241·85	·93
Cave Rocks	....	Voided leases	....	....	....	....	....	....	8,223·16	1,941·42	....
		Sundry claims	....	35·50	6·48	....	....	50·00	4,537·15	1,091·27	....
Coolgardie	5935, etc.	Gold Mines of Kalgoorlie (Aust.) Ltd.	....	12,530·00	4,635·81	....	....	....	139,263·00	70,153·59	907·43
	5876	(Bayleys West)	....	....	....	....	....	....	6·25	2·22	....
	6000	Dendon	....	312·50	38·99	....	....	....	948·50	126·51	....
	5868	El Dorado	....	19·00	6·38	....	....	498·20	194·45	1,041·32	....
	6010	Emperor of Coolgardie	5·34	46·50	58·30	....	....	10·45	46·50	58·30	....
	5844	Jackpot	....	120·50	63·23	....	....	....	9,898·50	4,140·04	....
	5884	Lone Hand	....	....	....	....	....	19·85	499·00	84·85	....
		Voided leases	....	....	....	....	1,301·71	4,784·08	1,111,680·99	449,737·93	4,820·20
		Sundry claims	8·51	1,266·00	191·78	....	219·47	2,802·92	80,696·94	28,771·11	·17
Eundynie	....	Voided leases	....	....	....	....	3·70	16·09	31,772·98	16,531·34	1·75
		Sundry claims	....	....	....	....	8·85	229·66	698·12	521·20	....
Gibraltar	G.M.L. 5723	Lloyd George	....	....	....	....	....	....	763·00	176·78	....
		Voided leases	....	....	....	....	....	33·97	38,762·63	20,114·27	....
		Sundry claims	....	183·00	11·79	....	1·39	50·76	3,488·60	1,412·01	....
Gnarlbine	....	Voided leases	....	....	....	....	....	13·95	2,731·75	1,341·60	....
		Sundry claims	....	....	....	....	....	4·90	1,186·10	504·18	....
Hampton Plains	P.P.L. 462	Bobby Dazzler	....	....	....	....	....	28·55	31·37	301·45	....
	419	Chatanooka	....	....	....	....	....	....	1,267·75	295·73	1·10
	335	D. & C. P. Clews	....	....	....	....	....	....	149·75	119·66	....
	338	Dry Hill	....	....	....	....	....	....	43·00	58·42	....
	465	G. Duggan & Party	....	....	....	....	....	....	53·75	17·54	....
	454	Golden Dollar	....	....	....	....	....	....	105·50	13·66	....
	319	Lady May	....	....	....	....	....	....	248·25	146·21	....

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
		COOLGARDIE GOLDFIELD—continued.										
		COOLGARDIE DISTRICT—*continued.*										
	319	(Lady May)	....	....	....	....	....	....	....	1,742·25	981·39	....
	334	Gold Mines of Kalgoorlie (Aust.) Ltd.	....	....	368·50	140·65	....	....	....	1,937·75	776·70	....
	468	Nichols & Hacket	....	....	....	....	....	....	....	24·25	5·30	....
	469	Cullen & Frank	....	....	....	....	....	....	6·46	3·75	2·34	....
	316, 330	Gold Mines of Kalgoorlie (Aust.) Ltd.	....	....	359·25	208·14	2·09	....	....	261,911·75	134,234·20	29,873·27
	316	(Surprise Gold Mine)	....	....	....	....	....	....	....	7,189·00	3,425·59	....
	330	(Barbara)	....	....	....	....	....	....	....	2,157·75	1,655·63	....
	471	A. J. Wells	....	....	....	....	....	....	....	45·00	1·40	....
	472	F. Clarke	....	....	....	....	....	....	....	30·75	4·02	....
	473	Austin & Hadlow	....	....	....	....	....	2·56	....	30·00	28·38	....
	475	F. J. Wallace	....	....	....	....	....	....	....	16·00	5·22	....
	478	A. E. Smith	....	....	....	....	....	....	....	22·25	57·73	....
	481	C. W. Avard	....	....	8·25	8·89	....	....	....	115·00	82·38	....
	482	T. R. Baker	....	....	361·75	42·43	....	....	....	817·00	132·31	·08
	486	H. Boucher	....	....	94·25	30·43	....	....	....	94·25	30·43	....
	487	F. C. Bray	....	....	35·00	2·78	....	....	....	35·00	2·78	....
		Cancelled leases	....	....	....	....	....	....	451·32	13,950·84	11,118·69	....
		Sundry claims and leases	....	....	....	....	....	1·63	132·06	1,948·00	856·51	....
Higginsville	G.M.L. 5647	Fairplay Gold Mine	....	....	24·25	16·48	....	....	62·70	28,519·75	3,177·22	·02
	6002	Two Boys	....	....	342·00	84·94	....	....	....	543·25	191·58	·08
		Voided leases	....	....	....	....	....	....	482·47	45,601·85	22,058·79	160·72
		Sundry claims	....	....	....	....	....	....	187·25	3,664·76	1,957·50	....
Larkinville	....	Voided leases	....	....	....	....	....	22·77	54·44	2,335·16	3,256·49	....
		Sundry claims	....	....	....	....	....	....	147·20	490·53	1,033·19	....
Logans	....	Voided leases	....	....	....	....	....	....	11·09	106,660·81	26,931·68	....
		Sundry claims	....	....	1,255·25	110·18	....	6·88	128·95	3,327·60	1,042·38	....
Londonderry	....	Voided leases	....	....	....	....	....	....	95·04	34,155·35	22,238·37	·35
		Sundry claims	....	....	17·25	1·74	....	16·68	78·66	4,208·92	2,682·09	22·42
Mungari	....	Voided leases	....	....	....	....	....	....	17·71	1,872·50	458·43	....
		Sundry claims	....	....	53·25	5·42	....	1·77	153·24	2,953·44	761·56	....
Paris	G.M.L. 5953, etc.	Paris Gold Mine Pty. Ltd.	....	....	18,276·00	5,003·04	4,996·64	....	....	28,783·00	8,324·71	6,372·96
	5873	(Paris West)	....	....	....	....	....	....	....	19·00	11·03	....
		Voided leases	....	....	....	....	....	·88	4·30	15,497·00	8,625·37	79·19
		Sundry claims	....	....	....	....	....	....	....	2,104·25	518·98	....
Red Hill	....	Voided leases	....	....	....	....	....	14·87	1,551·81	40,797·40	31,070·65	....
		Sundry claims	....	....	32·00	15·79	....	15·29	95·72	1,496·64	1,126·20	....
Ryans Find	5999	Little Nipper	....	....	17·50	173·36	....	....	796·29	33·00	282·69	....

		Voided leases	....	....	....	....	....	....	....	54·16	151·69	....
		Sundry claims	....	....	16·25	5·62	....	....	479·26	193·44	404·91	....
St. Ives	....	Voided leases	....	....	....	....	....	63·34	146·87	39,318·46	16,208·86	....
		Sundry claims	....	....	....	....	....	211·25	950·23	4,177·56	1,459·39	....
Wannaway	....	Voided leases	....	....	....	....	....	....	28·61	1,831·95	1,465·70	....
		Sundry claims	....	....	....	....	....	....	193·79	1,336·12	1,310·57	....
Widgiemooltha	5834	Harpers	....	....	....	....	....	....	9·54	40·00	93·06	....
	5451	Host Group	....	....	....	....	....	....	12·75	1,604·15	565·02	....
		Voided leases	....	....	....	....	....	17·95	1,252·70	22,743·81	11,970·29	·17
		Sundry claims	....	....	....	....	....	46·49	470·06	16,230·66	6,895·15	·07
	From District generally :											
	Sundry Parcels treated at :											
	State Battery, Coolgardie		....	....	....	*519·25	....	....	....	771·01	*40,699·92	17·13
	Australian Machinery Investment Co. Ltd. Plant		....	....	....	....	....	....	....	....	*3,044·44	86·31
	(T.A. 201) T. A. James Plant		....	....	....	....	....	....	....	361·00	*373·02	....
	Various Works		....	....	....	....	....	7·75	....	4,014·61	*29,780·07	223·06
	Reported by Banks and Gold Dealers		·02	1·56	....	....	....	14,989·79	739·40	48·25	139·56	1·05
		Total	**·02**	**91·13**	**36,401·50**	**11,719·35**	**5,002·15**	**17,030·18**	**18,628·48**	**2,959,717·35**	**1,523,632·15**	**43,114·15**
					KUNANALLING DISTRICT.							
Carbine	1048S	Carbine	....	....	....	....	....	....	....	13,853·50	7,065·75	....
	(33S), etc.	Carbine Leases	....	....	....	....	....	....	687·98	51,991·86	39,862·25	....
		Voided leases	....	....	....	....	....	....	....	20,116·00	5,470·81	....
		Sundry claims	....	....	20·50	9·24	....	136·27	96·96	6,538·13	2,333·15	....
Chadwin	....	Voided leases	....	....	....	....	....	....	....	4,837·80	5,298·69	2·50
		Sundry claims	....	....	....	....	....	14·28	82·36	5,987·55	2,953·07	·25
Dunnsville	....	Voided leases	....	....	....	....	....	....	828·58	17,548·85	8,657·45	....
		Sundry claims	....	....	7·50	10·25	....	21·00	1,034·08	3,025·21	2,113·31	....
Jourdie Hills	....	Voided leases	....	....	....	....	....	....	18·00	28,009·74	19,401·09	28·45
		Sundry claims	....	....	....	....	....	1·86	49·81	2,037·00	917·52	1·05
Kintore	....	Voided leases	....	....	....	....	....	18·70	169·33	56,822·89	40,044·61	677·88
		Sundry claims	....	....	69·25	10·18	....	111·91	102·70	4,869·53	2,577·94	....
Kunanalling	....	Voided leases	....	....	....	....	....	86·13	1,734·92	130,303·61	100,812·73	40·77
		Sundry claims	....	....	213·25	47·58	....	216·53	960·73	16,058·02	10,059·86	8·14
Kundana	....	Voided leases	....	....	....	....	....	....	....	465·00	68·12	....
		Sundry claims	....	....	....	....	....	....	....	475·25	60·38	....
	From District generally :—											
	Sundry Parcels treated at :											
	Goldfields Australian Development Plant		....	....	....	....	....	....	....	....	*548·07	....
	Various Works		....	....	....	....	....	42·23	....	1,782·26	*5,063·55	....
	Reported by Banks and Gold Dealers		....	....	....	....	....	871·79	17·93	....	5·85	·49
		Total	**....**	**....**	**310·50**	**77·25**	**....**	**1,520·70**	**5,783·38**	**364,722·20**	**253,314·20**	**759·53**

