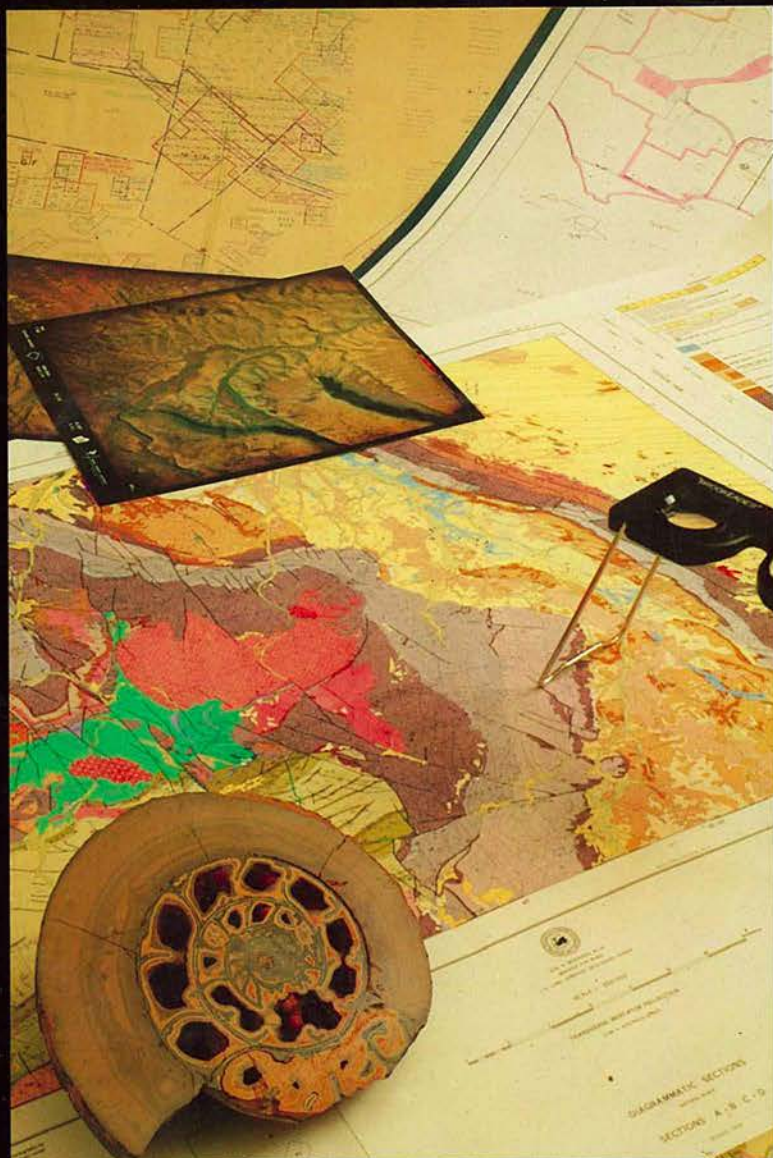


DEPARTMENT OF MINES WESTERN AUSTRALIA



# ANNUAL REPORT

1981

**WESTERN AUSTRALIA**

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**DEPARTMENT OF  
MINES**

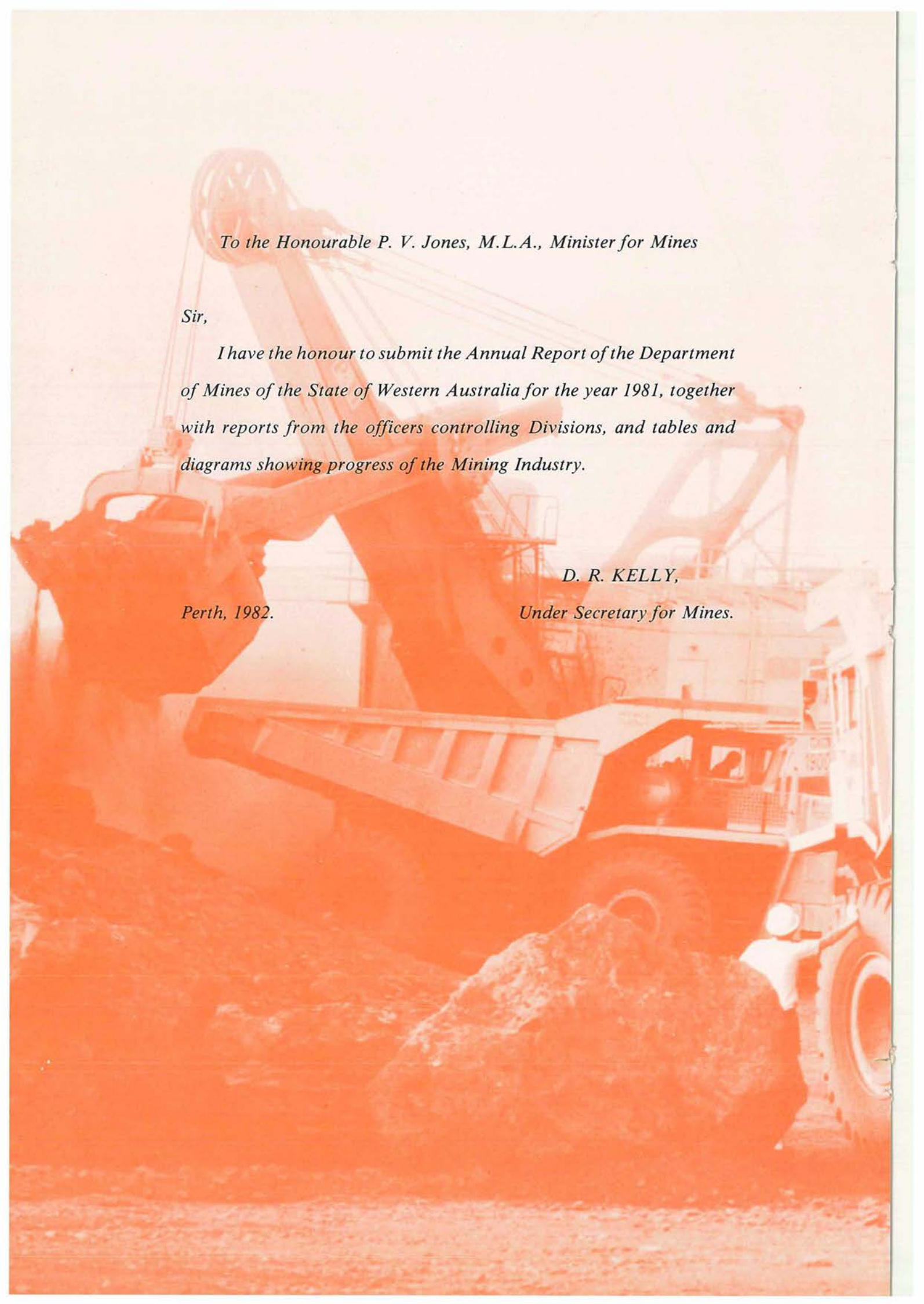
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**ANNUAL REPORT 1981**

**PERTH, 1982**

**PRESENTED TO BOTH HOUSES OF PARLIAMENT**





*To the Honourable P. V. Jones, M.L.A., 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 1981, together with reports from the officers controlling Divisions, and tables and diagrams showing progress of the Mining Industry.*

*Perth, 1982.*

*D. R. KELLY,*

*Under Secretary for Mines.*

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# Report of the Department of Mines for the Year 1981

The mining and mineral processing industry in Western Australia faced a difficult situation in 1981 and there was a slowing in the rate of activity due to the recession in world trade and industry.

The economic downturn is evidenced by reduced production levels, closure of some operations and deferral of capital expenditure on others. Further elaboration of the effect of the world economic situation on the State's economy is provided later in this report.

Contrary to this trend—or perhaps merely lagging behind it—exploration and the application for tenements continued at a high level.

The Department experienced a very busy year resulting from this exploration and a general high level of demand by industry and the public for the services of the various divisions of the Department.

After a decade of endeavour, new mining legislation in the form of the Mining Act 1978-81 and Regulations was brought to the point of readiness for introduction on January 1, 1982.

## This report

The format of this report has been changed from that of its predecessors.

The opportunity has been taken to transfer a number of statistical tables and diagrams which previously appeared in the text into a Statistical Digest which forms the last section of this report.

Other information of a more detailed nature will now be pub-

lished separately by the Department instead of being included in the Annual Report. Further details of these changes are given in the preface to the Statistical Digest.

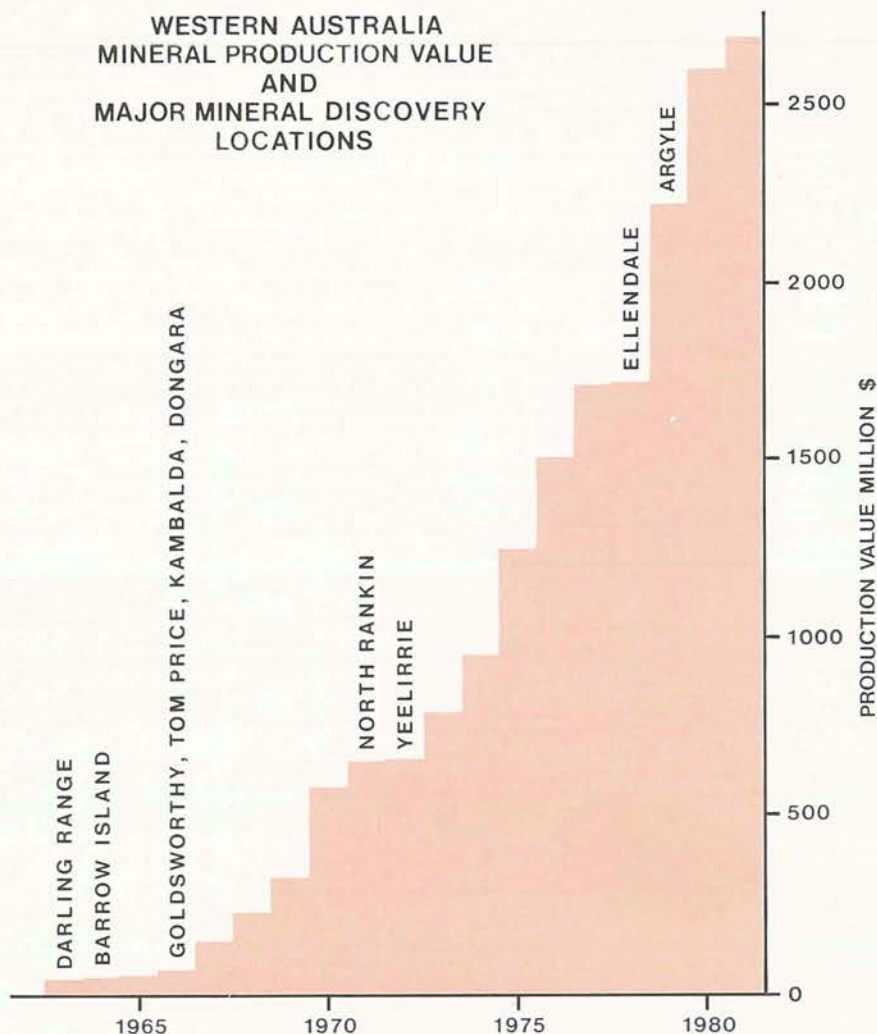
Separate reports dealing with the activities of the Registration and Administrative Divisions of the Department have also been included for the first time.

The aim has been to retain in the report essential information and statistics and to present a description of the activities of the Depart-

ment and of the mining industry, avoiding duplication and unnecessary detail in the process.

## Mineral production

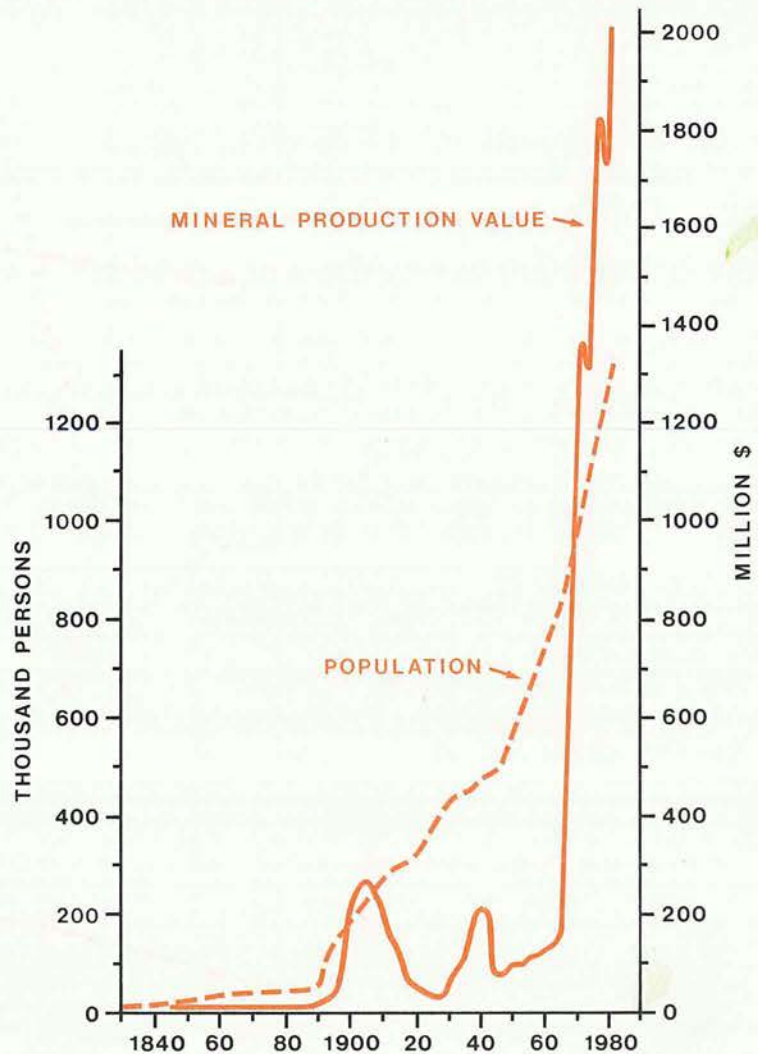
The value of Western Australia's mineral output (including gold, coal, and petroleum) for 1981 was \$2 692 million, an increase of 2.7 per cent from 1980. This slight increase in value is, however, less than cost increases; therefore, despite the apparent small gain shown in the following figure, the real result was a slight downturn reflecting the adverse conditions experienced by the industry during the year.



The performances of the major minerals in 1981 are set out in the adjoining table and illustrated in the diagram on page 122 of the Statistical Digest.

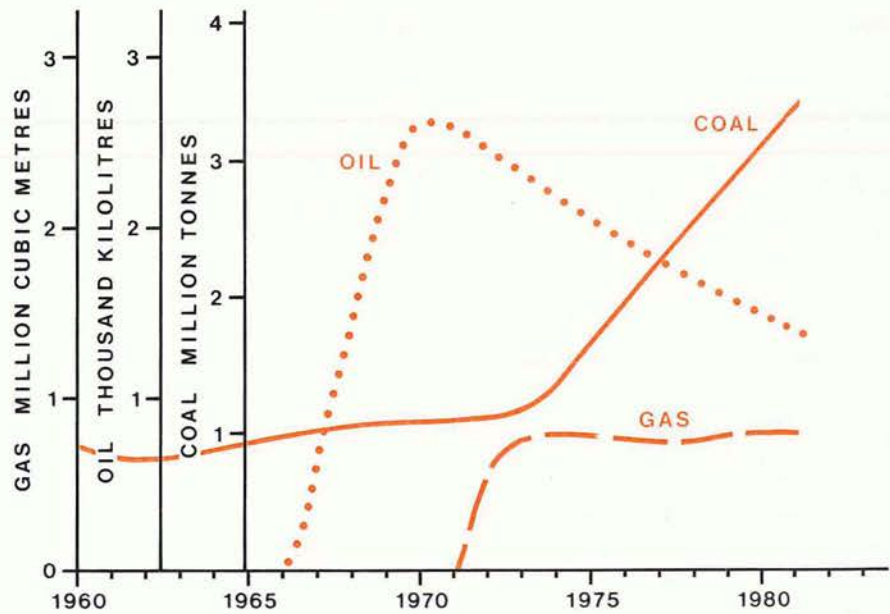
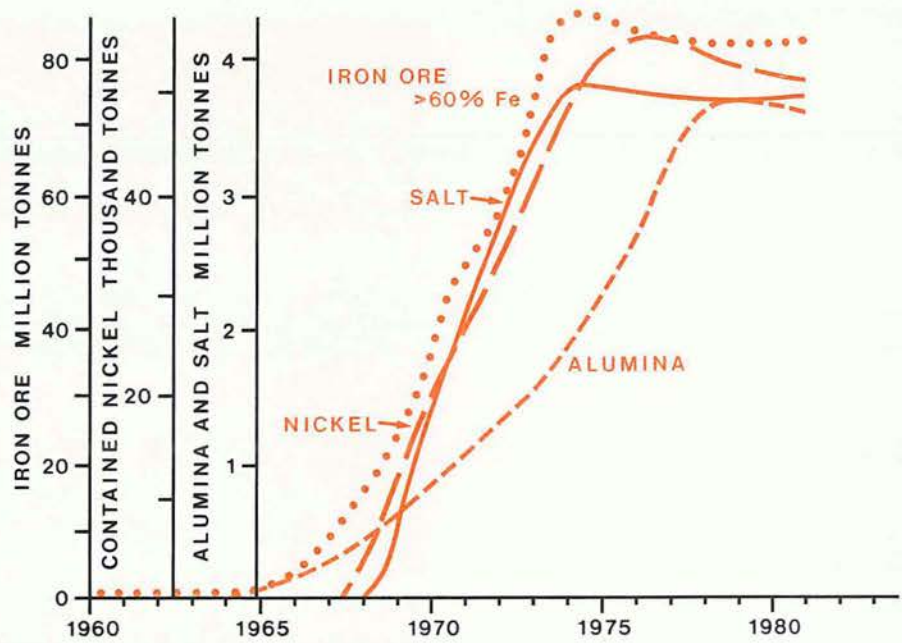
Mineral (Units)	Quantity produced		% Difference
	1980	1981	
Iron Ore (Mt) .....	85.0	75.3	-11.4
Alumina (Mt) .....	3.7	3.7	+0.4
<b>Nickel</b>			
Concentrates (kt) .....	396.5	405.9	+2.4
Ore (kt) .....	86.6	85.9	-0.8
<b>Petroleum</b>			
Crude Oil (ML) .....	1 624.7	1 439.3	-11.4
Natural Gas (m <sup>3</sup> x 10 <sup>6</sup> ) .....	859.7	831.9	-3.2
Condensate (t) .....	2.4	2.0	-13.4
Gold (t) .....	10.8	11.9	+10.1
Coal (Mt) .....	3.1	3.2	+3.3
<b>Mineral Sands</b>			
Ilmenite (kt) .....	1 256.7	963.1	-23.4
Rutile (kt) .....	91.7	61.6	-32.8
Zircon (kt) .....	327.7	226.5	-30.9
Others (kt) .....	37.9	26.6	-29.9
Salt (Mt) .....	3.7	3.6	-1.5
Tantalite-columbite (t) .....	159	298	+80.0
Tin concentrates (t) .....	558	921	+65.3

It is of interest to place the 1981 value of production in an historical context as shown here, where value over the years has been adjusted to a constant 1978 dollar. Periods when there has been a high value of mining production per head of population have been buoyant times for the State.

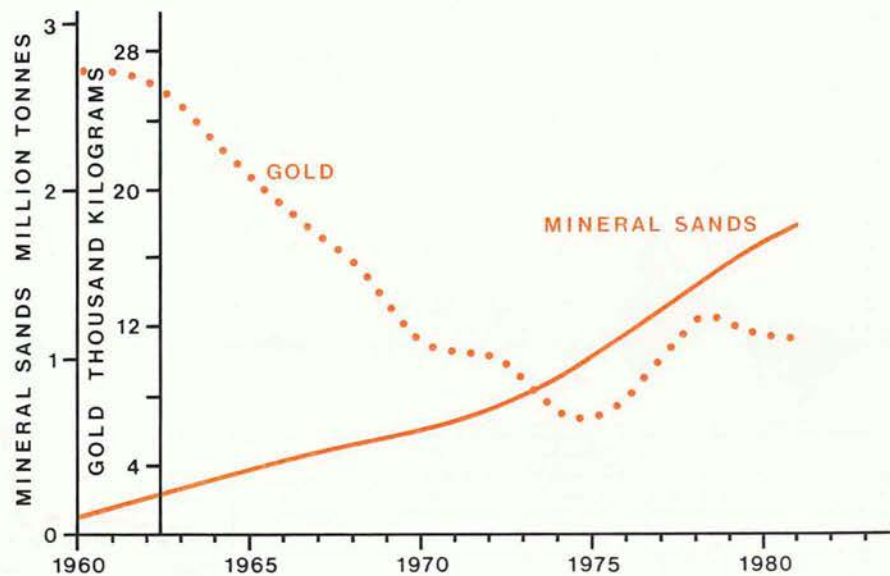




The changing quantity of the major minerals produced in the last two decades is shown in the adjoining figures.



Details of production and value for all minerals produced in Western Australia are given in the Table on page 160 in the Statistical Digest.





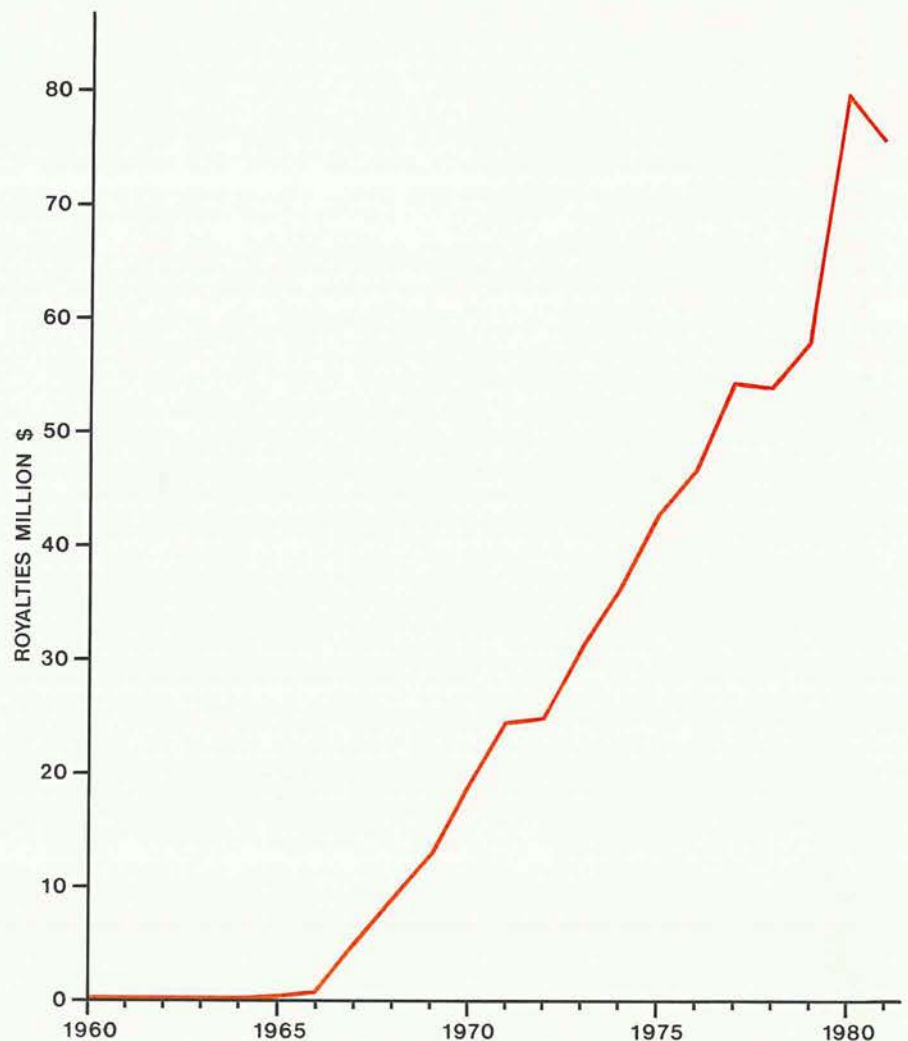
## Royalties

The royalty revenue for the year amounted to \$75.76 million which is \$3.88 million less than 1980, representing a decrease of 5.14 per cent. This largely reflects the 8 per cent reduction in iron ore royalties due to a 10 million tonne lower output in 1981 than in 1980.

Royalties set by Regulations under the Mining Act 1904 were reviewed during the year and increases in rates came into effect on December 1, 1981; accordingly there was little effect on the amount collected in 1981, particularly as the main revenue earners were not affected as they are covered by other acts such as the various agreement acts and the Petroleum Act.

	Royalties collected		Difference (\$ million)
	1980 (\$ million)	1981 (\$ million)	
Alumina.....	4.66	5.68	+ 1.02
Iron ore.....	62.03	57.24	- 4.79
Natural gas.....	1.24	1.38	+ 0.14
Crude oil.....	5.83	5.59	- 0.24
Other.....	5.88	5.87	- 0.01
<b>Total.....</b>	<b>79.64</b>	<b>75.76</b>	<b>- 3.88</b>

The accompanying diagram shows the trend of royalty revenue over the last decade.



## World Economic Environment\*

The level of mineral production realised in Western Australia is determined principally by the extent of overseas demand. Our situation thus hinges on the buoyancy of world trade and on the economic conditions prevailing in the importing countries.

The dependence of Western Australia upon international markets for mineral production is demonstrated by the fact that in 1980/81 an estimated 75 per cent of the value of the State's mineral output was directed to overseas exports.

The slowdown in world trade and the depressed economic conditions which have been experienced by the State's major trading partners over the last 12 months, has reduced the level of Western Australia's key mineral exports. The decrease in real terms of the value of mineral production for 1981 reflects this situation.

Given this relationship which exists between international economic conditions and the quantity and value of the State's mineral production, it is worthwhile to examine in some detail the current status and future outlook of the world economy.

### Current position

The international economic situation is experiencing a period of recession coupled with continuing inflation. Its origins can be traced to the Organisation of Petroleum Exporting Countries (OPEC) price increases which occurred in 1979/80 and which have affected growth trends in two ways.

The OPEC prices rises stimulated the rate of cost increase, in turn giving rise to inflationary expectations, which have combined to produce a more unfavourable op-

erating and investment climate. To this impact should be added the reaction of central governments to the prospect of rising prices. In all major industrialised nations government responded to the threat of renewed inflation through the introduction of policy designed to reduce the growth in the money supply, and thereby, in theory, to contain costs.

Although the tight money approach has, to some degree, prevented inflation returning to the levels recorded in the post 1973 OPEC rise period, it has also, through the encouragement of high interest rates and stricter control of government outlays, acted to reduce industrial production and increase unemployment through the suppression of investor and consumer demand.

As a natural consequence world trade has suffered, increasing by only 1.5 per cent in 1980 and stagnating in 1981. At the same time the danger of increased protectionism has arisen, as evidenced by the disputes concerning the level of the Japanese balance of trade surpluses with the European Economic Community (EEC) and the U.S.A., which *inter alia* have major ramifications for the world steel industry. Further, economic growth in industrialised nations has fallen sharply, with the International Monetary Fund estimating an increase in real Gross National Product for these countries of one per cent in 1981, against a 1.5 per cent rise in 1980 and an average expansion rate of four per cent per annum between 1976/1979.

Growth has also slowed in the developing nations that are faced by rising inflation, increasing balance of payments problems and accelerated debt burdens produced by the continuation of high interest rates. For example, the People's Republic of China, the State's third largest export market, achieved an expansion rate of only 3.4 per cent in 1981, compared with 8.7 per cent for 1980, with a drop in heavy industrial production of 1.2 per cent occurring.

### Future outlook

A consensus is emerging among economic commentators and organisations, including the International Monetary Fund and the World Bank, that world recovery from recession will be slower than that achieved following the 1973 oil crisis. The World Bank does not see a significant upturn in international activity and trade being realised until 1985. The Organisation for Economic Co-operation and Development (OECD), in December, 1981 recorded a growth rate of 1.25 per cent by the industrialised nations in 1981 and predicted the same average economic growth for 1982.\*

The basis for this pessimism is the likely effect of the anti-inflationary strategy pursued by the governments of the developed nations, led by the Reagan administration in the United States with its concentration on the control of the money supply and consequent effect on interest rates.

It has been suggested that international recovery cannot be achieved until inflation and interest rates in the United States display a consolidated downward trend and that this may not be before 1985.

A further important influence upon world economic prospects is the question of energy prices. A fall in oil prices has favourable implications by way of a reduction in inflationary pressures, stimulation of disposable income and improvement of the balance of payments situation for oil importing nations. Against these considerations must be measured the reduced trade demand from the OPEC bloc, the greater exchange and debt problems faced by oil producing developing nations such as Algeria, Nigeria and Indonesia and potential loss of Government revenue from oil industry taxes which could act to widen budget deficits further.

\*The contribution of the Department of Resources Development to this part of the Report is gratefully acknowledged.

\*In May 1982, OECD revised the 1982 growth forecast downwards to only 0.3 per cent as a result of the persistent tight monetary situation in the U.S.A.

Therefore, while cheaper energy may help to hold down inflation and encourage consumer spending, interest rate levels remain as the key to economic recovery.

The general world downturn that has occurred in terms of growth, industrial output, investment and employment has naturally been reflected in reduced requirements for basic raw materials. This has had a significant impact on the demand for Western Australian minerals as consideration of the principal commodities will show.

## Mineral Commodities

### Iron ore

During 1981, the Western Australian iron ore industry continued to be adversely affected by the downturn in the world steel industry, and in particular, by the slump in Japan.

In the 1969-79 period the Japanese economy achieved an annual growth rate of 5.4 per cent. Due to the influences previously cited, expansion slowed to 2.9 per cent in 1981, the smallest rise since 1975. Japan has been able to maintain growth, primarily through successful promotion of exports, which resulted in a \$US18 billion balance of trade surplus in 1981; but Japanese overseas sales are encountering increasing resistance in markets, including the U.S.A. and the EEC.

Because of these circumstances, the Japanese steel industry operated at only 70 per cent of its capacity during 1981, causing Western Australian iron ore producers to cut back to only 64 per cent of their capacity. Also, previous forecasts of world steel output growth of 4 to 5 per cent per annum to 1985, have been reduced to a rate of 2.5 per cent per annum. The Japanese steel industry has also scaled down future output expectations and now anticipates production to reach only 115 million tons in 1985 compared with 119 million tons in 1973 and 111 million tons in 1980. Overall recovery is basically dependent on

reduced interest rates and increased world trade.

This situation has implications for the Western Australian iron ore producers in that new demand is likely to emerge from small, fragmented markets rather than, as in the past, from major single customers such as Japan. This trend suggests an increased difficulty in securing contracts of sufficient tonnage to facilitate the establishment of new projects.

Revised economic goals in China allowed that country to become an exporter of scrap steel and pig iron. This has led to doubts about the future of BHP's Kwinana iron and steel operation which has depended largely on China and nearby countries for its markets.

Despite the poor outlook for iron ore in 1981, CSR Ltd pressed ahead to complete its evaluation of the Yandicoogina goethite deposits by mid-year. Marketing proposals were subsequently presented to the Japanese steel mills.

During the year, CRA Ltd acquired virtually all of the equity of Hamersley Holdings Ltd. This move may facilitate future development of the Marandoo deposit in which it also holds a 50 per cent interest.

Exploration by Goldsworthy Mining Ltd in the Shay Gap—Sunrise Hill area resulted in the delineation of an additional 30 Mt of ore. This should permit the existing operation to continue for another five years allowing more time for the development of its Area C deposits in the current depressed state of the market.

One highlight of the year was the shipment by Mount Newman Mining Co. Pty Ltd of its 300 millionth tonne of ore through Port Hedland on June 30th.

### Bauxite alumina

World consumption of aluminium declined by 3.7 per cent in 1980 and remained static throughout 1981. As a result, unsold stocks of metal stand at three million tonnes, while

the United States industry is operating at 72 per cent capacity and the Japanese at 60 per cent. Demand for aluminium is forecast to increase by 3.5 per cent per annum between 1980-85, compared with a rate seven per cent per annum over the 1965-80 period.

As a result of the reduced demand for alumina the Western Australian sector is currently characterised by under utilisation of capacity. During September 1981 Alcoa announced a 10 per cent cut back in production at the Kwinana and Pinjarra refineries while in December the Company decided to delay the start-up of operations at Wagerup to 1983. Also the Worsley joint venturers are experiencing difficulty in achieving contracts for projected production levels.

Despite the present situation of severe overcapacity and high stocks for the aluminium industry worldwide, limited exploration activity continued in W.A. during 1981.

Mitchell Plateau Bauxite Co. Ltd, a wholly owned subsidiary of CRA Ltd and manager of the study stage of the Mitchell Plateau bauxite project in which Alcoa of Australia Ltd, Billiton Aluminium Australia BV and several Japanese companies also have interests, continued the feasibility study of the Mitchell Plateau bauxite deposit in the Kimberley district. The study has included an extensive field programme to examine the physical and metallurgical characteristics of the ore body and its processing requirements. Detailed investigations have also been carried out on a number of alternative sites for an alumina plant to process Mitchell Plateau bauxite.

### Nickel

Nickel, whose uses are closely allied to the steel industry, has experienced subdued demand since the latter half of the 1970's when consumption increased at only 1.2 per cent per annum. Only minor increases in demand are anticipated to the mid-1980's and therefore



existing capacity is likely to prove sufficient to meet requirements.

However, the longer term outlook for nickel is more promising and from 1985 to 1990 world demand is seen as reviving to a growth rate of 4 per cent per annum. Western Australia, with its comparatively large resources of nickel sulphide ores, is better placed to benefit from such a situation than many competing areas whose reserves are of energy-expensive lateritic ores.

The favourable long-term outlook has generated new interest in the State's nickel deposits. During 1981, the Western Mining Corporation and the Shell Company of Australia re-opened the Mount Windarra mine near Laverton. Western Mining, together with BHP Ltd, was also involved in the opening up of the Carnilya Hill deposit southeast of Kalgoorlie.

Interest in nickel exploration also revived, with new programmes being commenced in the Widgiemooltha and Mount Keith areas.

### **Copper—lead—zinc**

The Teutonic Bore copper-zinc-silver mine 60 km north of Leonora was officially opened in June 1981. It has an expected seven-year life at an annual production of 300 000 tonnes of ore per year. Operators are Seltrust Holdings Ltd who own the deposit jointly with Mount Isa Mines Ltd.

The delineation of some 22 million tonnes of ore in the Scuddles deposit considerably enhanced the prospects of the Golden Grove project 60 km south of Yalgoo. Current exploration is being undertaken by Esso Exploration and Production Australia Inc. acting for a consortium comprising Esso, Amx Exploration Australia Inc., EZ Industries Ltd and Aztec Exploration Co. Pty Ltd.

Exploration for carbonate-hosted lead—zinc deposits in the Kimberley region continued at a high level during 1981. A joint venture comprising The BHP Co. Ltd

and The Shell Company of Australia carried out a considerable amount of drilling in the Pillara and Napier Ranges, while Aquitaine Australia Minerals and MIM Holdings Ltd continued their evaluation of the Sorby Hills prospects near Kununurra.

Real prices for copper are not expected to increase until there is a recovery from the present economic recession. During the 1980's overall copper consumption is expected to increase by 2 to 3 per cent per annum with the greatest growth coming from Japan and the newly industrialised countries in South East Asia. Uncertainty, arising from the depressed economic picture and weak metal prices, has delayed the commencement of new projects such as Golden Grove where development is dependent upon an upturn in world copper prices.

The zinc market is presently characterised by falling prices due to poor demand and the decline in the motor car industry has reduced the consumption of lead with a consequent weakening of its price.

### **Tin and tantalum**

High tantalum prices during 1980 generated considerable interest in the State's tin/tantalum resources. Production from several small deposits previously considered uneconomic continued through 1981, although falling prices raise doubts as to their future.

The demand for tin is being depressed by recessionary factors coupled with a changing pattern of consumption. The major use of tin, that of tinning, has been affected by the substitution of aluminium. However the prospects for existing producers are reasonably favourable provided there is a continuation of the long standing co-operation between producers and consumers as expressed in successive International Tin Agreements which provide market security for established enterprises.

At Greenbushes the operating company, Greenbushes Tin N.L., commenced underground development of the substantial reserves

of tin/tantalum-bearing pegmatite which had been announced late in 1980. Reduced prices have subsequently also delayed this operation.

### **Mineral sands**

Western Australia continues to be the major producer of heavy mineral sands in Australia based on the mining operations at Capel and Eneabba.

Whilst still of major significance in world markets, the Australian industry has lost the pre-eminent position it once enjoyed. This has come about due to entry of other overseas producers, notably South Africa, into world markets. The competition between the suppliers has intensified with the world wide recession.

Australian producers are attempting to maintain prices by restricting production, especially of rutile, and this could have implications for the level of operations, particularly at Capel. The purchase of Westralian Sands' Eneabba tenements by Allied Eneabba Ltd early in 1981 reflects the rationalisation taking place in the industry encouraged by tight economic circumstances.

### **Salt**

World consumption of salt is closely tied to the level of economic activity and growth. Consequently, present forecasts anticipate only a moderate expansion in production of 2.5 per cent per annum. The Western Australian industry is, however, confronted with additional problems in that increasing competition is emerging, particularly from China, for the sector's main market, Japan.

### **Energy**

The slowing down in the growth of industrial production internationally has led to a situation of over supply in the energy sphere. The recession in world demand is not, however, expected to have any serious effect

on the market for Australia's domestic crude oil production. At present only about two-thirds of Australia's liquid fuel requirements are met from domestic production and the decline in output from known fields indicates that, unless significant new discoveries are made, crude oil self sufficiency will be reduced to one half by the end of the decade. Current government energy policies are designed to stimulate domestic petroleum exploration and it is anticipated that industry will continue to respond with a substantial exploration effort.

Unlike crude oil, undeveloped and new discoveries of natural gas have only a limited chance of being used by the local market in the medium term and development of these discoveries is significantly affected by the reduction in demand for natural gas both overseas and internally.

The market for natural gas has also been affected by the current economic downturn. World sales of LNG totalled 25 million tonnes in 1979, dropping to 23 million tonnes in 1980 with a further decline to beneath 22 million tonnes occurring in 1981. The combination of reduced industrial activity and improved energy conservation has also caused revisions in the forecasts of future consumption levels. For example the Japanese in late 1981 cut by 3 million tonnes the projected requirements of natural gas for electricity in 1990.

This lower demand is among the factors which have delayed finalisation of sales contracts for gas from the North West Shelf to the Japanese market and prompted discussion of the possibility of a slower build up shipments to the plateau of 6 million tonnes of LNG per annum.

The impact of the economic downturn on the State's resource industries has also had a significant effect on expectations for gas sales internally. The alumina industry, the major potential consumer, has cut back production and is looking to defer expansion plans. The two

iron ore pellet plants in the Pilbara have also been closed through lack of demand for pellets worldwide.

The summation of all these factors is that the principal short term effect for Western Australia will probably be a slackening in the tempo of exploration. One indication of this was the reluctance of companies to bid for 11 permit areas made available for application during the year (only 2 were taken up).

### Uranium

The present existence of excess uranium supplies with the concurrent downward pressure on prices is unlikely to ease until at least the latter part of the decade.

This conclusion is based upon predictions\* that Western world uranium production is likely to show a progressive but erratic decline from the 1981 estimate of 111.0 million lbs to about 107.0 million lbs by 1990. Consumption is forecast to increase from 52.7 million lbs in 1981 to a peak of 104.3 million lbs in 1988 before falling back to 97.9 million lbs in 1990. Consequently it is projected that there will be a net increase in inventories throughout the whole of the 1980's and during this period the level of stocks held by electric utility companies will average five to six years' consumption.

Despite this unpromising outlook for uranium, Western Mining Corporation continued with its development of the Yeelirrie deposit, and Minatome Australia Pty Ltd announced its intention to carry out trial solution mining of uranium at its Manyingee Hill prospect south of Onslow. Proposals to develop the Lake Way uranium deposit were put forward by Delhi International Oil Corporation and Vam Ltd during the year, but no commencement date has been given.

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\* The report "Nuexco", a monthly publication on the uranium market.

### Gold

The price of gold fell during most of 1981. The extent of the fall from peak price of \$US850/oz in January 1980 to less than \$US400 in December 1981 is comparable to the mid 1970's when the price dropped from \$US197 to \$US103 over a period of 20 months.

The major gold mines in Western Australia continue to be Telfer, Mt. Charlotte and Central Norseman; however, profits from these ventures have fallen. Repercussions for the Western Australian industry will include a scaling down of operations at major mines with a view to reducing costs and the deferral of construction of a number of new projects. Exploration for gold has slowed.

Although it is difficult to isolate the factors influencing the demand for gold, it is generally accepted that they comprise four main elements—fabrication demand (industrial use, jewellers, etc); investment; speculation; and sales or purchases by the free world and Communist Governments. All influences are currently unfavourable due to the world recession, high interest rates and the sale by Russia of gold to finance its wheat imports.

Although an increased monetary role for gold may have important longer term price consequences for the metal, most sources are interested in the shorter term trading patterns. In general the view held by industry commentators is that no significant changes in the gold price level are likely to occur in 1982.

### Diamond

Ashton Mining Ltd announced in 1981 a second find of alluvial diamonds along Limestone Creek which is situated just east of the diamondiferous AK1 kimberlite and diamond-bearing gravels of Smoke Creek.

An Agreement Act for the mining of the Argyle diamond deposits in the Kimberley was passed in 1981. Careful control of marketing the predominantly industrial

grade diamonds will be needed as Argyle could produce a significant portion of world supply of this commodity.

### Other minerals

In July 1981, Agnew Clough Ltd made its first shipment of vanadium pentoxide from the metallurgically difficult Coates Siding deposit.

Target Minerals N.L. was able to increase garnet production from its Port Gregory deposit, and has plans to market high technology garnet products.

The discovery of a substantial resource of lithium was announced by Greenbushes Tin N.L. The metal occurs in spodumene associated with the tin/tantalum pegmatites at Greenbushes.

## Department of Mines

The role and structure of the Department was reassessed during the year and the functions of each of its nine divisions were confirmed in most cases, but re-defined in others. It is desirable that from time to time in this way there should be a reassessment of the activities of the Department and the role that it plays in support of the mining and petroleum industries and the community generally.

### Role

The Department administers one of the State's most important industries—that of mining and petroleum. Present government policy is designed to encourage investment in exploration, extraction and utilisation of mineral and petroleum resources and the multitude of departmental functions are structured to implement these policies. These activities have ramifications that reach directly or indirectly into the whole economic and social fabric of Western Australia.

The Department of Mines was established on 1st January, 1894 as a regulatory body to ensure the orderly and impartial development of the State's mineral resources, so that the State and the community in

general could participate to advantage in these activities. This role still successfully persists today.

The creation of the Geological Survey in 1897, followed by the establishment of a system of State gold batteries and the transfer to the Department in 1902 of the Government Analyst's Laboratory (later to become the Government Chemical Laboratories), saw the emergence of another important role—that of provision of services to the mining industry. These service facilities have evolved and developed with the growth of the mining industry. As the industry became prominent and complex regulatory functions demanded a depth of internal services and expertise, many of the sections of the Department traditionally involved in regulation became able to provide further services in the form of technical advice, tenement maps and safety recommendations. Progressively this role has been extended to the situation where the Department is called upon to provide services to sectors of the community other than those directly related to the mining industry.

At the present time more than half of the resources of the Department are directed towards the provision of services to the industry and the public; approximately one-quarter is involved in the regulatory role with the balance to the provision of internal services.

The service functions of the Department may be summarised as follows:

provision of basic geological and technical data to mineral and petroleum explorers;

assessment of petroleum, mineral and groundwater resources of the State;

compilation of historical records of mineral and petroleum production and mine and petroleum field development;

provision of batteries in areas of mineral potential to assist exploration and development;

provision of mineral and petroleum tenement maps;

provision of safety advice on mining and petroleum fields;

provision of geological advice on urban development;

provision of chemical advisory and analytical services to a wide range of industries, including mining;

research and development in mining and industry.

The regulatory functions may be summarised as follows:

regulate and award the rights to explore for and mine minerals and petroleum;

environmental controls on mining and petroleum extraction;

enforcement of safety regulations in the industry;

ensure the safe handling of explosives, flammable liquids and other dangerous goods;

assessment and collection of royalties.

At 31 December, 1981 the approved establishment of the Department of Mines was 787 persons comprising 592 permanent staff; 43 Ministerial appointees; and 152 wages employees. At year's end, 737 positions were occupied and 50 were unfilled.

The Department administers 16 separate pieces of legislation which are listed in the Statistical Digest; the main ones being the Mining Act 1904, Mines Regulation Act, Coal Mines Regulation Act, Explosives and Dangerous Goods Act, Petroleum Act and Petroleum (Submerged Lands) Act. During 1981, as has been the case for many years, substantial Departmental resources have been committed to the drafting of a new Mining Act and Regulations.



## Structure

The Department comprises nine divisions responsible to the Executive of the Department. The overall structure is shown below.

The role of each Division and its organisational structure is referred to separately in the report of each Division.

## Staff

The 592 Public Service Act positions in the Department at 31 December, 1981 comprise 258 in the Professional, 200 in the Administrative and Clerical and 134 in the General Divisions.

Due to resignations, retirements and transfer or promotion, 108 positions fell vacant during 1981 representing an 18.25 per cent turnover. At any one time up to 50 positions were vacant due to the time necessary to advertise, select and make appointments. The combined result was that the Department had considerable difficulty in meeting the demands on its services.

Particular problems were encountered in filling positions in the State Mining Engineer's, Petroleum,

and Geological Survey Divisions reflecting the high demand for qualified people in these areas. The rewards available to mining engineers, petroleum engineers and experienced geologists and geophysicists in industry are in excess of those paid by the Public Service, particularly during busy times.

The Geological Survey recruited a number of appointees from the United Kingdom to partly relieve the situation.

During the year there was a strengthening of the Registration and Surveys and Mapping Divisions by the provision of additional staff, numbering 15 and 4 respectively to meet a very high level of demand.

## Future activities

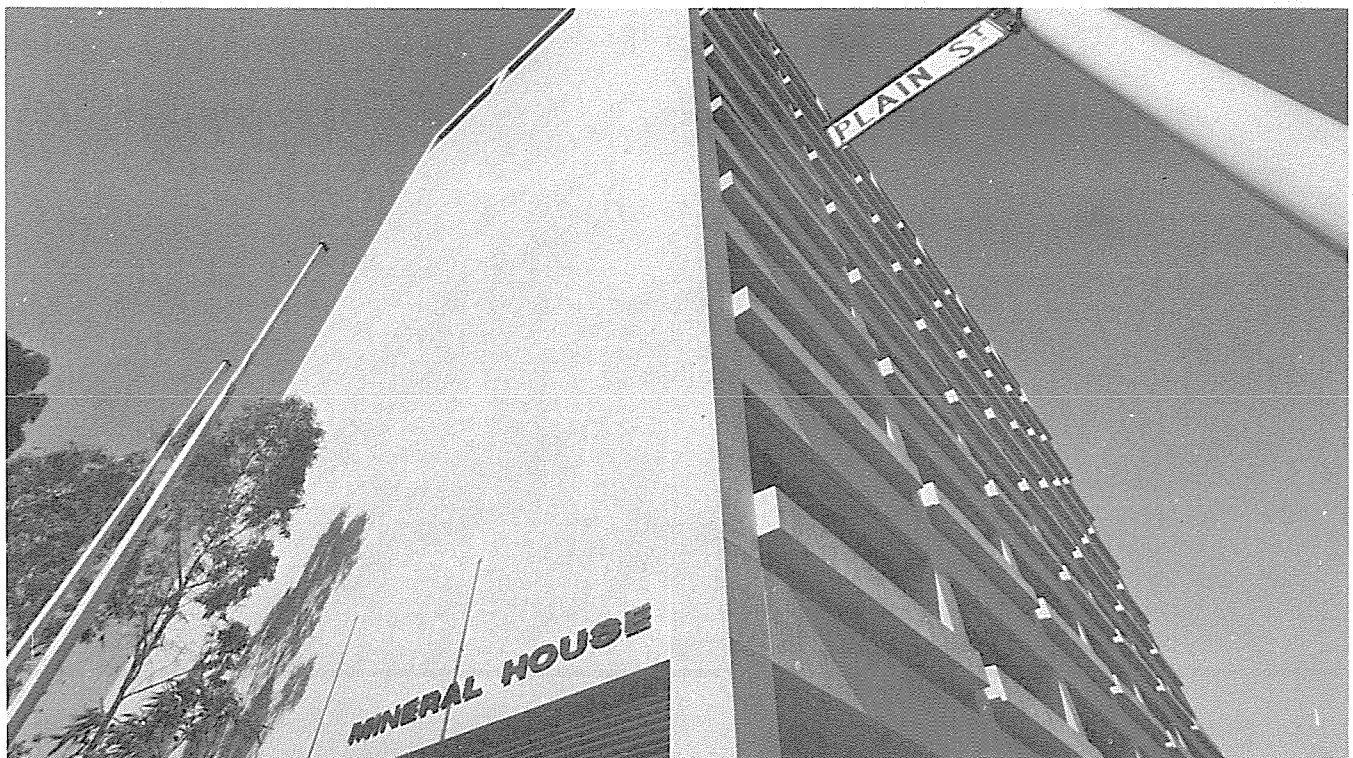
A major challenge facing the Department is that of introducing word processors, computers and other new technology to increase efficiency and at year's end planning for this was well in hand.

The Administrative Division of the Department is in the process of being strengthened by the addition

of specialists in the areas of management services, internal audit, word processing and computer management, so that the necessary changes can be effected.

Accommodation for the head office activities of the Department has been unsatisfactory for some years. As well as Mineral House where the majority of officers are stationed, there are a further four separate offices housing departmental staff. Planning for Mineral House Stage 2 is at an advanced stage awaiting funding priority. Stage 2 will comprise an eastwards extension of the existing building to double the available floor area.

The introduction on January 1, 1982 of the Mining Act 1978-81 to replace legislation first introduced in 1904 is a significant milestone in the history of the Department. It will necessitate a complete re-examination of established procedures and the workings of the new Act will be closely monitored particularly during the early years of operation and it may well be that further legislative amendments will be required.

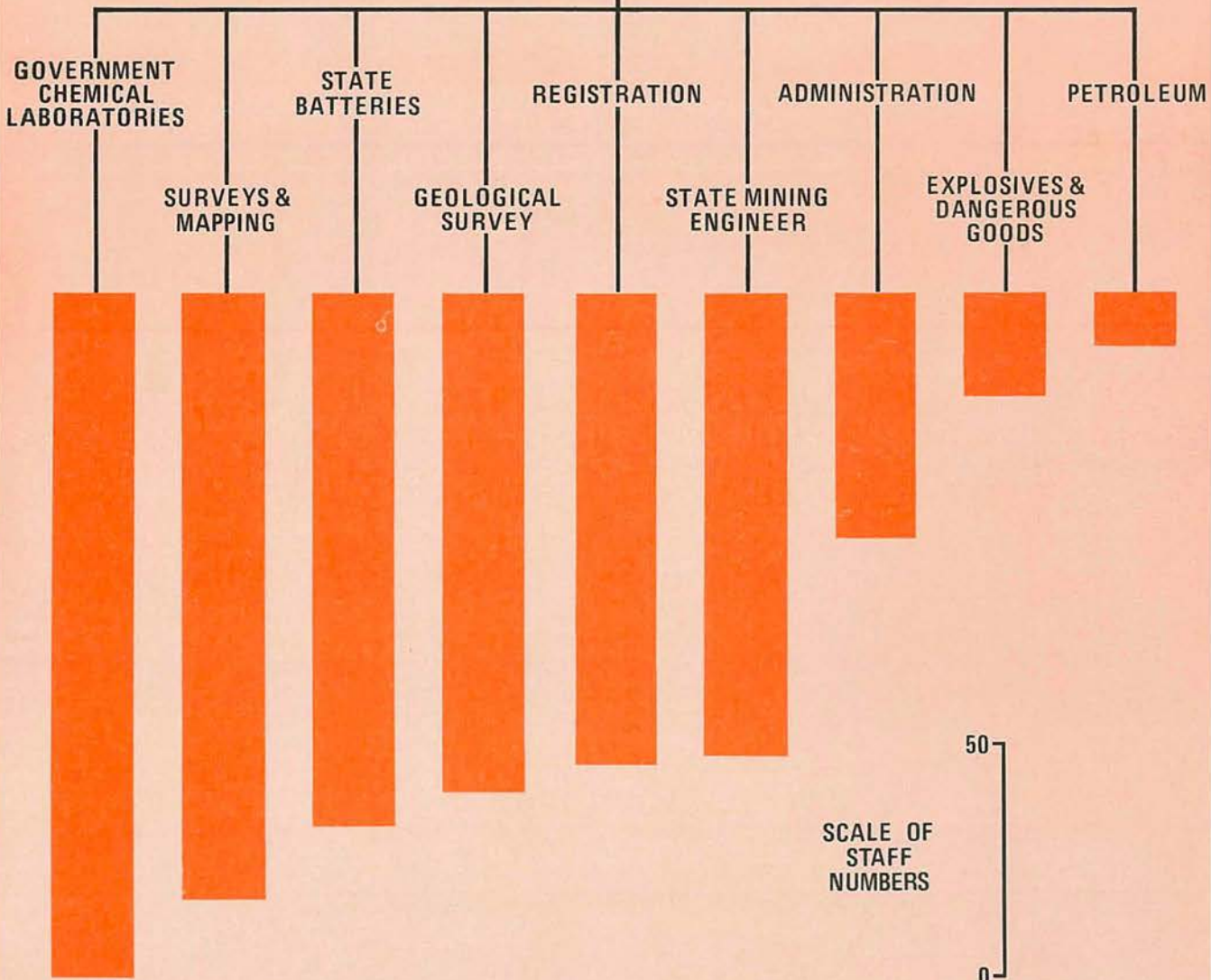


**DEPARTMENT OF MINES**

**UNDER SECRETARY  
D.R. KELLY**  
BE (Hons), PhD, MIE Aust

**ASST. UNDER SECRETARY  
E.J. BLAKE**  
Dip PTC Pub Admin

**ADMINISTRATIVE OFFICER  
A.L. DAY**



## Year of 1981

Highlights of the activities of the Department of Mines and of the mining industry in 1981 were as follows:

\* the Mining Act 1978 was further amended; the Regulations were finalised; staff were trained; information brochures were prepared and distributed to industry to permit the new Act to take effect from January 1, 1982;

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\* applications for new mining tenements continued to be received at a very high level numbering 24 939 for the year. This is of the same order as 1980, but is approximately five times greater than the mid 1970's levels;

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\* many years of detailed investigation of Devonian reef complexes in the northern part of the Canning Basin by officers of the Geological Survey Division were vindicated when oil was discovered in Blina No. 1 well by the Home Oil consortium. As a result of this success, these reef complexes are now assured of much closer exploration, in keeping with their true prospectivity;

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\* with less obvious economic significance, but with exciting implications for geological research, a gneissic rock from the Mt. Narryer area has been studied jointly by the Geological Survey Division and WAIT Physics Department and found to have an age of 3 633 million years. This is the oldest rock dated on the Australian continent and may be evidence of the earliest known emergence of a discrete land mass on the earth;

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\* construction of the North West Shelf project proceeded rapidly. The Explosives Division was heavily involved in establishing safe practices for the use of explosives on the Burrup Peninsula. The Petroleum Division also was closely engaged in examining and approving the proposals for the offshore platform and pipeline;

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\* on June 20, Sir James Foots officially opened the Teutonic Bore copper-zinc-silver mine. The mine was developed by Seltrust Mining Corporation Pty Ltd and Mount Isa Mines Limited;

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\* the Premier, Sir Charles Court, officially opened a new ore crushing and roasting plant on the Oroya lease at Trafalgar for Kalgoorlie Mining Associates (KMA). The new plant was required to treat sulphide ore currently being produced from the Perseverance and Lake View Shafts;



\* another milestone reached by KMA was the hoisting of the 10 millionth tonne of gold ore from the Hannans Reward Shaft at their Mount Charlotte operation;

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\* KMA let a contract to Thyssen Mining Construction of Australia Pty Ltd to sink a 6.5 metre diameter concrete lined circular shaft to approximately 1 170 metres at their Mount Charlotte operation;

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\* Western Mining Corporation Holdings Limited and the Shell Company of Australia Limited reopened the Windarra Nickel Mine and commenced development of a 3 metre diameter haulage shaft;

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\* Agnew Mining Company Pty Ltd at Leinster completed the sinking of a 7.6 metre diameter shaft to the 1 162 metre horizon;

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\* in May, the Premier, Sir Charles Court, officially reopened Hill 50 Gold Mine N.L. operations at Mount Magnet. Underground mining is progressing from the Morning Star Shaft and Water Tank Hill Shaft, and open cut mining from the Saturn deposit;

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\* Carbon-in-pulp operations for the treatment of battery sands were enlarged at Kalgoorlie, existing equipment was converted to this purpose at Meekatharra and a turn-key plant was installed at Coolgardie;

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\* a review of the functions of the Government Chemical Laboratories and inquiries to their clients confirmed a growing need for the expertise of the laboratories and the necessity for a substantial infusion of funds for equipment. The Government decided to set up a Scientific Co-ordinating Advisory Committee with terms of reference to cover planning, co-ordination and evaluation of all government analytical chemical services;

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\* the Western Australian Mining and Petroleum Research Institute (WAMPRI) was established under the Mining and Petroleum Research Act 1981. The inaugural Chairman is Mr J. H. Lord, a former Director of the Geological Survey Division of the Department.

## A TV camera that goes down holes.

One of the most useful tools used by the Drilling Branch of the State Mining Engineers Division is a TV camera that can be put down a borehole to look directly at the walls and check for damage. The camera is waterproof and can withstand a pressure of 1 000 metres of water so that it can be used in water bores up to 1 kilometre deep. The purchase of the camera was instigated by the Geological Survey as they hoped to examine the walls of uncased bore holes in what are called competent formations, such as limestone. By looking directly at the walls an estimate of the porosity of the rock could be obtained by measuring the cavities shown by the camera. This in turn would lead to an estimate of the quantity of water stored in the formation. The usual method is to take cores from the walls at various depths and measure the cavities in the cores. This is a slow and expensive method. The quantity of stored water is needed to work out how much water can be used in the area. Millstream is an example of an aquifer with many solution channels, making it difficult to find out the quantity of stored water by normal methods. A secondary consideration for buying the special T.V. camera was for the examination of existing bores for damage or silting up and, as so often happens, this is now the main use to which the camera is put.

The apparatus was purchased from a company in the United States and was designed to be put in a small vehicle and be powered from the batteries of the vehicle. This may be a satisfactory method in California but in our rather more stringent conditions in the North of the State it proved not a suitable arrangement. The control equipment had to be air-conditioned as the high temperatures led to too many failures in the electronic components so the whole of the equipment was put into a large truck together

with a 25KVA generator set to run the camera and winch and a powerful air-conditioner. The camera itself is a strong water-proof steel casing with lights, which is small enough to go down a hole with a minimum diameter of 14 centimetres. There are two viewing modes, one straight down and one with a rotating mirror to view the walls at right angles to the camera. To change from one mode to the other the camera has to be removed from the hole and the head changed. In operation the usual method is to first run the camera down to the bottom of the well with the straight ahead mode of viewing. Any major faults will be seen and a note of the depths at which these faults occur can be made. The camera is then withdrawn and the rotating head put on and a closer look at the damage can be made. The cable

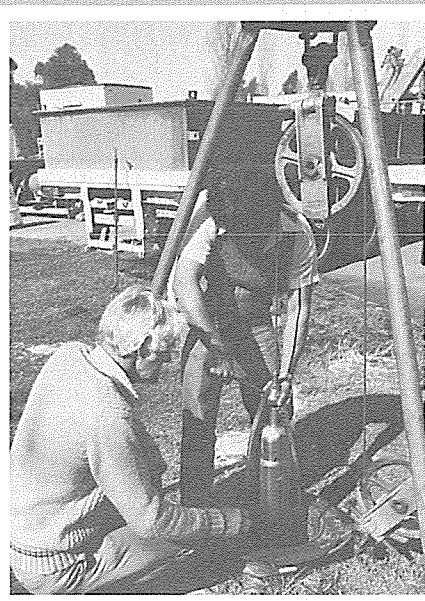


which lowers the camera is a normal logging type which is made up of high strength steel outer wires wound over a conductor. All the power for the camera and the return signal as well as the power for the lights go up and down through this single conductor. The returning signal is fed into a TV set so the operator can see what is happening and a video tape recording is made of all runs for study later. To aid the operator the depth of the camera at all times appears on the TV screen and is recorded on the video tape automatically so at any time when the tape is replayed all depth data are available.

For most work the operator can perform about 2 runs a day in a bore of some 500 metres depth and the Mines Department has 2 people skilled in its use. The camera has proved to be very popular and is often called in when a water bore is giving trouble. The camera allows the bore walls, screens and junctions to be examined for cave-in, corrosion or silting and the fault depth to be determined. Often a new bore will be investigated and a recording of the run given to the company or Shire having the bore drilled. This is good public relations as the people commissioning the bore can see that a good job has been done from the start.

The Mines Department operates the camera for anybody who has a legitimate use of the equipment and the cost is \$550 per day plus \$1 per metre scanned. This is a modest charge as the total equipment now in use is around \$100 000 capital investment.

The down-the-hole TV camera is the only one of its sort in Australia and soon will be joined by a new camera which will allow colour recording. This new equipment is being built in the Department and will soon be working as hard as the existing black and white camera.



## State Mining Engineer's Division

J. K. N. Lloyd  
State Mining Engineer

The value of mineral production (excluding petroleum and construction materials) at \$2 382 802 449 was 2.43 per cent higher than the value of production for the previous year.

Iron ore production at 75 308 919 tonnes was 9.7 million tonnes less than the output for 1980. Sales at \$1 130 million represented 47 per cent of the total value of mineral production for the year. Hamersley Iron Pty Ltd which exported 27.7 million tonnes through Dampier was the State's leading iron ore producer closely followed by Mt Newman Mining Co. Ltd, with 27.4 million tonnes exported through Port Hedland. There has been no iron pellet production since the pellet plants at Dampier and Cape Lambert were placed on a care and maintenance basis early in 1980. However, 23 000 tonnes of pellets were shipped from its stockpile at Cape Lambert by Cliffs W.A. Mining Co. Pty Ltd.

Alumina output from Pinjarra and Kwinana at 3.7 million tonnes had an estimated value of just over \$548 million based on average Australian values published by the Bureau of Mineral Resources. This Alcoa of Australia (W.A.) Ltd output was slightly higher than for the previous year. Bauxite feed for the two refineries was obtained from surface mining operations at Jarrahdale, Del Park, and Huntly. It is anticipated that production from the Willowdale minesite will commence in 1983 on completion of the Wage-rup refinery. Construction is continuing at the Worsley refinery site of Worsley Alumina Pty Ltd. In the West Kimberley goldfield, exploration continued on the Mitchell Plateau deposit. Exploitation of this reported 410 million tonne ore body is expected on increased demand for alumina.

Nickel ores and concentrates totalling 491 840 tonnes and valued at \$324 354 244 were obtained from mining operations at Kambalda, Nepean, Emu Rock, Carnilya Hill, Leinster and Windarra. Throughput at Western Mining's Kalgoorlie smelter amounted to 319 132 tonnes

was \$26 million less at \$153 313 613. Falling gold prices were responsible for the decline in total value as the Perth Mint selling price at the end of 1980 was \$503.05 per fine troy ounce as compared with \$356.90 per fine troy ounce at the end of 1981.



of concentrate and 70 842 tonnes of lateritic ore. The Company's nickel refinery at Kwinana also produced as by-products, ammonium sulphate, copper sulphide, and mixed sulphides.

At the end of the year Agnew Mining Co. Pty Ltd completed sinking its 7.6 metre diameter shaft to 1 162 metres. In the coming year the Company proposes to construct a 4.26 diameter vertical ventilation shaft to 1 030 metres using shaft drilling methods new to Australia. The progress of the C.S.D. 300 Hughes shaft drill will be watched with interest by this Department and the mining industry.

Although gold production increased by 1 086 kilograms to 11 888 kilograms as compared with the previous year, the total value

The State's leading gold producer was Newmont Holdings Pty Ltd at Telfer where recorded production for the year was 3 903 kilograms from 483 995 tonnes of ore.

During the five years that this open cut mine has been in production 2 130 404 tonnes of ore has yielded 24 909 kilograms of gold. Kalgoorlie Lake View Pty Ltd operating the Mt Charlotte mine at Kalgoorlie on behalf of the Kalgoorlie Mining Associates produced 2 574 kilograms of gold from 777 439 tonnes of ore. Production from its operations at Fimiston amounted to 766 kilograms. Work has commenced on the construction of a 6.5 metre diameter shaft, at Mt. Charlotte, to be known as Cassidy Shaft. At Norseman, Central Norseman Gold Corporation won 2 493 kilograms of gold from



208 244 tonnes of ore. Prospectors were active in most of the goldfields with over 500 small mines producing in many cases less than one kilogram of gold. It is expected that this interest will continue notwithstanding the depressed state of the gold market.

The beach sand mining industry income was down \$10 million as compared with the previous year. Four companies mining at Capel and Eneabba produced over a million tonnes of various heavy mineral sand concentrates valued at \$72.3 million.

Coal production continued to increase with a record output of 3.25 million tonnes valued at \$68.25 million at the pit head. The two operating companies between them produce coal from one deep mine and three open cuts. It is considered that the coal industry can meet future increased demands which have been estimated as 8 million tonnes per annum by the end of this century. This Division continued its work on the rehabilitation of old abandoned mine sites within the Collie basin. It is pleasing to note that both companies have appointed senior staff for the purpose of developing and carrying out rehabilitation programmes at and adjacent to open cut mine sites.

**Exploratory drilling**

The Drilling Branch was engaged throughout the year in exploratory



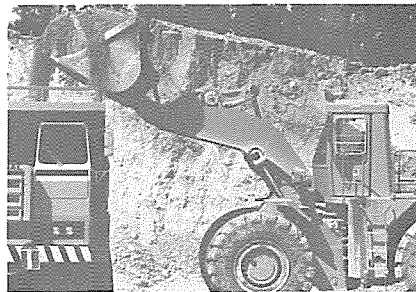
drilling for water at Boyanup, Gillingarra, Lake Clifton, Harvey, South Perth, Cundelee, and Guilderton. A record 12 420 metres was drilled as part of the Statewide groundwater investigation, drought relief, groundwater monitoring, and

an investigation of the effects from land clearing. Thirty-five bores were inspected using the Division's television camera unit which has proved to be a useful tool in the location and visual examination of defects in screens and casing.

**Mining development**

**Alumina**

*Alcoa of Australia Limited* mined a total area of 161 hectares, comprising 65.7 hectares of average depth 3.65 metres at the Jarrahdale minesite and 95.3 hectares of average depth 3.78 metres at the Del Park and Huntly minesites near Pinjarra. Total area rehabilitated was 209.2 hectares, which was 48.2 hectares in excess of the area mined during the year.



The Del Park section of the Pinjarra mining operation was relocated from the Marrinup site to the Scarp Road area in December. The new Willowdale mine was commissioned but full production will not commence until 1983. The overland conveyor from this site to the Wagerup refinery site was completed, dimensions being 5 kilometres long and 900 millimetres wide with a capacity of 2 000 tonnes per hour. The ore receival facility at Wagerup was commissioned.

Further work on the computer based Blasting Acoustics Model, operated to predict weather-caused exaggeration of the effects of blasting, resulted in an improved capacity to predict unacceptable levels of blast noise which may be reflected from the atmosphere onto remote locations.

Major items added or replaced included—Jarrahdale: four haul trucks, a second tertiary cone

crusher and a second vibrating wire screen. The fixed boom stacking conveyor was replaced with a slewing boom stacker.



Del Park and Huntly: one production loader and one rubber-tyred excavator with an hydraulic rock breaker.

Willowdale: one production loader, one road grader and seven 20 tonne trucks.

Pinjarra Refinery: a spent liquor heat recovery system to reduce steam wastage; a computerised process control in the digestion area; a 5 000 megalitre water storage facility; and a relief containment system to prevent discharge of caustic slurry to the atmosphere.

Kwinana Refinery: a fuel oil heating station in the powerhouse and an oxalate removal system.

**Arsenic**

There was very little activity in the Wiluna area to extract arsenic trioxide from the surface tailings dumps. Only 1.5 tonnes was produced.

**Attapulgit**

*Mallina Holdings Limited* excavated no ore but about 14 000 tonnes of stockpiled material was treated at Narngulu. Construction of a pilot plant to produce acid activated clay was commenced.

**Barite**

*Dresser Minerals International Inc.* operated a mine producing ore from five deposits in the North Pole area. 98 800 tonnes of ore were mined and treated at North Pole prior to

ceasing operation in September 1981. 27 700 tonnes of barite was transported to Port Hedland for further treatment. The mine and plant at North Pole have been placed on care and maintenance while the treatment plant in Port Hedland is worked intermittently using stockpiled ore to supply local consumers. Prior to closure of the mine 35 persons were employed. This has since been reduced to 5 full-time employees.

### Clays and shales

Four companies operated in the Perth Region during the year, excavating suitable clays for the manufacture of bricks.

*Midland Brick Company Pty Ltd*, the largest producer, operates pits in the Shires of Swan, Toodyay and Chittering.

*Chandler Clay Pty Ltd* is continually upgrading its operations and hopes to double output capacity in 1982. A pilot plant is under construction so that experimental work can be carried out on pelletising the rejected fines of the tailings dump. Reported production for the year was 6 658 tonnes of absorbent material.

### Coal

The new record output of 3 254 403 tonnes of coal from the Collie Coalfield exceeded the previous year's output by 102 933 tonnes. Open cut mines produced 2 577 548 tonnes or 79.2 per cent of the total output.

The total value of the coal produced was \$68 251 534, an increase of \$7 534 190 over the previous year's value.

There was an increase of 82 persons employed in the coal industry at Collie, to 992 at the end of the year.

The currently operating mines have together produced 32 891 925 tonnes or just over one half (51.2%) of the total output of 64 251 732 tonnes won from the field since mining commenced in 1898. Over

one quarter (26.24%) of this total output has been won from Muja Open Cut.

*Western Collieries Limited*. At the Western No. 2 Mine an increase in output of 46 095 tonnes resulted in a new record production figure of 676 855 tonnes of coal. Of this, 133 770 tonnes, or practically 20%, was from the separate East Extended Area from which 361 941 tonnes of coal have been extracted during the past five and half years since mining commenced there.

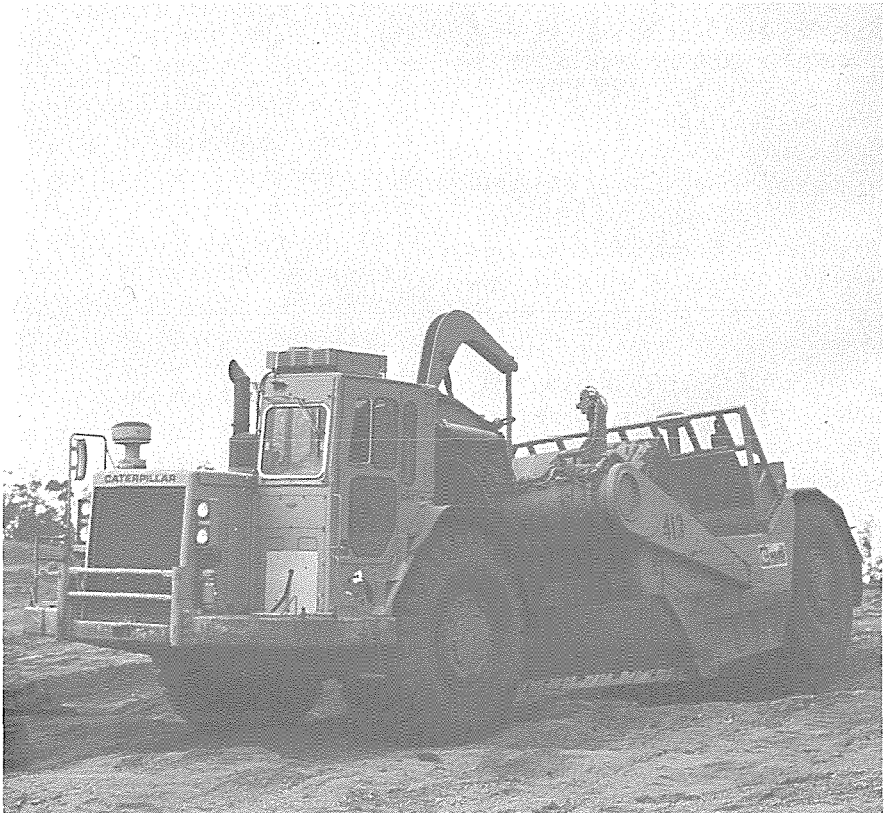
Spontaneous combustion, water problems and strata movements were experienced in various areas of the widespread colliery. These occurrences are indicative of the conditions to be met in extending mechanised operations and in maximising coal recovery from underground workings.

Work was completed in extensive areas of the mine, including No. 6A West "A" Panel, No. 3B East "A" Panel and in the lower areas of No. 4B East and No. 3B West Districts and No. 6A East "B" and "C" Panels. There is a continual reduction in the available

areas for winning coal as districts are becoming rapidly worked out in the main part of the mine. To offset this, rapid advances are being achieved in development at the East Extended Area, particularly where continuous mining units are installed in the North Laterals.

At the East Extended Area, some depressurisation of aquifers in the roof strata was being investigated in the general area of a group of development headings where dewatering holes were being drilled to a distance of some 30 m up from the roof of the workings. The Edeco Mini Hydrak drill which was installed for this Australian Coal Industry Research Laboratories Limited project was used for the purpose.

Four hundred carbon monoxide filter type self rescuers were purchased by the company in pursuance of a programme introduced by the Manager to promote the wearing of these devices on the basis of voluntary co-operation by the workforce. Training sessions were held and there appeared to be over fifty per cent positive response by the miners.



A gravimetric dust sampling survey was carried out during August. Whilst most of the respirable dust concentrations were well below the recommended Threshold Limit Value of  $5 \text{ mg/m}^3$ , it was apparent that the operating conditions in continuous miner working places must be constantly assessed and controlled.

The Western No. 5 Open Cut Mine the output of 835 053 tonnes of coal showed an increase of 51 631 tonnes over the previous year's output but was, however, less than the record output of 873 759 tonnes produced during 1979.

The large equipment in use at the mine included a Komatsu HD 1200M 120-tonne capacity mechanical drive dump truck and Komatsu D455A and Caterpillar D10 bulldozers. The latter two units have flywheel horsepower ratings of 463 kW (620 HP) and 522 kW (700 HP) respectively. As additional installations of large equipment are expected, there were significant extensions and improvements to the workshops, including the erection of additional bays to accommodate larger trucks.

Distances and areas are extensive within and between the various excavations of this widespread mine. Impressive progress was made on bush clearing and top overburden removal in continuation of mining to the south east of the Main Excavation and in preparation for opening out the Western No. 5C Area. Ancillary works included road construction, relocation of power lines and provision of slurry entrainment areas.

Rehabilitation procedures continued to be developed and included extensions to the backfilling of overburden in the mined out excavations and the adjointment of surface overburden dumps. Towards the end of the year, a Rehabilitation Officer was appointed to co-ordinate activities.

Wide areas of coal were exposed and won from the Cardiff and Neath Seams, mainly at the south-south eastern end of the Main Excavation and at several sites in the

Western No. 5B Excavations. Steep gradients of up to 1 in 5 provided some operational difficulties which required special working precautions.

Western Collieries Ltd initiated arrangements towards opening out a new open cut coal mine in the Western No. 3 Area.

*The Griffin Coal Mining Company Limited.* At the Muja Open Cut, with an output of 1 734 805 tonnes of coal, there was a decrease of 2 483 tonnes from this largest single producer on the field.

Several creeps of sedimentary strata over the faulted area on the granite contact on the west wall of Block No. 9 resulted in remedial measures being undertaken to restore stability on the wall. Seismic reflection and refraction surveys were undertaken to upgrade information on the fault and the granitic—sedimentary contact and, thereby, provide for improved forward planning of safe profiles on the wall as excavations continue to the north.

Major new workshop buildings were constructed and extensions and additions were effected for the administration offices and general infrastructure around the mine.

Large quantities of accumulated silt were removed from the old underground workings of the abandoned Hebe Mine, down from the face line of the open cut. Special precautionary measures were taken in operating excavators and vehicles on final overburden removal over the top of the Hebe Seam in this area where there is only the nominal coal beam in the roof, particularly where the coal was steeply dipping near the faulted zone.

Coal was won from diverse seams and widespread areas at the mine from and between the Ate Seam on Block No. 10 down to the Iona Seam on Block No. 8 and along the East Extension Area. Approximately one half of the output was, however, won from the Hebe

Seam, mainly from East Section Panel No. 7 and from the south of Block No. 9.

Good progress was made on opening out the Block No. 10 Excavation in continuation of development to the north on the west side of the major fault. Practically all of the coal on the upthrow or east side of the fault was exposed and won out to the northern limit of the currently opened out excavations.

The backfill programme proceeded very satisfactorily with progress evident on the widespread arc round the south eastern, southern and south western perimeters where, following connection with the west wall, the only discontinuity in the terraced profiles of the dumps was the south eastern access road entry.

The extensive range of heavy excavating and haulage equipment now includes four Demag H241 hydraulic excavators with  $14 \text{ m}^3$  capacity buckets.

The Chicken Creek Open Cut, the first new mine to be opened on the field during the past 11 years, commenced coal production from the box cut on the Centaur Seam on Monday, 19th October, 1981 after the passage of approximately eight months from the initial opening out with the commencement of bush clearing on the 26th February. The output amounted to 7 690 tonnes of coal.

Unconfined and confined groundwater provided considerable operational problems in this area where special depressurisation and dewatering techniques were being applied. Seventeen persons were employed at this mine which is located some 4 km to the east of Muja Open Cut.

Good progress was made on opening out the box cut down to the Centaur Seam. Prior to the introduction of scrapers towards the end of the year, the excavation was approximately 300 m long on the strike and approximately 100 m wide down dip from the backwall. Swamp reclamation and road formation was effected with overburden removed from the box cut.



## Cobalt

*Western Mining Corporation Ltd* transported the remainder of the broken stockpile from the "Patch" Cobalt Pit to the Kalgoorlie Nickel Smelter, and from 11 000 tonnes of ore treated some 83 tonnes of cobalt was recovered.

## Copper

*Seltrust Mining Corporation Ltd* and *Mount Isa Mines Ltd* brought their Teutonic Bore Mine into production during the year, after the 300 000 tonnes/year concentrator was commissioned in February. Ore produced from the open pit operation amounted to 305 000 tonnes after 5.34 million tonnes of overburden was removed. Portal construction for a decline was commenced in November. This portal is located on the eastern side of the pit wall and the decline will give access to the ore body which will be mined using underground mining methods.

Ore reserves are currently estimated at 1.38 million tonnes containing 4.2% copper, 13.1% zinc, 0.8% lead and 180 gms/tonne silver.

## Dimension stone and aggregate

Products under this heading include railway ballast, road metal, armour stone, aggregate for concrete, and granite blocks.

*Adelaide Quarry Industries* prepared a variety of aggregates for local requirements. The Narrogin quarry operated for most of the year and the Roelands quarry operations ceased in April.

The company opened a new quarry and assembled a crushing and screening plant near Karratha in January 1981.

From October to December 1981 the company operated a quarry 30 km east of Fitzroy Crossing to produce crushed rock and aggregate for the main Roads Department. An average of 10 persons were employed.

A contract to supply crushed rock to the main Roads Department resulted in this Company establishing a quarry about 20 kilometres north of Teutonic Bore. Production recorded was 32 000 tonnes of rock crushed in the latter part of the year.

This company also produced some 5 500 tonnes of crushed rock from a quarry east of Norseman.

*Specified Service Pty Ltd* operated a quarry and treatment plant at Mount Regal producing 164 000 tonnes of crushed aggregate for use in the Karratha area. A plant operated at Pannawonica in 1981 produced 75 000 tonnes of ballast and 30 000 tonnes of fines used in the construction of Cliffs Robe River Iron Associates railway line extension to the Eastern Deepdale deposits. An average of 8 persons were employed throughout the year.

