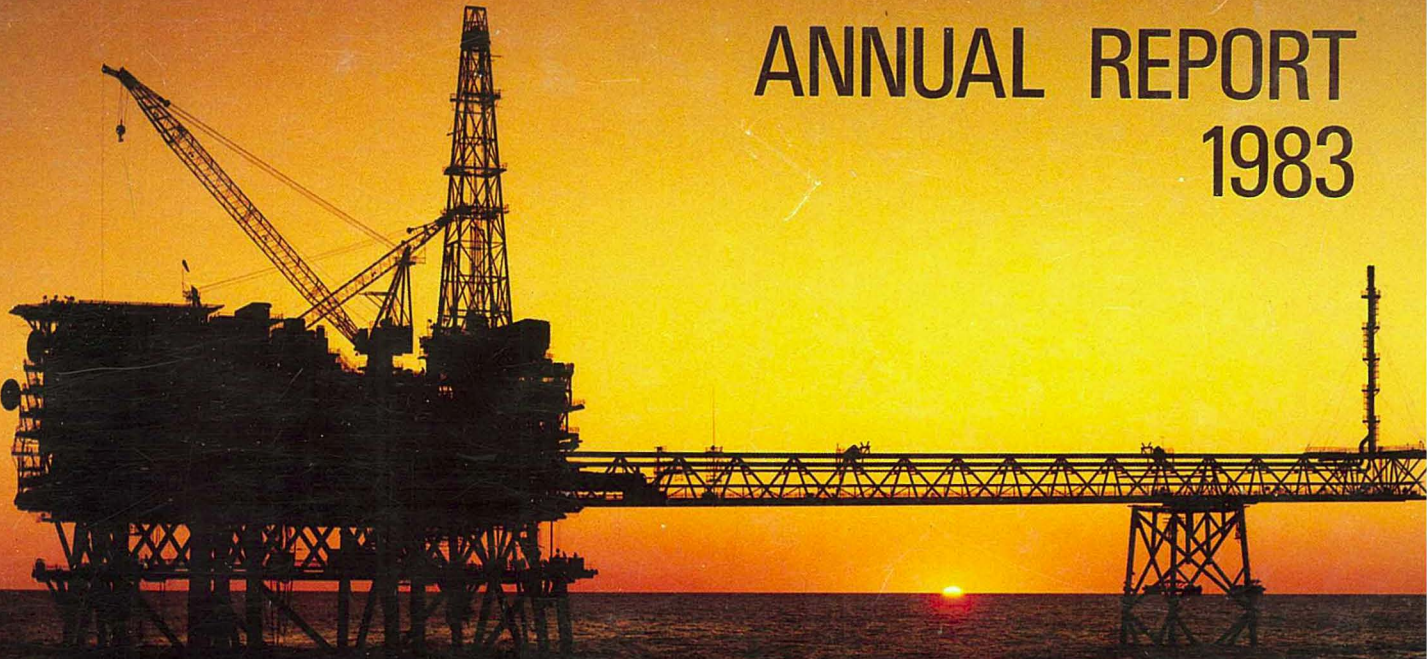


# ANNUAL REPORT 1983



DEPARTMENT OF MINES  
WESTERN AUSTRALIA  
ANNUAL REPORT 1983



DEPARTMENT OF MINES WESTERN AUSTRALIA

# ANNUAL REPORT 1983



**DEPARTMENT OF MINES**  
WESTERN AUSTRALIA  
Perth, 1984

PRESENTED TO BOTH HOUSES OF PARLIAMENT



*To the Honourable David Parker, B.A., M.L.A.,  
Minister for Minerals and Energy*

*Sir,*

*I have the honour to submit the Annual Report  
of the Department of Mines of the State of  
Western Australia for the year 1983, together  
with the reports from the officers controlling  
Divisions, and tables and diagrams showing  
progress of the Mining Industry.*

*D. R. Kelly,*

*Perth, 1984*

*Director General of Mines*

# CONTENTS

	Page
Introduction and Overview .....	5
The Year 1983 .....	13
Mining Engineering Division .....	17
State Batteries Division .....	27
Geological Survey Division .....	31
Petroleum Division .....	39
Surveys and Mapping Division .....	45
Government Chemical Laboratories Division .....	49
Explosives and Dangerous Goods Division .....	59
Registration Division .....	65
Administrative Services Division .....	69
Statistical Digest .....	73

## DIAMONDS—a first in the State

Commercial production of diamonds from the Argyle Diamond Mines Joint Venture deposits at Argyle in the East Kimberley, officially commenced on 1 January, 1983. Although minor quantities of diamonds were recovered in the latter part of the last century from Nullagine, Argyle represents the first commercial diamond production in Western Australia and the first in Australia since the early 1920s.