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
Yilgarn Goldfield.												
Blackburnes	....	Voided leases	....	....	....	....	....	....	....	1,282·50	341·37	....
		Sundry claims	....	....	....	....	....	....	....	392·50	81·15	....
Bullfinch	G.M.L. 3350, etc.	Great Western Consolidated N.L. (Copperhead)	....	....	207,078·00	30,149·04	5,570·63	....	....	3,238,965·00	447,395·72	125,126·15
		Prior to transfer to present holders	....	....	....	....	....	....	64·80	78,404·34	24,644·88	....
		Voided leases	....	....	....	....	....	....	10·14	490,643·07	185,701·81	27,963·57
		Sundry claims	....	....	....	....	....	8·47	45·49	7,564·39	4,114·27	8·50
Corinthian	....	Voided leases	....	....	....	....	....	....	23·46	284,243·98	58,510·80	4,136·81
		Sundry claims	....	....	....	....	....	....	2·68	1,088·35	640·61	....
Eenuin	(4491)	Sweet William	....	....	167·50	37·01	1·25	....	....	619·25	159·42	15·00
		Voided leases	....	....	....	....	....	....	196·74	10,208·06	10,660·65	·01
		Sundry claims	....	....	55·50	41·30	2·99	2·50	90·95	2,842·45	2,034·59	3·81
Evanston	....	Voided leases	....	....	....	....	....	....	79·27	64,533·06	33,191·88	10·14
		Sundry claims	....	....	....	....	....	4·98	....	638·35	159·55	....
Forrestonia	4506	Margaret Ellen	....	....	54·00	9·65	·70	....	....	54·00	9·65	·70
		Voided leases	....	....	....	....	....	....	....	1,185·00	298·15	....
		Sundry claims	....	....	167·25	113·55	7·96	....	....	553·25	273·63	7·96
Golden Valley	4247	Lily of the Valley	....	....	....	....	....	....	....	709·00	177·73	....
	3266, etc.	Radio Leases	....	....	1,714·00	1,334·99	204·09	....	2·70	43,778·80	64,218·25	1,511·94
		Voided leases	....	....	....	....	....	....	36·34	39,658·92	29,100·38	29·54
		Sundry claims	....	....	....	....	....	4·58	241·60	6,679·07	4,950·53	2·34
Greenmount	....	Voided leases	....	....	....	....	....	45·99	21·62	125,905·64	31,667·08	961·19
		Sundry claims	....	....	....	....	....	·46	4·27	3,152·58	832·58	5·28
Holleton	G.M.L. 4450	Brittania	....	....	....	....	....	....	....	2,200·00	1,726·15	....
		Voided leases	....	....	....	....	....	....	9·33	45,003·25	13,147·88	36·69
		Sundry claims	....	....	....	....	....	....	3·75	3,464·05	923·78	·20
Hopes Hill	(3414)	Great Western Consolidated N.L. (Pilot Group)	....	....	9,928·00	1,230·85	207·31	....	....	162,468·00	23,615·55	4,363·39
		Prior to transfer to present holders	....	....	....	....	....	....	....	19,446·12	2,948·68	....
		Voided leases	....	....	....	....	....	....	74·78	132,660·55	36,462·02	1·00
		Sundry claims	....	....	64·00	25·29	·96	21·12	95·75	4,671·27	1,457·81	·96
Kennyville	3875	Victoria	....	....	....	....	....	....	....	5,430·00	1,195·50	1·18
		Voided leases	....	....	....	....	....	....	18·76	55,876·63	21,625·66	·59
		Sundry claims	....	....	4·00	4·71	·14	....	5·06	8,704·50	2,342·20	·14

Koolyanobbing	....	Voided leases	....	....	....	....	....	....	·99	1,768·05	972·77	....
		Sundry claims	....	....	....	....	....	·26	17·33	724·85	339·23	....
Marvel Loch	4499	Bohemia	....	....	....	....	....	....	....	44·00	18·31	·98
	4434	Cornwall	....	....	12·00	1·81	·20	....	....	17,720·00	2,457·77	527·54
	4039	Cromwell	....	....	....	....	....	....	....	995·50	159·91	....
	3942, etc.	Edwards Reward Leases	....	....	1,539·00	452·63	80·45	....	....	72,739·50	31,747·38	361·73
	3942	(Edwards Reward)	....	....	....	....	....	....	....	2,080·00	2,016·32	....
	3943	(Sunshine)	....	....	....	....	....	....	....	3,866·00	2,384·79	....
	4034	Firelight	....	....	....	....	....	....	2·68	6,653·75	940·03	....
	3724	Francess Furness	....	381·91	1,640·00	768·76	102·23	....	391·78	18,264·25	8,541·65	130·94
	4428	Great Victoria	....	....	....	....	....	....	....	12,662·00	1,349·73	252·14
	4375	Great Western Consolidated	....	....	60,476·00	11,769·75	2,243·48	....	....	317,080·00	63,997·49	13,084·61
	4435	I.X.L.	....	....	62·00	8·13	·46	....	....	245·25	35·59	·62
	4507	Marvel Loch	....	....	135·50	25·01	·50	....	....	135·50	25·01	·50
	4230	May Queen	....	....	....	....	....	....	....	286·00	43·42	....
	3970	Mountain Queen	....	....	27·50	2·46	·12	....	....	1,289·50	470·96	1·75
	4384	Newry	....	....	....	....	....	....	....	6,061·75	714·72	97·34
	4419	Prince George	....	....	....	....	....	....	....	5,463·00	591·19	102·72
	4035	Undaunted	....	....	....	....	....	....	....	865·00	113·59	....
		Voided leases	....	....	....	....	....	....	1,546·04	872,852·33	211,470·10	2,509·29
		Sundry claims	....	....	162·75	45·45	·78	11·35	809·31	38,387·59	13,868·64	83·46
Mt. Jackson	....	Voided leases	....	....	....	....	....	....	180·85	55,166·78	39,927·52	2,313·77
		Sundry claims	....	....	....	....	....	6·44	52·87	10,935·95	4,879·54	70·74
Mt. Palmer	4250	Palmerston	....	....	....	....	....	2·03	....	583·00	97·60	....
	4345	Speedie	....	....	....	....	....	....	....	123·25	40·30	....
	M.L. 4	Yellowdine Gold Development Pty. Ltd. (In Liquidation)	....	....	....	....	....	....	....	93·00	136·46	....
		Voided leases	....	....	....	....	....	....	....	306,408·40	158,486·81	....
		Sundry claims	....	....	....	....	....	1,643·48	18·19	450·25	387·14	....
Mt. Rankin	G.M.L. 4462	Golden View	....	....	....	....	....	....	316·90	142·00	284·87	2·38
	4469	Lynette	....	....	61·00	68·23	5·53	....	....	896·50	367·17	24·18
	4461	Marjorie Glen Reward	....	....	104·50	65·88	2·85	....	191·46	3,181·05	4,020·82	4·09
		Voided leases	....	....	....	....	....	3·84	5·20	6,058·37	975·23	....
		Sundry claims	....	....	....	....	....	....	1·85	771·00	956·57	....
Parkers Range	4508	Buffalo	....	....	150·00	29·70	·42	....	....	150·00	29·70	·42
	4504	Constance Una	....	....	59·00	69·60	4·85	....	....	59·00	69·60	4·85
	(4423)	Spring Hill	....	....	92·50	5·12	·11	....	....	316·00	49·04	·11
		Voided leases	....	....	....	....	....	·42	270·76	63,766·85	32,763·19	27·32
		Sundry claims	....	....	112·00	26·21	·27	6·59	303·93	13,281·80	5,609·41	1·25
Southern Cross	4424	Excelsior	....	....	....	....	....	....	....	115·50	10·85	·81
	4002, etc.	Great Western Consolidated N.L. (Frasers)	....	....	112,980·00	18,202·45	3,309·27	....	....	368,822·00	88,484·65	18,948·60
		Prior to transfer to present holders	....	....	....	....	....	....	....	13,720·50	1,876·00	1·26
	3444	(Three Boys)	....	....	....	....	....	....	....	4,180·00	727·75	....
	3934	(Three Boys North)	....	....	....	....	....	....	....	106·00	14·66	....
	3981	(Three Kings)	....	....	....	....	....	....	....	104·00	10·01	....
	3444	(Yellowdine Options N.L.)	....	....	....	....	....	....	....	8,074·25	2,000·29	....
		Voided leases	....	....	....	....	....	4·89	261·35	454,906·68	215,351·50	364·41
		Sundry claims	....	....	62·50	25·19	2·03	95·90	648·99	8,439·16	2,669·04	2·64