*Bell Basic Industries Ltd* operated their large quarry at Maddington throughout the year. A new quarry is being developed to the east of this quarry.

*Bruce Rock Shire Council* operated their granite quarry throughout the summer months, the resultant aggregate being used for local purposes.

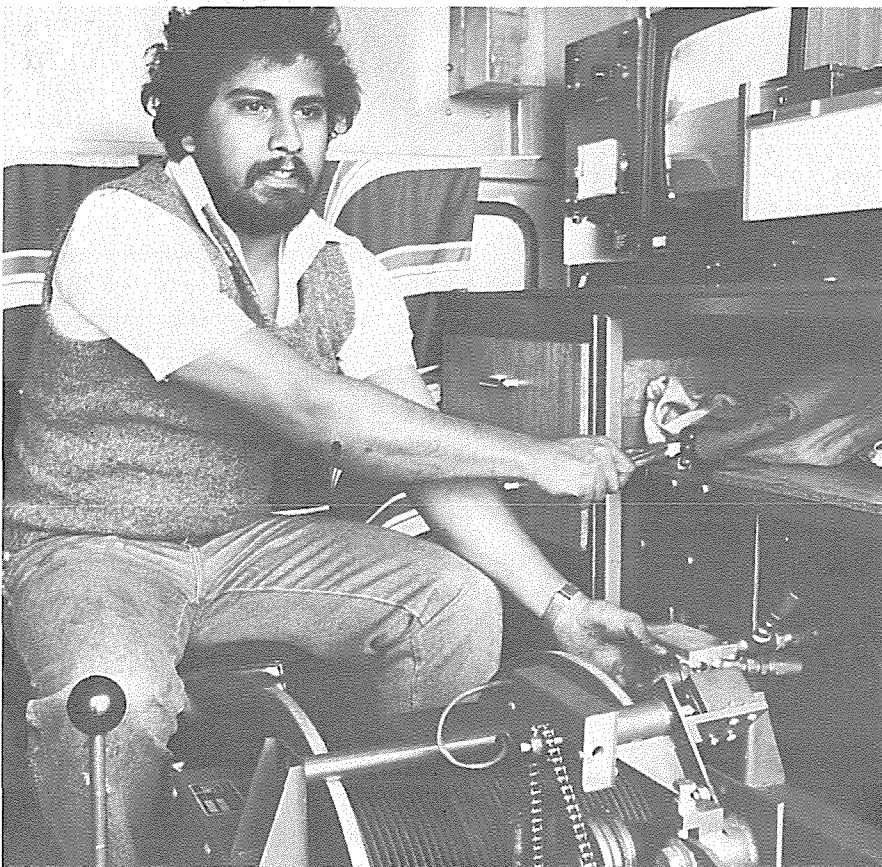
*John Holland (Constructions) Pty Ltd* operated the Meckering quarry, ceasing late in August. The crushed aggregate was for ballast and for use in the manufacture of concrete sleepers.

*Kellerberrin Shire Council* commenced operations in a small quarry producing crushed aggregate for their own use.

*Pioneer Concrete (W.A.) Pty Ltd* (Quarries Division) operated quarries at Herne Hill, Byford, Walkaway and Fernbrook. The Fernbrook quarry was commenced early in the year to supply aggregate for the Worsley Refinery project.

*The Readymix Group (W.A.)* at Gosnells and Gelorup quarries produced aggregate throughout the year. A plant was constructed from parts of two mobile plants at Albany and operated from February onwards. Operations at the Westrail Chris Hill quarry ceased in April when the contract was completed.

The Readymix Group operated a plant at Quobba between May and August, producing material for



road construction between the North West Coastal Highway and the Blowholes, north of Carnarvon.

A plant at Homestead Creek, near Newman, produced river shingles intermittently and the same mobile plant was used at Hardey River near Paraburdoo to supply river shingles for local use.

### Feldspar

*Unimil Pty Ltd* have re-opened the old feldspar quarries at Londonderry. On site a new crushing and wet screening plant capable of recovering 50 tonnes per day was installed. Final product recovery is made by hand picking off a slow moving belt. Three females are employed to do this work on a casual work basis. Four permanent employees work at the operation.

Material broken for the year amounted to 600 tonnes from which 400 tonnes of feldspar and 44 tonnes of lepidolite was recovered.

### Garnet

*Target Minerals N.L.* constructed and commissioned a four tonne per hour wet garnet concentrate plant on their mine site at Port Gregory. The drying, screening and packaging facilities at Geraldton were also expanded and upgraded.

### Gold

*Newmont Holdings Pty Ltd* operating at Telfer reported the production of 3 903 kilograms of gold in 1981 from 472 833 tonnes of ore milled. Some 11.12 million tonnes of material was broken in 1981; ore amounted to 398 000 tonnes, the remainder being waste and low grade ore.

Mining beneath the water table has commenced in the principal pit at Telfer making dewatering necessary. Pilot testing and studies into the processing of ore from low grade mineralization are at an advanced stage. An average of 267 persons were employed at the mine site, of

whom 121 were employees of Quest Mining, a contracting company employed for the removal of waste material from the opencut mine.

**Peak Hill Mining District.** *Pima N.L.* installed a new crushing and screening plant at the old Horseshoe Lights mine. At the same time, 277 400 cubic metres of waste was removed to allow open cut mining of the ore body and excavations made to form the cyanide leaching vats. The plant consists of a jaw crusher feeding two hammer mills as secondary and tertiary crushers. The product is divided by screens into coarse (+ 9 mm) and fine (- 9 mm) material. The coarse material is used to line the bottoms of the excavated cyanide leaching vats to provide an aquifer for pregnant solutions. The finer material fills the rest of the vats. The gold is recovered from solution by the carbon-in-pulp method.

Ore was introduced to the leaching process but no gold recovery was reported for the year. Towards the end of October only four of the eighteen men remained on site when ore breaking was suspended until gold extraction allowed a capital flow.

At *Peak Hill Goldmines* the four partners were constructing a treatment plant on the old Peak Hill State Battery reserve over which they hold a 21 year lease agreement, while also producing gold from alluvial material through a sluicing plant. The ore was produced from two of their leases in the vicinity of the old Peak Hill townsite.

**Murchison Mining District.** *Whim Creek Consolidated N.L.* mined the open cut on the Haveluck mine at Meekatharra for the first nine months of the year then used accumulated stockpiles over the final three months. The ore is treated by the heap leaching and carbon-in-pulp methods.

Dusty conditions have been improved by the placing of salt on the roads and watering it into the

soil. A Chem Jet dust suppression unit has also been added in the crushing and screening plant. A ball mill has been added to the carbon-in-pulp plant to improve extraction. A new contract for mining and carting, signed in July, required all vehicles and plant to be equipped with pressurised airconditioned cabs.

The Ingliston Gold Mine at Meekatharra was purchased by *Bond Resources* from the previous owners at the end of 1980. Mining of the No. 6 level stope was completed in July, and the latter part of the year was devoted to sinking the shaft to the No. 7 level and sinking a winze on the ore shoot below the No. 6 level. During the year, 21.2 metres of winzing and 40 metres of shaft sinking were completed. The total depth of the shaft increased to 313 metres from the surface. It is planned to upgrade the plant with the addition of a cyanidation and carbon-in-pulp extraction section. A new powerhouse and changeroom is to be constructed.

At Nannine, *Bond Resources* continued development until June when the crew was transferred to the Ingliston mine to develop there while the Nannine headframe was upgraded. Development figures were:

Driving	39.5 metres
Crosscutting	3.4 metres
Rising	17.7 metres

*Hill 50 Gold Mines N.L.* at Mt Magnet was officially re-opened in May under the management of Western Mining Corporation Limited. Throughout the year unwanted buildings were removed as labour permitted and a new plant installation completed. This included sections of the old plant which could be incorporated.

Underground development was carried out on the Tank Hill and Morning Star shafts, with some production from the Tank Hill Shaft. The main production came from the Saturn open cut with a little from the smaller Brown Hill open cut.



Development figures are as follows:

	Morning Star	Tank Hill
Shaft sinking (m)	94.1	—
* Special excavation (m <sup>3</sup> )	676.0	—
Driving (m)	46.2	145.6
Crosscutting (m)	138.3	80.8
Rising (m)	34.3	67.3
Stripping—ore (m <sup>3</sup> )	25.9	400.4
Stripping—mullock (m <sup>3</sup> )	241.9	71.5
Raise boring (m)	185.0	98.0

\*Special excavations include the 11 and 12 level plats and the 11 level control drive and loading level.

New equipment of note included the following.

Three 800 kilowatt generating sets were installed and commissioned bringing the powerhouse capacity to 3 200 kilowatts.

Mechanical and electrical installations in the treatment plant were completed.

A road hopper and coarse ore conveying system were installed.

The necessary offices, changerooms, crib rooms etc., were erected.

In the Morning Star shaft loading stations were completed below the 9 level and the 11 level.

*V. & D. Ridolfo Pty Ltd* during the year upgraded the central plant at Mt Magnet by the addition of a ball mill, automatic strake tables and a cyanide/pachuca/carbon-in-pulp recovery plant. A new diesel alternator was also installed. The plant will treat ore from their outlying mines and other ore may be purchased from small producers.

Twelve other small gold mines operated in the Murchison and Yalgoo goldfields and a large number of full time and part time prospectors were active throughout the area.

**East Coolgardie Mining District.** *Consolidated Gold Mining Areas N.L.*, who in 1979 successfully contested a Wardens Court hearing to obtain the Paringa Leases situated in the heart of the Golden Mile have sold these leases to C.S.R. Ltd.

Work done on the leases during the year included the rehabilitation of the Paringa South Shaft, the installing of a 372 kilowatt electric

winder, a 1.8 megawatt power generating station and various surface buildings. Ore breaking has commenced and at present there are some 7 800 tonnes of broken ore contained in stopes and underground ore pass systems.

Plans for the treatment of the ore are still vague; however several sites have been proposed by the company and a final decision will probably rest upon sulphur dioxide emission control requirements under the Clean Air Act.

*Western Mining Corporation Ltd* commenced the clean up of surface buildings to prepare for an open pit operation on the Great Boulder Leases at Fimiston. It is planned to develop the open pit over an approximate strike length of 650 metres, a width of 75 metres and to a depth of 30 metres. In an effort to retain the Main and Edwards Shafts, timber pentices have been constructed at the 60 metre level of each shaft. Plans of these pentices have been lodged with this office. To date 35 000 tonnes of gold-bearing material has been stockpiled on site.

The company has also reopened the old Victory Mine at St. Ives. Initially ore is being extracted by open pit mining but it is planned to decline off the bottom of the pit sometime in 1982. Production from this operation was 76 969 tonnes averaging 2.5 grams.

The Hunt Decline continued to supply some very high gold values during the year and gold won was treated at the Kambalda Treatment Plant as was gold won from the Siberia operations and the Victory open pit.

*Kalgoorlie Mining Associates* at the Mount Charlotte operations set off several large mass blasts enabling 1.2 million tonnes of broken ore to be produced. Ore treatment was down marginally on last year to 777 439 tonnes and gold recovered amounted to 2 574 kilograms.

The Man and Supply Shaft was deepened to the 17 level to improve servicing facilities and a new diesel truck with a payload capacity of 45 tonnes was purchased to assist the 30 tonne capacity trucks currently transporting ore from the mill holes to the underground crusher.

The collar construction of the proposed 6.5 metre diameter circular shaft has been completed and work on the presink is to commence early in the new year. This shaft is expected to be completed at the end of 1984 and in full production by 1987. Cost of the project will be around \$40 million.

Proven ore reserves at Mount Charlotte are quoted at 5.6 million tonnes at a grade of 4.7 grams/tonne.

At the Fimiston operations development and stoping off the Perseverance and Lake View Shafts continues to increase. Ore broken was reported at 135 819 tonnes while refractory ore treated at the Oroya plant was 178 870 tonnes. Gold recovered from this ore plus concentrates and plant clean up amounted to 766 kilograms. Ore reserves at Fimiston are quoted as 1.3 million tonnes at a grade of 8 grams/tonne. The average number of men employed was 635.

*North Kalgurli Mines Ltd*, towards the end of the year commissioned a Fluo Solids Roaster and a carbon-in-pulp plant at the Croesus Treatment Plant. In addition major renovations were carried out to the existing plant. Custom ore accounted for 95 700 tonnes of the 122 600 tonnes treated.

The majority of the underground workforce was concentrated in workings off the Main Shaft where a considerable amount of development work was done on the 10, 19 and 20 levels. Work has begun to



rehabilitate both the Croesus and North Kalgurli Shafts. Total gold production was 507.5 kilograms and the ore reserves remain unchanged from last year. The workforce was increased to 257 during the year.

At Mt. Monger the Daisy Mine closed down but several other small mines are still operating.

**Dundas Mining District.** *Central Norseman Gold Corporation Ltd* have completed the final stages of the Phoenix Plant modifications and have rehabilitated the Ajax Shaft down to the 460 metre level. Development work will now commence to pick up ore intersections indicated by surface diamond drilling.

Work has also commenced on the rehabilitation of the O.K. Shaft where a headframe has been erected so that the shaft may be repaired and development work commenced on the 2 and 5 levels. Both the Regent and Royal Shafts operated during the year and the North Royal Open Pit provided over 121 000 tonnes of gold ore after 2.6 million cubic metres of overburden was removed by scrapers and bulldozers.

Ore broken amounted to 232 558 tonnes while the recovery of gold from the 223 000 tonnes treated amounted to 2 493 kilograms. Total ore reserves are quoted at 413 100 tonnes while the average number of men employed remained around 352.

**Yilgarn Mining District.** Production of gold in the Yilgarn Area declined towards the end of the year. Several small mines either closed down or were put on a care and maintenance basis. Prospectors were active in the Parkers Range and Bullfinch areas.

*Kia Ora Gold Corporation N.L.* deepened the Marvel Loch Mine Shaft some 77 metres thus giving a total shaft depth of 208 metres. This enabled the Company to establish two new production levels and a loading pocket was constructed at the shaft bottom.

The Company was very active with surface exploration during the year and small ore bodies located

near the surface of the Marvel Loch Mine contain some 40 000 tonnes at a grade of 5 grams/tonne. The existing milling plant was upgraded during the year and custom milling carried out on ore from the Nevorio and Lenneberg Mines. The Company has recently acquired the Frances Firness Mine and in 1982 will sink the shaft some 30 metres to establish a level under the existing workings.

Ore, including custom ore treated during the year totalled approximately 40 000 tonnes from which 163 949 grams of gold were recovered.

Under a joint venture agreement between *BHP Co Ltd* and *Esso Australia*, dewatering of the Nevorio Gold Mine east of Marvel Loch was commenced. It is proposed to clear the mine to below the 4 level then commence a limited exploration programme which includes obtaining samples of ore for metallurgical testing, level development and diamond drilling. This work is planned for early 1982.

An open pit was established just east of the Nevorio Shaft and from 20 749 tonnes of ore treated at the Kia Ore Gold Treatment Plant some 83 930 grams of gold was recovered.

**Mount Margaret Mining District.** In the Northern Goldfields the *Lancefield Mine* continued to prosper. Both open pit and underground mining produced some 112 000 tonnes of ore which has been stockpiled until the gold treatment plant at Windarra is commissioned.

The new Eyer's Shaft has been sunk to a depth of 151 metres while Leighton Contractors Pty Ltd were contracted to remove 1.1 million cubic metres of overburden to expose additional oxidised ore. Men employed at Lancefield now number 56 and this will increase further once the Eyer's Shaft comes into production.

Of the smaller mines operating, the Tower Hill Mine had a successful year with all their ore being

treated at the North Kalgurli Mines Ltd Custom Mill. There were several small mines working around the Gwalia Open Pit.

#### **North Coolgardie Mining District.**

*Jones Mining N.L.* completed the sinking of a 70 metre shaft at the Goodenough Mine near Menzies and level development off the shaft bottom has encountered a high grade ore shoot. Ore treated to date is 1 342 tonnes at a grade of 7.27 grams/tonne.

#### **Gypsum**

*Bond Resources* operated their quarry at Mukinbudin.

*Swan Portland Cement Ltd* mined the Lake Hillman deposit near Kalannie and *Shark Bay Salt Joint Venture* increased the amount of gypsum mined at their Shark Bay deposits.

*W.A. Plaster Mills* and *H.P. Brady & Co Pty Ltd* continue to mine gypsum from Lake Seabrook and Lake Brown. In both areas good quality gypsum is becoming scarce. Some 32 864 tonnes were mined and transported from Lake Seabrook while 24 474 tonnes were mined at Lake Brown for processing and an additional 14 892 tonnes were stockpiled.

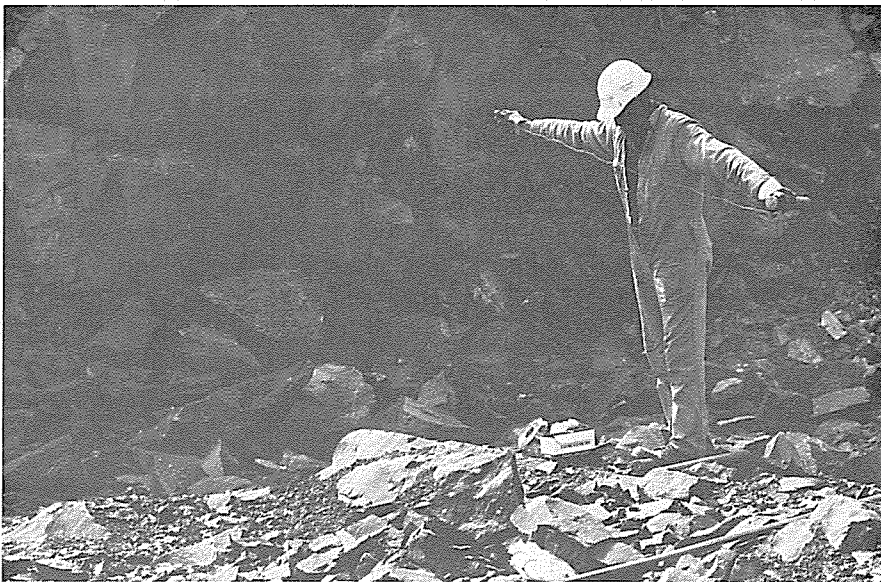
#### **Iron Ore**

*Hamersley Iron Pty Limited* produces ore from open cut mines at Tom Price and Paraburdoo. Crushing and screening plants at both minesites and a concentrator at Tom Price produce lump and fine ore which are blended and further processed at the port of Dampier. No pellets have been produced at Dampier since the pellet plant was placed on care and maintenance at the end of February 1980.

During the year 27.7 million tonnes of ore was shipped from Dampier of which 15.7 million tonnes was produced from Tom Price and 12.0 million tonnes from Paraburdoo.

New plant and equipment introduced during the year included—

- Modification of, and extension to the concentrator tailings system at Tom Price;
- Modifications and reconstruction of No. 2 crushing and screening plant at Tom Price was almost completed. Commissioning is scheduled for early 1982;
- Nine new haultrucks were brought into service at Tom Price as was a 50 tonne mobile crane;
- A new traffic crew building was constructed and commissioned for the railways section;
- Rehabilitation and upgrade of the Parker Point car dumper was completed early in 1981. The dumper is now fully enclosed and



- equipped with dust suppression and collection equipment;
- Development of the 4 west Orebody at Paraburdoo progressed satisfactorily with one shovel producing ore from this area from September, 1981.

Hamersley Iron Pty Ltd employed an average of 3 722 persons on their minesites during 1981.

*Cliffs Robe River Iron Associates*, mining ore which occurs on mesa tops along the Robe River near Pannawonica, continued operations throughout the year. After drilling and blasting, the ore is

loaded by electric shovels into haulage trucks which deliver the ore to one of two trainloading facilities.

Diesel electric locomotives haul trains consisting of up to 135 ore cars, 165 km from the mine to the Cape Lambert processing plant and port facility. At Cape Lambert the ore is crushed through four stages to minus 6 mm fines. This product is delivered to a 900 000 tonne capacity stockpile from which a bucket wheel reclaimer is used to deliver the product to the shiploader for loading of bulk carriers.

Since the pellet plant was placed on care and maintenance in April 1980 no pellets have been produced, but shipping of pellets continued from stockpiles. During the year 23 000 tonnes of pellets were shipped. A further 265 689 tonnes

of pellets remained on the stockpile at Cape Lambert. Shipment of pellets is expected to cease in March 1982 when the stockpile inventory will be exhausted. At this point it is planned to use this area to increase fines stockpiling capacity.

Production of fines during 1981 amounted to 12.9 million tonnes, about the same as the tonnage shipped. Average grade was 56.76% Fe.

Work on the Eastern Deepdale project was almost complete at the end of the year. The work included construction of a 24 km railway

line, train loadout facilities, 4.3 km of bitumen access road, workshops, offices, power supply and haulroads.

The project opens up 157 million tonnes of ore for mining, and production is anticipated in April/May 1982 after completion of mining Robe River mesas in the 2A train loadout area. Personnel and equipment from the 2A area will be transferred to Eastern Deepdale. Mining of mesas in the 2A loadout area will probably continue until 1983, after which all production will be from the Eastern Deepdale mesas. An average of 1 680 persons were employed by Cliffs Robe River Iron Associates at their minesites.

*Goldsworthy Mining Limited* produces ore from iron ore deposits at Goldsworthy, Shay Gap and Sunrise Hill. Ore at both minesites is primary crushed before being transported by rail to the treatment plant and port facility at Finucane Island. At Finucane Island, two products, lump ore (6 mm to 30 mm) and fines (minus 6 mm), are produced for export to Japan with spot sales to Korea.

The Goldsworthy mine, which produced 2.64 million tonnes of ore during 1981, is reaching the end of its economic life and mining is expected to be completed in 1982. Production from Shay Gap and Sunrise Hill totalled 4.50 million tonnes in 1981.

In the year, 2.70 million tonnes of lump ore, average grade 63.19% Fe and 2.66 million tonnes of fines, average grade 61.0% Fe were shipped from Finucane Island. Goldsworthy Mining Limited employed an average of 1 179 persons at their minesites during 1981.

*B.H.P. Minerals Limited* (formerly Dampier Mining Company Ltd) operates on Koolan Island and Cockatoo Island in Yampi Sound.

On Koolan Island ore was mined from the Main and Acacia ore bodies. Once drilled and blasted, ore is loaded by electric shovels or front end loaders into haulage trucks which deliver the ore to the primary crusher. After primary and

secondary crushing the ore is stored in a 60 000 tonne storage bin prior to being loaded onto vessels ranging in size from 50 000 tonnes to 115 000 tonnes capacity. During 1981 0.774 million tonnes of ore was shipped from Koolan Island at an average grade of 66.6% Fe. An average of 421 persons were employed on the island.

On Cockatoo Island a new fines stockpile loadout facility was completed during the year, increasing stockpiling capacity. A hydraulic backhoe excavator was introduced into production to assist in mining ore from below the high water mark. Only 0.68 million tonnes of ore was produced and this, at an average grade 68.8% Fe, was shipped. An average of 118 persons were employed on the Island.

*Mt Newman Mining Co. Pty Ltd* iron ore mining operations are centred on Mt. Whaleback, south of the Ophthalmia Range. Ore from the Whaleback mine is primary and secondary crushed before being stockpiled prior to transportation 426 km by rail to Nelson Point in Port Hedland. Low grade or contact ore is processed through a beneficiation plant to make a high grade product which is conveyed to the same stockpiles prior to riling.

During 1981, 31.61 million tonnes of ore and 63.99 million tonnes of waste were broken. The ore consisted of 30.35 million tonnes of Whaleback ore and 1.26 million tonnes of Marra Mamba ore. In 1981 14.32 million tonnes of lump ore and 13.12 million tonnes of fines were shipped from Nelson Point. At year end some 6.68 million tonnes of ore was stockpiled at the port and minesite.

Major projects completed during 1981 included—

- The extension of the Newman power station with installation of additional generating capacity;
- The new Ophthalmia dam and aquifer recharge system was completed at the end of the year. This will ensure adequate water supply for the Newman townsite

and mine and when full, will have a capacity of 30 million cubic metres of water;

- Upgrading of the No. 1 tertiary crusher building at Nelson Point was still in progress at the end of the year and is expected to be completed in mid 1982. Completion of the upgrading will allow more flexibility of treatment operations, improve spillage control, assist maintenance and cleanup operations and result in a reduction in exposure to dust of operating and maintenance personnel;
- An additional 100 houses for employees were commenced or completed during the year.

An average of 4 169 persons were employed by Mt Newman Mining Company Pty Ltd, together with 130 contractor's employees.

The *Australian Iron and Steel Pty Ltd* blast furnace facility at Kwinana was shut down from April to November and its future is uncertain due to world markets. The blast furnace was relined during the shut down.

*Agnew Clough Ltd (Wundowie Iron and Steel)* produced less than 4 000 tonnes of pig iron before operations ceased in February, due to declining world markets.

Production at the *Dampier Mining Company Ltd* Koolyanobbing quarries was substantially reduced during the year to an annual rate of one million tonnes of ore. Production at Dowd's Hill ceased in November and ore is now mined from the "A" and "D" deposits to take advantage of their low phosphorous content. Ore railed from Koolyanobbing in 1981 amounted to 1 205 291 tonnes. Average number of employees is quoted at 105 with some part time workers.

#### Lime

*Kalgoorlie Lime and Chemical Company* is commissioning a plant to produce lime products at Parkes-ton on the outskirts of Kalgoorlie.

The ore will be obtained from a limestone quarry situated near Kitchener on the Trans Australia Railway Line. There has been no significant production to date.

#### Limestone

There were 17 active limestone quarries in the metropolitan area and 10 in country areas.

*Bond Resources* is the largest producer followed by *Swan Portland Cement Ltd* and *Cockburn Cement Ltd*. The main usage is for road construction and cement production.

#### Magnesite

Mining of the deposits near Ravensthorpe by *Norseman Mining N.L.* was insignificant during 1981.

#### Mica

*Pilbara Mica Corporation Pty Ltd* mined mica from Mineral Claims on Pippingarra Pastoral Lease and transported the ore to Port Hedland. The company reported the production of 350 tonnes of mica from its treatment plant in the Port Hedland light industrial area. Sales to the Drilling Industry did not rise as the company had anticipated, and sales of mica for industrial purposes amounted to only 305 tonnes. Alterations to the production flowsheet were effected during the year to allow more flexibility in production of different sized mica products.

#### Mineral sands

*Allied Eneabba Pty Ltd* mined their deposit at Eneabba and the concentrates were treated at Narngulu, near Geraldton. An expansion of the wet circuit of the monazite plant has improved recovery rates of this mineral.

*Associated Minerals Consolidated Ltd* at Eneabba purchased additional mining plant from Jennings Industries Limited to allow for expanded activities. At Capel no new plant was added or installed during the year. The southerly advance of the primary wet plant increased due to the relatively shallow



ore in the Ludlow river area. This plant is now five to six kilometres from the secondary treatment plants.

The two beneficiation plants continued operations throughout the year.

*Cable Sands Pty Ltd* continued mining on the Prowse leases at Capel. Techniques had to be modified to combat the very high clay content in the ore zones. Two 25 metre thickeners were installed, one each in the primary and secondary wet plant water circuits. The ilmenite drier was converted to coal firing.

*Westralian Sands Limited* made no change to mining methods at the Yoganup Extended and North Capel orebodies. Exploration has continued at the Boyanup site and a test parcel prepared for metallurgical recovery trials. The drier was converted from oil to coal.

## Nickel

*Western Mining Corporation Limited Kwinana Nickel Refinery* increased nickel production over the previous year. By-products were ammonium sulphate, copper sulphide and mixed sulphides. The installation and commissioning of a 2 000 litre-per-minute water treatment plant was completed.

Western Mining Corporation Ltd continued to be the leading nickel producer in the State. The Windarra Mine, which is 50 per cent owned by the company was reopened and is expected to produce around 8 000 tonnes of nickel concentrate per year. The workforce at Windarra was increased to 264 and ore reserves have increased substantially to a reported 9.4 million tonnes. A three metre diameter raise bore has been completed from approximately the 467-metre horizon and will be equipped and used as a haulage shaft.

*Kambalda Nickel Operations* treated 1 430 745 tonnes of ore, comprising 1 265 958 tonnes (grade 2.82 per cent) from Kambalda,

76 374 tonnes (grade 3.63 per cent) purchased from Metals Exploration, and 88 413 tonnes (grade 3.76 per cent) from Carnilya Hill. On average 1 535 people were employed.

Because of improved ore reserves at depth in the Foster Ore Deposit, south of Kambalda, plans are in hand to sink a 4.5 metre diameter haulage shaft to a depth of 850 metres. Work will commence in mid 1982. Exploration south of Kambalda has resulted in additional ore being found. Reserves have been further enhanced with the purchase of the Mt. Edwards mine which has known reserves of 1.7 million tonnes of ore.

At the Kalgoorlie Nickel Smelter, production was significantly increased, with 319 132 tonnes of concentrate and 70 842 tonnes of lateritic ore being smelted. Towards the latter part of the year a major shut down of the smelter was required so that re-bricking of the furnace and repairing of boiler tubes could be effected.

The average number of men employed during the year was 367.

*Metals Exploration Ltd* continued operations at the Nepean Mine with a production of 92 090 tonnes of ore. Ore reserves are reported as being 325 810 tonnes at a grade of 3.17% Ni. The company is continuing to advance the decline for the development of ore blocks below the 12 level.

Feasibility studies are still continuing with respect to the Wannaway ore body south of Widgiemooltha and there is a possibility of a decline being developed from the surface for exploratory purposes. The company is also becoming active in the Forrestania Area, some 200 kilometres south of Southern Cross, as they recently acquired control of the known nickel ore deposits in the area.

*The Agnew Mining Company Pty Ltd* continues to develop its Agnew deposits. The sinking of the 7.6 metre diameter, 1 162 metre-deep shaft was completed at the end of the year and preparations are

now in hand to equip the shaft. Once this is completed a production headframe will be erected and the two new winders commissioned.

Early in 1982 a Hughes, Series 300 Combination Shaft Drill (CSD 300) will be assembled adjacent to the No. 1 shaft and will attempt to drill a 4.26 metre diameter vertical shaft to a depth of 1 030 metres. This technique, though previously used in other parts of the world, has never been used in the mining industry in Australia for vertical shaft sinking. If the CSD 300 is successful in drilling this shaft it is possible that it could revolutionise vertical shaft sinking in Australia, particularly in reasonably soft ground.

Some 418 875 tonnes of ore was treated in 1981 and 84 467 tonnes of concentrates recovered at a grade of 9.45% nickel and 0.41% copper.

## Salt

*Dampier Salt (Operations) Pty Ltd*, Lake Macleod Division, pumps a brine solution from a naturally occurring aquifer in Lake Macleod to crystallisers, where sodium chloride is deposited as a result of solar evaporation. The salt is harvested by mechanical harvesters and transported to a washing plant by trucks. At the washplant, the product is washed in brine to remove contaminants and stockpiled for drainage via a conveyor system and stacker. After drainage the salt is reclaimed by front end loader and transported by road to Cape Cuvier, where it is again stockpiled prior to ship-loading. On average 126 persons were employed at Lake Macleod in 1981.

*Dampier Salt (Operations) Pty Ltd*, at their Dampier Division, pumps sea water into primary concentration areas, which cover 8 200 hectares. Here the seawater is concentrated to a brine close to the saturation point for sodium chloride before being introduced to the crystallisers. Thereafter the operation is similar to that at Lake Macleod. An average of 172 persons were employed at Dampier in 1981.

*Leslie Salt Company* at their Port Hedland plant pump seawater into concentrating ponds at a rate of up to 800 cubic metres per minute. Through solar evaporation, the seawater is concentrated to a brine close to the saturation point for sodium chloride. This brine is pumped to crystallisers where further evaporation causes sodium chloride to be precipitated. When the depth of salt in the crystallising pond has reached approximately 20 cm the brine is drained off and the bed of salt harvested by mechanical harvesters and transported to the wash plant in road trains.

The salt is washed with brine solution to remove impurities in screw classifiers and on stainless steel static screens. The washed salt is drained on stainless steel static screens and stockpiled, where further drainage occurs. Road trains haul the salt to the port area stockpile and from there the salt is reclaimed for shiploading. An average of 67 persons were employed in Port Hedland of whom 18 were contractor's employees.

*Shark Bay Salt Joint Venture* continued operations at their Useless Loop site. Crystalliser pond area was increased by 13 per cent during the year to a total of 226 hectares.

*Lefroy Salt Pty Ltd* harvested 132 000 tonnes of salt from their Lake Lefroy ponds and exported 77 000 tonnes from their Esperance stockpile.

*W.A. Salt Supply* continued producing from sites located at Lake Deborah and Esperance. Total production amounted to 20 000 tonnes and a seasonal workforce of five men was used at each site.

### **Sand**

Thirty two sand pits were operated in the metropolitan area and thirteen in country centres. Many work on an intermittent basis dependent upon the orders received. The product is used for various purposes including glass manufacture, brick manufacture and cement.

### **Silica**

No mining of silica took place during the year from the Siberia deposit, but ore from the stockpile there was transported to the Kalgoorlie nickel smelter as and when required.

### **Talc**

*Three Springs Talc Pty Limited* developed and began operating an ore body east of the main pit. A hydraulic excavator and two dump trucks were added to the pit plant.

### **Tin and tantalite**

*Futuris Corporation Limited* operate an alluvial tin deposit at Friendly Creek, located approximately 100 km south west of Port Hedland. Plant capacity was increased in 1981 to 120 cubic metres per hour. The basic process is crushing and wet screening by trommel followed by separation through primary and secondary jigs.

The company reported that 25 000 tonnes of ore and 75 000 tonnes of waste were mined in 1981 for production of 38 tonnes of tin concentrate averaging 69.5% Sn. The average number of persons employed during the year was 25.

*Endeavour Resources Limited* operated at Moolyella near Marble Bar, mining tin and tantalite bearing eluvial and alluvial ores. The company reported that 300 000 cubic metres of waste was stripped to mine and treat 274 000 cubic metres of ore to produce 223.5 tonnes of tin/tantalite concentrates in 1981.

A further 308 000 cubic metres of waste was stripped from the Moolyella lead in preparation for an additional skid mounted mobile treatment plant with a capacity of 60 cubic metres per hour. This plant is schedule to go into production in mid 1982 and will only operate during the dry months. Employment varied from 30 early in the year to 45 when earthmoving and drilling contractors were active.

*Goldrim Mining Australia Limited* operated at Wodgina, mining an alluvial tin and tantalite deposit. The ore is treated by screens and jigs to produce a concentrate which is sent to Perth for separation. The company has reported an average weekly production rate of 900 tonnes of ore and 1 600 tonnes of waste. From the ore 15.93 tonnes of 52.9% Ta<sub>2</sub>O<sub>5</sub> and 9.61 tonnes of 72.8% Sn were recovered. New jigs and screens were installed in 1981, three dams were constructed to supplement existing water supplies and a new haul truck was purchased. The average number of employees in 1981 was seven.

*Pilgan Mining Pty Ltd* operated their mine and treatment plant at Pilgangoora throughout the year, treating 230 000 cubic metres of ore. A second plant was operated at Bare Hill, five kilometres north of the main plant between February and August, treating 27 440 cubic metres of ore. The plant at Trigg Hill treated 17 198 cubic metres of ore before ceasing operation in October 1981.

*Greenbushes Tin Ltd*, following the sharp decline in the tantalite market, reviewed their overall development and mining areas, and concentrated on tin after midyear. Underground development, primarily aimed at mining a large tantalite deposit, was reduced and priority given to mining the areas of higher tin content. The same priority was given to tin in the open cut mining.

A cassiterite tailings gravity-based retreatment plant was commissioned and processed 376 776 cubic metres of tailings. A ten tonne per hour tantalite concentration plant for the purpose of metallurgical testing was commissioned at the end of the year.

Experimental work on tin ore shipped from Tasmania by Aberfoyle Ltd continued throughout the year at the Kalgoorlie Nickel Smelter. Some 12 tonnes of tin was produced from 1 500 tonnes of ore.

## Uranium

*Yeelirrie Management Services Pty Ltd* treated some 6 100 dry tonnes of ore which had been transported from stockpiled ore at Yeelirrie to the Kalgoorlie Research Plant. Metallurgical testing of the ore continued throughout the year and the company has now announced that testing has been completed and the plant placed on care and maintenance.

## Vanadium

*Agnew Clough Limited (Coates Vanadium Division)* encountered several operational problems requiring major modifications and additions which included—

Undercover storage capacity for calcined pebbles, tank storage for pregnant liquor and polylined dam storage for barren liquor.

A wet scrubber system on the calciner exhaust stack.

Dust suppression equipment in the crushing and screening section.

A large fusion furnace and chilling table facility.

A total of 250 metres of exploratory drilling has indicated additional ore which, if proved, will double the total of proven ore available.

## Vermiculite

*Vermiculite Industries Pty Ltd* transported a further 176 tonnes of vermiculite from its Young River Mine to its processing plant in Perth. No mining was reported.

## Operations

### Inspectorates

**Perth.** The inspection staff worked well to maintain a good coverage of mining in the inspectorate over a period when increased activity in prospecting and mining for gold in the Yalgoo, Murchison and Peak Hill Mining Districts required many trips into these areas.

Several complaints were received from pastoralists regarding operators who have bulldozed surface areas of their pastoral leases, destroying pasture, to facilitate prospecting with the use of metal detectors. These operators are very difficult to track down as they work swiftly and leave the site. This practice has, unfortunately, led to a reversal of the good relationships

during the year. This includes ventilation inspections in the Karratha Inspectorate, which are undertaken from Perth.

**Karratha.** Iron ore mining continued as the dominant activity in the Inspectorate. Due to a downturn in worldwide industrial activity and particularly in the demand for steel, iron ore producers operated well



which previously existed between the genuine prospectors and the pastoralists.

On mines, greater emphasis was placed on ensuring the safe use of chemicals, and regular testing and sampling were undertaken by the Ventilation Section. All other inspectors have now become more involved in the use of toxic chemicals.

Although more fully covered elsewhere, it is worthy of note here that ground vibration tests of quarry blasting carried out by this inspectorate continues to prove that complaints of damage to residences are unfounded. In fact, it has been found that in general empty road trucks create ground vibrations of greater intensity at nearby residences than does blasting from rock quarries.

The nine Perth-based inspectors travelled a total of 230 000 kms

below full capacity in 1981. Company returns show a decrease of 3.7 per cent in the employment figures compared with 1980.

Following comprehensive exploration and evaluation programmes of their Argyle Prospect in the Kimberley region in 1981, it now appears that the Ashton Joint Venturers will commence mining for the commercial production of diamonds, on a limited scale, during the second half of 1982.

Iron ore producers continued their evaluation programmes and further winzes were sunk in the Newman, Tom Price and Paraburdoo areas.

**Kalgoorlie.** Activity within the Inspectorate continued at a consistent rate during 1981.

Highlights of the year included the official opening of the Teutonic Bore copper-zinc-silver Mine by the Chairman of Mt. Isa Holdings Ltd, Sir James Foots on June 20.



The mine was developed over a 2 year period by Seltrust Mining Corporation Pty Ltd and Mount Isa Mines Ltd. Mining operations in the initial stages will be confined to an open pit. However, a decline will be developed from within the pit to enable the deeper sections of the ore body to be mined.

On July 10 the Honourable Premier, Sir Charles Court, officially opened the new ore crushing and roasting facilities at the Oroya Plant of Kalgoorlie Mining Associates.

The plant features a Fluo Bed Roaster with a capacity of 160 tonnes per 24 hours and is the first roaster of this design to be installed in Australia to treat pyritic gold ore. Another milestone reached by the company during the year was the raising of the 10 millionth tonne of gold ore from the Mount Charlotte Operations.

The joint venture partners, Queen Margaret Gold Mines N. L. and Spargos Exploration N. L. officially re-opened the Mount Ida Gold Mine on May 26. This ceremony was performed by the Minister for Mines, the Hon. Peter Jones.

North Kalgurlie Mines Ltd also commissioned their new ore roasting plant towards the end of the year. The roasting unit is similar in design to the Fluo Bed Roaster commissioned earlier in the year at the Oroya Plant.

Several carbon-in-pulp plants were constructed and commissioned during the year with the larger plants being installed at the Croesus Plant of North Kalgurli Mines Ltd, Western Mining Corporation Ltd, Kambalda Ore Treatment Plant and the Windarra Treatment Plant.

The installation of gold treatment facilities at Kambalda and Windarra became necessary after Western Mining Corporation Ltd announced that the old Victory Gold Mine, south of Kambalda and the Lancefield Gold Mine, east of Windarra were to be re-opened.

Several new shaft sinking operations commenced during the year.

Kalgoorlie Mining Associates have let a contract to Thyssen Mining Construction of Australia Pty Ltd to sink a 6.5 metre diameter concrete lined circular shaft to an approximate depth of 1170 metres at their Mount Charlotte Operations.

Western Mining Corporation Ltd commenced sinking a 5 metre by 2 metre rectangular shaft at their Lancefield Gold Project.

The Agnew Mining Company Pty Ltd have contracted Australia Shaft Drilling Company to drill a 4.26 metre diameter shaft to a depth of 1030 metres at their Agnew Nickel Operations. This project will be watched with interest by the Mining Industry throughout Australia because this technique will be used for the first time in Australia for shaft drilling.

Most companies are experiencing difficulty in obtaining skilled labour for their underground operations and at the present time the larger companies have implemented continuous training programmes to ensure that future requirements for experienced miners will be met.

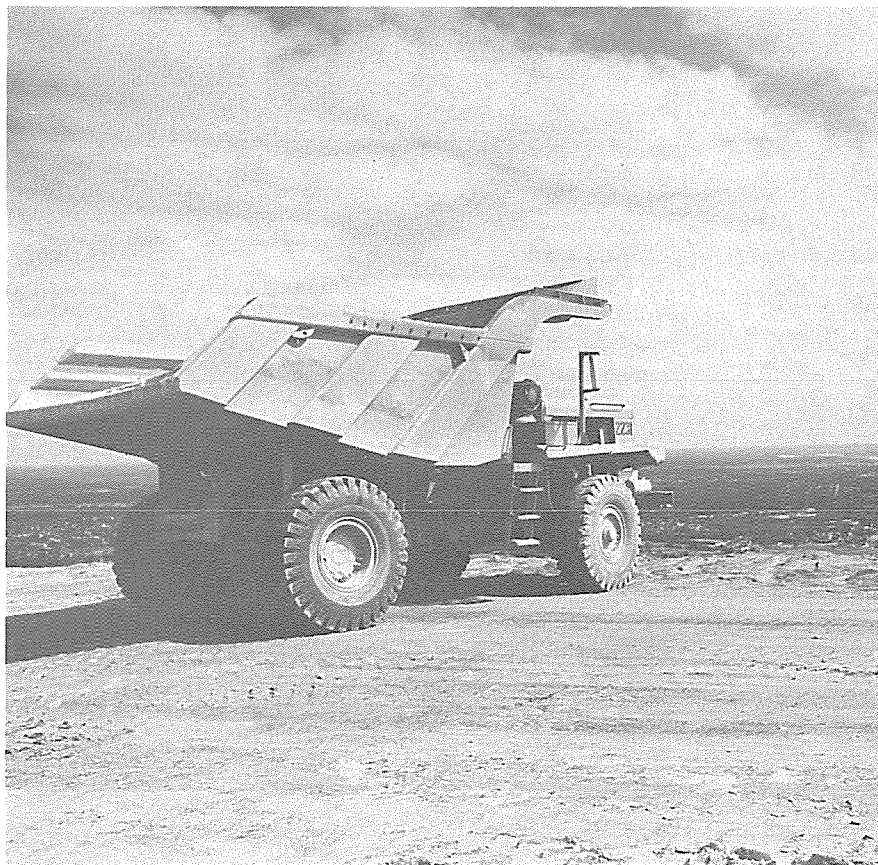
Prospecting activity throughout the Inspectorate remained high during the year and the departmental air compressors located at the various mining centres were in constant use.

The number of persons employed in the mining industry within the Kalgoorlie Inspectorate during the year was approximately 4 558.

### Drilling operations

During 1981 the Drilling Section was responsible for the drilling of 12 420 metres in 171 bores, the development of aquifers in 147 bores, the testing of aquifers in 15 bores, and the bore hole T.V. scanning of 35 bores. The work was carried out by departmental employees and equipment.

The metrage drilled is 6 572 metres more than the figure for 1980. The increase is due to the major part of the finance available to the Geological Survey of Western Australia for two financial years being used in one calendar year for purposes of efficient drilling.





A request to carry out bore hole T.V. scanning in Victoria was refused, because of prior commitments and uncertainties on policy.

A table of work carried out showing the purpose for which the bores were drilled, the type of work, the number of bores and the metrage drilled is shown on page 123.

### Accidents

It is regrettable that 14 men lost their lives in accidents on mines during the year. Five of these accidents (3 underground, 2 surface) occurred in gold mines; three (2 underground, 1 surface) in nickel mines; and three (2 surface, 1 underground) in tin mines. Other industry fatal accidents included 2 on iron ore mines and one at an alumina refinery.

Although the fatal accident record for the year compares unfavourably with 1980, it is noteworthy that over the past ten years there has been an irregular but general reduction in the accident rate. In 1981 the fatal accident rate was 0.6 per 1 000 employees as compared with a fatal accident rate of 1.1 per 1 000 employees for the year 1971.

Accident statistics are compiled from reports submitted by the Mining Industry to the District Inspectors of Mines and cover all classes of mining accidents associated with the mining and extraction of minerals, metals, rock and coal.

The following table shows the broad classification and industry

distribution of accidents during 1981.

Other statistics relating to fatal and serious accidents are shown in tables on pages 124 and 125.

Summary descriptions of fatal accidents appear on page 126.

**Winding machinery accidents.** Ten mishaps involving winding machinery and associated equipment were reported. Brief details follow.

On March 6 at the Regent Shaft (Central Norseman Gold Corporation N.L.) a skip was derailed. The wheel and axle of the skip were damaged. Reason for the derailment was not determined.

On March 26 at the South Paringa Shaft (Consolidated Gold Mining Areas N.L.) a cage door fouled the 7 level plat sill causing the cage to hang up in the shaft. The cage door had to be replaced and 10 metres of rope cut off.

On May 12 at the Ajax Shaft (Central Norseman Gold Corporation N.L.) a kibble sling failed under load. The failure was caused by the incorrect swivel connection between the rope and kibble. There was no damage.

On May 19, at Long Shaft (Western Mining Corporation Ltd) a Granby rail truck was pushed into the service compartment. The truck fell and jammed in the shaft steelwork just above the 10 level. At that time the service cage was stationed below the 11 level. Damage was sustained to the rope, capel, detaching gear, cage and shaft steelwork.

On August 19, at the Regent Shaft (Central Norseman Gold Corporation N.L.) a skip was derailed at the 1900 bin. The cause was a rock lodged near the rails. The skip and shaft timbers were damaged.

On September 15, at the Mt Edwards Shaft (Western Mining Corporation Ltd) a skip was inadvertently lowered onto the shaft protection gate. A misunderstanding between the winder driver and the platman was the cause. No damage resulted.

On September 17, at the Otter Juan Shaft (Western Mining Corporation Ltd) a skip hung up in the shaft above the loading pocket. The hang up was caused by a rock wedging between the skip and the shaft wall. There was no damage.

On November 13, at the Nepean Nickel Mine (Metals Exploration N.L.) two cage gates were dislodged from their hinges. It was found that while transporting a bogger earlier the gates had been deformed, subsequently causing this dislodgment. No other damage was found.

On November 13, at Long Shaft (Western Mining Corporation Ltd) a slack rope situation occurred. The winder driver tried to lower a chaired cage on the 15 level. Two metres of rope had to be cut.

On November 17, at the Timoni Shaft (Queen Margaret Gold Mines N.L.) the sheave wheel shaft over the south compartment failed. The failure appeared to be due to fatigue. No other damage was caused by this failure.

### Machinery on mines

The resurgence in mining activity, particularly in the underground gold mining industry, has kept the machinery safety function of this Division at full stretch.

A number of existing shafts have been refurbished and re-equipped and new shafts have been sunk. At the start of every new venture it is necessary to complete a design review of the proposed haulage system. This has to be followed up

Mineral	Number of Persons Employed	Accidents		
		Fatal	Serious	Minor
Bauxite (alumina)	3 686	1	64	168
Coal	992	—	82	547
Gold	2 450	5	135	380
Ilmenite etc.	640	—	16	52
Iron	12 011	2	185	579
Nickel	2 753	3	142	269
Salt	458	—	14	50
Tin/tantalite	397	3	7	31
Copper, silver, zinc	48	—	3	7
Other minerals	510	—	16	70
Rock quarries	248	—	6	8
Totals	24 193	14	670	2 161

by on-site inspections, testing, and certification of all the associated classified machinery.

Design submissions reviewed and completed during this year included the following:

White Hope Gold Mine located in Kalgoorlie.  
Lancefield Gold Mine located near Laverton.  
Yilgangi Queen Gold Mine at Yilgangi.  
Brown Shaft Gold Mine at Norseman.  
South Paringa Shaft Gold Mine in Kalgoorlie.  
North Kalgurli Gold Mine Shafts in Kalgoorlie.  
Nannine Gold Mine at Nannine.  
Goodenough Gold Mine at Menzies.  
Golden Valley Mines, Fraser Shaft at Southern Cross.  
Timoni Shaft at Mt Ida.  
Pelerum Nitro Gold Mine at Sandstone.  
Windarra Nickel Project at Windarra.  
Agnew Nickel Mine at Agnew—Shaft equipping.  
Design and testing of Falling Object Protection. Structure (F.O.P.S.) for mobile equipment used underground.

General safety inspections were carried out of the machinery on mines throughout the State by the five Special Inspectors of Mines (Machinery) of this Department. In addition the following certification work was completed:

2 261 pressure vessels (including boilers).  
778 cranes.  
22 lifts.  
46 power shovels.  
44 winding engines and hoists.

Examinations for Certificates of Competency carried out included:

114 Crane Drivers.  
19 Engine Drivers.  
16 Power Shovel Operators.  
20 Locomotive Drivers.  
19 Engine Drivers.  
5 Boiler Attendants.  
6 Winder Drivers.

### Electrical inspections

The State Mining Engineer's Division continued to use the services of Special Inspectors of Mines (Electrical) from the State Energy Commission for the bulk of electrical inspections on mine sites.

The Chief Inspector, Regulatory Services reports that his officers undertook a total of 743 electrical inspections, covering 313 mining operations, during the year. These included routine bi-annual inspections plus additional inspections in conjunction with major alterations or additions to plant and equipment.

There was one fatal accident during the year. This occurred at Port Hedland in a substation cable trench and resulted when a labourer operating a pneumatic jackhammer punctured a live, high voltage cable. Two serious electrical accidents were investigated and 27 minor electrical accidents were reported.

Inspectors investigated two fires on mining leases during the year. These occurred at the Cowra and Yandee rail maintenance camps. Investigations failed to establish the cause of the fires.

During the year electrical staff at Hamersley Iron Pty Ltd at Dampier, Goldsworthy Mining Ltd at Finucane Island, and Dampier Salt Pty Ltd at Lake McLeod were addressed on electrical safety and the requirements of the Mines Regulation Act and Regulations Part 5—Electricity in Mines.

In May 1981 at Dampier, electrical personnel from most mining companies in the Pilbara Region were addressed on major changes to the 1981 edition of Australian Stan-

dard 3000, SAA Wiring Rules and the Energy Commission's inspection role in the mining industry.

As a result of the increase in activity in the Perth Inspectorate, particularly relating to the Murchison Goldfields, an Inspector was transferred from Port Hedland to Perth to assist in mine inspection work. A total of 42 submissions were received and processed. These related mainly to exemptions (Mines Regulation Act and Regulations, Regulation 5.3) appointment of Electrical Supervisors (Mines Regulation Act and Regulations, Regulation 5.15(2)) and approval of high voltage installations (Mines Regulation Act and Regulations, Regulation 5.23(1)).

Inspectors have given additional attention to the application of Mines Regulation Act, Regulation 5.13(2) in regard to unlicensed and unauthorised electrical work on mining installations. As a result, prosecutions have been taken against two persons for unlicensed electrical work and unlicensed electrical contracting. Formal warnings have been issued in seven instances to mining personnel and electrical workers regarding unlicensed and unauthorised electrical work. In the interests of safety, Inspectors will continue to pay particular attention to unlicensed and/or unauthorised electrical work on mining installations in the future.





### Seismograph Recordings for blast and mechanically induced ground vibrations

In past years the majority of our seismic investigation work has been undertaken as a result of complaints from the public. Experience has proved that the real problem has been one of air blast over-pressures amplified by weather conditions. Strict blasting control, by companies operating close to residential areas, to reduce air blast has eliminated most of these complaints.

The Dallas Instruments ST4 Seismograph (described in the 1980 annual report) was primarily used throughout 1981 to establish blast control procedures for blasting being undertaken in close proximity to established or planned structures.

A series of blasts were monitored at the Woodside Liquefied Natural Gas Plant construction site, on Burrup Peninsula, to establish control limits during the concrete curing stage for nearby bridge construction sites.

A number of other readings to determine the extent of ground vibrations from mobile equipment at construction sites and on railways, were also undertaken.

### Rehabilitation

Rehabilitation of mine sites is now accepted by the mining industry as just another phase of the mining operation, particularly so by those companies that mine relatively large tracts of land which can be utilised after mining. The miners of mineral

continued throughout the year. The establishment of native vegetation on completed waste dumps is being assisted by deep-ripping of flat surfaces and accessways. The resultant furrows retain moisture and trap windblown seed. Where practicable, the companies also collect seed and spread it over areas where mining has been completed. At Goldsworthy, the life of the open-cut is drawing to a close and rehabilitation of the dumps is being accelerated, along with generally making the area safe to minimize the risks to future sightseers once the company leaves the area.

Hamersley Iron, Mt Newman and Cliffs Robe River Iron Associates are continuing their efforts to re-establish native vegetation, but with the harsh environment, there is little evidence of improvement when viewed on a year by year basis. However results are promising, and given time, it is expected that natural vegetation will become established on the waste dumps.

**Gold and nickel mining.** In the Eastern Goldfields Region, the Goldfields Dust Abatement Committee has been active in their efforts to encourage the return of native vegetation in regeneration zones within the environs of the Kalgoorlie-Boulder districts. Work is also continuing on stabilization of the "slime" dumps. Unfortunately tailings in the Fimiston area are derivatives of sulphide ores and to a large extent saline groundwater was used as the pumping medium. Consequently the material is unfavourable for plant establishment and other forms of stabilization such as rock or slag cover and/or bituminous compound surface spraying, are proving necessary. Unfortunately the Committee has a small budget and is restricted in its scale of operations. Small experimental plots are established and monitored, and it is hoped that the results will assist future mining projects in the establishment of stable tailings dumps. Mining companies in the Mt. Margaret, North Coolgardie, Coolgardie and Dundas Goldfields



Large, mass pillar blasts undertaken at the Mt. Charlotte Gold Mine in Kalgoorlie were closely monitored to determine vibration intensity and distribution patterns. Recommendations have been made to the company regarding blasting controls to ensure the safety of nearby buildings and the Kalgoorlie Reservoir.

A blast initiated in a quarry close to the South Dandalup Dam was monitored to determine the intensity of vibrations reaching the dam wall. They were found to be negligible.

sands, bauxite and alluvial tin are making excellent progress on the rehabilitation of their mining areas.

The rehabilitation of large, deep quarries remains an insurmountable problem, but the operators of such mines are now making steady progress towards the generating of plant growth on waste stock piles. This is particularly evident in the Pilbara iron ore mines and the metropolitan rock quarries.

**Iron ore mining.** Rehabilitation of disturbed land within the mine sites of all the Pilbara iron ore mines

have been planting trees around completed construction sites and each year there is a further awareness of the need to control the windblown dust from within their respective leases.

The indiscriminate removal of topsoil by gold prospectors equipped with graders and metal detectors has been cause for complaint by pastoralists, Inspectors of Mines and environmentalists generally. The department is now taking steps by way of prospecting licence conditions to minimize this practice.

**Bauxite mining.** In liaison with the Forests Department, the management of Alcoa of Australia Limited continued with their rehabilitation programme. Approximately 1.3 hectares of land (includes access roads etc) was rehabilitated for every hectare of land opened up for actual bauxite mining in the Jarrahdale and Pinjarra minesites. Considerable effort and money is also being expended on controlling "Jarrah die-back" disease in and around the minesites. This work is being extended, on an experimental basis,

minesite has already been successfully replanted with trees and its development is being closely monitored by the Forests Department.

**Tin-tantalum mining.** Greenbushes Tin N.L. was adversely affected by the downturn in tantalum price during the year. Consequently mining was concentrated on tin bearing ore bodies. This has resulted in new areas being opened up for mining with an apparent slow down in rehabilitation. In practice this has not been the case, as many areas which had been previously rehabilitated have been further improved. Backfilling of old mining areas has continued. Contouring, topsoiling and tree planting will commence in due course. The company continued to spend much greater sums on rehabilitation than is called for in its conditions of lease.

**Beach sand mining.** Companies involved with beach sand mining include Cable Sands, Westralian Sands, Associated Minerals Consolidated and Allied Eneabba. Both

plots but much more experimentation and research will be required before satisfactory rehabilitation is achieved on a large scale. A.M.C. have demonstrated their ability to rehabilitate land in the Capel area where large tracts of land are returned to pasture each year.

Westralian Sands have continued work throughout the year on their current mine sites at North Capel and Yoganup Extended. A considerable amount of work has been completed at the old Yoganup minesite, where trees have been planted and the margins of two large bodies of water were generally beautified and permanent water levels established.

**Diamond Exploration.** The "Diamond (Ashton Joint Venture) Agreement Bill 1981", when approved, will contain sections dealing with control of the environment and a continuous programme of investigation and research will be required to ascertain the effectiveness of the measures being taken.

### Ventilation

The term "Ventilation" is used loosely to cover all aspects of air supply, dust and atmospheric contaminants and the use of toxic substances.

The wide use of diesel engine equipment underground with the resultant necessity for increased air flows, has greatly assisted in the reduction of dust concentrations in the underground working environment. Surface mining operations have also made considerable progress in the suppression of dust emission. As a consequence, inspectors were able to direct some of their efforts to other matters related to the health and working environment of the workforce.

At Collie a survey of noise levels at the workshops areas of the various collieries was carried out by the Public Health Department early in December. This work may be extended into the wider workings of the collieries during the coming year when audiometry will also be included as part of a general health survey of miners.



into the untouched surrounding forest.

The management of Worsley Alumina Pty Ltd is gathering baseline data and studying the existing environment in order to formulate procedures for areas that will need rehabilitation. A trial area near the

A.M.C. and Allied have an agreement with the Government regarding progressive rehabilitation of the heathland at Eneabba and each company is endeavouring to regenerate the natural flora of the area. Varying degrees of success have been achieved at Eneabba in trial

During 1981, investigations were undertaken into the use of toxic substances in the mining industry. Their use was found to be very widespread and many problems were found, particularly with some proprietary trade name products used as solvents, cleaning agents etc. As a whole, mine management responded rapidly with the introduction of rigid controls, and safeguards for the use of such substances.

control measures, and for general discussions with mine management and ventilation officers.

Although isolated cases of high dust levels are still being recorded in the iron ore industry, the majority of the quarry workforce are protected by the use of air conditioned cabins on dozers and trucks which prevent, to a large degree, dust exposure. The Board is pleased to report that substantial improvements in dust emission controls have

Dust concentrations in underground gold mining operations are generally satisfactory with a few isolated areas still exceeding the Standard of Purity.

The Board was advised that the Mindust Computer System, which has been in operation since 1978, could not remain indefinitely on the Government Chemical Laboratory's computer and arrangements are being made for its transfer to the Health and Medical Services computer. Although the Mindust System has been of benefit to the Board and the mining industry it is subject to a number of limitations and deficiencies. The impending transfer of the system from the Mines Department to Public Health has presented an opportunity to re-assess the system and an updated programme to be known as the "Contam System" is now being designed. The Contam System will include all atmospheric contaminants. However, it is not anticipated that there will be any real increase in the number of samples to be taken by mining companies.

It is intended to almost eliminate positional dust sampling but to expand the sampling of working places in lieu.

Currently, a large number of toxic gas samples are taken in underground diesel mines. The inclusion of these results in the Contam System will improve their



### Ventilation Board

The composition of the Ventilation Board remained constant throughout the year and comprised the following personnel:

Mr J. K. Lloyd (Chairman)—State Mining Engineer

Dr F. Heyworth—Director, Occupational Health

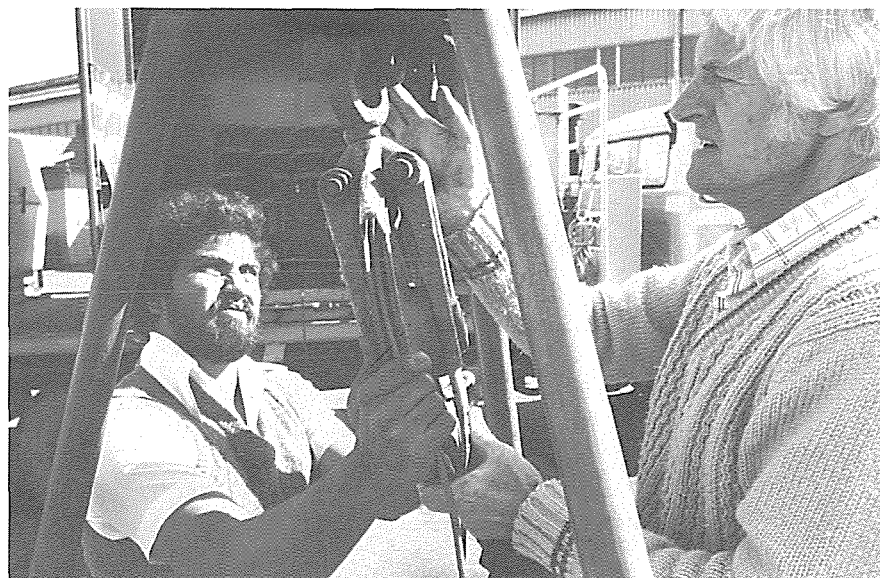
Mr R. A. Powell—Principal Assistant, Clean Air

Mr G. J. Dodge—Principal Senior Inspector of Mines

Mr I. Loxton—Senior Inspector of Mines

been achieved, particularly in the iron ore industry, since sampling first began in 1977.

In the nickel industry sampling results indicate the statutory limit of dust in the atmosphere is being met.



During the year the Board held 8 meetings and made 5 visits to mining operations. The Board was concerned at the high dust emissions being recorded at some hardrock quarries during previous years. They visited the quarries during the summer months to gain first-hand information of the operations and dust



accessibility to the Board, the Inspectorate and the Mining Companies.

A sampling programme to test Pilbara iron ore dust for asbestiform fibres which commenced in 1980, was continued and completed in 1981. A special sampling system had to be devised to exclude the bulk of coarse dust so as to permit the examination of asbestos fibres by a transition electron microscope. This device positively excluded the possibility that asbestiform fibres were in fact asbestos. It can now be stated that none of the samples taken contained asbestos.

The Board held discussions on the ashing of respirable dust samples collected in underground mines. In a research programme it was found that many mine air samples contained oil mist and vapour which lead to an apparently high dust level. Ashing counteracts the oil effect to give a lower and more correct measure of dust content. It has now been agreed that all future respirable samples taken in underground mines will be ashed and consequently a significant reduction in the number of dust samples exceeding the standard of purity can be expected.

Upon receiving requests from Alcoa of Australia and Selstrust Mining Corporation Pty Ltd, the Board recommended to the Hon. Minister for Mines that the Jarrahdale, Del Park and Huntly minesites of Alcoa and the Esperance storage and shiploading facility of Selstrust be re-classified from "Class B Mines" to "Class C Mines". The Hon. Minister agreed to the Ventilation Board's recommendation and approved of the re-classifications.

**Karratha Inspectorate.** Staff shortages and a growing need to investigate matters other than dust control adversely affected the number of dust orientated inspections accomplished by the Ventilation Section of the State Mining Engineer's

Division. Notwithstanding this, most mines in the Inspectorate were inspected.

Seventy-one personal gravimetric dust samples were taken on employees working at various mine sites to test compliance with the Regulations. Thirteen of the samples taken exceeded the Standard of Purity. In addition to the above, fifteen positional samples were taken.

Dust suppression and control in the iron ore industry has continued to improve during 1981.

There has been increased use of water cannons in quarries and on stockpiles, and reticulated water sprays on haulroads. Practically all drilling is now carried out using water injection and some drills are fitted with foam injection.

Exposure of some maintenance workers to high dust concentrations, which has been cause for concern, has been decreased by washing down the work areas before maintenance work begins.

A major reconstruction of the crushing and screening section of its port operations has been undertaken by one company, with the aim of overcoming problems associated with the exposure to dust of men cleaning up spillage and maintaining conveyors and chutes. One iron ore company makes extensive use of a heavy duty mobile "vacuum cleaner" to clean up spillage and to clean out bag houses, to good effect.

Efforts to reduce the ingress of dust into the cabs fitted to D9G bulldozers have achieved only limited success.

One company has been examining methods of measuring exposure of welders to fumes and dust.

The following table summarises results of dust sampling conducted by the Karratha Inspectorate in 1981.

	Total dust		Respirable dust		Positional
	-SoP	+SoP	-SoP	+SoP	
Hard rock quarries	6	4	4	1	—
Gold	2	—	12	3	1
Iron ore	28	3	5	—	12
Miscellaneous	1	2	—	—	2
<b>TOTAL</b>	<b>37</b>	<b>9</b>	<b>21</b>	<b>4</b>	<b>15</b>

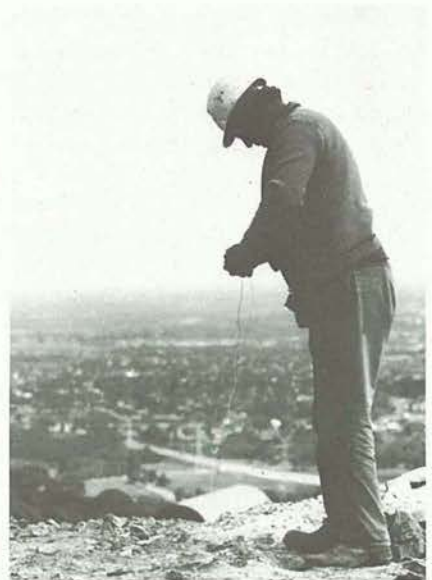
-SoP—Less than the Standard of Purity

+SoP—Greater than the Standard of Purity

The use of toxic and corrosive chemicals was examined on some mines. The inspections were carried out by a Ventilation Inspector and a chemist from the Government Chemical Laboratories.

The use of cleaning and degreasing fluids was examined on iron ore mines. There has been a general movement away from chlorinated hydrocarbon solvents to degreasing oils. The use of atomising sprays with these solvents has largely ceased.

Men involved in the handling of mercury and lead have been checked by means of urine samples to ensure their health is not affected by working with these materials. Mercury vapour leaking from a retort was responsible for increased and excessive levels of mercury in the air of a gold room and in the employee's blood. On the same mine, lead vapour emanating from an inefficient muffle furnace caused increases in atmospheric and blood leads to excessive levels. The level of activity was reduced until a new furnace was provided.





Toxic vapour tests were as follows. No fumings were reported.

	Less than Standard of Purity	Greater than Standard of Purity
Toluene	3	—
Trichloroethylene	4	—
Perchloroethylene	2	—
Mercury	1	1
Benzene	3	—
Methyl Chloride	2	—
White Spirit	2	—

**Perth Inspectorate.** Despite a general shortage of ventilation staff the two available officers visited most mines in the Perth Inspectorate.

One hundred and fourteen gravimetric dust samples were taken on employees working at various mine sites to test compliance with the Regulations. Twenty six of the samples taken exceeded the Standard of Purity. In addition to the above, 59 positional samples were taken.

Throughout the year the emissions of vanadium-bearing dust and fume on a vanadium plant has been difficult to control and has several times been excessive.

Earthmoving plant not fitted with cabs, has been the cause of exposure of operators to excessive dust levels on a mineral sands operation. Improvements are being effected.

Sand plants have been operated with significant exposure to the operators of highly siliceous dust. One of the large quarry operators has fitted water cannons to spray stockpiles during the hours of darkness much reducing the emission of dust during loading and almost eliminating wind blow dust.

Twenty four diesel engined vehicles for use underground in the Perth and Kalgoorlie Inspectorates were tested. Testing at the distributors premises prior to delivery results in better control, and saves time and expense for all parties.

Dust emissions in hardrock quarries and associated crushing and screening plants have improved generally.

The use of toxic and corrosive chemicals was examined on some mines. The inspections were carried out by a Ventilation Inspector and a chemist from the Government Chemical Laboratories.

The use of bromoform and tetrabromoethane in some mineral sands laboratories has been found to be a hazard with levels of the vapour being above the Standard of Purity. Improvements are in hand.

Toluene vapour in a linatex shop was cause for concern and steps are being taken to reduce the level to below the Standard of Purity.

A shaft sinker was affected by fumes when he went back down a shaft after blasting.

A mild explosion occurred at an aluminium refinery when flocculent dust was ignited by welding.

Permits for 5 diesel engines to be used underground were issued. All units were for use at Greenbushes Tin Ltd.

**Kalgoorlie Inspectorate.** A total of 611 gravimetric dust samples from underground and surface mining operations were collected by ventilation staff. These samples consisted of:

396 personal/workplace respirable dust samples of which 81 (20.4 per cent) exceeded the Standard of Purity (maximum allowable dust concentration). 193 personal/workplace total dust samples of which 8 (4.1 per cent) exceeded the Standard of Purity.

22 positional total dust samples, primarily for engineering control purposes.

Seventy four permits for diesel engined vehicles to be used underground were issued during 1981. Rated engine output ranged from 43 kilowatts (jumbo drilling machine) up to 372 kilowatts (dump truck). As in the previous year, personnel-carrying type vehicles constituted the majority of issued permits.

The undiluted exhaust gas emissions of 270 vehicles were tested for carbon monoxide (CO) and oxides of nitrogen (NOx) concentrations. Of these, 4 (1.5 per cent) were found to exceed the CO limit of 2 500 ppm, whilst only 1 (0.4 per cent) exceeded the limit of 2 000 ppm for NOx.

Inspections and tests by ventilation staff determined that some vehicles had one or more of the following faults:

- excessive (greater than 93°C) exhaust gas temperatures on loaders;
- poorly maintained speed restrictive gear lock-out devices, mainly on personnel carrying vehicles;
- defective brakes, lights or fire-extinguishers.

Underground workplace temperatures were routinely recorded to check compliance with Mine Regulations. Only 17 (1.2 per cent) of 1 398 workplaces tested did not comply. Problems in these areas included poor condition of ventilation equipment provided or miners had commenced operations before ensuring that their workplace was adequately ventilated.

The primary ventilation circuit on several mines was upgraded or expanded during the year. This mainly involved the downward extension of the circuit to the lower workings of the mine, or in some instances, new raise bored connections to the surface were made. No primary ventilation airflow problems were encountered.

Eight gas emissions were reported to the Department during the year. Three of these occurred from underground diamond drill holes and the remainder whilst boring in development headings. Most gas flows were minor. As a precautionary measure, miners were shifted from the workplace until the flow diminished. Tests conducted on the emissions usually indicated small percentages of methane, carbon monoxide and carbon dioxide.

Queen Margaret Gold Mines N.L. reported the most significant gas occurrence. A very high concentration of carbon dioxide gas was encountered during dewatering and refurbishing operations of an old shaft at Bulong. It was necessary to utilise self-contained breathing apparatus to enable workmen to install ventilation equipment in the mine to clear the gas.

Sixteen confirmed or suspected fuming accidents were reported. Three were at surface mining operations. Two workmen were overcome by sulphur dioxide fumes at a smelting plant, and a third suffered ill-effects from toxic vapours liberated by a rubber bonding chemical. Thirteen were at underground mining operations where workmen were affected by either gas, blasting fumes or diesel exhaust fumes.

One underground and two surface fires were reported. All occurred on the one minesite.

A fire on an underground diesel engined loader was caused by oil spillage from a loose oil filter onto the hot exhaust manifold. It was quickly extinguished and very little equipment damage resulted. Both surface fires occurred in the treatment plant. Molten metal from a boilermaker's cutting torch ignited the rubber lining of a launder. Flames spread to an adjacent conveyor belt. Considerable damage resulted. Another fire occurred in an electrical sub-station. Smoke and fumes actuated a fire protection system which quickly brought the fire under control. No personal injuries resulted from any of the above fires.

Two assay laboratory employees who were occupationally exposed to lead, recorded excessively high red blood cell lead concentrations. Each was attributed to personal hygiene matters rather than the work environment.

The Department continued to purchase new gas and dust monitoring equipment. Assistance with monitoring programs was provided to industry.

### **Board of Examiners**

**Mine Managers and Underground Supervisors Certificates of Competency.** The Board met on 5 occasions during the year, March 31, April 30, June 25, September 15 and November 11. Pre-requisite examinations in Mining Law towards the Mine Managers Certificate were conducted on April 29 at Kalgoorlie, Perth, Tom Price, Mt. Magnet, Norseman and Leonora. There were a total of 30 entries, of which 29 were accepted with 13 passes and 16 failures. The names of the successful candidates are listed on page 127.

Four candidates who had passed the Mining Law examination and had met all other requirements were awarded the Mine Managers Certificates of Competency. Their names are listed on page 127.

Because of an increased demand by the mining industry for the services of Underground Supervisors, examinations were held in May and October at Kalgoorlie, Greenbushes, Mt. Magnet and Perth. There were 81 entries of which 77 were accepted with 60 passing and 13 failing; 4 candidates did not sit. The number of candidates sitting for this examination was far greater than the Board had ever previously examined in any one year. The names of the successful candidates are listed on page 127.

The examinations in Mining Law and Quarrying for the Quarry Managers Certificate of Competency and the Restricted Quarry Managers Certificate of Com-

petency were held on May 4. The names of the successful candidates are listed on page 128. Some Board members visited country mining centres to interview applicants and conduct oral examinations for the Restricted Quarry Managers Certificate of Competency. Mr I. Kauler was welcomed to the Board as the Director of Technical Education's representative replacing Mr H. Duncan.

**Authorised Mine Surveyors Certificates.** The Survey Board issued seven certificates during 1981 of which two were re-issued under Regulation 10.4 of the Mines Regulation Act 1946-74 and five were initial certificates. The names of the successful candidates are listed on page 128.

**Power Shovel Operators Certificates of Competency.** A total of thirty Power Shovel Operators' Certificates of Competency were issued under the provisions of Regulation 17.3 of the Mines Regulation Act 1946-74. Twenty nine of these were issued to applicants in the Karratha Inspectorate and one in the Perth Inspectorate.

**Coal Mining Certificates of Competency.** Four Board meetings were held during the year at the Department of Mines Office, Collie. Three meetings were held under the Chairmanship of the Acting Chief Coal Mining Engineer, Mr J. K. N. Lloyd for whom the Assistant State Mining Engineer, Mr J. M. Faichney deputised at the other meeting. Board members H. W. Williams, D. Forrest and the Secretary attended all meetings.

Statutory examinations were held in April and October. The names of the successful candidates are listed on page 128.

Apart from direct applications for certificates of competency, the Board handled a number of enquiries from persons concerning their eligibility to be accepted as candidates or to receive partial or full exemptions from the statutory examinations.



## Organisation

**Staff.** During the year there were 3 resignations and 5 appointments to the Division staff.

At the end of the year 3 vacant items remained unfilled after repeated advertisement throughout Australia. The positions are for a Mining Engineer/District Inspector of Mines, and a Ventilation Officer at Kalgoorlie, and a Mechanical Engineer Special Inspector of Mines at Perth. Continued expansion of the coal mining industry and a greater interest in mine rehabilitation indicates that increased coal mining staff will be required in the coming year. It is anticipated also that a Senior Inspector will be needed in the Kimberley to provide a service to the mining industry which will be engaged in iron ore, bauxite and diamond mining as well as exploration for and possible production of gold, copper, lead and zinc in future years.

## Functions

The Division provides professional mining engineering service to the Mines Department and administers the Mines Regulation Act and the Coal Mines Regulation Act through District, Special and Workmen's Inspectors of Mines. An operational function is undertaken by the Drilling Branch which is equipped for rotary, diamond and percussion drilling.

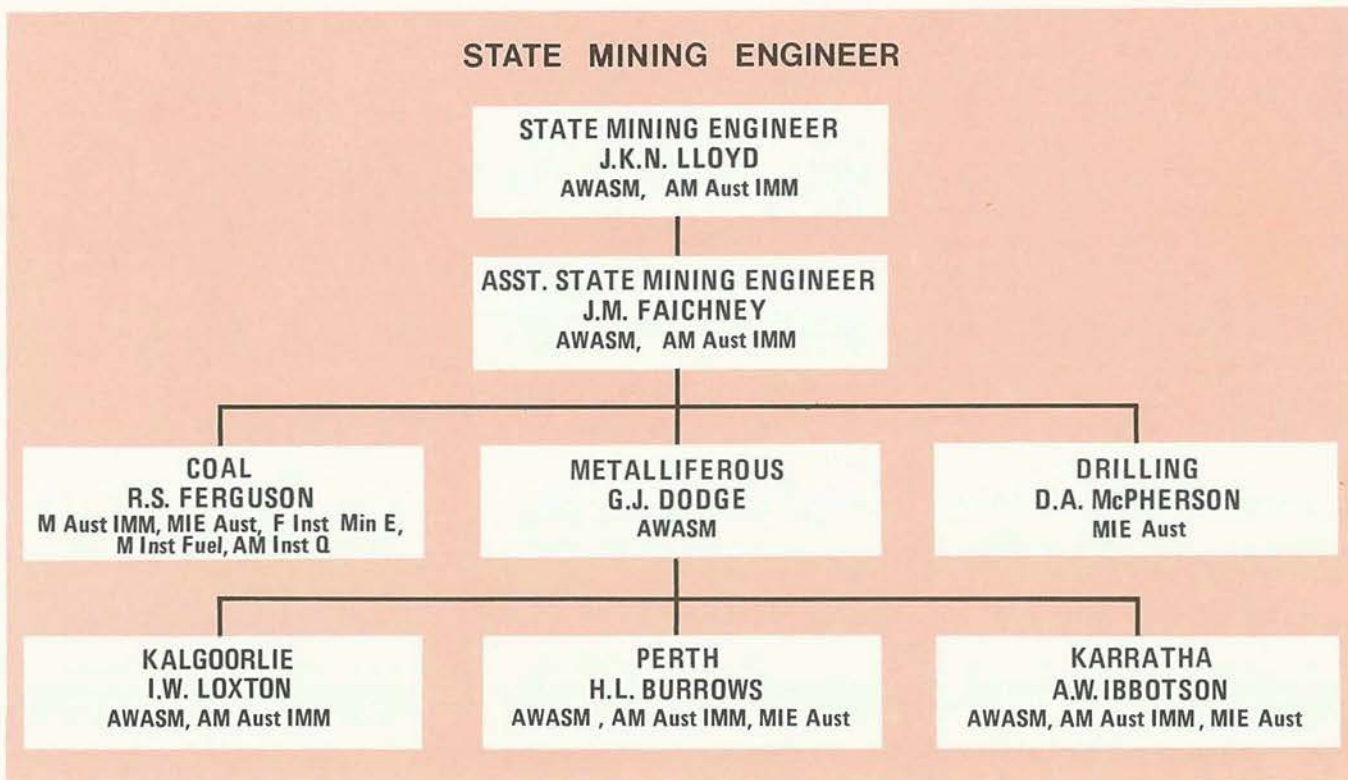
The Inspection Branch covers the whole of the State and has semi-autonomous inspectorates, geographically appropriate to the areas and centres where minerals and metals are mined, with offices at Perth, Kalgoorlie, Karratha and Collie. Inspectors of Mines are responsible for the enforcement of the Acts and are required to enter, examine and make enquiry regarding the state and condition of all mines, quarries and treatment plants and to ensure the well being of persons employed in the mining industry.

District Inspectors recommend conditions to be imposed on mining tenements as required, and a Rehabilitation Inspector represents the Department on committees concerned with the restoration of areas after surface mining.

The State Mining Engineer is chairman of those Boards concerned with the competency of mine and quarry management and underground mining supervisors. He is chairman of the Ventilation Board and is the Departmental representative on various Councils. Other mining engineers on the staff are also on Boards, Committees etc.

District Inspectors investigate all fatal mining accidents and most serious mining accidents.