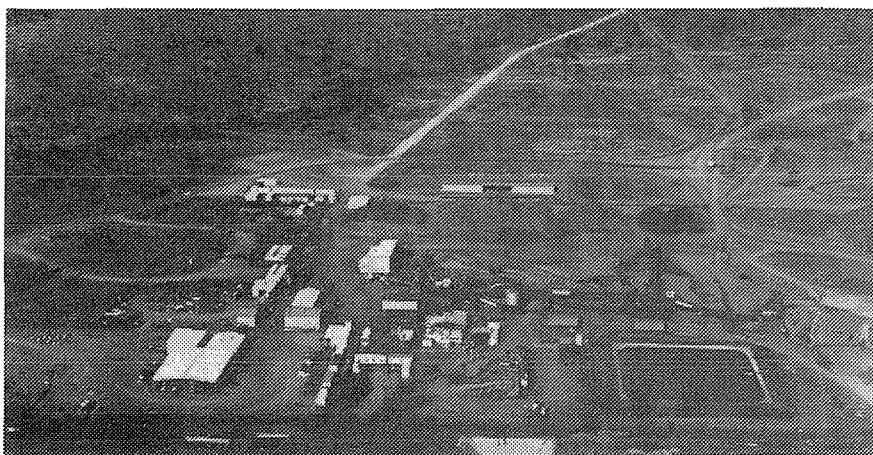
Diamondiferous alluvials were discovered in Smoke Creek in mid-1979 and in late 1979 the major reserve of the AK-1 (Argyle Kimberlite No.1) pipe was recognized. The project has involved extensive exploration, development and negotiation, and production from the alluvials has commenced little more than 3 years after discovery.

Authorization for the development of the deposits and for methods of marketing the diamonds is held under a special, ratified agreement between the State and the joint venture partners, which is administered by the Department of Resources Development. It was assented to in December, 1981 and subsequent proposals under this agreement to develop the alluvial deposits in Upper Smoke Creek and Limestone Creek, were approved by Government in December 1982. At these areas production is ongoing and will continue through to late 1985.

In mid 1983 the joint venture partners decided to proceed with the development of the AK-1 pipe, at an estimated cost of over \$450 million. The proposals put to the Government included the joint venturers' plan to commute a majority of the workforce from Perth, as opposed to building a major township in the Argyle area. In November 1983 the agreement was varied releasing the joint venturers from their obligation to build a township. In addition the royalty payment arrangements were modified to provide for a \$50 million prepayment of royalties. This enabled

the Government to buy a 5 per cent interest in the project.

Development work at the site commenced immediately on the removal of a vast quantity of waste rock adjacent to and overlying the pipe. With the current scheduling, production is due to commence late in 1985. Output is planned at a design capacity of 3 million tonnes of kimberlite ore per year.



Argyle Diamond Mines alluvial treatment plant.

There are two unique features of the Argyle deposits in a world diamond context. Firstly, the concentrations of diamonds in the ground of between 3 and 7 carats per tonne at Argyle are a factor of 10 times higher than most other deposits of the world. However, the value of the Argyle diamonds is much less than other producing deposits due to the low gem content. The world average value for diamonds is around US \$80 per carat, compared with the Argyle average of about US \$10 per carat in the alluvials and US \$6-7 per carat in the pipe. The low value of diamonds from the Argyle pipe reflects this low gem content of about 5 per cent, and the percentage is only slightly higher in the alluvials.

The Argyle production will be significant in the world market. At capacity the pipe will be adding in excess of 20 million carats per year to a natural diamond supply of only 55 to 60 million carats per year; but

more significantly in the ranges of cheaper industrial diamonds Argyle will be adding some 75 per cent to the market.

The diamond market is dominated by the De Beer's controlled Central Selling Organisation (C.S.O.) to which 95 per cent of the Argyle production is currently sold. The remaining 5 per cent, the State-owned Northern Mining share, is

marketed through a Belgian agent.

The valuation of diamonds is subjective and based on an assortment of parameters including size, weight, crystal shape, colour and quality. The concept of quality encompasses cutting characteristics which are a function of fracture and inclusion density or clarity. As a result the C.S.O. has over 5 000 categories of diamonds and for Argyle alone requires a production sort on the basis of over 500 categories.