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
		YILGARN GOLDFIELD—continued.										
Westonia	....	Voided leases	....	....	....	....	....	....	4·06	597,118·14	381,435·37	5,104·07
		Sundry claims	....	....	....	....	....	9·51	64·96	4,310·76	2,823·33	·72
		From Goldfield generally :—										
		Sundry Parcels treated at :										
		W. B. Ridge Evanstan Plant	....	....	....	....	....	....	....	....	*4,210·25	964·42
		Great Western Consolidated N.L. Plant (Nevoria)	....	....	....	....	....	....	....	....	*276·58	....
		Great Western Consolidated N.L. Plant (Frasers)	....	....	....	....	....	....	....	....	*1,357·18	85·92
		Great Western Consolidated N.L. Plant (Copperhead)	....	....	....	....	....	....	....	....	*5,770·90	458·63
		Kurrajong Battery	....	....	....	....	....	....	....	....	*409·57	....
		Pilot Cyanide Plant	....	....	....	....	....	....	....	30·00	*3,753·59	....
		R. R. Robinson's Plant (L.T.T. 1315H)	....	....	....	....	....	....	....	....	*1,408·40	....
		Three Boys Cyanide Plant	....	....	....	....	....	....	....	7·00	*4,001·02	19·78
		Harpers Battery	....	....	....	....	....	....	....	....	*479·51	96·24
		J. Cruickshank (L.T.T. 2/62)	....	....	35·00	12·21	·29	....	....	35·00	12·21	·29
		Great Western Consolidated N.L. (L.T.T. 2/61)	....	....	....	....	....	....	....	30·00	·30	·03
		Great Western Consolidated N.L. (L.T.T. 1/61)	....	....	....	....	....	....	....	....	*204·38	39·42
		State Battery, Marvel Loch	....	....	....	231·32	3·06	....	....	29·00	*1,882·23	3·06
		Various Works	....	....	....	....	....	....	....	364·98	*99,250·35	120·01
		Reported by Banks and Gold Dealers	....	....	....	....	....	325·11	81·41	·60	170·54	....
		Total	....	**381·91**	**396,943·50**	**64,756·30**	**11,752·93**	**2,197·92**	**6,198·40**	**8,145,806·52**	**2,414,539·94**	**210,000·13**

Dundas Goldfield.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Alluvial (1962)	Dollied and Specimens (1962)	Ore treated (1962)	Gold therefrom (1962)	Silver (1962)	Alluvial (Total)	Dollied and Specimens (Total)	Ore treated (Total)	Gold therefrom (Total)	Silver (Total)
Beete	G.M.L. 1908	Beete	....	....	400·50	298·37	20·11	....	....	644·50	497·15	21·00
	1907	Eldridge's Find	....	....	430·00	383·43	21·49	....	....	917·75	778·69	35·07
		Sundry claims	....	....	....	....	....	....	....	386·50	376·41	....
Buldania	....	Voided leases	....	....	....	....	....	....	3·02	846·05	708·99	....
		Sundry claims	....	....	....	....	....	....	39·25	1,324·27	861·36	·72
Dundas	....	Voided leases	....	....	....	....	....	1·88	28·02	6,241·98	2,560·53	155·02
		Sundry claims	....	....	36·25	2·85	·05	·76	413·85	2,275·25	1,165·27	20·08
Norseman	1911	Abbotshall	....	....	158·75	10·77	·03	....	....	419·25	38·55	·51
	1935	Bull Ant	....	....	158·25	3·44	·07	....	....	158·25	3·44	·07
	1288, etc.	Central Norseman Gold Corporation N.L.	....	....	181,834·00	109,506·21	51,892·69	....	....	3,407,087·20	1,554,906·03	1,026,966·94
		Prior to transfer to present holders	....	....	....	....	....	....	1,663·32	69,819·83	47,892·08	16,508·85
	1315, etc.	Norseman Gold Mines N.L.	....	....	....	....	....	....	....	964,099·00	241,009·50	353,206·54
		Prior to transfer to present holders	....	....	....	....	....	....	....	20,657·00	3,909·60	4,981·00
	1927	Iron Duke	....	....	85·00	9·28	....	....	....	85·00	9·28	....

	(1910)	Old Miller	....	....	15·00	1·00	....	....	....	508·00	30·44	....
		Voided leases	....	....	....	....	....	14·27	10,601·15	915,789·67	601,766·42	39,001·23
		Sundry claims	....	....	439·50	28·47	2·40	1.052·09	3,491·46	49,430·95	22,571·09	220·22
Peninsula	....	Voided leases	....	....	....	....	....	....	24·29	9,603·39	6,102·61	12·20
		Sundry claims	....	....	....	....	....	....	....	217·25	119·32	·97
	From Goldfield generally :											
	Sundry Parcels treated at :											
		M. E. Harrigan (L.T.T. 1447H)	....	....	....	....	....	....	....	87·00	5·36	....
		J. H. Smith (L.T.T. 1479H)	....	....	162·00	8·24	·56	....	....	162·00	8·24	·56
		State Battery, Norseman	....	....	....	....	....	....	....	427·89	*25,358·99	1,051·53
		Various Works	....	....	....	....	....	....	54·52	780·89	*15,110·71	2,588·35
	Reported by Banks and Gold Dealers		....	....	....	....	....	1,181·77	49·59	47·50	21·37	·70
		Total	....	....	**183,719·25**	**110,252·06**	**51,937·40**	**2,250·77**	**16,368·47**	**5,452,016·37**	**2,525,811·43**	**1,444,771·56**

Phillips River Goldfield.

Hatters Hill	....	Voided leases	....	....	....	....	....	....	4·38	1,599·55	1,222·72	....
		Sundry claims	....	....	....	....	....	74·91	24·26	5,386·60	2,755·81	26·09
Kundip	G.M.L. 263	Hillsborough	....	....	....	....	....	....	....	258·00	65·75	19·33
		Voided leases	....	....	....	....	....	113·28	556·17	84,866·58	60,584·54	4,008·81
		Sundry claims	....	....	....	....	....	90·27	73·02	6,434·68	1,951·87	54·65
Mt. Desmond	....	Voided leases	....	....	....	....	....	....	1·40	9·00	3,905·46	6,891·59
		Sundry claims	....	....	....	....	....	....	....	80·00	41·96	51·01
Ravensthorpe	M.L. 411	Wehr Bros.	....	....	....	....	....	....	....	....	‡1·99	....
	M.C. 35, etc.	Ravensthorpe Copper Mines N.L.	....	....	....	‡2,986·96	5,749·09	....	....	....	‡9,530·16	29,539·86
	M.L. 421	Big Surprise	....	....	....	....	....	....	....	6·46	‡3·03	116·48
		Voided leases	....	....	....	....	....	....	141·80	24,723·55	26,070·94	4,384·07
		Sundry claims	....	....	....	....	....	163·96	7·68	7,267·82	3,197·97	41·12
West River	....	Voided leases	....	....	....	....	....	....	....	....	10·34	31·06
		Sundry claims	....	....	....	....	....	....	....	....	6·60	3·44
	From Goldfield generally :—											
	Sundry Parcels treated at :											
		F. E. Dain's Plant (T.A. 11)	....	....	....	....	....	....	....	....	*128·45	....
		Various Works	....	....	....	....	....	....	....	27·00	*4,118·73	515·43
	Reported by Banks and Gold Dealers		....	....	....	....	....	164·69	14·61	....	8·47	....
		Total	....	....	....	**2,986·96**	**5,749·09**	**607·11**	**823·32**	**130,659·24**	**113,604·79**	**45,682·94**

Northampton Mineral Field.

Northampton	....	Sundry leases and claims	....	....	....	....	287·17	....	....	....	....	5,185·58
		Total	....	....	....	....	**†287·17**	....	....	....	....	**†5,185·58**

Table I.—*Production of Gold and Silver from all sources, etc.*—continued.

Mining Centre	Number of Lease	Registered Name of Company or Lease	Total for 1962					Total Production				
			Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver	Alluvial	Dollied and Specimens	Ore treated	Gold therefrom	Silver
			Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.
South-West Mineral Field.												
Burracoppin	....	Voided leases	....	....	....	....	....	....	....	710·85	706·38	....
		Sundry claims	....	....	....	....	....	....	·98	372·75	213·97	....
Donnybrook	....	Voided leases	....	....	....	....	....	23·24	....	1,613·30	816·23	....
		Sundry claims	....	....	....	....	....	44·01	43·03	119·50	15·71	15·18
Lake Grace	G.M.L. 106H	Griffin's Find	....	....	75·50	40·73	....	....	....	294·00	154·39	....
		Sundry claims	....	....	....	....	....	....	....	27·75	17·91	....
Ongerup	103H	Horneblende	....	....	....	....	....	....	....	24·50	2·85	....
		Sundry claims	....	....	....	....	....	....	1·58	·33	1·74	....
	From Mineral Field generally :—											
	Miscellaneous: voided leases and sundry claims		....	....	....	....	....	245·83	3·07	1,472·10	353·19	....
		Total	....	....	**75·50**	**40·73**	....	**313·08**	**48·66**	**4,635·08**	**2,282·37**	**15·18**
State Generally.												
	Sundry Parcels treated at :											
	Various Works		....	....	....	....	....	....	....	27·00	9,009·75	31,521·73
	Reported by Banks and Gold Dealers		3·17	5·12	....	49·29	....	1,189·24	1,110·21	....	966·97	1,140·93
		Total	**3·17**	**5·12**	....	**49·29**	....	**1,189·24**	**1,110·21**	**27·00**	**9,976·72**	**32,662·66**

TABLE II

Production of Gold and Silver from all Sources, showing in fine ounces the output, as reported to the Mines Department during the year 1962.