The Drilling Branch activities are now mainly directed towards groundwater exploration throughout the State, but it also undertakes construction site investigations. Gold and mineral (iron ore) exploratory drilling has been carried out in the past.





## Carbon-in-pulp—a method for gold recovery

In 1980 a carbon-in-pulp treatment plant started operations in Kalgoorlie. This was developed with the aid of a grant of \$52 000 given to the State Batteries in the 1979/80 period for the establishment of a test plant. Another carbon-in-pulp plant was installed at Coolgardie in 1981 by private contract on a turn-key plant operation basis.

To understand the importance of these plants it will first be necessary to understand how gold is recovered from ores brought to the battery for treatment.

Gold is found in many types of ore, some very rich in gold and others of lower grade. The first step in recovery is to crush the ore and mix it with water to make a fine slurry. This is passed over a copper sheet, the surface of which has been treated with mercury. The mercury attracts most of the gold from the slurry and the resulting gold amalgam can be collected and re-torted. This operation will drive off the mercury, which is collected for re-use, leaving behind the gold for further purification. Gold not recovered by this amalgamation treatment is discharged with the spent slurry known as tailings. If the original ore was rich in gold, the tailings may contain an appreciable gold content that would warrant further treatment by a chemical solution process known as cyanidation.

In the cyanidation process a potassium cyanide solution is used to dissolve out the gold which can then be recovered from solution by the addition of zinc dust. A chemical reaction occurs in which the gold is replaced by the zinc and precipitates out. Further purification will give a high purity gold. One problem with this zinc method is that the cyanide solution needs to be

clear. Some ores are so fine and clay-like that filtration to produce a clear gold-cyanide solution is nearly impossible, and it is for these types of ore that carbon-in-pulp treatment methods have been developed.

Many slightly different processes have been developed with the use of carbon and these often depend on what equipment is available to the mining engineers when first setting up a plant. A typical method would involve adding the granular activated carbon directly to the ground ore, or pulp, together with the cyanide solution. As the gold is dissolved out it is adsorbed on to the activated carbon, and the ore, which has been ground to smaller size than the carbon, can be separated with the use of a simple screen. The ore-carbon mixture must be kept agitated and this can be done in a number of ways such as the use of a pachuca, which is a vessel using air agitation. After a suitable time of contact the ore and the carbon can be separated and the gold recovered from the carbon.

Some privately operated carbon-in-pulp systems use a number of vessels connected together in which the pulp moves from one vessel to the next in a continuous operation. The carbon moves in the opposite direction adsorbing more gold as it moves up the chain until finally it is removed for gold recovery to take place.

Highly adsorbant carbon can be loaded to 20 kg of gold per tonne. The adsorbed gold is recovered by treatment with a hot caustic solution of cyanide after impurities have been washed out of the carbon with acid. The carbon, after suitable washing can be re-used many times. In the early days the gold was recovered by burning but as good quality activated carbon costs about \$2 500 per tonne its recovery is essential to minimise costs.

To obtain the gold from the stripping solution, electrolysis in a special cell is used. The gold is reduced from the solution at a cathode made from wire wool. This gives a large surface area on which the gold is deposited and which can be dissolved in hydrochloric acid leaving the gold for further treatment.

The carbon-in-pulp method was invented around the turn of the century but it has taken many decades for the method to become a practical method for gold recovery. There were two main reasons for the delay. Much work had to be done to produce a strong and active carbon. The granulated carbon has to stand up to considerable mechanical stress and if it is too friable the gold will still bind but the carbon will not be recoverable from the pulp. The granulated carbon now in use is obtained from the husks of coconut shells and is treated to make it active in the adsorption of gold. The second reason for the delay in producing a commercial method was the design of a suitable stripping process for the recovery of the gold.

The State Battery now has three units in operation and these are being used to recover gold from the tailings stored at the unit locations. The carbon-in-pulp method will reduce the capital and operating costs, provide employment in the recovery of gold from the stored tailings, and reduce the amount of money needed from the government by liberating the equity locked up in the dumped tailings.

# State Batteries Division

E. J. Green  
Superintendent

The average price for gold for the year 1981 was \$399.25 an ounce. This was a reduction of \$134.75 on the previous years average.

Carbon-in-pulp operations for the treatment of battery sands were escalated at Kalgoorlie, Coolgardie and Meekatharra. General upgrading at Kalgoorlie and the purchase of a new pachuca should increase production in the following year.

The new turn-key carbon-in-pulp installation at Coolgardie after early start-up problems should effectively treat 200 tonnes per operating day in the following year on two shift operation.

The ball-mill installation at Meekatharra had not been accepted by the prospectors and was converted to a carbon-in-pulp plan by using the fine ore bin as a pachuca. This unit is operating effectively.

Production value from the carbon-in-pulp plants generally is below expectations because of low gold prices and low tailing grades. There was reduced output at Kalgoorlie and Coolgardie due to supply and start-up delays.

The battery at Paynes Find was converted to a bin and cracker feed and brought into top condition; this leaves Sandstone as the only hand-fed battery to be converted. The power supply at Yarri was converted to alternating current from a diesel generator supply. Purchases have been made to similarly convert Boogardie, Ora Banda, Menzies and Sandstone.

During the year 133 125 tonnes of sands were sold for royalty receipts of \$194 929.86.

## Operations

**Crushing Gold Ores.** One 20-head, five 10-head, and eight 5-head mills crushed 45 989.6 tonnes of ore made up of 363 separate parcels, an average 126.69 tonnes per parcel. The bullion recovered amounted to

287.599 3 kilograms, estimated to contain 243.74 kilograms of fine gold, equal to 5.3 grams per tonne of ore. The average value after amalgamation but before cyanidation was 2.42 grams per tonne, giving an average value of ore received of 7.72 grams per tonne; in addition, 237 smelts produced 202.352 3 kilograms of bullion estimated to contain 171.5 kilograms of fine gold.

Treatment of prospector carbon in the newly established Kalgoorlie stripping plant produced 42.344 kilograms of gold bullion from 16 strips. This bullion was estimated to contain 35.89 kilograms of fine gold.

In total, 451.114 3 kilograms of fine gold was produced compared with 402.060 8 kilograms of fine gold in the previous year from the amalgamation, smelting and carbon stripping activities of the State Batteries.

The gross cost of crushing 45 989.6 tonnes of ore was \$45.65 per tonne. In 1980, 58 593.2 tonnes were crushed at the gold plants for a cost of \$34.88 per tonne. This year the nett cost of crushing was \$37.05 per tonne compared with \$28.02 per tonne in 1980.

**Cyaniding.** Five plants treated 12 214 tonnes of tailings for a product of 27.147 kilograms of fine gold.

The average content was 3.04 grams per tonne before cyanidation while the residue after treatment was 0.85 grams per tonne, giving a theoretical recovery of 75.3%. The actual extraction was 73.05%.

The cost of vat cyanidation was \$28.76 per tonne. This was higher than the previous year when 18 814.5 tonnes were treated at a cost of \$23.31 per tonne.

In addition, carbon-in-pulp plants at Kalgoorlie, Coolgardie and Meekatharra treated 19 105 tonnes for the production of 20.170 kilograms of fine gold at a cost of \$14.37 per tonne.

Silver recovered from all cyanidation of gold tailings was valued at \$817.37.

## Treatment of ore other than gold.

The Northampton Battery crushed 37 tonnes of lead ore for the recovery of 1.65 tonnes of concentrate. The Marble Bar magnetic plant treated one tonne of ore for the production of 0.652 tonnes of concentrate.

**Value of production.** The estimated value of production from the State Batteries in 1981 and the total since their inception, excluding the value of gold tax paid to the Commonwealth, is shown in the following table.

	1981 (\$)	Since inception (\$)
Gold	6 397 951	64 941 891
Other metals		
Silver .....	817	10 668
Tin (concentrate) .....	5 219	506 365
Tungsten (concentrate) .....	—	97 674
Copper (ores for agricultural use) .....	—	11 932
Lead and zinc (concentrate) .....	804	1 650 865
Tantalite—columbite (concentrate) .....	—	207 030
Garnet (concentrate) .....	—	131 001
Other metals Total .....	6 840	2 615 535
Grand Total .....	6 404 786	67 557 426

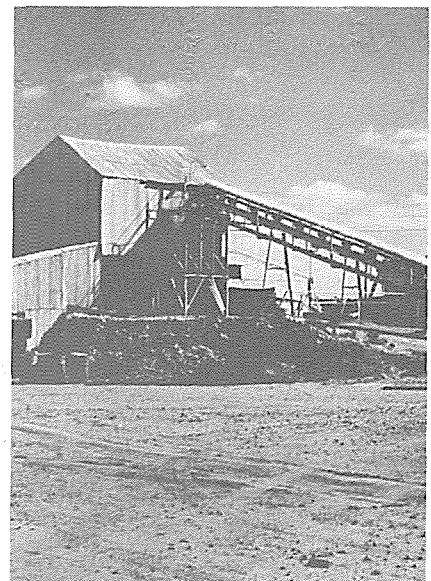


The loss of \$1 753 450 shown in the following table is a decrease of \$179 120 on the previous year. It does not include depreciation and interest on capital.

	Tonnes	Expenditure	Receipts	Loss (\$)
Crushing (goldmills)	45 989.6	2 099 182	461 204	1 637 978
Crushing (Northampton)	37	67 572	6 452	61 120
Magnetic separator	1	2	60	58cr
Cyaniding (vats)	12 214	351 367	119 187	232 180
Cyaniding (C-I-P)	19 105	274 551	257 392	17 159
Sale of battery tailings & option fees	133 125	—	194 929	194 929cr
Totals	210 471.6	2 792 674	1 039 223	1 753 450

Capital expenditure was incurred as shown below.

	(\$)
Coolgardie Barker Mill experimentation & C-I-P infrastructure	24 676
Boogardie—A/C power conversion preparation	4 678
Kalgoorlie—Ore bins, C-I-P plant, fencing and tank	80 188
Laverton—Water pump and conveyor	7 677
Marvel Loch—5-Head extension	39 668
Norseman—Wheel weigher	3 297
Ora Banda—A/C power conversion preparation	1 865
Paynes Find—Plant renewal	37 965
Sandstone—A/C power conversion preparation	13 615
Yarri—A/C power changeover	14 965
All battery spares	24 963
Motor vehicles	73 400
Total	326 957

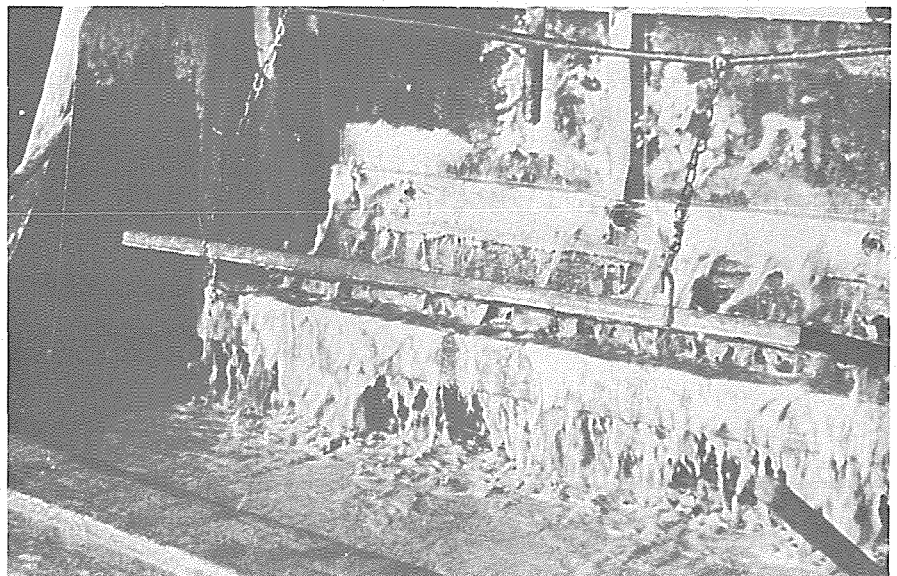


Administrative expenditure for 1981 was \$396 490, equal to \$5.12 per tonne crushed and cyanided, compared with an expenditure of \$345 291 (\$4.32) for 1980.

**Cartage Subsidy.** Comparative figures on cartage subsidy paid on ore carted to State Batteries during the last three years are shown below.

Year	Tones crushed	Tonnes subsidised	Percentage subsidised
1979	60 910.0	12 977.1	21.30
1980	61 058.75	19 999.0	32.75
1981*	46 027.6	19 075.2	41.4

\* Cartage Subsidy rescinded 31/12/81.



There has been no cartage subsidy paid on ore carted to private plants in the last three years. Full details of the State Batteries Trading for 1981 are given in the Tables on pages 129 to 132.

## Organization

**Staff.** During 1981 an average of 110.7 men were employed at State Batteries throughout the State. This figure does not include the Superintendent of State Batteries.

The average number employed is made up on a monthly average of 85.2 wages staff and 25.5 ministerial appointments.

Due to the fluctuating supplies of ore to be treated the total number of staff employed ranged between 104 and 118 men.

Engineering Draftsman Mr G. Rasmussen retired after fifteen years service. Manager D. Hoddy resigned to take up a position in private enterprise.

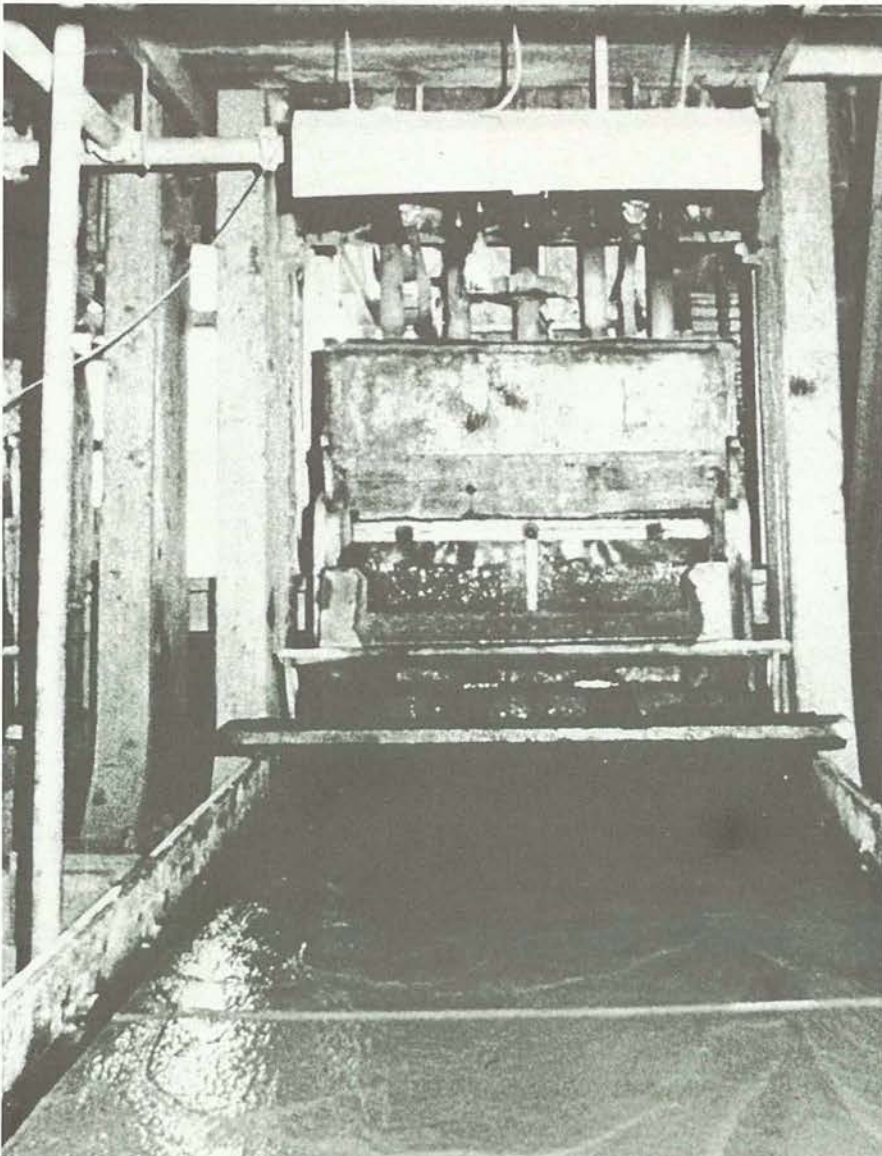
Manager Jenkin was transferred from Kalgoorlie to Head Office to start duties as State Batteries Inspector. Other transfers were Manager Sparrowhawk from Norseman to Kalgoorlie; Manager Elsegood from Marvel Loch to Coolgardie, Foreman Spain from Yarri to Marvel Loch and Foreman Bell from Meekatharra to Norseman. Foremen Spain and Bell will be utilized as acting Managers until the positions are filled.

## Functions

As a practical means of encouraging and assisting mining activity, this Division operates a network of State-owned batteries and ore treatment plants. Ore is treated at a reasonable cost for prospectors and small mine operators. Most of the ore treated is for gold, but facilities exist for gravity concentration.

Batteries are operating at 15 sites: Boogardie, Coolgardie, Kalgoorlie, Laverton, Leonora, Marble Bar, Marvel Loch, Meekatharra, Menzies, Norseman, Northampton, Ora Banda, Paynes Find, Sandstone and Yarri.

The prime purpose of the State Batteries is to provide a service that is of assistance in the sampling and developing of mines. They are not intended to be custom mills for operating mines and the equipment provided for sampling a variety of ores is not suitable for the most efficient treatment of a particular run of mine ore.



### STATE BATTERIES

SUPERINTENDENT  
E.J. GREEN

Dip WASM 14/1/13

BATTERY MANAGERS  
AT 14 LOCATIONS



## The Canning Basin: exciting prospects for further oil discoveries

In May 1981, potentially commercial oil was discovered in a wildcat well, Blina No. 1, drilled in the northern Canning Basin. This was the first well drilled by a consortium of companies headed by Home Oil of Canada, and was a success, not only for the consortium, but also for the Geological Survey.

The well is situated on the Lennard Shelf along the northern margin of the Canning Basin. During the Devonian Period, about 350 million years ago, the marine environment in this area must have resembled that of the present-day coast of Queensland, and plant and animal life flourished in the warm, nutrient-rich water.

The result was the development of an extensive barrier reef complex on a basement of much older rocks, around islands and promontories and along the mountainous mainland shore that existed at that time. Individual reef complexes ranged from small atolls to extensive fringing reefs covering several hundred square kilometres. The complexes consist of three main units, termed facies.

—the platform facies; consisting of a reef rim about 30 to 150 metres wide, composed of limestone built up by colonial organisms such as corals, with extensive areas of limestone laid down in the back-reef shelf lagoons,

—marginal-slope facies; includes detritus from the reef rim broken off by wave action and large blocks, perhaps dislodged by earth tremors, which are deposited along the seaward slope in front of the reef rim,

—basin facies: shale, siltstone, sandstone, and some limestone laid down on the basin floor in front of the reefal platforms. Water depths in the basin ranged up several hundred metres.

Over the 20 million year period when these reef complexes developed, the area gradually subsided and the organisms of the reefal platforms, needing light and air for life, kept pace in their growth with subsidence until the reef complexes had attained a thickness of up to 2000 metres.

Eventually, for reasons still incompletely understood, reef growth ceased, and the complexes were buried beneath younger sediments.

Meanwhile the soft tissue remains of marine animals and plants were accumulating and being buried in the basin sediments in an oxygen-deficient environment, so that they did not entirely decay. Millions of years later when the sediments were deeply buried the organic matter was subject to temperatures in the range from 70 to 120°C, converting it to oil.

This oil from the basin source rocks later migrated into porous limestones of the reefal platforms and into porous dolomites interbedded with the overlying cap rocks.

Along the northern edge of the Lennard Shelf area, subsequent uplift exposed the younger cover rocks to erosion processes. In places these overlying rocks have been stripped completely, re-exposing the Devonian reefs.

The exhumed reefal structures were first recognised as such by geologist A. Wade in 1924, but they were not regarded as being particularly prospective for oil until the mid 1950s soon after oil had been discovered in buried Devonian reef structures in Alberta, Canada. West Australian Petroleum Pty Ltd (WAPET) over the period 1958 to 1973 drilled many test wells designed to intersect the reef complexes beneath cover rocks, and two wells (Meda Nos. 1 and 2) encountered encouraging but non-commercial shows of oil and gas.

One of WAPET's geologists, Dr Phillip Playford, was convinced of the high petroleum potential of the Lennard Shelf and, after joining the Geological Survey in 1962, he initiated a comprehensive study of the reef complexes by the Geological Survey, later with assistance of the Commonwealth Bureau of Mineral Resources, companies, and universities.

It was realized from the published results of these investigations that the Lennard Shelf reef complexes provided unsurpassed opportunities for surface study of a classic ancient reef belt.

On invitation Dr Playford toured the United States and Canada to address symposia on these rocks as Distinguished Lecturer of the American Association of Petroleum Geologists in 1978.

In 1980 he toured Australia for the Petroleum Exploration Society of Australia, as its Distinguished Lecturer.

With the petroleum potential of the Devonian reef complexes now well established, the Lennard Shelf and adjoining parts of the Canning Basin have become the principal foci for onshore petroleum exploration in this State. The search requires sophisticated seismic methods and interpretation to detect subsurface reef margins, which commonly give only subtle indication of their presence. The targets can only be evaluated by drilling, and although future success cannot be guaranteed, the interpretation of seismic and drilling results has been greatly improved through the extensive research that has been carried out.

The success of Blina No. 1 has certainly justified the Geological Survey's confidence in the area and the many years of field and laboratory studies conducted by Survey geologists and their co-workers.



Several of the factors which restricted the performance of the Geological Survey in 1980 were still present during 1981. Mineral exploration activity continued at a relatively high level, and while the consequent rate of staff loss decreased, delays in the arrival of newly appointed geologists from overseas caused significant understaffing in most sections through the year. Special requirements such as the involvement of senior staff in planning for the introduction of the new (1978) Mining Act on 1 January 1982, also contributed to make 1981 the second year in succession in which few projects were completed, and little new work was initiated.

### Exploration activity

Exploration for diamond, base metals, iron ore, uranium, gold and coal continued at very high levels. Although no new significant discoveries were made there were varied and important developments throughout the mining industry.

An agreement Act for the mining of the Argyle diamond deposits in the Kimberley was passed. Careful control of marketing the predominantly industrial grade diamonds will be needed as Argyle could produce a significant portion of world supply of this commodity. During the year Ashton Mining Ltd announced that alluvial diamond deposits in Limestone Creek immediately east of Smoke Creek, where the diamantiferous kimberlite is located, appear to be as large as the diamond bearing gravels of Smoke Creek.

Greenbushes Tin NL, who in late 1980 announced the discovery of very large tantalum deposits near Greenbushes township, disclosed plans for establishing a tantalum refinery at Kwinana. The presence of large reserves of lithium in the

form of spodumene close to the tantalum deposit was revealed, and it is considered that lithium can be mined economically together with the tantalum deposit.

Mt Goldsworthy Mining Associates announced that its proposals for the development of Mining Area 'C' had been formally submitted to the Japanese steel industry. The company also reported that recent exploration near existing operations has identified sufficient tonnages of high grade ore to support current levels of operation until the late 1980s. Cliffs Robe River announced the formal go-ahead for the development of the Eastern Deepdale project near Pannawonica and CSR completed evaluation of the Yandicoogina limonite deposits. Elsewhere in the Hamersley Basin iron ore was the subject of continuing steady exploration.

Plans for an experimental solution mining plant for uranium at the small Manyingee deposit some 65 km southeast of Onslow were made public. Uranium at Manyingee is unlike the known deposits within the State such as Yeelirrie and Lake Way where the mineral occurs within calcrete. Manyingee uranium is found in sandstones and as such resembles the major uranium occurrences of the United States. The chances of further discoveries of sandstone-type uranium deposits within the State are good.

Gold continued to attract large-scale exploration activity despite its falling price. The Mt Ida mine, 75 km east of Leonora, was reopened and production resumed from the Hill 50 Gold Mine NL leases at Mt Magnet. Gold production was commenced also from centres near Cue, Laverton and Menzies.

Interest in coal continued throughout 1981, particularly exploration for shallow Eocene lignite similar to that found north of

Esperance. Company reports indicate that one deposit near Grass Patch contains more than 200 million tonnes of brown coal, and the total resource may be more than 1 000 million tonnes. A high salt content and a high moisture content may downgrade this discovery.

An extensive programme of delineation drilling has proved more than 50 million tonnes of open cut coal of Jurassic age near Eneabba in the northern Perth Basin. Exploration for oil shale in portions of the same Eocene palaeodrainage channels as those containing the above-mentioned lignites continued in the Eastern Goldfields during 1981. Elsewhere, many of the Exploration Permits applied for under the Petroleum Act for oil shale have either been converted to conventional exploration for petroleum or have been surrendered. On 1 January 1982 exploration for oil shale ceased to be controlled by the Petroleum Act, and acquired the same status as coal, as a mineral to be sought under the provisions of the Mining Act 1978.

Conventional onshore petroleum activity increased in 1981 with 32 wells completed during the year and 5 drilling at year end. Of these, 5 were new pool wildcats on Barrow Island, 12 were extension tests to delineate leads discovered previously, and 4 were deep diamond core holes drilled to evaluate seismic anomalies. The highlight of onshore drilling in 1981 was the recovery of oil at 905 barrels per day in a drill stem test of Devonian limestones in the Blina 1 well in the Canning Basin. This was the first flow of hydrocarbons in potentially commercial quantities in the basin and was responsible for a rush of applications for permits over parts of the basin not already being explored. Two extension tests to the Blina discovery were drilled during 1981 and both flowed oil on test. A stratigraphic corehole in the central

Canning Basin also intersected 172 metres of vuggy Ordovician dolomite containing both fluid and 'dead' oil, further heightening interest in the basin. In the northern Carnarvon Basin, just west of the town of Onslow, gas was found at a depth of 500 metres in the Lower Cretaceous Birdrong Sandstone in the Tubridgi 1 and Wyloo 1 bores. Preliminary delineation of this shallow, low-pressure accumulation by 5 extension tests was being completed at the end of the year. In the Perth Basin, two extension tests to the 1980 Woodada gas discovery were drilled during 1981 but production testing on them has been inconclusive. Two extension tests to the low volume pumper at Mt Horner (originally discovery by Wapet in 1965) were also completed during 1981 to follow the Mt Horner No. 3 well drilled in 1980. These produced oil on stimulation.

Offshore, the pace of drilling activity slowed because of a shortage of suitable drilling vessels. Six wells (5 new field wildcats and one extension test) were completed during the year and 3 extension tests were drilling at the end of the year. Wapet's Gorgon 1 well in the Carnarvon Basin produced major flows of gas from several horizons pointing to this being a major discovery, but the nearby West Tryal Rocks field was downgraded by production of water in tests of several zones in the No. 3 well drilled this year. At the end of the year, Woodside's Goodwyn 6 extension test was preparing to test interesting indications of oil in this Triassic horst block (also in the Carnarvon Basin). Aquitaine's Tern 2 (12 km from Tern 1 in the Bonaparte Gulf Basin) was also preparing to test a gas zone.

Geophysical activity increased onshore in 1981 with six seismic crews operating for the greater part of the year. In addition, a small gravity survey was carried out in the eastern Canning Basin and an aeromagnetic survey was flown over the coastal Eucla Basin. Marine seismic surveys were carried out for many operators throughout the year. Five

different boats were employed in these surveys at various times throughout the year with up to three boats operating in WA waters for parts of the year.

A matter that has caused the Survey some concern during 1981 has been the reorientation of the Commonwealth Government contribution to geological research following the reorganisation of the Bureau of Mineral Resources. Consequent changes in the balance of the BMR's work program, and some uncertainty concerning the continuity of its planning procedures, particularly in relation to State work, have led to an apparent increase in overlap of functions and responsibilities which needs resolution.

## Operations

### Hydrogeology Branch

Improvements in drill operating efficiency resulted in an increase in the aggregate depth drilled for groundwater exploration during 1981 to over 9 800 metres despite continued financial constraints.

This permitted the completion of four boreholes on the Boyanup Line to a maximum depth of 1 000 metres and subsidiary observation bores to between 250 and 400 metres. This not only provided detailed hydrogeological information on a new section but extended knowledge of the very large storages of domestic quality groundwater in this part of the Perth Basin. Drilling was also completed on two sites of a new east-west section to the east of Lancelin to be known as the Gillingarra Line. The maximum depth reached was 1 200 metres.

A program of shallow drilling in the Southwest Coastal Groundwater Area was completed with the drilling of a further 15 bores and extensive test pumping in the Lake Preston area. The evaluation of groundwater resources will greatly assist the Public Works Department in the management of abstraction for irrigation. Exploratory

drilling for the Harvey shallow groundwater resources investigation has commenced on the coastal plain to the east of Lake Preston, extending as far as Harvey and Waroona. More than 30 bores have been drilled into the superficial aquifers.

Exploratory drilling in the Perth metropolitan area continued, with the completion of a further 17 artesian monitoring bores for the purpose of defining geological structure and the recharge relations of the deep aquifers. Five shallow bores were drilled at Jandakot and a further four at Lake Jandabup, these being, respectively, peripheral observation bores to the Jandakot scheme and for evaluating lake hydrology. Close liaison continued to be maintained with Metropolitan Water Supply Sewerage and Drainage Board in all aspects of water supply development. In order to facilitate the construction of the Munster sewerage pumping station, advice was provided on the dewatering of an excavation which needed to have negligible effect on market gardens and the environment.

A number of small town water supply investigations were completed at the request of the Public Works Department. These were at Mount Magnet, Miling, Leonora, Bolgart, Yerecoin and Greenbushes. An evaluation of the effects of pumping for the Rottneest Island water supply was also carried out. Investigations were completed for aboriginal communities at Ringers Soak, Cundelee and Warburton. A further evaluation was made of the groundwater resources used for irrigation and other purposes in the Swan Valley.

Advice continued to be provided on the disposal of Laporte factory effluent at Australind. A long-term study of the effects of directly injecting strong effluent into a limestone aquifer by means of boreholes was commenced. A survey of liquid waste disposal sites in the Metropolitan area made substantial progress. Advice was given to local authorities and the Public Works

Department concerning waste disposal sites and the use of treated waste water for artificial recharge.

The demand for advice on farm water supply sources during 1981 showed a slight decline, with 82 inspections completed. A program of drought relief drilling in Kent and Gnowangerup Shires was mounted to establish emergency watering points.

However, as expected, the success rate was low: only three bores out of a total of 38 proved to be successful in locating small supplies of stock-quality water.

A continued increase in the demand for hydrogeological advice by State and local government authorities is reflected in a rise to 44 of the number of specialist reports prepared.

The compilation of bore records throughout the State continued, but staff shortages in the professional area prevented the processing of the data and the commencement of systematic hydrogeological mapping.

### **Engineering and Environmental Geology Branch**

Engineering geology activities were largely confined to investigations for other Government Departments and instrumentalities.

For the Public Works Department geological studies and, in two cases, geophysical surveys were made at the Harding River Dam Site (Roebourne), at dam sites near Manjimup and on the Harris River (Collie). Geological mapping associated with safety reviews of existing dams and with the need to locate a suitable quarry for a breakwater at Hopetoun was carried out.

For the Metropolitan Water Board geological studies and geophysical surveys were made at the North Dandalup Dam Site and at two dam sites on the Little Dandalup River (Dwellingup). Safety reviews of existing dams involved geological logging and mapping. Progressive geological logging was carried out during the construction of the Wungong and Bibra tunnels.

Geological studies were made of the proposed railway routes along the Preston Valley from Collie to Bunbury for Westrail, and geological mapping was carried out to aid the search for quarries for ballast and the siting of a minor dam in the Avon Valley.

In addition, the branch gave advice to members of the general public and was engaged in other miscellaneous and minor tasks.

Environmental geology covered a wide range of activities. Environmental geology maps of Bunbury and of Harvey were completed and are now being finalized by the cartographers. Existing data are being compiled preparatory to mapping Perth.

Reports received from the Environmental Protection Authority (e.g. System Six, Burrup Peninsula Environmental Review and Management Program on the liquified natural gas project) and from the Department of Conservation (e.g. Alcoa and Wagerup Triennial Reviews) were reviewed and comments made on behalf of the Department of Mines.

Reports were made for amendments to various town planning schemes and meetings were held with other organisations (Basic Raw Materials Studies, National Conservation Strategy, and Mining and Management Planning Group). Appraisals were made of mineral tenement applications in the South West Mineral Field.





Field inspections were made of quarry sites at Gwambygine and Bencubbin; various seminars were attended (e.g. Coastal Management); geological displays were prepared, and general advice was given to government departments and the public.

### Regional Geology Branch

Compilation and production of 1st edition 1:250 000-scale sheets, covering the whole of Western Australia, is almost complete (as shown in the figure).

Peak Hill (2nd edition) 1:250 000 sheet is nearing completion. Field work continued on the Wyloo 1:250 000 sheet (2nd edition). Two officers, based in the Kalgoorlie Regional Office, continued field work on the Widgiemooltha 1:250 000 sheet (2nd edition) and commenced work on the Boorabbin 1:250 000 sheet (2nd edition).

The Nabberu Basin Bulletin and the Gascoyne Province synthesis are nearing completion.

A detailed map of the Mount Narryer area (Byro 1:250 000 sheet) was completed and further geochronological samples collected.

Further geochronological sampling for Rb-Sr, Sm-Nd and U-Pb dating was undertaken on the Winning Pool, Glenburgh, Byro, Youanmi and Jackson 1:250 000 sheets.

### Sedimentary Geology Branch

The processing of data submitted by petroleum companies and the re-issue of large tracts, compulsorily relinquished by various companies at the conclusion of tenure periods of their permits, continued throughout the year. There has been considerable interest shown in acquiring petroleum permits in Western Australia in 1981. By the end of the year, there were very few parts of the sedimentary basins in the State which were not occupied by current petroleum permits.

The maps and explanatory notes for the Carnarvon Basin 1:250 000 sheets were prepared during the year and should be available in 1982. Preparation of a bulletin covering both the onshore and offshore portions of the basin is well advanced.

A further field season in the Bonaparte Gulf Basin greatly advanced the re-evaluation of the Palaeozoic outcrop of the basin, and work in this basin and the nearby Ord Basin will be completed in 1982. A thorough review of the sedimentation and coal reserves of the Collie Basin, an area which is proving to be critical to the overall evaluation of the State's energy resources, was commenced late in the year.

### Mineral Resources Branch

The Explanatory Notes on the Pemberton 1:250 000 sheet were completed and the Branch's contribution to the remapping of the Wyloo Sheet finalized.

In the Hamersley Basin, the Rocklea, Milli Milli and Bellary Domes were mapped as part of a study of the Early Proterozoic Fortescue Group rocks. Field work on the Mount Monger project was completed and a report is in preparation. A map of the Warriedar Fold Belt is in the hands of the draftsmen but the report has been delayed.

Work on the study of bauxite in the Darling Range area continued during the year, and further inspections were made of Ministerial Temporary Reserves for iron ore.

Forty-one rolls of microfilm were added to the library of open-file reports, bringing the total number of rolls now available to 200.

Miscellaneous investigations included inspections of: four uranium prospects in the Gascoyne Province; an extension to the talc deposit at Three Springs; a radiometric anomaly at Wonnerup; Polly's Patch, Gordon's and other gold prospects; the Yandicoogina iron ore

deposits; and a limestone-bearing area being resumed by the Government.

### Common Services Branch

In the **petrology section** an increase in demand for petrographic services during 1981 was reflected in the preparation of 104 petrological reports covering 2 031 samples.

Petrology staff were directly involved in the preparation of 7 papers published during 1981. Topics ranged from petrography through geothermometry and geobarometry to geochronology. Studies on kimberlites and alkaline granites continued and a study of metamorphism in the Southern Cross Province was commenced.

The co-operative geochronology program with the Western Australian Institute of Technology resulted in the publication of 6 Rb-Sr papers and the continuation of 17 Rb-Sr studies into 1982. The Sm-Nd programme has resulted in one published article and several other articles are near completion. Nearly completed are two traverses across the margin of the Yilgarn Block, five studies of Yilgarn plutons, and three studies of greenstone belts.






The laboratory prepared 1 400 petrographical thin sections, 76 sedimentary thin sections, 108 polished mounts and 6 polished thin sections. Six hundred and ninety-four samples were prepared for chemical or isotopic (geochronological) analysis. One hundred and fifty-eight specific gravity, 80 mineral separations, and 19 grain-size analyses were completed.

The Government Chemical Laboratories continued to identify mineral samples and to provide access to x-ray diffractometer and computer facilities.

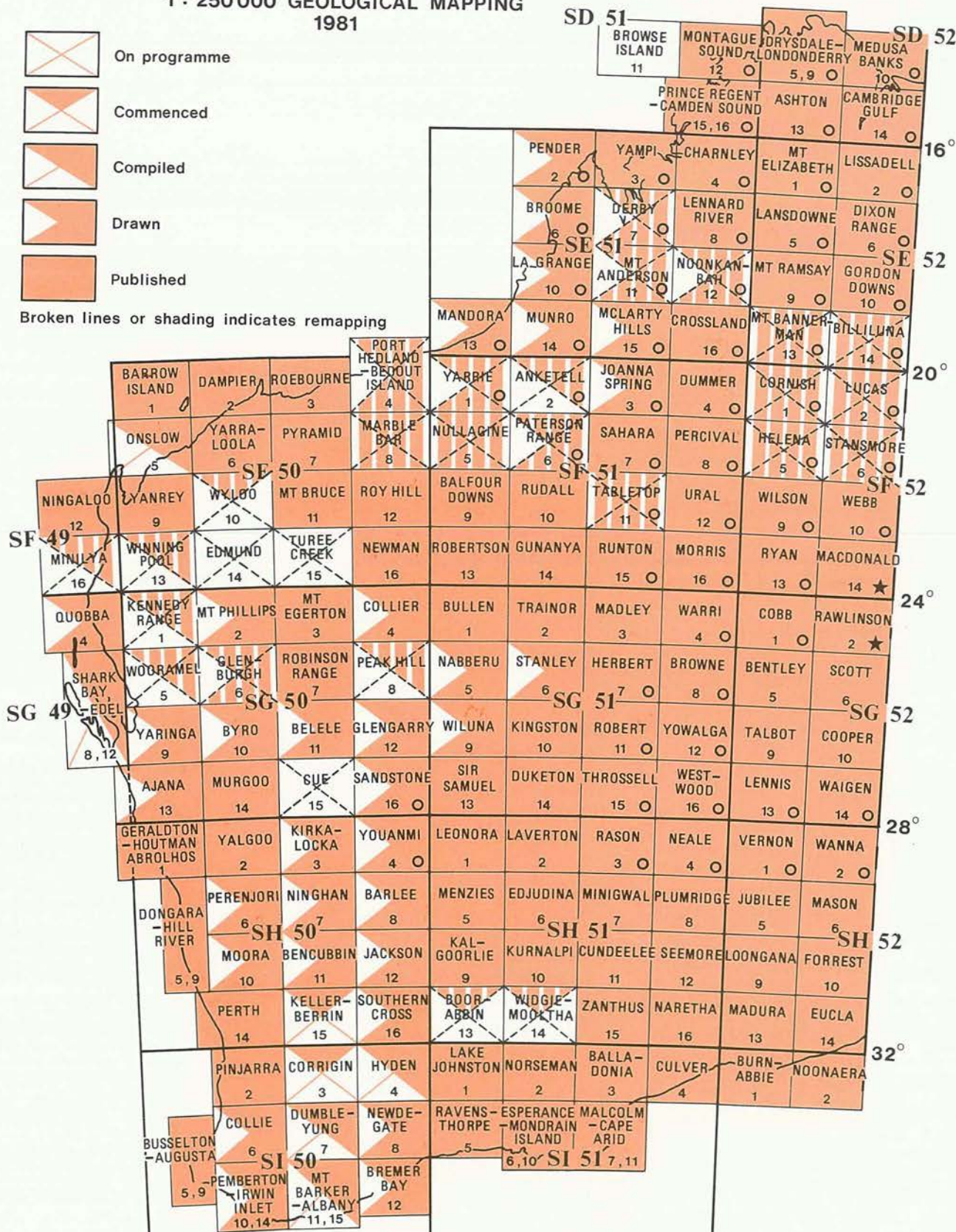
Forty-eight reports were written by the **palaeontology section** during the year. These covered: Mesozoic palynology of the Perth metropolitan and southern Perth Basin areas for the Hydrogeology Branch; Precambrian stromatolite studies for the Regional Geology

# GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

1 : 250 000 GEOLOGICAL MAPPING  
1981

-  On programme
-  Commenced
-  Compiled
-  Drawn
-  Published

Broken lines or shading indicates remapping



-  Mapped by GSWA
-  Mapped by BMR
-  Mapped by GSWA and BMR



Branch; and various investigations in the Carnarvon, Canning and Bonaparte Gulf Basins for the Sedimentary Geology Branch; all of which involved the preparation of 345 palynological samples and 52 thin sections by the laboratory staff.

About 7 000 samples from relinquished petroleum tenements and 1 000 samples arising from the routine work of the section were catalogued. All officers from the section presented papers on their current research to the Fifth Australian Geological Convention held in Perth in August, 1981.

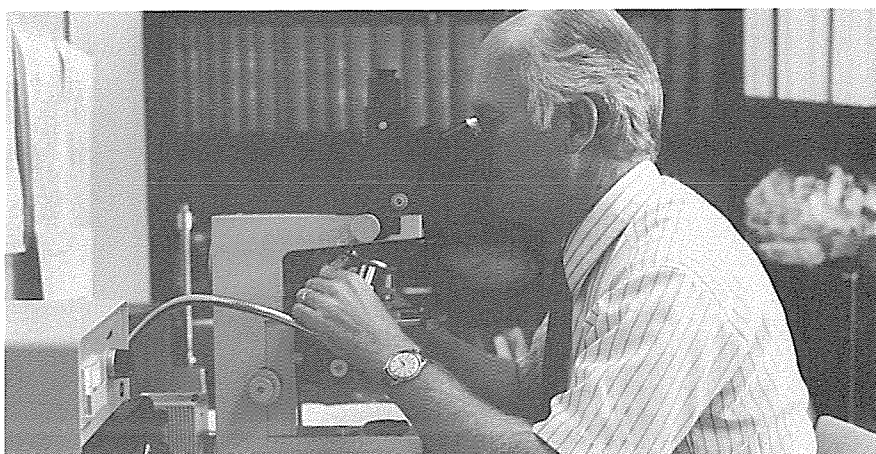
Although the **geophysical section** logged 146 wells in 1981, 38 of these were to check well completion details and were thus made in previously logged bores. Activity was maintained at the 1980 level however and the average depth of bores logged was 290 metres.

Field surveys included seismic refraction work at the Lefroy Brook, North Dandalup (2), Little Dandalup (2) and Harding River dam sites. Refraction surveys were also used to assist the Department of Agriculture in Katanning in experiments to counteract saline seepage and to assess the possibility of pollution from the Red Hill liquid disposal site.

A gravity and magnetic investigation of the Warriedar Greenstone Belt was conducted to elucidate the structure in two cross sections. An interpretation of residual gravity anomalies near Perth confirmed the thickening of the South Perth Shale encountered in stratigraphic bores. A survey for additional groundwater supplies for Laverton township included the application of magnetic, electromagnetic, resistivity and seismic methods; several prospective boresites were nominated.

About 60 public enquiries were answered during the year and the usual water-testing facilities and servicing of equipment were maintained.

During the year the **geochemistry section** continued study on three major projects: the geochemistry and petrology of the Mount Edgar



and Corunna Downs batholiths (Pilbara); the chemical composition and mineralogy of the iron-formations of the Hamersley area; and geochemistry of the volcanic sequences of the Pilbara (jointly with the Bureau of Mineral Resources).

The **technical information section** edited and prepared numerous works for publication. One bulletin, dealing with the geology of the Pilbara Block, is in press and two more, one dealing with the geology of the Bangemall Basin and one dealing with Devonian stromatopoids of the Carnarvon Basin, have been received. A mineral resources bulletin dealing with the nickel deposits of Western Australia is in the final stages of preparation for the printer.

Report 11, which deals with the Cadoux earthquake, is at the printer and should be released within the first quarter of 1982.

Nine full-colour sheets of the 1:250 000-scale geological map series of Western Australia, with accompanying explanatory notes, were published; and five more are with the Government Printer. Fourteen records, eight of which accompanied preliminary editions of 1:250 000-scale geological maps, were issued.

One information pamphlet was re-written, but is not yet published.

During the second half of the year, the popular interest in gold prospecting waned markedly. This has the effect of reducing public enquiries to a manageable level. The

section responded to some 2 510 inquiries, 580 of which required detailed research. Drafting and copying requisitions totalled 1 300.

Members of the public visiting the **library** totalled 4 931, of whom 1 135 made use of the microfilm reading and printing facilities. Staff loans totalled 7 726, and 457 inter-library loans were arranged.

### Regional offices

The Kalgoorlie office was established at its full strength of three officers for a short period during the year until the promotion of one geologist to a head-office position again reduced the staff to two. A new appointee is expected to commence duty early in 1982.

The staff housing expected for establishment of the Karratha office in 1981 did not materialize and part of the available office accommodation there was lost to meet another Department's urgent need. The setting up of the Karratha office is not now scheduled for early 1982.

### Organisation

**Staff.** The scale of mineral exploration and development in Western Australia is such that the Geological Survey would be hard pressed to service it adequately even if fully staffed. At anything less than full strength it is bound to fall behind in some areas, and this is undesirable for an organisation that is uniquely

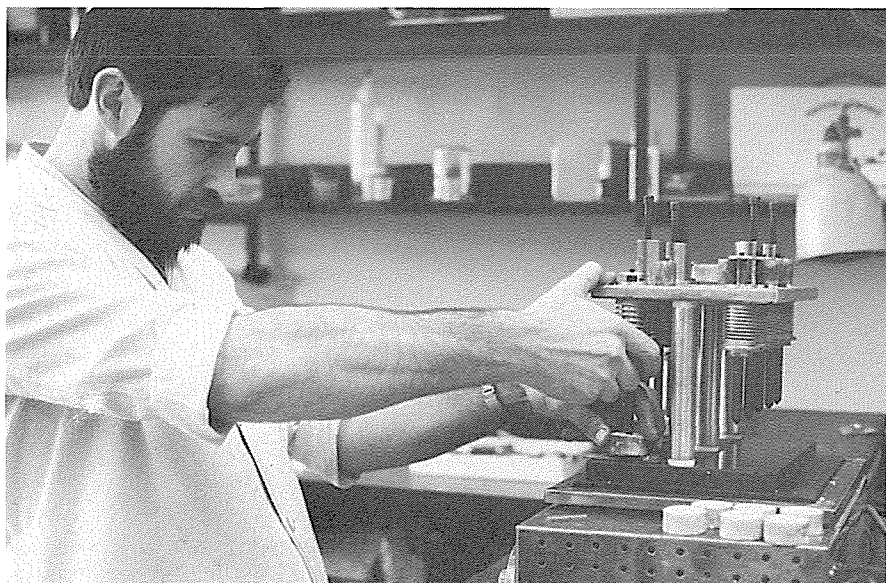


placed to provide the geological knowledge required by industry in the development of new exploration concepts, rather than simply endeavour to record and keep abreast of the results.

On the brighter side, it is gratifying to note that, at the end of the year, the only professional vacancies that appeared to have no early prospect of being filled were those requiring significant experience in the petroleum exploration industry. Consequently, except in some special areas of the Survey's responsibilities, 1982 promises to be a year of increased production, during which its level of achievement should recover from the effects of the massive staff losses (almost entirely to private enterprise) which

permission was granted to recruit geologists from overseas as there were insufficient suitably qualified applicants from within Australia. There are many well qualified geologists available from overseas (particularly in the United Kingdom) but landing them in Perth is a slow and expensive process. Consequently the operational strength of the Survey has been severely depleted for the whole year.

In the professional staff there were 12 new appointments, 8 resignations, 1 promotion and 1 transfer to another Division. Clerical and general staff had 3 new appointments, 4 resignations, 1 transfer in from another Division and 1 temporary relief officer appointed.



began in 1979 as a direct consequence of the upsurge in exploration activity.

The death (through sudden illness) of geologist Stephen James Williams on August 11, 1981, is recorded with particular regret. Mr Williams joined the Division in January 1974, and throughout his service displayed an aptitude for and dedication to his profession that heralded a promising career.

With 8 professional staff resignations and 12 appointments the number of vacancies was reduced to 10 at the years end. During 1980

**Accommodation.** The Geological Survey is comfortably accommodated, the only major shortcoming being the physical separation of the Hydrogeology and Engineering and Environmental Geology Branches from the rest of the Survey. These two groups moved during the year into rented offices of a good standard. The 10-minute walk involved to the new quarters is not itself a major inconvenience; greater productivity losses result from continued delays in transfer of files and future extra costs to be considered in electronic data processing lines.

## Functions

The primary role of the Geological Survey Division of the Mines Department is to systematically record and interpret the geology of Western Australia. This information is made available to Government, Industry and the general public in order to assist in the exploration, development and conservation of the State's mineral, fossil-fuel and groundwater resources, and to assist in a variety of community needs, including urban planning, agricultural-land release and such development projects as railway, harbour, road and dam construction.

Results of the Survey's activities are published in annual reports, memoirs, bulletins, mineral resources bulletins, reports, records, geological map sheets with accompanying explanatory notes and information pamphlets.

The Geological Survey Division is divided into six branches: Regional Geology, Mineral Resources, Sedimentary Geology, Hydrogeology, Engineering and Environmental Geology and Common Services.

**Regional Geology.** This branch maps the Precambrian areas of the State, which contain most of the known mineral deposits. This mapping forms the basis for mineral and groundwater exploration in those areas.

**Mineral Resources.** This branch is responsible for assessing the State's mineral resources, advising on mineral exploration and development, and undertaking research projects designed to assist the discovery of new mineral deposits.

**Sedimentary Geology.** This branch advises on petroleum and coal exploration, and collates the results of this exploration. It also undertakes regional and detailed geological mapping, stratigraphic research, and subsurface geological and geophysical studies of the State's Phanerozoic sedimentary basins, in order to assist exploration for petroleum, coal and groundwater.

**Hydrogeology.** The Hydrogeology Branch is engaged in studies relevant to groundwater exploration, development, conservation and pollution. The branch undertakes both regional investigations of groundwater regions and detailed investigations of smaller areas for metropolitan, township and industrial water supplies. The exploration for groundwater utilizes geological and geophysical techniques and test drilling. Advice is also given to private landholders on groundwater for domestic, irrigation and stock use.

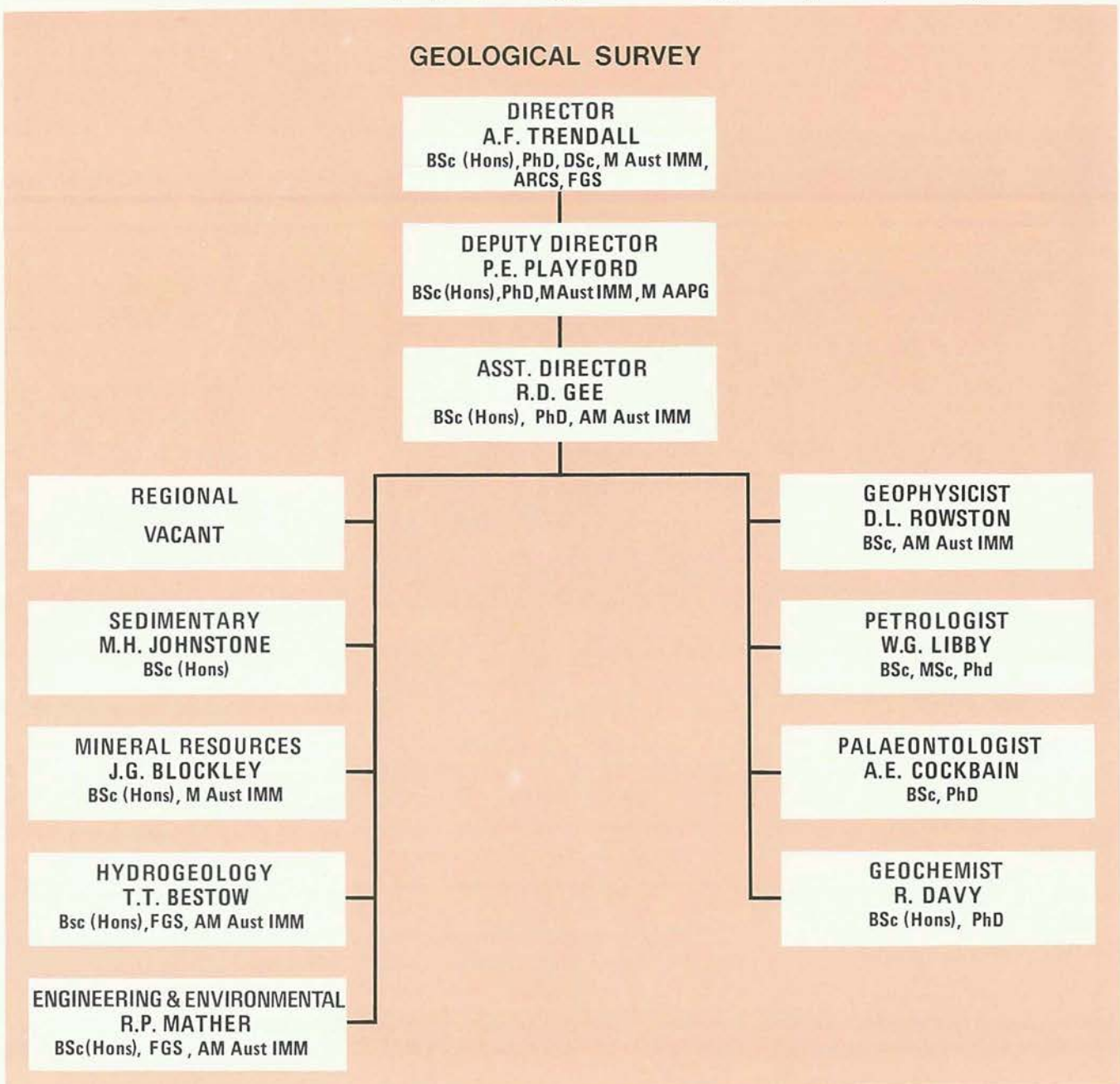
**Engineering and Environmental Geology.** The engineering section of this Branch carries out detailed investi-

gations to assist other government departments in various engineering projects, such as damsite and tunnel construction. It also provides advice to Government, Industry and the public on geological factors relevant to building construction. The environmental geology section advises on geological aspects of environmental issues. It is also responsible for the preparation of urban geology maps designed to assist urban planning and conservation, and for the assessment of industrial/mineral resources.

**Common Services.** The Common Services includes various specialist groups (Petrology, Palaeontology,

Geophysics and Geochemistry) who provide their specialist services to the various branches as required, and also carry out research in their individual fields. The technical information section provides general geological advice to the public, and is responsible for editing the Survey's publications. This branch also includes clerical, library and laboratory staff, and geological and technical assistants.

The Geological Survey has its own records system, a large geological library (including a microfilm library), a core-storage facility (at Dianella), and a general workshop/store (at Morley).



## Other Activities

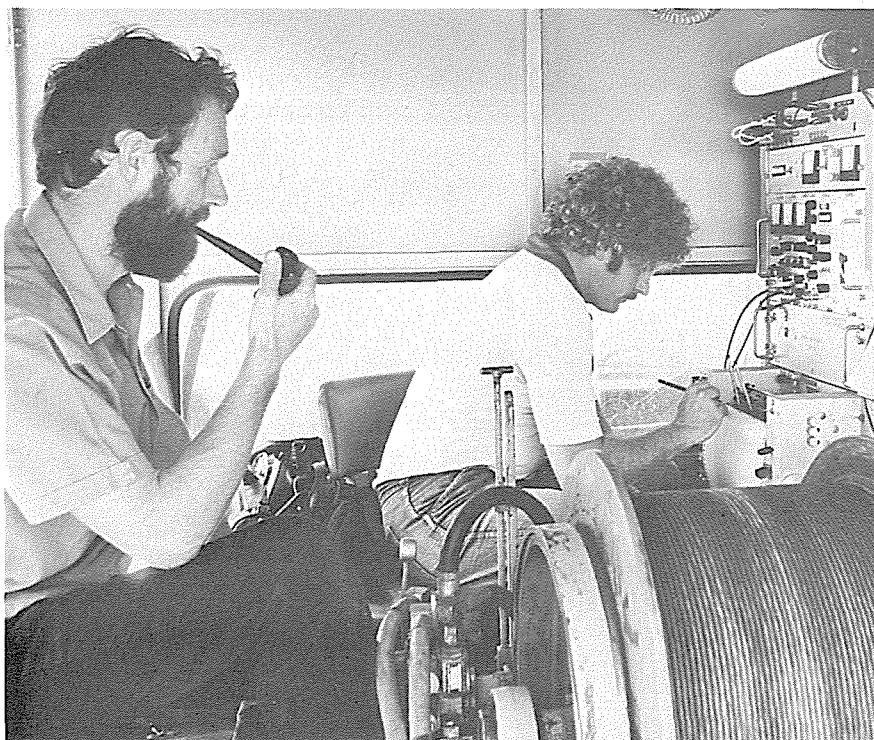
The following publications were issued during 1981:

Geological Survey of Western Australia Annual Report 1980.

Geological maps at 1:250 000 scale with explanatory notes for the following sheet areas:

Bullen—International Grid SG 51-1  
Pinjarra—International Grid SI 50-2  
Gunanya—International Grid SF 51-14  
Kingston—International Grid SG 51-10  
Robinson Range—International Grid SG 50-7  
Rudall—International Grid SF 51-10  
Runton—International Grid SF 51-15  
Sir Samuel—International Grid SG 51-13  
Trainor—International Grid SG 51-2

Preliminary Geological map of Sandstone 1:250 000 sheet (SG 50-16 International Grid).



## Records

1978/6 Dampier Archipelago lime-sand and limestone; by E. R. Biggs and P. D. Denman.

1980/6 Explanatory notes on the Belele 1:250 000 geological sheet, Western Australia; by M. Elias.

1981/1 Wells drilled for petroleum exploration in Western Australia to the end of 1980; by K. A. Crank (microfiche only).

1981/2 Geology and hydrogeology of the Picton line of bores, Perth Basin; by P. H. Wharton (microfiche).

1981/3 Explanatory notes on the Barlee 1:250 000 geological sheet, Western Australia; by I. W. Walker and D. F. Blight (microfiche).

1981/4 Explanatory notes on the Bencubbin 1:250 000 geological sheet, Western Australia; by D. F. Blight, R. J. Chin and R. A. Smith (microfiche only).

1981/5 Explanatory notes on the Bremer Bay 1:250 000 geological sheet, Western Australia; by R. Thom and R. J. Chin.

1981/6 Uranium exploration in Western Australia—A history of investigation and a guide to microfilm open-file information; by J. D. Carter (microfiche only).

1981/7 Explanatory notes on the Jackson 1:250 000 geological sheet, Western Australia; by R. J. Chin and R. A. Smith.

1981/8 Explanatory notes on the Shark Bay-Edel 1:250 000 geological sheet, Western Australia; by B. P. Butcher, W. J. E. van de Graaff and R. M. Hocking.

1981/9 Explanatory notes on the Newdegate 1:250 000 geological sheet, Western Australia; by R. Thom, R. J. Chin and A. H. Hickman.

1981/10 Explanatory notes on the Pemberton-Irwin Inlet 1:250 000 geological sheet, Western Australia; by S. A. Wilde and I. W. Walker.

1981/11 The occurrence of coal at Iffley Coupe; by L. J. Furness.

1981/12 A geological bibliography of the Carnarvon Basin, Western Australia to 1981; by H. T. Moors.

Publications in press comprised Report 11: The Cadoux earthquake, 2 June 1979.

Bulletin 127: Geology of the Pilbara Block and its environs.

Geological maps at 1:250 000 scale with explanatory notes for the following sheet areas:

Broome—International Grid SE 51-6

Collier—International Grid SG 50-4

Derby—International Grid SE 51-7

Glengarry—International Grid SG 50-12

Joanna Spring—International Grid SF 51-3

La Grange—International Grid SE 51-10

Mandora—International Grid SE 51-13

McLarty Hills—International Grid SE 51-15

Mount Anderson—International Grid SE 51-11

Munro—International Grid SE 51-14

Noonkanbah—International Grid SE 51-12

Onslow—International Grid SF 50-5

Pender—International Grid SE 51-2



Southern Cross—International Grid SH 50-16

Wiluna—International Grid SG 51-9

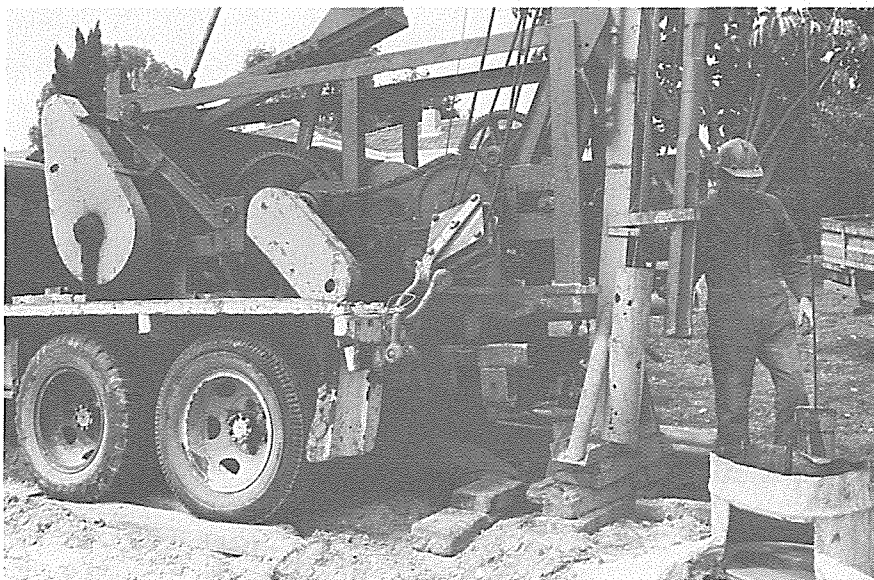
Urban geology maps 1:50 000:  
Bunbury—Burekup, de  
Witt—Packard and Harvey  
—Lake Preston.

Manuscripts in preparation

Bulletin 128: Geology of the Bange-  
mall Group—the evolution of a  
Proterozoic intracratonic sedi-  
mentary basin.

Bulletin: The Gascoyne Province.

Mineral Resources Bulletin 14:  
Nickel mineralization in West-  
ern Australia.



Geological maps at 1:250 000 scale with explanatory notes, the field work having been completed:

Ajana, Anketell, Barlee, Belele, Bencubbin, Bremer Bay, Byro, Collie, Corrigin, Dumbleyung, Glenburgh, Hyden, Jackson, Kellerberrin, Kirkalocka, Moora, Mount Barker-Albany, Mount Phillips, Nabberu, Newdegate, Ninghan, Paterson Range, Pemberton-Irwin Inlet, Perenjori, Port Hedland-Bedout Island, Quobba, Sandstone, Shark Bay—Edel, Stanley, Yaringa, Yarrarie, Youanmi.

Urban geology maps 1:50 000:  
Boodarie and Port Hedland.

Numerous reports compiled by Geological Survey staff, sometimes with other authors, were published externally and are listed below.

Allen, A. D., 1981, Late Tertiary and Quaternary stratigraphy of the Swan Coastal Plain, near Perth, Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 59.

Allen, A. D., 1981, Groundwater resources of the Swan Coastal Plain, near Perth, Western Australia, in Whelan, B. R. (ed.), *Groundwater Resources of the Swan Coastal Plain (1981)*; CSIRO, Perth, W.A. p. 29-80.

Backhouse, J., 1981, Late Jurassic and Early Cretaceous palynology of the Perth Basin: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 67.

Baxter, J. L., 1981, Heavy-mineral bearing siliciclastic and bioclastic barrier sand-deposits on the Swan Coastal Plain: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 59.

Bunting, J. A., 1981, Sedimentary environments and palaeogeography of the Earraheedy Group, Nabberu Basin, Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 41.

Cockbain, A. E., 1981, Distribution of stromatoporoids in the Devonian reef complexes of the Canning Basin: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 49.

Compston, W., Williams, I. S., McCulloch, M. T., Foster, J. J., Arriens, P. A., and Trendall, A. F., 1981, A revised age for the Hamersley Group: *Geol. Soc. Australia, Fifth Geol. Convention Abstract*, p. 40.

De Laeter, J. R., Fletcher, I. R., Rosman, K. J. R., Williams, I. R., Gee, R. D., and Libby, W. G., 1981, Early Archaean gneisses from the Yilgarn Block, Western Australia: *Nature*, v. 292, No. 5821, p. 322-324.

Gee, R. D., 1981, Tectonic framework of Proterozoic sedimentation along the northern margin of the Yilgarn Block: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 39.

Glikson, A. Y., and Hickman, A. H., 1981, Geochemistry of Archaean volcanic successions, eastern Pilbara Block, Western Australia: *Australia Bur. Mineral Resources Rec. 1981/36*.

Grey, K., 1981, Studies of some Precambrian stromatolites in Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 44.

Hocking, R. M., 1981, Fluvatile sedimentation in a coastal setting; the Tumblagooda Sandstone (Silurian), Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 24.

John, B. M., Glikson, A. Y., Peucat, J. J., and Hickman, A. H., 1981, REE geochemistry and isotopic data of Archaean silicic volcanics and granitoids from the Pilbara Block, Western Australia: implications for the early crustal evolution: *Geochimica et Cosmochimica Acta*, v. 45, p. 1633-1652.

- Johnstone, M. H., 1981, The importance of continental fragmentation history to petroleum accumulation, *in* Creswell, M. H., and Vella, S. P. (eds.) *Gondwana Five, Proceedings of the Fifth International Gondwana Symposium*, Wellington, New Zealand, 1980, p. 329-334.
- Marcos, G., 1981, Some geotechnical aspects of weathering profiles in the Darling Range—Perth area, Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 84.
- Marston, R. J., Groves, D. I., Hudson, D. R., and Ross, J. R., 1981, Nickel sulfide deposits in Western Australia: a review: *Economic Geology*, v. 76, No. 6.
- Mather, R. P., 1981, Investigation for a quarry for breakwater construction at Rocky Point, Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 83.
- Moore, P. S., and Hocking, R. M., 1981, Wave-dominated shelf sedimentation—a model from the Permian of the Carnarvon Basin, Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 25.
- Moors, H. T., 1981, An alluvial fan—fluvial plain depositional model for the Devonian Willaraddie Formation and Munabia Sandstone of the Carnarvon Basin, Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 23.
- Muhling, P. C., and Brakel, A. T., 1981, Basement tectonic control of sedimentation in the Proterozoic intracratonic Bangemall Basin: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 40.
- Playford, P. E., 1981, Environmental controls on the morphology of modern stromatolites at Hamelin Pool, Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 45.



- Playford, P. E., 1981, Early submarine cementation and its consequences in Devonian reefs of the Canning Basin: *Geol. Soc. Australia, Fifth Geol. Convention Abstracts*, p. 51.
- Richards, J. R., Fletcher, I. R., and Blockley, J. G., 1981, Pilbara galenas. Precise isotopic assay of oldest Australian leads; model ages and growth curve implications: *Mineralum Deposita*, v. 16, p. 7-30.
- Stewart, A. J., Williams, I. R., and Elias, M., 1981, Notes on the preliminary Youanmi 1:250 000 geological series map, Western Australia: *Australia Bur. Mineral Resources Rec. 1981/23*.
- Wilde, S. A., 1981, A brief review of the geology of southwestern Australia: *in* Johnstone, T. E. (Ed.), *Mineral Fields of the South West*, Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention, Field Excursions Guidebook*, p. 3-21.
- Wilde, S. A., 1981, the Collie Basin *in* Johnstone, T. E. (ed.), *Mineral Fields of the South West*, Western Australia: *Geol. Soc. Australia, Fifth Geol. Convention, Field Excursion Guidebook*, p. 33-45.

A field excursion open to the public was conducted over the period October 26 to 29, 1981 to acquaint interested persons (mainly geologists) with the results of regional geological mapping on the Youanmi, Barlee and Jackson 1:250 000 sheets. A lecture "Geological synthesis of the Central Yilgarn" was first presented at the Sandstone Shire hall followed by a three-day trip inspecting localities of particular interest. Over 100 people attended the lecture and most of these participated in the field excursion.

A program of eight talks on the more interesting results of the Survey's work in 1980 was delivered on March 26. Attendance at the various talks ranged from 25 to 85.

The number of talks delivered was less than in previous years, a direct result of depleted staff.



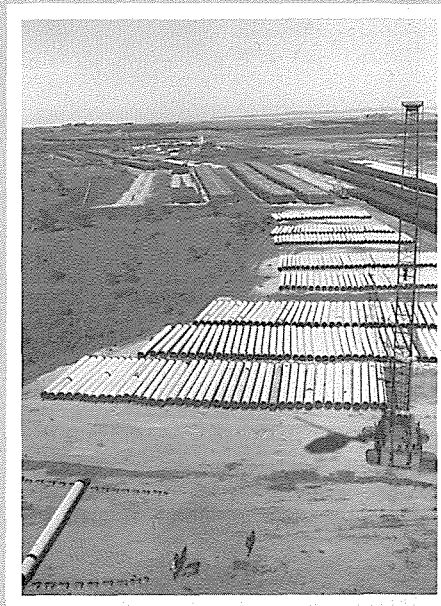
## North West Shelf gas project—new technology for Australia

The North West Shelf gas project means, not only a source of gas, but the introduction of new technology to Australia. The offshore platform itself will exceed in size and weight any previous platform destined for Australian waters and the submarine pipelines bringing the gas and condensate ashore will be one of the largest diameter pipelines to be installed in deep waters throughout the world. The platform will perform the dual function of a drilling facility and a production treatment plant. It is designed to stand in some 125 metres water depth with a clearance under the deck structure for the 100 year maximum wave height and to continue production during a cyclone. There are slots to permit the drilling of 34 wells and, by means of directional drilling, the wells will spread out from the seabed to penetrate as large an area as possible of the hydrocarbon-bearing sands which are some 4 000 metres below seabed.

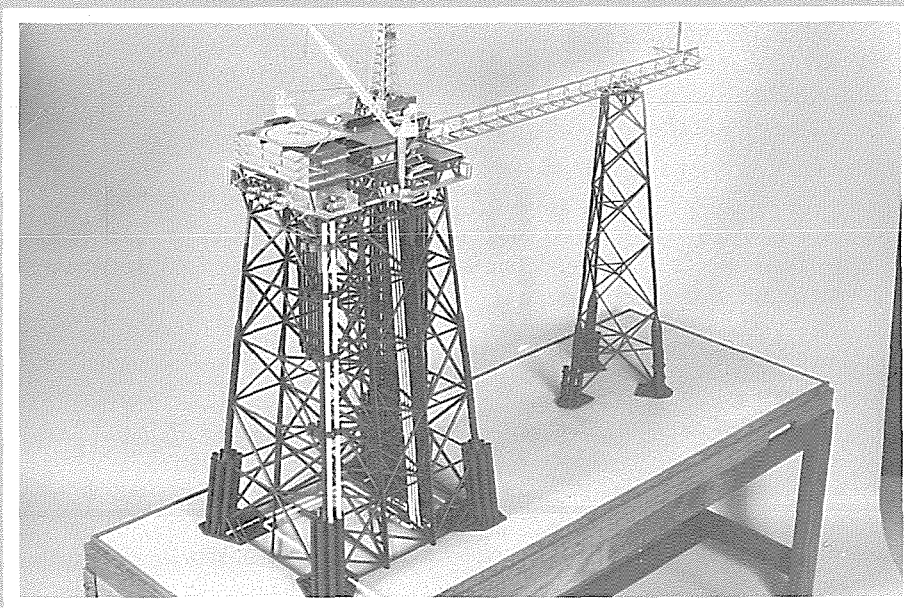
The gas from each well surfaces in the production treatment plant on the platform at about 95°C and contains both liquid hydrocarbons (condensate) and water. These are separated out in three production trains as it is necessary to remove the water to reduce corrosion of the submarine pipeline. The condensate and gas are recombined offshore before travelling the 135 kilometre journey to the onshore treatment plant in two-phase flow within the submarine pipeline. Once onshore it is necessary to separate the gas and condensate for further treatment and this initial separation is carried out at a 5 200 cubic metre capacity slug catcher, the largest yet to be built in the world. Construction of the offshore platform, drilling and production facilities and living quarters and equipment manufacture has commenced on a world-wide basis but a

major portion of the work is being done in Australia. The jacket, weighing some 22 000 tonnes at load out, is being fabricated in Japan, and the flare tower and bridge in Adelaide. The platform facilities are being constructed in modular construction units at Jervoise Bay, Geraldton and Singapore. By this technique, most of the equipment, piping, electrical installation and instrumentation can be completed onshore before being delivered by barge to the platform. There will be 20 major modules installed in the initial stages of the development; a further 2 compression modules will be added later when the field gas pressure starts declining.

Construction of the submarine pipeline will be breaking new ground as several new techniques are planned. The excavation of the pipe trench in Mermaid Sound incorporates the use of advanced underwater explosive techniques. The pipe-lay barge will adopt for the first time, a technique of double jointing the pipes on board before welding the pipes to the pipeline. A new method of preheating the pipes before welding using a heat-induc-



tion treatment process will be used to combat steel hardness. In this process a stainless steel clamp encircles the joint between 2 pipes and by inducing an electro-magnetic field creates a heat band 100 mm wide at 400°C in less than 4 minutes. And finally the pipeline will be lowered into the seabed for long-term protection by the use of a marine plough. This method has only been used before on small diameter pipelines.





The number of permits to explore for petroleum reached an all time high in Western Australia in 1981. At the end of the year there were 135 permits current (56 offshore and 79 onshore). A feature of the year was the keen interest in the Canning Basin following the discovery of oil at Blina. Almost the whole of the Canning Basin is now under permit or application.

Oil was discovered in the first well drilled by Home Oil Australia Ltd in its permit EP 129 in the Canning Basin. Two zones produced oil flows, the lowermost of which flowed oil at the rate of 905.7 barrels of oil per day from Devonian reef limestone. The Blina field appears to be the first commercial oil field in the Basin.

A shallow gas reservoir was discovered by Otter Exploration N.L. at Tubridgi in the onshore Carnarvon Basin, near the town of Onslow. Seven wells have been drilled in the field which is still being evaluated.

A limited amount of development drilling was carried out by WAPET in the Barrow and Dongara fields. At Dongara No. 24 a previously untested hydrocarbon-bearing zone in the Kockatea Shale (Triassic) section, called the "Aranoo sands" by WAPET, was discovered. Additional evaluation will be needed before the extent of this reservoir can be decided upon.

Good progress was made in 1981 on construction of the initial phase of the North West Shelf natural gas project since the formal go-ahead was announced in September, 1980. Contracts for work and equipment in excess of \$800 million were placed and commenced for an offshore drilling/production platform, a submarine pipeline, a supply base on the Burrup Peninsular, site drainage for the onshore gas treatment plant, infrastructure and service installations. Fabrication is

in progress in industrial centres throughout Australia and in Japan, South Korea, Singapore, Europe and the United States.

Total recoverable reserves at the end of 1981 (estimated with a probability of greater than 25 per cent) are estimated to be at least  $14.1 \times 10^6 \text{m}^3$  of crude oil,  $56.8 \times 10^6 \text{m}^3$  of condensate,  $29.4 \times 10^6 \text{m}^3$  of LPG and  $529.6 \times 10^9 \text{m}^3$  of natural gas. The main change compared to the 1980 estimates involved the addition of WAPET's Gorgon gas discovery in the offshore Carnarvon Basin.

Total crude oil production from Barrow Island decreased in 1981 by 17 per cent compared to 1980 due mainly to tanker unavailability. However, it should be noted that the infill and development well programme initiated in 1978 contributed 13 per cent of the total production in 1981.

Total royalty paid on Barrow Island crude increased by 8 per cent over 1980. Royalty paid on production from the northern Perth Basin fields increased by 6 per cent over 1980.

### Petroleum Exploration and Development

#### Tenements

The number of permits to explore for petroleum reached an all time high for Western Australia in 1981. At the end of the year 135 permits were current, including 56 offshore and 79 onshore. These permits cover areas of 644 206 square kilometres and 799 686 square kilometres respectively. (See tables on pages 133 to 136). The accompanying map shows in simplified form the petroleum tenements at December 31, 1981.

The area still available for application both onshore and offshore totals 554 147 square kilometres.

At the end of the year 50 applications (43 onshore, 7 offshore) were being processed. (See tables on pages 136 and 137).

Five offshore areas which had been advertised in 1980, with a closing date in 1981, attracted 17 applications, with 6 for Area W80-51 alone. Sixteen areas were made available for application with a closing date in 1981, and attracted 17 applications, with 10 applications for one area (W81-67).

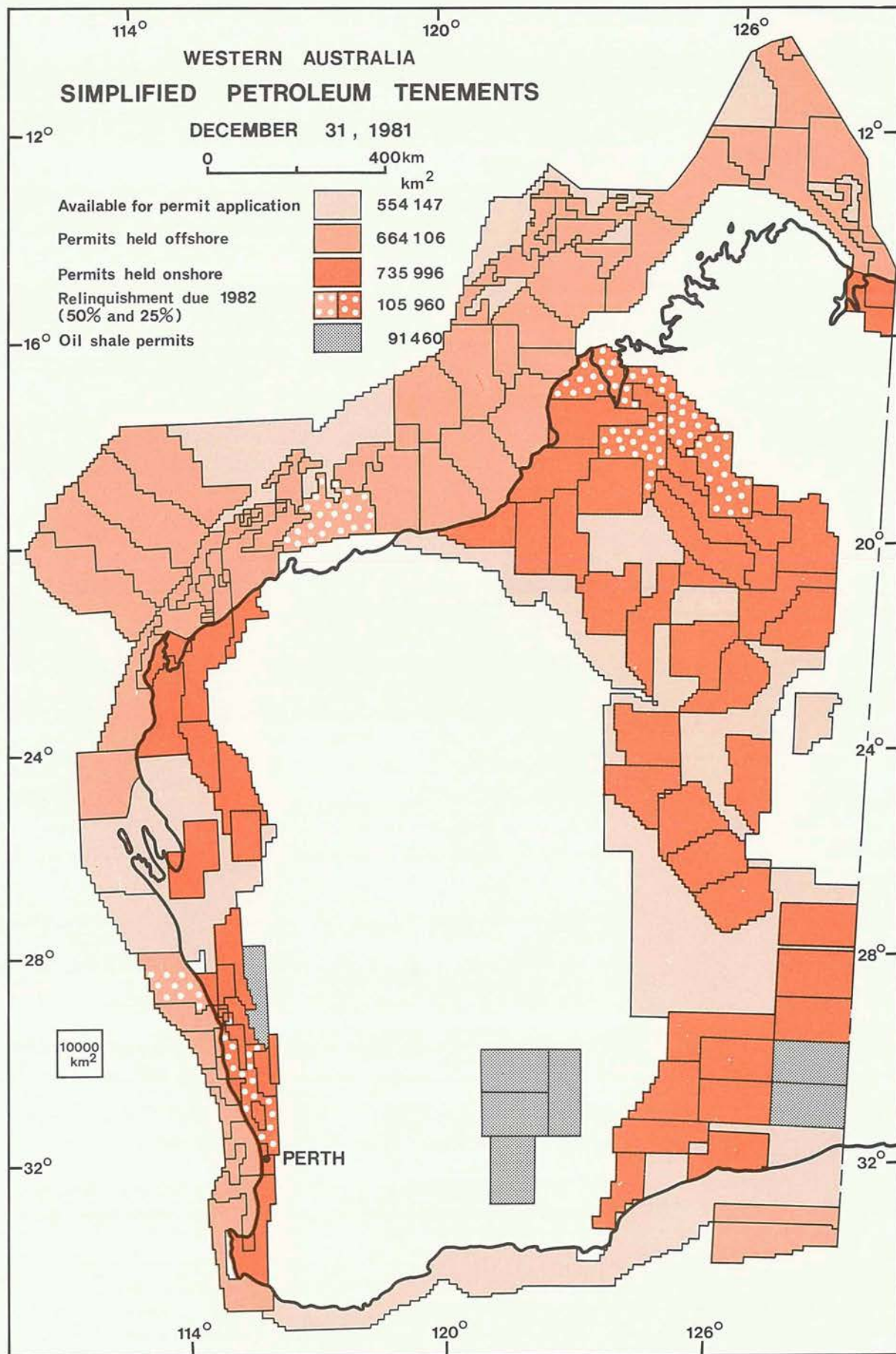
Of the 34 offshore applications made during the year and the 19 applications outstanding at the beginning of the year, 11 permits covering 94 527 square kilometres were granted, 35 applications were refused and 7 applications were being dealt with at the end of the year. Four permits were surrendered in 1981 and 3 surrendered applications were being considered at the end of the year.