Because of the complexity and unique characteristics of diamonds, the Government has engaged a qualified diamond valuer. His role is primarily to assist in the process of verification of values for royalty purposes, ensuring that the State receives a fair and reasonable payment for the right given to the Argyle Diamond Joint Venture to exploit diamonds whose ownership, as with all mineral commodities, is vested with the State.

## The Mining and Mineral Processing Industry in 1983

### Performance

The year of 1983 marked the beginning of an upturn in the economic situation in Western Australia after several years of worldwide recession. Commodity prices and demand showed signs of improvement from early 1983. Some companies were able to make better utilization of capacity, and overall results for the year were better than those for 1982. Data accumulated from the industry Australia-wide showed average effective after-tax returns on funds employed of 4.7 per cent for 1982/83, compared with 3.6 per cent for 1981/82. However even this increased level compares poorly with the 9.4 per cent average for the previous 7 years (Australian Mining Industry Council), and would still be unsatisfactory to industry.

Devaluation of the Australian dollar by 10 per cent in early March improved the competitiveness of the industry, which had previously suffered from the high inflation rate in Australia. The advantage thus gained has been eroded by the gradual strengthening of the Australian dollar against the U.S. dollar, resulting from the decision, generally welcomed by the industry, to allow the Australian dollar to float.

The severe economic climate of 1981 and 1982 forced industry to contain costs by a number of stringent measures. While Australian inflation was 11.5 per cent in 1982/83, the equivalent for the mining industry was 7.6 per cent. This has been achieved by cutting overheads, reducing the work force and selling off unproductive or surplus assets.

Production rates have been maintained; indeed, for most commodities, are better than those for 1982. However decisions to expand made prior to 1981 have burdened industry with large capital expenditure

commitments and resultant interest on largely overseas borrowings.

The mining industry in Western Australia has generally managed to maintain operations through the recession, in contrast to many of its competitors around the world who have faced temporary shutdown periods or permanent closure. For a number of commodities this shakeout of less efficient overseas producers has strengthened the position of those suppliers remaining. Hopes of a sustained recovery may also have had some beneficial effect on market conditions during the year. Whatever the cause, existing operations and the newly installed capacities throughout the State are currently in a good position to benefit from any further recovery in demand.

### Exploration activity and development

Exploration has been the main victim of the harsh economic environment of previous years. Cost cutting measures by producers, lack of immediate incentives for exploration groups, and the current reluctance to commit major long-term investments have considerably curtailed activities. The gold and oil industries are the only exceptions to this generalization. Apart from these commodities the only significant new discovery announced during 1983 was the copper find by WMC at Nifty in the Throssell Range in the East Pilbara.

Buoyant gold prices, which peaked at over US\$500/oz in early 1983, led to intensified exploration, development and expansion in production in the gold industry.

Stock market activity was strong and many of the major mining companies diversified into gold.

The petroleum industry in 1983 showed a decline of over 60 per cent in seismic lines run and about 17 per cent in drilling, although the number of wells increased slightly; however this is in comparison with 1982 which

was a record year. Start-up of the Blina oilfield and the discovery at Sundown, both in the Canning Basin, combined with the discovery of small oil fields off the Pilbara coast and the major oil discovery of Jabiru in Commonwealth waters off the Kimberley coast, have sustained high levels of oil exploration. However, at years end there was concern in industry that the Commonwealth's proposed resources rent tax could be a disincentive to future exploration activity.

Diamond exploration has slowed from the high levels of activity generated by the 1979 Argyle discovery. Commercial production at Argyle commenced at the beginning of the year.

Two new major bauxite-alumina operations in the South West at Worsley and Wagerup are expected to start production early in 1984.

Construction work on the Damper to Wagerup gas pipeline was on schedule to bring the N.W. Shelf gas project on-stream by mid-1984.

### Mineral production and royalties

**Production and value.** Production levels increased for alumina, nickel, natural gas, gold, coal, salt, tin and tantalum. Iron ore, oil, mineral sands and primary base metals showed reduced output as shown in the accompanying table. Diamonds were an important new commodity in the State in 1983.

The 1983 statistics for production and value of the main mineral commodities in the State (see page 87) show that there has been a slight overall improvement in value of production compared with the very depressed 1982 situation. This has been brought about mainly by higher unit prices assisted by the devaluation of the Australian dollar.

The total value of mineral output rose by about 10 per cent to \$3 677 million in 1983, more or less matching inflation.