Goldfield	District	District: Alluvial	District: Dollied and Specimens	District: Ore Treated	District: Gold Therefrom	District: Total Gold	District: Silver	Goldfield: Alluvial	Goldfield: Dollied and Specimens	Goldfield: Ore Treated	Goldfield: Gold Therefrom	Goldfield: Total Gold	Goldfield: Silver
		Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.
Kimberley	....	....	....	....	....	....	....	31·01	....	....	....	31·01	....
West Kimberley	....	....	....	....	....	....	....	....	....	....	....	....	....
West Pilbara	....	....	....	....	....	....	....	....	....	107·00	8·73	8·73	·17
Pilbara	Marble Bar	1·48	....	1,713·75	374·44	375·92	39·39	15·25	5·04	4,368·25	1,582·37	1,602·66	44·90
	Nullagine	13·77	5·04	2,654·50	1,207·93	1,226·74	5·51						
Ashburton	....	....	....	....	....	....	....	....	....	....	....	....	....
Gascoyne	....	....	....	....	....	....	....	1·26	·77	104·50	271·92	273·95	9·62
Peak Hill	....	....	....	....	....	....	....	3·44	....	2,432·00	265·83	269·27	11·32
East Murchison	Lawlers	6·92	....	529·75	210·60	217·52	7·51	8·67	2·13	705·25	342·23	353·03	15·69
	Wiluna	1·75	....	26·00	10·90	12·65	1·43						
	Black Range	....	2·13	149·50	120·73	122·86	6·75						
Murchison	Cue	6·69	....	402·75	126·41	133·10	53·79	14·89	10·45	174,503·75	94,654·09	94,679·43	7,295·88
	Meekatharra	6·66	....	1,696·25	277·75	284·41	17·47						
	Day Dawn	....	·17	58·00	12·98	13·15	·16						
	Mt. Magnet	1·54	10·28	172,346·75	94,236·95	94,248·77	7,224·46						
Yalgoo	....	....	....	....	....	....	....	6·12	....	585·50	146·89	153·01	9·54
Mt. Margaret	Mt. Morgans	17·07	....	49·00	47·00	64·07	1·25	19·65	2·34	125,371·00	27,163·75	27,185·74	2,485·87
	Mt. Malcolm	2·58	2·34	125,322·00	27,116·75	27,121·67	2,484·62						
	Mt. Margaret	....	....	....	....	....	....						
North Coolgardie	Menzies	....	....	28,296·75	14,993·33	14,993·33	80·28	....	12·99	32,319·50	17,554·49	17,567·48	295·94
	Ularring	....	12·99	665·75	990·06	1,003·05	46·21						
	Niagara	....	....	969·75	249·70	249·70	9·53						
	Yerilla	....	....	2,387·25	1,321·40	1,321·40	159·92						
Broad Arrow	....	....	....	....	....	....	....	·04	12·51	3,210·18	922·36	934·91	3·00
North-East Coolgardie	Kanowna	·55	....	551·80	126·90	127·45	1·83	1·70	....	640·80	136·65	138·35	1·83
	Kurnalpi	1·15	....	89·00	9·75	10·90	....						
East Coolgardie	East Coolgardie	4·80	8·71	2,027,847·25	526,451·74	526,465·25	133,463·72	4·80	8·71	2,027,855·28	526,464·85	526,478·36	133,463·72
	Bulong	....	....	8·03	13·11	13·11	....						
Coolgardie	Coolgardie	·02	91·13	36,401·50	11,719·35	11,810·50	5,002·15	·02	91·13	36,712·00	11,796·60	11,887·75	5,002·15
	Kunanalling	....	....	310·50	77·25	77·25	....						
Yilgarn	....	....	....	....	....	....	....	....	381·91	396,943·50	64,756·30	65,138·21	11,752·93
Dundas	....	....	....	....	....	....	....	....	....	183,719·25	110,252·06	110,252·06	51,937·40
Phillips River	....	....	....	....	....	....	....	....	....	....	2,986·96	2,986·96	5,749·09
Northampton Mineral Field	....	....	....	....	....	....	....	....	....	....	....	....	287·17
South-West Mineral Field	....	....	....	....	....	....	....	....	....	75·50	40·73	40·73	....
State Generally	....	....	....	....	....	....	....	3·17	5·12	....	49·29	57·58	....
Total	....	....	....	....	....	....	....	**110·02**	**533·10**	**2,989,653·26**	**859,396·10**	**860,039·22**	**218,366·22**

TABLE III

Return showing total production reported to the Mines Department, and respective Districts and Goldfields from whence derived, to 31st December, 1962.

Goldfield	District	District: Alluvial	District: Dollied and Specimens	District: Ore Treated	District: Gold Therefrom	District: Total Gold	District: Silver	Goldfield: Alluvial	Goldfield: Dollied and Specimens	Goldfield: Ore Treated	Goldfield: Gold Therefrom	Goldfield: Total Gold	Goldfield: Silver
		Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Fine ozs.	Tons (2,240 lb.)	Fine ozs.	Fine ozs.	Fine ozs.
Kimberley	....	....	....	....	....	....	....	9,027·48	2,934·84	22,751·90	17,240·32	29,202·64	128·76
West Kimberley	....	....	....	....	....	....	....	1·30	24·68	1·00	2·49	28·47	13,575·29
West Pilbara	....	....	....	....	....	....	....	6,339·37	374·74	24,900·96	24,317·02	31,031·13	1,910·66
Pilbara	Marble Bar	15,266·02	4,568·94	340,366·47	329,057·98	348,892·94	32,823·69	25,707·63	7,475·99	489,472·64	464,297·91	497,481·53	33,902·74
	Nullagine	10,441·61	2,907·05	149,106·17	135,239·93	148,588·59	1,079·05						
Ashburton	....	....	....	....	....	....	....	9,267·37	482·46	6,807·10	2,913·43	12,663·26	41,971·38
Gascoyne	....	....	....	....	....	....	....	698·13	118·60	665·50	1,373·78	2,190·51	36·54
Peak Hill	....	....	....	....	....	....	....	3,387·79	5,300·88	780,949·73	322,602·53	331,291·20	3,786·27
East Murchison	Lawlers	7,103·38	2,343·19	2,013,656·17	823,390·37	832,836·94	27,195·68	9,010·40	22,207·27	12,618,310·83	3,650,668·08	3,681,885·75	60,217·33
	Wiluna	236·48	1,254·11	8,873,604·19	1,871,198·74	1,873,689·33	10,300·39						
	Black Range	1,670·54	18,609·97	1,731,050·47	955,078·97	975,359·48	22,721·26						
Murchison	Cue	5,108·19	9,104·99	6,812,884·31	1,401,866·76	1,416,079·94	274,151·36	25,626·54	59,151·26	14,172,044·12	5,645,856·13	5,730,633·93	492,576·28
	Meekatharra	14,638·23	18,260·03	2,308,502·31	1,308,238·96	1,341,137·22	5,172·91						
	Day Dawn	3,245·17	11,341·80	2,037,297·13	1,375,554·00	1,390,140·97	169,436·29						
	Mt. Magnet	2,634·95	20,444·44	3,013,360·37	1,560,196·41	1,583,275·80	43,815·72						
Yalgoo	....	....	....	....	....	....	....	1,808·02	3,223·19	443,188·08	263,935·27	268,966·48	1,516·17
Mt. Margaret	Mt. Morgans	3,561·34	9,398·51	1,217,557·31	717,818·26	730,778·11	5,821·61	11,764·75	35,421·85	11,332,821·77	4,928,555·34	4,975,741·94	259,802·13
	Mt. Malcolm	4,059·87	16,668·99	7,587,091·22	3,036,693·52	3,057,422·38	187,789·82						
	Mt. Margaret	4,143·54	9,354·35	2,528,173·24	1,174,043·56	1,187,541·45	66,190·70						
North Coolgardie	Menzies	1,687·70	7,014·92	1,827,358·68	1,377,781·71	1,386,484·33	32,165·60	4,847·49	19,869·92	3,596,569·43	2,524,532·20	2,549,249·61	64,779·58
	Ularring	129·52	7,216·11	533,879·95	443,802·49	451,148·09	21,986·80						
	Niagara	1,718·36	1,821·77	942,881·02	528,007·28	531,547·41	5,704·85						
	Yerilla	1,311·91	3,817·12	292,449·78	174,940·72	180,069·75	4,922·33						
Broad Arrow	....	....	....	....	....	....	....	21,981·86	27,995·95	1,363,543·01	742,578·05	792,555·86	5,429·35
North-East Coolgardie	Kanowna	106,536·32	13,526·67	1,009,343·31	627,221·98	747,284·97	3,044·55	119,372·96	21,825·58	1,023,126·63	646,072·46	787,271·00	3,057·26
	Kurnalpi	12,836·64	8,298·91	13,783·32	18,850·48	39,986·03	12·71						
East Coolgardie	East Coolgardie	33,712·76	41,146·84	81,515,341·10	34,973,593·85	35,048,453·45	5,442,574·89	61,117·98	57,181·41	81,703,128·93	35,105,897·10	35,224,196·49	5,442,587·81
	Bulong	27,405·22	16,034·57	187,787·83	132,303·25	175,743·04	12·92						
Coolgardie	Coolgardie	17,030·18	18,628·48	2,959,717·35	1,523,632·15	1,559,290·81	43,114·15	18,550·88	24,411·86	3,324,439·55	1,776,946·35	1,819,909·09	43,873·68
	Kunanalling	1,520·70	5,783·38	364,722·20	253,314·20	260,618·28	759·53						
Yilgarn	....	....	....	....	....	....	....	2,197·92	6,198·40	8,145,986·52	2,414,539·94	2,422,936·26	210,000·13
Dundas	....	....	....	....	....	....	....	2,250·77	16,368·47	5,452,016·37	2,525,811·43	2,544,430·67	1,444,771·56
Phillip's River	....	....	....	....	....	....	....	607·11	823·32	130,659·24	113,604·79	115,035·22	45,682·94
Northampton Mineral Field	....	....	....	....	....	....	....	....	....	....	....	....	5,185·58
South-West Mineral Field	....	....	....	....	....	....	....	313·08	48·66	4,635·08	2,282·37	2,644·11	15·18
State Generally	....	....	....	....	....	....	....	1,189·24	1,110·21	27·00	9,976·72	12,276·17	32,662·66
Total		....	....	....	....	....	....	**335,068·07**	**312,549·54**	**144636045·39**	**61,184,003·71**	**61,831,621·32**	**8,207,469·28**

TABLE IV.

Total output of Gold Bullion, Concentrates, etc., entered for export and received at the Perth Branch of the Royal Mint from 1st January, 1886.