At the end of 1981 there were 56 current offshore permits covering 664 206 square kilometres.

Onshore tenement activity increased in 1981 to 68 applications compared to 50 in 1980. Many of the applications were competing for the same or overlapping areas. Just two areas were advertised with a closing date, one of which (L81-60) attracted 7 applications.

Of the 68 onshore applications made during the year, plus 22 outstanding from the previous year, 13 permits were granted, 28 applications were refused, 3 were withdrawn and 1 lapsed, to give a total of 79 current onshore permits covering 799 686 square kilometres. At the end of the year 42 applications were being processed.

A feature of the year was the keen interest in the onshore Canning Basin following the discovery of oil at Blina. Almost the whole of the Canning Basin is now under permit or application.



Dealings during the year are listed in the tables on page 138 *et seq*, and a summary comparison of dealings in the years 1980 and 1981 is tabulated on page 142.

### Appraisal and development

In the Barrow Island Field, West Australian Petroleum Pty Ltd commenced a new phase of its appraisal and development programme in August 1981. One hundred and eighty-eight line kilometres of seismic were also shot during the year. Eleven wells were drilled in 1981.

Two wells, Y-14M and Y-34M, were follow-up wells to the successful new pool wildcat, Y-24M, completed as a Muderong oilwell in 1980. Both wells have produced small amounts of oil from the same sections and were shut in at the end of the year.

Four wells, R-18, R-43, R-63 and K-11, were drilled to the main Windalia Sand reservoir. R-18 and R-63 have both produced oil after stimulation but R-43 and K-11 have not yet established production. Artificial lift will be required for these wells.

Four wells, S-62M, R-33M, Q-56M and K-46M were tests of the Muderong section below the main Windalia reservoir. In S-26M the Muderong Greensand has been perforated and swabbed dry; only water was produced from two zones.



Further testing in the Muderong section is continuing. In Q-56M and K-46M testing and evaluation was not complete at the end of the year.

One well, L-46G, a shallower pool test of several zones in the Gearle Siltstone, was drilled as a follow-up to L-44G.

WAPET plans a much more extensive drilling programme for Barrow in 1982. Between 40 and 50 wells are proposed for the year including 32 infill wells which should significantly improve the ultimate recovery of oil from the Windalia reservoir. This programme results

from the computer modelling of the Windalia reservoir in the G-block carried out between 1978 and 1981.

Routine well servicing continued during the year, including 9 wells being repaired and some stimulation work being carried out. A programme of cathodic protection for well casings will be commenced in 1982. An increase in routine well servicing will require the addition of a third Ideco workover rig in 1982.

The status of the 602 wells on Barrow Island to the end of 1981 is shown in the table on page 143. All but 67 of these wells are completed in the Windalia Sandstone which is the principal reservoir of the Barrow Island Field.

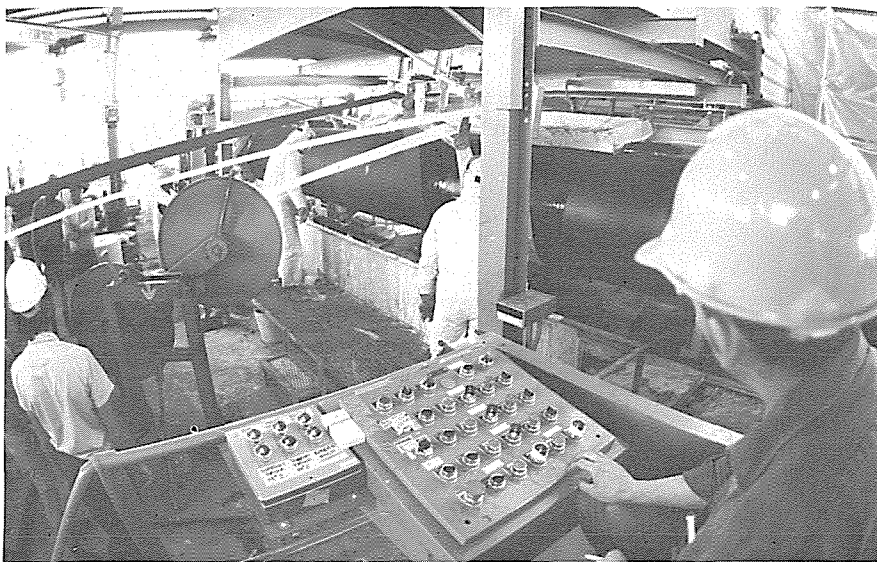


In the Dongara, Mondarra and Yardarino Fields (Operator—West Australian Petroleum Pty Ltd) 4 additional wells were completed during 1981: Dongara Nos. 23, 24 and 25, and a water disposal well, WDW 1. Dongara No. 23 in PL1, which reached total depth the previous year, was completed as a gas well in the Dongara Sandstone, Wagina Sandstone and Irwin River Coal Measures. Dongara No. 24 explored previously untested sandstones in the Kockatea Shale (Triassic) section (called the "Ara-noo Sands" by WAPET). Gas was



produced from 2 zones in this section. The well was later completed as a gas well in the Dongara/Wagina section. Dongara No. 25 also tested the "Aranoo" section and a small amount of oil was encountered.

Dongara No. 21, which was completed as an Irwin River Coal Measures gas well in 1980, was recompleted in the "Aranoo" in 1981 (known as No. 21A by WAPET). Some oil was recovered but additional evaluation is needed before the extent of the "Aranoo" reservoir can be decided upon.



Three of the 4 oil wells in Dongara Field are now on pumps; No. 10 a gas well, produces associated oil. Mondarra No. 2, which was placed on production in 1980, is still producing satisfactorily.

A workover on the Yardarino Island Field.

In the from the Dongara Field (including a small amount from Yardarino) was 45.12kl compared with 49.54kl for 1980. Gas production from the 3 fields averaged  $2\ 338 \times 10^3 \text{m}^3$  per day.

In the North Rankin, Angel and Goodwyn Fields (Operator—Woodside Petroleum Development Pty Ltd) North Rankin No. 6, was commenced in 1980 and completed in 1981. It was drilled in an area of poor seismic control in the northwest of the field, and a 53 metres gas column in the lower Jurassic—Upper Triassic section

was encountered. A revised structural interpretation as the result of the drilling of this well has led to a small revision to the reserves estimated for the field.

An appraisal well, Goodwyn No. 6, was drilled towards the end of 1981 and was tested early in 1982.

The North West Shelf gas project, which involves the development of the North Rankin, Goodwyn and Angel Fields is well into its first phase. This phase comprises the construction and instal-

lation of an offshore drilling/production platform, a submarine pipeline to carry the gas and condensate ashore, an onshore gas treatment plant and associated infrastructure. The sale of 414 MJ of gas per day (10.9 million cubic metres per day) under a long term contract to the State Energy Commission of Western Australia has been signed. Liquid Petroleum Gas (LPG) and condensate will be sold to markets in Australia wherever possible. Negotiations for the sale of 6.0 million tonnes per annum of Liquid Natural Gas (LNG) to Japan are continuing.

The jacket at present under construction in Japan will, in April 1982, commence its 6-week tow to the North West Shelf where it will stand in 125 metres of water. The production and accommodation module construction is taking place at specially built construction yards

in Western Australia; the drilling modules are being built in Singapore and the flare tower and bridge are under construction in South Australia.

The pipe for the 134 km submarine pipeline was manufactured in Japan and the external anti-corrosion and weight coatings are being applied at a coating yard in Western Australia.

It is estimated that some 800 people are employed in construction activities in the Burrup area and approximately 3 000 people are directly employed on contracts associated with the project in other parts of Australia.

Oil was discovered by Home Oil Australia Ltd in 1981 at Blina in the first well drilled in permit EP 129 in the onshore Canning Basin. In the discovery well two zones produced oil flows, the lowermost of which flowed oil at the rate of 905.7 barrels of oil per day from Devonian reef limestone. The upper zone yielded 37.6 barrels per day on tests from a dolomite section above the reef. Follow-up wells Blina Nos. 2 and 3 also flowed oil on test.

Towards the end of the year Blina No. 1 was placed on a long term production testing programme and by the end of the year 1 121 kilolitres (7 050 barrels) of crude had been produced and trucked to the refinery at Kwinana. Although it appears that the first commercial oil field in the Canning Basin has been discovered, the recoverable reserves are yet to be calculated and the field is still the subject of study.

Otter Exploration NL, discovered a shallow gas reservoir at Tubridgi No.1 and in a follow-up well, Wyloo No.1, in the onshore Carnarvon Basin near the town of Onslow. Gas was discovered in the Birdrong Sandstone and a greensand within the Muderong Shale (Early Cretaceous). Tubridgi No. 1 tested  $179 \times 10^3 \text{m}^3$  per day, and Wyloo No. 7 tested  $120 \times 10^3 \text{m}^3$  per day, both on 13 mm choke. It has been shown since that these wells are on the same anticlinal structure and subsequent appraisal drilling

has extended the reservoir area. A total of 7 wells have been drilling with only one dry hole, Tubridgi No.3. Testing has also revealed a possible gas reservoir in the Gearle Siltstone (Late Cretaceous). The field is still being evaluated.

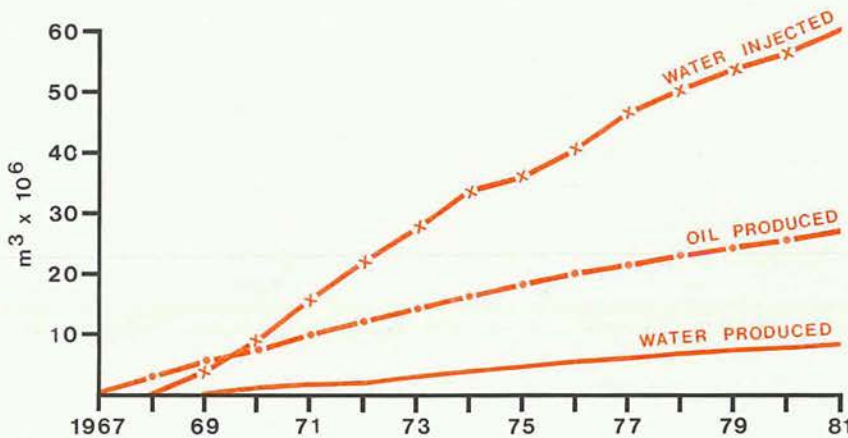
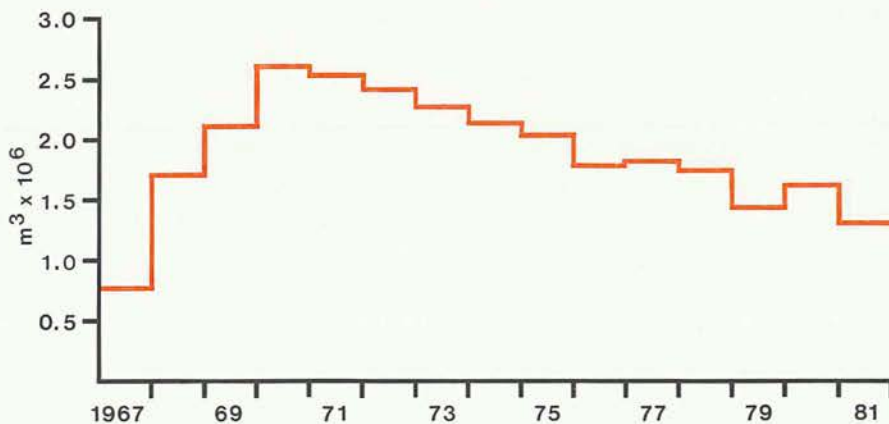
### Petroleum production

The total production of crude oil from the Barrow Island Field during 1981 was 1 340 694 kilolitres. In addition, small amounts of natural gasoline and liquid petroleum gas were extracted from associated gas which has no direct market outlet at Barrow Island. About 15 per cent of the associated gas is used as field fuel and the remainder is processed for the extraction of plant products such as liquid petroleum gas and natural gasoline. The natural gasoline is blended with the crude oil for sale and the liquid petroleum gas is sold to markets in the north-west of the State as liquid petroleum gas or is blended with the crude oil for sale to refineries. A small amount (439 kilolitres) is used as vehicle fuel on Barrow Island.

During 1981, the infill and development wells drilled since 1978 contributed about 178 000 kilolitres of crude oil, or about 13 per cent of the Barrow Island oil production for the year. However total crude oil production decreased in 1981 by 17 per cent compared to 1980 due to tanker unavailability.

Breakdowns of annual and cumulative production for the reservoirs of Barrow Island Field are shown in the table on page 143. Annual production of crude since production commenced in 1967 and the cumulative production of liquids and water injected are shown on the accompanying figures. It can be seen that the volume of water injected exceeds the volume of crude oil and water produced; the difference is due largely to the volume of gas produced from the Windalia reservoir.

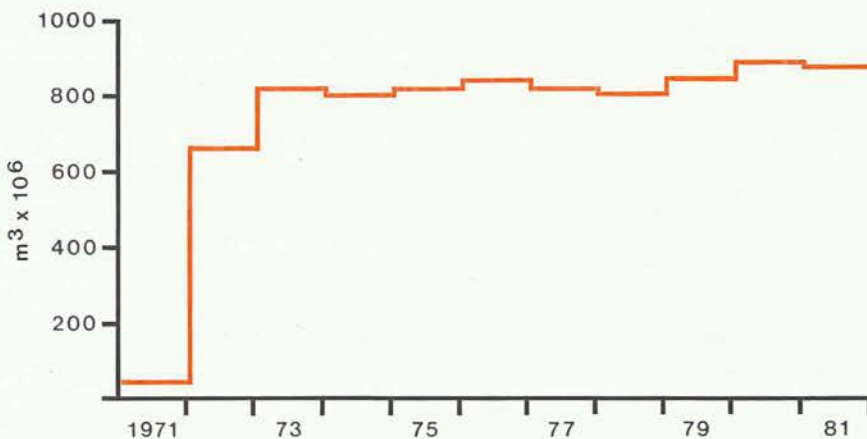
Total royalty paid on Barrow Island crude oil sales during 1981 was \$6 164 643, an increase of \$449 310 or 8 per cent over 1980.



The increased royalty despite the decreased production reflects the increased price of Barrow Island crude which has risen from \$175.12 per kilolitre for the latter half of 1980 to \$195.34 per kilolitre at the end of 1981. For the Dongara, Mondarra and Yardarino Fields 1981 annual and cumulative production is shown in the table on page 143. Cumulative production of natural gas from fields currently in production amounts to  $8.2 \times 10^9 \text{m}^3$

since October 1971 when commercial production commenced.

Gas production averaged  $2\,338 \times 10^3 \text{m}^3$  per day during 1981 from the Dongara, Mondarra and Yardarino fields. Annual production since 1971 is shown in the accompanying figure and it is estimated that about 68 per cent of the reserves of the northern Perth Basin gas field have now been produced. Oil production averaged about 45 kilolitres per day during 1981.



Royalty paid on petroleum production from the northern Perth Basin fields during 1981 was \$1 527 001 an increase of \$86 044 or 6 per cent over 1980. A table summarising 1981 and cumulative production appears on page 144.

### Reserves

The total recoverable reserves of the State at the end of 1980 are estimated with a probability of greater than 25 per cent to be at least  $14.1 \times 10^6 \text{m}^3$  of crude oil,  $56.8 \times 10^6 \text{m}^3$  of condensate,  $29.4 \times 10^6 \text{m}^3$  of liquid petroleum gas and  $529.6 \times 10^9 \text{m}^3$  of natural gas. The table on page 144 shows details of these reserves.

The main change to the reserves estimates for 1981 is the addition of the Gorgon discovery which increased recoverable gas reserves by  $84.1 \times 10^9 \text{m}^3$ . There has also been a number of small revisions as a result of production and production history in the existing fields. Small changes were made to reserve estimates for North Rankin and Angel Fields from new seismic evidence and from the drilling of North Rankin No. 6.

### Operations

#### Legislation

An Act to amend the Mining Act 1978, the Petroleum Act, 1967-1972 and the Petroleum (Registration Fees) Act 1967 was assented to on 30th October, 1981.

Under this amendment the definition of "oil shale" has been changed (Section 5 of the Petroleum Act, 1967-1981). Oil shale now "includes naturally occurring hydrocarbons that are or may be contained in rocks from which they cannot be recovered otherwise than by mining those rocks as oil shale". The definition of "petroleum" has been amended to exclude oil shale.

Under this and other amendments, existing oil shale permits will remain in force until their expiry dates but no new oil shale permits will be granted under the Petroleum

Act. If oil shale is discovered on existing permits the permittee is directed to apply for mining leases under the Mining Act, 1978.

Registration fees have been increased under Section 4 of the Petroleum (Registration Fees) Act, 1967-1981.

#### Engineering

The petroleum engineering (construction) section continued with the appraisal of design and safety aspects of the North Rankin "A" offshore platform and the 134 km long submarine pipeline to bring the petroleum products ashore. The designs were submitted by Woodside Offshore Petroleum Pty Ltd on behalf of the Joint Venturers for the North West Shelf Development project.

Inspections were made at yards within Western Australia to ensure that agreed standards were maintained on the construction of the production facilities, living accommodation, helideck for the offshore platform, and the anti-corrosion and weight coating of the submarine pipeline. Offshore inspections of vessels and associated diving facilities engaged in the dredging of the pipeline route were made.

The expenditure committed by the Joint Venturers for the North West Shelf Development is now in excess of \$800 million.

### Accidents

Figures relating to accident statistics in the petroleum exploration and production industry are shown in the table and figures on pages 145 and 146.

There was a considerable decrease in the number of accidents in 1981 compared to 1980 (222 versus 347) and there were no fatalities. The biggest decrease was in accidents associated with offshore drilling which was partly a reflection of the decrease in offshore drilling activity compared to the previous year, but was nevertheless a very encouraging statistic.

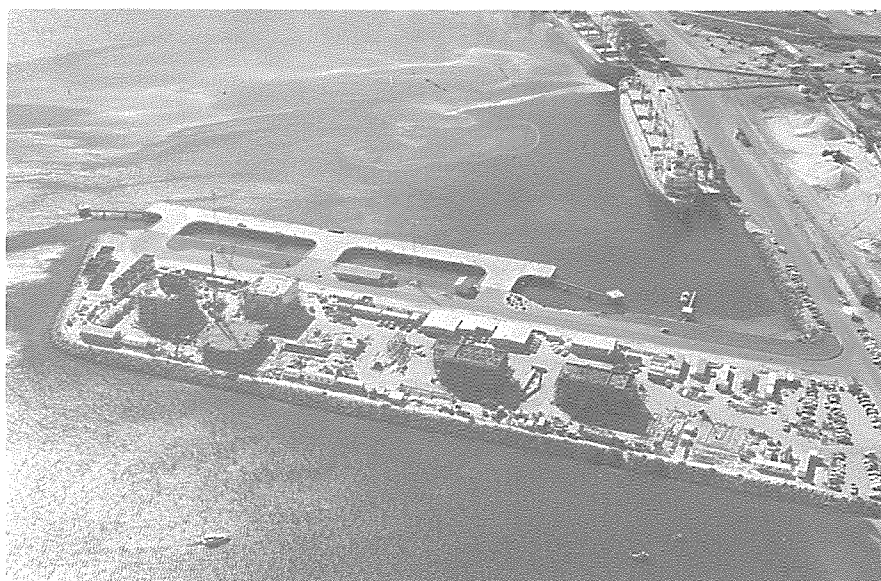
### Pipelines

A total of 238 work proposals relating to the Dongara to Pinjarra Natural Gas Pipeline from Government Departments, instrumentalities and other parties were processed during 1981 compared with 262 in 1980.

There were 3 encroachments on the pipeline during the year, 2 by Telecom and 1 by the State Energy Commission.

### Organisation

During 1981 there were 3 appointments, 2 promotions and 4 resignations, and at the end of the year the positions Reservoir Engineer and Petroleum Engineer (offshore construction) were vacant.





The high level of activity in the industry has caused difficulties in attracting and retaining the experienced professional staff necessary for the efficient functioning of the Division.

## Functions

The primary purposes of the Petroleum Division are to control petroleum exploration and production in both the onshore and offshore regions of the State, in accordance with the State Petroleum Act, the joint State/Commonwealth Petroleum (Submerged Lands) Act, and the Petroleum Pipelines Act. It has technical and administrative functions.

**Technical functions.** These are carried out to ensure that equipment

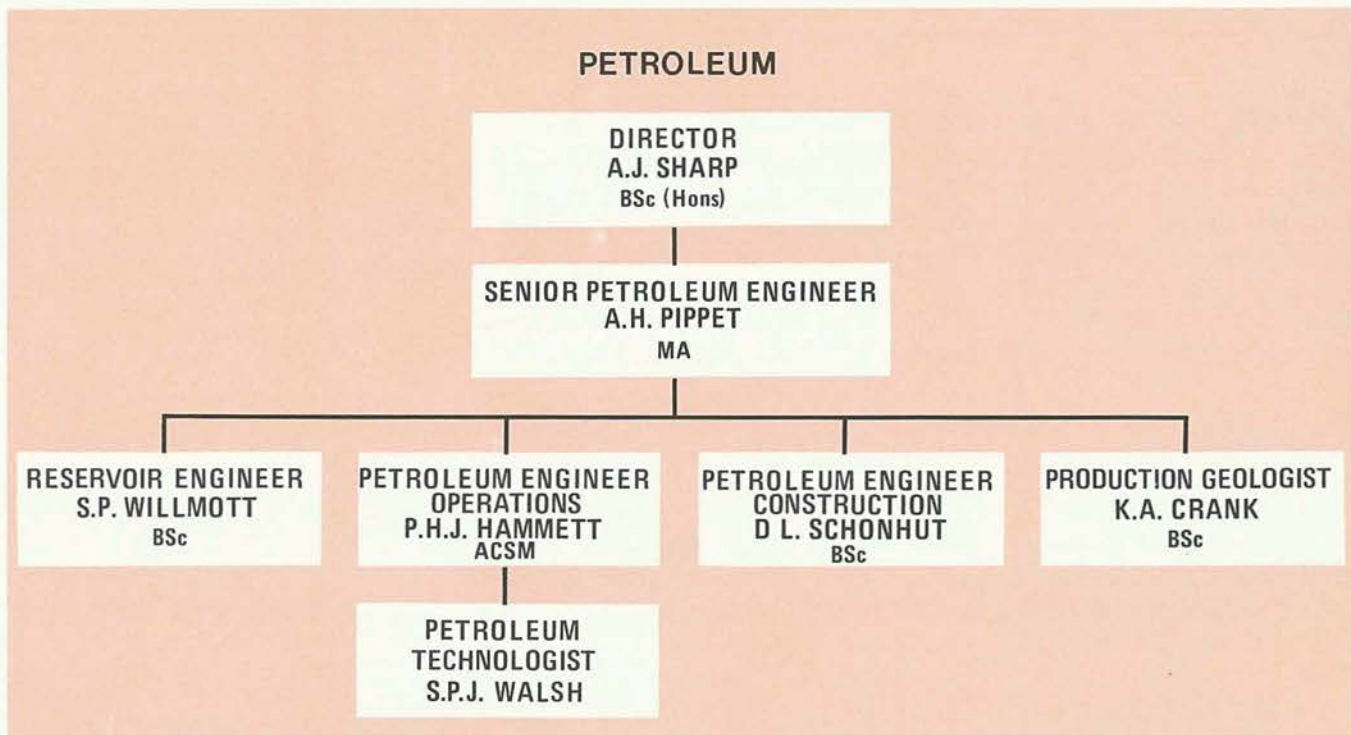
and techniques used in exploration, drilling, testing, development and production are safe and in accordance with good oil-field practice; that pipelines, offshore platforms and structures used in petroleum operations are designed, constructed, maintained and operated in accordance with good engineering practice; and that the maximum recovery is obtained from petroleum reservoirs. The technical functions also induce estimation and advice on the State's recoverable petroleum reserves and liaison with State and Commonwealth Departments and the petroleum industry on all technical matters.

**Administrative functions.** The Division makes available new and relin-

quished areas for exploration, advises on fees and royalties, and formulates policies for the encouragement of petroleum exploration and development. It also assesses, processes and recommends on the grant of exploration permits, production licences and pipeline licences; on applications to carry out operations in permit and licence areas; on the cancellation of petroleum titles; and on the renewal, transfer and creation of interests in petroleum titles.

## Other activities

During May the Director, Mr A. J. Sharp, attended the Offshore Technical Conference in Houston, Texas accompanying the Minister for Mines, the Hon. Peter Jones.





## Geological maps—a valuable working tool for the prospector

For the serious prospector, a geological map of his area of interest is as important to him as his geological hammer and water bottle. These maps are attractively presented, each with a booklet of explanatory geological notes and can be bought from the Department of Mines for \$8.00. The most useful maps for prospecting are at 1: 250 000 scale and there are 161 of them to cover the State. Geological field work has been completed for this map series but about 20 sheets remain to be drawn and published in full colour.

Because geological knowledge is always advancing, older maps have to be progressively updated and the detail shown is becoming more and more complex. This, in turn, requires more attention to reproduction methods and colour design as the maps are only as good as the detail which can be read from them.

The information shown on the maps is the surface geology only. There is a diagrammatic cross-section on each sheet which gives an assessment of the underlying rocks, but this information can only be tentative as the geologists providing the data for the map do not always have access to exact subsurface data.

To produce one of the 1: 250 000 maps a start is made with aerial photographs. The Department of Lands and Surveys has complete air-photo coverage of the State and it is from stereo-pairs of these photographs that the geologists start to map the surface geology.

Since about 1950, the advent of the aerial photograph has revolutionised all forms of mapping Australia, not the least being geological mapping. Without this important tool the geologist and the cartographer had to work using plane-table or other time consuming methods for ground location or were forced to utilise whatever pre-existing maps were available. These, of necessity carried limited information, or were

in other ways unhelpful. It may not generally be appreciated that the aerial photograph has done for mapping what computers and word processors have done for data processing in more recent times. For this reason the early regional geological maps showed only a broad distribution of rock types and it is instructive to compare an early published map of an area with the latest and see, not only the advances made in the printing of the sheets, but also the increased amount of geological detail shown.

Usually 2 or 3 geologists are required to geologically map each sheet area in the field. This team is assisted by other staff specializing in particular aspects of geology such as palaeontology and petrology. The geologist starts work in his office by getting all the aerial photographs and other base information together. This base information consists of line compilations which show roads, tracks, wells, windmills, fences and drainage patterns and other information of a topographic and cultural nature. These line compilations, which are the fundamental maps, provide the base onto which the geological boundaries, marked in the field directly onto the air-photos, can be transposed to construct the basic geological map.

The time spent on field examination can vary from 6 months up to 2 years dependant upon the complexity of the geology.

When the geologist has finished his field work he transfers his geological boundaries from the air-photos onto line compilations which are then handed over to the cartographer to produce a preliminary edition geological map for quick publication. This only takes 3 to 6 months after the field work is completed and is released to the public as a two-colour map showing the line compilation data and the geology in a coded form. The full colour map usually takes 12 to 18 months to publish as a considerable amount of drafting work must be

done. The preliminary edition of 300 copies is printed by the Government Printer and when the full colour map is made, 2 500 copies are printed.

For each colour used in the final maps, a separate drawing is made. The colours show the ages of the rock and are standardised throughout Australia: generally pale yellows and greens for the younger rocks and darker browns, reds and greens for the older rocks. Older rocks are exposed over more than half of Western Australia and include some of the oldest known.

Some idea of the complexity needed in some sheets can be gained from the Marble Bar map. In the 1958 edition 7 colours were used to show 13 rock units whereas the 1978 edition has 88 rock units distinguished by combinations of 16 basic colours. The problem of achieving a large variety of tints that can be individually identified by the eye is solved by the cartographers' careful colour design and the manipulation of screens. Overprinting of colours requires perfect registration throughout all phases of map preparation and printing. To obtain the accuracy of registration of small details, problems of temperature, humidity and mechanical stability of the drafting films, printing plates and paper have to be foreseen and countered from the earliest drawing stage.

The printing of the full colour maps presents further problems as the work is so specialized that very few printers are able to undertake the work. In addition to the maps printed by the Government Printer, others are produced by suitably equipped private firms.

The Surveys and Mapping Division now has considerable experience and expertise in all phases of production of complex coloured geological maps. This will be used to present the results of geological investigations with increasing refinement.



## Surveys and Mapping Division

W. R. Moore,  
Superintendent

The year has been characterised by growth and forward movement associated with the functions and responsibilities of the Division.

With an area of some 2 527 000 square kilometres, Western Australia has numerous and widespread mineral and petroleum deposits and prospects. To prepare and maintain maps recording the exploration and development of our mineral resources is a large task that has two basic thrusts: preparation of geological maps; and maintenance of maps and plans to show the disposition of mining and petroleum tenements.

Accelerated production of 1:250 000 scale geological maps this year resulted in the preparation of 6 one-colour preliminary edition maps and 11 multi-colour editions. This is the highest production rate yet achieved.

The wide range in sizes of tenements and the intensity with which some ground is held by different owners in many different places dictates the need for a wide range of scales. The strategy followed in the case of tenement maps has been to produce maps, in regional blocks, having common scales such that as many map sheets as possible will join with another map of the same scale. This is to avoid many scale changes between maps. Scales in common use are 1:250 000, 1:100 000 and 1:50 000.

The normal pattern of tenement map production was interrupted during the year because of the need to produce some detailed plans at larger scales of certain of the more popular gold mining centres. This was due to the intense pegging which has taken place over the past few years. The increase in applications for mining tenements required more staff being engaged on this activity than has been the case for some time. Extensive overtime was necessary throughout the year to achieve this work.

The Division continues to experience difficulty in accessing and

maintaining records relating to mining tenements in order that these can be shown on the plans. A computerised mining tenement information system currently under development should overcome this problem.

### Operations

#### Surveys Branch

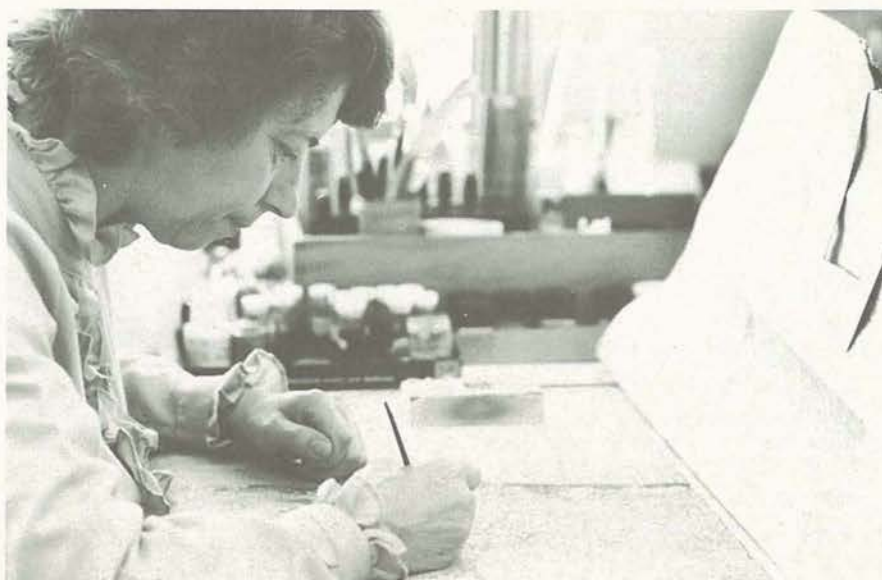
**Surveys.** During 1981, 34 surveyors attached to 21 Practices under contract to the Department completed surveys of mining tenements, as shown in the table.

The cost per tenement quoted in the table excludes some advance payments made during the previous calendar year when some of the surveys were commenced. This cannot, therefore, be directly related to the 1980 tenement survey cost. The 2 183 tenements surveyed in 1981 represents an 88 per cent increase over the 1980 figure. This increase

is an inflated figure as a result of the carry-over of surveys which were delayed by unseasonable rains in the first half of 1980. Apart from this there was a generally high demand for surveys. The average size of tenements fell to 39.15 ha (57.78 ha in 1980) reflecting the survey of a larger proportion of Gold Mining Leases.

The expenditure per kilometre increased to \$287.59 in 1981 (\$236.41 in 1980) representing an 18 per cent increase, caused primarily by a 20 per cent increase in survey fees which took effect from 17 July 1981, together with the survey of some remote tenements. The survey of all tenements was monitored closely because of the proposed inauguration of the 1978 Mining Act on 1 January 1982. This was to ensure that the tenements that were surveyed would be those most likely to be transitioned into tenements under the new Act.

	1981	1980
Number of tenements surveyed	2 183	1 163
Cost per tenement	\$396.98	\$406.75
Number of field books lodged	310	145
Total boundary line run	2 618km	1 834km
Total traverse line run	187km	167km
Total area delineated by survey	85 428ha	67 200ha
Distance travelled (positioning)	68 675km	76 207km
Total value of cadastral survey	\$806 960	\$473 052
Total value of geodetic surveys	\$87 775	\$42 467
Total value of special surveys	\$1 885	\$43 496





At the end of December 1981 survey instructions for 321 tenements were on issue. The work performed by the various practitioners is listed in the following table. The examination of 809 tenements was completed during the year but pressure of other activities resulted in a backlog of 3 357 for finalisation.

**Field Inspections.** A requirement was put to this Division on Wednesday 20 October to survey by Friday 6 November 1981 a proposed Mineral Lease for the Argyle Diamond Agreement. The survey was to involve 78 km of boundary, encompassing 13 620 ha in the remote north of Western Australia in some very rugged country at a time of the year when weather conditions were becoming extreme and work could be brought to a standstill at any time by seasonal rains.

The Ashton Joint Venture was responsible for transport to the site,

accommodation, messing, on-site transport and general support. Survey contractors to the Mines Department indicated their availability to proceed on short notice and a firm commitment to survey was made on Thursday 21 October. The Draftsman-in-Charge (Surveys) accompanied the field party to advise on Mines Department requirements for the survey.

The survey parties left Perth on the morning of Saturday 23 October in two chartered aircraft and arrived at the Argyle camp later in the evening after flying through severe rain squalls near Halls Creek. Heavy gear, such as survey posts and spikes, were to follow as soon as possible by road transport.

The survey commenced on Sunday with helicopter and ground reconnaissance of the area in hot and humid weather. Strict adherence to the boundaries as indicated by the peggings of all applicants was necessary in the northern areas

and in the following days the survey proceeded as planned using a bulldozer for clearing and a helicopter for quick transport of survey staff. Deployment of equipment was determined by the nature of the terrain encountered. This ranged from rugged and hilly, through heavily timbered country broken by numerous gorges, to some reasonably level and open ground.

The southern boundary was established by a second survey party using another helicopter. Because boundaries in this area were not confined by abutting peggings it was possible to develop an alternative survey technique. With the theodolite stationed at an initial corner, the helicopter was used to hover at an appropriate height over the next pegged corner and a theodolite setting then made on it.

The bulldozer then cleared a line in this direction guided by a survey hand who staked a provisional line behind the bulldozer. At the end of each line the average variation of the staked line to the aiming mark was within the width of the dozer blade, with the greatest variation being about three metres over about six kilometres of line. Survey measurements and permanent marking then proceeded along the staked line.

A third survey team of the engaged contractors arrived from Halls Creek on Sunday evening. By Friday 29th the survey of the external boundary, corner to corner, and a survey connection to Lissadell geodetic station were completed.

By Tuesday 3rd November the contractors had supplied details of boundary measurements with a plan to the Mines Department in Perth in time for the production of a plan to attach to the Ashton Diamond Agreement.

What appeared at first to be a physical impossibility in a remote area was achieved by the impressive back-up support provided by the Ashton Joint Venture together with the dedication of the survey contractors, plus the excellent liaison between all the people involved.

Company	Surveyor(s)	No. of Surveys
J. Zuideveld and Associates	J. Zuideveld	248*
Ranieri Bateman & Ingram Pty Ltd	J. Ranieri G. Batentan P. Lengkeek P. Neale	203
D.F.V. Wilson & Associates	D. Wilson	210
K. R. Maguire	K. Maguire	103
Bennetti Croghan & Associates	R. Bennetti	243
Markey Campbell & Thomson (Aust)	T. Markey K. Baruffi A. Buzzai	61
McGay Surveys	D. McGay	117
Fisher Lewis	P. Watt E. Still K. Duffy	196
McKimmie Jamieson & Partners Pty Ltd	G. Chignell H. Karl C. Bloomfield	57
Phil Heyhoe	A. Quinn	58
Hille & Thompson	P. Heyhoe P. Hille J. Delfos	82
K. F. Paterson & Associates	C. Parker R. Owen	115
R. G. Agnew	R. Agnew M. Agnew	129
Kanther & Shipp	C. Shipp	97
A. R. Williams & Associates	A. Williams R. Beardman	106
F. R. Rodda	F. Rodda	40
K. M. Edwards & Associates	K. Edwards	62
Mapping Services (1979)	J. Zadnik	17
I. M. Gordon	I. Gordon	9
19	33	2 183

\*Inflated by perimeter surveys being included.



**Levelling.** Levelling to obtain reduced levels of various bore sites for the study of underground water reservoirs was undertaken by the Survey Branch for the Geological Survey Hydrogeological Branch in the Lancelin-Moore River and the Capel-Donnybrook areas.

Another party, traversing a length of 146 km, levelled to 194 gravity stations in the Golden Grove area. The reduced levels of the gravity stations were required to assist a study of the structure of the Warriedar greenstone belt.

**Control Projects and Co-ordinate Traversing.** A reasonably high level of activity on control for co-ordination in 1981 has placed work in a position where a good base is

**Petroleum Activity.** The interest in Petroleum Permits has continued through 1981, occupying two staff members nearly full time in preparation of documents and index plans. Nearly 1 600 (1 400 in 1980) copies of the state petroleum map have been sold, about half of which went to 133 subscribers on the quarterly mailing list. The quarterly maps and supporting booklet are now printed by the Government Printer resulting in a much improved publication which has been well received by the industry.

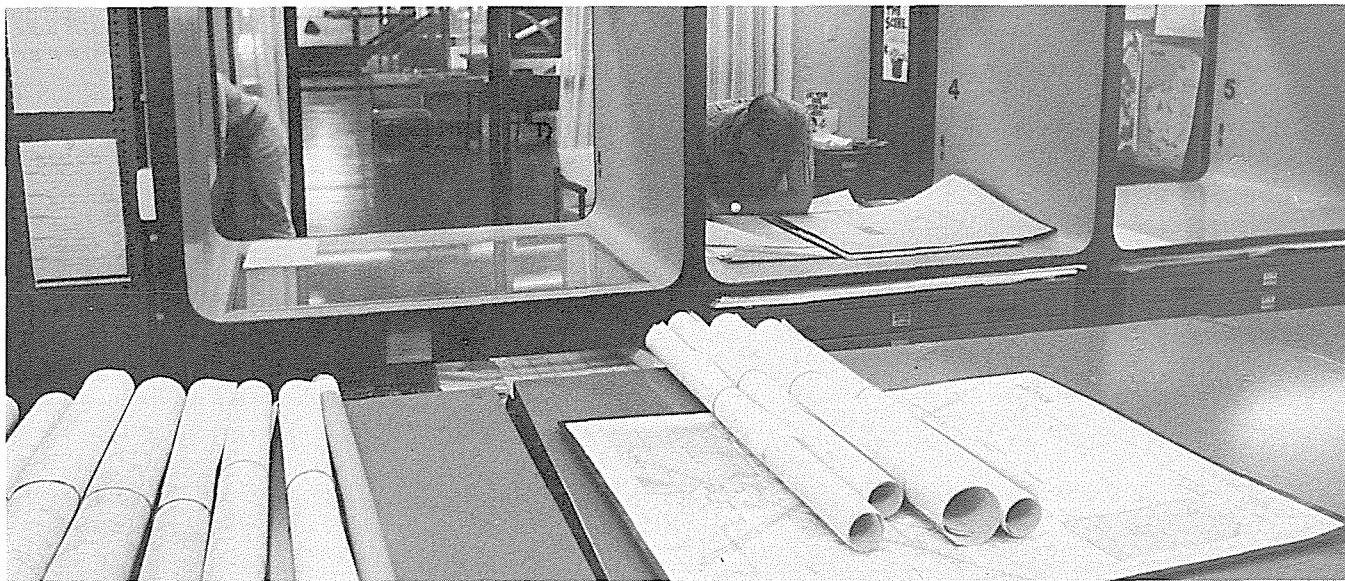
**Computer Services.** The supervision of existing systems and the maintenance of programmes for geodetic calculations has proceeded. Other areas worked on include the production of contour plots using the SURFACE package at the Main

The Surveys Branch will be heavily involved in the eventual MTIS as graphical representation of information is to be an important part of the system.

The Surveys Branch requires the on-going availability of their computer services section. However, it is important that staff who have studied the proposed MTIS on a secondment basis should be kept involved with this work because of their knowledge of the system and of the functions of the Department.

Computer graphics is undergoing rapid technological advancement and the Surveys Branch needs to keep up with this important area.

A firm programme to provide the Australian Map Grid over all existing plans presently on other projections is awaiting implemen-



available for future co-ordination of areas of mining importance. The list is given in the Table on page 147.

**New Standard Plans.** The forecast increase in activity to produce new standard plans in 1981 has not eventuated due to pressure to issue survey instructions. Only thirteen 1:50 000 scale and three 1:10 000 scale new standard plans were produced in the year. There is now a large backlog of required new standard plans, together with the need for ongoing revision and up-dating of existing plans.

Road Department's CYBER computer, together with a system to print-out the list accompanying petroleum tenement maps.

A Tektronics 4054 graphics work station is on order to enable staff to become conversant with this technology and to test programmes as they are produced. Three staff spent five months at the Systems Research Institute of Australia undertaking a preliminary study for the proposed Mining Tenement Information Service (MTIS), a Mines Department data management system.

tation and the availability of staff. Computer time costs remain at about \$5 000 per year.

The maps on pages 148 and 149 show the locations of Survey Branch field activities and progress on the Australian Map Grid Standard Plan Programme in 1981.

### Mapping Branch

**Geological Mapping.** During the year 32 maps for the 1: 250 000 regional geological series were in various stages of production, of which

11 full colour first editions and six preliminary editions were completed. There were no coloured editions of the 1: 50 000 urban geology map series produced during the year but three maps are in progress: Picard-de Witt, Bunbury-Burekup and Harvey-Lake Preston.

Three coloured maps to accompany the Bangemall Basin Bulletin were printed and two coloured maps for the Pilbara Block Bulletin were reprinted. Work is proceeding on a coloured map and two coloured figures for the Nickel Bulletin.

A new map, which is in the final stages of production, is a minerals deposit map of the State at a scale of 1: 2 500 000. It shows the locations of all mineral deposits of economic significance in relation to a generalized geological background. In conjunction with this map, a clear film sheet showing these mineral deposits has been prepared, which can be used as an overlay to the State Geological Map. The Division expects much interest in this map from mining companies and the general public.

**Thematic Mapping.** These relatively new 1:5 000 000 scale maps are in popular demand with members of the public as they show interesting statistical data in a clear graphical form.



Two previous editions, the Mineral Production Map and the Administrative Divisions Map were revised and reprinted during the year. An addition to the map series was Gold in Western Australia. This map shows areas held under gold mining leases, in units of 1: 50 000 sheets, and includes relevant information of general interest. Another new map which is nearing completion will show oil and gas production in Western Australia. The map portrays the current exploration activity, illustrates new oil

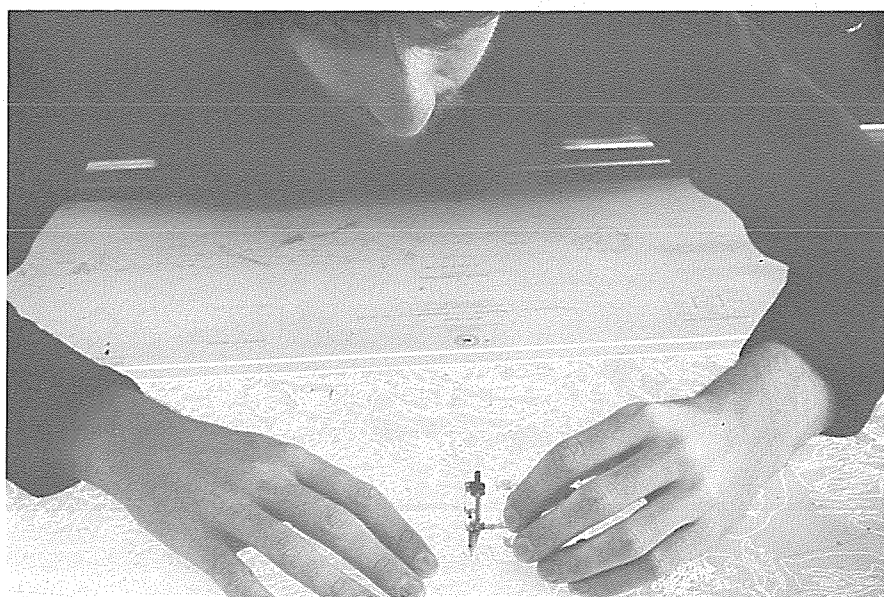
and gas fields, wells, and pipeline construction progress. Two new maps were added to the 1: 1 000 000 series which show areas held under gold mining leases. These are the Hamersley Range and Oakover River. There are now 6 sheets in this series and it is anticipated that the coverage will not be extended.

**Cadastral Maps.** Eighty-four 1: 100 000 maps were produced during the year in the Kimberley, Gascoyne and Esperance areas. At this scale there is now a complete coverage north of 19° South Latitude.

In response to gold exploration in the Eastern Goldfields, it was necessary to produce larger scale maps over areas that were previously adequately mapped, in order to show tenements more clearly. Nineteen 1: 25 000 maps were produced to overcome this congestion.

Thirty-three 1: 250 000 maps were drawn to complete the coverage of the eastern desert area of the State.

The work just outlined shows a significant increase in the production of cadastral plans over the previous year.





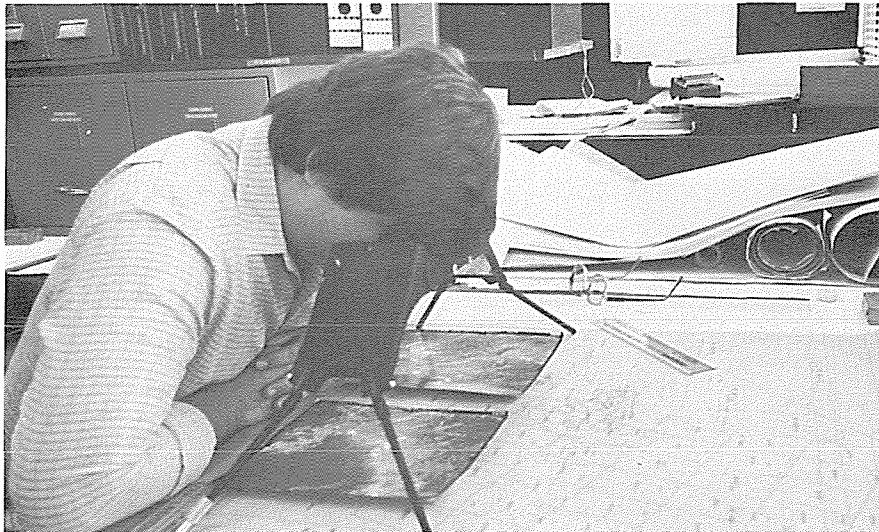
The programme of revision of existing plans has been carried forward due to the priority given to the mapping of areas of potential interest which were not previously adequately mapped.

The map on page 150 shows the progress made on cadastral mapping in 1981.

**Geological Publications.** A total of 807 diagrams, for a wide range of publications, display purposes and lectures, was produced during the year. The major publications for which these diagrams were required were the Nickel Bulletin, Bangemall Basin Bulletin and the Annual Report.

The demand for 35mm colour slides and overhead projection transparencies has more than doubled in 2 years and continued growth is expected. During the year 357 slides and transparencies were produced.

**Reprographic Services.** The Reprographic Section provides a variety of photographic and printing services for all divisions of the Department, The Geological Survey



and the Government Chemical Laboratories being big users of these services. To their credit, the staff of this section have satisfactorily performed their duties despite difficult conditions and outdated equipment. Action is being taken to update facilities in an effort to pro-

vide a more efficient work station so as to ease the pressure under which they have to operate. Many items of work requiring processing have been delayed due to lack of facilities.

Approval has been received to purchase a replacement plan-printing machine and a request has been forwarded to replace the process camera and to obtain an automatic processor.

The Division expects the work load of this section to increase at a rate of 10 to 15% annually.

A total of 445 prints and slides was processed in response to requests from many divisions of the Department, with colour processing forming the bulk of the orders. During the year, 3 120 items of work requiring the vacuum frame were processed and 1 701 items were prepared with the process camera, compared with 2 585 and 1 697 respectively, in the previous year.

The number of jobs does not give a true indication of the volume of work. For example every colour map produced during the year requires a colour proof prior to printing. The Yaringa 1: 250 000 map,

for instance, is an average sheet of 11 colours, but it required 37 exposures to produce the variety of tints used. The Plan Printing Section printed 56 581 plans, mounted 857 plans and bound 710 booklets, giving an overall total of 58 148 items of work.

The increased activity in oil exploration has generated a demand for transparent copies of seismic well logs; these prints, which only count as one job in the above figures, can range from three to 20 metres long.

### **Public Plans Branch**

1981 commenced on a very high note with 3 459 Mining Tenements being received in January.

The 1981 total of 28 462 tenements was the highest number received for the past 10 years. While the charting and appraisal of Mining Tenements and the preparation and maintenance of Public Plans remains the principal responsibility of the Public Plans Branch, numerous other tasks, not reflected in the Branch's productivity figures and graphs, were undertaken.

Land alienation proposals and land tenure changes and adjustments are becoming a more critical consideration in processing tenements and required more resources to be channelled in this direction.

Inaugural Public Plans prepared and introduced into the Department's Public Plan system totalled 74 plans; this represents the largest number introduced in recent years, and reflects the changing nature of mining industry exploration activities.

Special Purpose Maps covering various aspects of land development, mining, and agreements, coupled with the associated infrastructure development of powerlines, gas and water pipelines, has imposed increasing demands on staff time and plan maintenance.

Public Plan preparation requires involved and time-consuming manual checks on the status of tenements and the proposed introduction of a computerised Mining Tenement Information System is eagerly awaited to provide more direct and faster processing. Other tasks, undertaken in the Mapping Information Centre would also benefit from this system.

Receipt of 689 Temporary Reserve applications maintained the very high inputs of the previous two years, notwithstanding the two-month moratorium imposed from November. The principal objective in that section, to complete the processing of Temporary Reserves for approval prior to 31 December 1981, was accomplished.

Each section of the Public Plans Branch experienced difficulty in maintaining some work objectives and arrears developed with certain tasks particularly in Coal Exploration areas, where mapping was inadequate.

A controlled overtime programme kept the tenement backlog within acceptable limits.

Preparation for the introduction of the 1978 Mining Act and the contribution to the Mining Registrars' Conference were significant features of the Branch's work.

The relocation of the Mapping Information Centre from the first floor to the ground floor and the reallocation of Drafting Office space on the third floor of Mineral House was time consuming.

Colour-coded storage, and recording of 28 450 late Prospecting Area applications was instituted. With 19 500 of these tenements completed, the system is already saving considerable research time.

The microfilming of 5 000 archival Public Plans was undertaken and 3 500 have now been completed. The Plans were firstly microfilmed in colour for public viewing and secondly in black and white for security and to provide print copies as required.

Surface and underground plans from 60 mining operations were received. Work Orders totalling 143, while doubling the previous years output, represents only a part of the Technical Sub-Section's research and activity.

The figures on page 151 illustrate the increase in Branch activities resulting from tenement applications in 1981.

## Organisation

**Staff.** During the year the staff of the Division increased by 8 to a total of 132.

The effects of greatly increased mineral exploration imposed unacceptable delays in processing applications with resultant inconvenience to industry and the public. To alleviate this situation, 4 new Drafting Assistant positions were created on 22 May 1981 but budget restrictions prevented these positions being



advertised until November. Consequently these positions were vacant at the end of the year. Four trainees were recruited to keep pace with current natural growth.

There was 1 retirement from the clerical staff and resignations were accepted from 2 draftsmen and 1 general assistant from the photographic area. These 4 vacancies remain unfilled.

**Accommodation.** Demands by the public and industry upon the Division have required an expansion in services provided. This in turn has affected accommodation requirements and demand has now exceeded the amount of space available. A number of sections are poorly accommodated, with no room for expansion.

Areas of particular congestion, which must be taken into account in any future reorganisation, are the

Reprographic and Computer Services Sections as well as some drafting areas. Relocation of certain offices was carried out with the aim of providing a more convenient location and an up-graded technical support to the public enquiry area. The public plan enquiry counter and staff were relocated to the ground floor as the first point of public contact, and an improved area to service public enquiry of a technical nature was provided on the third floor.

## Functions

The division monitors, determines and documents the boundaries of mining tenements and provides a service for the production and maintenance of all maps and plans from field surveys, computations, plotting, drafting and cartography to photographic reproduction.

The Division is divided into three Branches and twelve sections.

**Survey Branch.** The Survey Branch is responsible for the survey of all mining tenements using private surveyors for the performance of the field work. The Branch issues instructions to and monitors the work of the surveyors, and edits and certifies the plans and diagrams for acceptance by the Department as the true boundaries of mining holdings. The surveys are integrated into the State geodetic network and all



necessary calculations and adjustments are carried out. The Australian map grid is the basis for co-ordination and is used for the laying down of all maps. Automatic map plotting is used when possible and the Branch makes use of computers and digitisers for data storage and map production.

**Mapping Branch.** The Mapping Branch compiles and prepares the multi-coloured geological maps which form part of the programme for the systematic mapping of the geology of the State at 1: 250 000 scale. It also prepares and draws all other maps, plans and other material for publication, in black and white and in colour, for such publications as Bulletins and Annual Reports. Cadastral plans are produced which serve as the base for the public plans of the Department.

The Branch undertakes all plan printing, copying and reprographic activity associated with production of maps and plans including enlargement and reduction. It has a wide range of photographic capabilities and processes negatives and positives for plate-making and carries out photography in both black and white and colour and prepares 35mm slides, enlarged prints and slide duplicates.

**Public Plans Branch.** The Public Plans Branch is responsible for checking and charting all applications for mining tenements and

temporary reserves. It prepares and maintains maps and plans for distribution to Mining Registrars in the regional offices and for all public and departmental requirements. It provides search facilities for ownership and status of land and mineral rights and maintains a record and custody of plans and sections of mines and underground workings.

A clerical section handles all the records of the Branch, such as registering of applications, approvals, cancellations, survey details and other action affecting surveys and plans of mining tenements, together with a full record of plans and plan movements. It attends to public inquiries at the counter.

#### Other Activities

**The Mining Act 1978.** The Division participated in the planning for the implementation of the new Mining Act on 1st January 1982. Meetings were held on a regular basis by senior staff to develop departmental procedure.

A contribution was made to the information brochures produced to advise the public, in everyday language, of the requirements of the new Act. This consisted of a comprehensive statement, with appropriate examples and sample diagrams, of how to describe boundaries of land required to be included in a mining tenement. These pamphlets should satisfy most enquirers.

As the new Act provides for granting of larger leases, up to 1 000 ha, and requires survey of leases only, the decision by the mining industry as to what type of tenement will be applied for is awaited.

The Tenth Conference of Geological Cartography held in Perth 16-20 November, was attended by the principal geological cartographers in each State and the Commonwealth, represented by the Bureau of Mineral Resources, Geology and Geophysics. The Conference is held biennially as an adjunct to the Government Geologists Conference and was hosted this year by the Surveys and Mapping Division. The discussions and conclusions are published as "Proceedings Tenth Conference of Geological Cartography, 1981".

The Australian Photographic Industry Association Conference "Photographics '81" held in Sydney July 31 to August 5, was attended by the Senior Photographic Technician, Mr J. Steele.

The International Conference of the American Congress of Surveying and Mapping held in San Francisco 10-16 September, was attended by the Assistant Superintendent Mr D. T. Pearce. As Director of the forthcoming International Cartographic Association Conference to be held in Perth 1984, he gave a presentation on behalf of the host city.

### SURVEYS AND MAPPING

**SUPERINTENDENT**  
**W.R. MOORE**  
Dip Cart, MAIC, MISAust, MIMES, (WA)

**ASST. SUPERINTENDENT**  
**D.T. PEARCE**  
Dip Cart, MAIC

**MAPPING**  
**G.R. SHARP**  
Dip Cart, MAIC

**PUBLIC PLANS**  
**D.L.J. WALSH**  
Dip Cart, MAIC

**SURVEYS**  
**D.J. POLLARD**  
Dip Cart, MAIC



## “Fingerprinting” the remains of fires.

Fires cost the community many millions of dollars a year and many are deliberately lit. One of the functions of the Government Chemical Laboratories is to help the police decide if arson has occurred and that time and money should be spent in trying to apprehend the culprit.



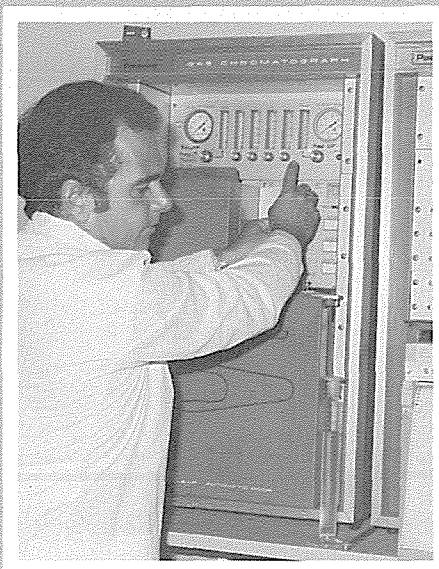
The physical evidence at the scene of the fire can, in some cases, immediately point to arson; quantities of paper or rags present where it is unreasonable to expect them, cans of petrol or kerosene left behind or distinctive burn marks, on say, a carpet, all point to a fire deliberately lit. But what if the arsonist has used an accelerant, such as petrol, white spirit, etc., and taken all the cans and bottles away with him? Can these chemicals still be detected, even though the fire may have caused extensive damage?

As a number of people have found to their cost, the accelerants can leave a distinctive “fingerprint”.

The key to successful identification of the accelerant is the collection of a good sample from the seat of the fire. This sample must be collected as soon as possible and put into a clean air-tight container for analysis.

Carpets, curtains and rags can soak up considerable amounts of petrol and other solvents which are then protected from the flames. Even though the fire may have caused the evaporation of the solvents they leave residues which can be detected. Petrol can, for instance, be evaporated to 5% or less of its

original volume and still be unequivocally identified. Petrol has a number of additives present, such as ethylene dibromide, and if this compound is found in the remains from the fire, the use of petrol is almost certain.



When the suspected samples are received at the laboratory, the first thing the chemist does is to smell the contents of the container. This may seem like a crude method of analysis but the nose is a sensitive detector of some compounds. After this initial investigation the vapours in the air space above the charred remains are sampled and injected into an apparatus called a gas chromatograph. If petrol or similar substances are present the chart of the instrument records a series of peaks which give the “fingerprints” that the chemist is looking for.

The accelerants most commonly used are petrol and kerosene, but mineral turpentine, white spirit and heating oil have also been used. Each of these compounds gives a distinctive pattern by chromatography and, if present, can be identified.

Some years ago, a man devised an elaborate system of setting fire to his flat using candles. Candle wax is not volatile but can be extracted from the remains after steam distillation. Gas chromatography relies on the substances being volatile at reasonable temperatures, up to about 300°C, so other analytical means are required for identification of less volatile substances such as the waxes. The method of identification used in that particular case was infra-red spectroscopy, as candle wax has a distinctive absorption profile.

In 1981, samples from 50 fires were received and of these, 10 were confirmed as being cases of arson.

# Government Chemical Laboratories Division

R. C. Gorman  
Director

While 1981 was an interesting and stimulating year professionally, it was at the same time a very busy year with respect to decisions affecting the long term future of the Laboratories and their administration. The review of the Laboratories' functions, inter departmental relationships, building and site requirements, staffing and funding, referred to in the 1979 and 1980 Annual Reports, culminated this year in a report a Government from the Public Service Board. This report arrived at the conclusion that the Laboratories were in need of a substantial infusion of funds for equipment.

Before implementing the recommendations of the report the Government decided that all analytical laboratories within Government agencies should be investigated. This investigation took the form of a detailed questionnaire to all Departments and Authorities on their need for analytical work and Laboratories' services, their own facilities, and the use of possible alternatives. With two minor exceptions the response from the various client departments was very encouraging. They saw a strong and growing need not only for the Laboratories analytical expertise in a wide range of fields but also for the expert advisory and consultancy role given by officers of the Laboratories. In view of the response the Government decided that there was a very definite need for the continued function of these Laboratories and that a Scientific Co-ordinating and Advisory Committee should be set up to look at all Government analytical laboratories, with the following main terms of reference.

1. Provide advice with respect to rationalisation, co-ordination and overall planning of analytical chemical services.
2. Foster co-ordination and communication between Government

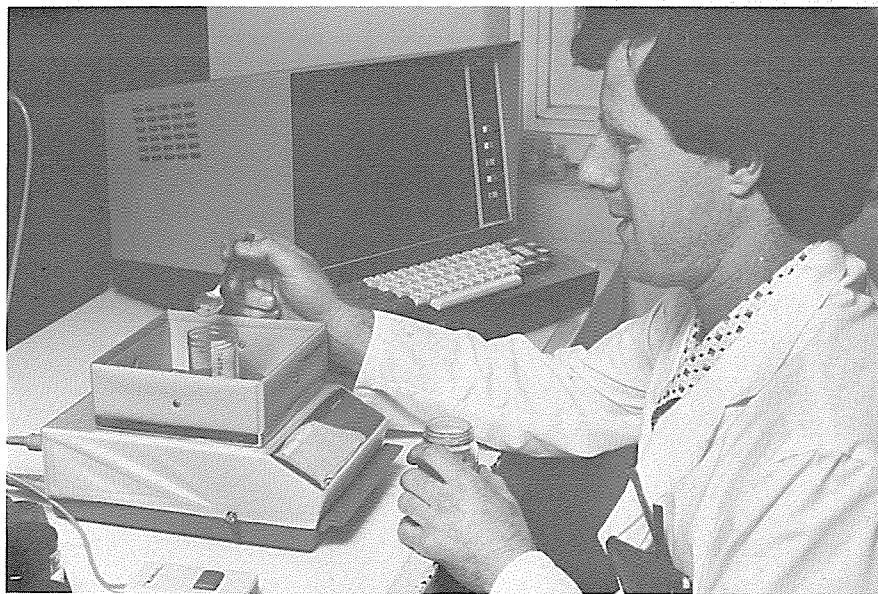
Agencies maintaining analytical chemical services.

3. Evaluate all proposals to establish new analytical laboratories or to extend existing facilities.
4. Evaluate all major proposals relating to changes in staffing levels, equipment requirements and accommodation of analytical chemical laboratories.

It is expected, when the Committee starts its function in 1982, that resolution of many problems should result, leading to the Laboratories performing a more efficient role in the advancement of the State.

examples of the more interesting investigations are listed below.

The study of formaldehyde evolution from urea formaldehyde insulating foam. Examining the safety of the manufacturing process of 2,4,5-T. The examination of dioxin in an old fire damaged sample of 2,4,5-T for the Commonwealth, which other laboratories in Australia were either not able or not prepared to do. The investigation of the effects of vapour pressure and air concentrations of organochlorine pesticides with respect to their uptake by lactating mothers. The reviewing of the triholomethan levels in local water supplies and finding



For the first year since 1971 there has been a decrease in the number of samples received over the previous year. This slight decrease of less than 3 per cent is mainly due to a decrease in samples from the Department of Agriculture. Increased samples were still received in the Food and Industrial Hygiene, Forensic Chemistry and Water Divisions. A table showing the source and allocation of all work received in 1981 is given on page 152.

The year has been a stimulating one professionally; some

that chloroform levels were non-existent, primarily because low levels of bromide in the waters caused the formation of bromine-substituted methanes in preference. The activation of attapulgit to extend its commercial properties. The investigation of lupin alkaloids with respect to utilisation of lupins for human and animal food. All of these and many others were problems examined and solutions sought and in most cases found, during 1981.



## Operations

### Agricultural Chemistry

This Division of the Laboratories provides a support facility in agricultural chemistry mainly for the Department of Agriculture's research programmes and inspection services. Some advisory and analytical service is provided to primary producers. Expertise is available for assistance with soils, engineering problems and evaluation of air pollution effects on vegetation. Other work is described in more detail in an Annual Technical Report which has been introduced this year for presentation of reviews on progress in research projects, summaries of investigations arising from studies of chemical problems encountered and improvements in methodology.

**Plant Section.** Investigation of the quantification and composition of the total alkaloids in W.A. sweet lupinseed continued in anticipation of a need for this information in relation to the use of lupinseed as a high protein food for animals and humans. Effort was directed towards procuring stocks of pure alkaloids and defining conditions for a gas chromatography method for accurate assay of individual alkaloids.

The work showed such promise that approval was obtained from the Rural Credits Development Fund for purchase of a gas chromatograph with the performance specifications required to continue this research.

Certificates of Analysis were issued for 119 samples of fertilizers and manures examined. Of these only 9 per cent were deficient in the concentration of one or more constituent. The main deficient constituent was potassium.

An indication of the closer attention being paid to the quality of fertilizers sold in W.A. is the successful prosecution of a manufacturer whose product was below standard. This is the first occasion, since the inception of the Act of 1928, that this Division of the Laborator-

ies has been involved in a prosecution as a result of a Certificate of Analysis.

In investigating plant feeding stuffs, Vitamin A (retinol) estimation was greatly simplified by proving of a HPLC (high performance liquid chromatograph) method for use with stock rations. The HPLC was also used for estimation of alpha and beta carotene in sweet potato varieties grown in the Kimberley.

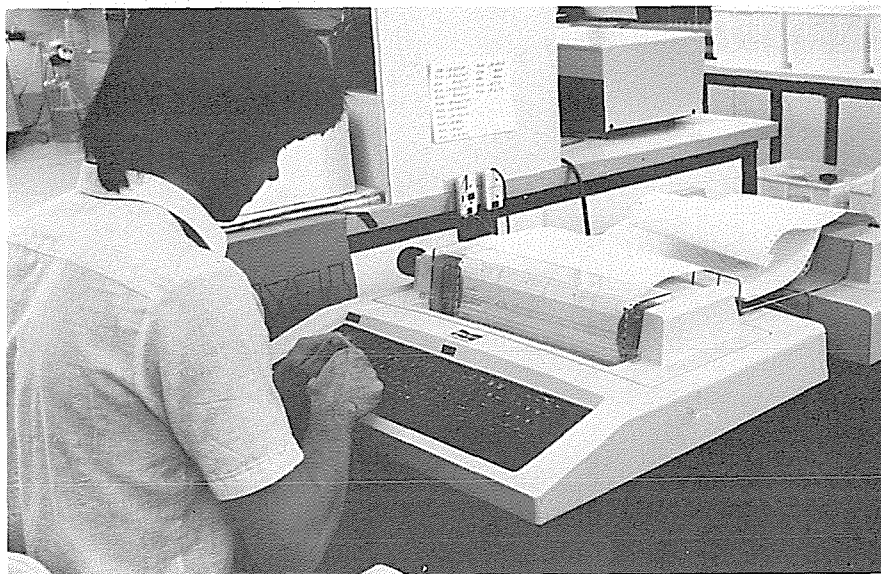
A finding of importance to animal nutritionists involved with feeding trials arose from the final stages of a study of the effects of supplementation of pig rations with Christmas Island rock phosphate, alumina and limestone. Trouble was experienced with inconsistencies in the levels of additives in different batches of rations. An inspection of the mixing and sampling processes and chemical analysis of the rations showed that segregation of the supplements during mixing and incorrect sampling procedures were responsible. Similar disparities between calculated and analysed amounts of components in feeds

able curd. A tissue test for monitoring plant nitrogen status was investigated by following the changes in nitrate content of leaf blades and petioles during the growth of the crop. Evaluation of the results of analysis indicated that the concentration of nitrate in tissue samples one week after application of fertilizer or three weeks after transplanting may be a useful basis for a predictive test for advisory purposes.

**Soil Section.** The demand for soil testing services by primary producers and advisers continued. There was a marked increase in the number of enquiries for pH data in addition to tests for extractable phosphorus, potassium and copper.

Peanuts require adequate levels of soil calcium for pod development. Extraction of sandy soils with 0.1M HCl proved useful in assessing residual calcium where gypsum and lime were applied to trials at the Ord River.

Contribution to the second year of the acidic soils project continued with generation of chemical data aimed at eventually defining opti-



from other trials indicate that the mixing problems may be more prevalent than is generally appreciated.

Growers of cauliflowers are supplying markets in S.E. Asia. Over-use of nitrogenous fertilizer results in reduced yields of market-

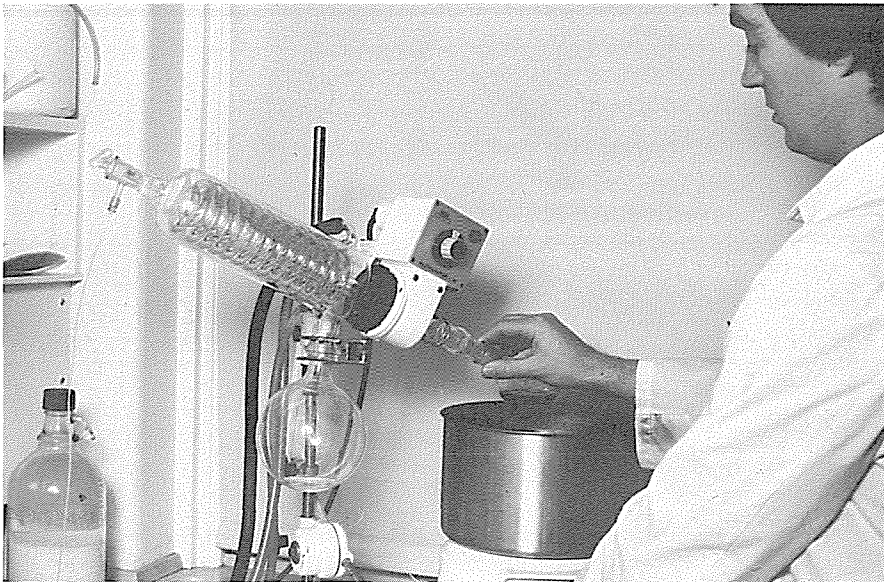
imum rates of application of lime, measurement of response to lime and effects of liming on trace element availability. To date there is no relationship between extractable aluminium in the soils and either crop responses to lime treatment or aluminium content of plant tops.



Work with zinc to provide chemical data to determine residual values, the effects of using high analysis fertilizers having relatively low zinc contents and closer definition of rates of zinc fertilizer required to maintain animal health was commenced.

**Trace and Environment Section.** A trace-back exercise to establish the origin of above normal levels of cadmium and lead in animal viscera resulted in sampling of soils and pastures. The levels of cadmium and lead found were normal.

A revival of interest in cobalt nutrition of ruminants in the Albany district led to spraying of pastures with cobalt sulphate solution in the early spring and subsequent analysis. Adequate levels of cobalt for animal health were maintained through the growth flush period, when deficiencies usually occur.



Monitoring of effects of brickwork emissions on grapevines was reduced during the year. Roofing tiles were checked for fluoride content before and after firing to provide information for a fluoride balance study carried out by Public Health Department.

The acidic soils project which covered soils of the wheatbeld, high rainfall areas and Esperance districts showed the effects of liming by changes in the balance of molybdenum, copper and sulphur intake in the grazing ruminant.

## Engineering Chemistry

In retrospect 1981 was an unusual year. The principal departure from normality was the absence for the entire year of the Chief of this Division of the Laboratories who remained on secondment to the Department of Resources Development. Responsibilities were adjusted to cope with the situation but it was not practicable to maintain the numerical strength by recruiting another professional officer at a lower level in view of uncertainty as to the duration of the arrangement. The staff responded well to the challenge and disruption was less than might have been expected because the staff accepted extra responsibility and workload. This report indicates that, as usual, a wide variety of requests from industry was accommodated. The Pindan project for another government of-

pressed air and water services to particular points.

**Contract investigations.** To facilitate fluidised bed testwork during the year, the Lindberg Hevi-Duty wrap-around furnace was received for use in conjunction with a stainless steel 105mm diameter fluidised bed reactor. A mobile supporting frame was constructed to allow the furnace to be used in a vertical stance for fluidised bed and shaft furnace applications and in a horizontal or inclined mode for other applications. The furnace is rated at 7.5kW and will provide close control of temperature up to 1 200°C. The unit was barely installed when inquiries were made about its availability and suitability for contract investigations.

Fluidised bed technology is widely used for processes requiring intimate contact between fluids and solids. The technique requires a fluid flowing upward through a bed of solid particles at a velocity which supports the particles and puts them into turbulent motion without carrying them out of the bed. The fluid can be liquid and this is the original form of the phenomenon. The later methodology in which gases are the fluidising medium is now over 50 years old and is a well researched and widely practised chemical engineering process.

However the wealth of documented knowledge and background experience does not ensure the automatic success of every fluidised bed process. Two cases in which advice was given were concerned with instances where commissioning troubles were experienced with new fluidised bed processes. In one case the determination of fluidising velocities was required and in the second case preliminary enquiries were made for a programme of testwork in 1982. In both instances the size range of the materials being fluidised created experimental difficulties for the small test unit. Nevertheless, in the work completed for one company useful results were obtained and in subsequent discussion

some modifications to the commercial unit were suggested. For the second company, it is anticipated that a schedule of useful testwork will be formulated.

For another company testwork with a more tractable material was completed. Although no experimental handling difficulties were experienced, it became apparent that the residence time of the solid in the reactor was a significant variable when the process was operated continuously by simultaneously adding feed to an withdrawing product from the bed. The unit was modified to complete this particular schedule of tests as a series of batch operations. It is probable that the unit will need another modification for the projected testwork.

In the short time that the present unit has been in use it has become evident that a larger unit will be required for more practically oriented research work both for industry and the Laboratories. However, increasing the bed diameter to 250mm will require matching increases in air supply, feeding and product collection arrangements, furnace, etc., and will need to be carefully designed on the basis of experience accumulated with the present and previous units.

Testwork on attapulgite during the year completed an investigation begun late in 1979. The company concerned is mining Australia's largest known deposit of attapulgite at Lake Nerramynne about 130km north-east of Geraldton. The ore is sun-dried on-site and then brought to Narngulu near Geraldton for processing by crushing, drying and sizing. The product is suitable for use in horticulture, scavenging liquid spillages and as pet litter.

The company sought assistance in extending the range of uses for its product with particular emphasis on its activation to produce a bleaching earth. The encouraging results indicated in last year's report were confirmed and extended during this year. A large scale test was conducted at a commercial edible oil works when the activated attapulgite was substituted for the bleaching earth

normally used in the factory. The tallow being processed was bleached as satisfactorily by the activated attapulgite as by the earth in regular use.

The attapulgite had been prepared in the Laboratories in what was essentially an up-scaled laboratory method. Although only 25kg of attapulgite was treated in a batch operation, there were no obvious problems that would prevent translation of the process to pilot scale size. During the year the company announced its intention to construct a pilot plant and it is anticipated that the Laboratories will be involved in further work for the company in 1982.

The need to maintain confidentiality of the company's process restricts this report on the testwork done. This is generally true of contract testwork even when the results obtained do not lead to commercial application. In this particular case, two papers on the topic have been prepared and the company's permission will be sought to submit them for publication.

A wide variety of short-term testwork was requested during the year and a few examples are indicated below. It was possible to meet the demand because of the extent to which staff expertise and equipment have been built up over many years. The availability of these to industry (at cost) is an extension of government policy aimed at assisting the development of the State.

A company sought testwork aimed at characterising the gold ore from a mine which it is planning to re-develop. The work involved grindability and Work Index determinations, size analyses and measurements of settlement and filtration parameters. The results will be applied to the design of a processing circuit as part of the company's feasibility study.

Another company was anxious to recover fine charcoal from its dumps because of its present value as a fuel for their metallurgical processing. A brief investigation of a screening-elutriation method gave promising results with an acceptable

yield of low-ash charcoal and this was reported to the company's satisfaction.

**Projects for other departments.** The soil stabilisation for brick making project continued throughout the year but it is expected to draw to a close in 1982. The State Housing Commission had made a second grant of \$30 000 to the Office of Regional Administration and the North West and part of this permitted the employment of a laboratory technician for 5 to 8 months. The funds also provided for the project leader, Mr R. V. Field, to visit north west centres to select soils for stabilisation testwork. Twenty six samples from areas around Kununurra, Broome, Port Hedland and Karratha were brought back for preliminary testwork and ten soils were quickly selected for more detailed work. Some other sands were sampled for use as mortar sands and these were assessed at Leederville Technical School.

**Special project.** The National Association of Testing Authorities (NATA) invited the Laboratories to participate in inter-laboratory coal testing and two samples of coal were received for analysis. The results of the test are expected from NATA early in 1982.

As might have been expected the two coals analysed were black coking coals from the Eastern States and quite unlike Collie coal. Analyses were carried out for moisture, ash, volatile matter, gross specific energy, carbon, hydrogen, sulphur and carbon dioxide. Some analyses were not attempted because they apply only to coking coals and require special apparatus. The Division has never needed such apparatus because, unfortunately, no deposits of coking coal of commercial significance have been found in this State.

#### **Food and Industrial Hygiene**

This Division of the Laboratories has continued to receive a wide variety of samples calling for complex



and sophisticated analysis. There has been an increased demand for pesticide residue analyses and there is often a backlog in reporting these analyses. The acquisition of another automated gas chromatograph has greatly assisted in the handling of these samples.

There has been a two per cent increase in the total number of samples received last year. There has been a marked increase in the number of foods received but a corresponding decrease in the number of miscellaneous samples.

Numerous enquiries for technical information and advice from Government departments, instrumentalities and the public have been handled during the year.

The source and type of samples received are given in a table on page 153. Some highlights of 1981 are given below.

**Foods.** Two separate cases of the misuse of bottles used to contain drinks have been investigated this year. In both cases a concentrated solution of potassium hydroxide was found in the bottles concerned. In one case a bottle labelled soda water had been filled with the potassium hydroxide solution and the bottle placed amongst similar bottles. Several people had burning to their mouths when a drink in which it was used was consumed. In the other case a lemonade bottle had been filled with the solution and later given to youths of a football team, several of whom had to receive medical treatment for burning of the mouth and throat. These cases illustrate the dangers that can occur when food containers are used for storage of other materials.

A store was selling peanuts at a price well below the current market price. These peanuts were sampled and found to be very mouldy. Aflatoxins were not detected in the peanuts but because of their adverse appearance it was recommended that they should not be sold for human consumption.

**Industrial hygiene.** This year several of the Laboratories' officers have

accompanied inspectors from the State Mining Engineer's Division on minesite inspections. Mr G. A. Taylor visited seven minesites in the Pilbara area and three in the Kwinana—Pinjarra area; Mr D. E. Fleming visited three in the Eneabba—Geraldton area and fifteen in the eastern goldfields; and Mr F. E. Uren visited one at Greenbushes. These inspections were to evaluate the hazards of the various chemicals used and their handling in the mining situation.

From these inspections it was noted that the safety gloves used were frequently unsatisfactory for the handling of solvents. Officers conducted a series of tests on a wide range of safety gloves for penetration using the particular solvents found on the minesites. A report was compiled and circulated giving a list of recommendations of which gloves were suitable for use with the various solvents and solvent mixtures.

During the year, 492 biological samples have been examined from workers to monitor their industrial exposure to various chemicals. The most requests were for fluoride followed by P.C.B's, mercury, lead, arsenic, and herbicides.

**Pesticide residues.** Mention was made in last year's report of the outbreak of cattle tick in the south of the State and the consequent treatment of the cattle and analysis of the renal fat samples. The monitoring programme continued this year. Four of the 203 samples examined had coumaphos levels marginally above the 1 mg/kg coumaphos maximum residue level (MRL). Of more concern was the fact that in 50 of the samples ethion was found and only four of these samples were below the MRL of 2.5 mg/kg. Ethion is more persistent than coumaphos and the cattle were not being held for a sufficient withholding period before slaughter. These findings have led to a total ban on the use of ethion on cattle to be moved from the north of the State to the south.