Mineral	Units	Production		% Difference
		1982	1983	
Alumina	Mt	3.7	4.0	+8.1
Base metals (primary)				
Copper conc.	kt	61.4	35.7	-72.0
Zinc conc.	kt	101.8	26.4	-285.6
Coal	Mt	3.7	3.9	+5.4
Diamond	M carats	—	6.5	—
Gold	t	20.8	23.9	+14.9
Iron ore	Mt	78.2	75.0	-4.3
Mineral Sands				
Ilmenite	kt	1 075.9	881.3	-22.1
Rutile	kt	80.2	86.2	+7.5
Zircon	kt	297.1	272.4	-9.1
Others	kt	31.6	23.1	-36.8
Nickel				
Concentrate	kt	457.8	494.0	+7.9
Ore	kt	98.2	19.4	-406.2
Petroleum				
Oil	ML	1 278.0	1 260.8	-1.4
Natural gas	m <sup>3</sup> x 10 <sup>6</sup>	881.2	1 052.7	+19.5
Condensate	kt	2.7	3.2	+18.5
Salt	Mt	3.4	3.9	+14.7
Silver	t	50.3	25.6	-96.5
Tantalite conc.	t	20.4	272.4	+1 235.3
Tin conc.	t	720.0	774.8	+7.6

Even though iron ore production fell by 4 per cent, or over 3 million tonnes, and despite a price reduction negotiated in early 1983, the industry still managed to record an overall increase in value of 3.3 per cent. This results from the combined effects of devaluation and the lag before the reduced price becomes effective. Iron ore made up 42 per cent

of the total value of mineral production.

Conversely while nickel production increased, its overall value dropped by over 13 per cent, reflecting continuing depressed prices. Both gold and petroleum industries ranked higher than nickel in terms of value of production for the first time in a number of years. Gold (up 15 per

cent in production level and 45 per cent in value) and petroleum products (up 21 per cent in value) were the major areas of improvement over 1982. In the smaller industries the prime area of recovery was tin/tantalum (up 41 per cent in production and 113 per cent in value). The accompanying diagram shows the relative importance of the main mineral commodities within Western Australia in value terms.

Details of production and value for all minerals produced in the State are tabulated in the Statistical Digest on pages 87 and 90.

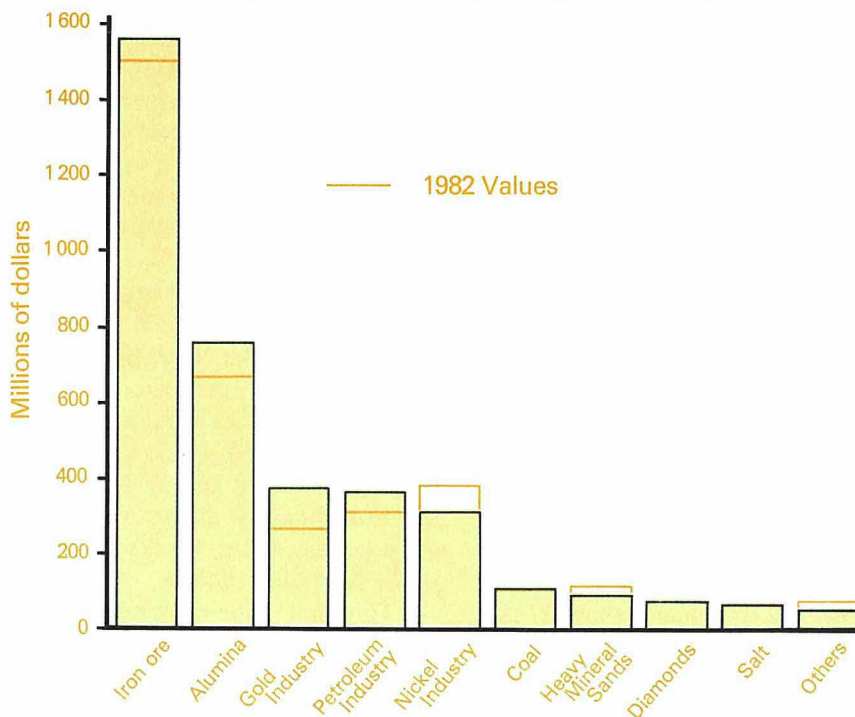
**Royalties.** Royalty revenue for the year amounted to \$105.7 million, a rise of 11.6 per cent or \$11.0 million. This increase reflects higher revenues from all the main commodities, except nickel. For nickel the royalty was calculated on the actual price rather than on the INCO world-producer posted price, and the reduction in royalty revenue from nickel reflects this change and the overall fall in value of the product. The accompanying histogram shows the trends in the royalty total and sources of royalty revenues over the last decade.