Year	Export	Mint	Total	Estimated Value
	Fine ozs.	Fine ozs.	Fine ozs.	£A
1886	270·17	....	270·17	1,147
1887	4,359·37	....	4,359·37	18,518
1888	3,124·82	....	3,124·82	13,273
1889	13,859·52	....	13,859·52	58,871
1890	20,402·42	....	20,402·42	86,664
1891	27,116·14	....	27,116·14	115,182
1892	53,271·65	....	53,271·65	226,284
1893	99,202·50	....	99,202·50	421,385
1894	185,298·73	....	185,298·73	787,099
1895	207,110·20	....	207,110·20	879,749
1896	251,618·69	....	251,618·69	1,068,808
1897	603,846·44	....	603,846·44	2,564,977
1898	939,489·49	....	939,489·49	3,990,697
1899	1,283,360·25	187,244·41	1,470,604·66	6,246,732
1900	894,387·27	519,923·59	1,414,310·86	6,007,610
1901	923,698·96	779,729·56	1,703,416·52	7,235,654
1902	707,039·75	1,163,997·60	1,871,037·35	7,947,661
1903	833,685·78	1,231,115·62	2,064,801·40	8,770,719
1904	810,616·04	1,172,614·03	1,983,230·07	8,424,226
1905	655,089·88	1,300,226·00	1,955,315·88	8,305,654
1906	562,250·59	1,232,296·01	1,794,546·60	7,622,749
1907	431,803·14	1,265,750·45	1,697,553·50	7,210,750
1908	356,353·96	1,291,557·17	1,647,911·13	6,999,881
1909	386,370·58	1,208,898·83	1,595,269·41	6,776,274
1910	233,970·34	1,236,661·68	1,470,632·02	6,246,848
1911	160,422·28	1,210,445·24	1,370,867·52	5,823,075
1912	83,577·12	1,199,080·87	1,282,657·99	5,448,385
1913	86,255·13	1,227,788·15	1,314,043·28	5,581,701
1914	51,454·65	1,181,522·17	1,232,976·82	5,237,352
1915	17,340·47	1,192,771·23	1,210,111·70	5,140,228
1916	26,742·17	1,034,655·87	1,061,398·04	4,508,532
1917	9,022·49	961,294·67	970,317·16	4,121,646
1918	15,644·12	860,867·03	876,511·15	3,723,183
1919	6,445·89	727,619·90	734,065·79	3,618,509
1920	5,261·13	612,581·00	617,842·13	3,598,931
1921	7,170·74	546,559·92	553,730·66	2,942,526
1922	5,320·16	532,926·12	538,246·28	2,525,812
1923	5,933·82	498,577·59	504,511·41	2,232,186
1924	2,585·20	482,449·78	485,034·98	2,255,927
1925	3,910·59	437,341·56	441,252·15	1,874,920
1926	3,188·22	434,154·98	437,343·20	1,857,715
1927	3,359·10	404,993·41	408,352·51	1,734,572
1928	3,339·30	390,069·19	393,408·49	1,671,093
1929	3,037·12	374,138·96	377,176·08	1,602,142
1930	1,753·09	415,765·00	417,518·09	1,864,442
1931	1,726·66	508,845·36	510,572·02	2,998,137
1932	3,887·07	601,674·33	605,561·40	4,403,642
1933	2,446·97	634,760·40	637,207·37	4,886,254
1934	3,520·40	647,817·95	661,338·35	5,558,873
1935	9,868·71	639,180·38	649,049·09	5,702,149
1936	55,024·58	791,183·21	846,207·79	7,373,539
1937	71,646·91	928,999·84	1,000,646·75	8,743,755
1938	113,620·06	1,054,171·13	1,167,791·19	10,363,023
1939	98,739·88	1,115,497·76	1,214,237·64	11,842,964
1940	71,680·47	1,119,801·08	1,191,481·55	12,696,503
1941	65,925·94	1,043,391·96	1,109,317·90	11,851,445
1942	15,676·48	832,503·97	848,180·45	8,865,495
1943	6,408·34	540,057·08	546,475·42	5,710,669
1944	1,824·99	464,439·76	466,264·75	4,899,997
1945	5,029·38	463,521·34	468,550·72	5,010,541
1946	6,090·14	610,873·52	616,963·66	6,640,069
1947	5,220·09	698,666·29	703,886·38	7,575,574
1948	4,653·72	660,332·07	664,985·79	7,156,909
1949	4,173·14	644,252·48	648,425·62	7,962,808
1950	4,161·53	606,171·88	610,333·41	9,466,270
1951	5,589·45	622,189·64	627,779·09	9,725,343
1952	9,608·62	720,366·44	729,975·06	11,847,917
1953	5,396·30	818,515·65	823,911·95	13,299,092
1954	3,089·08	847,451·09	850,540·17	13,313,618
1955	4,091·55	837,913·72	842,005·23	13,175,559
1956	2,331·10	810,048·68	812,379·78	12,705,581
1957	2,042·27	894,638·71	896,680·98	14,038,185
1958	1,810·69	865,376·80	867,187·49	13,554,934
1959	2,321·99	864,286·87	866,608·86	13,541,929
1960	2,068·66	853,690·02	855,758·68	13,371,661
1961	2,942·58	868,902·39	871,844·97	13,706,870
1962	4,539·02	854,829·18	859,368·20	13,435,730
Total	11,586,504·20	51,779,978·57	63,366,482·77	470,814,744

	1961 £A	1962 £A
Estimated Mint value of above production	453,500,893	466,928,519
Overseas Gold Sales Premium distributed by Gold Producers Association, 1920–1924	2,589,602	2,589,602
Overseas Gold Sales Premium distributed by Gold Producers Association from 1952	1,288,519	1,296,623
Estimated Total	£A457,379,014	£A470,814,744
Bonus paid by Commonwealth Government under Commonwealth Bounty Act, 1930	161,448	161,448
Subsidy paid by Commonwealth Government under Gold Mining Industry Assistance Act, 1954, from 1955	3,629,474	4,251,043
Gross estimated value of gold won	£A461,169,936	£A475,227,235

TABLE V.

Quantity and Value of Minerals, other than Gold, Reported during the year 1962

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		ASBESTOS (Chrysotile)			
			Long Tons		£A
L.T.T. 145H	Pilbara	Hancock, L. G.	52·50	....	(*b*)1,102·50
		ASBESTOS (Crocidolite)			
M.C. 53, etc.	West Pilbara	Australian Blue Asbestos Ltd.	15,616·95	....	1,691,933·16 (*b*)
		BARYTES			
M.C. 20N	Murchison	Rumble, P. R.	494·35	....	(*a*)3,115·75
		BENTONITE			
M.C. 537H, etc.	South-West	Collins, A. C.	485·00	....	(*a*)1,212·50
		BERYL (*f*) (*g*)			
				BeO Units	
P.A. 2639	Pilbara	Coffin, G.	3·78	40·38	570·60
M.L. 370	Pilbara	Henderson, J. M.	2·68	30·57	473·85
M.C. 304	Pilbara	White, A. L.	3·74	48·02	744·30
M.C. 340, etc.	Pilbara	Sherlock, R. D. and Parker, J.	1·30	15·48	240·10
M.C. 106	Pilbara	Hasleby, H. M. & H. B.	5·59	61·82	902·20
M.C. 116	Pilbara	Tabba Tabba Mining Syndicate	3·26	33·60	504·45
Crown Lands	Pilbara	Sundry Persons	36·46	418·15	5,876·05
M.C. 241	West Pilbara	Nomads Pty. Ltd.	12·42	136·11	2,107·34
Crown Lands	West Kimberley	Sundry Persons	1·61	17·82	276·20
Crown Lands	Ashburton	Sundry Persons	0·81	8·55	118·90
Crown Lands	Gascoyne	Sundry Persons	21·94	246·51	3,680·95
M.C. 62	Murchison	Goodwin, John	3·16	34·72	480·20
Crown Lands	Murchison	Sundry Persons	5·89	69·64	970·43
P.A. 3716	Murchison	Spencer, J. P. and Hannan, A. E. C.	1·92	23·00	299·05
M.C. 26	Yalgoo	Todd, Donald	9·49	109·94	1,613·20
M.C. 34	Yalgoo	Palmer, L.	21·12	241·44	3,631·35
M.C. 35	Yalgoo	Meka Mining Syndicate	29·46	338·03	4,831·75
P.A. 2571	Yalgoo	Nevill, J. L.	0·71	8·05	117·10
P.A. 2573	Yalgoo	Hodder, L.	3·79	44·25	641·95
P.A. 2580	Yalgoo	Phillips, E. R.	17·80	204·38	3,095·90
P.A. 2590	Yalgoo	Johansen, K. J.	1·03	10·04	144·85
P.A. 2597	Yalgoo	Dunn, L. J.	0·46	6 ·04	93·65
P.A. 2567	Yalgoo	Little, C. and Todd, D.	0·18	2·07	30·00
Crown Lands	Yalgoo	Sundry Persons	0·48	6·14	91·25
M.L. 80, etc.	Coolgardie	Australian Glass Manufacturers Co. Pty. Ltd.	1·02	11·07	171·55
P.A. 7553	Coolgardie	Bucktin, R.	1·10	12·10	177·55
M.C. 98	Phillips River	Frayne, W. L.	4·26	44·85	567·45
			195·46	2,222·77	(*b*)32,452·17
		BISMUTH (*f*) (*g*)			
			lb.	Bi. lb.	
Crown Lands	Gascoyne	Sundry Persons	181·00	96·93	(*b*) 40·20
		BUILDING STONE (Spongolite)			
			Tons		
Q.A. 1	Phillips River	Ferrier, J. H.	669·00	....	(*c*)2,994·00
		CLAYS (Cement Clay)			
M.C. 492H, etc.	South-West	Cockburn Cement Pty. Ltd.	14,108·73	....	17,636·00
M.C. 725H	South-West	D. F. D. Rhodes Pty. Ltd.	903·00	....	553·00
Private Property	South-West	Bell Bros. Pty. Ltd.	6,623·00	....	2,959·80
			21,634·73	....	(*c*)21,148·80
		CLAYS (Fireclay)			
			Long Tons		
M.C. 522H, etc.	South-West	Bridge, J. S. & T. D.	12,424·50	....	17,497·80
M.C. 304H, etc.	South-West	Clackline Refractories Ltd.	1,935·00	....	1,935·00
Private Property	South-West	Darling Range Firebrick Co. Pty. Ltd.	939·00	....	892·05
M.C. 732H	South-West	Midland Brick Co. Pty. Ltd.	2,696·00	....	1,348·00
M.C. 504H, etc.	South-West	H. L. Brisbane & Wunderlich Ltd.	2,790·00	....	4,135·00
M.C. 685H	South-West	Kargotich Bros.	4,000·00	....	3,000·00
			24,784·50	....	(*c*)28,807·85
		CLAYS (White Clay-Ball Clay)			
P.A. 5306E	East Coolgardie	Gardner, J. A.	26·00	....	78·00
M.C. 109H	South-West	H. L. Brisbane & Wunderlich Ltd.	656·00	....	3,592·00
			682·00	....	(*c*) 4,030·00

Table V.—*Minerals other than Gold*—continued

Quantity and Value of Minerals, other than Gold, Reported during the year 1962

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		CLAYS (Brick, Pipe and Tile Clays)*			
M.C. 736H	South-West	Morgan, J.	580·00	....	580·00
Private Property	South-West	Stoneware Pipes & Tiles Pty. Ltd.	622·00	....	839·70
Private Property	South-West	Stoneware Pipes & Tiles Pty. Ltd.	1,044·00	....	1,044·00
M.C. 670H	South-West	Stoneware Pipes & Tiles Pty. Ltd.	1,866·00	....	1,866·00
M.C. 789H	South-West	Peters, O. V. & M. E.	3,000·00	....	3,750·00
			7,112·00	....	(*c*) 8,079·70

* Incomplete : Figures relate only to production reported from holdings under the Mining Act.