A nursing mother reported to the Public Health Department that her home was about to be treated with heptachlor. It was arranged to obtain a sample of breast milk before the treatment and several samples following the treatment. After the treatment there was a rapid rise in the heptachlor level which then tapered off. The rapid rise in the heptachlor level was considered to be due to the volatility of heptachlor. To test this hypothesis an animal experiment was arranged with the assistance of Department of Agriculture officers. Ewes with lambs would be exposed to an atmosphere of heptachlor and aldrin and their intake of pesticides from feeds monitored. The amount of pesticide in their blood and milk and the atmosphere was also monitored. The trial has concluded but the large number of samples generated by the trial are yet to be evaluated.

**Miscellaneous.** Food warming trays imported from Europe were found to be defective and potentially dangerous. Quicklime and water packed in a compartment in the tray base are mixed when the plastic bag containing the water was scored by pulling a tab on the side of the tray. The exothermic reaction heats the food placed in the tray. However in some of the trays the bag of water had either leaked prior to use or was not scored when the tab was pulled. In the latter case the loosely packed quicklime constituted a health hazard if the crimped tray was opened to ascertain the cause of the failure. Also if the tray was punctured by a knife or fork the lime solution would be a health hazard.

The Public Health Department requested that the Laboratories investigate a case of carbon monoxide poisoning in a dwelling. Four occupants of the house had suffered the symptoms of carbon monoxide poisoning the previous day and had moved from the house. It was found that the back of the open fire place in the lounge room, in which there had not been a fire for four days, was still warm. On investigation it

was found that below the grate was an ash pit covered with a sheet of iron. Into this ash pit, through the unrestricted opening, large pieces of wood and ashes could be swept. The ash pit had a cleaning box at floor level in the garage situated below the lounge room. After removing the goods stored in front of the cleaning box, still smoldering embers were found. Normally gases from this fire would pass up through the chimney and not enter the house. The house was equipped with a large exhaust fan designed to draw cool air into the house on summer evenings. A kerosene heater had been used on the day the people were effected by carbon monoxide, and to remove the fumes from the heater, the exhaust fan was used. As the house was shut up, the only way replacement air could enter the house was by way of the chimney. The chimney air, high in carbon monoxide from the smoldering fire in the ash pit, was thus drawn into the house, causing distress to the occupants.

The Laboratories have also been called to investigate odours within two houses. It had transpired that both houses had been insulated with a urea formaldehyde foam. Tests for formaldehyde within the houses had shown there were concentrations of formaldehyde well below the threshold limit value but if the occupants were sensitized to formaldehyde it may have been sufficient to cause the breathing problems they described.

### Forensic Chemistry

The unprecedented level of demands made on the services of the Forensic Chemistry Division of the Laboratories in 1980 was exceeded in 1981 after a busy year of criminal activity. Manpower resources were severely tried by the massive escalation of illicit drug work, by the increased number of requests to look for drugs in connection with driving offences and by the greater array of examinations required of the Physical Evidence Section whilst there was no diminution in the level of toxicological work received.

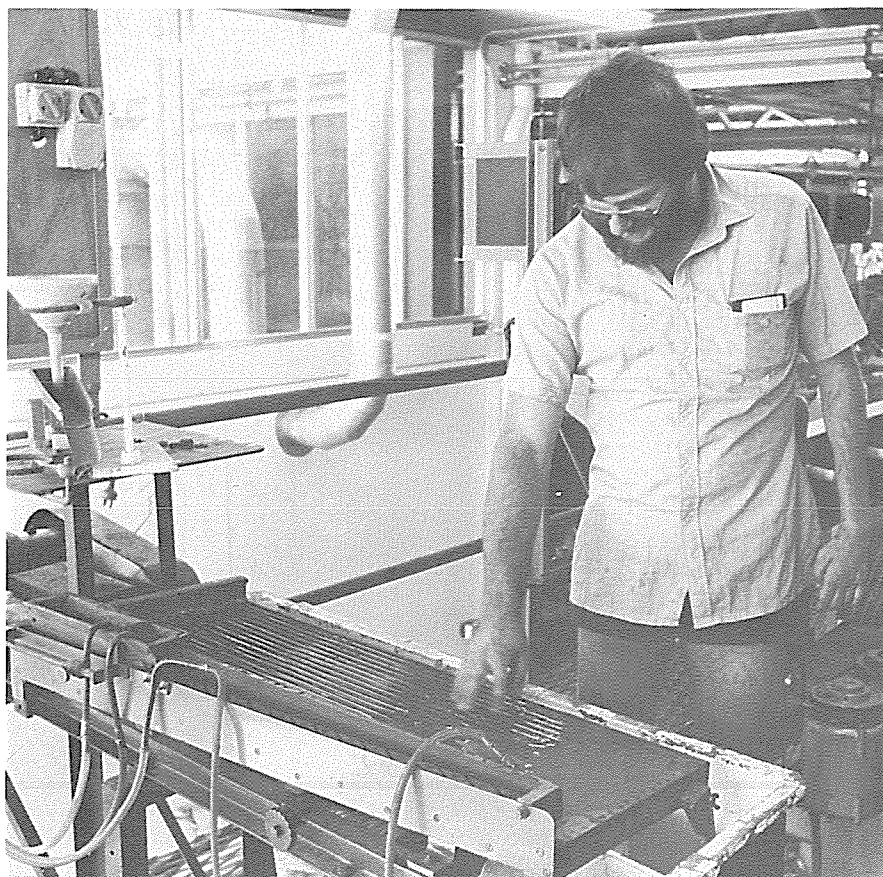
Whilst the demands for chemical analysis and examinations of exhibits continue to grow so too does the associated Court work. The process of producing expert evidence and the physical appearance in the Courts is one of the demanding and time-consuming functions of this Division of the Laboratories. As chemical advisors to the Police and other government departments another important source which has continued to expand is the consultant and advisory role which also on occasions results in the tendering of expert evidence to the Court.

Despite the difficulties of staff limitations, accommodation problems and difficulties in obtaining adequate finance for equipment, the staff has demonstrated a conscientious approach to their tasks and are to be complimented on the quantity of work performed and also on the quality of their efforts.

The type and source of samples received in 1981 are shown in the table on page 154.

**Alcohol, drugs and driving.** 568 blood samples arising from drink driving offences represented a 27 per cent increase over the previous year. In addition to alcohol levels, requests to analyse the blood for drugs increased considerably. This very time-consuming work will require additional staff to handle the large increase in workload anticipated if proposed legislation is enacted to give the Police power to take blood and urine samples from persons who give a negative breath alcohol test but who show obvious signs of intoxication.

Drugs detected in blood submitted in connection with driving offences in 1981 were amitriptyline, diazepam, methadone, methaqualone, morphine, oxazepam, phenylbutazone and phenytoin. In addition benzoylcegonine (a metabolite of cocaine), cannabis derivatives, diphenhydramine and oxazepam were found in urine samples which a limited number of subjects volunteered.





Blood and urine from fatal traffic accident victims are routinely submitted to the Division for determinations of alcohol content. In 1981, 384 such exhibits were received, a distribution of alcohol in the bloods of drivers, passengers, pedestrians, motorcycle riders and cyclists being shown in the table.

Alcohol (per cent)	Motor vehicle drivers	Passengers	Pedestrians	Motor cycle riders	Push cycle riders
not detected	48	27	11	13	2
less than 0.05	5	—	2	—	—
0.050-0.079	6	2	—	1	—
0.080-0.099	3	1	—	2	—
0.100-0.149	6	2	2	4	—
0.150-0.199	10	7	4	2	—
0.200-0.249	9	5	4	4	—
0.250-0.299	7	5	1	—	—
more than 0.299	3	3	5	—	—
Total	97	52	29	26	2

The figures reveal that 41 per cent of all motor vehicle drivers (including motor cyclists) killed as a result of traffic accidents had blood alcohol levels greater than 0.08 per cent whilst 28 per cent had levels in excess of 0.15 per cent.

An astonishingly high blood alcohol level of 0.89 per cent was found in the driver of a truck in the remote north of the State. Investigations concluded that there was no reason to suspect any contamination of the blood sample. Evidence was given that the deceased quickly consumed a large quantity of spirits shortly before the truck ran off the road. Further information revealed that the deceased drove so erratically that his passengers disembarked and refused to ride in the truck.

The problems of the drinking driver are frequently highlighted but rarely is there much publicity about drink affected pedestrians who present a hazard to drivers and to themselves. Of the 29 pedestrians who were fatal victims of traffic accidents and from whom blood samples were received, fourteen (48 per cent) had blood alcohol levels greater than 0.15 per cent. Five of these had levels more than 0.3 per cent of which two were even greater than 0.4 per cent.

**Drugs.** The number of drug cases dealt with during 1981 was 357, comprising 2 172 exhibits, an increase of approximately 50 per cent compared to 1980. The majority of cases were received from the CIB Drug Squad, other cases being received from the Department of Corrections and the WA Alcohol and

drugs and poisons involved in the 352 cases of sudden death which were the subject of Police investigation.

Drug or poison	No. of positive identifications
Carbon monoxide	39
Pentobarbitone	13
Oxazepam	12
Phenytoin	11
Trichloroethanol	8
Phenobarbitone	8
Amitriptyline	8
Nortriptyline	7
Amylobarbitone	6
Quinalbarbitone	5
Morphine	5
Thioridazine	4
Various*	48

\*Desipramine, diazepam, imipramine, lignocaine, nitrazepam (3 each). Benzotropine, butobarbitone, diazinon, dogoxin, doxepin, lithium, quindidine, theophylline (2 each), Dextromoramide, codeine, sulendac, Freon 11, chlorpheniramine, methylphenobarbitone, diphenhydramine, dextromethorphan, pethidine, cocaine, methadone, propoxyphene (1 each).

Drug Authority. Details of the number of cases submitted by the Police in which various drugs were identified are listed in the table.

Type of drug	Number of cases
Cannabis and/or products	272
Heroin	41
Amphetamines	9
L.S.D.	3
Cocaine	3
Bromodimethoxy-amphetamine	2
Morphine	1
Methadone	1
Pethidine	1
Schedule Drugs (various)	20

The diverse range of items submitted for examination have included hessian bags, vacuumings from vehicle interiors, clothes, hand swabs, drug paraphernalia such as syringes, spoons, capsules, plastic bags and home-made pipes, and in one particular case one of the Laboratories' chemists was involved in a complete search of a room of a suburban house, including examination of the floors, walls and skirting boards.

**Toxicology.** The heavy demands in recent years on the toxicology section were maintained again in 1981. The table lists the details of the

**Criminal investigation.** Of the case-work received during the year, polymeric samples formed a large proportion. These were received mainly as paint flakes, fibres and a variety of miscellaneous materials. One of the most significant developments in 1981 was the application of high resolution capillary gas chromatography equipped with a pyrolysis unit to greatly improve analysis of polymeric samples. It is now possible to separate and record complex pyrolysis "fingerprints" characteristic of polymer type, and also to discriminate minor differences within polymers of the same basic type. Typical examples include differentiation of acrylic lacquers, white household glass paints and rubbers. The use of a nitrogen-specific detector with the new gas chromatograph has enabled even further differentiation of certain polymeric material.

Debris from 49 fires was examined during the year. This represents a significant decline in numbers compared to the 64 examined in 1980 despite an increase in the number of known arson cases. In only 20 per cent of the cases was any accelerant detected in the



debris. This also represents a significant decline in the number of "positives" which in previous years was around 45 per cent. In the reports of a considerable proportion of cases examined, some comments were made on the shortcomings in sample collection and packaging. Similar experiences in Victoria led to the formation in 1976 of a fire investigation unit staffed by chemists and a technician. From 82 fires they examined in 1976, the work of the unit has grown to 341 in 1981. However, of the samples collected by the fire investigation unit, 83 per cent were found to be "positive". In 90 percent of all fires attended, proof of a fire caused was found. These factors suggest that it may be appropriate to reorganise fire investigations in W.A. along the lines of the successful Victorian model.

**Maritime pollution by oil.** The acquisition of high resolution capillary gas chromatography has provided improved characterisation of fuel oils from oil spills. Minor components of n-alkane and aromatic compound mixtures are now better resolved, resulting in improved discrimination of oils of similar type. Nitrogen compound "fingerprints" of fuel oils using this equipment also provide additional assistance in the comparison of oils.

The new equipment was most useful in the examination of the 11 cases of marine oil spillage. In 5 cases the oil from the spill matched oil from a vessel or other suspected source. Three samples of oil from unknown vessels were examined, one of these being a residual fuel oil from a 5km stretch of beach at Yankep. Other cases examined involved spillage of diesoline, heavier bunkering fuel and lubricating oil.

### Industrial Chemistry

**Materials science.** One case in which this Division of the Laboratories was requested to arbitrate was in a failure where one manufacturer's gloss latex topcoat paint had been applied over another manufacturer's pink primer. The first men-

tioned manufacturer disclaimed responsibility on the grounds that their paint was only formulated for use with their own primer. An accelerated wetting test was developed using different pink primers and latex topcoats, and this test showed that the suspect paint was in fact faulty, even when used with the prescribed primer, and that failure occurred by water penetration of the top paint coat, causing blistering and adhesion failure regardless of the nature of primers and substrates. The existing test method, in AS1580 "Methods of Test for Paints, Varnishes, Lacquers and Related Materials", for resistance to wetting is not adequate to demonstrate this blistering fault and it is likely that a modified form of the test method developed by us may be included in the above Standard in due course.

Technical assistance was given to the consultants engaged by the Metropolitan Water Board for the construction of the Bibra Lake Sewer Tunnel. This 2 kilometre concrete tunnel, 2.2 metres in diameter, is lined for protection with a fibreglass reinforced plastic laminate. This lining, being fabricated off-site in 6 metre lengths, is estimated to cost over \$1 000 000, and is believed to be the largest single fibreglass reinforced plastic pipeline contract ever let in Australia. The Laboratories' role was that of monitoring raw materials and finished products by chemical and physical examination, as stringent limits have been set regarding synthetic resin quality, occluded air, reinforcement quantity, chemical resistance of the exposed surface, and general workmanship.

A section of a large fibreglass reinforced plastic fan blade from a power station cooling tower was examined to ascertain the cause of failure during service. Although the overall composition was up to specification, with respect to the resin and glass contents, localized areas showed cavities with no glass reinforcement, with other areas consisting entirely of fibreglass with no wetting out by the resin. These

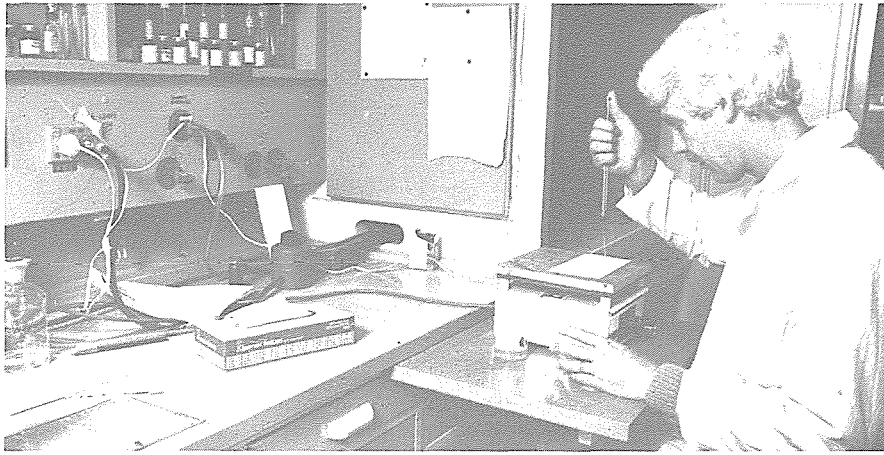
faults produced areas of very low strength and are indicative of poor workmanship. Twenty three floor covering materials were examined. Of these, 17 were for assessment as a guide to selection, and 6 were for resolving product quality and workmanship disputes.

The assessment samples comprised linoleum, sheet vinyl, carpets and ceramic tiles. The type of suitability tests included wear resistance, dimensional stability, stain resistance, and in some cases, non-slip properties. The results were generally satisfactory, and most of the materials were considered acceptable, although installation in light duty areas only was recommended for some samples.

Five samples of foam-filled sandwich panels were examined after a domestic fire. In two of the samples which were only slightly fire damaged, some fire retardant material could still be detected, and were found, when fire tested, to be self-extinguishing. The more severely heat-damaged samples appeared to be lacking in fire retardant, and it is probable that these had lost their retardant by volatilisation due to heat of combustion of other materials and would then have contributed to the fire.

Further work was done on preparation of tung oil from locally grown fruit for the Office of Regional Administration and the North West. Oil was obtained by solvent extraction and by pressing from fruit picked early, mid-season and late. Best yields were obtained by both methods from late picked fruit. Solvent extraction gave a yield of 34.1 per cent and pressing 12.9 per cent.

**Assistance to industry.** The utilisation of locally produced micaceous iron oxide as a paint pigment was investigated on behalf of a potential local producer. Paints using these pigments were formulated to an approved specification by an experienced paint manufacturer and a series of 36 test panels coated with various combinations of primer and topcoats were exposed in the salt



spray corrosion test apparatus (BS3900 Part F4) for 500 hours. Evaluation of the paint films and the metal substrate after exposure showed that the local material compared favourably with imported products. On the other hand, metal panels coated with a paint formulated from local natural iron oxides performed poorly in a salt spray test.

**Investigational.** The investigation into formaldehyde evolution from urea formaldehyde insulating foams continued to a satisfactory stage, where the rate of change of formaldehyde in foam with time, and also the rate of evolution of formaldehyde from the foam into adjacent air was established. Urea formaldehyde foam is an economical, fire resistant material of good insulating properties, and which can be *in-situ* foamed into otherwise inaccessible areas but the material is somewhat suspect from the health viewpoint because of formaldehyde vapour emissions.

#### Kalgoorlie Metallurgical Laboratory

A high demand for metallurgical services was experienced in 1981. Some 40 percent of the samples submitted were associated with metallurgical investigations.

Analytical services for the public were controlled more closely to suit metallurgical workloads and this led to a reduction in the number of reports issued when compared with 1980.

During 1981 the laboratory issued 377 certificates of which 77 were associated with investigations and 23 on the request of government departments.

There was a sharp decline in the number of gold tailings deposits tested and a decline in request for investigations from prospectors.

The laboratory was understaffed for most of 1981 and most internal research programs had to be deferred.

The falling price of gold in 1981 caused a decline in the demand for services towards the end of 1981 and lower demand in 1982 is expected.

**Metallurgical investigations.** All investigations in 1981 were associated with the recovery of gold. The main demand for testwork came from mining companies and prospecting syndicates. Many ben-

eficiation investigations were undertaken to establish basic behaviour of ores and tailings when subjected to standard amalgamation and cyanidation tests designed to maximise gold recovery. Three investigations were carried out at pilot plant level.

The laboratory continued to provide services to North Kalgurli Mines Limited for the purpose of establishing gold recoveries for Custom Plant clients.

During the year a standard test method for gold recovery from refractory gold ores was developed and tested. A refractory ore is defined as one that is not amenable to satisfactory gold recovery by standard amalgamation and cyanidation techniques and requires roasting. Commonly the gold is intimately associated with pyrite and arsenopyrite. Flotation is used to concentrate free gold and gold-bearing minerals before roasting.

During 1981, 172 non-refractory and 8 refractory ore parcels were tested.

There was an increase in demand for testing of new gold ore bodies and 22 reports were issued. Most ore bodies were not refractory and the gold could be satisfactorily recovered by standard amalgamation and cyanidation techniques. A small number were refractory and required roasting.

Four investigations examined the possibility of leaching gold ores at coarse size. Gold recoveries were





generally poor. To be successfully leached at coarse size the gold in the ore must be very fine and the associated rock porous so that cyanide can penetrate and saturate all gold surfaces.

The demand for investigations into tailing retreatment dropped by 50 per cent in 1981 and only 17 reports were issued.

Most tailing deposits have had a previous retreatment attempt and the availability of suitable deposits is diminishing rapidly. Many remaining tailing deposits have treatment problems due to the presence of carbon, copper minerals or refractory gold. Some can be treated after regrinding to liberate gold locked in quartz. Tailing retreatment showed a trend away from the vat leaching method by individuals or prospecting syndicates. Only 4 reports were issued on this technique compared with 13 in 1980.

Most investigation requests were for agitation cyanidations to simulate air-agitation or slurried tailings and gold adsorption onto activated carbon.

A number of agitation cyanidation plants and activated carbon stripping plants came into operation in 1981. During 1981, 5 investigations were carried out that were related to processing problems.

The use of activated carbon for gold recovery after cyanidation has been the choice of most new ore and tailing treatment plants and refinement of transporting, screening, stripping and re-activating processes is developing through operating experience.

**Analytical services.** Analytical demands associated with metallurgical tests were the main source of work load in this section. Most of the requests were for gold and silver analyses.

Gold analysis of solid samples was exclusively carried out by the fire assay method. In this method, parting of the gold and silver bead was carried out by digestion with sulphuric acid. The assay was finished gravimetrically.

Gold analysis of cyanide solution samples was exclusively carried out by atomic absorption. The standards for this method had additions of cyanide and lime to compensate for matrix effects. Each group of samples analysed contained a check standard that had been fire assayed.

Gold analysis of amalgams was by fire assay methods after a digestion with nitric acid to dissolve mercury present.

Assaying of gold bullions and state battery sands were carried out on request. In 1981, 85 gold bullions and 19 battery sands were analysed. During the year 19 gold specimens were estimated for gold content.

**Advisory.** The laboratory provided an advisory service to many small gold-treatment operators, government officers and the public. During 1981, 174 enquiries of this nature were handled.

#### **Mineral Division of the Laboratories**

Greater emphasis has been placed this year on applied mineralogy and mineral chemistry in problem solving. Examinations in depth have been made of problems mainly in the areas of building materials, occupational health, and forensic evidence.

Sample submission during the year reflected the cut back in some programs in other divisions of the Mines Department and other Departments, and alteration of some monitoring programs to include greater participation by the industries concerned.

The trend was evident across the board, involving mineral exploration, occupational health and air pollution work. The main exception was an increase in requests for silicate rock analyses involving continued demands on X-ray and computer equipment. The age of the X-ray equipment continues to cause concern regarding the possibility of a complete breakdown of the service it provides.

Details of sample submissions are tabulated on page 154.

**Rock and mineral analyses.** Work in this area again arose essentially in support of Geological Survey Division projects and mapping programs. A large proportion of the examinations made consisted of full silicate and trace element analysis with calculation of CIPW norms and quantitative X-ray diffraction estimation of mineral species forming the rocks.

A major program for incorporation in a Bulletin on the Gascoyne Province was an investigation into the synthesis of the Province. It consisted of a geochemistry project to differentiate and compare field occurrences of granitoids derived from metasediments and from basement gneiss remobilisation, and to compare them with the Minnie Creek batholith.

Also for the Gascoyne Bulletin was a project on a migmatite formation. The examinations were to help determine whether the migmatite was developed by in-situ partial melting or by external magma injection, and also to document for comparative purposes the composition of the metasedimentary granite/migmatite suite.

As part of the Hamersley Iron Formation study several suites of samples were examined. These consisted iron formation, chert and black shale with carbonates.

The elemental associations in different but contiguous rock suites were established for the Warriardar project prior to an exploration survey.

For the Carnarvon Basin Bulletin a complete examination was made of the properties of unusual ultramafic rocks now highly weathered.

Mineralogical and chemical analyses of material collected to assist the characterisation of kimberlites in Western Australia is proceeding.

Mapping or remapping of sheets in the geological series required examinations to determine economic potential, rock differentiations, and causes of anomalies.

Gossans from Mt. Monger contained elevated values of zinc, copper, manganese, and arsenic, variable throughout the suite.

For the Dumbleyung sheet an anomalous mineral occurrence in a ferruginous quartz vein at Lake Grace was examined. Also data for determination and comparison of types of granitoid rocks throughout the south west of the State were prepared. For the Wyloo sheet analyses were made to assist determination of the basalt type.

In connection with a resumption/compensation case material was provided for Court evidence regarding the value of resumed quarry resources of limestone.

Other examinations to assist the administrative functions of the Department were a survey of gold-bearing material from Mt. Magnet and a similar survey of rock and soil types of the "Rabbit Warren" prospecting area.

**Cement and concrete.** Work carried out in this area represented an important section of work and involved the assessment of material proposed to be used in constructional work for Government departments and instrumentalities as well as investigations into reasons for material failures.

Materials proposed for use in concrete work require both chemical and mineralogical expertise to ensure that potentially deleterious minerals are not present. As much of the material examined is proposed for use in the North-West, the initial examinations are important to eliminate the possibility of future expensive repair work.

While a routine pattern has been established for such assessments the identification of failed concrete constructions involves lengthy investigations and the use of sophisticated techniques. The work, at times, is further complicated by the inability to view the problem in situ and the unavailability of the materials originally used. In some cases, therefore, only probable causes of failure can be advanced.

**Mineralogy.** Identifications were carried out as previously for Government departments and the public where necessary. The public samples are now treated entirely on a cost basis where laboratory examination is required. Visual identifications are provided gratis. Specimens received as donations were examined before addition to the Laboratories collection.

Examination is continuing of material made available by the lease holders of kimberlite occurrences of Ellendale and Argyle during an excursion to the sites. Garnets of four distinct colours are being studied in detail from kimberlite occurrences in the Ellendale area. Particular attention has been paid to garnets, micro-ilmenites and other heavy minerals in the gravel concentrates from the kimberlites in the Carnarvon area.

Other garnets in a microcline-quartz-muscovite matrix from Mt. Edgar area were shown to be almandine-spessartines similar to almandine-spessartines in other North-West pegmatites, thus enabling the containing rocks to be classified as pegmatite rather than granite.

Geological investigations in the Weeli Wolli area disclosed four stratabound layers rich in a mineral shown to be axinite (a mineral normally formed by hydrothermal deposition). The unusual occurrence of axinite in this form prompted detailed examination of the axinites. Very little variation in the axinite composition was observed. The comparative study has now been extended to axinites from intrusive dolerites from the Weeli Wolli formation.

Also from Weeli Wolli, composite samples of banded iron-formation were checked for evidence of weathering. Magnetite altering to hematite along edges of grains indicated incipient weathering. A shale composite from the same locality showed no weathering effects.

Specimens of a uraniferous garnet-bearing mica pegmatite from Northeast of Yinnietharra on the Mt. Phillips sheet were examined to

determine the mode of occurrence of the uranium. The radioactivity was due to thin yellow joint fillings of *B*-uranophane and traces of a uranium-bearing rare-earth columbate-tantalate, with a very low general radioactivity in the feldspars, presumably due to radioactive potassium.

An examination to determine the source of a radioactivity anomaly in the Minnipup area consisted to determination of uranium in several gravity fractions and detailed analysis of all mineral constituents. The only radioactive mineral identified was monazite. No concentration of uranium in any fraction was noted.

Another radioactivity anomaly near Paraburdoo occurred in conglomerate which contained up to 370 ppm uranium and 25 ppm thorium.

Black opaque material occurring as segregations in stromatolites from Wongawall Creek (Kingston 1:250 000 sheet) was shown to be amorphous manganese oxide.

Two rock-forming minerals associated with the Mt. Alfred copper prospect in Central Yilgarn were grey analcite and blue hyaline allophane with interstitial aluminous lizardite.

A suite of samples from the Poona area was submitted with the suggestion that they contained the beryllium mineral bertrandite; none was found. The minerals present included beryl, fluorite, gypsum, tourmaline, actinolite, dolomite, miloschitic clay, nontronite, weathered micas and quartz.

Other mineralogical examinations were made for specific purposes such as clays in soils for engineering purposes or total mineral composition to supplement complete chemical analyses of rocks from mapping programmes.

The co-operation of the Chairman of the International Mineralogical Association's Commission on New Minerals and New Mineral Names, which has enabled an up-to-date record to be maintained, is gratefully acknowledged.

**New mineral occurrences.** Listed in the table are localities from which the specific minerals were recorded in the Division for the first time this year.

Locality	Mineral
Kimberley	
Walgidee Hills	Shcherbakovite
North-West	
Mt Whaleback	Pyrite
Harding River	Palygorskite
Mt Phillips	B-uranophane
Murchison	
Cue	Stibiconite
Mt Magnet	Prehnite
South-West	
Hertha Swamp	Greigite
Cocanarup	Manganocolumbite
Pemberton	Todorokite
New Norcia	Corundum
Central	
Coolgardie	Joselite
Coolgardie	Bismocelite
Southern Cross	Manganotantalite
Kalgoorlie	Tomichite
Teutonic Bore	Embolite
Teutonic Bore	Osarizawaite
Teutonic Bore	Silver (native)
Teutonic Bore	Copper (native)

Greater detail of localities may be available on application depending on the source of the material.

**Mineral dusts.** A large variety of mineral dusts was examined in relation to atmospheric contamination and health hazard in the work place, on behalf of the Public Health Department, the Department of Labour and the State Mining Engineers Division of the Mines Department. The examinations consisted of identifying and quantifying mineral constituents or metals derived from minerals.

Largely the work related to regular monitoring of townsites and work places in co-ordinated programs for specific elements or minerals.

**Non-metallic dusts.** Many non-metallic dusts were examined from monitoring programs in operation from previous years.

Amongst these were dust collected in the vicinity of various industries and processing works, for which the contribution from the industry and from indigenous materials was required. This was complicated in some cases where the

same minerals occurred from both sources and individual differentiating characteristics had to be sought.

**Fibrous mineral hazards.** The non-metallic dust which has attracted most attention over several past years has been that containing asbestos. Associated with this has been the examination of many materials containing or suspected of containing asbestos fibres.

The nature of samples received reflected a shift of emphasis from asbestos to non-asbestos-based materials. The reasons for this are seen to be the impact of programmes to remove asbestos insulation from buildings and vehicles and the gradual replacement of asbestos by substitute materials for many purposes. The development, announced by a local manufacturer of asbestos-free fibre cement products for the building industry should assist the continuation of this trend.

**Consumer affairs.** Materials with mineralogical aspects were again examined for the Bureau of Consumer Affairs. Most of these were building materials such as concretes, mortars and tile bedding materials relating to the suitability of original materials and the mixes used.

A particular type of swimming pool tile was found to yield an unusual amount of lead into the water following examination of the tile surface and a deposit formed.

An examination was made of the various parts of a set of earrings offered by a mail order firm. The concern was not the value of the set but possible breakdown of the post with continued contact with perspiration. The post consisted of brass with successive coatings of nickel and a very thin layer of gold. Some fracturing of the nickel occurred with bending but while intact the gold provided an inert surface.

**Forensic examinations.** In connection with a charge of illegal dealing of potatoes initiated in 1980 further comparisons were made of soils from the Manjimup area. The soils

examined were from suggested alternate sites of production and differed in the presence of gibbsite, and in other characteristics, from the soil attached to the potatoes.

Sands adhering to the inside of a wheel arch of a vehicle, suspected of having caused damage to the surface of a suburban oval, were found to be species common in the Perth area without any distinctive features by which correlation with the oval could be made. A similar lack of distinctive features in sands taken from the scene of an alleged rape, and from the suspect's shoes prevented any correlation with sand from the victim's car. This material was collected from the car mat and was clearly a mixture of sands and road material from several sources, none necessarily that of the other two samples. The fact that large portions of the Metropolitan area have common assemblages of minerals is a handicap in this type of work.

In the case of a suspected arson, sands taken from various positions in a vehicle which was suspected to have been at the scene were shown to be consistent with having originated at the scene and also had common non-mineral features.

Sand adhering to support stakes lying at the site of plots in which cannabis was cultivated was shown to be consistent with sands from several positions adjacent to the plots. Apparent off-cuts of the stakes, found in the garage of a suspect, did not carry this type of sand but only dust consistent with an urban industrial environment.

Evidence was given in a case of suspected unlawful possession of gold in which the defendant claimed that a bullion bar received from a battery represented a crushing consisting of equal parts of ore from two of his leases. Comparison of material from these leases with stockpile and tailings samples from the battery showed that the stockpile contained unmixed material from the first lease and the tailings contained material from the same lease mixed with significant amount



of material from an unknown source. Material from the second lease, which would have been readily detected because of distinctive mineral composition, was not found in either sample from the battery.

Mineralogy as well as chemical analysis was important in a case of alleged theft of tantalite concentrates which reached a very high market price during the year. A suspect had drums of concentrate on his utility outside the complainants plant and also at his home. This was stated to have come from another lease held by the suspect.

Analysis of the tantalite for grade and penalty elements, together with identification of distinctive indicator minerals, was used to define the probable origin of various exhibits.

In a case of fraud the victim paid several hundred dollars for a bottle of mercury supposedly containing gold. This was shown to contain only a few cents worth of gold and silver.

**Miscellaneous.** Amongst other materials examined, the following had unusual or special interest.

Material from the venturi area of a crematorium furnace was examined as a potential source of blockage. The major component was potassium sodium sulphate with other complex sulphates of sodium, potassium, zinc and lead.

Several marine concretions recovered from historic wrecks off the W.A. coast, in which corrosion products were dispersed, were examined to determine whether iron corrosion products had formed which would differentially absorb alkali ions from seawater. This was not established in the case of rubidium, but considerable strontium was observed causing distortion of the calcite lattice.

#### **Water division of the Laboratories**

1981 was a fruitful and demanding year. It was fruitful in terms of the record number of samples received while still maintaining the same degree of activity in the consultative

and advisory area; it was demanding in that an increasing amount of time was required to be spent on matters which do not appear to be directly related to efficiency of performance. These latter matters were mainly concerned with deriving data and preparing information for the various interim stages of the review of the Laboratories, but also included commenting upon a greater number of reports generated by other Departments in areas where we are directly involved.

An examination of the table on page 152 will show that the sample received for 1981 was 9 535 and this is more than 1 100 in excess of that of 1980, and almost 800 higher than the maximum received in any other year. Apart from 1980 where there was a reversal of approximately four per cent, there has otherwise been a consistent six per cent average annual increase of samples received since 1970.

**Country water supplies.** Because of the dirty water problem experienced at Geraldton and the known existence of significant iron levels in the aquifers of the racecourse, prison and sandpatch borefields servicing the Albany town supply, an inspection and extensive sampling survey of Albany water was undertaken. Although the average iron level from these borefields is similar to that at Geraldton, namely 0.7 mg/L, some bacterial removal occurs in the borehole and the borefield pipelines. This water, containing some particulate iron from the bacterial deposits is aerated when it enters a large holding tank, whose holding duration is about one day. Further iron precipitation and deposition occurs in the holding tank. Most of the water from this holding tank is passed through a base-exchange softener, with the nett result that the water entering the reticulation mains to Albany contains less than 0.3 mg/L of iron, an acceptable level which should not cause consumer complaints. The iron removal process through the

bacterial action in the pipeline, deposition in the holding tank and by filtration at the softeners was effective but by no means optimum or efficient in terms of the maintenance required for the blockage problems caused by the bacterial deposition.

At Denham, identification of the deposits between the sand filter after the raw water treatment and the prefilter to the Reverse Osmosis (R.O.) unit as being predominantly manganese bacterial in origin, coupled with the apparent slight decreases in the unit's performance, led to detailed examination of waters in the treatment system.

Complaints of dirty water in Geraldton in January 1981 led to a field inspection and a recommended sampling program to assess the exact extent of the problem. The dirty water was due to a suspension of hydrated iron oxide. All the waters in the borefield at Allanooka contain relatively high levels of free carbon dioxide (50 to 100 mg/L). Some of these waters are also oxygen-bearing (up to several mg/L) which makes them very corrosive to steel and other metals; most of the bores which are devoid of oxygen contain levels of iron in excess of 0.3 mg/L. Approximately 20 per cent of the bores contained iron levels in excess of 1 mg/L and associated with these there was also generally a manganese level in excess of 0.05 mg/L. The source of the iron in the water was not entirely due to natural presence in the aquifer and corrosion of the steel casing and column of the bore were also contributing factors. The initial recommendation was to use only those bores with acceptable iron levels so that a satisfactory blend of less than 0.3 mg/L went into the town. This was not possible on days of high demand where it was necessary to use water with an iron content of 0.5 mg/L. Recommendations included the use of sodium silicate to complex the iron or to aerate and sand filter. Laboratory scale tests showed that for two of the high iron-containing bores (2 and

9 mg/L), delays of two minutes between aeration and filtration were adequate to reduce iron levels to less than 0.2 mg/L. This is a borefield which would be well suited to testing the "VYREDOX" principle, i.e. of injecting aerated water into the borefield equivalent in volume to about 10 per cent of the withdrawal.

Commencement of chlorination of the Derby reticulated supply caused some problems due to discoloration by the manganese present in most of the bores servicing the town. Prior to chlorination the manganese content had apparently been partly fixed by bacteria to the walls of the reticulation pipes and the remainder passed to the householder in true solution i.e. without discoloration. Ten of the seventeen bores servicing the town had manganese levels of 0.1 mg/L or higher and when a 0.1 mg/L manganese water is chlorinated, the manganese is frequently insolubilised as a colloid where it imparts an apparent colour of 10 to 20 units to the water. Subsequently after chlorination commenced, in addition to the discoloration by the soluble manganese, the existing bacterial growths were being killed and entrained in the supply. It was recommended that the four bores with manganese levels in excess of 0.5 mg/L (the N.H. & M.R.C. current guideline) be removed from service; and with the remainder inputting an average of 0.1 mg/L the discoloration problem after chlorination would possibly be acceptable. Because iron was also associated with the observed manganese discoloration, a future treatment plant should be designed to get both iron and manganese down to levels of 0.1 and 0.05 mg/L respectively.

Salinity problems in Wellington dam have initiated investigations by the Public Works Department into the feasibility of separating the contribution by the Harris River into a separate dam supply with a salinity value more in line with that of the catchment dams in the metropolitan area. Because the colour of this water, at 50 units during the main runoff period in 1981, was cause for

concern, some investigations were undertaken to predict its effect on the final quality of water in the dam. Past records, although containing no specific measurements, had recorded no significant differences in colour between the Harris River and other tributaries to Wellington dam. Evidence from both Mundaring and Wellington during the latter part of 1981 indicated that natural processes reduce colour by an average of between 5 to 10 units per month, Wellington dam itself having a colour level of 30 units in August 1981. Based on dam capacities being several fold average runoff it did not seem likely that colour problems would reach a stage where colour removal treatment was required. Nevertheless jar tests for clarifier performance and laboratory scale "in-line" treatment trials were carried out and indicated that there were no likely technical problems in removing the colour level down to 5 units, the current N.H. & M.R.C. objective.

In February 1981, water from the town dam at Kojonup appeared to suddenly produce an objectionable taste and odour. By the end of that month the taste threshold was 100, i.e. it needed a one hundred fold dilution to eliminate the taste. Other than by using activated carbon filters there was no other way to render this water immediately suitable for the town supply. The earthy/musty taste was considered to be due to micro organisms of the actinomycetes type in the earth dam and treatment with both chlorine and copper sulphate was recommended at intervals of several weeks. The purpose of the treatment was to reduce the numbers of actinomycetes by reducing the food supply. By March the taste threshold had dropped to 10, and by the beginning of April to 2, at which level it was considered satisfactory for blending with the Wellington dam supply. It was recommended that regular chlorine treatment with intermittent copper sulphate dosing at the dam should be practised, soon after completion of winter runoff.

Samples of water from the Millstream Complex showed that diesel oil from a leakage in an underground fuel pipeline adjacent to one of the service bores (No. 5) had gained access to the entire reticulated supply. Although none of the samples in the reticulation of the towns serviced by the complex contained an obvious film, it was fairly obvious that other than water-soluble diesel oil had gained access to the approximately 150km of total mains. It was the gradual solubilisation of this film that caused the taint in the water to last for several weeks instead of the four days calculated from piston type removal. Initially taste threshold values were in reasonable agreement with quantitative analysis by capillary column gas chromatography (based on a taste detection limit of 0.1 mg/L), but later, possibly due to bacterial breakdown or preferential volatilisation or solubilisation, the taste characteristic and also the carbon atom configuration altered to present a more difficult interpretation of the actual levels present. Diesel oil levels in the town reticulated samples were generally less than 0.3 mg/L, the World Health Organisation recommended maximum, but were nevertheless not considered acceptable because of their taste. Carbon filters or alternative supplies were the only satisfactory recommendations that could be made until the taste disappeared. Any diesel oil remaining in the aquifer would eventually be bacterially decomposed; and in the interim, provided the taste threshold was less than two, the water from the offending bore could be blended into the headworks supply. Continuous pumping of the contaminated bore, at a reduced rate if necessary, was recommended in order to prevent movement of the contamination through the porous/cavernous limestone aquifer.

The water from the Wannere-nooka shaft, which is one of the six sources for the Northampton town supply, is passed through a base-exchange softener prior to entering the reticulation. The softener's main

role is not to soften the water but to remove heavy metals so that their levels comply with that of a drinking water. In the raw water, the level of cadmium is at the maximum allowed in a drinking supply while the copper, lead and manganese levels are frequently higher. The manganese is effectively removed for only a short time after the softening capacity of the resin has been exhausted. The lead is still being removed to below drinking water levels when the quantity through the softener is four times its softening capacity. Copper and cadmium removal characteristics are intermediate between those of manganese and lead. The reticulated treated water is satisfactory with respect to these metals.

**Metropolitan water supply.** The Water Division of the Laboratories currently performs for the Metropolitan Water Board only those more detailed or comprehensive types of analyses associated with underground water supplies. This involves not only the production, investigation and monitoring boreholes associated with the underground aquifers but also for those boreholes intended for special studies. Several projects which were initiated in 1981 included the liquid waste disposal site at Canning Vale and the effects of piggeries in both the Gnangara and Jandakot mounds. As with previous studies in liquid and solid waste disposal, all evidence to date suggests that plumes of contamination are considerably shorter than several hundred metres from the point of disposal.

A bore census in the Munster/Coogee region, involving approximately 100 bores being sampled at fortnightly intervals in November/December 1981, was intended to assess whether salt water intrusion (from the sea) was generally or specifically affecting the quality of some of these waters. Salt water, approximating to one third that of sea water, was present at a depth of about 20m below the water table but there was a considerable depth of water overlying this with

salinities varying up to 1 500 mg/L. The sulphate to chloride ratio in the fresher upper water was much higher than that of sea water for nearly all the bores examined; the ratios of the increases of sulphate to chloride with depth were usually similar to that of sea water. Such a result implies negligible flushing of the aquifer with fresh water. The sulphate accumulation of up to 300 mg/L in the upper fresher water is considered to be the result of decades of superphosphate application. The freshwater input/drawoff is in a delicate state of balance and consideration should be given to using only those phosphate fertilizers without calcium sulphate. The problem will be the subject of further studies by the Metropolitan Water Board in conjunction with the hydrology section of the Geological Survey of W.A.



**Environmental.** Activity in the Laporte effluent disposal area during 1981 has been diverse. In addition to the regular monitoring of the dune system, where normal strength effluent is disposed by means of surface ponds, monitoring for two separate trials for concentrated effluent injection into the deep Tamala Limestone aquifer also commenced. It has also been a busy year in relation to examining and commenting on various reports associated with reviewing the whole disposal procedure and studying the

various options available for dune and pipeline to sea disposal. There has also been considerable activity on the Steering Committee of a successful 12 month project completed at Murdoch University in 1981.

The research project at Murdoch, using both a mini-scale disposal system and also batch tests, appears to have satisfactorily resolved the iron immobilisation process and found most of the reasons for such a process. It confirmed predicted processes of immobilisation by these Laboratories of siderite formation and explained some unreported results by these Laboratories where immobilisation was achieved with the dune sands but not with calcite. In brief summary the project explained the iron immobilisation through an iron carbonate process, but not necessarily siderite; and explained the capability of the

dune sand to do this because of its aragonite content.

There were no major changes to the Swan River quarterly monitoring programme during 1981, a year with slightly less than average rainfall. The manner in which the rain fell caused greater runoff than is considered seasonally normal, and this caused greater input of nutrients and organic matter. The main effect of this was to cause greater dissolved oxygen depletion at those depth sites which are normally subject to some depletion.



The report of the Peel-Harvey Estuarine System Study (1976-1980) was released during 1981. It was interesting to note that the major cause of the problems in this estuarine system was considered to be due to the accumulation of phosphorus in the sediments of the Harvey Estuary. This was a conclusion which was also reached in Report of Investigations No. 21 from these Laboratories in 1979 and where 50 percent of the phosphorus input from the Harvey River was calculated to have been trapped in the sediments (the Study figure for 1978 was approximately 50 percent).

Although this study by the Department of Conservation and Environment was far more comprehensive than ours, which studied only the water, a comparison of the two approaches does show that quarterly monitoring of the water over a lengthy period at only several percent of the total cost of the comprehensive study, can be utilised to provide some of the answers.

1981 was also a dramatic year in terms of unfavourable or highly trophic conditions encountered over an extensive area of the system during two of the four sampling periods. Previously these unfavourable conditions had not been encountered. Firstly the bloom of *Nodularia spumigena*, which commenced in October 1980 and continued through to mid January 1981, was responsible for vast differences in dissolved oxygen saturation between surface and depth sites in January 1981, the extreme being at Pt Mealup in the middle of the Harvey Estuary with values of 250 and 14 percent saturation respectively. The corresponding chlorophyll "a" level at the surface at that time was 1.04 mg/L. Secondly, during the survey of July 1981 there was salinity stratification. Although this was regarded as relatively unstable in such a wide expanse of shallow water under windy conditions, the oxygen depletion as the result of such stratification was adequate to reduce values at depths throughout the entire

Harvey Estuary to less than 20 percent saturation. In the Peel Inlet at the same time the dissolved oxygen values at depth were also cause for concern at about 50 percent saturation.

During the December 1981 sampling, the blue-green *Nodularia spumigena*, which had again reached bloom proportions during October, had caused chlorophyll "a" levels in the Harvey Estuary to reach values of approximately 0.15 mg/L. At that time, only one site, Pt Grey at the junction of the Peel Inlet and Harvey Estuary, had an undesirable dissolved oxygen concentration at depth, the value being 30 percent saturation. Similar dissolved oxygen values that occurred in January 1981 would however be predicted prior to the disappearance of the bloom.

The occurrence of the blue-green bloom for such lengthy periods was an aspect that was not a real problem at the time of publication of the 1976-80 Study. The main problem during that study period was considered to be the proliferation of the macroflora, *Cladophora*. The capacity of *Nodularia spumigena* to fix atmospheric nitrogen, thereby adding to what might have otherwise been considered a limiting level, together with its aesthetic effect (both appearance and odour), and also its considered influence on the fish and crab numbers, make it a much less desirable organism than *Cladophora*.

There do not appear currently to be any specific problems in the Leschenault Inlet area, but because of proposals to set up industries in the vicinity in the near future, it is intended to carry out a heavy metal study similar to that completed for the Swan River in 1980. It will be a one year study with samples being taken at monthly intervals.

**Miscellaneous.** A uniform yellow deposit present in a number of concrete swimming pools was found to contain lead as a major constituent. In all instances the deposition was associated with blue ceramic tiles which had suffered varying degrees

of surface deterioration. It was not resolved whether the tile deterioration was due to short-term abnormal pH conditions, but it was shown that the outer exposed surface of these particular tiles contained lead as a major component and that this could be dissolved into neutral pH water. A mechanism for the formation of the yellow deposit could be oxidation of the plumbite by chlorine to the yellow lead sesquioxide  $Pb_2O_3$ . Levels of lead in solution in the pool water from such affected pools varied between 0.3 and 1.0 mg/L.

A purple crystal formation has occurred in two separate swimming pools during the past several years. These crystals appear to form on surfaces of the pool and need vigorous brushing to be dislodged. X-ray diffraction analyses of the crystals from both these pools and also from synthetically prepared crystals from a solution of 800 mg/L of isocyanuric acid and 10 mg/L of cupric ion gave three identical patterns. Chemical analysis implied that the composition of the crystals is likely to be a double isocyanurate molecule of copper and sodium, with perhaps some of the hydrogen being replaced with chlorine. Its simplest molecular structure without chlorine substitution appears to be  $Cu(H_2C_3N_3O_3)_2 \cdot 2NaH_2C_3N_3O_3$ . The formation of such crystals appears to occur only when excessive amounts of isocyanuric acid (well beyond the recommended maximum of 50 mg/L) are present together with copper levels in excess of several mg/L. These high copper levels appear to have been obtained in the two instances by lowering of the pH for short periods and thereby causing corrosion of recirculating equipment containing copper or copper alloys.

As a follow up of the work on asbestos cement pipes reported in 1980, the analytical figures obtained by Hardies Laboratories for nominal 100mm diameter pipe of thickness 12.7mm that had been in service for approximately 15 years, were used to calculate life expectancy. The analytical results were

supplied for 7 sections, each of approximately 2mm thickness through the walls of each of the four pipes supplied. Life expectancies were calculated on the time required for the circumferential tensile strength to reduce to 20.6 mega pascals. The calculation used made due allowance for the attack on the outer surface of the pipes and also for the magnesium substitution on the inner surface. These calculations predicted a life expectancy in excess of 70 years.

Previous reported work on the cement-lined pipes from the 550km Mundaring/Kalgoorlie mains (see 1976 Annual Report) had implied magnesium substitution for approximately 50 per cent of the calcium leached (on a molar basis). Such a substitution would enhance the life expectancy of these pipes which had previously been based on calcium leaching alone. Samples of water collected from Mundaring and Kalgoorlie over a three month period during 1981 revealed a magnesium substitution equivalent to 20 per cent of the calcium leached.

A similar exercise on the water entering and discharging from the 50km Allanooka/Geraldton Mains during 1981 revealed that approximately 50 per cent of the calcium leached was substituted by magnesium (on a molar basis).

These two exercises show that any future considerations for life expectancy of concrete and cement lined mains must take into consideration this magnesium substitution aspect. For a variety of reasons, including the lack of an alternative supply, exaggerated claims in advertisements, or the undesirable taste aspects of some treated chlorinated reticulated supplies, a number of people are resorting to rainwater tanks. Apart from the health aspects associated with bacterial and other infestation from roof and gutter debris, there are other additional factors to be considered.

Galvanised tanks are not completely without their corrosion problems, and those that have not

utilised the "plastic sausage", containing zinc and calcium metaphosphates, are worst affected. One tank recently failed due to perforation within eighteen months with the formation of a voluminous white deposit of zinc hydroxy carbonate over the entire inner tank surface. The plastic sausage may for a short time maintain zinc levels in the water, in excess of the maximum allowed for a drinking supply of 15 mg/L.

Glass-fibre reinforced tanks are also not without their problems; but the problem here is one of taste which is usually considered to be due to inadequate curing and cleaning prior to installation and water addition. Styrene monomer is usually the agent causing the taste and U.S.S.R. Standards and our own tests suggest that 0.1 mg/L of styrene is adequate to impart an objectionable taste to the average consumer. Chemical tests are currently less sensitive than such organoleptic testing and it is sound advice not to drink a water that has a taste which can not be identified.

## Organization

### Staff

There has been no increase again this year in staff and the establishment of the Laboratories is the same as in 1979, with 83 Professional Division, 49 General Division and 12 Clerical Division Officers and 2 Wages staff.

There has been a slight turnover in staff but because of the very satisfactory quality of new recruits, this has not been detrimental. There has been an ongoing problem in trying to fill metallurgical positions at the Kalgoorlie Metallurgical Laboratory. Despite frequent and widespread advertisements, we have not been able to fill one of these positions for nearly 2 years. There is currently a large demand by the mining industry for qualified metallurgists and it is difficult for us to compete.

## Accommodation

Alterations to the older part of the Agricultural Chemistry Laboratories were completed this year. New work areas to accommodate modern automated instrumentation were completed by The Public Works Department staff with a minimum of interruption and with excellent co-operation.

New P.V.C. fume cupboards made to our own design were installed in two areas of the Laboratories; these feature variable speed extraction fans, a balanced and filtered air supply, internal wash-down spray, safety glass sliding sashes and heat sensors.

Stage 1 of the airconditioning was finally completed late in the year but it was not expected to be operational until February 1982. Progress on Stage 2 of the airconditioning, which has been approved, will hopefully proceed more rapidly.

Shortage of space has become critical in the Agricultural Chemistry, Food and Industrial Hygiene, and Forensic Chemistry Laboratories. Major increases in the volume of work of these Divisions of the Laboratories are seriously taxing our facilities and hampering efficiency and safety in many areas. The need for the planned expansion on the Hay Street frontage is now urgent.

### Equipment

Major equipment received during the year included:

An automatic atomic absorption spectrophotometer with double beam optics and a graphite furnace accessory. This equipment will provide a rapid output of analytical data for conventional field experiments and will allow development of special techniques of trace element analysis which are required for studies of soils and plants of W.A.

A peristaltic pump, a colorimeter and an actuated injector valve; these supply essential back up to ageing equipment. The valve is used in evaluation of flow injection

automatic analysis techniques as an alternative to the commonly used segmented flow methods.

A Lindberg Hevi-Duty wrap-around furnace for use with the fluidised bed reactor.

A Hewlett Packard automatic injection gas chromatograph for automation of blood alcohol analyses.

A Varian Vista 44 automated gas chromatograph for pesticide residue work to replace two old and obsolete smaller manual models.

**Computer facilities.** The PDP 11/40 computer was significantly upgraded with the purchase of the following equipment:

Control Data Corporation 9448-64 disk drive with an Emulex SC 21-C controller to replace RK05 disks, to increase disk capacity from 26 M bytes to 70 Mbytes. An MR11 bootstrap loader to replace the BM873 bootstrap which was not compatible with the new disk.

A Grant Electrical Industries ultra-isolation transformer of 7.5 kVa capacity to protect against transient voltage spikes.

Four terminals (two VT100, one LA120 and one LA34) to support data acquisition programmes.

The 1980 survey of the Mines Department computing requirements recommended that applications from other Divisions be transferred from the Government Chemical Laboratories' computer to bureau facilities; little progress was made in this respect during the year.

The Deputy Director continued as Chairman of the Mines Department Computer Co-ordinating Committee. The professional staff of the Laboratories continued to manage the computer system and provide programming assistance and technical advice to other Divisions of the Department.

A Mettler PC440 electronic balance in Agricultural Chemistry was connected to the computer using a 20ma current loop, this has halved the time for weighing small plant samples.

The HP3340 integrator on a new auto injection gas chromatograph in Forensic Chemistry was linked through the RS232 outlet on the integrator to the existing computer system for blood alcohol analysis. This will remove some of the load on the computer by doing the integrating before a signal is transmitted to the computer. The auto injection was the final link in a completely automated analysis process.

Software development continued to facilitate the use of the Siemens Automated X-ray fluorescence spectrometer. This instrument is used for major and trace element analysis of rocks.

Software for the 4 channel AAIL Auto-analyser system was completed and is now in regular use along with the 2 channel system and automated Varian AA375 atomic absorption instrument. Much of this software has been written in RATFOR, a structured language implemented as a FORTRAN preprocessor. Other programmes for handling automated major ion analyses in water are being developed with the aim of generating analytical reports directly from the computer.

### Functions

The Laboratories provide chemical laboratory facilities to Government departments and instrumentalities and to a lesser extent to private industry and the general public. The functions are varied, and largely unrelated to the mining industry. The separate functions, as carried out by seven Divisions of the Laboratories are :

**Agricultural chemistry** performs chemical work for the Department of Agriculture on applied agricultural research, and fertilizer and stockfood regulatory matters. Soils, fertilizers, cereals, pastures, oilseeds and horticultural crops are examined for soil fertility, fertilizer usage and plant nutrition. Stock food and animal tissues are analysed to assist in diagnosing problems in animal health and veterinary pathology.

**Engineering Chemistry** is concerned with research and development on the beneficiation, processing and utilisation of minerals and solid fuels. Investigations are carried out up to pilot plant level and are based on metallurgical and chemical engineering themes. Some contract work for the mining industry is undertaken and charged at cost. The Kalgoorlie Metallurgical Laboratory performs routine metallurgical test work and research and development for the mining industry.

**Food and Industrial Hygiene** provides a chemical service to the Department of Health and Medical Services with respect to nutritional properties of foods and compliance with standards. Industrial working conditions are monitored with respect to solvents, anaesthetics and hazardous chemicals. Pesticide residues in foods, crops, soils, wildlife and waters are measured, and advice given on their control.

**Forensic Chemistry** undertakes forensic chemical work for the Police Department and the Road Traffic Authority. This involves detection of poisons, analysis of blood and urine in connection with drink-driving offences, identification of illicit drugs and examination of exhibits from scenes of crimes. Analytical and advisory service is provided at cost to horse and greyhound racing organisations.

**Industrial Chemistry** provides a consultancy, advisory and testing service to Government and industry on industrial products such as building materials, plastics, paints, textiles and detergents. It also undertakes pilot plant research for the further use of industrial and agricultural resources, except those of an extractive metallurgical nature.

**Mineral Division** of the Laboratories services the true function of a chemical branch of the Mines Department. It is concerned with the mineralogy and chemical composition of the State's minerals, ores and rocks. It is also responsible for



examining dusts in relation to health and environmental issues for the Public Health Department, and inorganic building materials for all departments.

**Water Division** of the Laboratories provides an analytical advisory and consultancy service to all departments for quality of water in relation to drinking, industrial, agricultural and environmental uses. It investigates treatment of potable water and industrial wastewater, and is involved in quality monitoring of river, lake, estuarine and marine waters.

### Other activities

**Conferences and workshops.** Because of the wide field of chemistry and overlapping disciplines that are covered by the Laboratories and because of the isolation of W.A. there

is a continuing need for staff to attend a range of scientific conferences, to keep abreast with current developments. During the year important conferences attended were:

The first-ever meeting of directors of State and Commonwealth chemical laboratories in Hobart, attended by the Director.

The inaugural meeting of the Australian Pesticides Analytical Committee in Melbourne was attended by the Director.

The first Asian & Pacific Chemical Congress in Singapore, was attended by Mr J. Jago as representative of the Laboratories, Mr H. Hughes as President of the Royal Australian Chemical Institute, W.A. Branch and Mr F. Uren privately.

The Sixth Australian Symposium on Analytical Chemistry in Canberra, attended by Messrs P. Wolson and M. Rowe.

The Australasian Corrosion Association Conference in Brisbane, attended by Mr P. Jack.

A workshop on "Solvent Extraction" related to mineral processing arranged by the Australian Mineral Foundation in Adelaide was attended by Mr R. Field.

The Annual Meeting of Scientific Officers & Engineers engaged in Occupational Health, attended by Mr J. Genovese.

A Fruit & Vegetable Post Harvest Research Workshop in Brisbane, attended by Mr M. Rowe.

The Conference of Residue Chemists in Brisbane, attended by Mr G. Ebell.

The Annual Conference of Forensic Toxicologists and Annual Conference on Illicit Drugs held in Canberra and attended by Mr N. Campbell.

## GOVERNMENT CHEMICAL LABORATORIES

**DIRECTOR**  
R.C. GORMAN  
BSc, FRACI, MAIAS

**DEPUTY DIRECTOR**  
H.C. HUGHES  
BSc, FRACI, MAIAS

**AGRICULTURAL CHEMISTRY**  
J. JAGO  
BSc, ARACI

**ENGINEERING CHEMISTRY**  
B.A. GOODHEART  
BSc, MIE Aust, ARACI

**FOOD & INDUSTRIAL HYGIENE**  
F.E. UREN  
APTC Chem, ARACI

**INDUSTRIAL CHEMISTRY**  
E.B.J. SMITH  
BSc, D Phil, MAIAS,  
ARIC, ARACI, APIA

**FORENSIC CHEMISTRY**  
V.J. McLINDEN  
APTC Chem, ARACI

**MINERAL**  
D. BURNS  
BA, BSc, ARACI

**WATER**  
N.E. PLATELL  
BSc, ARACI

A seminar on Australian Criminological Research in Canberra, attended by Mr B. Lynch.

The Fourth International Conference on the Control & Use of Drugs in Horses and the National Symposium on Drugs in Sport, in Melbourne, attended by Mr V. McLinden and Mr. A. Stenhouse; the latter was financially supported by the Western Australian Trotting Association.

The Royal Australian Chemical Institute Polymer Symposium at Blackheath N.S.W., attended by Mr D. Ingraham.

The Oil & Colour Chemists Association Convention at Goulburn, N.S.W. and the subsequent Government Paint Committee meeting in Melbourne attended by Dr B. Smith.

The Standards Association of Australia Mineral Standards Committee in Adelaide, attended by Mr D. Burns.

The S.A.A. Sub-committee meetings on The Chemical Analysis of Iron Ores, in Melbourne and Perth, attended by Mr M. Costello.

The S.A.A. Sub-committee meeting on The Chemical Analysis of Heavy Sands, in Southport and Perth, attended by Mr J. Gamble.

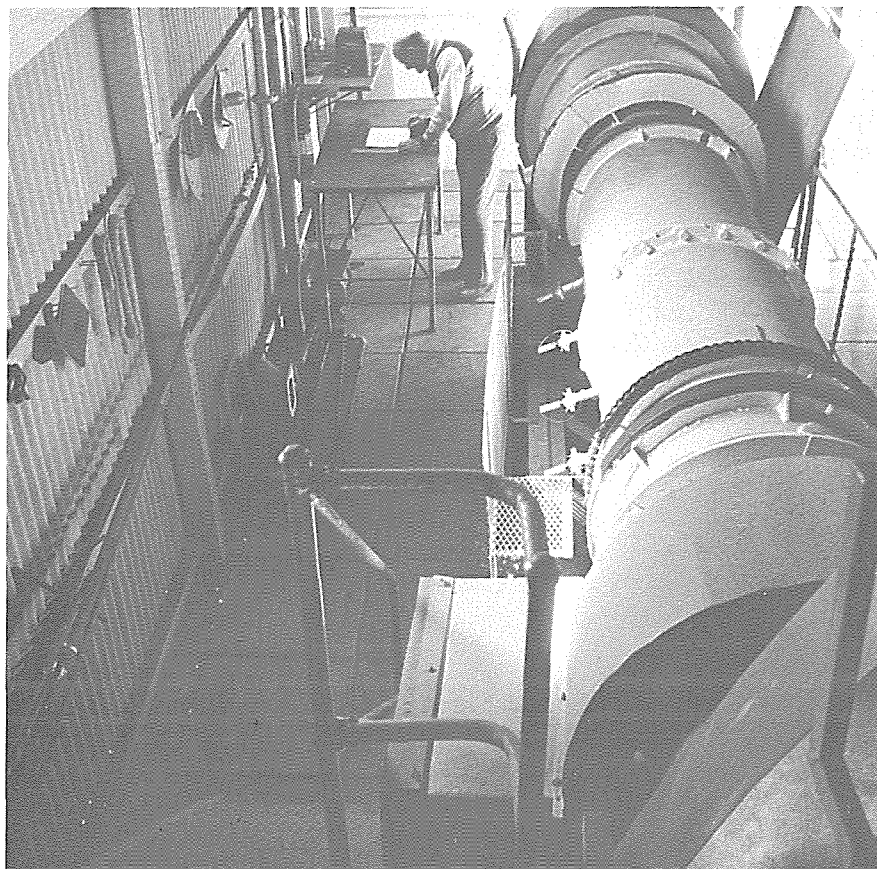
The Advanced Management Course at the Australian Administrative Staff College at Mount Eliza, Victoria, was attended by Mr V. McLinden.

The Australian Water & Waste Water Convention in Perth, attended by Messrs R. Gorman, P. Jack and N. Platell.

There were a number of other local conferences and workshops attended by various members of staff. These conferences included "An International Symposium on Copper in soils & Plants", a workshop and seminar on atomic absorption spectrophotometry and graphite furnace thermal ionisation techniques, a biochemists workshop, a symposium on "Thermal Methods of Analysis", a seminar on "Chemical Hazards in the Workplace" and a

workshop on "Inductively-Coupled Plasma & Atomic Absorption methods".

"Alkyl Mercury in Marine Sediment in Cockburn Sound" G. A. Taylor, D. C. Collett and A.



The out of State visits were arranged to coincide where possible with subsequent conferences to reduce costs. In all cases staff took the advantage of these conferences to visit related laboratories or industries in the Eastern States, to make full benefit of the opportunity to learn of advancements in their areas of interest.

**Papers and publications.** The following papers and publications were given or made during the year:

"Rapid Gas-Liquid Chromatographic Determination of Low Levels of Erucic Acid in Rapeseed Using an Internal Standard" N. L. Wilson, *J. Sc. Fd. & Agric.* **32**, 1103-1108, 1981.

"High Performance Liquid Chromatographic Separation of Fat-Soluble Vitamins in Cod Liver Oil & Feeds" R. R. Elton-Bott and C. I. Stacey (W.A.I.T.). *Anal. Chim. Acta* **127**, 213-218, 1981.

Chegwidden (D. C. & E.), *Bull. Env. Con. Tox.* **26**, 757-763, 1981.

"Identification of Single Fibres by X-Ray Diffraction in Forensic Analysis" B. F. Lynch and G. C. Kerrigan (W.A.I.T.), *X-Ray Spec.* **10**, 4, 196-7, 1981.

"Trace Elements in Liver from a Sudden Infant Death Syndrome Survey" P. E. Wilson, presented to the Fourth International Symposium on Trace Element Metabolism in Man & Animals, Perth, 1981.

"Measurement of Drift of 2,4D-Ester from a Commercial Application to Crops" G. F. Ebell, presented to 10th Conference of Residue Chemists, Brisbane, 1981.

"Measurement of Toxic Chemicals" G. A. Taylor, presented to IFAP Seminar on Chemical Hazards in the Workplace, Perth, 1981.

"Post-Harvest Bitter Pit Trials on Apples using  $Ca^{45}$  as a Tracer" M. B. Rowe, presented to Sixth

Australian Symposium on Analytical Chemistry, Canberra, 1981.

"Rate of Post-Harvest Calcium-Uptake in Apples" M. B. Rowe, presented to Fruit & Vegetable Post Harvest Research Workshop, Brisbane, 1981.

"Dieldrin Residues, A Western Australian Study" E. Shewchuk, prepared for Pesticides Advisory Committee, Perth, 1981.

"Evidence from Glass" B. F. Lynch, K. W. Terry and A. Van Riessen (W.A.I.T.), and "The Identification of Small Glass Fragments for Forensic Purposes" B. F. Lynch, K. W. Terry and A. Van Riessen (W.A.I.T.), both presented to seminar on Australian Criminological Research, Canberra, 1981.

"Caffeine Levels in the Blood of Doped Horses" V. J. McLinden and A. M. Stenhouse, presented to the Fourth International Conference on the Control of the Use of Drugs in Horses, Melbourne, 1981.

"Forensic Mineralogy" M. W. Pryce, presented to Forensic Science Society and Australian X-ray Analytical Association, Perth, 1981.

**Committees.** Staff members served during the year on the following statutory or *ad hoc* intra- and interdepartmental committees:

Effluent Licensing Panel under the Rights in Water & Irrigation Act.

Environmentally Hazardous Chemicals Committee.

Fluoridation of Public Water Supplies Advisory Committee.

Food and Drug Advisory Committee.

Food Analysis Subcommittee on National Health and Medical Research Council.

Government Paint Committee.

Government Tender Board

Oils Committee

Paints Advisory Committee

Pesticide Formulation Committee

Detergents Advisory Committee

Floor Cleaning & Maintenance Products Committee.

Laboratory Safety Committee on the Industrial Foundation for Accident Prevention.

Laporte Effluent Disposal, Environmental and Hydrogeological Subcommittees and Sand Dunes Research Steering Committee.

Laporte Industrial Factory Agreement Review Committee.

Lupin Technology Committee.

Mines Department Computer Coordinating Committee.

National Association of Testing Authorities

National Council

Chemical Registration Committee

W.A. State Committee.

Pesticides Advisory Committee.

Poisons Advisory Committee.

Scientific Advisory Committee under the Clean Air Act and associated subcommittees.

Standards Association of Australia

Contaminants in Soils Committee

Iron Ores Committee

Iron Ore Chemical Analysis Committee

Heavy Mineral Sands Chemical Analysis Committee

Laboratory Glassware and Related Apparatus Committee.

State Advisory Committee to Australian Coal Industry Research Laboratories on Collie Coal Mining Research.

Swan River Management Authority, Industrial and Biological Committees.

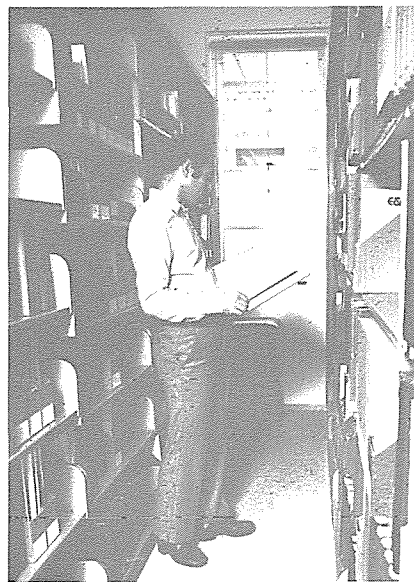
Veterinary Preparations and Animal Feeding Stuffs Advisory Committee.

Waste Disposal Technical Committee.

Water Purity Advisory Committee.

Water Quality Criteria, E.P.A. Marine and Estuarine Working Group.

The work on these Committees required in many cases an appreciable amount of time and effort by staff. Contributions by staff on these committees has been greatly appreciated by the various client Departments and authorities.





## The Symbols of Danger

Symbols are becoming more and more common in everyday life. Anybody searching for a toilet will know the problems of trying to decide if the little figure is more like a man than a woman, and drivers are bombarded with symbols of all kinds. Travellers to foreign countries know the benefits of a universal code of symbols and when it comes to labelling dangerous goods, international agreement is vital.

The United Nations formed a group now called the International Maritime Organization (IMO), to formulate a code for the labelling of dangerous goods when in transit. The major recommendations of the IMO have been accepted by most developed countries around the world, except that the USA does not follow the recommendations in total.

The symbol chosen to mean a dangerous substance is a diamond and it has different colours for different classes of goods. For instance, the colour of the diamond for a flammable substance is red, while an oxidizing substance shows a yellow diamond. There is a certain logic in the colours chosen as an explosive, which is generally a mixture of combustible and oxidizing substances, has a diamond of orange colour—a mixture of red and yellow.

The Emergency Information Panel, as it is called, will give further information to people such as the police or fire brigade and all bulk tankers will be required to carry such information. One feature of this panel will be an area incorporating a Hazchem Code. This was pioneered by the London Fire Brigade and gives, in a few symbols, the crux of the emergency information. Three symbols, comprising one number and two letters, are used to guide the handling of any spill. A typical hazchem code is 2WE. The number 2 shows that only water spray, foam or dry

agents are to be used and not jets of water. W shows that the spill should be contained, full body protection and breathing apparatus are to be used, and that the substance may be violently or explosively reactive, while E means that the evacuation of people should be considered. Liquid petroleum gas tankers would have this code on their hazchem panel. Petrol and related products would show 3YE. Also shown on the panel is a number which identifies the compound being transported. Each dangerous substance is given a different number and the list of compounds is brought up to date at regular intervals by the United Nations committee. Each substance is given a classification number, such as 1 for explosives, 2 for compressed gases, as well as a unique number identifying the compound in question.

Standards have also been set for packaging and are to be classed as I, II or III depending on the strength of packaging required which is measured by standard drop tests or pressure tests. International agreement will mean that exporters and importers of dangerous goods will have the same regulations to satisfy in most countries. This can only mean cheaper and easier pro-

duction as similar packaging can be used for any particular substance. The hazards of any substance will also be clear to a user by observing the symbols in use.

The UN committee has been active for many years, but Australia has been actively concerned with the symbols only for the last 3 to 4 years. Now Australia has accepted the recommendations, and regulations based on an Australian code are being prepared for their use in all states. Although NSW incorporated most of the Australian code into their existing Dangerous Goods Regulations, Mr Harry Douglas, the Chief Inspector of Explosives and Dangerous Goods in WA has drawn up new regulations for WA which are consistent with the principles of the Australian Code and all existing regulations in other states. The resultant legislation will be the Dangerous Goods (Road Transport) Regulations. Anything that is transported and is classified as a dangerous substance will require the proper labelling. As a minimum, the correct symbol (a diamond) will have to be shown on all packaging and vehicles conveying dangerous goods and in some cases a full panel of information will have to be included.



## Explosives and Dangerous Goods Division

H. Douglas  
Chief Inspector

1981 was a very exciting and demanding year for the Explosives and Dangerous Goods Division. The year saw the completion of the final draft of the Dangerous Goods (Road Transport) Regulations and its submission to Parliamentary Counsel for drafting into a form suitable for proclamation. At the end of the year, the Regulations had not been returned from Parliamentary Counsel but, in anticipation of the need to administer the new regulations, funds were allocated by Treasury for the employment in 1982 of additional staff.

The proposed Dangerous Goods (Road Transport) Regulations are consistent with the requirements of the Australian Code for the Transport of Dangerous Goods by Road and Rail and this harmony with other States is developing rapidly in other areas. Historically, Explosives Regulations have been applied independently in each State and, as all have their historical basis in the United Kingdom statutes, variations between States are not great. However, the regulations are silent on many matters and interpretations and policy matters do vary. To restore consistency, all States are working towards uniformity of regulations and policy in matters concerning explosives. In this regard to annual Australasian Conference of Chief Inspectors has assisted greatly in permitting a free interchange of ideas and opinions on the necessity or otherwise of current safety requirements.

A typical area not adequately covered by statute is that of container shipments of explosives. The first recorded shipment of containerised electric detonators was received, without mishap, at the Port of Fremantle in 1981. Before the container was packed or loaded on board ship, considerable work had been done by the Division; liaising with Chief Inspectors in other States and the UK, testing the

packaging format, ensuring mechanical handling equipment was of an acceptable standard, specifying the method and position of loading and ensuring the consignment was removed from the wharf as quickly as possible. The activities of the Division did not cease with the removal of the container from the wharf as the unpacking of the container was supervised at the Kalgoorlie Explosives Reserve and samples were removed for subsequent testing.

The awarding of a national contract to a local steel fabrication firm, to manufacture all tanks for the conveyance of bulk flammable liquids for a major oil company resulted in a significant increase in the number of plans for these tanks being examined by the Division. There was a corresponding increase in the number of pressure tests to be supervised. This is quite a technical task and the Division Inspectors responded to the demands made of them in a most satisfactory manner.

It is six years since the first self-service station was opened in Western Australia and there are now 132 distributed throughout the State. Without regular supervision these outlets have the potential to develop into a major threat to public safety and to avoid this, a disproportionate amount of time is spent inspecting self-service sites. The increased number of inspections pays dividends as problems, such as the filling of containers held in the boot of the vehicle, the use of plastic containers for petrol and the dispensing of fuel by children, are encountered and overcome rapidly before they develop further to the detriment of safety.

The theft of a case of explosives generated considerable concern in the southwest of the State early in the year. The theft prompted an overall review of Westrail's operations and a detailed examination

by the Division of the standards of security at all storage points in the southwest. This is reflected in the increase in explosives inspections for the year over the number recorded for 1980.

Also on the subject of security, a major explosives company was the subject of a bomb threat in the middle of the year. As most of the company's magazines are within the Woodman Point Explosives Reserve, and hence the responsibility of the Division to some extent the Inspectorial staff assisted the watchmen at Woodman Point for a period to double the security provided at the Reserve. This continued for about three days including one weekend and as nothing unusual was observed in that time the security schedule was returned to normal.

Finally with the increasing importance that operations at the North West Shelf project are having upon the State it is appropriate to record the part the Explosives and Dangerous Goods Division has taken in this operation. Explosives are a major tool in the development of the site, and while it is vital to proceed with the works speedily, due regard must be paid to safe working practices which, after all, have been developed from learning experiences based on past events. Initial reports from the site indicated that operators were not complying with Statutory requirements for explosives work. However, as the Division maintains a regular, though not continuous presence in the Pilbara area, it was relatively simple to ensure inspection of the Burrup Peninsula area every time an Inspector was in the vicinity, thereby ensuring a frequent watch on operations. This inspectorial action was reinforced by lectures to operators and discussions with management who were extremely co-operative. Assistance was also given by





on-site training exercises and the latest report indicated that there was now no problem concerning explosives usage on site.

## Operations

### Legislation

In accordance with the provisions of Section 42(2)(b) of the Explosives and Dangerous Goods Act the Third Schedule to the Act was amended to declare specific hazardous substances, as published in the *Government Gazette* dated 12 June 1981, to be dangerous goods.

Section 62 of the Act was amended to enable the introduction of fees and charges for services which are currently provided free of charge.

Since the last reprint, in 1970, of the Explosives Regulations 1963 there have been a considerable number of amendments which over the years have tended to make these regulations difficult to follow. Accordingly a complete reprint of these regulations was undertaken and published in the *Government Gazette* dated 13 January 1981.

There were several amendments to the Flammable Liquids Regulations 1967, affecting five regulations one of which extended exemption from the licensing pro-

visions to those flammable liquids stored in containers not exceeding four litres in capacity.

Additions made to the list of authorised explosives are shown in the following table.

Class 1.1B:	(0030) Magnadets	(Z)
Class 1.1C:	(0160) Propellant AR	
	2206	(ZZ)
	(0160) Propellant AR	
	2207	(ZZ)
	(0160) Propellant AR	
	2208	(ZZ)
	(0160) Propellant AR	
	2209	(ZZ)
Class 1.1D:	(0241) Aquapour	(ZZ)
	(0081) Morcol	(ZZ)
	(0042) Anzomex Sliders	(ZZ)

### Manufacture of explosives

Advice was given on site to a major mining company before it carried out maintenance work involving welding on its ammonium nitrate storage and handling facility. Routine inspections were made of all the main explosives manufacturing plants throughout the State. Particular attention was paid to operations at the Burrup Peninsula where a new manufacturing facility was set up to provide explosives for the supply base and liquid natural gas plant site works.

The manufacture of nitrate based explosives at licensed plants throughout the State showed a 4.5% decrease when compared with figures for 1980, and correspond to a

7% decrease in iron ore production. The improved blasting technique first mentioned in the 1979 Annual Report which resulted in increases in iron ore production from smaller quantities of ammonium nitrate fuel oil has spread through the industry and the blast ratio seems now to have stabilized. The table compares the nitrate based explosives produced in 1981 to the previous year.

	1980 (tonnes)	1981 (tonnes)
ANFO	57 363	54 625
Water Gel	2 921	2 948
Totals	60 284	57 573

### Importation and usage of explosives

The quantity of explosives imported into the State increased significantly over the 1980 figures; the small diameter cartridges of nitrate-based-gel explosives more than doubled while those of a nitroglycerine base increased by 21 per cent. Despite the substantial increase in cartridge water gel explosives nitroglycerine-based explosives still dominate this area of the market.

All the above explosives were imported by authority of a License to Import and some 26 consignments of other explosives were imported by authority of an Entry Permit most of which were for the oil industry for developmental work. Each of these consignments was examined while it was in bond before being released to the importer.

During the year there was a continued demand for permits for the purchase of explosives for theatrical purposes and pop group entertainment. In each case the proposed system was examined carefully and approval given only when the required standard of safety could be assured. Operations involving public displays of fireworks continued to be closely monitored in each of the thirty five instances for which permits were issued. Similarly the Inspectorate maintained a close watch on the sale and use of explosives elsewhere throughout the State.



## Explosives licences and permits

The number of licences issued for explosives increased by 7.6 per cent over the previous year, with the more significant increases being in the number of Licences to Convey Explosives and Shotfirer's Permits.

A comparison of the number of licences and permits issued for explosives during the past two years is shown in the table below.

<i>Licences</i>	1980	1981
Import	8	8
Explosives manufacture	6	9
Blasting agent manufacture	401	393
Storage—Mode A	35	35
Storage—Mode B	7	7
Magazine Type		
One (1 000 kg)	122	137
Magazine Type		
Two (5 000 kg)	45	42
Magazine Type		
Three (more than 5 000 kg)	77	75
Sell	31	31
Convey	65	88
<b>Total Licences</b>	<b>797</b>	<b>825</b>
<i>Permits</i>		
Shotfirers	1 442	1 592
Fireworks display	37	35
Entry permits for explosives	26	26
<b>Total Licences and Permits</b>	<b>2 302</b>	<b>2 478</b>

There was a 50 per cent increase over the previous year in the number of participants undergoing training and examination for Shotfirer's Permits.