During the year the new State Government announced its intention to commission a review of all mineral (including petroleum) revenues in Western Australia. In addition the Commonwealth Government has proposed that the current systems of imposts on resource industries be replaced by a single resource rent tax. In both cases royalties will form a major area for consideration.

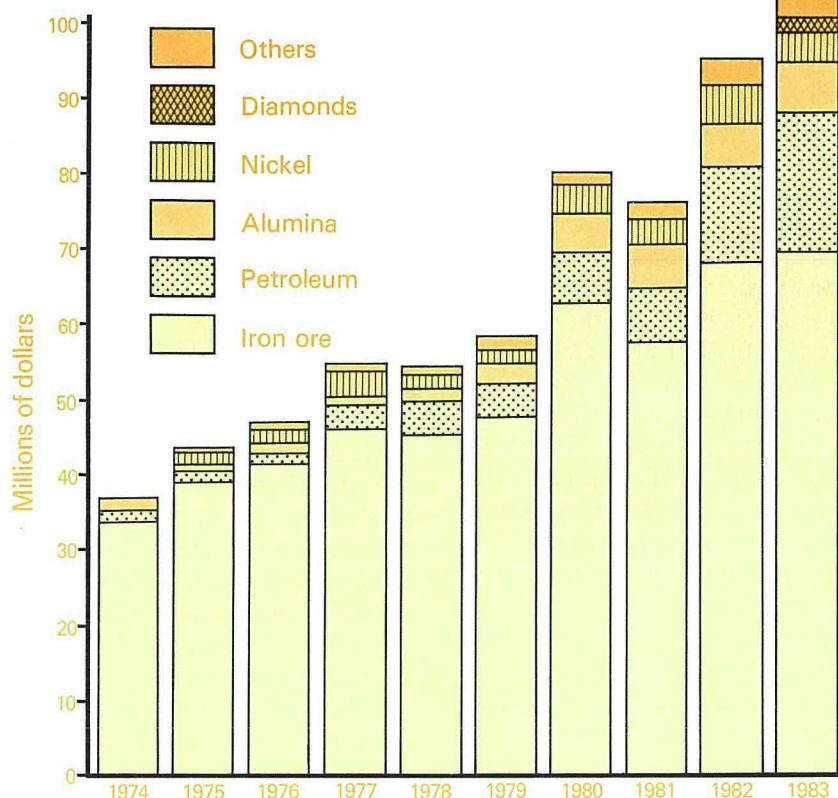
#### Future outlook

The improvement outlined above reflects increased industrial production in the developed nations of the world, encouraged by economic growth in the U.S.A. The strength and endurance of the U.S. recovery are still subject to argument and many economists and mineral producers are guarded in their optimism. The O.E.C.D. forecasts a growth of 3 per cent in major industrialized countries for 1984, while others predict rises in interest rates again in

VALUE OF MINERAL PRODUCTION 1983



## ROYALTY REVENUE



the U.S., leading to higher inflation which in turn will influence growth.

Australia is still burdened with higher inflation rates than most O.E.C.D. nations, and while this continues it will affect the mineral industry's competitiveness in the international market. However, recently applied efficiency measures and the investment decisions made about 5 years ago to install modern, efficient plant are already allowing the Western Australian mining industry to respond to stronger demand. Continuing increased demand is predicted through 1984.

Major capital expenditure programmes will probably continue to decline until profitability improves significantly. The resurgence in the gold industry in the State is an exception to this generalization and gold has been the production mainstay of some of the larger mineral producers over recent years. Development plans could lead to production levels of more than 30 tonnes of fine gold per year within the next two or three years.

## Commodity reviews

### Introduction

Historically mining has given strong impetus to the development of Western Australia and mineral production is currently one of the most important factors in the State's economy.

The State's mining industry is largely dependent on the export trade and Western Australia makes a significant contribution to world markets in iron ore, alumina, nickel, heavy mineral sands, diamond, and tantalum. It will also be a significant source of natural gas when exports begin from the North West Shelf later in the decade.

### Iron ore

In 1983 Australia was the largest exporter of iron ore in the world and maintained its position as third largest iron ore producer. The Pilbara Region of Western Australia, provided most of Australia's exports.

Out of a total production of 75.0 million tonnes in the State in 1983, 69.6 million tonnes or 93 per cent was exported. Clearly the viability of the industry is heavily dependent on world demand for steel.