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		COAL			
			Long Tons		£A
M.L. 448, etc.	Collie	Griffin Coal Mining Co. Ltd.	554,634·40	....	1,025,895·80
M.L. 437, etc.	Collie	Western Collieries Ltd.	364,477·60	....	954,882·20
			919,112·00	....	1,980,778·00 (*e*)
		COPPER ORE AND CONCENTRATES (*f*) (*g*)			
				Copper Units	
M.C. 35, etc.	Phillips River	Ravensthorpe Copper Mines N.L.	5,063·22	97,867·00	(*b*)196,718·35

Gold and Silver content transferred to respective Items.

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		COPPER (Metallic By-product) (*f*) (*g*) (*i*)			
				Copper Tons	
G.M.L. 5873, etc.	Coolgardie	Paris Gold Mines Pty. Ltd.	....	* (*g*) 47·20	(*b*) 8,680·50

* From 214·04 tons Gold/Copper Concentrates reported. Gold and Silver content transferred to respective Items.

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		CUPREOUS ORE AND CONCENTRATES (Fertiliser)			
			Long Tons	Average Assay Cu%	£A
G.M.L. 314L	Pilbara	Copper Hills Copper Mine	272·00	15·28	11,900·00
M.C. 374L	Pilbara	Clarke, J.	8·40	18·50	487·60
P.A. 827L	Pilbara	Criddle, J. E.	5·96	24·20	459·80
P.A. 834L	Pilbara	Henderson, J. R. and C. B.	63·78	12·80	1,940·05
M.L. 158	Ashburton	Heinsen, J. J.	45·15	4·43	249·15
P.A. 341	Ashburton	Rose, W.	42·80	7·18	450·70
M.C. 25	Ashburton	Copper Consolidated Syndicate	1·90	12·45	59·55
M.L. 165, etc.	Ashburton	Parkinson, L. J. ; Camp, F. J. and Armstrong, N. G.	27·62	16·30	1,203·35
P.A. 335	Ashburton	Brindal, A. E. and Gribble, W. T.	23·30	10·46	555·55
P.A. 336	Ashburton	Allen, J.	0·56	20·00	26·95
L.T.T. 1456H	Murchison	Motter, Z. E.	3,621·15	2·00	7,242·30
L.T.T. 1465H	Murchison	Gabon Syndicate	902·52	2·37	4,053·25
M.C. 23N	Murchison	Scott, F. M.	40·79	3·43	305·10
P.A. 1553	East Murchison	Howarth, C. A.	11·90	9·20	321·05
P.A. 900P	Peak Hill	Motter, Z. E.	40·45	9·17	725·55
M.C. 59P, etc.	Peak Hill	Parkinson, L. T.	260·37	9·68	7,495·22
M.L. 68P	Peak Hill	Thaduna Copper Mining Co.	3,360·52	6·51	44,151·20
P.A. 887P	Peak Hill	Jimblebar Copper Syndicate	50·69	9·05	810·45
M.C. 65P	Peak Hill	Lee, R.	21·90	8·15	510·45
M.C. 96P	Peak Hill	Alac, M.	13·50	12·73	446·55
M.C. 14	Yalgoo	O'Callaghan & Howlett	160·75	8·18	2,816·60
M.C. 6F	Mt. Margaret	Alac, M.	75·81	8·44	1,218·90
P.A. 1669F	Mt. Margaret	Cable, J. L.	51·45	10·64	1,150·85
P.A. 5349W	Broad Arrow	Hill, J. W.	5·00	10·05	101·75
P.A. 5349W	Broad Arrow	Wilkerson, K. H.	8·75	5·30	46·40
P.A. 5349W	Broad Arrow	Brockhoff, B. L.	6·90	6·30	54·35
P.A. 2683Z	North Coolgardie	Ellis, J.	4·93	5·50	37·95
M.L. 410	Phillips River	Kuzmins, W.	35·75	14·46	1,683·25
M.C. 151	Phillips River	Arbus, M.	2·00	7·00	18·90
M.C. 160	Phillips River	Kuzmins, W.	26·75	13·24	1,284·65
M.C. 35, etc.	Phillips River	Ravensthorpe Copper Mines N.L.	25·65	8·69	730·90
M.L. 416	Phillips River	Wehr, W.	7·65	7·00	174·05
Crown Lands	Northampton	Sundry Persons	5·58	9·10	98·10
M.C. 871H	South-West	Mullins, R. W. & Jordan, R. J.	6·40	4·40	21·15
Temp. Res. 2104H	Outside Proclaimed	United Aborigines Mission	36·57	16·41	1,737·10
			9,275·18	4·98	94,568·72 (*a*) (*b*)
		DIATOMACEOUS EARTH			
			Calcined Material Tons		
M.C. 241H	South-West	H. L. Brisbane & Wunderlich Ltd.	15·00	....	(*c*) 300·00
		FELSPAR			
M.L. 80, etc.	Coolgardie	Australian Glass Manufacturers Co. Pty. Ltd.	1,267·00	....	(*a*) 6.883·80
		FULLER'S EARTH			
M.C. 456H	South-West	Read, D. J. & T. I.	120·00	....	(*a*) 480·00

(19)—70240

Table V.—*Minerals other than Gold*—continued

Quantity and Value of Minerals, other than Gold, Reported during the year 1962

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		GLASS SAND			
M.C. 417H, etc.	South-West	Australian Glass Manufacturers Co. Pty. Ltd.	9,054·62	....	5,883·90
M.C. 365H, etc.	South-West	Leach, R. J.	1,107·00	....	1,660·50
M.C. 161H, etc.	South-West	Leach, L. J.	164·00	....	164·00
			10,325·62	....	(c) 7,708·40
		GYPSUM			
			Long Tons		£A
M.C. 30, etc.	Yilgarn	Ajax Plaster Co. Pty. Ltd.	6,695·00	....	5,560·00
M.C. 51, etc.	Yilgarn	H. B. Brady Co. Pty. Ltd.	9,541·00	....	8,642·60
M.C. 9, etc.	Yilgarn	Perth Modelling Works	10,899·00	....	7,901·75
M.C. 25, etc.	Dundas	Garrick Agnew Pty. Ltd.	18,669·46	....	59,684·45
M.C. 612H, etc.	South-West	Hewitt, B.	4,039·00	....	4,589·00
M.C. 485H, etc.	South-West	Fitzgerald, E. J.	1,746·67	....	1,440·90
M.C. 712H	South-West	House, R. P. ; Parry. J and Lyne, H.	60·00	....	60·00
			51,650·13	....	87,878·70 (a) (b)

Includes 18,669·46 tons for Export and 60·00 tons for Agricultural Purposes. Plaster of Paris reported as manufactured during the year being 20,223·00 tons from 28,475·50 tons of Gypsum by four Companies. Gypsum used in the manufacture of Cement = 6,093·67 tons.

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		IRON ORE (for Pig)			
				Pig Iron Recovered Tons	
Temp. Res. 1258H	Yilgarn	Charcoal Iron & Steel Industry	72,168·00	46,195·00	1,016,290·00 (c) (d)

Average Assay of Ore used = 61·74% Fe.

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		IRON ORE (for Export)			
				Average Assay Fe%	
M.L. 10, etc.	West Kimberley	Australian Iron & Steel Ltd.	1,320,355·00	63·05	1,309,643·00 (b)
		LEAD ORE AND CONCENTRATES (f) (g)			
				Lead Content Tons	
M.L. 234	Northampton	Mary Springs Lead Mine	155·56	115·27	6,045·45
M.L. 276	Northampton	Nooka Mining Syndicate	203·15	131·71	6,143·25
M.L. 266	Northampton	Yiappa Lead Mine Syndicate	84·32	58·89	2,967·40
			443·03	305·87	(b) 15,156·10

Silver : Quantity and Value transferred to Silver Item.

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		LIMESTONE*			
M.C. 461H	South-West	Lime Fertilisers (W.A.)	228·00	....	79·80
M.C. 727H	South-West	Perron Bros. Pty. Ltd.	20,074·00	....	2,007·40
M.C. 723H	South-West	Plozza, C. W. & W. A.	116·00	....	145·00
M.C. 432H	South-West	Anticich, J.	585·25	....	585·25
M.C. 692H, etc.	South-West	Franconi, D. & S.	7,342·00	....	10,487·50
M.C. 532H	South-West	Gibbs, C. E. & A. J.	2,135·00	....	2,668·75
M.C. 702H, etc.	South-West	Makrides, J.	357·00	....	714·00
M.C. 575H, etc.	South-West	Susac, F. & Y.	3,990·00	....	4,987·50
M.C. 684H	South-West	Cooper, D. B.	1,150·00	....	1,437·50
M.C. 728H	South-West	Llewellyn, A. W.	150·00	....	187·50
M.C. 710H	Outside Proclaimed	Lister, J. ; Lang, K. J. and Dunn, H. E.	354·00	....	708·00
			36,481·25	....	(c) 24,008·20

* Incomplete : Figures relate only to production reported from holdings under the Mining Act.