Three in-service and four evening courses for Shotfirers were conducted by the Explosives Inspectorate for 152 personnel and 99 passed the examination. Thirty-nine candidates withdrew from the courses before the examination and a further 14 failed the examination.

A total of 168 candidates, most of whom had some previous experience in the use of explosives, were examined without having attended a comprehensive training course. Of these, 141 passed the examination and 27 failed.

The increase in the number of persons in the public sector seeking a Shotfirer's Permit is largely attributed to an increasing demand by mining and exploration companies for personnel qualified in the use of explosives.

## Explosives Reserves

**Woodman Point.** It is most pleasing to report that no instance of illegal entry on to the Reserve occurred during 1981 and this is attributed to the presence and activity of the diligent watching staff at the Reserve who are working in a most unaccommodating environment. Although no reduction in security was tolerated, the facilities at the Reserve are deteriorating at an accelerating rate as maintenance expenditure is minimised in anticipation of the move to the new Explosives Reserve. Unfortunately the schedule for relocation received a set-back during 1981 due to a severe fiscal restrictions facing the Government and the transfer has been deferred for at least twelve months. This affected the Department for Youth Sport and Recreation which had anticipated the residential use of recreation facilities which currently encroach within the safety zones of some magazines on the Reserve. Conflict was avoided by deferring residential use of the recreation facilities so the magazines could continue to be used to their full capacity.

The security fence around the reserve was broken in two places during the year and was badly damaged in a third as a result of storms on two occasions and an accident involving a recreation vehicle which was being driven on the fire break outside the Reserve. By working double shifts, security was increased in the areas where the fence has fallen down and nothing untoward occurred before repairs were effected.

During a strong storm, an unsecured, unlocked, empty rail wagon was pushed along by the wind until it crashed through the locked gates at the northern end of the Reserve and then jumped off the rails. Action was taken with the Company to whom the wagon was consigned to prevent a recurrence of this type of event.

An anonymous telephone threat to blow up the magazines resulted in Inspectoral staff standing in for watchmen during part of one weekend thereby enabling watchmen to be deployed in pairs to double patrols during the hours of darkness. No observation was made of any attempt to carry out the threat and after 72 hours, security patrols returned to normal.

A detailed survey involving an officer from the Bush Fires Board was conducted on the Reserve with a view to improving the fire protection facilities and action has commenced to improve the fire breaks,





remove dead scrub which has accumulated from previous clearing, slash down existing weed growth, fell numerous dead trees and purchase more appropriate fire extinguishing equipment. The new extinguishing equipment will be transferrable to the new Explosives Reserve.

As in previous years, routine maintenance was carried out on the Reserve rail siding and the road works, and minor refurbishing was approved for the watchmen's residences. Also, the annual survey of the waters around the jetty was conducted by the Metropolitan Water Board and approval was given for an aerial geophysical survey which encroached into the restricted air space adjoining the Reserve.

The main function of the Reserve continues to be as a storage and despatch area for explosives used in the South West Division and Departmental staff again played an active part in ensuring compliance with all aspects of the Regulations relating to explosives manufacture, storage and conveyance. All vehicles leaving the Reserve (more than 2 850) with explosives were checked by the Reserve staff and some 5 329 tonnes of explosives were despatched to various locations by road and rail. Action was taken during the year to increase the inspection and supervision of rail wagons leaving the Reserve.

**Kalgoorlie.** A fire protection system has been installed at the Kalgoorlie Explosives Reserve in the area adjacent to the explosives manufacturing plant. The major company using the Reserve has also installed an office on the Reserve thereby permitting closer supervision of the day to day manufacturing activities and despatch of explosives. Two new sites for fifty-tonne magazines were located within the Reserve and one each allocated to the major importers of explosives.

**Karratha.** The Karratha Explosives Reserve was formally gazetted as a Reserve vested in the Hon. Minister for Mines during the year and a forty-tonne magazine site has been occupied to supply cartridged explosives for W.A.'s North West Shelf liquid natural gas project.

**Geraldton.** The Main Roads Department installed a magazine on the Geraldton Explosives Reserve bringing the total number of magazines located within this Reserve to three.

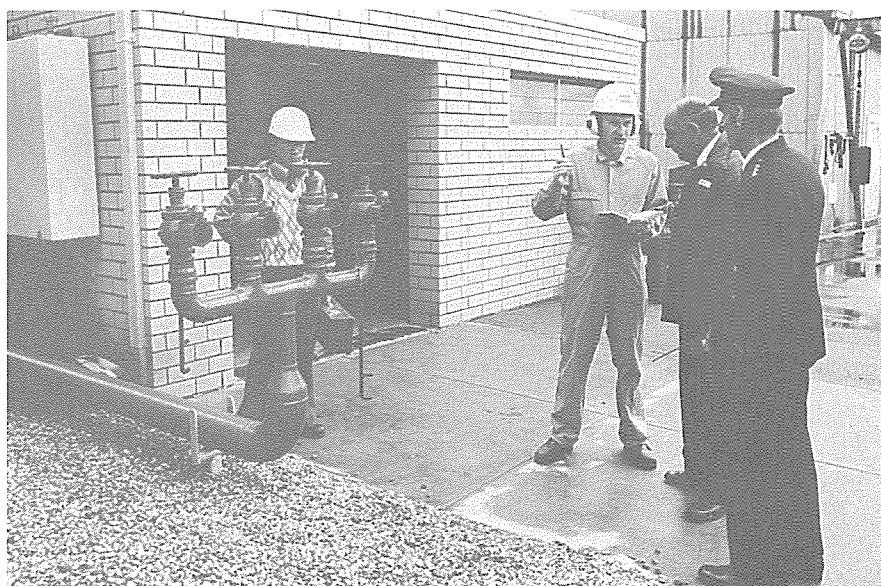
**Collie.** No further developmental work was done either for storage or manufacture at the Collie Explosives Reserve.

## Inspectoral activities

**Explosives security.** An estimated 138 kg of explosives and 1 174 detonators were collected by the Inspectorate from 30 different locations throughout the State. As in previous years, the majority of the explosives were returned to Woodman Point Explosives Reserve where they were destroyed by the magazine staff. In some cases, however, explosives were badly deteriorated and, being considered to be too sensitive to be transported any significant distance, were destroyed at the nearest safe place. A further 3 675 kg of explosives which had deteriorated in storage were condemned and their destruction by the owner was supervised by the staff of the Woodman Point Explosives Reserve. Approximately 220 deteriorated or outdated marine distress signals were also safely destroyed. Three different consignments comprising a total of 89 packets of fireworks were intercepted by Customs and confiscated and destroyed by Inspectors by authority of section 12 (1) (d) of the Explosives and Dangerous Goods Act.

Seven instances of theft were reported, two of which were from isolated mine leases. These were referred to the Mines Inspectorate to follow up and a recommendation was made to the Mining Companies concerned to provide improved standards of security for their explosives.

Early in the year a 25 kg case of gelignite was reported stolen when a railways consignment of 30 cases was checked by the Consignee at Greenbushes. Despite extensive enquiries by the Police and the Division Inspectorate it was not possible to determine exactly where the explosives had been stolen between Woodman Point and Greenbushes or who perpetrated the theft. A contributing factor which hindered the investigation was the inadequate security and surveillance provided for rail consignments of explosives. Action has now been taken to substantially upgrade the standard of explosives security throughout all rail consignments.



While investigations into the aforementioned theft were still proceeding, two other thefts occurred, one at Capel and the other at a Perth metropolitan quarry. Fortunately these thefts were of lesser amounts and, more importantly, they were not related to the theft at Greenbushes. The one at Capel occurred when children broke into a shed used to store explosives on a mine site and stole several seismic charges all of which have since been recovered. The other occurred when the ventilator panel of a quarry magazine was broken open allowing the theft of gelignite and detonating cord from inside. In both instances, satisfactory action has now been taken to improve the standard of security for future storage of explosives.

Explosives and detonators were stolen from a country depot of the State Energy Commission during an unchecked period of two weeks. Storage in work boxes for excess gelignite had been arranged in an unused shed as a proper security magazine was not available. This incident prompted a general tightening of security procedures at all State Energy Commission country depots.

Railway fog signals were stolen from an unlocked Westrail train guard's van at a country siding. Although such devices must be readily available for use by railway personnel, it is essential, because of the injuries that have been caused from the irregular use of railway fog signals in the past, that these explosives be maintained in locked storage areas.

A portion of a stick of gelignite wrapped in newspaper was found by two boys on the Stirling Bridge at Fremantle. The explosive was subsequently collected by an Inspector and safely destroyed.

**Explosives storage, use and conveyance.** A total of 843 inspections of explosives facilities were carried out during 1981. Many new magazines were completed to Australian Standard Specifications either to replace



existing substandard magazines or to accommodate the requirements for explosives storage associated with new resource projects.

Most of the requirements of the relevant Australian Standard are being applied to vehicles licensed to convey explosives in Western Australia. Some deviations from the Standard are permitted to cater for local conditions. For example load sizes and coverings are more liberal than in other States; however, it is doubtful that anywhere else in the world would it be possible to drive 1 200 km on a main road and not pass through a built up area. There are several such routes in Western Australia and those alone are sufficient to support deviations from conditions which apply in other, more densely populated States.

The use of explosives at the North West Shelf project on Burrup Peninsula received close attention which resulted in a considerable improvement in working conditions at quarrying operations within the area. The Division Inspectors attended the site on several occasions where they conferred with management supervised examinations, lectured on safe usage and working practices and advised on the storage and transport requirements of the Regulations. Excellent liaison was developed between this Branch and representatives of the construction companies at all levels.

Legal action was instituted on two occasions against the licensees of explosives conveying vehicles for breaches of the regulations. In one of the incidents a vehicle was found with several cases of detonators amongst a load of several tonnes of a high explosives. In the other case, a semi-trailer loaded with explosives parted from its prime mover when the driver, having stopped for a meal, attempted to resume his journey. An explosives inspector happened to be on site and his investigation revealed that the vehicle was not fitted with signs nor was the exhaust correctly located as required by the Regulations.

**Analysis and testing.** Chemical analysis was continued throughout the year to monitor the quality of ammonium nitrate prill destined for the Mining Industry. An improved coating material for the prill was introduced in 1980 and accurate control of the coating process has ensured the level of combustible material on the prill remains below the Internationally acceptable level of 0.2 per cent combustible material expressed as carbon.

Nitroglycerine-based explosive continued to be examined by the ABEL Heat Test. The 747 tests conducted in 1981 was 24 per cent more than in 1980. There was a dramatic decrease in the quantity of safety fuse imported in 1981 and



this is reflected in the decrease in numbers of samples tested; from 69 in 1980 to 3 in 1981. All samples tested were satisfactory.

Following a 12 month successful trial period, the REO BM125-10 exploder was given unrestricted approval for use in Western Australia. Also, during the year, a further 200 photo-electric circuit testers were checked for maximum current output. As in past years these instruments, which produce less than one milliamp of current within the firing circuit, were approved for use in mining operations for the checking of electric firing circuits in accordance with the Mines Regulations Act Regulations, 1976.

Tests conducted on a new model of electronic exploder, manufactured in Taiwan, resulted in non-approval as safety features considered necessary for use in Australia, were not present. Meanwhile, tests are continuing on two types of large capacity exploders, the REO 5000 Sequential Blasting Machine and the Multi-Channel Exploder.

A locally made circuit tester, the Brookeades DCT 2000 was examined and approved subject to compliance with specified labelling requirements. The meter was the first examined in this State to have an LCD digital readout and no moving parts—a significant innovation because of the rough handling these meters are usually subjected to in the field.

As mentioned earlier, a container load of detonators was received at Fremantle from the United Kingdom. Although tests indicated the detonators, when packaged as proposed by the manufacturer, may not be mass explosive, the tests were not conclusive enough to warrant classification of the consignment as sub-class 1.4 explosives (i.e. having no significant hazard). Tests on new packaging methods and the behaviour of the detonators when so packed continued through 1981 and are not yet concluded.

Samples of distress flares were tested for the Harbour and Light Department who were subsequently

advised that the flares complied with the requirements of the Navigable Waters Regulations.

Several samples of amorces from prospective importers were tested and approved. Also, a variety of fireworks intercepted by Customs and confiscated by this Division were tested to confirm that they would not have been considered suitable for release to the public even under the provisions of Regulation 131 (3) (a) which allows the exemption of items containing small amounts of explosives.

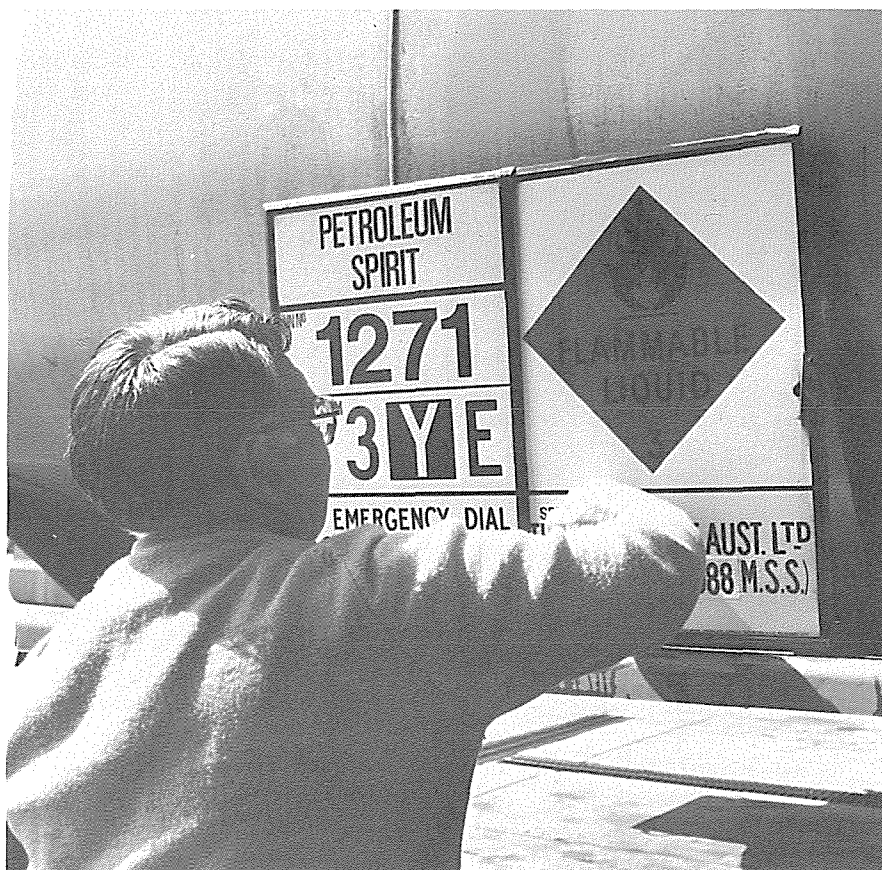
Samples of ICI's Magnaprimers, Anzomex Sliders and Aquapour and Du Pont's water gel explosives Tovex 200, 300, 700, 800 and Extra were tested and all were approved for general distribution and use in Western Australia.

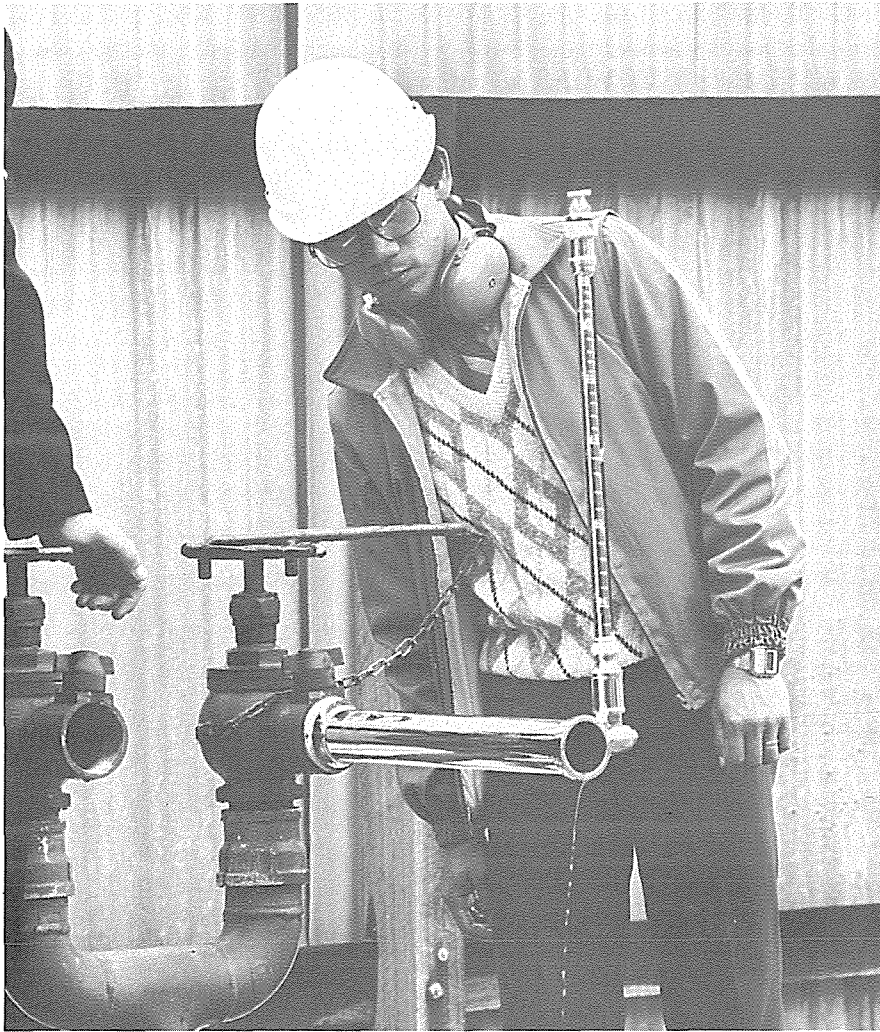
A completely new system of explosives initiation by electrical means in the form of ICI's Magnadets was tested approved. The system comprises a conventional electric detonator with its lead wires wound round a ferrite toroid and the entire electrical system

is sealed and insulated. The lead wire windings form the secondary winding of a transformer coupling while the primary winding consists of a single cable which runs from a special exploder box which generates 15 000 Hz through the toroid and back to the exploder. The system is protected against stray currents; it does not respond to DC or AC power developed by standard 240 volts or 440 volts supplies and will withstand a static discharge of 30 kV from a 2500 pf condenser. It is apparent that use of such a system would significantly improve safety in the electrical firing of explosives.

**Flammable liquids and gases.** A total of 6 131 inspections of premises and vehicles were completed whilst the number of licensed premises fell by 270 to 4 825. This continued reduction in licensed premises was forecast in the Annual Report for 1980 and is due to the closure of smaller service stations and some depots in country districts.

The number of self-service sites continued to increase and is now





132. Effective supervision resulted in problems of pump pre-authorisation being noted and corrected. Those companies affected were required to modify their electronic consoles to maintain a pre-authorised time not greater than 15 seconds.

Swimming pool chemicals on licensed premises were in general maintained and stored to the standards required, but it was necessary in one instance to confiscate excess storage and a prosecution is pending.

Liquefied petroleum gas tanks are gradually increasing in number at premises licensed to store flammable liquids and careful examination has been found necessary to ensure Australian Standard recommendations are maintained. Preliminary plans for the first underground LP gas installation in Western Australia have been submitted and are still under examination.

Division activity continued to increase in respect of the inspection and pressure testing of tanks used in the conveyance of flammable liquids. Twenty-one sets of tank drawings and specifications from local and interstate manufacturers were examined and 15 pressure tests were supervised by the Inspectorate.

The problem of petrol retailing from bulk fuel depots continued without resolution. Numerous complaints were received alleging that fuel was being sold from bulk fuel depots in an unsafe manner and all were investigated. In most cases depot licensees either complied with the safety requirements of the Regulations or took action to do so. Where it was not practicable for a licensee to modify his premises and dispensing would result in danger to the public safety, instructions were issued that dispensing to the public

must cease. In some cases complaints continued to be submitted where inspection had shown that there was no breach of the Regulations, but, as the dispensing at that stage is a commercial problem, related to petrol pricing rather than safety, it is beyond the scope of the Flammable Liquids Regulations and no further action could be taken.

Legal action was instituted against the licensees of three bulk fuel depots for unsafe practices concerning petrol dispensing in bulk depots, but legal advice subsequently indicated that because of an omission the charges would be successfully defended. The charges were withdrawn and the omission was corrected by an amendment to the regulation.

**Miscellaneous dangerous goods.** As the gazetting of the Dangerous Goods (Road Transport) Regulations becomes imminent, the number of inquiries from the Public increases. Generally, inquiries relate to the content and effects of the regulations but there are also numerous inquiries about conditions that are required for the safe storage of dangerous goods. The following is a brief summary of inquiries handled by the Division during 1981.

Several companies were requested to improve their storage facilities for liquefied oxygen located on premises which were licensed to store flammable liquids. The improvements resulted in the premises complying with the requirements of Australian Standard 1894-1976 "The Safe Handling of Cryogenic Fluids".

The shipment of anhydrous ammonia referred to in the 1980 Annual Report did not eventuate. For several months during 1981, the Division continued to be involved in discussions to ensure that the conditions for off-loading and conveyance would be consistent with current safe working practices gazetted elsewhere in Australia.



A detailed review was made of Woodside's liquefied natural gas proposals for their onshore treatment plant at Withnell Bay. It was recommended that the Company's proposals be accepted subject to the submission to the Western Australian Government of safety audits which were to be conducted at various stages by one of the partners in the project that had known technological expertise in this field.

At the request of the transport company concerned, the Division reviewed a proposal to import sodium cyanide in 880 kg packages and advised on the detailed submission which would be required before the packages could be approved for use in Western Australia. Negotiations are continuing for the approval of the package.

Discussions were held with representatives of CIG concerning the reticulation of a five per cent mixture of hydrogen in nitrogen as an oxidation inhibitor in the manufacture of copper wire.

The standard of construction of tanks was reviewed and a route approved for the delivery of anhydrous hydrogen fluoride in bulk, from New South Wales to the BP refinery.

The Forests Department was advised on safe working procedures for the storage and handling of an oxidizing agent used in the manufacture of incendiaries for aerial burning.

Hammersley Iron Pty Ltd, was advised on the conditions which applied to the safe storage of liquefied chlorine.

Advice was given to the Hedland High School on the storage of numerous hazardous chemicals used in their science laboratory.

The National Safety Council was advised that further legislative action was not believed to be warranted to control the operation of LP Gas appliances in vehicles used as mobile homes.

Detailed advice was given to a transport company concerning the conveyance of flammable liquid intended for use in the manufacture

of explosives to blast the underwater trench on the North West Shelf project. The product was more complex than a normal flammable liquid, as it was potentially explosive, so the off-loading at Port Hedland and conveyance to the Burrup Peninsula was supervised by an Inspector.

A company intending to distribute a dilute solution of hydrofluoric acid as a cleaning agent was advised of the applicable standards for packaging and marking which would be required by the Dangerous Goods (Road Transport) Regulations.

Alcoa of Australia Limited was advised on the conditions which would apply to the storage of a quantity of compressed industrial gases in an area adjacent to their flammable liquids storage compound.

While off-duty, an Inspector noted in a large supermarket, the storage of a significant quantity of swimming pool chlorinating agent stacked adjacent to a display of small packages of flammable liquids. Although the premises were exempt from licensing under Regulation 12 (1) (a) the matter was drawn to the attention of the store's safety officer. Action was subsequently taken to separate the two commodities.

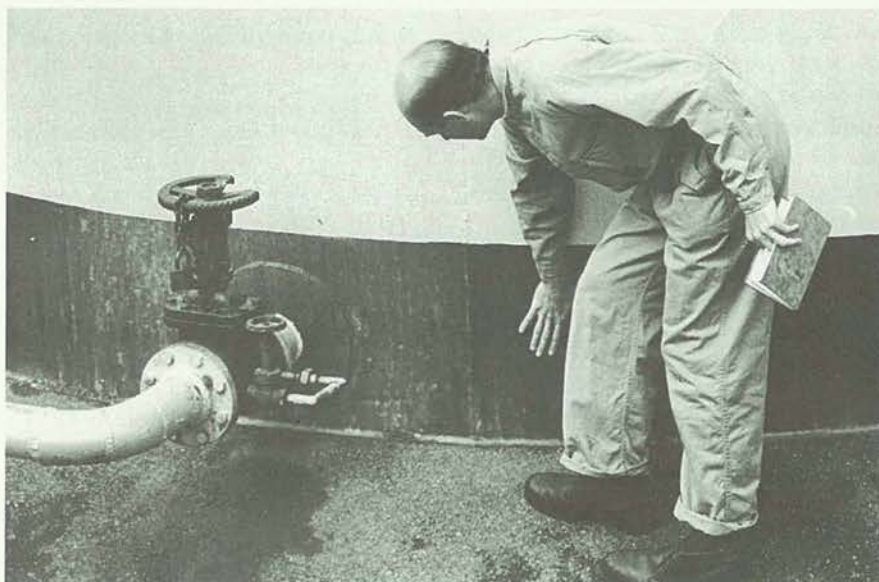
14.5 kg of sundry dangerous chemicals consisting mostly of flammable liquids or alkali metals were brought by the owners to the Inspector's attention and subsequently disposed of at the Woodman Point Explosives Reserve.

**Summary of general duties inspections.** The full complement of Inspectors being available through the year was reflected in the overall increase in total inspections to 7 096, from 5 830 in 1980. The details are shown in the table below.

	1980	1981
Explosives:	291	665
Magazines etc.	30	96
Vehicles	29	54
Use	29	28
Destruction		
Licence to manufacture blasting agent	76	122
Flammable Liquids:		
Licensed and exempt premises	4 517	5 293
Advice	214	272
Vehicles	644	566
Totals	5 830	7 096

#### Accidents and outrages

**Explosives.** Only three incidents of this category involving explosives were reported during 1981 and only one of these was investigated by the Explosives Division Inspectorate.







The remaining two were followed up by other authorities and satisfactorily reported as required under the Act.

A boy of thirteen suffered second degree burns to his arms when he set fire to a fireworks composition he found in a stone quarry. Despite inquiries by the Police and Division officers, the manufacturer or owner of the composition could not be traced.

While crabbing from a jetty in the Swan River, two boys picked up a cartridge of gelnite from the river bed. Police divers searched the river bed but no further cartridges were found. A man suspected to be the owner of the explosive was found but no prosecution could be instituted because of lack of evidence.

During a walk near a large gold ore slime dump at Boulder, a boy of thirteen found an old detonator. While carrying the detonator by the connected fuse, the detonator exploded causing injuries to fingers of his right hand and to his left leg.

**Flammable liquids.** Thirteen accidents involving flammable liquids were reported during the year and all but one were investigated by the Inspectorate who never ceased to be dismayed by the ignorance displayed of the dangerous properties of flammable liquids. Only three of the incidents reported during 1981 could be accurately described as "accidents" in that the event occurred because of circumstances

which could not have been foreseen and avoided. It is particularly disturbing that seven of the accidents occurred in industrial circumstances where the persons involved were actively and regularly dealing with flammable liquids and had the benefit of safety training programmes.

Shortly after a 9-metre launch had been refuelled with petrol the boat caught fire and burned fiercely, causing injuries to several of the occupants. The initial source of the fire was attributed to an electrical spark which ignited flammable liquid vapours which in turn set fire to the main structural parts of the boat.

Hot metal pieces from flame cutting equipment being used to repair a diesel powered truck fell into the vehicle's 800 litre fuel tank which subsequently exploded. The man using the flame cutting equipment suffered injuries in the explosion but was dragged to safety by his work mates before the fire reached him.

A man was injured in an explosion which occurred in a sand drying machine used to make resin coated moulding sand for a foundry. Although methanol was used in the resin, it was not possible to conclusively determine whether the resin/methanol was the cause of the fire as there was a likelihood that it could have been caused by leaking liquefied petroleum gas. The Company has now taken action to

completely redesign the process and the equipment used.

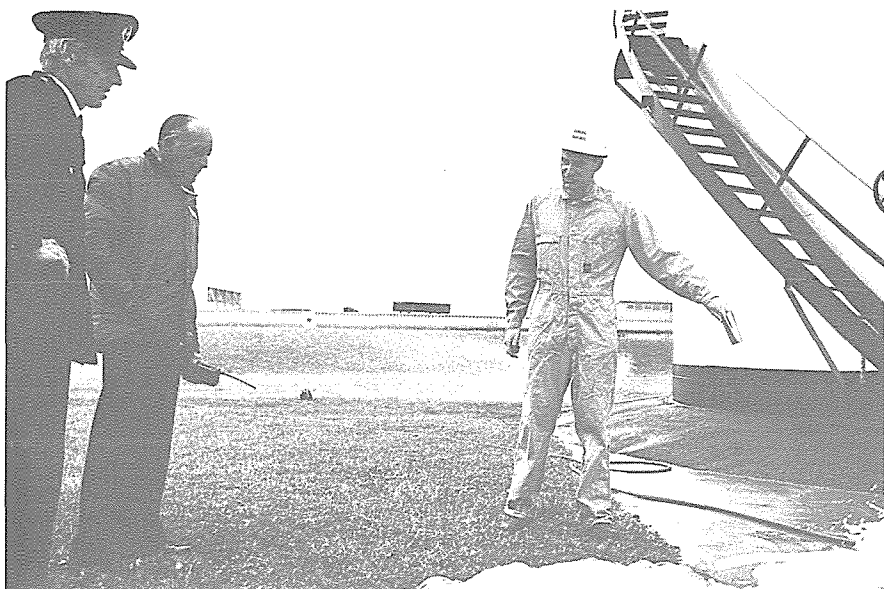
Two separate accidents involving bitumen kettles were investigated. In both accidents distillate used to reduce the viscosity of the bitumen had become super-heated and had caught fire with very costly results.

An oil company agent was burned when a tanker vehicle he was loading caught fire. The tank compartment being loaded had previously been used to contain petrol and was being splash-filled with distillate through an open hatch when the fire started. A static electricity discharge line which had been incorrectly attached to the tank was later found to be ineffective. The tank was about one third full and the operator was in the process of dipping the tank during filling when the fire occurred. This description could be taken as a "copy book" example of what not to do when loading a fuel tanker and the fire could almost certainly have been avoided if any of the following precautions had been taken: (a) if a loading tube had been used so the product was not splash-filled, (b) if the petrol vapour had been removed from the tank before filling, (c) if the static line had been correctly fitted, or (d) if the operator had avoided dipping the tank while filling was in progress.

A tanker vehicle overturned and the tank separated from its chassis mounting after a tyre of the vehicle blew out. The product in the tank was automotive distillate and no fire resulted.

In Northam, a domestic oil-fired hot water system was started and left to operate while the house occupant went out for the evening. On his return it was found that the heater unit had been destroyed by fire. The fuel from the heater was tested and shown to be consistent with kerosine, the recommended fuel for that heater and no further action was taken by this Division.

An assistant at a service station placed about 1 litre of motor spirit in an open tin with the intention of



cleaning some engine parts. While carrying the container to his work place, he tripped, spilled the petrol and the fumes were ignited by an electric radiator. Remarkably, damage was minimal and no personal injuries occurred.

At Mount Magnet, a man suffered superficial burns to his arms and legs and temporary loss of hearing as the result of an explosion in an 8 200 litre bulk fuel tank he was welding. No precautions had been taken to free the tank of vapour which was split open along the line of the dividing bulk-head in the explosion.

As the result of a motor car crash on a remote dirt road, two teenagers died and three were injured due to a petrol fire. Fuel for the engine was being supplied by a hose from an open 20 litre can placed on the front seat of the vehicle. In the crash, fuel was spilled and the vapour was reported to have been ignited by a cigarette smoked by one of the passengers.

A tanker vehicle rolled on to its side while loaded with 6 000 litres of mixed products including 4 000 litres of petrol. The product was transferred to another tanker without further mishap and the tanker was righted in due course. The owner of the tanker expressed concern at the action of the emergency services which failed to direct traffic away from the danger area, used

spark ignition motors near the tanker and permitted an ambulance to come within 3 metres of the overturned vehicle. Action is being taken to educate the persons concerned.

A grass fire went out of control on a railway reserve and spread to grass inside a fuel depot which was reputedly empty but in fact was storing 84 kilolitres of fuel of mixed classes. An Explosives Inspector was in the area at the time and he extinguished part of the fire as it burnt towards the bulk tank. The local Volunteer Fire Brigade attended soon after and extinguished the rest of the fire. No flammable liquids were actively involved in the fire and a potentially disastrous event was averted due to the quick action of the Inspector. Action has been taken by the company which operated the depot to ensure that other premises they close are in fact empty of product and remain so.

**Other dangerous goods.** At the request of the Fire Brigade, an Inspector attended at the scene of a fire which involved cylinders of oxygen and acetylene. Approximately 6 cylinders of acetylene had been stored adjacent to an office on a construction site. The office/storage area was surrounded by dry grass which was ignited from an unknown source. The safety relief valves on all cylinders functioned

satisfactorily and although the fire became quite fierce when the acetylene began burning, none of the cylinders exploded.

An officer from the Division advised the emergency services personnel on site when an unidentified drum of chemical was located in the Chittering Valley. As the drum was believed to be leaking hydrogen cyanide, action was taken to neutralise the cyanide on site to avoid conveying it through the metropolitan area to a safe disposal site. Neutralisation was effected and the resultant solution, in three 200-litre drums was conveyed to the Woodman Point Explosives Reserve. The following day chemists from the Government Chemical Laboratories re-examined the solution to ensure that all the cyanide had been destroyed.

The Division was advised but not actively involved, when approximately 30 kg of sodium cyanide was spilled when the trailer upon which it was travelling separated from its towing vehicle in the Miling area. The distributor of the goods and the contractor conveying them cooperated to successfully neutralise the spilled chemical.

Advice was given on site to the emergency services when a drum of nitrocellulose was found leaking in a railway carriage at the Kewdale freight terminal. Upon the arrival of a representative of the chemical company importing the consignment, additional alcohol was added, the drum resealed and then conveyed to its destination.

## Organisation

**Staff.** Mr W. Bennett retired as Officer in Charge of the Woodman Point Explosives Reserve after almost 10 years service with the Division. Mr T. Deacon has now been appointed to the position.

At 31 December the staff of the Explosives and Dangerous Goods Division remained at 22 and consisted of: Six clerical, eight inspectorate, and eight Reserve security.



## Functions

The Division is responsible for the administration of the Explosives and Dangerous Goods Act and the relevant regulations. These regulations ensure the safe handling of flammable liquids and explosives. The more specific functions are as follows.

Issues licences for the import, manufacture, sale, storage and transport of explosives and flammable liquids. Regularly inspects all storages and facilities and gives advice on the construction of new facilities.

Conducts examinations for Shotfirers Permits.

Tests representative samples of explosives for quality and performance standards.

Controls the Woodman Point Explosive Reserve, and regulates other privately operated explosive reserves. Investigates all accidents related to explosives or flammable liquids. Contributes to a variety of National and State co-ordinating and policy committees regarding the handling of dangerous goods.

This Division does not control the use of explosives on mines, this function being exercised by the State Mining Engineer's Division.

## Other activities

The Chief Inspector participated in the activities of several committees which required interstate travel:

SAA Committee ME/15, Storage and Handling of Liquefied Petroleum Gases;

SAA Committee ME/17, Storage and Handling of Flammable and Combustible Liquids;

SAA Committee AU/17, Road Tankers for Hazardous Liquids and Gases;

ATAC Advisory Committee on the Transport of Dangerous Goods by Road and Rail;

AAPMA Dangerous Goods Committee.

Other Committees, which met in Western Australia, and in which the Chief Inspector participated were:

The Environmentally Hazardous Chemicals Committee;

The Emergency Procedures Subcommittee of the above, which is charged with formulating a State wide policy for procedures to follow in an emergency involving dangerous goods;

The Western Australian Advisory Committee of the Transport of Dangerous Goods, which was set up to co-ordinate the regulations which apply to the Transport of Dangerous Goods in Western Australia.

The Chief Inspector also attended the 16th Annual Conference of Chief Inspectors of Explosives which was held in New Zealand. While in that country, opportunity was taken to examine compressed natural gas (CNG) plants, the

method of distributing CNG and its use as an automotive fuel.

Two lectures on the Transport of Dangerous Goods in Western Australia were delivered by the Chief Inspector. One was to a meeting of Government Safety Officers and the other was to the Australian Fire Protection Association.

Inspector K. Douglas delivered a lecture to Assistant District Engineers of the Main Roads Department on the subject of Transport, Handling and Storage of Flammable Liquids and Explosives.

Inspector W. Gildare gave a lecture on explosives safety to the St John Ambulance Association.

Mr Gildare also submitted a paper to the Department of Agriculture for publication in their Journal. The paper explained a method of encouraging tree growth by the use of explosives prior to planting.

The Inspector and Research officer together with other Inspectors maintained the Division Shotfirer training programmes throughout the year.

The Deputy Chief Inspector attended a two week, live-in management training programme at the University of Western Australia.

All the general duties Inspectors attended a one day seminar run by the Standards Association of Australia, on the subject of electrical equipment and explosive atmospheres.

## EXPLOSIVES

CHIEF INSPECTOR  
H. DOUGLAS  
APTC (Chem), ARACI, AM Aust IMM

DEPUTY CHIEF INSPECTOR  
K.R. PRICE  
BSc (Hons), ARACI, Grad Dip Admin

CLERICAL  
STAFF

INSPECTORATE

WOODMAN POINT  
EXPLOSIVES RESERVE  
SECURITY STAFF



## The Mining Act 1978-1981

On December 11, 1981, the Mining Act 1978-1981 was proclaimed to come into force on January 1, 1982. The Act has had one of the longest gestation times of any Act brought before parliament. Indeed, Mr Men-saros, the then Minister for Industrial Development, Mines, Fuel and Energy, said in his speech to the Legislative Assembly in August, 1978, '... there would hardly be a single piece of legislation which was subjected to more protracted, more numerous and more patient negotiations'.

The beginnings of the legislation go back to June of 1970 when the Government set up a committee to examine and make recommendations about proposed changes to the Mining Act, 1904. There were some 239 submissions to the committee and 53 witnesses appeared before it. What the committee found was that the old Act was outmoded, ambiguous and vague and that even senior members of the legal profession had difficulty in giving confident advice on mining matters. The committee recommended to the Government that the old Act should be repealed and a new Act submitted to the Parliament.

Because mining has such deep roots in Western Australia and affects so many people, from the small scale prospector to international mining companies, much work and effort was needed to produce an Act that would be satisfactory for everybody; protecting the environment, and special interest groups such as farmers and Aborigines, but at the same time allowing mining to develop with the necessary freedom from overbearing restraint.

One area that caused a lot of discussion was the original intention to do away with the Miners Right. Many people were reluctant to see this basic 'licence' being dropped

and the Government finally acquiesced and re-introduced it in the new legislation. A holder of the Miners Right, which costs \$10, can prospect on Crown land open for mining, except land already held as a mining tenement, search for minerals and conduct tests for any mineral and take and keep samples of up to 20 kg of rock, ore or minerals for testing purposes.

The major part of the legislation concerns the various licences and leases which will apply to mining in W.A. The 1978-1981 Mining Act reduces the 39 different types of titles provided in the present Act to three basic tenements: a Prospecting Licence, an Exploration Licence, and a Mining Lease. Ancillary to these are the General Purpose Lease and the Miscellaneous Lease.

The Prospecting Licence allows the holder to remove up to 500 tonnes of ore and is granted for a period of 2 years. Each licence can cover an area of not more than 200 ha and a rent of 50c per hectare is payable by the holder. Normally, no more than 10 licences may be held by one person. There is also a minimum annual exploration expenditure commitment which the holder must meet.

An Exploration Licence allows the holder to remove up to 1 000 tonnes of ore and is granted for a period of 5 years. At the end of the third and fourth years 50 per cent of the area of the licence must be surrendered. This prevents the tying up of land for long periods and allows other people to gain access after a suitable period. The fees required to be paid are \$150 for the application and a rent of \$18 per sq km. A minimum annual expenditure of \$20 000 is required.

A Mining Lease is required for all mining which is to take place

and is granted for a period of 21 years but can be renewed indefinitely. The maximum area included in one lease is 1 000 ha and there are various provisions for payment of rent, application fee and survey costs.

A General Purpose Lease is designed to allow the deposition or treatment of tailings or the storage of operating machinery. Such a lease is only available to the holder of a mining lease.

The final licence covered in the new Act is a Miscellaneous Licence and is granted to the holder of an exploration licence, prospecting licence or mining lease for various purposes such as a road licence, water licence.

The new Act lays down clearly the marking out and the methods of applying for mining tenements, and there is now one set of requirements as against many different requirements in the old 1904 Act.

One area that required much thought was the provisions relating to private land. Farmers were worried that the new Act would allow anybody to damage their crops and pastures without any suitable compensation. The new Act stops any person from entering private land without a permit which is issued by the mining warden. The permit allows the prospector to search for minerals and remove samples from an outcropping on the surface only and he may mark out a mining tenement but cannot mine or disturb the surface.

The Department of Mines has produced a series of information pamphlets which gives the requirements of the Act in a concise form and should be obtained by all those persons who have interests in prospecting and mining, even if only in a small way.

Mineral exploration activity during the year remained at the high level set in 1980, with 24 939 applications being received and the number of existing titles, 22 157 in 1980, being increased to 32 038 in 1981.

This high level of activity is also demonstrated by 26 091 title dealings being registered during the year.

To cope with the increased level of activity the staff of the Registration Division (including Outstations), was increased by 15 to a total of 99.

Major Division activities during the year included preparation for the proclamation of the Mining Act, 1978 on 1 January 1982, a conference for the Mining Registrars, the preparation of information pamphlets, establishment of an Information Centre to deal with public enquiries, and the formulation and eventual implementation of new procedures to accompany the Mining Act 1978.

The new procedures included a review to simplify and improve Division methods, including the streamlining of register entries.

Conjointly, with the introduction of the Mining Act 1978, Departmental fees and charges were reviewed to bring them into line with registration charges set by other Government departments.

Studies were also undertaken into computerised information systems with a view to the long term computerisation of mining tenement records.

The Registration Division is also responsible for the various registration tasks under the petroleum Acts. A new petroleum registration section was created during the year to handle the increased volume of 484 items comprising applications, transfers, agreements and applications for approval to drill and conduct systematic surveys. This is compared with 345 items handled in 1980.

### Operations

Division activities during the year remained at the high level set in the previous year.

The 1980 upsurge in mining activity resulted mainly from the increase in the price of gold and the search for alternative energy resources. This momentum continued through 1981 exemplified by the number of applications received for Coal Mining Leases, Gold Mining Leases, Mineral Claims and Tem-

porary Reserves. As indicated by the table on page 155, the number applied for in 1981 generally approached the total number of tenements previously in force. For Coal Mining Leases the 6 253 applications lodged in 1981 was far in excess of the 174 tenements previously in force.

The increase in activity during the year was also reflected in the 24 764 dealings registered. Compared with 1980, when 9 945 were





registered, the significance of this increase can be appreciated.

Similarly the level of public counter activities continued throughout 1981 with the issue of 8 197 Miner's Rights and receipt of 5 407 tenement applications, 13 670 dealings and 1 230 applications for exemption.

In the field of petroleum exploration and development there was a 32% increase in the number of applications for permits, licences, access authorities, pipeline licences and scientific investigations when compared with the previous year. Applications for permission to drill wells and conduct seismic surveys increased by 55%. The most significant increase however, was in the number of applications received for the registration of transfers and instruments creating interest, such as farm-out agreements. These increased nearly threefold.

Apart from receiving and processing these large numbers of applications, the Registration Division

activities during the year also included preparation for the proclamation of the Mining Act 1978 from 1 January, 1982, and a Mining Registrar's Conference.

The Mining Registrar's Conference, which was held between 25 and 27 November, 1981 was necessary to familiarise the Mining Registrars with all aspects of the new Act. Apart from outlining the ramifications of the new Act, the conference aimed to point out the necessary concepts, processes and procedures arising from its introduction.

With the impending proclamation of the new Mining Act on 1 January, 1982, the Registration Division was involved in a general gearing-up process. An information centre was established and a series of pamphlets prepared for the benefit of the public. A staff training programme was initiated along the lines of the Mining Registrar's Conference in order to facilitate the introduction of the Act.

## Organisation

**Staff.** Of 60 items at Head Office and 39 items at Outstations, comprising a total staff of 99, there were 5 vacancies at 31 December, 1981.

During the year, to provide staff to meet increasing demands on the Division's services, 15 new items were created. Recruiting to fill these items, together with some restructuring within the Division, resulted in an abnormally high number of changes to the staff. There were 8 appointments, 18 promotions and 7 resignations.

**Accommodation.** Office accommodation within Mineral House for the Registration Division was improved during the year. The Division was able for the first time to occupy the whole of the first floor, acquiring some areas previously assigned to the Surveys and Mapping Division. Opportunity was taken to rearrange the layout to improve work flow and upgrade the standard in some areas. However, with the need to accommodate extra staff, space is still at a premium.

## Functions

The basic tenet of mining legislation that promotes orderly exploration and mining is that minerals are owned by the State. The Registration Division receives applications and allocates titles that give legal right for individuals and companies to explore for, mine, and exploit minerals and onshore petroleum. Offshore petroleum rights are jointly vested in the State and Australian Governments, with the registry function controlled by the Registration Division.

The Division also provides full research and secretarial services to the Department in all matters concerning title, including the handling of Ministerial correspondence, Parliamentary questions, commentary on agreement Acts and attendance at meetings.



For these purposes, the Registration Division has a substantial establishment in Perth, and also maintains regional Mining Registrar offices located at Kalgoorlie, Southern Cross, Coolgardie, Mount Magnet, Meekatharra, Leonora, Marble Bar, Norseman and Cue. Registration Division also controls the mining tenure roles in other regional centres of the District Clerks of Court attached to Crown Law Department.

The Perth establishment is divided into four sections as follows:

**Applications Section.** Handles all mining tenement applications, preparing appropriate recommendations to the Minister for approval or refusal.

**Dealings Section.** Handles the maintenance of register transactions including transfers mortgages of titles, compiles Mineral Claim registers and provides rating information for Local Government Authorities.

**General Section.** Processes temporary reserve applications and exemption applications, maintains securities, prepares documents for Executive Council, operates the public counter, carries out the functions for the Mining Registrar South West and Warburton Mineral Fields and Phillips River Goldfield and receives certain documents for the regional Mining Registrars.

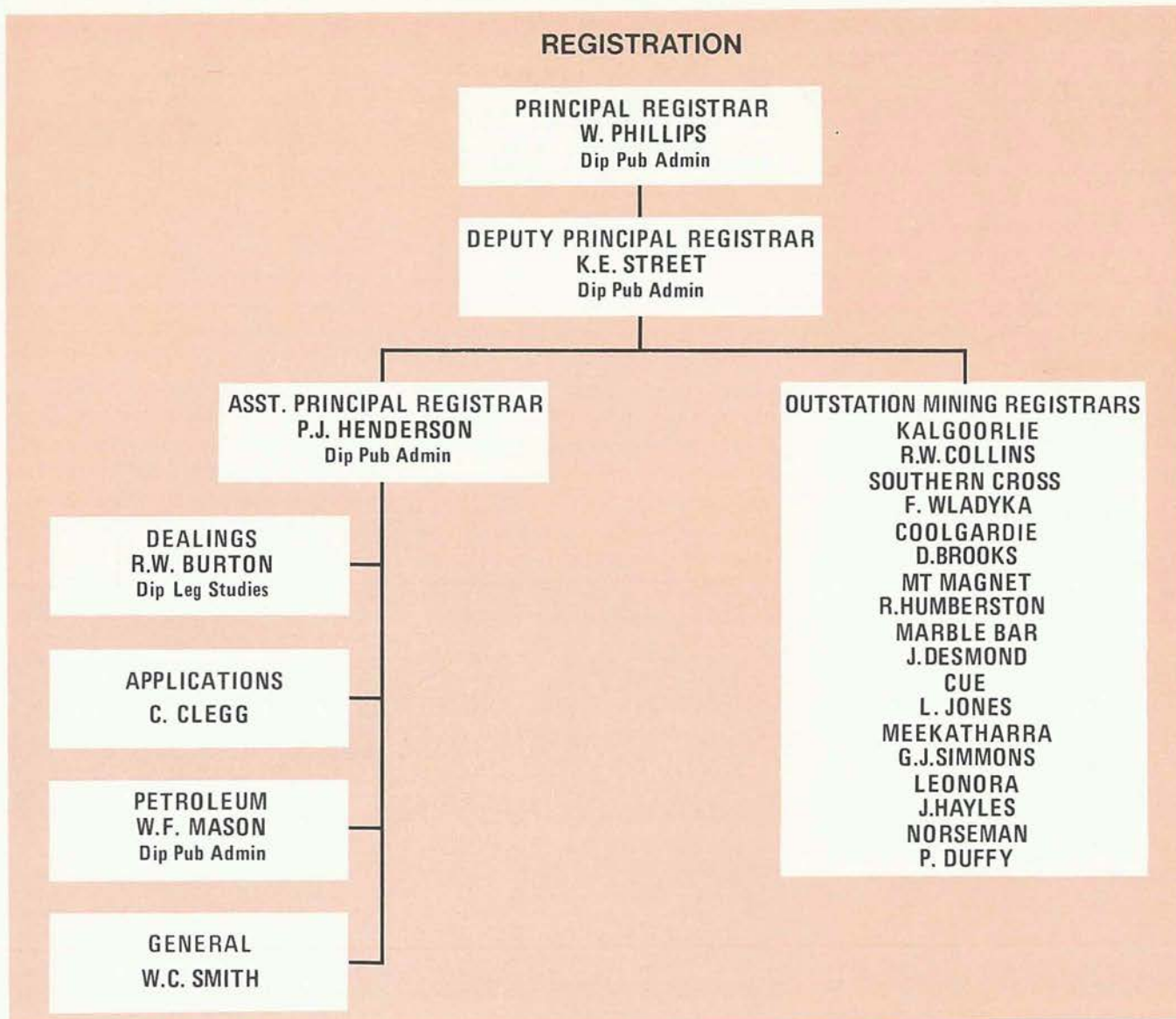
**Petroleum Registration Section.** Responsible for the various registration tasks, comprising applications,

transfers, agreements and approval to drill and conduct systematic surveys, under the Petroleum Acts.

### Other activities

The following Information Pamphlets, designed to assist the public on the proclamation of the Mining Act 1978, were compiled and published.

- No. 1 Mining Act 1978-1981 and regulations. Basic provisions.
- No. 2 Miner's Rights.
- No. 3 Marking out and applying for mining tenements.
- No. 4 Private land provisions.
- No. 5 Transitional provisions.
- No. 6 Guidelines on reporting requirements.



## A Mining Tenement Information System Pilot Study

Mining Tenement information has traditionally been recorded by hand. When a query is made, a manual search through numerous indexes and registers is needed, and in most cases considerable time and effort is required. Such searches are frequently requested by the exploration and mining industry, and various Divisions of the Mines Department in their day-to-day activities are constantly referring to recorded mining tenement information.

If all mining tenement information could be fed into a computer to make a data base then the searches would obviously be quicker and easier. Ultimately it might even be possible for the general public to have ready access to some of the information through computer terminal.

Having constructed the data base the task then is to devise suitable programmes to instruct the computer to retrieve information in required forms and, just as importantly, to train staff in the use of computers in data base operations. This task is much more complicated than it seems at first. Western Mining Corporation has a system which is geared to its requirements and this was offered to the Mines Department for experimentation; but it was not sufficiently comprehensive for the more detailed requirements of the Mines Department. The Department therefore sought to develop its own M T I S.

A Research and Development Grant was approved to allow some officers from the Department to develop a pilot scale M T I S. The work was done at the Systems Research Institute of Australia (SRIA), which is a cooperative of Government and private companies formed to undertake computer research initially for the mining and energy industries. SRIA has a number of general computer programmes (software) applicable to data base systems and the aim was

to use these as tools to develop the pilot M T I S. Various courses are also provided to train staff in computer programming and three members of the Mines Department staff worked on the pilot system from July to October. For the purposes of the pilot study, selected current and relinquished mining tenements within the Cue District of the Murchison Goldfield were chosen. This involved computerisation of information to prepare a data base relating to 500 mining tenements.

The broad objectives of the study were threefold.

1. To allow officers of the Department to gain education and experience in data base techniques.

2. To make officers more aware of the requirements that need to be defined in the final system and

3. To produce a simplified, experimental data base system which would carry out at least a part of what would be in the final M T I S.

The pilot study was able to develop programmes which would search the data base and on command display specifically required aspects of the information. These included: current status of any selected tenement; current tenements held by a given person; tenements on which rent was outstanding; tenements located on a given map sheet; and various combinations of these and other search topics.

After the pilot study had been in use for a while, members of the Mines Department were shown how the system worked and the speed with which the computer could retrieve information. Altogether some 80 staff members visited S R I A to see the demonstration. The visitors ranged from the executive to junior officers of the Department, most of whom were impressed by the possibilities of a full-scale M T I S.

Given that there are some 66 000 surveyed tenements and an even larger number that have been in force without survey, some idea

of the likely size of the final M T I S can be gained. Getting this information into the computer (data capture) will not be the only problem. Another is to computerise the land positions of the mining tenements. This will require survey and other location information to be digitised so that the computer can record and manipulate the data in numeric form rather than in the more usual form of a drawn plan. Work has already begun on this task. Registration, Surveys and Mapping, and Geological Survey Divisions of the Mines Department will all use the location programme extensively.

The next step will be made as soon as a permanent Computer Manager is appointed to the Department. His first task will be to help define the exact requirements for a working system and to produce an overall plan for implementation.

Eventually all land use is likely to be computerised by the WA Government in a total Land Information System (L I S) but the problems are immense and will have to be tackled step by step. A good M T I S must be an essential part of the L I S. Meanwhile, when fully developed, the M T I S will be a valuable addition to the Mines Department's services to the public and is sure to be closely examined by other States with important mining activities.





The Administrative Division expanded its activities during 1981, responding to changes in management style instituted in the Department. The changes sought to improve coordination in several existing areas of procedural activity common to all Divisions and to institute new management methods throughout the Department.

As a result of this and the greater degree of accountability and communication required by the Government of all its departments the Administrative Division sought, by increasing the efficiency of its existing service branches and introducing new technology, to provide better services for the Executive and other Divisions.

The continued high level of activities throughout the Department made it difficult to keep abreast of routine work, but with some new staff positions created and filled during the year some progress has been made with new initiatives. At present the Division carries out its operations through its Management Services, Personnel, Records, Accounts, Royalty and Statistics and Systems Audit Branches.

## Operations

One of the early tasks of the newly formed **Management Services Branch** was to act on a survey of Departmental typing functions previously conducted by officers of the Organisation and Methods Division of the Public Service Board. This led to a recommendation that word processing equipment, comprising two central processing units and nine work stations, should be installed under the control of a coordinator of typing services.

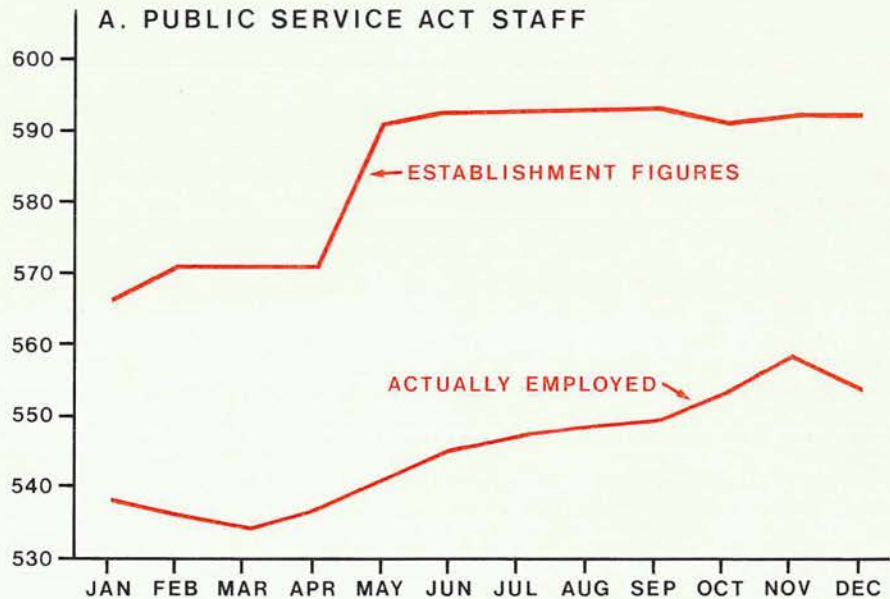
A further survey was carried out into the need for telex equipment, resulting in a recommendation that a service should be installed in 1982.

Coordination of computerised scientific functions of the Department has been in progress for some years by the Department's Computer Coordinating Committee. The Management Services Officer has been able to provide assistance and secretarial support to this Committee pending formation of a Computer Services Branch.

For most of the year the **Staff Branch** had no permanent staff officer and relieving officers had to

handle the considerable volume of routine work in addition to creation of 28 new items. These were approved by the Public Service Board during 1981 mainly to cope with work generated in this and the preceding year by increased mining industry activity.

Establishment and actual staff variations for the Mines Department during 1981 are shown on the following figures.





The **Records Branch** created almost 32 000 files in 1981 compared with 26 000 in the previous year. This reflected the large number of tenement applications lodged. Promotion, transfers and resignations caused a 50 per cent turnover in staff which made it difficult to maintain services.

The **Accounts Branch** recorded the Departmental expenditure of \$16.767 million for 1981/82 and collected revenue (including royalties) of \$90.830 million. Also during the year the Branch supervised the introduction of a computerised system of accounting from Treasury. The aim of the system is to provide better budgetary control and more detailed performance analyses.

Under the Mine Workers Relief Act, lump sum settlements were paid to 487 beneficiaries during 1981. In the same period the number of contributors to the fund fell from 10 436 to only 360 as mine employees are now adequately covered by workers compensation. The fund is in a sound financial position to meet its liabilities throughout the balance of the wind-down process.

Only 14 persons were receiving benefits through the Miners Phthisis Act which was superseded by the Mine Workers Relief Act in 1932.

Currently there are 1 139 coal industry workers covered by the Coal Mining Industry Long Service Leave Act.

The **Royalty and Statistics Branch** assessed and collected \$78.341 million as royalties on mineral production for the financial year 1980/81. The Branch recorded the production of mineral commodities to a total value of \$2 692 million for the calendar year 1981 and tables summarising this production are shown on pages 156 to 166.

In 1980 a firm of consultants was commissioned to report on the computing needs of the Department.

This confirmed the need for in-house computer expertise and approval was given in the Staff Budget for 1981/82 for the creation of the

positions of a Computer Manager and an Analyst/Programmer which would form the nucleus of a Branch. It is anticipated that the creation of the positions and the appointment of staff will take place in 1982.

Another recommendation was that a Mining Tenement Information System should be developed and during 1981 an exercise was prepared to demonstrate the feasibility of such a scheme. The development of the system will be continued.

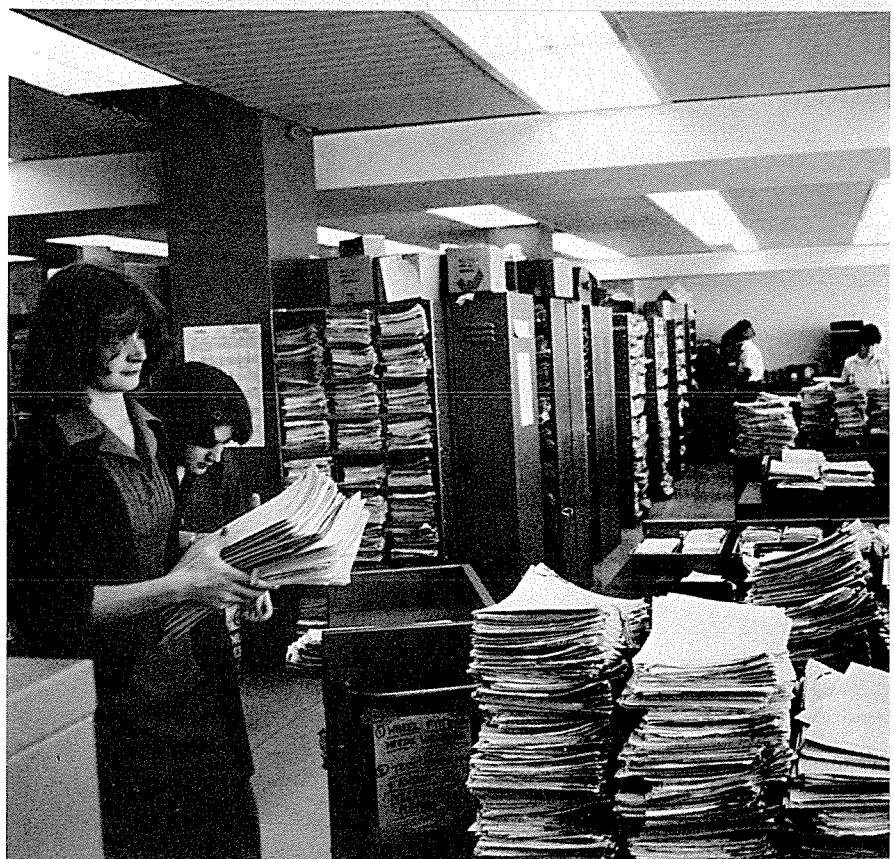
It is intended to vigorously pursue the computerisation of those areas where benefits can be realised and to enhance the existing computer applications within the Divisions.

## Organisation

**Staff.** Mr A. Mistilis was appointed to the position of Administrative Officer following the resignation of the previous occupant during a year that was marked by a greater use of

the Division to achieve better coordination of administrative services throughout the Department. A Management Services Officer and assistant, and an Internal Auditor were appointed by the end of the year and reviews of several existing or proposed administrative functions had been commenced or completed. As referred to elsewhere, other Branches of the Division were also inconvenienced by staff turnover.

**Accommodation.** The problems caused by inadequate accommodation continued to inconvenience the Department during 1981. Planning for an extension of Mineral House commenced as early as 1972 and, although drawings were completed in 1979, continuing lack of funds prevented construction. While this delay persisted it was decided in 1981 that a review of the Department's accommodation requirements should be made to determine if the planned extension would meet the Department's foreseeable requirements.



Meanwhile to alleviate overcrowding in Mineral House, the State Mining Engineers Division was relocated nearby in the State Housing Commission building. There are now nearly 100 officers housed in locations remote from Mineral House.

Lack of adequate and integrated accommodation has become a limiting factor in planning for greater efficiency in many operations.

## Functions

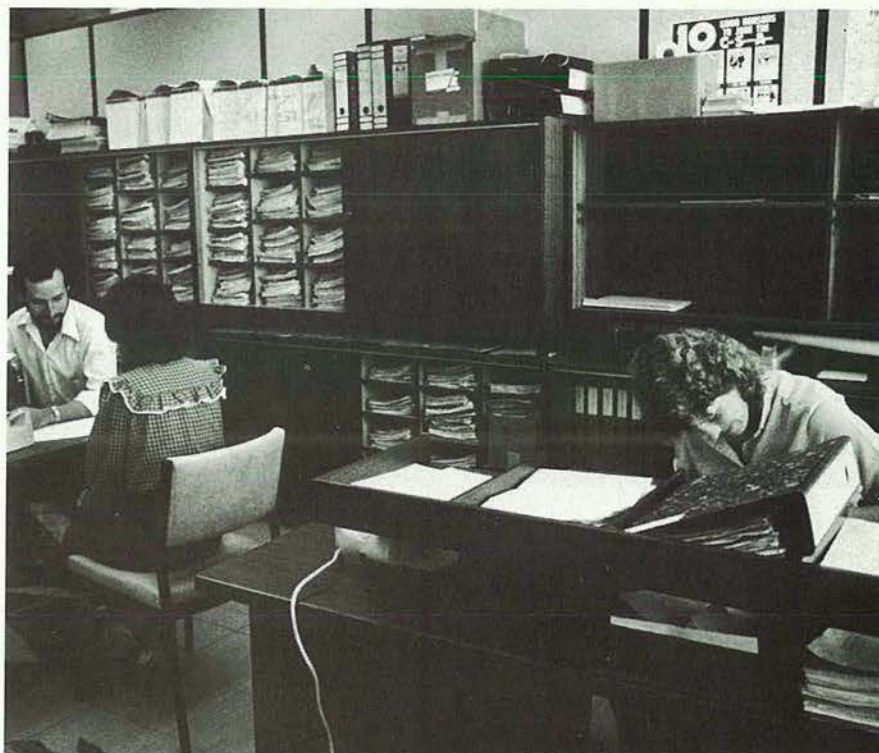
The Administrative Division comprises six Branches with functions as follows.

Management Services undertake work management surveys, and plan and supply logistical support for systems designed to enhance operating efficiency.

The Staff Branch maintains all personnel records and ensures that correct staffing procedures are followed.

The Records Branch maintains and controls a system of files on current and historical activities of the Department. It is also responsible for the flow of correspondence in and out of the Department and provides photocopying services.

The Accounts Branch is responsible for payment of salaries and accounts, recording revenue,



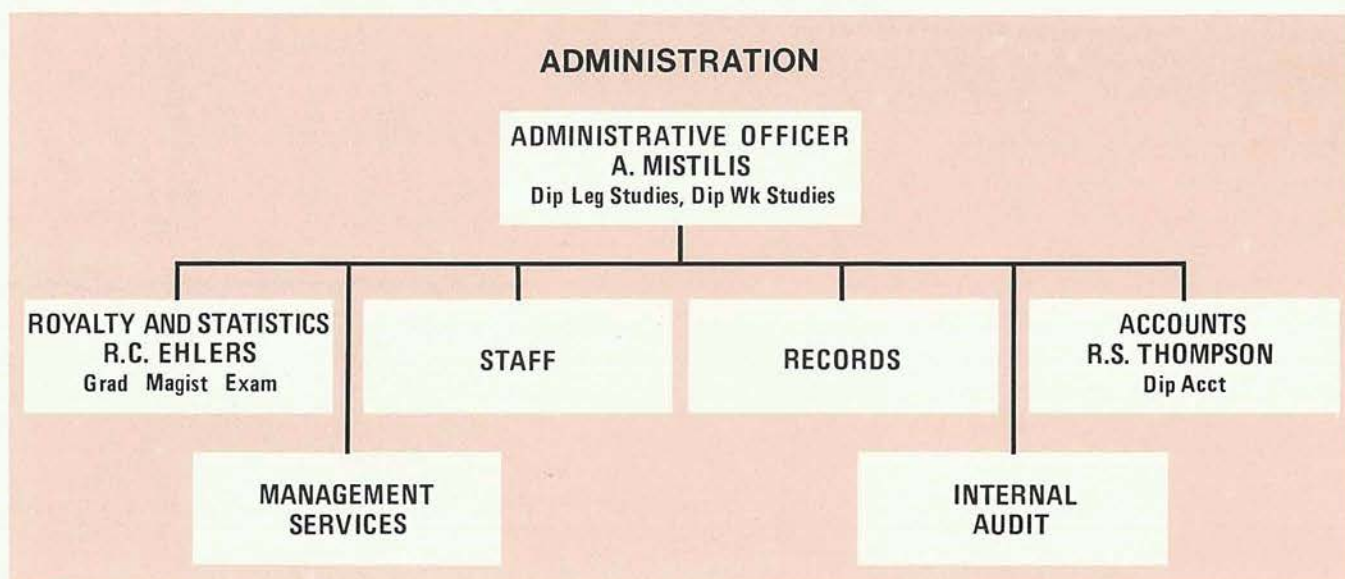
collating budgets and requisitioning stores and equipment. The Accountant also holds the following positions: Chairman, Coal Mine Workers Pension Tribunal; Administrator, Coal Mining Industry Long Service Leave Trust Fund; Chairman, Miners Phthisis Board; and Superintendent, Mine Workers Relief Act.

The Royalty and Statistics Branch is responsible for assessing and collecting mineral and petroleum royalties and collecting and

recording statistics relating to all aspects of mineral production.

The Internal Audit Branch, initially established to carry out standard audit functions, will progressively develop a programme of system-based checks to verify that other Departmental procedures are being correctly operated.

Although provision had been made for a Computer Services Branch, staffing had not been achieved at the years end.







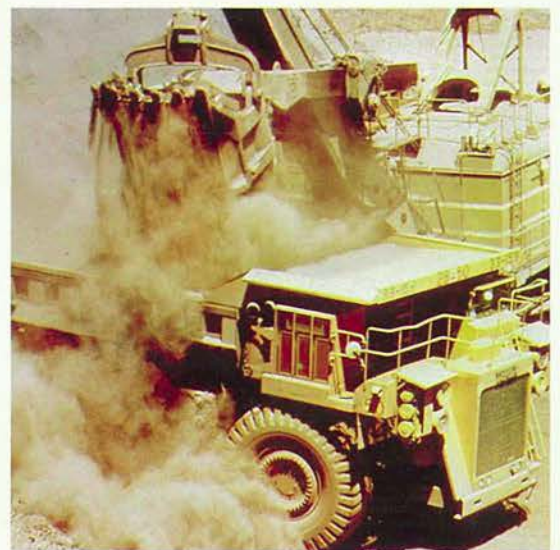
Kwinana petroleum refinery.



Belt conveyor shifting bauxite.



Pipe sections for Northwest Shelf sea floor pipeline.

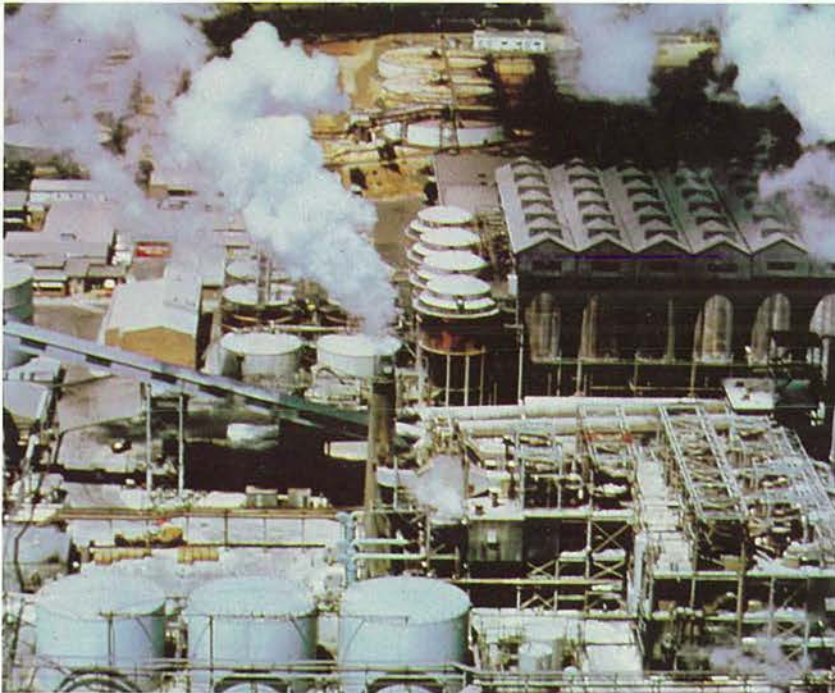


Trucking iron ore from the mine face.

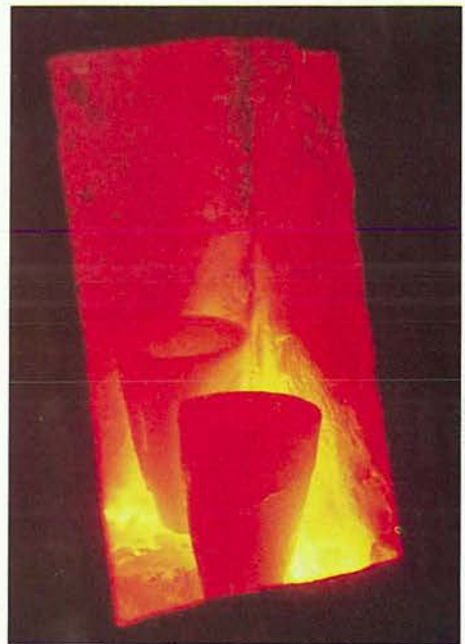




Offshore oil drilling rig flaring gas.



Part of Alcoa alumina plant at Kwinana.



Fire assaying gold.

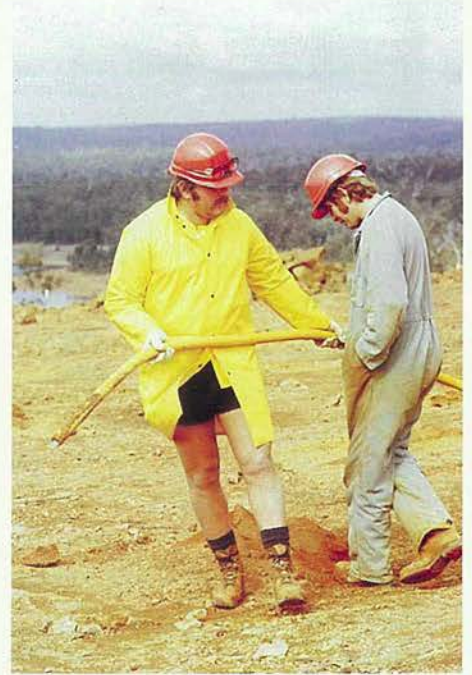


Removing waste at iron ore mine.





Loading bauxite at Alcoa pit.



Experimenting with a new explosive for bauxite mining.



Constructing modules at Jervoise Bay for the Northwest Shelf gas production platform.





Preparing to log a water bore near Gngara.



Drilling blast holes.



Petrol tanker showing correct information panel.





Examining part of the mineral collection at Government Chemical Laboratories.



Aerial view of Alcoa alumina plant at Kwinana.



Explosives Division officers inspecting premises.



Testing paints at Government Chemical Laboratories.

## Statistical Digest

This section of the Annual Report contains most of the tables and diagrams that in previous years appeared elsewhere in the volume in the Divisional Reports. Also the more widely used of the tables previously published under Mining Statistics are included.

Notable omissions are the details of gold and silver production from individual mines and total output of gold bullion, concentrates etc entered for export and received at the Perth Mint. Since the repeal of the Gold Buyers Act a considerable amount of gold is disposed of elsewhere than the Perth Mint and Mint figures therefore no longer ac-

curately describe the total gold production.

Any reader who now finds the statistical information inadequate for his purposes may inquire directly to the Statistics Branch of the Administrative Division where detailed records are maintained. The extent of these inquiries will determine the manner in which statistics should be published.

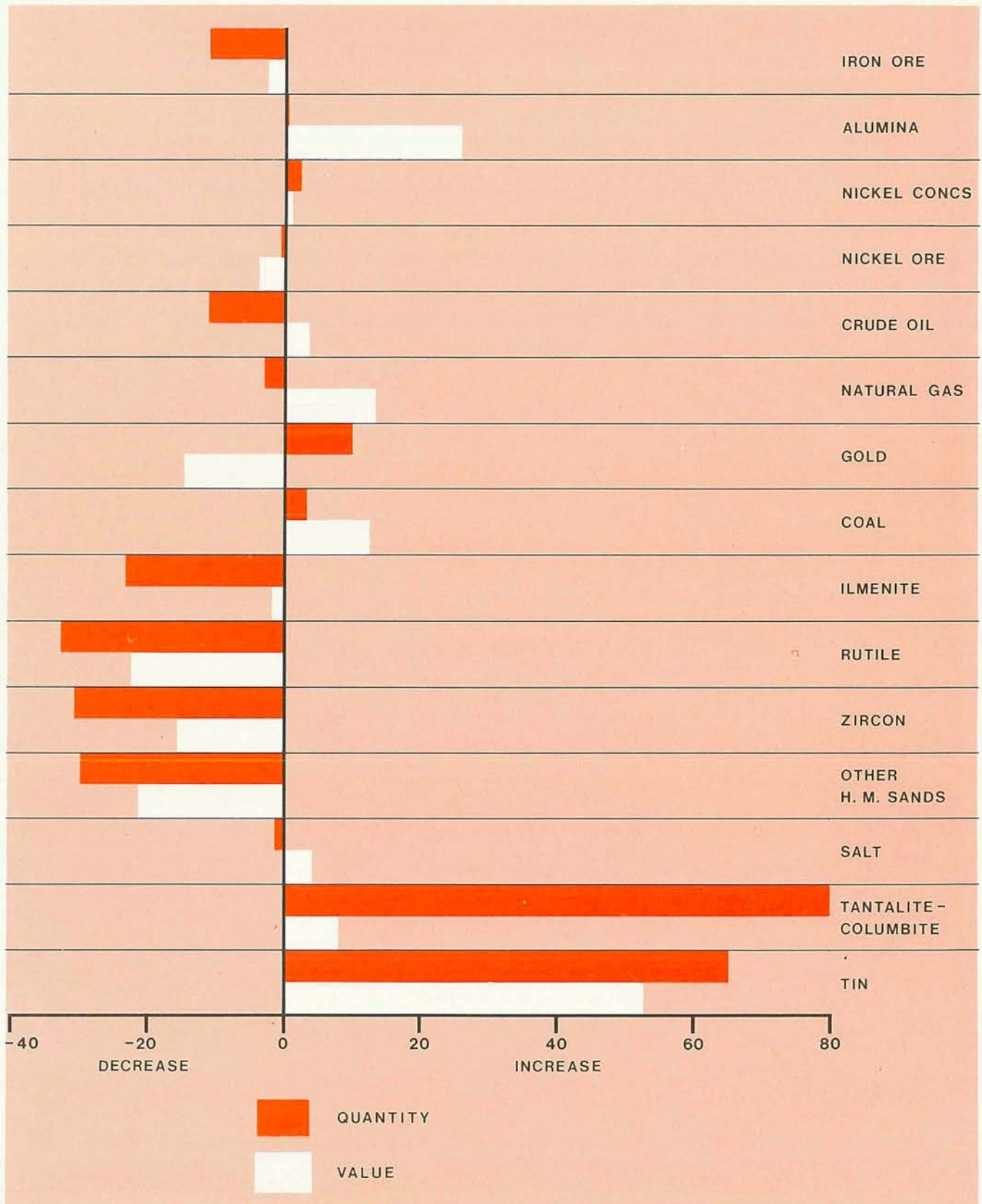
For convenience the tables summarising annual mineral production and royalties and comparing these with last year are grouped together at the end of the Statistical Digest.

### Legislation Administered by Department of Mines

Coal Miners' Welfare Act  
Coal Mines Regulation Act  
Coal Mine Workers (Pensions) Act  
Coal Mining Industry Long Service  
Leave Act  
Explosives and Dangerous Goods Act  
Miners Phthisis Act  
Mines Regulation Act  
Mines Workers' Relief Act  
Mining Act  
Mining Development Act  
Petroleum Act  
Petroleum (Registration Fees) Act  
Petroleum Pipelines Act  
Petroleum (Submerged Lands) Act  
Petroleum (Submerged Lands) Regis-  
tration Fees Act  
Western Australian Coal Industry  
Tribunal Act.



The percentage valuations of 1981 production and value of those in 1980 are illustrated in the figure below. For most commodities the decline in quantity has been compensated for by increased prices.