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		LITHIUM ORES (Petalite) (f) (g)			
			Long Tons	Li20 Units	£A
M.L. 80, etc.	Coolgardie	Australian Glass Manufacturers Co. Pty. Ltd.	84·00	358·68	(a) 402·86
		LITHIUM ORES (Spodumene) (g)			
M.C. 23	Phillips River	Frayne, W. L.	24·15	152·15	(c) 346·85
		MAGNESITE			
M.C. 76, etc.	Phillips River	Basic Materials Co. Pty. Ltd.	224·01	....	(b) 1,593·20

Table V.—*Minerals other than Gold*—continued

Quantity and Value of Minerals, other than Gold, Reported during the year 1962

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		MANGANESE (Metallurgicall Grade) (*f*)			
			Long Tons	Average Assay Mn%	£A
M.C. 268, etc.	Pilbara	Northern Mineral Syndicate	38,399·22	51·09	581,222·45
M.C. 194L, etc.	Pilbara	D. F. D. Rhodes Pty. Ltd.	7,218·00	43·91	67,194·00
M.C. 517, etc.	Pilbara	Pindan Pty. Ltd.	2,560·07	45·14	22,892·95
M.C. 244L, etc.	Pilbara	Westralian Ores Pty. Ltd.	17,206·00	49·44	199,423·00
M.C. 289L	Pilbara	Wright Prospecting Pty. Ltd.	2,217·79	43·27	19,042·25
M.C. 24P., etc.	Peak Hill	Westralian Ores Pty. Ltd.	19,915·50	43·16	247,262·50
			87,516·58	47·99	1,137,037·15 (*b*)
		MANGANESE (Battery Grade)			
				Average Assay MnO_2%	
M.L. 61P	Peak Hill	Westralian Ores Pty. Ltd.	216·50	70·00	(*b*) 4,347·50
		MANGANESE (Low Grade)			
				Average Assay Mn%	
M.C. 24P, etc.	Peak Hill	Westralian Ores Pty. Ltd.	1,804·50	Not known	14,240·50
M.L. 61P	Peak Hill	Westralian Ores Pty. Ltd.	65·00	Not known	237·25
			1,869·50	....	(*a*) 14,477·75
		MINERAL BEACH SANDS (Ilmenite) (*f*)			
				Average Assay TiO_2%	
D.C. 56H, etc.	South-West	Cable (1956) Ltd.	21,547·85	55·50	*See* Footnote
D.C. 13H, etc.	South-West	Ilmenite Pty. Ltd.	22,683·00	55·10	
M.C. 619H, etc.	South-West	Westralian Oil Ltd.	51,322·79	59·21	
M.C. 516H, etc.	South-West	Western Titanium N.L.	110,251·32	54·95	
			205,804·96	56·09	(*b*) 911,605·63

Footnote : Current values for separate Companies not available for publication.

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		MINERAL BEACH SANDS (Monazite) (*f*) (*g*)			
				ThO_2 Units	
M.C. 516H, etc.	South-West	Western Titanium N.L.	950·15	6,475·98	(*b*) 28,543·80
		MINERAL BEACH SANDS (Rutile) (*f*) (*g*)			
				TiO_2 Tons	
M.C. 516H, etc.	South-West	Western Titanium N.L.	874·27	841·24	(*b*) 19,906·35
		MINERAL BEACH SANDS (Leucoxene) (*f*) (*g*)			
				TiO_2 Tons	
M.C. 516H, etc.	South-West	Western Titanium N.L.	750·30	649·76	10,054·02
M.C. 619H, etc.	South-West	Westralian Oil Ltd.	38·25	29·83	713·00
			788·55	679·59	(*b*) 10,767·02
		MINERAL BEACH SANDS (Zircon) (*f*) (*g*)			
				ZrO_2 Tons	
M.C. 516H, etc.	South-West	Western Titanium N.L.	4,132·47	2,731·70	(*b*) 44,343·30
		PETALITE (*See* Lithium Ores)			
		PHOSPHATIC GUANO			
M.C. 714H	South-West	Ward, R. J.	68·00	....	(*c*) 680·00
		PYRITES ORE AND CONCENTRATES (for Sulphur) (*g*)			
			Content	Sulphur Content Tons	
G.M.L. 5345E, etc.	East Coolgardie	Gold Mines of Kalgoorlie (Aust.) Ltd.	(*i*) 12,341·07	5,470·08	68,376·07
G.M.L. 1460,etc.	Dundas	Norseman Gold Mines N.L.	37,120·00	17,677·31	287,914·00
			49,461·07	23,147·39	356,290·07 (*a*)

Table V.—*Minerals other than Gold*—continued

Quantity and Value of Minerals, other than Gold, Reported during the year 1962

Number of Lease, Claim or Area	Goldfield or Mineral Field	Registered Name of Producer	Quantity	Metallic Content	Value
		QUARTZ GRIT			
Q.A. 2	Collie	Rowden, E.	25·00	....	(*c*) 21·00
		SEMI-PRECIOUS STONES (Chalcedony)			
			lb.		
P.A. 2689Z	North Coolgardie	Smith, N. L.	448·00	....	(*a*) 200·00
		SILVER			
			Fine oz.		
	By-product Gold Mining		244,082·30	....	115,582·30
	By-product Copper Mining		4,166·52	....	1,983·95
	By-product Lead Mining		212·11	....	95·05
			248,460·93	....	117,661·30
		SPODUMENE (*See* Lithium Ores)			
		TALC			
Private Property	South-West	Three Springs Talc Pty. Ltd.	4,980·95	....	71,810·05 (*b*) (*c*)
		TANTO-COLUMBITE ORES AND CONCENTRATES (*f*) (*g*)			
				Ta_2O_5 Units	
M.C. 621	Pilbara	Trigg Hill Mining Syndicate	0·05	2·66	250·75
M.C. 106	Pilbara	Hasleby, H. M. and H. B.	0·35	20·13	1,327·95
Crown Lands	Pilbara	Sundry Persons	7·38	339·23	18,607·65
M.C. 244, etc.	West Pilbara	Nomads Pty. Ltd.	3·66	134·54	11,540·92
Crown Lands	Gascoyne	Sundry Persons	0·70	23·29	837·85
M.C. 35	Yalgoo	Meka Mining Syndicate	1·91	54·21	3,950·00
M.C. 27	Yalgoo	Todd, Dan, and Breeze, B. F.	1·72	117·83	10,664·15
P.A. 2571	Yalgoo	Nevill, J. L.	0·20	9·76	672·25
P.A. 2580	Yalgoo	Phillips, E. R.	0·14	6·16	466·75
M.C. 26	Yalgoo	Palmer, L.	0·16	3·92	309·77
M.C. 69, etc.	Greenbushes	Austin Bros.	2·68	121·64	9,565·55
Crown Lands	Greenbushes	Sundry Persons	0·29	9·43	680·05
			19·24	842·80	(*b*) 58,873·64
		TIN (*f*) (*g*)			
				Tons	
D.C. 43, etc.	Pilbara	Northern Mineral Syndicate	71·90	52·26	51,797·25
D.C. 201, etc.	Pilbara	Mineral Concentrates Pty. Ltd.	120·93	82·44	86,174·00
D.C. 48, etc.	Pilbara	Pilbara Exploration N.L.	30·68	21·97	23,856·60
D.C. 254	Pilbara	Johnston, J. A.	111·25	78·21	80,514·25
D.C. 16, etc.	Pilbara	Leonard, H. V.	98·54	68·80	71,430·95
D.C. 257	Pilbara	Russell, H. H.	0·82	0·56	599·25
Crown Lands	Pilbara	Sundry Persons	8·05	5·31	5,513·50
M.L. 13, etc.	Kimberley	McIntyre, S. J.	0·46	0·30	295·95
M.C. 69, etc.	Greenbushes	Austin Bros.	16·90	10·03	10,250·55
M.C. 126, etc.	Greenbushes	Angus, A. J.	0·81	0·40	405·75
M.L. 647, etc.	Greenbushes	Vultan Syndicate	3·96	2·45	2,334·50
Crown Lands	Greenbushes	Sundry Persons	1·14	0·74	1,096·45
			465·44	323·47	334,269·00 (*b*)
		TUNGSTEN ORES AND CONCENTRATES (Scheelite) (*f*) (*g*)			
				WO_3 Units	
L.T.T. 1252H	North Coolgardie	Linnett, A. S. and Hawkins, A. N.	7·35	491·06	(*b*) 3,883·40

REFERENCES

(*a*) Value F.O.R.
(*b*) Value F.O.B.
(*c*) Value at Works.
(*d*) Value of Mineral Recovered.
(*e*) Value at Pit Head.
(*f*) Only results of shipments finalised during the period under review.
(*g*) Metallic Content calculated on Assay basis.
(*h*) Concentrates.
(*i*) By-product of Gold Mining.
(*j*) By-product of Tin Mining.

TABLE VI.—TOTAL MINERAL OUTPUT OF WESTERN AUSTRALIA

Recorded mineral production of the State to 31st December, 1962, showing for each mineral, the progressive quantity produced and value thereof, as reported to the Department of Mines ; including Gold (Mint and Export) as from 1886, and Other Minerals as from commencement of such records in 1899.