**STATE MINING ENGINEER'S DIVISION**  
**Drilling carried out by Mines Department in 1981**

Place	Purpose	Type of work	Number of bores	Metrage
Boyanup	Groundwater investigation	Rotary drilling	11	5 296.7
		Development	11	
Gillingarra	Groundwater investigation	Rotary drilling	11	3 741
		Development	8	
		Abandoned	1	
Lake Clifton	Groundwater investigation	Rotary drilling	17	399.5
		Development	17	
		Pump test	4	
Harvey shallow	Groundwater investigation	Rotary drilling	38	701.5
		Development	35	
		Abandoned	3	
Manjimup	Investigate effect of forest clearing of groundwater and surface water	Rotary drilling	15	128.4
		Development	15	
		Pump test	9	
Gnowangerup	Drought relief	Rotary drilling	47	1 120.6
		Development	46	
		Abandoned	2	
Cundeleece		Rotary drilling	18	97.6
		Development	2	
		Abandoned	1	
Broad Arrow	Mine treatment water supply	Rotary drilling	8	466.1
		Development	7	
South Fremantle	Monitoring groundwater pollution from ash dump	Rotary drilling	3	158.5
		Development	3	
South Perth	Recreation area watering	Rotary drilling	2	290.08
		Development	2	
		Pump test	1	
Guilderton	Recreation area watering	Rotary drilling	1	20
		Development	1	
		Pump test	1	
Canning Basin	Groundwater protection	Restrictors in bores	6	
Various	Various	T.V. camera scan	35	
Total				12 419.98

### Fatal and Serious Accidents Showing Districts and Causes, 1981

DISTRICTS	Explosives		Falls		Shafts		Fumes		Miscellaneous underground		Surface		Total	
	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious
West Kimberley												4		4
Pilbara											2	58	2	58
West Pilbara											2	98	2	98
Peak Hill												33		33
Gascoyne												4		4
Murchison						1				9	1		1	10
East Murchison				5		4			1	5		6	1	20
Mount Margaret			1	3						6		7	1	16
North Coolgardie			1										1	
Broad Arrow												1		1
East Coolgardie				8					1	75		40	1	123
Coolgardie				21	1					54	1	9	2	84
Yilgarn						2						4		6
Dundas		1		1						10		4		16
Greenbushes			1	1							1	6	2	7
South West											1	108	1	108
Collie				1						44		37		82
Total for 1981		1	3	40	1	7			2	203	8	419	14	670
Total for 1980	1		1	26		4				138	3	373	5	541



### Serious Accidents for 1981

Class of Accident	Inspectorate				Totals	
	Perth	Karratha	Kalgoorlie	Collie	1981	1980
Major injuries (exclusive of fatal)—						
Fractures:						
Head	2	1	3	—	6	—
Shoulder	2	2	—	—	4	4
Arm	7	12	4	—	23	9
Hand	1	—	4	2	7	10
Spine	—	—	2	—	2	1
Rib	2	1	1	—	4	6
Pelvis	—	—	2	—	2	—
Thigh	—	—	1	—	1	1
Leg	2	1	11	—	14	5
Ankle	3	5	4	—	12	6
Foot	2	2	10	—	14	6
Amputations:						
Arm	1	—	—	—	1	—
Hand	1	—	—	—	1	—
Finger	3	2	—	—	5	6
Leg	—	—	—	—	—	2
Foot	—	—	—	—	—	—
Toe	—	—	—	—	—	—
Loss of eye	—	—	—	—	—	—
Serious internal	—	—	1	—	1	1
Hernia	8	3	1	2	14	8
Dislocations	1	—	—	—	1	4
Other Major	—	—	2	1	3	3
Total major injuries	35	29	46	5	115	72
Minor injuries						
Fractures:						
Finger	6	9	11	4	30	19
Toe	2	3	—	—	5	7
Head	8	4	3	2	17	9
Eyes	6	2	6	—	14	14
Shoulder	4	6	5	6	21	26
Arm	7	7	13	3	30	21
Hand	8	24	47	3	82	69
Back	22	57	55	34	168	146
Rib	2	1	3	1	7	5
Leg	15	42	37	14	108	73
Foot	5	3	27	5	40	47
Other minor	8	7	13	5	33	33
Total minor injuries	93	165	220	77	555	469
Grand Total	128	194	266	82	670	541

NOTE: The Perth, Karratha and Kalgoorlie Inspectorates comprise the following Mining Districts:

PERTH—South West, Greenbushes, Collie, Northampton, Yalgoo, Murchison, that portion of the Gascoyne Mining District south of latitude 25° South, and that portion of the Peak Hill Mining District south of latitude 24° South.

KARRATHA—Kimberley, West Kimberley, Pilbara, West Pilbara, Ashburton Mining Districts, that portion of the Gascoyne Mining District north of latitude 25° South, and that portion of the Peak Hill Mining District north of latitude 24° South.

KALGOORLIE—East Murchison, Mt Margaret, North Coolgardie, North East Coolgardie, Broad Arrow, East Coolgardie, Coolgardie, Yilgarn, Dundas, Eucla, Warburton, Napperu and Phillips River Mining Districts.

The statistics reported for the Collie Inspectorate are of accidents which occurred on coal mines in the Collie Coal Field.

**Summary Descriptions of Fatal Accidents  
Reported during 1981**

Name Occupation Date of Accident	Mine/Details and Remarks
A Vulpe Storeman/Driver 05/03/81	Western Mining Corporation Ltd Kambalda. Death was due to severe head and chest injuries sustained when the motor vehicle he was driving and a locomotive collided at a railway crossing on Durkin Road Kambalda.
A J Wooldridge Electrical Fitter 11/04/81	Hill 50 Gold Mine N L. Death was due to electrocution sustained when he came in contact with live, exposed fuses while working on the main powerhouse switchboard.
R Gibson Miner 04/05/81	Western Mining Corporation Ltd Lancefield Gold Mine. Death was due to severe chest injuries sustained when he was buried beneath a fall of rock from the north wall of the Evers Shaft during sinking operations.
N L Armstrong Prospector/Miner 01/06/81	Gold Mining Lease 47/473. No inquest was held into this fatality. Mr Armstrong was fatally injured when run over by a tractor/front end loader while carrying out servicing with the engine running.
P E Walton Fork Lift Driver 20/06/81	Alcoa of Australia Ltd—Pinjarra Refinery. Death was due to traumatic asphyxia, crush injury of chest sustained when the fork lift he was driving overturned after hitting a concrete foundation footing pinning him beneath the overhead protection guard.
J M Dellaca Underground Foreman 25/06/81	Mt Ida Gold Mine Timoni Shaft. Death was due to traumatic asphyxia sustained when he was crushed beneath a fall of ground while barring down in a leading stope on the 4 level.
M McCarthy Engineer 07/07/81	Greenbushes Tin N L. Death was due to subdural haematoma—fractured skull sustained when he fell through an opening in the first floor level of the tantalite plant then under construction.
R Williams Underground Loader Driver 16/07/81	Agnew Mining Co Pty Ltd—Agnew Nickel Mine. Death was due to severe crush injury to the chest sustained when the loader he was driving fell into a stope ore pass following the collapse of a retaining wall.
S Cross Miner 22/07/81	Greenbushes Tin N L—Jon Mac Decline. A coronial finding was not available at time of writing. The deceased sustained chest injuries when trapped beneath a fall of rock during scaling of the L46 Sill Drive of the 1220 Level.
M T Kendrick Field Assistant 25/08/81	Pilgan Mining Pilgangoora Tin Mine. A coronial finding was not available at time of writing. The deceased was thrown into the air when a tractor tyre he was inflating, burst. He sustained head fractures on hitting the concrete floor.
M G Turich Miner 11/09/81	North Kalgurli Mines Pty Ltd. Death was due to fracture of cervical spine, such injury being sustained when he was buried in a run of ore in the 700 Level No. 1 Shrink Stope.
G J Swalling Truck Driver 23/10/81	Hammersley Iron Pty Ltd—Tom Price. An inquest into the fatality was pending at the time of writing. The deceased received multiple injuries when the truck he was driving left a haul road and plunged down an embankment.
P Tsakisiris 02/11/81	Mt Newman Mining Co Pty Ltd—Nelson Point. An inquest into the fatality was pending at the time of writing. The deceased received electrical shock when the jackhammer he was using penetrated a high voltage electrical cable.
A Millen Trainee Miner 17/12/81	Western Mining Corporation Ltd Kambalda. Death was due to extensive multiple injuries sustained when he fell down the service compartment of the Long Shaft together with a 6 tonne locomotive which he was using.

## Mining Law Examination Pass List 1981

Brown, P. G. H.	Nitsche, J. S.
Coles, A. J.	Phillips, J. B.
Crossley, W. J.	Pilgrim, J. S.
Denison, S. L.	Stephens, C. W.
Dumma, K.	Suckling, I. M.
Loxton, W. G.	Wilson, C. J.
Moran, T. M.	

## Mine Managers Certificates of Competency issued 1981

		Certificate number			Certificate number
Crossley, W. J.		127	Coles, A. J.		129
Stephens, C. W.		128	Moran, T. M.		130

## Underground Supervisors Certificates of Competency issued 1981

		Certificate number			Certificate number
Singleton, S. J.		A149	Green, G. A.		A177
Singleton, D. W.		A150	Hemingway, J.		A178
Sylva, B. K.		A151	Brown, P. G. H.		A179
Sullivan, B. D.		A152	Carter, K. A. J.		A180
Starr, W. B.		A153	Dimer, E.		A181
Metcalf, C. A.		A154	Durig, R.		A182
O'Neil, A. M.		A155	Ellis, T. B.		A183
Brown, G. D.		A156	Forsyth, P. J.		A184
Furness, R.		A157	Giles, G. J.		A185
Matthews, J. G.		A158	Higgins, N. J.		A186
Lawrence, J. S.		A159	Higgs, D. A.		A187
Teifenbacher, J. H.		A160	King, C. R.		A188
Evans, W. H.		A161	Krpan, A.		A189
Moran, T. M.		A162	McKenzie, K. J.		A190
Turner, R. N.		A163	Quinlivan, D. F.		A191
Pinkus, P. C.		A164	Salmi, J. R.		A192
Pilgrim, J. S.		A165	Sanders, N. B.		A193
Sime, R. H.		A166	Saville, F. R.		A194
Vranges, S. T.		A167	Simmons, J. H.		A195
Naylor, G.		A168	Smith, B. J.		A196
Epis, E. J.		A169	Wyse, P. G.		A197
Welten, P. J.		A170	Suckling, I. M.		A198
Hurkens, H. J.		A171	Warnock, J.		A199
Loxton, W. G.		A172	Doherty, G. B.		A200
Hrstic, K.		A173	Fox, J. P.		A201
Little, K. R.		A174	Rymer, S. B.		A202
Parkyn, B. W.		A175	Sculthorpe, P. D.		A203
Lebrun, G. M.		A176			



**Quarry Managers  
Certificates of Competency issued 1981**

		Certificate number			Certificate number
Alcock,	D. C.	41	Fuenzalida,	S.	46
Brown,	S.	42	Gilfillan,	J. G.	47
Dickey,	G.	43	Hawkey,	N. T.	48
Geldard,	D.	44	Conner,	C. J.	49
Gosling,	T.	45			

**Restricted Quarry Managers  
Certificates of Competency issued 1981**

		Certificate number			Certificate number
Lindon,	D. C.	51	Ridge,	C. F.	66
Dalecki,	E. S.	52	Rollo,	N. E.	67
Deakin,	J.	53	Savickis,	A.	68
Crossley,	G. D.	54	Shaw,	M. J.	69
Patterson,	R. J.	55	Dickens,	R.	70
Daly,	J. A.	56	Harrison,	T.	71
Dixon,	H.	57	Penwarden,	K. G.	73
Edwards,	P. S.	58	Burnett,	A. W.	74
Elgar,	C. S.	59	Archer,	R. J.	75
Gilchrist,	A. G.	60	Zankl,	W.	76
Horne,	K. A.	61	Little,	K. M.	77
Jensen,	R. C.	62	Fusai,	A.	78
Jones,	H.	63	Buckley,	T. A.	79
Mangan,	R. F.	64	Hirte,	R. J.	80
McDonald,	W. S.	65	Greenaway,	D. L.	81

**Authorised Mine Surveyors  
Certificates issued 1981**

		Certificate number			Certificate number
Neagle,	W. J.	53	Barnes,	A. J.	56
Zuvich,	J. J.	54	Hewlett,	B. M.	57
Durbin,	W. L.	55			

**Coal Mining Certificates of Competency issued 1981**

		Certificate number			Certificate Number
First Class Mine Manager:			Open Cut Mine Manager:		
Janetzki,	J. W.	45	Macky,	I. W.	8
Anderson,	R. P.	46	Watkins,	J. S.	9
Third Class (Deputy):			Deputy (Open Cut):		
Elliott,	K. S.	91	Robinson,	D. W.	7
Farmer,	T. S.	92	Archer,	K. L.	8
Hansord,	C. T.	93	Hayward,	W. L.	9
Pinto,	C. A.	94	FPeters,	L. H.	10
Turley,	P. J.	95	Pilatti,	E. J.	11
White,	A. E.	96	Smith,	D. B.	12
Allison,	J. W.	97	Vidotto,	O.	13
Sheppard,	A. J.	98			
Sherwood,	R. J.	99			
Kent,	G. B.	100			

Messrs Janetzki and Anderson were granted First Class Mines Manager's Certificates of Competency in recognition of their qualifications obtained in Queensland.

**STATE BATTERIES DIVISION**  
**Schedule No. 1—Details of Gold Ore Treated at State Batteries in 1981**

Battery	Number of Parcels treated	Tonnes Crushed	Yield by Amalgamation		Amalgamation tailings content of fine gold	Fine gold content of ore	
			Bullion	Estimated Fine Gold		Kilograms	Grams per Tonne
			Kilograms	Kilograms	Kilograms		
Boogardie	15	1 095	7.6355	6.4709	4.0174	10.4883	9.58
Coolgardie	56	5 031.3	19.0976	16.1850	9.9810	26.1660	5.28
Kalgoorlie	77	11 351	53.401	45.2569	21.5638	66.8207	5.89
Laverton	33	3 803.8	15.489	13.1269	5.8962	19.0231	5.00
Leonora	38	5 438	45.6724	38.7071	19.8722	58.5793	10.77
Marble Bar	13	2 546	49.1207	41.6295	10.3383	51.9678	20.41
Marvel Loch	31	3 912.6	28.0808	23.7973	10.3280	34.1253	8.72
Meekatharra	14	2 188	11.314	9.5886	4.8673	14.4559	6.60
Menzies	18	1 892.1	13.2092	11.1944	9.1008	20.2952	10.72
Norseman	25	2 186	18.7290	15.8728	5.2027	21.0755	9.64
Ora Banda	25	4 308.8	10.4484	8.8549	6.0999	14.9548	3.47
Paynes Find	7	383	8.2072	6.9555	0.7355	7.6910	20.08
Sandstone	4	180	1.8255	1.5470	0.6166	2.1636	12.02
Yarri	7	1 674	5.369	4.5500	2.8755	7.4255	4.43
Totals	363	45 989.6	287.5993	243.7368	111.4952	355.2320	7.72

Average Per Parcel.....126.69 tonnes

Average Yield by Amalgamation (Fine Gold).....5.31 grams per tonne

Average Tailing Grade (Fine Gold).....2.42 grams per tonne

**Schedule No 2—Extraction of Gold by Vat Treatment of Tailings by State Batteries in 1981**

Battery	Tonnes Treated	Head value		Tail value		Calculated recovery		Actual recovery	
		Grams per tonne	Total content Kilograms	Grams per tonne	Total content Kilograms	Kilograms	%	Kilograms	%
Kalgoorlie	3 650	2.55	9.3395	0.68	2.4915	6.848	73.3	6.778	72.6
Leonora	5 700	2.99	17.058	0.76	4.350	12.708	74.5	12.679	74.3
Marvel Loch	896	6.44	5.7721	2.08	1.8682	4.3455	75.3	4.375	75.8
Menzies	1 410	2.52	5.5539	0.66	0.9392	2.6147	73.6	2.599	73.1
Ora Banda	558	2.58	1.4396	1.29	0.7198	0.720	50.0	0.716	49.7
Totals	12 214	3.04	37.1631	0.85	10.3687	27.2362	73.3	27.147	73.05

**Schedule No. 3—Direct Purchase of Tailings by State Batteries in 1981**

Battery	Tailings purchased Tonnes	Initial payment \$
Boogardie	337.5	1 106.44
Coolgardie	986.6	2 720.26
Kalgoorlie	573.1	1 091.97
Laverton	100.8	171.89
Leonora	2 589.3	6 838.24
Marble Bar	1 034.1	3 047.75
Marvel Loch	474.7	2 140.70
Meekatharra	81.0	140.07
Menzies	527.4	1 635.27
Norseman	157.5	512.13
Ora Banda	326.0	628.28
Paynes Find	57.6	129.44
Sandstone	56.7	150.67
Total	7 311.3	20 313.11

Schedule No. 4.—Statement of Receipts and Expenditure for MILLING at State Batteries in 1981

Battery	Tonnes	Management supervision	Wages	Stores	Expenditure total working	Cost per tonne	Repairs, renewals	Sundries	Gross expenditure	Cost per tonne	Receipts	Receipts per tonne	Profit	Loss
Boogardie	1 095	26 163.44	29 835.27	18 646.15	74 644.86	68.17	5 379.15	13 230.64	93 254.65	85.17	10 225.70	9.34	—	83 028.95
Coolgardie	5 031.3	31 505.81	80 319.59	40 394.36	152 219.76	30.26	14 599.51	39 602.65	206 421.92	41.03	44 607.22	9.01	—	161 814.70
Cue	—	—	—	—	—	—	—	—	—	—	568.00	—	568.00	—
Kalgoorlie	11 351	71 125.86	195 542.55	85 183.14	351 851.55	31.00	35 858.47	107 137.97	494 847.99	43.60	125 511.58	11.06	—	369 331.41
Laverton	3 803.8	16 375.12	64 784.92	17 229.06	98 389.10	25.87	8 618.77	26 959.94	133 967.81	35.22	33 098.87	8.71	—	100 868.94
Leonora	5 438	17 556.72	62 559.94	21 636.68	101 753.34	18.72	7 267.06	38 697.58	147 717.98	27.17	58 009.86	10.67	—	89 708.12
Marble Bar	2 546	16 494.35	80 827.46	10 131.95	107 453.76	42.21	9 024.92	19 232.43	135 711.11	53.31	25 605.91	10.06	—	110 105.20
Marvel Loch	3 912.6	24 227.98	75 485.63	16 992.45	116 706.06	29.83	4 103.63	27 941.89	148 751.58	38.02	37 371.00	9.56	—	111 380.58
Meekeatharra	2 188	28 608.67	73 872.06	15 982.94	118 463.67	54.15	3 656.67	24 687.42	146 807.76	67.10	22 476.65	10.28	—	124 331.11
Menzies	1 892.1	15 386.87	62 485.08	12 328.78	90 200.73	47.68	2 706.55	16 613.94	109 521.22	57.89	20 764.00	10.98	—	88 757.22
Norseman	2 186	17 838.56	67 128.13	14 952.09	99 918.78	45.71	4 731.04	19 307.05	123 956.87	56.71	20 804.25	9.52	—	103 152.62
Ora Banda	4 308.8	15 638.51	74 201.56	30 181.04	120 021.11	27.86	3 814.54	29 615.85	153 451.50	35.62	34 601.52	8.03	—	118 849.98
Paynes Find	383	3 808.60	39 317.68	12 060.71	55 186.99	144.10	6 193.29	15 540.75	76 921.03	200.84	4 008.85	10.47	—	72 912.18
Sandstone	180	3 594.63	13 983.98	2 735.33	20 313.94	112.86	1 384.49	3 753.62	25 452.05	141.40	1 650.00	9.17	—	23 802.05
Yarri	1 674	13 091.95	52 975.57	14 991.61	81 059.13	48.43	3 525.13	17 814.36	102 398.62	61.17	14 790.75	8.84	—	87 607.87
Head Office	—	—	—	—	—	—	—	—	—	—	7 109.51	—	7 109.51	—
Sub total	45 989.6	301 417.07	973 319.42	313 446.29	1 588 182.78	34.54	110 863.22	400 136.09	2 099 182.09	45.65	461 203.67	9.90	7 677.51	1 645 655.93
Mag Plant	0.75	—	—	—	—	—	—	2.26	2.26	3.02	60.00	80.00	60.00	—
Northampton	37.00	15 789.00	22 190.22	7 087.66	45 066.88	1 218.03	3 207.25	19 298.31	67 572.44	1 826.29	6 452.42	174.39	—	61 120.02
Totals	46 027.35	317 206.07	995 509.64	320 533.95	1 633 249.66	35.49	114 070.47	419 436.66	2 166 756.79	47.08	467 716.09	10.03	7 737.51	1 706 778.21



**Schedule No. 5—Statement of Receipts and Expenditure for CYANIDING at State Batteries in 1981**

Battery	Tonnes	Management Supervision	Wages	Stores	Expenditure Total Working	Cost per Tonne	Repair Renewals	Sundries	Gross Expenditure	Cost per Tonne	Receipts	Receipts per Tonne	Profit	Loss
Boogardie	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Coblgardie	—	—	5 714.21	—	5 714.21	—	—	328.29	6 042.50	—	—	—	—	6 042.50
Kalgoorlie	3 650	2 070.00	30 156.36	78 562.39	110 788.75	30.36	1 697.96	30 887.39	143 374.10	39.28	44 586.09	12.22	—	98 787.96
Laverton	—	—	—	—	—	—	—	1 588.75	1 588.75	—	—	—	—	1 588.75
Leonora	5 700	—	59 357.68	24 196.35	83 554.03	14.66	—	37 262.88	120 816.91	21.20	34 983.23	6.14	—	85 833.68
Marble Bar	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Marvel Loch	896	—	15 246.56	5 888.17	21 134.73	23.59	—	7 437.92	28 572.65	31.78	29 819.54	33.28	1 349.23	—
Meekatharra	—	—	—	—	—	—	—	—	—	—	1 980.69	—	1 980.69	—
Menzies	1 410	3 381.77	15 500.38	7 138.37	26 020.52	18.46	95.40	10 113.41	36 229.33	25.70	7 283.36	5.17	—	28 945.97
Norseman	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Northampton	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ora Banda	558	1 470.28	3 482.22	3 064.22	8 016.72	14.37	22.02	6 703.95	14 742.69	26.42	533.99	.96	—	14 208.70
Paynes Find	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sandstone	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yarri	—	—	—	—	—	—	—	—	—	—	—	—	—	—
<b>Sub total</b>	<b>12 214</b>	<b>6 922.05</b>	<b>129 457.41</b>	<b>118 849.50</b>	<b>255 228.96</b>	<b>20.90</b>	<b>1 815.38</b>	<b>94 322.59</b>	<b>351 366.93</b>	<b>28.76</b>	<b>119 186.90</b>	<b>9.76</b>	<b>3 329.92</b>	<b>235 509.94</b>

**CARBON-IN-PULP**

Coolgardie	7 389	—	5 689.50	28 582.97	34 272.47	4.64	4 341.65	45 951.84	84 565.96	11.45	79 032.30	10.70	—	5 533.66
Kalgoorlie	10 952	14 624.84	14 576.50	62 681.46	91 882.80	8.39	8 366.64	65 391.08	165 640.52	15.13	178 360.12	16.29	12 719.60	—
Meekatharra	764	—	349.89	16 535.35	16 885.24	22.11	2 201.43	5 258.34	24 345.01	31.87	—	—	—	24 345.01
<b>Sub Total</b>	<b>19 105</b>	<b>14 624.84</b>	<b>20 615.89</b>	<b>107 799.78</b>	<b>143 040.51</b>	<b>7.49</b>	<b>14 909.72</b>	<b>116 601.26</b>	<b>274 551.49</b>	<b>14.37</b>	<b>257 392.42</b>	<b>13.48</b>	<b>12 719.60</b>	<b>29 878.67</b>
Special Agreements	—	—	—	—	—	—	—	—	—	—	194 929.86	—	194 929.86	—
<b>Totals</b>	<b>31 319</b>	<b>21 546.89</b>	<b>150 073.30</b>	<b>226 649.28</b>	<b>398 269.47</b>	<b>12.72</b>	<b>16 725.10</b>	<b>210 923.85</b>	<b>625 918.42</b>	<b>19.88</b>	<b>571 509.18</b>	<b>—</b>	<b>210 979.38</b>	<b>265 388.62</b>

Less interest paid to Treasury  
Total

4 320.00  
269 708.62

**State Batteries Trading and Profit/Loss Account for the Year Ended 31 December, 1981**

1980			1981	
\$	\$		\$	\$
1 410 579		<i>Trading costs:</i>		
441 908		Wages .....	1 484 336	
156 212		Stores .....	547 183	
530 087		Repairs, renewals and Battery spares .....	183 742	
		General expenses and administration .....	634 681	
	2 548 649			2 849 942
		<i>Earnings:</i>		
	606 467	Milling, cyaniding, mag plant, carbon-in-pulp and Special Agreements .....		1 039 225
	1 942 182			
				<b>Operating Loss For Year</b>
				1 810 717
		<i>Other charges:</i>		
63 435		Interest on capital .....	68 302	
43 810		Depreciation .....	73 160	
52 157		Superannuation—employers share .....	56 731	
	159 402			198 193
	2 101 584			2 008 910
				<b>Total loss for year</b>

**State Batteries Balance Sheet as at 31 December, 1981  
Funds Employed**

		<i>Capital:</i>		
1 505 663		Provided from General Loan Fund .....	1 613 829	
641 850		Provided from Consolidated Revenue Fund .....	858 028	
	2 147 513			2 471 857
		<i>Reserves:</i>		
57 243		Commonwealth Grant—assistance to gold mining industry .....	57 243	
27 573		Commonwealth Grant—assistance to metalliferous mining .....	27 573	
	84 816			84 816
		<i>Liability to Treasurer:</i>		
3 141 659		Interest on capital .....		3 209 961
		<i>Other Funds:</i>		
18 163 437		Provided from Consolidated Revenue Fund (Excess of payment over collections) .....		19 904 454
	23 537 425			25 671 088
		<i>Deduct</i>		
		<i>Profit and Loss:</i>		
21 297 460		Loss at commencement of year .....	23 399 044	
2 101 584		Loss for year .....	2 008 910	
	23 399 044			25 407 954
				<b>Total loss from inception</b>
	138 381			263 134
				<b>Funds Employed</b>

**Employment of Funds**

		<i>Fixed assets</i>		
2 136 431		Plant, buildings and equipment .....	2 418 364	
1 822 283		Less depreciation .....	1 895 443	
	314 148			522 921
		<i>Current assets</i>		
83 294		Debtors .....	125 063	
100 586		Stores .....	131 621	
75 010		Battery spares .....	73 602	
		<i>Purchase of tailings:</i>		
46 661		Treasury Trust Account .....	41 134	
52 318		Tailings not treated .....	56 029	
	357 869			427 449
	672 017			950 370
		<i>Deduct</i>		
		<i>Current Liabilities:</i>		
84 657		Creditors Liability to Treasurer .....	183 341	
446 000		(Superannuation—Employers share) .....	502 731	
2 979		Purchase of tailings: Creditors .....	1 164	
	533 636			687 236
	138 381			263 134
				<b>Funds Employed</b>

PETROLEUM DIVISION

Tenements Held Under the Petroleum (Submerged Lands) Act, 1967

Permit Numbers	Registered Holders	Number of graticular sections	Area (km <sup>2</sup> )	Expiry date
<b>EXPLORATION PERMITS</b>				
WA-1-P-R2	Woodside Oil Ltd, Woodside Petroleum Development Pty Ltd, Mid-Eastern Oil Ltd, Shell Development (Australia) Pty Ltd, BP Petroleum Development Australia Pty Ltd, California Asiatic Oil Company, Hematite Petroleum Pty Ltd.	75	6 750	14/11/84
WA-13-P-R2	West Australian Petroleum Pty Limited	35	2 545	29/08/84
WA-18-P-R2	Australian Aquitaine Petroleum Pty Ltd	52	4 320	16/04/85
WA-23-P-R2	West Australian Petroleum Pty Limited	4	320	03/10/84
WA-24-P-R2	West Australian Petroleum Pty Limited	16 (Part 1) 36 (Part 2)	4 125	17/10/84
WA-25-P-R2	West Australian Petroleum Pty Limited	64	5 125	16/10/84
WA-28-P-R2	Woodside Oil Ltd, Woodside Petroleum Development Pty Ltd, Mid-Eastern Oil Ltd, Shell Development (Australia) Pty Ltd, BP Petroleum Development Australia Pty Ltd, California Asiatic Oil Company, Hematite Petroleum Pty Ltd.	16 (Part 1) 16 (Part 2) 2 (Part 3) 46 (Part 4)	6 455	24/03/85
WA-32-P-R2	Woodside Oil Ltd, Woodside Development Pty Ltd, Mid-Eastern Oil Ltd, Shell Development (Australia) Pty Ltd, BP Petroleum Development Australia Pty Ltd, California Asiatic Oil Company, Hematite Petroleum Pty Ltd.	50	4 120	02/07/85
WA-33-P-R2	Woodside Oil Ltd, Woodside Petroleum Development Pty Ltd, Mid-Eastern Oil Ltd, Shell Development (Australia) Pty Ltd, BP Petroleum Development Australia Pty Ltd, California Asiatic Oil Company, Hematite Petroleum Pty Ltd.	74 (Part 1) 23 (Part 2)	8 040	18/05/85
WA-34-P-R2	Woodside Oil Ltd, Woodside Petroleum Development Pty Ltd, Mid-Eastern Oil Ltd, Shell Development (Australia) Pty Ltd, California Asiatic Oil Company, Hematite Petroleum Pty Ltd.	74	6 135	02/07/85
WA-35-P-R2	Woodside Oil Ltd, Woodside Petroleum Development Pty Ltd, Mid-Eastern Oil Ltd, Shell Development (Australia) Pty Ltd, Hematite Petroleum Pty Ltd.	62	5 150	02/07/85
WA-36-P-R1	Woodside Oil Ltd, Woodside Petroleum Development Pty Ltd, Mid-Eastern Oil Ltd, BP Petroleum Development Australia Pty Ltd, Hematite Petroleum Pty Ltd.	18	1 520	18/05/80
WA-37-P-R2	Woodside Oil Ltd, Woodside Petroleum Development Pty Ltd, Mid-Eastern Oil Ltd, Shell Development (Australia) Pty Ltd, BP Petroleum Development Australia Pty Ltd, Hematite Petroleum Pty Ltd.	27 (Part 1) 3 (Part 2)	2 495	02/06/85
WA-58-P	Western Energy Pty Ltd, Stirling Petroleum N.L.	222	17 890	11/07/82
WA-59-P	Western Mining Corporation Limited.	190	14 320	18/06/82
WA-62-P	Oxoco International Inc., Peyto Exploration Inc., Voyager Petroleum Ltd, Australian Oil and Gas Corporation Ltd, Bridge Oil Limited, Endeavour Resources Ltd, AAR Ltd, Offshore Oil N.L., BP Petroleum Development Australia Pty Ltd.	226	18 265	07/03/83
WA-64-P	Offshore Oil N.L., Southern Cross Exploration N.L., Hallmark Minerals N.L.	22	1 760	28/02/83
WA-68-P	Oxoco International Inc., Peyto Exploration Inc., Voyager Petroleum Aust. Ltd., Bridge Oil Ltd.	249	20 730	07/03/83
WA-74-P	Pelsart Oil N.L.	253	21 270	24/06/83
WA-77-P	Magnet Metals Ltd, Jeerinah Mining Pty Ltd, Sundance Resources (Cayman) Limited, Crux (International) Limited, Scorpio Petroleum Ltd, Pluto Petroleum Ltd.	254	21 270	01/08/83
WA-84-P	Mobil Oil Australia Ltd, Phillips Australian Oil Co., Australian Gulf Oil Company, M.I.M. Investments Pty Ltd, BP Petroleum Development Australia Pty Ltd.	400	32 330	18/11/83
WA-93-P	Hudbay Oil (Australia) Ltd, Pan Canadian Petroleum Limited Australian Oil & Gas Corporation Limited.	400	32 470	18/11/83
WA-96-P	Eso Exploration and Production Australia Inc., Hematite Petroleum Pty. Ltd.	400	32 180	18/11/83
WA-97-P	Eso Exploration and Production Australia Inc., Hematite Petroleum Pty Ltd.	400	32 080	18/11/83
WA-102-P	CNW Oil (Australia) Pty Ltd, Star Oil & Gas Ltd, Oakwood International Petroleum N.L., Cultus Pacific N.L.	234	18 410	15/03/84
WA-103-P	Natoñas of West Australia Inc., Wainoco International Inc., Bonaparte Petroleum Limited, Petro Energy Limited, Lennard Oil N.L., White Pine Mining Pty Ltd.	247	20 610	29/12/83
WA-104-P	Oberon Oil Pty Ltd.	242	19 970	07/03/84
WA-109-P	Eso Exploration and Production Australia Inc., Oil Company of Australia N.L., Santos Ltd.	75	6 150	04/07/84
WA-110-P	Cultus Pacific N.L., CNW Oil (Australia) Pty Ltd, Oakwood International Petroleum N.L., Star Oil & Gas Ltd.	25	2 000	24/07/84
WA-113-P	Haoma Gold Mines N.L.	44	3 240	22/09/84
WA-114-P	Era South Pacific Pty Ltd, F S P Exploration Pty Ltd, Carr Boyd Minerals Ltd, Hill Minerals N.L., Monarch Petroleum N.L., Attock Petroleum Ltd.	239	19 500	03/01/85
WA-115-P	Geometsals Oil Exploration Pty Ltd	14	1 040	09/11/84
WA-116-P	Geometsals Oil Exploration Pty Ltd	250	19 450	09/11/84
WA-117-P	Pursuit Exploration Pty Ltd	248	20 200	15/11/84
WA-119-P	Weaver Oil & Gas Corporation Australia	227	18 500	28/05/85
WA-120-P	Weaver Oil & Gas Corporation Australia	250	20 205	28/05/85
WA-125-P	Eso Exploration and Production Australia Inc., Hematite Petroleum Pty Ltd.	162	11 655	08/08/85
WA-126-P	Eso Exploration and Production Australia Inc., Hematite Petroleum Pty Ltd.	230	16 350	08/08/85
WA-128-P	Cultus Oil & Gas Pty Ltd., York Resources N.L., Archean Investments Limited, CNW Oil (Australia) Pty Ltd.	54	3 730	07/08/85
WA-135-P	Chapman Oil of Australia Inc., Wainoco International Inc.	231	16 440	13/11/85
WA-136-P	Conex Oil Exploration Pty Ltd, Geometsals Oil Exploration Pty Ltd.	173	14 220	04/01/86
WA-137-P	BP Petroleum Development Australia Pty Ltd, AAR Limited, Australian Oil & Gas Corporation Limited, Bridge Oil Ltd, Endeavour Resources Ltd, Offshore Oil N.L., Oil Company of Australia N.L., Pelsart Oil N.L., Oxoco International Inc., Peyto Exploration Inc., Voyager Petroleum Aust. Ltd., Stirling Petroleum N.L., Western Energy Pty Ltd.	84	6 810	24/03/86



**PETROLEUM DIVISION**  
**Tenements Held Under the Petroleum (Submerged Lands) Act, 1967—continued**

Permit Numbers	Registered Holders	Number of graticular sections	Area (km <sup>2</sup> )	Expiry date
WA-139-P	Oil & Minerals Quest N.L. Terrex Resources N.L., Mincorp Ltd., Mid-East Minerals N.L.	80	6 560	20/12/86
WA-142-P	BP Petroleum Development Australia Pty Ltd, AAR Limited, Australian Oil & Gas Corporation Limited, Bridge Oil Ltd, Endeavour Resources Ltd, Offshore Oil N.L., Oil Company of Australia N.L., Pelsart Oil N.L., Oxoco International Inc., Peyto Exploration Inc., Voyager Petroleum Aust. Ltd. Stirling Petroleum N.L., Western Energy Pty. Ltd.	36	2 925	18/11/86
WA-144-P	Mesa Australia Ltd, Monarch Petroleum N.L., Geometals Oil Exploration Pty. Ltd., Conex Oil Exploration Pty. Ltd.	15	1 110	15/01/87
WA-147-P	Mesa Australia Ltd., Bridge Oil Ltd., Oxoco International Inc., Peyto Exploration Inc., Voyager Petroleum Aust. Ltd, Cluff Oil (Aust) N.L.	128	24 360	28/02/87
WA-149-P	Mesa Australia Ltd., Western Mining Corp. Ltd., Offshore Oil N.L., Pan-Continental Petroleum Ltd., Sydney Oil Co. Ltd., Petro Energy Ltd., Golden West Hydrocarbons Pty. Ltd., Pan Pacific Petroleum N.L.	62	4 950	28/02/87
WA-155-P	Esso Exploration & Production Aust. Inc., Hematite Petroleum Pty. Ltd.	75	5 730	28/02/87
WA-162-P	Diamond Shamrock Oil Co. (Aust) Pty. Ltd., Era Petroleum N.L., Eastern Petroleum Aust. Pty. Ltd., Northern Michigan Exploration Co., International Energy Development Corp Of Aust. Pty. Ltd., Magnet Metals Ltd., Lennard Oil N.L., Monarch Petroleum N.L., Stirling Petroleum N.L.	88	6 580	23/08/87
WA-165-P	Alberta Eastern Gas (1978) Ltd., Asamera Inc.	56	4 160	31/08/87
WA-170-P	Esso Exploration & Production Aust. Inc.	87	6 330	23/08/87
WA-171-P	Balmoral Resources N.L., Forsayth Oil and Gas N.L., Phoenix Oil and Gas N.L., Anvik Aust. Petroleum Pty. Ltd., Hampton Trust Ltd., Southern Pacific Hotel Corp., Energy Pty. Ltd., Eagle Corp. Ltd., Atlas Churchill Pty. Ltd., Finmet Mining N.L.	42	3 100	19/11/87
WA-174-P	BP Australia Ltd., Monarch Petroleum N.L., Mesa Aust. Ltd., Offshore Oil N.L., Whicher Oil N.L.	101	7 270	02/09/87
WA-177-P	Weaver Oil & Gas Corp. Aust	233	19 246	09/09/87
WA-192-P	Australian Occidental Pty. Ltd., Bond Corp. Holdings Ltd., Ranger Oil (Aust) Ltd Texas Eastern Aust. Inc., Reading & Bates Aust. Petroleum Co., Pontoon Oil & Minerals N.L., Pelsart Oil N.L.	164	11 690	16/12/87
<b>PRODUCTION LICENCES</b>				
Licence numbers				
WA-1-L	Woodside Oil Ltd, Woodside Petroleum Development Pty Ltd, Mid-Eastern Oil Ltd,	5	—	29/09/01
WA-2-L	Shell Development (Australia) Pty Ltd, BP Petroleum Development Australia Pty Ltd,	4	—	29/09/01
WA-3-L	California Asiatic Oil Company, Hematite Petroleum Pty Ltd.	5	—	29/09/01
WA-4-L		4	—	29/09/01
WA-5-L		5	—	29/09/01
WA-6-L		4	—	29/09/01

**Tenements Held Under the Petroleum Act, 1936**

Lease Numbers	Registered Holder	Number of graticular sections	Area (km <sup>2</sup> )	Expiry date
<b>PETROLEUM LEASES</b>				
PL-1H	West Australian Petroleum Pty. Ltd.	N/A	259	09/02/88
PL-2H		N/A	259	09/02/88

**Tenements Held Under the Petroleum Act, 1967**

Permit Numbers	Registered Holders	Number of graticular sections	Area (km <sup>2</sup> )	Expiry date
<b>EXPLORATION PERMITS</b>				
EP-23-R2	West Australian Petroleum Pty. Ltd., Mesa Aust. Ltd.	33	2 465	06/08/85
EP-24-R2	West Australian Petroleum Pty. Ltd.	39 (Part 1) 24 (Part 2) 22 (Part 3)	6 265	06/08/85
EP-36-R2	Woodside Oil Ltd., Woodside Petroleum Development Pty. Ltd., Mid-Eastern Oil Ltd., Shell Development (Australia) Pty. Ltd., BP Petroleum Development Australia Pty. Ltd., California Asiatic Oil Company, Hematite Petroleum Pty. Ltd.	1	85	15/04/86
EP-41-R1	West Australian Petroleum Pty. Ltd.	102 (Part 1) 1 (Part 2) 3 (Part 3)	8 400	18/07/81
EP-61-R1	West Australian Petroleum Pty. Ltd.	4	320	19/09/81
EP-62-R1	West Australian Petroleum Pty. Ltd.	2	160	19/09/81
EP-65-R1	West Australian Petroleum Pty. Ltd.	2	160	19/09/81

**Tenements Held Under the Petroleum Act, 1967—continued**

Permit Numbers	Registered Holders	Number of graticular sections	Area (km <sup>2</sup> )	Expiry date
EP-66-R1	West Australian Petroleum Pty. Ltd.	1	80	19/09/81
EP-88	Western Mining Corporation Limited	1	75	18/06/81
EP-89	Western Mining Corporation Limited	2	150	18/06/81
EP-90	Western Mining Corporation Limited	4	300	18/06/81
EP-91	Western Mining Corporation Limited	7	530	18/06/81
EP-96	XLX N.L.	3	225	03/11/81
EP-97	Whitestone Petroleum Australia Ltd., Amax Iron Ore Corporation International Energy Development Corporation of Australia Pty. Ltd., Australian Consolidated Minerals Ltd., YOM Oil Ltd.	64	5 185	16/09/81
EP-100	D. A. Hughes, D. J. Hughes, Strata Oil N.L., Landshare Investment Pty. Ltd., J. M. Goldberg, Wise Nominees Pty. Ltd., Cladium Mining Pty. Ltd., A. R. Burns, V. W. Burns, D. R. Gascoine, J. Gascoine, B. C. Forster, Haoma Petroleum Pty. Ltd.	163	12 000	03/10/82
EP-101	Whitestone Petroleum Australia Ltd., Amax Iron Ore Corporation, International Energy Development Corporation of Australia Pty. Ltd., Australian Consolidated Minerals Ltd., Australian Occidental Petroleum Inc., Vamgas Ltd., YOM Oil Ltd.	172	14 040	24/06/82
EP-102	Whitestone Petroleum Australia Ltd., Amax Iron Oil Corporation, International Energy Development Corporation of Australia Pty. Ltd., Australian Consolidated Minerals Ltd., YOM Oil Ltd.	200	16 180	24/06/82
EP-103	Whitestone Petroleum Australia Ltd, YOM Oil Ltd, International Energy Development Corporation Of Australia Pty. Ltd.	184	14 950	22/08/82
EP-104	Esso Exploration and Production Australia Inc., Oil Company of Australia N.L., Santos Ltd.	199	16 280	31/08/82
EP-105	Colgas Inc., Mesa Australia Ltd.	4	300	29/11/82
EP-106	Oberon Oil Pty. Ltd	1	80	07/03/83
EP-107	Era South Pacific Pty Ltd Era West Australia Inc., E.S.P. Explorations Pty Ltd, Cambridge Royalty Co., Cambridge Petroleum Royalties Ltd, North West Mining N.L.	146	11 740	30/06/83
EP-110	Samantha Mines Pty. Ltd. Otter Exploration N.L., Onslow Oil & Gas Exploration Pty. Ltd.	200	15 830	03/08/83
EP-111	Jervois Sulphates (N.T.) Ltd.	42	3 155	21/10/83
EP-112	Weaver Oil & Gas Corporation Australia	135	9 600	29/04/84
EP-114	Swan Resources Ltd, Eagle Corporation Ltd.	196	15 970	22/07/84
EP-126	Australian Aquitaine Petroleum Pty. Ltd., Alliance Petroleum International Ltd, Vamgas Ltd, Western Mining Corporation Ltd.	47	3 880	17/08/84
EP-129	Home Oil Australia Ltd, Australian Occidental Petroleum Inc., Alberta Eastern Gas (1978) Ltd, Vamgas Ltd.	43	3 510	07/08/84
EP-130	Mesa Australia Ltd, Western Mining Corporation Ltd, Offshore Oil N. L. Monarch Petroleum N.L. Whicher Oil N.L.	18	1 285	22/08/84
EP-134	Mobil Oil Aust. Ltd	200	15 935	22/07/84
EP-137	J. O. Clough & Son Pty Ltd, Avon Engineering Pty. Ltd.	72	5 730	22/07/84
EP-142	Chapman Oil of Australia Inc. Wainoco International Inc.	200	16 190	10/10/84
EP-143	Western Mining Corporation Ltd.	198	15 930	20/09/84
EP-144	Magnum Minerals Pty. Ltd. Openpit Mining & Exploration P/L	180	13 270	08/02/85
EP-146	Magnum Minerals Pty. Ltd. Openpit Mining & Exploration P/L	180	13 270	08/02/85
EP-147	Dampier Mining Co.	192	13 930	08/02/85
EP-158	C.S.R. Ltd.	180	13 270	08/02/85
EP-164	Medcon Petroleum Ltd, Brunswick Oil N.L. Pontella Nominees Pty Ltd, Willara Petroleum Pty Ltd, Royal Resources Exploration Inc, Meridian Oil N.L., Delta Petroleum Pty. Ltd	172	13 840	17/06/85
EP-166	Winthrop Investments Ltd. Monarch Petroleum N.L. Meda Petroleum N.L., Geotechnics (Australia) Pty. Ltd.	200	15 700	08/01/85
EP-168	Terrex Resources N.L. Oil, and Minerals Quest N.L. Zanex Ltd, Capital Oil Corporation Ltd, Mincorp Ltd.	200	15 200	16/04/85
EP-169	Eagle Corporation Ltd, Pan Continental Mining Ltd, Elvet Exploration Pty Ltd, Mergul Holdings Pty Ltd	182	14 000	06/06/85
EP-170	Oil Company of Australia N.L. Offshore Oil N.L. E.S.P. Interior Pty Ltd, Pan Pacific Petroleum N.L., Strata Petroleum Pty Ltd.	83	6 650	13/07/85
EP-171	Eagle Corporation Ltd.	96	7 400	20/04/85
EP-174	Australian Aquitaine Petroleum Pty Ltd, Alcoa of Australia Ltd, Alliance Minerals Australia N.L.	32	2 380	16/04/85
EP-175	Getty Oil Development Co Ltd, Union Texas Aust. Inc, Alliance Petroleum International Ltd.	193	15 620	23/01/85
EP-178	The Shell Company of Australia Ltd.	200	15 375	30/04/85
EP-179	The Shell Company of Australia Ltd.	200	15 480	30/04/85
EP-180	The Shell Company of Australia Ltd.	200	15 260	30/04/85
EP-181	C.R.A. Exploration Pty Ltd.	109	8 170	15/08/86
EP-182		200	14 700	28/05/85
EP-183	C.R.A. Exploration Pty. Ltd., Eagle Corporation Ltd, Swan Resources Ltd.	200	14 850	28/05/85
EP-184		200	14 960	28/05/85
EP-185		200	15 070	28/05/85
EP-186		200	15 650	22/07/85
EP-187		200	15 530	22/07/85
EP-188	Esso Exploration and Production Australia Inc.	118	9 230	22/07/85
EP-189	Esso Exploration and Production Australia Inc.	144	11 180	22/07/85
EP-192	Carr Boyd Minerals Ltd, Hill Minerals N.L., Monarch Petroleum N.L.	191	13 900	28/07/85
EP-193		200	14 700	25/08/85
EP-194		200	14 850	25/08/85
EP-195		199	14 670	25/08/85
EP-196	Western Mining Corporation Ltd.	194	14 150	25/08/85
EP-197		199	14 810	25/08/85
EP-198		143	10 320	25/08/85
EP-201		31	2 330	04/12/85

**Tenements Held Under the Petroleum Act, 1967—continued**

Permit Numbers	Registered Holders	Number of graticular sections	Area (km <sup>2</sup> )	Expiry date
EP-204	Phoenix Oil & Gas N.L., Girvan Oil & Gas Pty Ltd, Eastmet Ltd, Oilmin N.L., Transoil N.L., Petrolmin N.L., Basin Oil N.L., Reef Oil N.L., Pan-Continental Petroleum Ltd, Mid-Eastern Minerals N.L., Petro Energy Ltd.	32	2 330	29/12/85
EP-205	Whim Creek Consolidated N.L., Swan Resources Ltd., Eagle Corp. Ltd.	200	15 770	14/01/86
EP-209	Banner Resources Pty Ltd., Forsyth Oil & Gas N.L., Era Petroleum N.L., Phoenix Oil & Gas N.L., Girvan Oil & Gas Pty Ltd.	200	15 600	15/04/86
EP-216	Ranger Oil (Aust.) Ltd., Pontoon Oil & Minerals N.L., Pioneer Concrete Services Ltd.	199	16 000	13/01/86
EP-219	Mobil Oil Aust. Ltd.	185	14 760	21/01/86
EP-221	Meridian Oil N.L., Valiant Consolidated Ltd., Southern Basins Petroleum N.L., Energy Exploration Pty. Ltd.	200	15 880	02/09/86
EP-224	Phoenix Oil & Gas N.L., Girvan Oil & Gas Pty Ltd, Scomeld Pty Ltd.	106	12 720	02/09/86
EP-225	Western Mining Corp. Ltd.	200	16 100	06/03/86
EP-231	Southern Goldfields Ltd., East Hampstead Pty. Ltd., Royal Resources Exploration Inc., Dune Petroleum Pty Ltd.	138	11 103	28/03/86
EP-232	Meridian Oil N.L., Energy Exploration Pty Ltd., Southern Basins Petroleum N.L., International Energy Development Corp. of Aust. Pty Ltd.	195	15 538	23/09/86
EP-239	Weaver Oil & Gas Corp. Aust.	200	15 826	14/07/86
EP-240	Texon Energy Corp., Great Eastern Mines Ltd.	56	13 313	02/11/86
EP-250	Winterbottom Oil & Gas Pty. Ltd., Winterbottom Holdings Ltd., Churchill Atlas Pty. Ltd., Moage Ltd.	76	6 266	23/08/86
EP-278	Agnew Clough Ltd.	24	1 780	19/11/86
<b>PRODUCTION LICENCES</b>				
Licence Numbers				
PL 1	West Australian Petroleum Pty. Ltd.	5	—	24/10/92
PL 2	West Australian Petroleum Pty. Ltd.	4	—	24/10/92

**Petroleum Tenements Under the Petroleum Pipelines Act, 1969**

Number	Expiry Date	Registered Holder
<b>PIPELINE LICENCES (ONSHORE)</b> 1 to 5	01/12/91	California Asiatic Oil Co., Texaco Overseas Petroleum Co., Shell Development (Australia) Pty Ltd, Ampol Exploration Ltd.
<b>PIPE LICENCES (OFFSHORE)</b> WA-1-PL	05/01/2002	Woodside Petroleum Development Pty Ltd, Woodside Oil Ltd, Mid-Eastern Oil Ltd, Shell Development (Australia) Pty Ltd, Hematite Petroleum Pty Ltd, BP Petroleum Development Australia Pty Ltd, California Asiatic Oil Company.

**Tenement Applications Pending Under the Petroleum (Submerged Lands) Act, 1967**

Numbers	Registered Applicant	Number of graticular sections	Area (km <sup>2</sup> )
WA-122-P	Oil & Minerals Quest N.L., Consolidated Gold Mining Areas N.L., Seleka Mining & Investments Ltd., Oklahoma Crude Pty. Ltd., Coldstream Crude Oil & Gas Pty. Ltd.	202	16 760
WA-133-P	Otter Exploration N.L., Pegasus Oil & Gas N.L., Eyre Petroleum Pty. Ltd., Laradef Pty. Ltd.	202	16 760
WA-180-P	Seahawk Oil Aust N.L., Texas Gas Exploration Corp., Voyager Petroleums Aust. Ltd., Sunlite Oil International Inc., Albion International Resources Inc., Petro-Pacific Resources Inc., Cocks Eldorado N.L., Longreach Oil Ltd., Strata Oil N.L., Hopefield Pty. Ltd.	61	5 050
WA-184-P	International Energy Development Corp. of Aust. Pty. Ltd., Northern Michigan Exploration Co., Era Petroleum N.L., Pancontinental Petroleum Inc., Offshore Oil N.L., Strata Oil N.L., Winterbottom Oil & Gas Pty. Ltd., Southern Cross Exploration N.L.	59	4 780
WA-187-P	Esso Exploration & Production Aust. Inc.	32	2 661
WA-188-P	Esso Exploration & Production Aust. Inc.	71	5 870
WA-191-P	Marathon Petroleum Aust. Ltd., Tricentrol North Sea Ltd., Lasmo International Oil Development Ltd., International Energy Resources Ltd., Churchill Energy Ltd., Brunswick Oil N.L.	59	4 780



## Tenement Applications Pending Under the Petroleum Act, 1967

Numbers	Registered Applicant	Number of graticular sections	Area (km <sup>2</sup> )
EP-227	Coho Aust. Ltd., Churchill Energy Ltd.	189	14 590
EP-233	International Energy Development Corp. of Aust. Pty. Ltd., Meridian Oil N.L., Energy Explorations Pty. Ltd., Southern Basins Petroleum N.L.	193	15 479
EP-237	Mesozoic Resources Ltd.	148	15 458
EP-242	Abrolhos Oil & Investment Ltd., Hawkstone Investment Ltd., Western Continental Oil & Gas Pty. Ltd., Dominion Mining & Oil N.L., Forsyth Oil and Gas N.L., Sun-downer Minerals N.L.	200	15 406
EP-243	Getty Oil Development Co. Ltd., Alliance Petroleum International Ltd., LL&E Aust. Inc.	75	7 811
EP-251	Dakota Resources Inc., Juniper Petroleum Corp., Can Del Ltd., Mannville Oil & Gas Ltd.	126	9 970
EP-252	Whim Creek Consolidated N.L., Northgate Exploration Ltd., Eagle Corp. Ltd.	200	15 652
EP-253	Balmoral Resources N.L., Eagle Corp. Ltd.	30	2 417
EP-255	International Mining Corp. N.L.	120	9 496
EP-256	Balmoral Resources N.L., Eagle Corp. Ltd.	100	7 994
EP-257	Balmoral Resources N.L., Eagle Corp. Ltd.	175	13 848
EP-259	Orex Pty. Ltd.	171	13 625
EP-260	Orex Pty. Ltd.	99	7 888
EP-261	Orex Pty. Ltd.	126	9 880
EP-262	Phoenix Oil & Gas N.L., Shallow Nominees Pty. Ltd., Australis Mining N.L., Maitland Mining N.L., Northland Minerals Ltd., Consolidated Resources N.L., Vidor Ltd.	29	2 337
EP-266	XLX N.L.	148	11 694
EP-270	Tantalex Ltd.	104	8 354
EP-271	Petrogulf Resources Ltd., Chieftain Development Co. Ltd., Emirex Petroleum Co. Ltd., Southern Basins Petroleum N.L., Ocita Pty. Ltd., Tannenbar Exploration Ltd.	148	11 649
EP-272	Petrogulf Resources Ltd., Chieftain Development Co. Ltd., Emirex Petroleum Co. Ltd., Southern Basins Petroleum N.L., Ocita Pty. Ltd., Tannenbar Exploration Ltd.	132	10 604
EP-274	Canada Northwest Aust. Oil N.L., Crusade (Carnarvon) Pty. Ltd., C.S.B.P. Farmers Ltd., Chieftain Development Co. Ltd.	132	10 291
EP-275	Strata Oil N.L., The Griffin Coal Mining Co. Ltd., Eagle Corp. Ltd.	189	14 241
EP-276	Rio Alto Exploration Ltd., Consolidated Cinola Mines Ltd., Waddy Lake Resources Inc.	46	3 689
EP-277	Rio Alto Exploration Ltd., Consolidated Cinola Mines Ltd., Waddy Lake Resources Inc.	100	7 994
EP-279	Hugall & Hoile Pty Ltd., Magnet Metals Ltd., Monarch Petroleum N.L., Stirling Petroleum N.L., Lennard Oil N.L.	199	15 514
EP-280	Rio Alto Exploration Ltd., Consolidated Cinola Mines Ltd., Waddy Lake Resources Inc.	46	3 653
EP-281	Canso Resources Ltd., Southern Goldfields Ltd.	199	14 519
EP-282	Phoenix Oil & Gas N.L., Girvan Oil & Gas Pty. Ltd., Scomeid Pty Ltd.	29	2 337
EP 283	Churchill Atlas Pty. Ltd. Windsor Resources N.L.	122	4 960
EP 284	Churchill Atlas Pty. Ltd. Windsor Resources N.L.	61	4 628
EP 285	Churchill Atlas Pty. Ltd. Windsor Resources N.L.	46	3 653
EP 286	Churchill Atlas Pty. Ltd. Windsor Resources N.L.	105	8 249
EP 287	Landmark Oil & Gas Ltd., Australis Mining N.L., Consolidated Resources N.L., Maitland Mining N.L., Northland Minerals Ltd., Clifford Minerals Ltd.	29	2 337
EP 288	Placer Cego Petroleum Ltd., Cape Range Oil N.L., Blight Oil & Minerals N.L., National Mutual Life Association of Australasia Ltd., Pan-Continental Petroleum Ltd., Mungeroo Development Pty. Ltd.	47	3 800
EP 289	Idec of Aust. Pty. Ltd., Amax Aust. Ltd., Whitestone Petroleum Aust. Ltd., Vamgas Ltd., Australian Consolidated Minerals Ltd., Yom Oil Ltd.	47	3 800
EP 290	Sion Resources Aust. Ltd., Southern Tier Oil Ltd., Agak Pty. Ltd.	29	2 337
EP 291	Ranger Oil (Aust) Ltd., Bridge Oil Ltd., International Oil Pty., Project Oil Exploration Ltd., Pontoon Oil & Minerals N.L., Pelsart Oil N.L., Pioneer Concrete Services Ltd.	47	3 800
EP 292	ESP Interior Pty. Ltd., Oil Company of Aust. N.L., Offshore Oil N.L., Pan Pacific Petroleum N.L., Strata Oil N.L.	47	3 800
EP 293	Strata Oil N.L., The Griffin Coal Mining Co. Ltd., Eagle Corp. Ltd.	188	14 134
EP 294	New Frontiers Ltd., Australian Oil & Gas Corp. Ltd., Endeavour Resources Ltd., First Oil & Gas N.L., Gulf Canada Ltd., Oakwood International Petroleum N.L.	47	3 800
EP 295	Golden West Hydrocarbons Pty. Ltd., Petrofina S.A., Sion Resources Aust. Ltd., Chimelle Pty. Ltd., Charterhall Oil Aust. Pty. Ltd., Weeks Aust. Ltd.	47	3 800
EP 296	Balmoral Resources N.L.	47	3 800
EP 297	Emirex Petroleum Co. Ltd., Chieftain Development Co. Ltd., Berkeley Exploration & Production Ltd., Cabre Exploration Ltd., Gane Petroleum Corp. Ltd.	198	15 668
EP 298	Emirex Petroleum Co. Ltd., Chieftain Development Co. Ltd., Berkeley Exploration & Production Ltd., Cabre Exploration Ltd., Gane Petroleum Corp. Ltd.	193	15 428

**Dealings Under the Petroleum (Submerged Lands) Act, 1967, During 1981  
Advertisements (Section 20)**

Area Number	Basin	Date Gazetted	Closing Date	Number of Graticular Sections	Area <sup>2</sup> (km <sup>2</sup> )
<b>"CLOSING DATE" SECTION 20(1)</b>					
W81-56	Browse	01/05/81	28/08/81	57	4 320
W81-57	Browse	01/05/81	28/08/81	32	2 661
W81-58	Browse	01/05/81	28/08/81	71	5 870
W81-59	Browse	01/05/81	28/08/81	60	4 940
W81-60	Browse	01/05/81	28/08/81	31	2 570
W81-61	Browse	01/05/81	28/08/81	61	5 050
W81-62	Canning	01/05/81	28/08/81	104	8 480
W81-62	Canning	01/05/81	28/08/81	104	8 480
W81-64	Canning	01/05/81	28/08/81	93	7 550
W81-65	Canning	01/05/81	28/08/81	59	4 780
W81-66	Carnarvon	01/05/81	28/08/81	52	4 200
W81-67	Carnarvon	01/05/81	28/08/81	164	11 690
W81-56	Browse	27/11/81	26/03/82	57	4 320
W81-59	Browse	27/11/81	26/03/82	60	4 940
W81-60	Browse	27/11/81	26/03/82	31	2 570
W81-62	Canning	27/11/81	26/03/82	104	8 480
W81-63	Canning	27/11/81	26/03/82	104	8 480
W81-64	Canning	27/11/81	26/03/82	93	7 550
W81-66	Carnarvon	27/11/81	26/03/82	52	4 200
W82-68	Canning	27/11/81	26/03/82	400	32 510
W81-69	Carnarvon	27/11/81	26/03/82	249	19 010
W81-70	Bonaparte	27/11/81	26/03/82	22	1 830
W81-71	Bonaparte	27/11/81	26/03/82	31	2 580

**Access Authorities and Consents (Section 112)**

Number	Applicant	Basin or Area of Survey	Permit or Area Requiring Access Authority
AA 109	Esso Exploration and Production Australia Inc	Carnarvon	WA-155-P
AA 110	ESP Exploration Pty Ltd	Canning	WA-114-P
AA 111	Mesa Australia Ltd	Carnarvon	WA-149-P
AA 112	Hudbay Oil (Aust) Ltd	Carnarvon	WA-93-P
AA 113	Conex Oil Exploration Pty Ltd	Browse	WA-136-P
AA 114	West Australian Petroleum Pty Ltd	Carnarvon	WA-25-P
AA 115	Magnet Metals Limited	Bonaparte	WA-77-P
AA 116	Lennard Oil N.L.	Bonaparte	WA-103-P
AA 117	Lennard Oil N.L.	Bonaparte	WA-103-P
AA 118	Australian Aquitaine Petroleum Pty Ltd	Bonaparte	WA-18-P
AA 119	Esso Exploration and Production Australia Inc	Carnarvon	WA-155-P
AA 120	Mesa Australia Ltd	Perth	WA-144-P
AA 121	Woodside Petroleum Development Pty Ltd	Carnarvon and Canning	WA-28-P & WA-33-P
AA 122	Woodside Petroleum Development Pty Ltd	Browse	WA-35-P
AA 123	Woodside Petroleum Development Pty Ltd	Browse	WA-37-P
AA 125	Australian Aquitaine Petroleum Pty Ltd	Bonaparte	WA-18-P
AA 126	Weaver Oil & Gas Corporation Aust	Browse/Canning	WA-119-P
AA 128	Weaver Oil & Gas Corporation Aust	Canning	WA-120-P
AA 129	BP Development Australia Pty Ltd	Perth	WA-174-P
AA 130	Australian Occidental Petroleum Inc	Carnarvon	WA-192-P
AA 131	West Australian Petroleum Pty Ltd	Carnarvon	WA-25-P
AA 132	West Australian Petroleum Pty Ltd	Carnarvon	WA-25-P
AA 133	Woodside Petroleum Development Pty Ltd	Browse	WA-32-P

## Dealings Under the Petroleum (Submerged Lands) Act, 1967, During 1981

### Exploration Permit Applications and Grants (Sections 21 and 22)

Application for Permit Number	Area Number	Application	Date Received	Basin	Number of graticular sections	Area (km <sup>2</sup> )	Status	Operating Date
WA-122-P	W76-16	Oil & Minerals Quest <i>et al</i>	16/03/79	Browse	202	16 760	Pending	—
WA-133-P	W76-16	Otter Exploration <i>et al</i>	20/04/79	Browse	202	16 760	Pending	—
WA-144-P	W77-40	Mesa <i>et al</i>	01/08/80	Perth	15	1 111	Granted	16/01/81
WA-146-P	W80-47	Weeks Petroleum <i>et al</i>	10/10/80	Bonaparte Gulf	291	24 360	Refused	13/02/81
WA-147-P	W80-47	Mesa Aust. <i>et al</i>	10/10/80	Bonaparte Gulf	291	24 360	Granted	01/03/81
WA-148-P	W80-47	Stirling Petroleum <i>et al</i>	10/10/80	Bonaparte Gulf	291	24 360	Refused	13/02/81
WA-149-P	W80-50	Mesa <i>et al</i>	30/10/80	Carnarvon	75	4 950	Granted	01/03/81
WA-150-P	W80-48	Mesa <i>et al</i>	30/10/80	Carnarvon	75	5 730	Refused	19/02/81
WA-151-P	W80-48	Getty <i>et al</i>	31/10/80	Carnarvon	75	5 730	Refused	19/02/81
WA-152-P	W80-48	Phillips <i>et al</i>	31/10/80	Carnarvon	75	5 730	Refused	19/02/81
WA-153-P	W80-49	Phillips <i>et al</i>	31/10/80	Carnarvon	2	160	Refused	01/03/81
WA-154-P	W80-48	L. L. and E. Australia Inc. <i>et al</i>	31/10/80	Carnarvon	75	5 730	Refused	19/02/81
WA-155-P	W80-48	Esso <i>et al</i>	31/10/80	Carnarvon	75	5 730	Granted	01/03/81
WA-156-P	W80-50	Esso <i>et al</i>	31/10/80	Carnarvon	62	4 950	Refused	13/02/81
WA-157-P	W80-49	CNW <i>et al</i>	31/10/80	Carnarvon	2	160	Refused	01/03/81
WA-158-P	W80-48	Australian Gulf Oil Co <i>et al</i>	31/10/80	Carnarvon	75	5 730	Refused	19/02/81
WA-159-P	W80-48	Stirling <i>et al</i>	31/10/80	Carnarvon	75	5 730	Refused	19/02/81
WA-160-P	W80-50 (part)	Oil & Minerals Quest N.L.	31/10/80	Carnarvon	60	4 950	Refused	13/02/81
WA-161-P	W80-48	Sion Resources Aust Ltd	31/10/80	Carnarvon	75	5 730	Refused	19/02/81
WA-162-P	W80-51	Diamond Shamrock <i>et al</i>	02/02/81	Perth	88	6 580	Granted	24/08/81
WA-163-P	W80-52	Diamond Shamrock <i>et al</i>	02/02/81	Perth	56	4 160	Refused	21/08/81
WA-164-P	W80-51	Alberta Eastern Gas <i>et al</i>	02/02/81	Perth	88	6 580	Refused	18/08/81
WA-165-P	W80-52	Alberta Eastern Gas <i>et al</i>	02/02/81	Perth	56	4 160	Granted	01/09/81
WA-166-P	W80-51	Mobil Oil	02/02/81	Perth	88	6 580	Refused	18/08/81
WA-167-P	W80-51	Tricentral North Sea <i>et al</i>	02/02/81	Perth	88	6 580	Refused	18/08/81
WA-168-P	W80-52	Tricentral North Sea <i>et al</i>	02/02/81	Perth	56	4 160	Refused	21/08/81
WA-169-P	W80-54	Tricentral North Sea <i>et al</i>	02/02/81	Perth	87	6 330	Refused	17/08/81
WA-170-P	W80-54	Esso	02/02/81	Perth	87	6 330	Granted	24/08/81
WA-171-P	W80-53	Balmoral <i>et al</i>	02/02/81	Perth	42	3 100	Granted	20/11/81
WA-172-P	W80-54	Balmoral <i>et al</i>	02/02/81	Perth	29	2 116	Refused	17/08/81
WA-173-P	W80-51	Mesa <i>et al</i>	02/02/81	Perth	88	6 580	Refused	18/08/81
WA-174-P	W80-55	B.P. <i>et al</i>	02/02/81	Perth	101	7 270	Granted	03/09/81
WA-175-P	W80-55	Abrolhos <i>et al</i>	02/02/81	Perth	101	7 270	Refused	27/08/81
WA-176-P	W80-51	Canada NW <i>et al</i>	02/02/81	Perth	88	6 580	Refused	18/08/81
WA-177-P	W76-19	Weaver Oil & Gas Corp. Australia	14/04/81	Browse	233	19 246	Granted	10/09/81
WA-178-P	W76-19	Sea Hawk Oil International Inc. <i>et al</i>	15/04/81	Browse	233	19 246	Refused	01/09/81
WA-179-P	W81-60	Sea Hawk Oil Australia N.L. <i>et al</i>	27/08/81	Browse	31	2 570	Refused	19/11/81
WA-180-P	W81-61	Sea Hawk Oil Australia N.L. <i>et al</i>	27/08/81	Browse	61	5 050	Pending	—
WA-181-P	W81-67	Sea Hawk Oil Australia N.L. <i>et al</i>	27/08/81	Carnarvon	68	—	Refused	10/12/81
WA-182-P	W81-67	BP Australia Limited <i>et al</i>	27/08/81	Carnarvon	164	11 690	Refused	10/12/81
WA-183-P	W81-67	Mesa <i>et al</i>	28/08/81	Carnarvon	164	11 690	Refused	10/12/81
WA-184-P	W81-65	Iedca Pty Ltd <i>et al</i>	28/08/81	Carnarvon	59	4 780	Pending	—
WA-185-P	W81-67	Iedca Pty Ltd <i>et al</i>	28/08/81	Carnarvon	164	11 690	Refused	10/12/81
WA-186-P	W81-67	New Frontiers Limited <i>et al</i>	28/08/81	Carnarvon	164	11 690	Refused	10/12/81
WA-187-P	W81-57	Esso	28/08/81	Carnarvon	32	2 661	Pending	—
WA-188-P	W81-58	Esso	28/08/81	Browse	71	5 870	Pending	—
WA-189-P	W81-67	Esso	28/08/81	Carnarvon	164	11 692	Refused	10/12/81
WA-190-P	W81-67	Getty Oil Development <i>et al</i>	28/08/81	Carnarvon	164	11 690	Refused	10/12/81
WA-191-P	W81-65	Marathon Petroleum Aust Ltd <i>et al</i>	28/08/81	Carnarvon	59	4 780	Pending	—
WA-192-P	W81-67	Australia Occidental Pty Ltd <i>et al</i>	28/08/81	Carnarvon	164	11 690	Granted	17/12/81
WA-193-P	W81-67	Chimelle Pty Ltd <i>et al</i>	28/08/81	Carnarvon	164	11 690	Refused	10/12/81
WA-194-P	W81-67	Phillips Australia Oil Co. <i>et al</i>	28/08/81	Carnarvon	164	11 690	Refused	10/12/81
WA-195-P	W81-67	Hudbay Oil Australia <i>et al</i>	28/08/81	Carnarvon	164	11 690	Refused	10/12/81

### Offshore Permits Surrendered

Permit Number	Basin	Permittee	Date Surrendered	Number of graticular sections		Area (km <sup>2</sup> )
				Original	Surrendered	
WA-68-P	Browse/Bonaparte	Oxoco	Appln.	249	249	20 730
WA-79-P	Canning	Hematite	1/5/81	235	235	19 155
WA-80-P	Carnarvon	Otter	1/5/81	16	16	1 300
WA-81-P	Carnarvon/Perth	Conoco	28/8/81	249	249	19 010
WA-84-P	Carnarvon	Phillips	Appln.	400	400	32 330
WA-90-P	Perth	Woodside	7/8/81	400	400	32 470
WA-93-P	Carnarvon	Hudbay	Appln.	400	232	32 470



**Dealings Under the Petroleum Act, 1967, during 1981**

**Advertisements (Section 30)**

Area Number	Basin	Date Gazetted	Closing Dates	Number of graticular sections	Area (km <sup>2</sup> )
<b>"CLOSING DATE" (SECTION 30 (1))</b>					
L81—59	Perth	19/06/81	11/09/81	24	1 780
L81—60	Canning	21/08/81	13/11/81	47	3 800

**Access Authorities (Section 106)**

Number	Applicant	Basin or area of survey	Permit or area requiring Access Authority
AA 21	Amax Iron Ore Corporation	Canning	EP 97, 101, 102
AA 22	Mesa Australia Ltd	Perth	EP 105
AA 23	Whitstone Petroleum Australia Limited	Canning	EP 103
AA 24	Mesa Australia Ltd	Perth	EP 100
AA 25	Amax Iron Ore Corporation	Canning	EP 101
AA 26	E.S.P. Exploration Pty Ltd	Canning	EP 170
AA 27	Amax Iron Ore Corporation	Canning	EP 102
AA 28	International Energy Development Corp.	Canning	EP 103
AA 29	Esso Exploration & Production Australia Inc.	Canning	EP 104
AA 30	Esso Exploration & Production Australia Inc.	Carnarvon	EP 188, 189
AA 31	Home Oil Australia Limited	Canning	EP 129
AA 32	Monarch Petroleum N.L.	Carnarvon	EP 166

**Exploration Permit Surrenders (Section 98)**

Permit Number	Basin or Area	Permittee	Date of surrender (Gazetted)	Number of graticular sections		Area (km <sup>2</sup> )
				Original	Surrendered	
EP 157	Eastern Goldfields	Swan Resources	30/10/81	192	192	13 930
EP 182	Officer	CRA	Appln.	200	200	14 700
EP 193	Eucla	WMC	Appln.	200	200	14 700
EP 194	Eucla	WMC	Appln.	200	200	14 850
EP 195	Eucla	WMC	Appln.	199	199	14 670
EP 196	Eucla	WMC	Appln.	194	194	14 150
EP 197	Eucla	WMC	Appln.	199	199	14 810
EP 198	Eucla	WMC	Appln.	143	143	10 320

**Renewals**

Permit Number	Basin	Permittee	Number of graticular sections	First term expiry date	Status	Graticular sections renewed	Area (km <sup>2</sup> )	Expiry date
EP 36 R2	Browse	Woodside	1	15/04/81	Renewed	1	85	15/04/86
EP 41 R2	Carnarvon	Wapet	90	18/07/81	Appln.			
EP 61 R2	Carnarvon	Wapet	4	19/09/81	Appln.			
EP 62 R2	Carnarvon	Wapet	2	19/09/81	Appln.			
EP 65 R2	Carnarvon	Wapet	2	19/09/81	Appln.			
EP 66 R2	Carnarvon	Wapet	1	19/09/81	Appln.			
EP 88 R1	Perth	WMC	1	18/06/81	Appln.			
EP 89 R1	Perth	WMC	2	18/06/81	Appln.			
EP 90 R1	Perth	WMC	4	18/06/81	Appln.			
EP 91 R1	Perth	WMC	7	18/06/81	Appln.			
EP 97 R1	Canning	IADC of Aust.	64	16/09/81	Appln.			
EP 96 R1	Perth	XLX	3	03/11/81	Appln.			

## Exploration Permit Applications, Grants and Withdrawals (Sections 31 and 32)

Application for Permit Number	Area Number	Applicant	Date Application	Basin	Number of Graticular Sections	Area (km <sup>2</sup> )	Status	Operative Date
EP 181	L79-56	CRA Exploration Pty Ltd	11/01/80	Perth	109	8 170	Granted	16/08/81
EP 202	L75-8	CRA	30/06/80	Carnarvon	187	14 520	Refused	26/06/81
EP 203	L76-21	North Broken Hill <i>et al</i>	30/06/80	Perth	168	12 720	Refused	17/07/81
EP 205	(Parts of areas) L75-17, L78-41, L78-39	Whim Creek Cons. <i>et al</i>	18/07/80	Canning	200	15 770	Granted	15/01/81
EP 206	(Part of area) L 78-42	Whim Creek Cons. <i>et al</i>	18/07/80	Canning	200	15 650	Refused	14/01/81
EP 207	(Part of area) L78-42	Whim Creek Cons. <i>et al</i>	18/07/80	Officer	200	15 590	Refused	14/01/81
EP 209	Unlisted	Banner Resources <i>et al</i>	25/07/80	Officer	200	15 600	Granted	16/04/81
EP 211	Unlisted	The Mintaro Slate & Flagstone Co. Ltd.	05/08/80	Eucla	131	9 506	Refused	26/06/81
EP 212	Unlisted	The Mintaro Slate & Flagstone Co. Ltd.	05/08/80	Eucla	199	14 520	Refused	26/06/81
EP 214	Unlisted	The Mintaro Slate & Flagstone Co. Ltd.	12/08/80	Canning	189	14 500	Refused	30/11/81
EP 215	Unlisted	The Mintaro Slate & Flagstone Co. Ltd.	17/09/80	Officer	200	15 200	Refused	26/06/81
EP 216	L80-57	Ranger <i>et al</i>	07/10/80	Canning	199	16 000	Granted	14/01/81
EP 219	L80-58	Mobil Oil Australia Ltd.	10/10/80	Canning	185	14 760	Granted	22/01/81
EP 220	L80-58	Meridian Oil NL <i>et al</i>	10/10/80	Canning	185	14 760	Refused	15/01/81
EP 221	L75-16	Meridian Oil NL <i>et al</i>	10/10/80	Canning	200	15 880	Granted	14/04/81
EP 224	(Part of area) L76-21	Phoenix Oil & Gas NL <i>et al</i>	04/11/80	Perth	106	12 241	Granted	03/09/81
EP 225	(Parts of areas) L76-29, L78-37, L75-14	WMC	02/12/80	Canning	200	16 100	Granted	07/03/81
EP 226	L76-21	Minwest Fidelity <i>et al</i>	03/12/80	Perth	170	12 720	Refused	24/08/81
EP 227	Unlisted	Minwest Fidelity <i>et al</i>	03/12/80	Canning	189	14 590	Pending	—
EP 228	(Part of area) L76-29	Anjoli Pty Ltd	30/11/80	Canning	119	9 605	Refused	07/03/81
EP 229	(Part of area) L75-10	Anjoli Pty Ltd	30/11/80	Canning	62	4 980	Refused	24/12/81
EP 230	Unlisted	Mintaro Slate & Flagstone <i>et al</i>	31/12/80	Canning	200	15 145	Refused	26/06/81
EP 231	L75-12	Southern Goldfield Ltd <i>et al</i>	07/01/81	Canning	138	11 103	Granted	29/03/81
EP 232	L75-15	Meridian Oil NL <i>et al</i>	28/01/81	Canning	195	15 538	Granted	24/08/81
EP 233	(Part of areas) L75-15, L76-29	Meridian Oil NL <i>et al</i>	28/01/81	Canning	193	15 479	Pending	—
EP 234	L75-10	Meridian Oil NL <i>et al</i>	28/01/81	Canning	97	7 805	Refused	24/12/81
EP 235	L75-15	Perthshire Petroleum Ltd.	30/01/81	Canning	194	15 458	Refused	14/08/81
EP 236	Unlisted	Strata <i>et al</i>	02/02/81	Officer	189	14 995	Lapsed	14/08/81
EP 237	L75-17	Mesozoic Resources Ltd	04/02/81	Canning	148	11 916	Pending	—
EP 238	Unlisted	Balmoral Resources	04/02/81	Carnarvon	98	7 452	Withdrawn	04/12/81
EP 239	(Part of area) L78-39 Plus area unlisted	Weaver Oil & Gas Corp. Aust.	09/02/81	Canning	200	15 826	Granted	15/07/81
EP 240	L78-27	Texas Energy Corp <i>et al</i>	18/02/81	Canning	56	4 491	Granted	03/11/81
EP 241	L78-38	Texas Energy Corp <i>et al</i>	18/02/81	Canning	132	10 604	Refused	20/09/81
EP 242	Unlisted	Abrohos Oil & Invest. Ltd <i>et al</i>	24/12/81	Carnarvon	193	14 857	Pending	—
EP 243	Unlisted	Getty Oil Development Company	04/03/81	Canning	75	6 043	Pending	—
EP 244	L75-10	Churchill Atlas Pty Ltd	18/03/81	Canning	62	4 980	Refused	24/12/81
EP 245	L78-39	Churchill Atlas Pty Ltd	18/03/81	Canning	108	8 546	Refused	01/07/81
EP 246	Unlisted	CRA Exploration Pty Ltd	26/03/81	Officer	200	15 406	Refused	26/06/81
EP 247	Unlisted	CRA Exploration Pty Ltd	26/03/81	Officer	200	15 208	Refused	26/06/81
EP 248	Unlisted	CRA Exploration Pty Ltd	26/03/81	Officer	200	15 070	Refused	26/06/81
EP 249	Unlisted	Miller-Christensen Oil Corp	27/03/81	Canning	47	4 757	Refused	14/08/81
EP 250	L76-19	Winterbottom Oil & Gas Pty. Ltd. <i>et al</i>	01/04/81	Bonaparte Gulf	76	6 266	Granted	24/08/81
EP 251	(part of area) L78-41	Dakota Resources Inc. <i>et al</i>	22/04/81	Canning	126	9 970	Pending	—
EP 252	Unlisted	Whim Creek Consolidated <i>et al</i>	25/05/81	Canning	200	15 652	Pending	—
EP 253	(part of area) L76-29	Balmoral Resources NL Eagle Corp Ltd	12/06/81	Canning	30	2 417	Pending	—
EP 254	(part of area) L76-29	Agak Pty Ltd	11/06/81	Canning	120	9 655	Withdrawn	20/07/81
EP 255	L78-41	International Mining Corp N.L.	15/06/81	Canning	120	4 969	Pending	—
EP 256	Unlisted	Balmoral Resources NL Eagle Corp Ltd	15/06/81	Canning	100	7 994	Pending	—
EP 257	Unlisted	Eagle Corporation Ltd	15/06/81	Canning	175	13 848	Pending	—
EP 258	Part of area L75-8	Hugall & Hoile Pty Ltd <i>et al</i>	24/06/81	Carnarvon	199	15 514	Refused	20/07/81
EP 259	L78-37, L78-38	Orex Pty. Ltd.	07/07/81	Canning	171	13 625	Pending	—
EP 260	L78-39	Orex Pty. Ltd.	07/07/81	Canning	99	7 888	Pending	—
EP 261	L78-42	Orex Pty. Ltd.	07/07/81	Canning	126	9 880	Pending	—
EP 262	L76-29	Phoenix Oil & Gas NL <i>et al</i>	07/07/81	Canning	29	2 337	Pending	—

### Exploration Permit Applications, Grants and Withdrawals (Sections 31 and 32)—*continued*

Application for Permit Number	Area Number	Applicant	Date Application	Basin	Number of Graticular Sections	Area <sup>2</sup> (km <sup>2</sup> )	Status	Operative Date
EP 263	Unlisted	XLX NL	07/07/81	Canning	193	15 504	Refused	24/12/81
EP 264	Unlisted	XLX NL	07/07/81	Canning	97	7 816	Refused	24/12/81
EP 265	L75-15	XLX NL	07/07/81	Canning	194	15 458	Refused	04/10/81
EP 266	Unlisted	XLX NL	07/07/81	Canning	148	11 649	Pending	—
EP 267	Unlisted	XLX NL	07/07/81	Canning	47	4 757	Refused	04/10/81
EP 268	Unlisted	XLX NL	07/07/81	Canning	98	7 809	Refused	04/10/81
EP 269	Part of Area L76-29	Swan Resources Australia Ltd Southern Tier Oil Ltd, Agak Pty Ltd	21/07/81	Canning	29	2 337	Withdrawn	13/11/81
EP 270	Unlisted	Tantalex Limited	03/08/81	Canning	104	8 354	Pending	—
EP 271	L75-17	Petrogulf Resources Limited	06/08/81	Canning	148	11 649	Pending	—
EP 272	L78-38	Petrogulf Resources Limited	06/08/81	Canning	132	10 604	Pending	—
EP 273	Unlisted	International Mining Corp.	13/08/81	Canning	64	4 990	Refused	18/12/81
EP 274	L75-8	Canada North West Oil NL <i>et al</i>	13/08/81	Carnarvon	132	10 291	Pending	—
EP 275	Unlisted	Strata <i>et al</i>	28/08/81	Officer	189	14 241	Pending	—
EP 276	Unlisted	Rio Alto Exploration	04/09/81	Canning	46	3 689	Pending	—
EP 277	Unlisted	Rio Alto Exploration	11/09/81	Canning	100	7 994	Pending	—
EP 278	L81-59	Agnew Clough Limited	11/09/81	Perth	24	1 780	Approved	20/11/81
EP 279	L75-8	Hugall and Hoile Pty Ltd	15/09/81	Carnarvon	199	15 514	Pending	—
EP 280	Unlisted	Rio Alto Exploration	18/09/81	Canning	46	3 653	Pending	—
EP 281	Unlisted	Southern Goldfield Limited	28/09/81	Eucla	199	14 519	Pending	—
EP 282	L76-29	Phoenix Oil & Gas NL	30/09/81	Canning	29	2 337	Pending	—
EP 283	L75-8	Churchill Atlas & Windsor Resources	01/10/81	Carnarvon	64	4 960	Pending	—
EP 284	Unlisted	Churchill Atlas & Windsor Resources	01/10/81	Carnarvon	61	4 628	Pending	—
EP 285	Unlisted	Churchill Atlas & Windsor Resources	01/10/81	Carnarvon	46	3 653	Pending	—
EP 286	L78-42	Churchill Atlas & Windsor Resources	01/10/81	Canning	105	8 289	Pending	—
EP 287	L76-29	Landmark Oil & Gas Ltd <i>et al</i>	14/10/81	Canning	29	2 337	Pending	—
EP 288	L81-60	Placer Cego Petroleum Limited	02/11/81	Canning	47	3 800	Pending	—
EP 289	L81-60	IEDC of Australia P/L	13/11/81	Canning	47	3 800	Pending	—
EP 290	(Part of Area) (L76-29)	Swan Resources Aust. Ltd.	13/11/81	Canning	29	2 337	Pending	—
EP 291	L81-60	Ranger Oil (Aust) Ltd.	13/11/81	Canning	47	3 800	Pending	—
EP 292	L81-60	ESP Interior Pty. Ltd.	13/11/81	Canning	47	3 800	Pending	—
EP 293	Unlisted	Strata Oil N.L. <i>et al</i>	13/11/81	Officer	188	14 134	Pending	—
EP 294	L81-60	New Frontiers Limited	13/11/81	Canning	47	3 800	Pending	—
EP 295	L81-60	Golden West Hydrocarbons Pty. Ltd.	13/11/81	Canning	47	3 800	Pending	—
EP 296	L81-60	Balmoral Resources N.L.	13/11/81	Canning	47	3 800	Pending	—
EP 297	Unlisted	Emirex Petroleum Co. Pty. Ltd <i>et al</i>	01/12/81	Canning	198	15 668	Pending	—
EP 298	Unlisted	Emirex Petroleum Co., Pty Ltd <i>et al</i>	01/12/81	Canning	193	15 428	Pending	—

### Summary Comparison of Exploration Permit Dealings (1980-1981)

	1980		1981	
	No.	Area (km <sup>2</sup> )	No.	Area (km <sup>2</sup> )
<b>Area Advertised</b>				
Onshore	3	33 090	2	5 580
Offshore	10	65 570	16	126 521
<b>Totals</b>	<b>13</b>	<b>98 660</b>	<b>18</b>	<b>132 101</b>
<b>Permits Granted</b>				
Onshore	33	417 805	14	170 125
Offshore	4	30 515	11	94 527
<b>Totals</b>	<b>37</b>	<b>448 320</b>	<b>25</b>	<b>264 652</b>
<b>Permit Applications (pending at end of year)</b>				
Onshore	23	184 895	43	240 662
Offshore	19	53 070	7	35 121
<b>Totals</b>	<b>42</b>	<b>237 965</b>	<b>50</b>	<b>275 783</b>
<b>Permits Held</b>				
Onshore	66	633 460	79	799 686
Offshore	49	665 265	56	664 206
<b>Totals</b>	<b>115</b>	<b>1 298 725</b>	<b>135</b>	<b>1 463 892</b>
<b>Permits Surrendered</b>				
Onshore	2	800	1	13 930
Offshore	Nil	—	4	71 935
<b>Totals</b>	<b>2</b>	<b>800</b>	<b>5</b>	<b>85 865</b>
<b>Renewals</b>				
Onshore	2	8 730	1	85
Offshore	12	55 585	—	—
<b>Totals</b>	<b>14</b>	<b>64 315</b>	<b>1</b>	<b>85</b>
<b>Permits Expired</b>				
Onshore	Nil	—	Nil	—
<b>Totals</b>	<b>Nil</b>	<b>—</b>	<b>Nil</b>	<b>—</b>



## Barrow Island Field—Well Completion Status by Reservoir on 31st December, 1981.

Horizon/Pools	On Production	On Injection	Shut in			Abandoned <sup>3</sup>	Total
			Producers <sup>1</sup>	Injectors	Miscellaneous <sup>2</sup>		
Tertiary-Carbonates <sup>4</sup>	—	8	1	—	—	—	9
Early Cretaceous—Gearle	4	—	6	—	2	—	12
Windalia Radio—larite	—	—	1	—	—	—	1
Windalia Sand	284	134	44	60	9	4	535
Muderong	7	—	5	—	6	—	18
Flacourt (Water Source)	6	—	4	—	—	1	11
Flacourt (Oil)	—	—	1	—	—	—	1
5500' to 6200' sands	—	—	3	—	—	—	3
Upper Jurassic-Dupuy	2	—	5	—	—	—	7
"Other Jurassic"	—	—	—	—	1	1	2
Middle Jurassic	—	—	3	—	—	—	3
<b>Totals</b>	<b>303</b>	<b>142</b>	<b>73</b>	<b>60</b>	<b>18</b>	<b>6</b>	<b>602</b>

<sup>1</sup>Shut in producers includes wells where attempts to obtain commercial production have been unsuccessful.

<sup>2</sup>Miscellaneous includes wells cased but not currently perforated plus wells completed in the water leg for observation.

<sup>3</sup>Abandoned wells are fully plugged and abandoned.

<sup>4</sup>Includes salt water disposal.

General—Recompleted wells are included in horizon/pool of current completion.

## Barrow Island Field, Petroleum Production during 1981 (Kilolitres)

Reservoir	Production for Year 1981					Cumulative Production				
	Oil & Condensate (kL)	Natural Gasoline (kL)	Liquefied Petroleum Gas (kL)	Gas (10 <sup>3</sup> m <sup>3</sup> )	Water (kL)	Oil & Condensate (kL)	Natural Gasoline (kL)	Liquefied Petroleum Gas (kL)	Gas (10 <sup>3</sup> m <sup>3</sup> )	Water (kL)
Gearle	7 378	—	—	2 278	5 838	73 258	—	—	16 221	12 074
Windalia	1 297 940	4 820	3 552	100 654	910 685	27 975 382	41 801	39 530	2 340 000	9 291 155
Muderong	28 878	—	—	3 884	17 977	274 567	—	—	44 045	111 010
Flacourt	783	—	—	199	3 147	1 231	—	—	199	3 534
Early Cretaceous	14	—	—	2	11	16 639	—	—	96 050	44 103
Late Jurassic	5 701	—	—	2 057	40 933	330 410	—	—	157 815	380 653
Middle Jurassic	—	—	—	—	—	1 896	—	—	60 324	616
<b>Totals</b>	<b>1 340 694</b>	<b>4 820</b>	<b>3 552</b>	<b>109 074</b>	<b>978 591</b>	<b>28 673 383</b>	<b>41 801</b>	<b>39 530</b>	<b>2 714 654</b>	<b>9 843 145</b>

Oil and Gas Disposal 1981:

Royalty paid: \$6 164 643

Oil—1 422 757 kL.

Water injected during 1981—2 831 x 10<sup>3</sup> kL.

Gas—15 552 10<sup>3</sup> m<sup>3</sup>—field fuel

Cumulative water injected—61 565 x 10<sup>3</sup> kL.

LPG—2 948 kL sold as LPG; 811 kL blended with crude; 439 kL used as vehicle fuel.

Natural gasoline—4 820 kL blended with crude oil.

## Dongara, Mondarra and Yardarino Fields, Petroleum Production during 1981

Field	Number of producing wells at 31/12/81	Production for Year 1981				Cumulative Production			
		Gas (10 <sup>3</sup> m <sup>3</sup> )	Condensate (kL)	Oil (kL)	Water (kL)	Gas (10 <sup>3</sup> m <sup>3</sup> )	Condensate (kL)	Oil (kL)	Water (kL)
Dongara	15	801 985	2 090	16 223	9 497	7 543 520	31 462	86 353	62 157
Mondarra	2	29 608	495	—	377	519 333	7 304	—	4 653
Yardarino	1	21 880	85	246	1 974	94 036	85	1 858	4 810
<b>TOTALS</b>	<b>18</b>	<b>853 473</b>	<b>2 670</b>	<b>16 469</b>	<b>11 848</b>	<b>8 156 889</b>	<b>38 851</b>	<b>88 211</b>	<b>71 620</b>

Total gas sold in 1981 = 831 929 m<sup>3</sup> x 10<sup>3</sup>

Total condensate sold 1981 = 2 630 kL

Total oil sold in 1981 = 16 518 kL

Royalties: Gas .....\$1 392 873

Condensate .....\$17 795

Oil .....\$116 346

Total: \$1 527 011

### Summary of Petroleum Production to 31st December 1981

	Oil (10 <sup>6</sup> m <sup>3</sup> )		Gas C <sub>1</sub> + C <sub>2</sub> (10 <sup>9</sup> m <sup>3</sup> )		LPG C <sub>3</sub> + C <sub>4</sub> (10 <sup>6</sup> m <sup>3</sup> )		Condensate C <sub>5</sub> + (gasfields) (10 <sup>6</sup> m <sup>3</sup> )	
	1981	Cumulative	1981	Cumulative	1981	Cumulative	1981	Cumulative
Carnarvon Basin:								
Barrow Island	1.341	28.660	0.109	2.559	0.004	0.040	0.004	0.041
Other	—	0.011	—	0.158	—	—	—	0.004
Perth Basin:								
Dongara	6.016	0.086	0.802	7.544	—	—	—	0.029
Mondarra	—	—	0.030	0.520	—	—	—	0.007
Yardarino	—	0.002	0.022	0.094	—	—	—	—
Other	—	—	—	0.062	—	—	—	0.003
<b>Totals</b>	<b>1.357</b>	<b>28.759</b>	<b>0.963</b>	<b>10.937</b>	<b>0.004</b>	<b>0.040</b>	<b>0.004</b>	<b>0.085</b>

### Summary of Identified Recoverable Reserves at 31st December 1981

	Oil (10 <sup>6</sup> m <sup>3</sup> )		Gas C <sub>1</sub> + C <sub>2</sub> (10 <sup>9</sup> m <sup>3</sup> )		LPG C <sub>3</sub> + C <sub>4</sub> (10 <sup>6</sup> m <sup>3</sup> )		Condensate C <sub>5</sub> + (gasfields) (10 <sup>6</sup> m <sup>3</sup> )	
	P1	P2	P1	P2	P1	P2	P1	P2
<b>PRODUCING FIELDS</b>								
Carnarvon Basin:								
Barrow Island	11.21	12.49	0.34	0.37	0.06	0.06	0.06	0.06
Perth Basin:								
Dongara	0.24	0.24	3.73	3.73	—	—	0.02	0.02
Mondarra	—	—	0.07	0.07	—	—	neg.	0.01
Yardarino	neg.	neg.	0.02	0.02	—	—	—	—
<b>Total</b>		<b>12.73</b>		<b>4.19</b>		<b>0.06</b>		<b>0.09</b>
<b>UNDEVELOPED FIELDS</b>								
Angel	—	—	22.80	43.60	—	—	5.35	10.23
Goodwyn	0.17	0.17	63.10	86.00	8.70	11.10	4.77	17.17
Gorgon*	—	—	4.09	84.11	—	—	0.01	0.30
North Rankin	—	—	201.00	235.00	15.80	18.20	19.23	22.10
Tidepole	0.97	1.18	13.03	17.21	—	—	2.26	2.99
West Tryal Rocks*	—	—	8.25	58.94	—	—	0.55	3.94
<b>Total</b>		<b>1.35</b>		<b>525.46</b>		<b>29.30</b>		<b>56.73</b>
<b>Total Reserves</b>		<b>14.08</b>		<b>529.65</b>		<b>29.36</b>		<b>56.82</b>

P1 probability 75%; P2 probability 25%. \* Excludes inerts

## Accident Statistics Relating to the Petroleum Exploration, Production and Pipeline Industry During 1981

### Petroleum Industry Categories

Nature of Injury	Drilling Activities		Barrow Island Oil Field	Dongara Gas Field	Total
	Onshore	Offshore			
Head	1	9	5	—	15
Eye	2	12	8	2	24
Trunk	5	26	24	—	55
Arm	1	10	6	—	17
Hand	8	23	17	3	51
Leg	11	9	11	2	33
Foot	5	9	9	1	24
Occupational	—	1	—	—	1
Other	—	1	1	—	2
<b>Totals</b>	<b>33</b>	<b>100</b>	<b>81</b>	<b>8</b>	<b>222</b>

### Agency of Injury

Machinery in Operation	10	13	6	1	30
Vehicles	2	—	1	—	3
Tools-hand	4	5	2	—	11
Tools-power	—	—	2	—	2
Manual Handling	3	18	14	2	37
Harmful contacts	—	—	1	—	1
Persons falling or striking	2	26	12	1	41
Objects flying or falling	4	16	16	2	38
Other	8	22	27	2	59

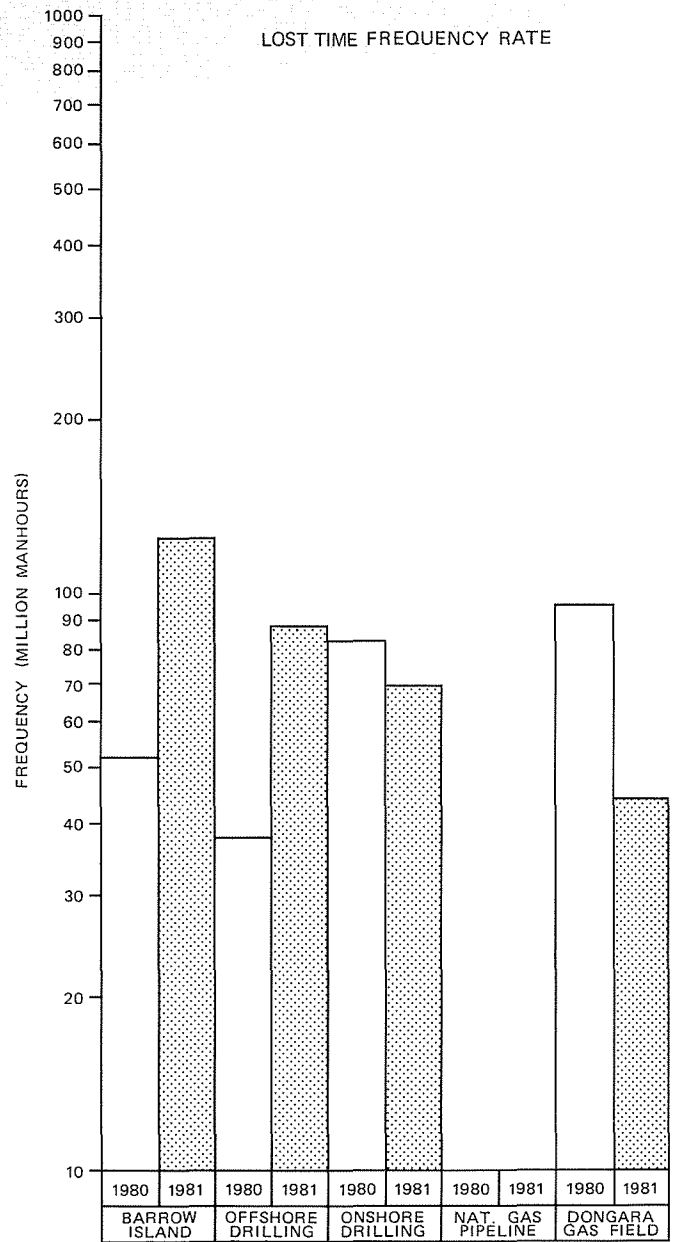
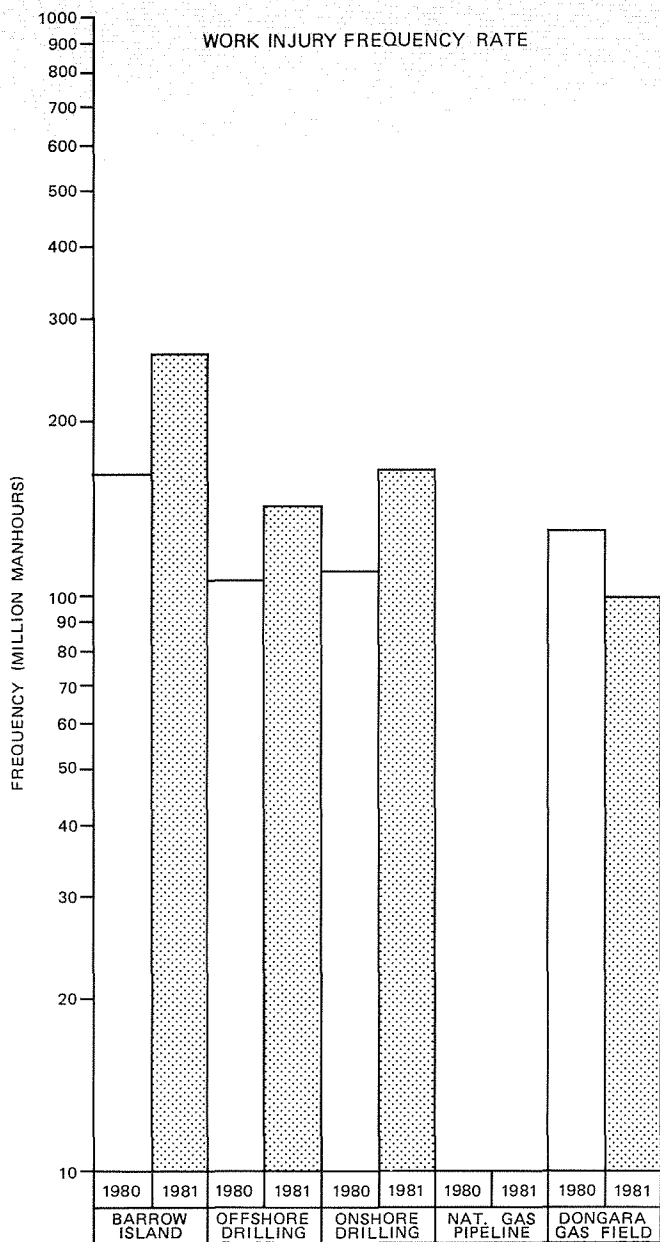
### Magnitude of Injury

Minor	19	38	42	4	103
Serious	14	62	39	4	119
Fatal	—	—	—	—	—

### Time Factor

Manhours exposure	200 030	703 466	309 898	87 965	1 301 359
Manhours lost	1 440	14 172	3 432	216	19 260





The frequency rates shown are depicted as recommended by the Australian Standards Association AS 1885-1976. The Work Injury Frequency Rate is the number of work injuries per year related to a million-manhour unit. The Lost-time Injury Frequency rate is the number of lost-time injuries per year related to a million-manhour unit as follows:

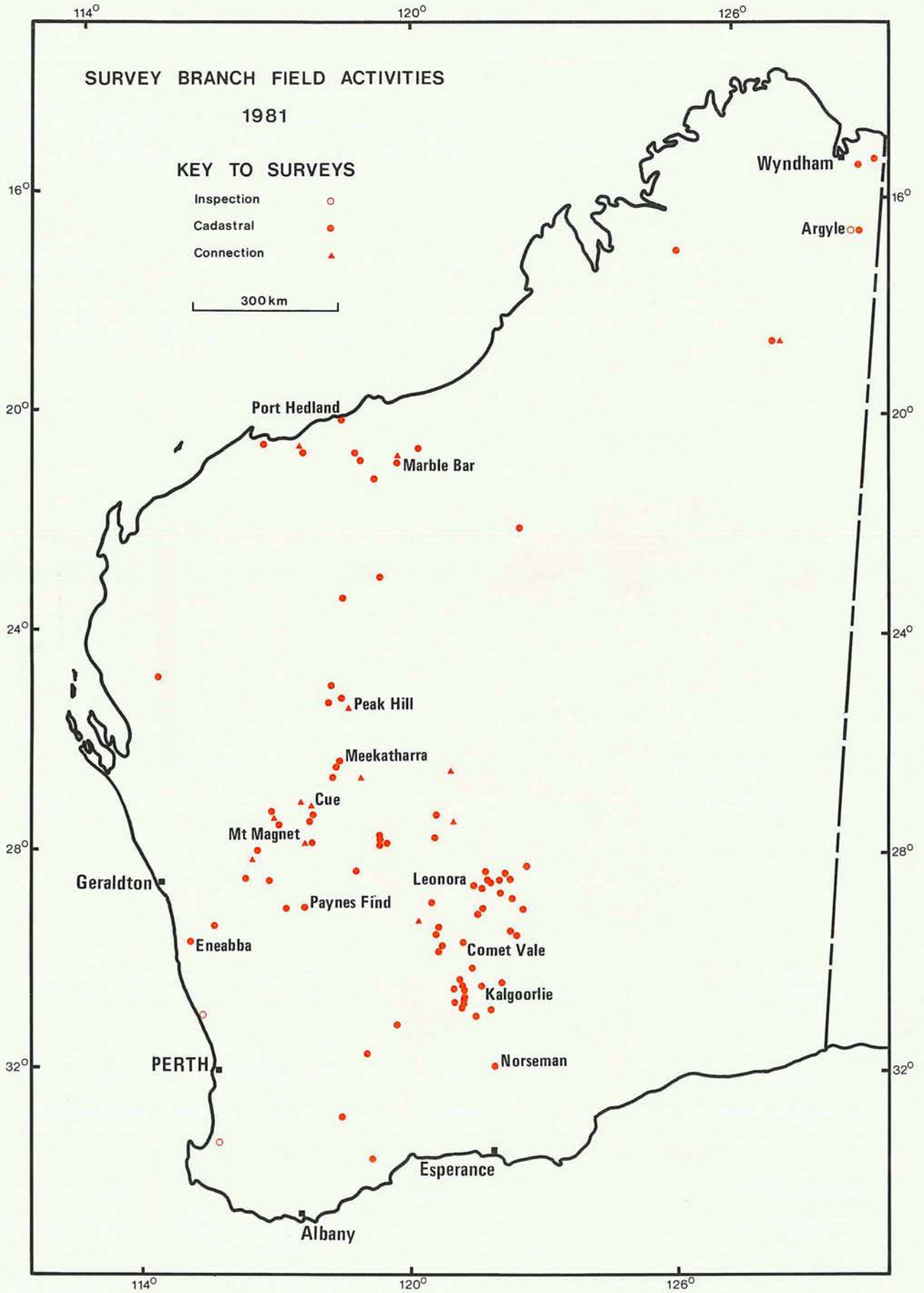
$$\text{Lost-time injury rate} = \frac{\text{Number of lost-time injuries} \times 1\,000\,000}{\text{Manhours exposure}}$$

**SURVEYS AND MAPPING DIVISION**  
**Control projects in 1981**

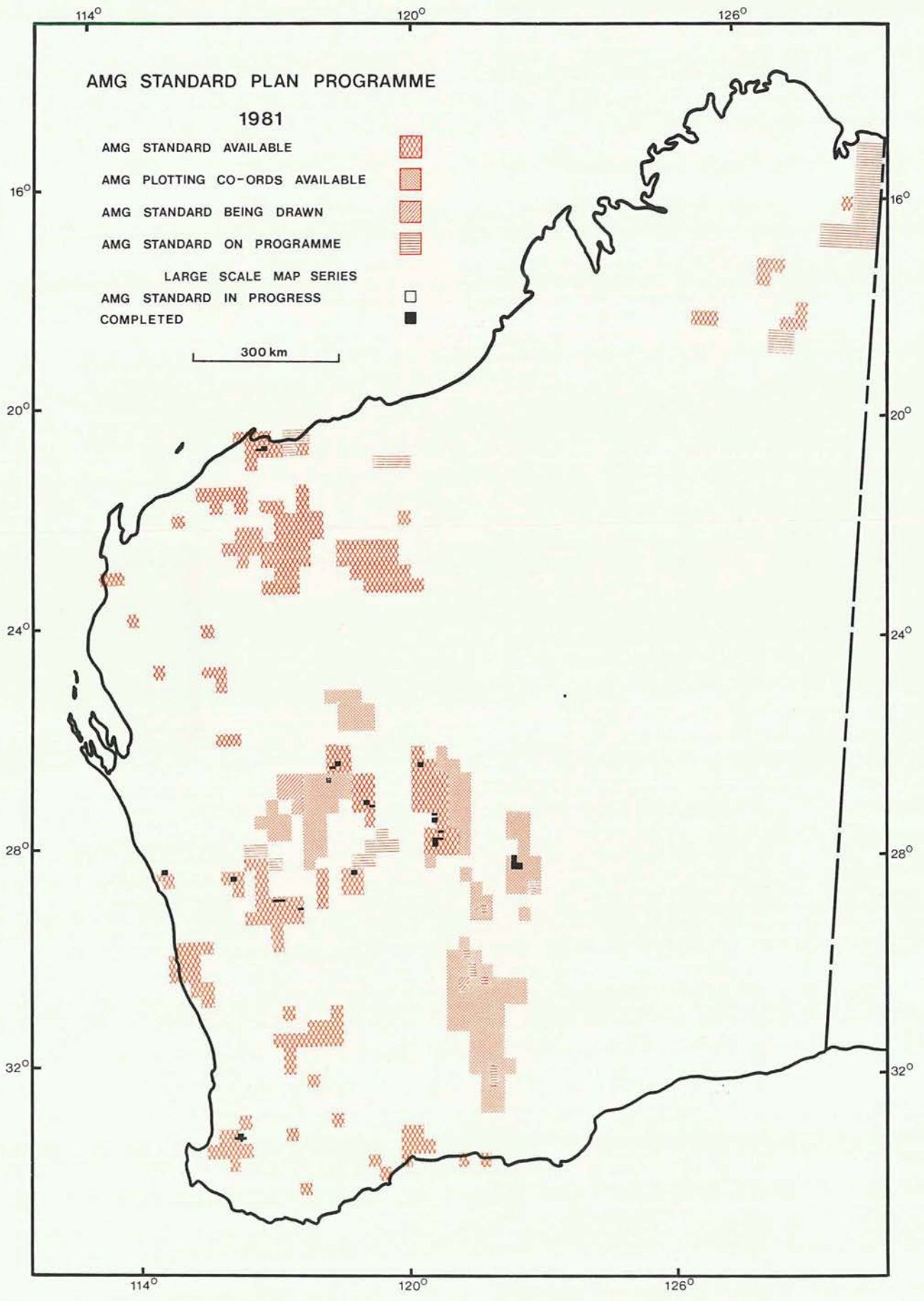
Projects	Kilometres		Stations established	Traverse Length	Points co-ordinated
	NS	EW			
<b>Completed</b>					
Nanadie-Cogla	38	15	—	146	148
Big Bell	70	40	7	755	1 087
Hillview	22	35	1	166	119
Ravensthorpe	20	33	—	1 818	3 253
Boddington	14	15	—	220	261
Laverton-Duketon	137	96	—	745	805
Kanowna-Bulong	Remeasure of Eastern Section			127	320
Kalgoorlie-Norseman	200	70	—	1 800	3 069
<b>In progress</b>					
Peak Hill	75	75	11		
Jundee-Mt Joel	100	80	7		
Mt Phillipson-Weebo	113	56	10		
Mt Magnet	140	60	15		
Cue	70	90	12		
Bullfinch-Southern Cross	50	30	—		
Copperfield	40	15	—		
<b>New</b>					
Warda Warra	55	35	5		
Yalgoo	40	25	4		
Marvel Loch	83	47	Existing control		
Dockrell	43	28	8		
Whim Creek	42	40	6		
Moolyella	35	50	9		
Callion-Day Rock	70	60	15		

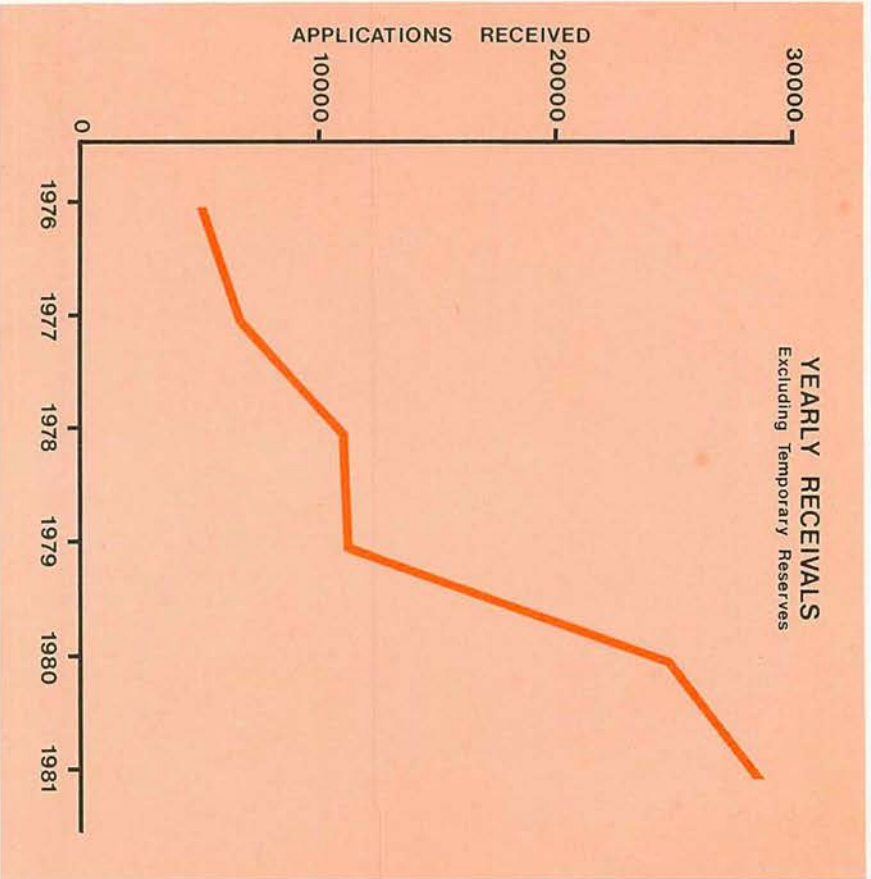
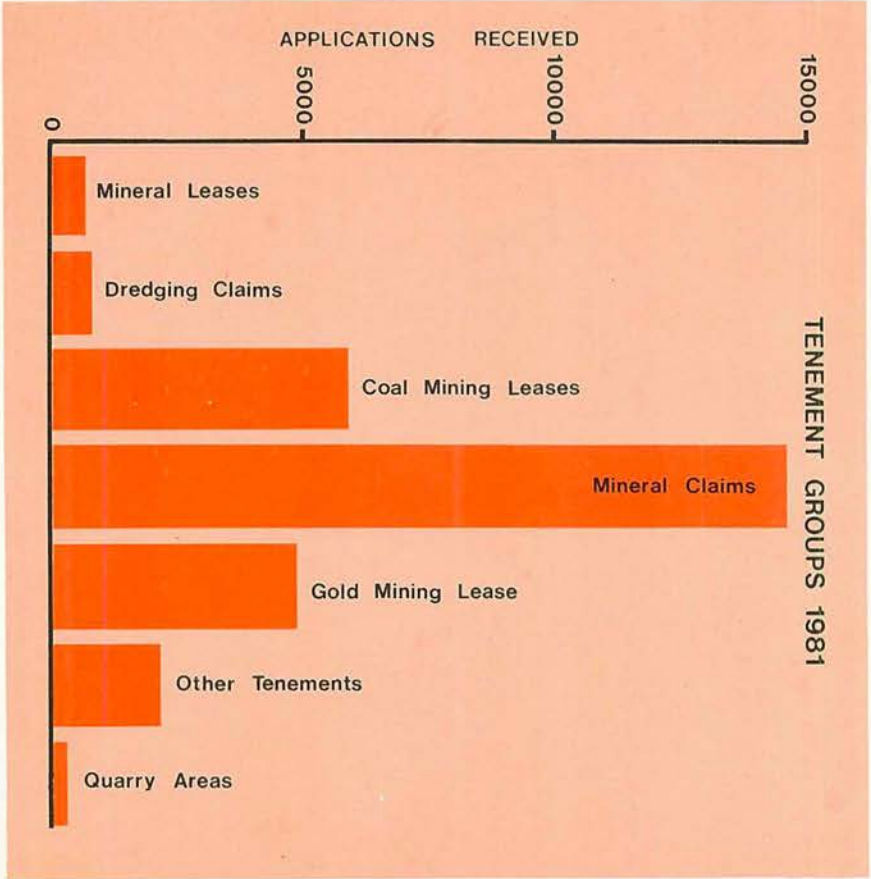
**Plans and Documents in Use**

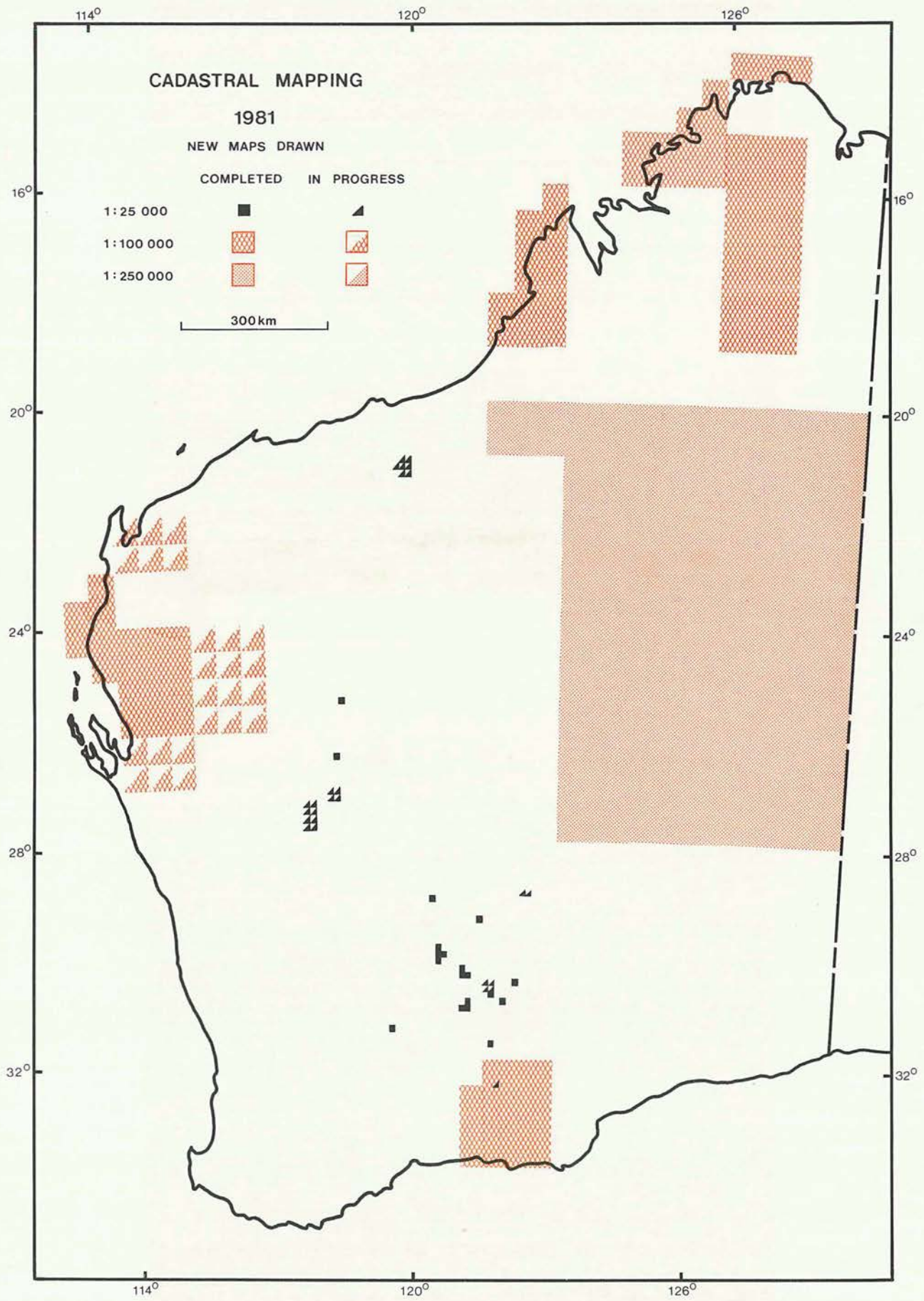
	Current	Archived
<b>Public Plans</b>		
1: 1 000 000 Index Plans	14	105
1: 1 000 000 Temporary Reserve Series	14	56
1: 1 000 000 Petroleum Series	34	39
1: 250 000 Public Plans	95	411
1: 100 000 Public Plans	160	89
1: 50 000 & 1: 25 000 Public Plans	1 237	2 693
Large Scale Series	12	22
Lands Old Series (Imperial)	143	877
Mines Old Series (Miscellaneous)	17	387
Lands Old Series (T.M.)	14	182
Old Index Sheets (10 mile)	—	137
Petroleum Map (M175)	1	74
<b>Totals</b>	<b>1 741</b>	<b>5 072</b>
<b>Standard Plans</b>		
Index 1: 1 000 000	14	14
Index 10 Mile	—	19
Old Projection (20 Chain)	550	118
Transverse Mercator	209	10
Australian Map Grid		
1: 100 000	1	—
1: 50 000	209	21
1: 25 000	29	5
1: 10 000	38	—
Provisional (All Scales)	381	28
<b>Totals</b>	<b>1 431</b>	<b>215</b>
<b>Field Books</b>		
Cadastral Surveys	6 608	
<b>Survey Plans</b>		
Diagrams (Imperial)	49 880	
Diagrams (Metric)	9 700	
Original Plans (Imperial)	286	
Original Plans (Metric)	1 090	
<b>Total</b>	<b>60 956</b>	













**GOVERNMENT CHEMICAL LABORATORIES**  
**Source and Allocation of Work 1981**

Source	Agricultural Chemistry	Engineering Chemistry	Food and Industrial Hygiene	Forensic Chemistry	Industrial Chemistry	Kalgoorlie Metallurgical Laboratory	Mineral	Water	Total
<b>State</b>									
Agriculture Department	23 445	26	1 033	8	1		36	12	24 561
Conservation & Environment Department			127					203	330
Consumer Affairs Bureau			3		19		12	18	52
Corrections Department				41					41
Education Department	32		4		3				39
Fisheries & Wildlife Department			7				4	28	39
Forests Department			23		1		12		36
Geological Survey		4					478	329	811
Government Chemical Laboratories	5	56	323	163	2		200	6	755
Greyhound Racing Control Board				277					277
Harbour & Lights Department				11					11
Hospitals			45	2					47
Labour & Industry Department			10		2		30		42
Leschenault Inlet Management Authority			4					72	76
Main Roads Department			2				40	5	47
Metropolitan Water Board			287		6		12	1 688	1 993
Mines Department			148			81	553		782
Peel Inlet Management Authority								96	96
Police Department			2	3 945	18	27	46		4 038
Public Health Department	40	1	2 580	11	17		1 416	135	4 200
Public Works Department	15		373		21		71	6 073	6 553
Regional Administration & the North West	8	54	3		4		8	27	104
Road Traffic Authority				576			4		580
State Energy Commission			4		10		2		16
State Housing Commission			16		5		3	2	26
State Tender Board			8		112				120
Swan River Management Authority								353	353
Waterways Commission			50						50
W.A. Drug & Alcohol Authority				11					11
W.A. Trotting Association				732					732
W.A. Turf Club				1 341					1 341
Other Authorities (7)			5		7		6	9	27
<b>Public</b>									
Pay	1 182	170	72	26	64	1 155	340	479	3 488
Free						5	50		55
<b>Totals</b>	<b>24 727</b>	<b>311</b>	<b>5 129</b>	<b>7 144</b>	<b>292</b>	<b>1 268</b>	<b>3 323</b>	<b>9 535</b>	<b>51 729</b>

**Type and Source of Samples Determined by  
the Water Division of the Government Chemical Laboratories**

	Agriculture Department	Dept. of Conservation & Environment	Bureau of Consumer Affairs	Dept. of Fisheries & Wildlife	Geological Survey	Leschenault Inlet Management Authority	Metropolitan Water Board	Peel Inlet Management Authority	Public Health Department	Public Works Department	Office of Regional Administration and the North West	State Housing Commission	Swan River Management Authority	Other Departments	Public pay	Total
Corrosion & Deposits			1						3	25				2	8	39
Effluents		6					15		10	467			13		28	539
Environmental Monitoring						72		96					315			483
Miscellaneous Waters—			3	5					5	5			4	2	6	30
Fluoridated							882			1 116						1 998
Network Survey	12	197	14	23	329		791		117	1 840	27	2	21	16	437	1 840
General										2 620						4 606
<b>Totals</b>	<b>12</b>	<b>203</b>	<b>18</b>	<b>28</b>	<b>329</b>	<b>72</b>	<b>1 688</b>	<b>96</b>	<b>135</b>	<b>6 073</b>	<b>27</b>	<b>2</b>	<b>353</b>	<b>20</b>	<b>479</b>	<b>9 535</b>

**Type and Source of Samples Determined by the Food and Industrial Hygiene Division of the Government  
Chemical Laboratories**

	Department of Agriculture	Department of Conservation and Environment	Forests Department	Government Chemical Laboratories	Hospitals	Department of Labour & Industry	Metropolitan Water Board	Mines Department	Public Health Department	Public Works Department	State Housing Commission	Waterways Commission	Other Departments	Public Pay	Total
<b>Food</b>															
Apples	46														46
Apple pomace	16														16
Baby food									60						60
Celery	14														14
Coconut									198						198
Chicken tissue									50						50
Eggs	14								2						16
Fish		2							947			3	6	10	968
Fruit juice									10						10
Grapes	26								2						28
Liquor									25						25
Meat									51						51
Milk animal	46			4					5						55
Milk human				2					46						48
Pheasants									15						15
Potatoes	32								2						34
Rice	111								6						117
Shellfish		20					3		166						189
Tea									11						11
Tripe									39						39
Various	19				1				129	1			1	1	152
<b>Industrial hygiene</b>															
Air	24			33	7	8		40	160	2			6		280
Blood									139					12	151
Dust								6	127				1		134
Inspections				1	1	1		3	9				1	9	25
Medical gases					2					117					119
Urine				1	1		78	93	103	41				17	334
Various				8			2		47					6	63
<b>Miscellaneous</b>															
Animal toxicology	13														13
Feedstuffs	13			7	5		4								29
Investigations	2			2		1			5				1		11
Pesticides	55			3					21	1	16		2	4	102
Rapeseed	12														12
Renal fat	203								3						206
Sandalwood			23												23
Seawater		103													103
Sheep blood, milk & tissue	260			232											492
Silt										18		4			22
Soil	109						3		33	6				2	153
Specimens from patients					23				56					6	85
Toothpaste									18						18
Water	4			21			191		30	185				1	432
Various	14	2		9	5		6	6	65	2		47	20	4	180
<b>Totals</b>	<b>1 033</b>	<b>127</b>	<b>23</b>	<b>323</b>	<b>45</b>	<b>10</b>	<b>287</b>	<b>148</b>	<b>2 580</b>	<b>373</b>	<b>16</b>	<b>54</b>	<b>38</b>	<b>72</b>	<b>5129</b>

**Type and Source of Samples Determined by the  
Mineral Division of the Government Chemical Laboratories**

	Agriculture Department	Bureau of Consumer Affairs	Geological Survey	Government Chemical Laboratories	Labour and Industry Department	Main Roads Department	Metropolitan Water Board	Mines Department	Police Department	Public Health Department	Public Works Department	Other Departments	Public			Total
													Pay	Concession	Free	
Building materials				1	2	12					34	3	2			54
Cement and concrete		8				2	8				3					21
Dusts					22			498		1 290	7	2	13			1 832
Explosives								17								17
Forensic examinations									46							46
Geochemistry			133													133
Mineral identification	1		11	95	2	7		1		30	2	3	73	39		264
Miscellaneous	1	4	39	19	4		4	12		52	10	19	19			183
<b>Ores and minerals</b>																
Alunite				15												15
Clay						1					4	8	1			14
Gold Assays			36	7				13					66	20	50	192
Gold Specimens				20									62			82
Iron			26	14									12			52
Lead								12						1		13
Limestone			10										7			17
Scheelite				14												14
Silicate analysis			223	3									5			231
Soils	34					18				44	11	8	3			118
Other				12									12	1		25
<b>Totals</b>	<b>36</b>	<b>12</b>	<b>478</b>	<b>200</b>	<b>30</b>	<b>40</b>	<b>12</b>	<b>553</b>	<b>46</b>	<b>1 416</b>	<b>71</b>	<b>43</b>	<b>275</b>	<b>61</b>	<b>50</b>	<b>3 323</b>

**Type and Source of Samples Determined by the  
Forensic Chemistry Division of the Government Chemical Laboratories**

	Department of Corrections	Government Chemical Laboratories	Greyhound Racing Control Board	Harbour and Light Department	Other Departments	Public Health Department	Police Department	Road Traffic Authority	Western Australian Alcohol and Drug Authority	Western Australian Trotting Association	Western Australian Turf Club	Public pay	Total
<b>Blood &amp; Urine Alcohol</b>													
Sobriety								570					570
Traffic Deaths							382						382
<b>Criminal investigation</b>					2	2	467						471
<b>Doping control in sport</b>													
Greyhounds			277										277
Horses									729	1 340		17	2 086
<b>Drugs</b>		6	20		1	2	2 128	4	11				2 172
<b>Miscellaneous</b>													
Maritime Pollution				11			22	1					34
Specimens from prisoners or patients		35				1						2	38
Various					1		2	1	3	1		2	14
<b>Projects</b>													139
<b>Toxicology</b>													
Animal					6	1	10					5	22
Human						5	934						939
<b>Totals</b>	<b>41</b>	<b>163</b>	<b>277</b>	<b>11</b>	<b>10</b>	<b>11</b>	<b>3 945</b>	<b>576</b>	<b>11</b>	<b>732</b>	<b>1 341</b>	<b>26</b>	<b>7 144</b>



**REGISTRATION DIVISION**

**Mining Act 1904-1978  
Mining Tenements Applied for and in Force in 1981**

Statistical Divisions		Mineral Claim	Gold Mining Lease	Coal Mining Lease	Other	Totals
South West and Other	Applied for	1 949	143	5 726	40	7 858
	In force	2 522	762	134	294	3 712
Murchison	Applied for	2 732	846	75	34	3 687
	In force	5 204	1 527	Nil	326	7 057
North West	Applied for	4 366	348	353	16	5 083
	In force	8 913	317	40	984	10 254
Eastern Goldfields	Applied for	5 313	2 775	99	124	8 311
	In force	6 177	3 613	Nil	1 225	11 015
Totals	Applied for	14 360	4 112	6 253	214	
	In force	22 816	6 219	174	2 829	56 977

**ADMINISTRATIVE DIVISION**  
**Average number of men employed in mining operations**  
**in Western Australia during 1981**

Company	Location	Above ground	Under ground	Total
<b>ALUMINA</b>				
Alcoa of Australia Ltd	Jarrahdale/Kwinana	1 781	—	1 781
	Del Park/Pinjarra	1 597	—	1 597
<b>COAL</b>				
Griffin Coal Mining Co. Ltd	Collie	345	—	345
Western Collieries Ltd	Collie	291	326	617
<b>COPPER—SILVER—ZINC</b>				
Seltrust Mining Corporation Pty Ltd	Teutonic Bore	141	—	141
<b>GOLD</b>				
Central Norseman Gold Corporation N.L.	Norseman	222	130	352
Hill 50 Gold Mines N.L.	Mt Magnet	99	49	148
Kalgoorlie Mining Associates (Mt Charlotte)	Kalgoorlie	23	177	200
Kalgoorlie Mining Associates	Boulder	140	224	364
North Kalgurli Mines Ltd	Boulder	47	210	257
Newmont Pty Ltd	Telfer	109	—	109
All other operators	State generally	514	203	717
<b>IRON ORE*</b>				
B.H.P. Minerals Ltd (Formerly Dampier Mining Co Pty Ltd)	Yampi	539	—	539
	Koolyanobbing	118	—	118
	Kwinana	310	—	310
Cliffs Western Australia Mining Co Pty Ltd	Pannawonica/Cape Lambert	1 680	—	1 680
Goldsworthy Mining Ltd	Goldsworthy/Port Hedland	1 179	—	1 179
Hamersley Iron Pty Ltd	Tom Price-Paraburdoo/Dampier	3 722	—	3 722
Mt Newman Mining Co Ltd	Newman/Pt Hedland	4 299	—	4 299
<b>MINERAL BEACH SANDS</b>				
Allied Eneabba Pty Ltd	Eneabba	197	—	197
Cable Sands Pty Ltd	Capel	83	—	83
W.S.L. Group	Capel	160	—	160
Western Titanium Ltd	Capel	133	—	133
	Eneabba	134	—	134
<b>NICKEL</b>				
Agnew Mining Co Pty Ltd	Leinster	200	103	303
Metals Exploration N.L.	Nepean	83	103	186
Western Mining Corporation	Kambalda	774	761	1 535
	Kalgoorlie Smelter	367	—	367
	Kwinana Refinery	403	—	403
Western Mining Corporation and Shell Co of Australia	Mt Windarra	190	157	347
<b>PETROLEUM—CRUDE OIL</b>				
West Australian Petroleum Pty Ltd	Barrow Island	128	—	128
	Dongara	9	—	9
<b>SALT</b>				
Dampier Salt Ltd	Dampier	189	—	189
	Lake McLeod	124	—	124
Lefroy Salt Co	Lake Lefroy	5	—	5
Leslie Salt Co	Port Hedland	50	—	50
Shark Bay Salt Joint Venture	Shark Bay	80	—	80
<b>ALL OTHER MINERALS (including rock quarries)</b>				
		1 155	—	1 155
	Totals	21 620	2 443	24 063

Open cut workers classed as above ground.

\*Total includes railways, port and other support staff.

**Quantity and value of minerals produced during 1980 and 1981  
in Western Australia**

Mineral	Quantity Unit	1980		1981		Increase or decrease for year compared with 1980	
		Quantity	Value \$	Quantity	Value \$	Quantity	Value \$
Alumina (from Bauxite)	Tonne	3 663 989	436 014 691	3 678 480	548 093 520	+14 491	+112 078 829
Barytes	"	26 602	650 042	24 668	1 109 904	-1 934	+459 862
Building stone	"	4 243	118 090	4 367	158 944	+124	+40 854
Clays	"	402 637	426 706	275 130	205 100	-127 507	-221 606
Coal	"	3 151 470	60 717 341	3 254 403	68 251 534	+102 933	+7 534 193
Cobalt (by-product of nickel mining)	"	983	13 023 142	609	7 689 911	-374	-5 333 231
Copper (by-product of nickel mining)	"	3 132	4 751 650	2 858	3 240 056	-274	-1 511 594
Copper concentrates	"	—	—	5 205	1 154 174	+5 205	+1 154 174
Emeralds (cut)	Carat	13 000	78 000	—	—	-13 000	-78 000
Feldspar	Tonne	2 568	116 932	3 181	145 799	+613	+28 867
Garnet sands	"	76	7 540	1 344	151 517	+1 268	+143 977
Glass sands	"	129 367	39 283	113 239	56 343	-16 182	+17 060
Gold	Kilo-gramme	11 233	179 314 357	12 047	153 313 613	+814	-26 000 744
Gypsum	Tonne	293 370	1 126 629	354 836	1 444 659	+61 466	+318 030
Iron ore (pig iron recovered)	"	38 988	4 241 104	3 763	526 820	-35 225	-3 714 284
Iron ore	"	84 971 629	1 158 386 783	75 302 640	1 129 628 976	-9 668 989	-28 757 807
Limestone	"	607 812	1 792 235	637 350	2 028 155	+29 538	+235 920
Manganese	"	1 693	36 738	1 196	29 885	-497	-6 853
Mica	"	352	79 225	354	94 751	+2	+15 526
Mineral beach sands							
Ilmenite	"	1 256 720	30 084 556	963 128	29 636 688	-293 592	-447 868
Monazite	"	10 978	3 684 252	10 715	4 148 454	-263	+464 202
Rutile	"	91 667	23 292 830	61 595	18 141 673	-30 072	-5 151 157
Leucoxene	"	26 911	5 545 374	15 786	3 202 746	-11 125	-2 342 628
Zircon	"	327 692	20 142 466	226 463	16 974 854	-101 229	-3 167 612
Xenotime	"	21	32 192	58	187 219	+37	+155 027
Nickel concentrates	"	396 534	303 751 597	405 946	306 484 456	+9 412	+2 732 859
Nickel ore	"	86 565	18 554 973	85 894	17 869 788	-671	-685 185
Ochre	"	53	897	839	14 281	+786	+13 384
Palladium (by-product of nickel mining)	Kilo-gramme	328	1 834 614	401	1 254 422	+73	-580 192
Platinum (by-product of nickel mining)	"	64	954 184	65	868 736	+1	-85 448
Petroleum—crude oil	Kilolitre	624 748	268 782 192	439 274	278 612 808	-185 474	+9 830 616
Petroleum—natural gas	Thousand cubic metres	859 688	25 494 035	831 929	28 927 638	-27 759	+3 433 603
Petroleum—condensate	Tonne	2 435	N.A.	2 050	N.A.	-385	N.A.
Salt	"	3 680 844	37 553 115	3 624 031	39 074 797	-56 813	+1 521 682
Semi precious stones	Kilo-gramme	3 012	8 982	4 228	7 114	+1 216	-1 868
Silver	"	2 050	895 251	10 627	3 082 411	+8 577	+2 187 160
Talc	Tonne	113 211	N.A.	133 996	N.A.	+20 785	N.A.
Tanto/Columbite ores and concentrates	"	159	12 233 116	298	13 179 471	+139	+946 355
Tin concentrates	"	558	6 721 875	922	10 260 637	+364	+3 538 762
Vermiculite	"	159	1 590	—	—	-159	-1 590
Zinc concentrates	"	—	—	10 129	2 899 744	+10 129	+2 899 744
<b>Totals</b>			<b>2 620 488 579</b>		<b>2 692 151 598</b>		<b>+71 663 019</b>



### Comparison of Royalties collected in 1980 and 1981

Mineral	Royalty collected		Increase or decrease compared with 1980
	1980	1981	
	\$	\$	\$
Alumina	4 659 327.03	5 675 188.39	+ 1 015 861.36
Amethyst	31.24	22.45	-8.79
Barite	1 315.42	1 504.74	+ 189.32
Building stone	446.40	477.36	+ 30.96
Chalcedony	.07	.10	+ .03
Clay	23 866.21	14 469.34	-9 396.87
Coal	81 295.91	75 655.34	-5 630.57
Cobalt	35 529.52	24 970.38	-10 559.14
Emerald	240.00	150.00	-90.00
Feldspar	140.58	208.24	+ 67.66
Fullers earth (attapulgite)	1 056.42	—	-1 056.42
Garnet sands	—	1 484.70	+ 1 484.70
Glass sand	4 980.13	6 111.67	+ 1 131.54
Gold	10.00	9 915.02	+ 9 905.02
Gypsum	13 239.47	15 649.62	+ 2 410.15
Ilmenite	497 624.16	492 175.88	-5 448.28
Iron ore	62 027 689.47	57 237 793.49	-4 789 895.98
Leucoxene	80 633.12	71 497.36	-9 135.76
Limestone	30 577.07	32 122.50	+ 1 545.43
Manganese	265.65	136.29	-129.36
Mica	471.47	265.74	-205.73
Monazite	48 508.30	110 354.26	+ 61 845.96
Moss opal	2.36	8.12	+ 5.76
Natural gas	1 242 650.01	1 382 454.94	+ 139 804.93
Natural gas (condensate)	14 643.95	18 426.56	+ 3 782.61
Nickel	3 556 529.68	3 478 284.53	-78 245.15
Ochre	2.65	36.75	+ 34.10
Oil (crude)	5 829 563.23	5 585 755.88	-243 807.35
Palladium	1 814.55	1 841.85	+ 27.30
Platinum	1 859.13	1 841.84	-17.29
Rutile	633 282.61	588 109.06	-45 173.55
Salt	209 997.70	302 601.43	+ 92 603.73
Talc	15 430.45	6 514.14	-8 916.31
Tanto-columbite	54 535.54	72 785.50	+ 18 249.96
Tin	137.30	147.52	+ 10.22
Vanadium	—	4 972.35	+ 4 972.35
Vermiculite	7.25	11.25	+ 4.00
Xenotime	1 723.66	473.14	-1 250.52
Zinc	—	2 022.68	+ 2 022.68
Zircon	572 580.36	531 084.71	-41 495.65
Totals	79 642 008.07	75 747 535.12	-3 894 472.95

**Production of Gold and Silver from all Sources Showing in Kilograms the Output as Reported to the Department of Mines during the Year 1981**

Goldfield	District	District						Goldfield						
		Alluvial Kg	Dolled and Specimens Kg	Ore Treated Tonnes	Gold Therefrom Kg	Total Gold Kg	Silver Kg	Alluvial Kg	Dolled and Specimens Kg	Ore Treated Tonnes	Gold Therefrom kg	Total Gold Kg	Silver Kg	
West Kimberley		—	—	—	—	—	—	—	—	—	—	—	—	—
Kimberley		—	—	—	—	—	—	6.412	1.726	1 486.00	1.748	9.886	0.190	
Pilbara	Marble Bar	5.850	1.545	486 374.00	3 944.018	3 951.413	197.696	—	—	—	—	—	—	
	Nullagine	3.589	2.841	927.00	12.311	18.741	0.103	9.439	4.386	487 301.00	3 956.329	3 970.154	197.799	
West Pilbara		—	—	—	—	—	—	.208	0.413	—	12.025	12.646	0.760	
Ashburton		—	—	—	—	—	—	0.353	—	—	—	0.353	—	
Gascoyne		—	—	—	—	—	—	—	—	415.00	4.655	4.655	—	
Peak Hill		—	—	—	—	—	—	—	—	—	—	—	—	
East Murchison	Lawlers	—	—	234.00	0.879	0.879	—	5.228	0.341	3 568.00	1.919	7.488	—	
	Wiluna	2.090	0.787	—	—	2.877	—	—	—	—	—	—	—	
	Black Range	0.505	0.354	670.00	65.848	66.707	5.824	2.595	1.141	904.00	66.727	70.463	5.824	
Murchison	Cue	9.563	2.468	1 520.00	2.880	14.911	0.155	—	—	—	—	—	—	
	Meekatharra	7.312	1.204	288 125.00	373.381	381.897	1.499	—	—	—	—	—	—	
	Day Dawn	—	—	50.00	0.040	0.040	—	—	—	—	—	—	—	
	Mt Magnet	5.927	1.392	66 361.00	280.848	288.167	16.266	22.802	5.064	356 056.00	657.149	685.015	17.920	
Yalgoo		—	—	—	—	—	—	.661	0.072	530.00	12.430	13.163	1.456	
Mt Margaret	Mt Morgans	1.426	1.276	4 806.00	51.426	54.128	0.053	—	—	—	—	—	—	
	Mt Malcolm	4.524	9.670	32 042.00	174.959	189.153	1.334	—	—	—	—	—	—	
	Mt Margaret	2.709	2.754	3 529.00	10.390	15.853	0.065	8.659	13.700	40 377.00	236.775	259.134	1.452	
North Coolgardie	Menzies	—	.058	1 175.00	54.814	54.872	14.360	—	—	—	—	—	—	
	Ularring	—	0.071	1 634.00	9.157	9.228	0.092	—	—	—	—	—	—	
	Niagara	0.040	0.094	637.00	1.984	2.118	—	—	—	—	—	—	—	
	Yerilla	0.274	0.137	4 938.00	47.464	47.875	6.944	0.314	0.360	8 384.00	113.419	114.093	21.396	
Broad Arrow		—	—	—	—	—	—	0.366	2.112	21 919.00	62.498	64.976	0.196	
North East Coolgardie	Kanowna	0.338	2.265	797.00	1.545	4.148	0.110	—	—	—	—	—	—	
	Kurnalpi	0.484	0.260	359.00	0.897	1.641	0.080	0.822	2.525	1 156.00	2.442	5.789	0.190	
East Coolgardie	East Coolgardie	7.077	3.702	982 894.00	3 459.658	3 470.437	717.321	—	—	—	—	—	—	
	Bulong	1.040	—	271.00	0.503	1.543	—	8.117	3.702	983 165.00	3 460.161	3 471.980	717.321	
Coolgardie	Coolgardie	1.904	0.084	245 224.00	612.858	614.846	264.030	—	—	—	—	—	—	
	Kunanalling	0.075	0.165	1 667.00	2.779	3.019	—	1.979	0.249	246 891.00	615.637	617.865	264.030	
Yilgarn		—	—	—	—	—	—	.226	0.286	49 059.00	209.817	210.329	37.463	
Dundas		—	—	—	—	—	—	0.070	0.840	210 037.00	2 506.848	2 507.758	701.841	
Phillips River		—	—	—	—	—	—	—	4.445	1 009.00	12.616	17.061	2.757	
South West Mineral Field		—	—	—	—	—	—	—	—	120.00	0.265	0.265	—	
Northampton Mineral Field		—	—	—	—	—	—	—	—	—	—	—	—	
State Generally		—	—	—	—	—	—	—	—	—	—	—	—	
Outside Proclaimed Goldfield		—	—	—	—	—	—	1.980	1.578	—	—	3.558	—	
TOTALS								70.231	42.940	2 412 377.00	11 933.460	12 046.631	1 970.595	

## Quantity and value of minerals reported during the year 1981

Number of Lease, Claim or area	Producer	Goldfield or Mineral Field	Quantity (Tonnes unless Otherwise stated)	Metallic content	Value \$
<b>Alumina</b>					
ML 70/1SA	Alcoa of Australia Ltd.	South West	2 251 032		335 403 768
ML 70/1SA	Alcoa of Australia Ltd.	South West	1 427 448		212 689 752
			3 678 480		548 093 520 (1)
<b>Barite</b>					
ML 45/1522	Dresser Minerals International Inc.	Pilbara	24 668		1 109 904 (b)
<b>Building stone</b>					
Quartz					
MC 70/2110	Snowstone Pty. Ltd.	South West	3 156		142 020
MC 70/1921	Cutts J. E.	South West	150		200
Quartzite					
MC 70/1158-9	House R.P.	South West	847		13 600
Spongolite					
MC 70/726	Universal Milling Co. P/L	South West	170		2 463
Lepidolite					
ML 15/80 etc.	Universal Milling Co. P/L	Coolgardie	44		661
			4 367		158 944 (a) (c)
<b>Clays</b>					
Cement Clays					
MC 70/788	Bell Bros. P/L	South West	26 919		68 046
Fire Clay					
MC 70/436-7	Midland Brick Co P/L	South West	174 432		45 723
MC 70/304 etc	Clackline Refractories Ltd	South West	4 347		8 694
White-Clay, Ball-Clay					
MC 70/109, 540, 70/13193	Bristile Ltd.	South West	946		11 952
MC 70/522-3	Bridge J. S.	South West	68 046		68 046
Kaolin					
MC 70/247, 605	Universal Milling P/L	South West	440		2 639
			275 130		205 100 (a) (c)
<b>Coal</b>					
CML 12/448	Griffin Coal Mining Co. Ltd.	Collie—Open cut	1 742 494		37 325 634
CML 12/437	Western Collieries Ltd.	Collie—Open cut	835 053		13 499 572
		Deep mine	676 856		17 426 328
			3 254 403		68 251 534 (c)



<b>Cobalt</b>				Cobalt Tonne	
ML 15/152 etc.	Metallic by-product of nickel mining Western Mining Corp.	Coolgardie		554.804	6 268 096
ML 38/255 S.A.	Agnew Mining Co. P/L	East Murchison		54.953	1 421 815
				608.757	7 689 911
<b>Copper</b>				Copper Tonne	
ML 15/152 etc.	Metallic by-product of nickel mining Western Mining Corp.	Coolgardie		2 412.933	2 743 285
ML 38/255 S.A.	Agnew Mining Co. P/L	East Murchison		445.320	496 771
				2 858.253	3 240 056
<b>Copper Concentrates (g)</b>				Cu Tonne	
ML 37/3758-62	Seltrust Mining Corp. P/L	Mt. Margaret	5 205	783	1 154 174 (b)
<b>Feldspar</b>					
MC 59/5800, 5987	Chandilla Exploration & Investments Pty. Ltd.	Yalgoo	254		3 808
MC 70/2110	Snowstone P/L	South West	2 782		139 100
ML 96/100,108	Universal Milling Co. P/L	Coolgardie	145		2 891
			3 181		145 799 (a)
<b>Garnet Sands</b>					
MC 70/11563	Target Minerals N.L.	South West	1 344		151 517 (b)
<b>Glass Sands</b>					
MC 70/417-8	Australian Glass Manufact.	South West	40 315		54 523
MC 70/1076	Readymix Group (W.A.)	South West	71 104		N.A.
MC 70/6056	L. V. Zaninovich	South West	1 820		1 820
			113 239		56 343 (c)
<b>Gold</b>			Ore Treated Tonne	Total Gold Recovered kg	
GML 45/1430	Newmont Prop. Ltd.	Pilbara	483 995	3 903.075	49 673 186
GML 45/1457, 45/1869, 45/1447	Hill 50 Gold Mines N.L.	Murchison	63 216	276.867	3 523 598
GML 51/2008 & 2105	Whim Creek Consolidated N.L.	Murchison	281 033	339.375	4 319 117
GML 37/1860	Tower Hill	Mount Malcolm	27 843	123.194	1 567 851
GML 26/6663, 6837, 7124	Kalgoorlie Lake View P/L	East Coolgardie	178 870	765.765	9 745 646
GML 26/6563, etc.	Kalgoorlie Lake View P/L (Mt. Charlotte)	East Coolgardie	777 439	2 573.559	32 752 862
ML 15/163 etc	Great Boulder Holdings	Coolgardie	207 518	272.807	3 471 927
ML 15/152 etc	Western Mining Corp. (Ex nickel mining)	Coolgardie	—	178.463	2 271 225
GML 63/1936 etc.	Central Norseman Gold Corp.	Dundas	208 244	2 493.139	31 729 382
	Minor Producers	State Generally	184 219	1 120.388	14 258 819
			2 412 377	*12 046.632	153 313 613

\* Includes alluvial, dollied and specimens.

Number of Lease, Claim or area	Producer	Goldfield or Mineral Field	Quantity (Tonnes unless otherwise stated)	Metallic content	Value \$
<b>Gypsum</b>					
MC 77/50 etc.	West Australian Plaster Mills	Yilgarn	30 236		109 841 (a)
MC 77/50 etc.	H. B. Brady & Co. P/L	Yilgarn	24 529		59 883 (a)
MC 70/15466 etc.	Swan Portland Cement Ltd.	South West	14 888		304 371 (c)
MC 70/1115-6	R. W. McAndrew	South West	17 149		34 298 (a)
MC 70/611 etc.	Amalgamated Industries Ltd.	South West	1 000		15 000 (a)
MC 9/43,49,50	Agnew Clough Ltd.	Gascoyne	267 034		921 266 (b)
			354 836		1 444 659
(Plaster of paris reported as manufactured during the year 38 062 tonnes from 53 970 tonnes of gypsum by 2 Companies)					
<b>Iron Ore</b>					
			Ore treated Tonne	Pig iron recovered Tonne	
Pig Iron					
ML 77/2 S.A.	Wundowie Iron and Steel Industry	Yilgarn	6 279	3 763	526 820 (a) (d)
				Av. Assay Fe %	
Ore Railed to Kwinana					
ML 77/2 S.A.	Dampier Mining Co. Ltd.	Yilgarn	*1 192 606	63.00	11 756 182 (m)
Ore Shipped Interstate					
ML 52/244 S.A.	Mt. Newman Mining Co. Ltd.	Peak Hill	5 584 621	64.00	76 432 171 (b)
ML 4/10 etc.	Dampier Mining Co. Ltd.	West Kimberley	371 084	68.96	4 081 924 (b)
Ore Exported Overseas					
ML 4/50 etc.	Dampier Mining Co. Ltd.	West Kimberley	773 697	66.94	12 428 544 (b)
ML 4/10 etc.	Dampier Mining Co. Ltd.	West Kimberley	312 974	68.80	4 100 446 (b)
ML 52/244 S.A.	Mt. Newman Mining Co. Ltd.	Peak Hill	21 851 487	63.00	353 120 966 (b)
ML 47/4 S.A.	Hamersley Iron Pty. Ltd.	West Pilbara	27 680 839	63.54	439 558 569 (b)
TR 2401H	Cliffs WA Mining Co. P/L	West Pilbara	12 176 439	56.83	140 954 894 (b)
ML 45/235 S.A.	Goldsworthy Mining Ltd.	Pilbara	5 358 893	62.13	87 195 280 (b)
			75 302 640		1 129 628 976
*Includes 954 261 tonnes shipped interstate					
<b>Limestone</b>					
For building, burning, and agricultural purposes					
MC 70/684,70/728	Bell Bros. Pty. Ltd.	South West	12 922		12 922
MC 70/1662	Bell Bros. Pty. Ltd.	South West	8 292		7 297
MC 70/1290	Bellombra V.	South West	7 145		71 450
MC 70/1755	Cockburn Cement Ltd.	South West	201 000		201 000
MC 70/1660	Swan Portland Cement Ltd	South West	339 407		1 459 333
MC 70/2734, 70/2735	Swan Portland Cement Ltd	South West	58 080		263 149
MC 70/1093	Sunrise Investments P/L	South West	1 000		1 500
ML 47/513	Specified Services P/L	West Pilbara	9 004		9 004
MC 70/17025	Wolfe S. H.	South West	500		2 500
			637 350		2 028 155 (c)

Manganese			Av. assay Mn%		
Metallurgical grade ML 52/14	Universal Milling Co. P/L	Peak Hill	1 196	47.5	29 885 (b)

Mica					
MC 45/7145, 8416	Pilbara Mica Corp P/L	Pilbara	354		94 751 (b)

Mineral Beach Sands			Av. assay TiO <sub>2</sub> %		
Ilmenite (g)					
MC 70/516	Western Titanium Ltd.	South West	242 947	54.93	N.A.
MC 70/389	Western Mineral Sands P/L	South West	170 209	54.00	N.A.
MC 70/619 etc.	Westralian Sands Ltd.	South West	174 723	55.00	N.A.
MC 70/746 etc.	Cable Sands Pty. Ltd.	South West	109 472	54.00	N.A.
MC 70/7062	Allied Eneabba Pty. Ltd.	South West	132 802	60.35	N.A.
MC 70/7002	Western Titanium Ltd.	South West	92 668	59.04	N.A.

922 821

Upgraded Ilmenite (g)					
MC 70/516	Western Titanium Ltd.	South West	40 307	91.94	29 636 688 (b)

Rutile (g) (h)			TiO <sub>2</sub> Tonne		
MC 70/7002	Western Titanium Ltd.	South West	25 779	24 607	7 424 277
MC 70/7062	Allied Eneabba P/L	South West	35 816	34 377	10 717 396
			61 595	58 984	18 141 673 (b)

Leucoxene (g) (h)			TiO <sub>2</sub> Tonne		
MC 70/516	Western Titanium Ltd.	South West	641	577	118 523
MC 70/619 etc.	Westralian Sands Ltd.	South West	10 434	9 389	2 051 461
MC 70/746	Cable Sands Pty. Ltd.	South West	4 711	4 235	1 032 762
			15 786	14 201	3 202 746 (b)

Monazite (g) (h)			ThO <sub>2</sub> Unit		
MC 70/516	Western Titanium Ltd.	South West	2 644	15 721	1 044 847
MC 70/619 etc.	Westralian Sands Ltd.	South West	2 101	13 310	744 540
MC 70/746 etc.	Cable Sands Pty. Ltd.	South West	558	3 547	202 837
MC 70/7062	Allied Eneabba Pty. Ltd.	South West	5 412	33 621	2 156 230
			10 715	66 199	4 148 454 (b)



Number of Lease, Claim or area	Producer	Goldfield or Mineral Field	Quantity (Tonnes unless otherwise stated)	Metallic content	Value \$
<b>Mineral Beach Sands—continued</b>					
Zircon (g) (h)			ZrO <sub>2</sub> Tonne		
MC 70/516	Western Titanium Ltd.	South West	26 651	17 424	2 015 161
MC 70/619 etc.	Westralian Sands Ltd.	South West	30 206	19 468	2 223 411
MC 70/746 etc.	Cable Sands Pty. Ltd.	South West	9 303	6 105	839 548
MC 70/7062	Allied Eneabba Pty. Ltd.	South West	78 440	51 886	5 869 446
MC 70/7002	Western Titanium Ltd.	South West	81 863	54 041	6 027 288
			226 463	148 924	16 974 854 (b)
Xenotime (g) (h)			Y <sub>2</sub> O <sub>3</sub> kg		
MC 70/516	Western Titanium Ltd.	South West	25	7 845	63 688
MC 70/746 etc.	Cable Sands Pty. Ltd.	South West	33	9 768	123 531
			58	17 613	187 219 (b)
<b>Nickel Concentrates</b>			Av. assay Ni %		
ML 15/152 etc.	Western Mining Corp.	Coolgardie	264 726	12.26	212 066 219
ML 15/336	Selcast Exploration Ltd.	Coolgardie	231	16.45	233 642
ML 26/130, 26/131	Western Mining Corp.	East Coolgardie	31 535	12.59	25 288 392
ML 36/255 S.A.	Agnew Mining Corp. P/L	East Murchison	79 420	9.46	49 097 100
ML 38/31, 38/34	Western Mining Corp. & Shell Co. of Aust.	Mt. Margaret	30 034	10.00	19 799 103
			405 946		306 484 456 (o)
<b>Nickel Ore</b>			Av. assay Ni %		
MC 15/1288, MC 15/248	Metals Exploration	Coolgardie	85 894	3.32	17 869 788 (c)
<b>Ochre</b>					
MC 20/26, 29	Universal Milling Co. P/L	Murchison	839		14 281 (a)
<b>Palladium</b>					
Metallurgical by product nickel mining ML 15/152 etc.	Western Mining Corp.	Coolgardie		kg 401.099	1 254 422

**Platinum**Metallic by-product nickel mining  
ML 15/152 etc.

Western Mining Corp.

Coolgardie

kg  
65.114

868 736

**Petroleum**

Crude Oil

1H

West Aust. Petroleum P/L

Ashburton

Kilolitres

1 422 756

275 831 175 (m)

LIC 1

West Aust. Petroleum P/L

South West

16 518

2 781 633 (q)

1 439 274

278 612 808

Natural Gas

LIC 1

West Australian Petroleum P/L

South West

Cubic Metres x 10<sup>3</sup>

831 929

28 927 638 (p)

Condensate

LIC 1

West Australian Petroleum P/L

South West

Tonne

2 050

N.A.

**Salt**

State Total Reported to Mines Department

3 624 031

39 074 797 (b)

**Semi-Precious Stones**

Serpentinite

MC 45/99

S. H. Stubbs

Pilbara

kg

270

1 080

Amethyst

MC 9/444.256

F. Soklich

Gascoyne

898

4 490

Moss Opal

MC 63/60

F. Soklich

Dundas

3 040

1 524

Chalcedony

MC 9/498. 884

F. Soklich

Gascoyne

20

20

4 228

7 114

**Silver**

M L 37/3758-62

Seltrust Mining Corp. P/L

Mt Margaret

kg

8 494.024

2 556 000

By-product of gold mining

1 836.418

430 635

By-product of nickel mining

296.896

95 776

10 627.338

3 082 411

**Talc**

M L 70/433

Three Springs Talc P/L

South West

Tonne

119 814

N.A.

M L 52/190

Westside Mines N.L.

Peak Hill

14 182

N.A.

133 996

N.A.

Number of Lease, Claim or area	Producer	Goldfield or Mineral Field	Quantity (Tonnes unless otherwise stated)	Metallic content	Value \$
<b>Tanto-Columbite Ores and Concentrates</b>					
			Ta <sub>2</sub> O <sub>5</sub>	kg	
ML 1/657 etc.	Greenbushes Tin N.L.	Greenbushes	102.00	45 556	8 398 404
MC 45/668 etc.	Endeavour Resources Ltd	Pilbara	106.79	4 054	372 007
MC 45/920, DC 45/755	Pilgan Mining P/L	Pilbara	73.21	26 232	3 745 278
MC 45/107 etc, DC 45/553	Goldrim Mining Aust. Ltd.	Pilbara	14.38	7 645	641 489
MC 59/5052	Jays Exploration P/L	Gascoyne	1.37	255	22 293
			297.75	83 742	13 179 471 (b)
<b>Tin Concentrates</b>					
				Sn Tonne	
ML 1/657 etc.	Greenbushes Tin N.L.	Greenbushes	599.46	432.34	7 575 727
MC 45/668 etc.	Endeavour Resources Ltd	Pilbara	207.19	147.16	1 921 110
MC 45/107 etc., DC 45/55/3	Goldrim Mining Aust. Ltd	Pilbara	8.42	6.05	91 587
MC 45/920, DC 45/755	Pilgan Mining Pty Ltd	Pilbara	64.28	22.51	317 659
MC 45/672, 700	D. N. & L. E. Hart	Pilbara	10.11	7.39	91 177
MC 47/305	Futuris Corp. Ltd.	West Pilbara	32.09	22.10	263 377
			921.55	637.55	10 260 637 (b)
<b>Zinc Concentrates</b>					
ML 37/3758-67	Seltrust Mining Corp. P/L	Mt Margaret	10 129	Zn Tonne 3 613	2 899 744 (b)
			VALUE OF MINERALS (other than gold).....2 538 837 985		
			VALUE OF GOLD..... 153 313 613		
			TOTAL VALUE.....2 692 151 598		

N.A. Not available for publication.

(a) Estimated F.O.R. value.

(b) Estimated F.O.B. value.

(c) Value at works.

(d) Value of mineral recovered.

(e) Value at Pithead.

(f) Estimated value based on current price published.

(g) Only results of sales realised during the period under review.

(h) Metallic content calculated on assay basis.

(i) Concentrates.

(j) By-products of gold mining.

(k) By-products of tin mining.

(l) Value based on the Average Australian Value of Alumina as published by the Bureau of Mineral Resources in the Australian Mineral Industry Review.

(m) Value based on the price per barrel as assessed by the Commonwealth Government for Barrow Island Crude Oil at Kwinana.

(n) Nominal price.

(o) Estimated F.O.B. value based on the current price for nickel cathodes.

(p) Nominal price at well head.

(q) Net well head value.