Mineral		Quantity	Value
			£
Abrasive Silica Stone	tons	1·50	9·00
Alunite (Crude Potash)	,,	9,073·05	215,864·72
Antimony Concentrates (a)	,,	9,829·69	242,497·00
Arsenic (a)	,,	38,674·08	747,205·00
Asbestos—			
Anthophyllite	,,	509·35	6,773·31
Chrysotile	,,	9,951·26	407,093·35
Crocidolite	,,	110,013·52	12,403,728·09
Tremolite	,,	1·00	25·00
Barytes	,,	2,867·06	18,876·55
Bauxite (e)	,,	36,741·00	....
Bentonite	,,	8,176·40	28,235·66
Beryl	,,	3,444·46	447,020·29
Bismuth	lb.	12,384·00	3,770·30
Building Stone (i)	tons	44·45	1,353·00
Building Stone (Spongolite)	,,	669·00	2,994·00
Calcite	,,	5·00	25·00
Chromite	,,	14,419·05	208,296·75
Clays—			
Brick, Pipe and Tile Clay (i)	,,	50,624·00	49,364·00
Cement Clay	,,	236,209·05	169,820·81
Fireclay	,,	211,904·01	228,692·73
White Clay—Ball Clay	,,	20,387·60	59,471·30
White Clay—Kaolin	,,	5,103·23	8,624·17
Coal	,,	31,961,394·29	47,016,431·83
Copper Ore and Concentrates	,,	276,928·01	2,827,972·35
Copper (Metallic By-product) (a)	,,	68·38	11,540·15
Corundum	,,	63·15	655·00
Cupreous Ore (Fertiliser)	,,	76,021·69	1,117,333·45
Diamonds (f)	carats	....	24·00
Diatomaceous Earth	tons	426·00	6,160·75
Dolomite	,,	3,041·82	13,021·60
Emeralds (Cut and Rough)	carats	18,381·68	1,922·00
Emery	tons	21·15	375·00
Felspar	,,	64,021·61	216,516·61
Fergusonite	,,	0·30	391·40
Fuller's Earth	,,	282·40	1,188·05
Gadolinite	,,	1·00	112·00
Glass Sand	,,	96,786·52	69,493·06
Glauconite (g)	,,	6,467·00	150,384·50
Gold (Mint and Export)	fine ozs.	63,366,482·77	470,814,744·00
Graphite	tons	153·20	1,304·20
Gypsum	,,	769,857·13	793,925·70
Iron Ore—			
For Pig Iron (g)	,,	484,583·32	6,307,718·06
For Export	,,	7,403,343·00	7,340,901·69
For Flux	,,	58,064·35	37,048·00
Jarosite	,,	9·54	37·50
Kyanite	,,	4,215·69	21,781·00
Lead Ores and Concentrates	,,	467,368·93	4,777,573·21
Limestone (i)	,,	155,713·88	76,072·10
Lithium Ores—			
Petalite	,,	267·96	1,225·90
Spodumene	,,	33·04	488·50
Magnesite	,,	18,757·88	87,164·84
Manganese—			
Metallurgical Grade	,,	586,649·34	7,677,108·91
Battery Grade	,,	1,472·25	30,662·10
Low Grade	,,	3,772·36	30,517·15
Mica	lb.	32,930·00	3,984·24
Mineral Beach Sands—			
Ilmenite Concentrates	tons	644,784·47	3,004,976·06
Monazite Concentrates	,,	2,306·86	70,771·70
Rutile Concentrates	,,	2,345·97	55,969·05
Leucoxene Concentrates	,,	1,417·00	20,247·22
Zircon Concentrates	,,	18,924·16	196,055·20
Crude Concentrates (Mixed)	,,	155·95	776·50
Ochre—			
Red	,,	8,657·96	96,065·80
Yellow	,,	447·60	2,977·75
Phosphatic Guano	,,	11,826·06	72,400·45
Pyrites Ore and Concentrates (for Sulphur) (b) (g)	,,	969,883·15	5,650,334·87
Quartz Grit—	,,	773·50	657·35
Semi-precious Stones—			
Chalcedony	lb.	448·00	200·00
Chrysoprase	,,	5·00	5·00
Opaline	,,	25·00	3·75
Prase	,,	2,240·00	40·00
Tiger Eye Opal	,,	120·00	97·00

TABLE VI.—TOTAL MINERAL OUTPUT OF WESTERN AUSTRALIA—*continued.*

Mineral		Quantity	Value
			£
Sillimanite	tons	2·00	13·00
Silver (c)	fine ozs.	10,464,832·88	2,197,934·03
Soapstone	tons	565·40	1,927·85
Talc	,,	41,089·85	548,479·88
Tanto-Columbite Ores and Concentrates	,,	518·13	535,123·64
Tin	,,	20,152·24	3,283,473·00
Tungsten Ore and Concentrates—			
Scheelite	,,	163·05	68,724·97
Wolfram	,,	303·42	61,758·65
Vermiculite	,,	1,832·96	11,830·60
Zinc (Metallic By-product) (d)	,,	408·40	1,990·07
Zinc Ore (Fertiliser)	,,	20·00	100·00
Total Value to 31st December, 1962		....	£580,568,452·27 (h)

(a) By-product from Gold Mining.

(b) Part By-product from Gold Mining.

(c) By-product from Gold, Copper and Lead Mining.

(d) By-product from Lead Mining.

(e) Value not yet available for publication.

(f) Quantity not recorded.

(g) Value of mineral recovered.

(h) Excludes Value of Bauxite.

(i) Incomplete—being only production reports from holdings under the Mining Act.

Footnote.—Comprehensive mineral production records maintained in the Statistical Branch of the Department of Mines show locality, producers, period, quantity, assayed or metallic content, and value of the various minerals listed above.

TABLE VII.

SHOWING AVERAGE NUMBER OF MEN EMPLOYED ABOVE AND UNDER GROUND IN THE LARGER GOLDMINING COMPANIES OPERATING IN WESTERN AUSTRALIA DURING THE YEARS FROM 1953 TO 1962 INCLUSIVE.

COMPANY	1953			1954			1955			1956			1957			1958			1959			‡1960			1961			1962		
	Above	Under	Total	Above	Under	Total	Above	Under	Total	Above	Under	Total	Above	Under	Total	Above	Under	Total	Above	Under	Total	Above	Under	Total	Above	Under	Total	Above	Under	Total
Anglo-Westralian Mining Pty.	37	5	42	28	6	34	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
†Boulder Perseverance, Ltd.	155	112	267	152	114	266	171	114	285	181	113	294	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Broken Hill Pty. Co. Ltd.	4	....	4	2	....	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Blue Spec Gold Mines, Ltd.	33	15	48	30	15	45	17	9	26	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Big Bell Mines Ltd.	200	215	415	179	167	346	44	16	60	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Consolidated Gold Area N.L.	1	1	2	1	2	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Comet Gold Mines Ltd.	10	6	16	4	2	6	3	....	3	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Central Norseman Gold Corporation N.L.	155	228	383	158	227	385	166	225	391	159	209	368	165	226	391	166	232	398	173	214	387	169	209	378	163	220	383	151	213	364
Eclipse Gold Mines N.L.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	27	8	35	17	10	27	17	15	32	18	13	31	16	9	25
Golden Horseshoe (New) Ltd.	42	....	42	42	....	42	39	....	39	35	....	35	6	....	6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Gold Mines of Kalgoorlie (Aust.) Ltd.	184	182	366	199	186	385	257	192	449	228	223	451	417	500	917	392	538	930	374	455	829	375	446	821	374	430	804	379	436	815
Great Boulder Pty. Ltd.	349	359	708	342	372	714	359	379	729	349	380	729	330	400	730	323	387	710	308	399	707	290	385	675	296	385	681	300	369	669
*Great Western Consolidated	186	113	299	191	150	341	224	271	441	232	270	502	220	223	443	220	241	461	207	218	425	197	174	371	164	124	288	144	92	236
Hill 50 Gold Mine N.L.	68	63	131	73	63	136	82	73	155	98	85	183	108	94	202	103	103	206	95	88	183	97	87	184	97	93	190	99	110	209
†Kalgoorlie Enterprise Ltd.	8	98	106	8	89	97	7	101	108	8	100	108	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
§Kalgurli Ore Treatment Co. Ltd.	77	....	77	78	....	78	65	....	65	40	....	40	33	....	33	28	....	28	....	....	....	....	....	....	....	....	....	....	....	....
Lake View and Star Ltd.	494	519	1,013	488	498	986	482	487	969	471	523	994	460	517	977	433	525	958	451	535	986	432	513	945	417	514	931	411	527	938
Moonlight Wiluna Gold Mines Ltd. (Timoni)	39	37	76	42	34	76	39	33	72	37	32	69	36	31	67	35	31	66	31	27	58	31	24	55	30	30	60	33	39	72
Mountain View Gold N.L.	4	6	10	3	6	9	3	1	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Mt. Charlotte (Kalgoorlie) Gold Mines N.L.	3	6	9	3	2	5	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
North Kalgurli (1912) Ltd.	76	207	283	83	193	276	95	236	331	156	239	395	158	250	408	163	263	426	181	251	432	181	249	430	187	246	433	208	243	451
Northern Minerals Syndicate Ltd. (Paris Mine)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	6	4	10	15	11	26	20	17	37	28	21	49
Gold Mines of Kalgoorlie (Aust.) Ltd. (Barbara and Bayleys Leases)	68	108	176	77	95	172	79	95	174	37	73	110	34	61	95	23	48	71	19	36	55	18	37	55	18	36	54	15	28	43
New Coolgardie Gold Mines N.L. (Callion Leases)....	7	34	41	9	42	51	8	35	43	3	11	14	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Ora Banda Amalgamated Ltd.	3	2	5	1	2	3	....	2	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Paringa Mining and Exploration Co. Ltd.	2	2	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Porphyry (1939) Gold Mines Ltd.	3	3	6	2	2	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Radio Gold Mines	5	5	10	5	5	10	6	6	12	6	6	12	7	7	14	6	6	12	6	6	12	6	6	12	6	5	11	5	5	10
†South Kalgurli Consolidated	67	107	174	64	106	170	53	99	152	13	84	97	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Sons of Gwalia Ltd.	102	157	259	102	138	240	102	146	248	105	156	261	107	146	253	109	142	251	99	137	236	106	139	245	103	143	246	96	137	233
Sunshine Reward Amalgamated Leases	8	7	15	8	7	15	7	4	11	8	7	15	2	....	2	8	3	11	5	2	7	3	1	4	2	2	4	2	2	4
Wiluna Gold Mines Ltd.	2	1	3	1	1	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
All other Operators	846	523	1,369	734	495	1,229	634	388	1,022	544	407	951	498	349	847	476	313	789	521	398	919	469	290	759	509	283	792	524	321	845
State Average (inc. Diggers)	3,238	3,121	6,359	3,109	3,019	6,128	2,933	2,912	5,845	2,710	2,918	5,628	2,581	2,804	5,385	2,512	2,840	5,352	2,493	2,780	5,273	2,406	2,586	4,992	2,404	2,541	4,945	2,411	2,552	4,963

* Including Copperhead, Frasers, Nevoria, Corinthian and Pilot Groups.

‡ Effective workers only and totally excluding non-workers for any reason whatsoever.

† Absorbed by Gold Mines of Kalgoorlie (Aust.) Ltd. from 1957.

§ Absorbed by Gold Mines of Kalgoorlie (Aust.) Ltd. from 1959.

By Authority : ALEX. B. DAVIES, Government Printer