World steel production continued at extremely low levels, only 1.7 per cent higher than the 10-year low recorded last year. However Japan, the major consumer of the State's exports, showed a 2.4 per cent drop in crude steel production from the previous year.

Japan's intake of Australian iron ore continued at similar levels to the previous year, being about 48 per cent of its total requirements. This represents 67 per cent of the State's iron ore exports. The Asian market in total amounted to 81 per cent of all exports; the balance went to Europe.

Iron ore is the premier mineral commodity in the State, comprising 42 per cent of the total value of mineral production during 1983, even though the industry has continued to operate at only 68 per cent of the 110 million tonnes annual production capacity during the year. At these low operating levels and in the wake of a 12.8 per cent reduction in negotiated price for 1983, most producers are operating at a poor level of profitability. The devaluation of the Australian dollar has helped to offset the price reduction while general improvements in productivity and cost control have helped to contain cost increases. The State Government has taken steps to improve labour relations within the industry and has received an encouraging response. However, indications of a further 10-12 per cent price reduction in the coming year, without any significant signs of increased demand for iron ore, are likely to add to the problems of the industry.

A review commissioned by the State Government to assess the long-term future of the Pilbara iron ore industry and the role of Government in furthering the industry, indicated that world demand for iron ore is highly unlikely to reach levels which could sustain a new iron mine in the Pilbara before the 1990's.



The two major iron ore producers, Hamersley Iron and Mt Newman Mining, began the year with very large ore-stock levels. Despite the effects of industrial action in mid-year Mt Newman Mining generally managed to continue its shipping schedule, although stocks at the port were eventually almost depleted. However, both its production and total shipments were considerably reduced from 1982 levels. Hamersley Iron increased its shipments by almost 4 million tonnes from 1982 to 1983, while at the same time there was a decrease in production.

The Robe River operation again maintained relatively high shipment levels and recorded modest profits in relation to investment. A capital investment of \$25 million was committed to port improvements including deepening of the Cape Lambert shipping channel to improve market competitiveness by allowing larger vessels to be handled.

Goldsworthy Mining negotiated a continuation of sales to Japan from their Sunrise Hill operations from April 1983 through to early 1985, and the company is discussing possible extensions to the contract beyond this date to allow mining to continue.

The Koolyanobbing mine ceased operation in August after working at very low levels following the closure of Australian Iron and Steel's blast furnace at Kwinana in early 1982. BHP announced its intention to stop mining operations at Cockatoo Island during 1984 due to exhaustion of recoverable ore reserves.

### Bauxite/Alumina

There was a rapid rise in the free market price of aluminium in the early part of 1983, attributable, amongst other things, to a strengthening in demand, as shown by a 7 per cent increase in world aluminium consumption in the first half of 1983. When supply balanced demand the price stabilized as illustrated in the accompanying graph.

Two major projects, with a combined investment of over \$A1 000 million and refinery capacity of 1.6

million tonnes per year, are expected to commence operation in 1984.

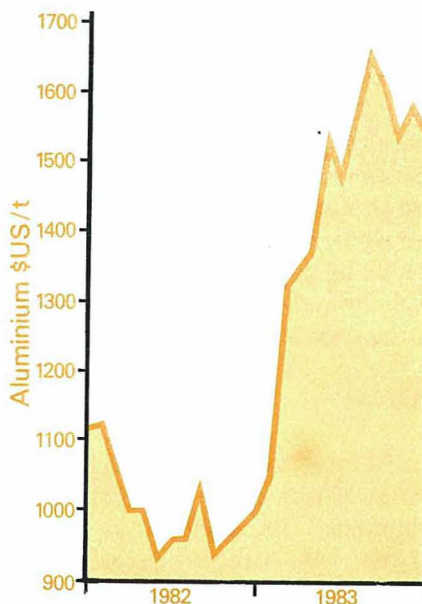
Commissioning of Alcoa's new Willowdale mine and Wagerup refinery has been held in abeyance since construction was completed in May 1982, but the improved market situation led to announcement in August of firm plans to start production in February 1984. Construction problems have delayed completion of the 1 million tonne per year Worsley Project from 1983 until early 1984.

Alcoa's existing plants at Kwinana and Pinjarra returned to full operating capacity in the second quarter, giving an 86 per cent overall operating level for 1983 from Alcoa's Western Australian operations. This compares with a general world figure of 69 per cent.

Improvements in prices, raised shipment levels and devaluation of the dollar have brought profit figures for the last 6 months of the year that are double those of the first half. Alcoa's full year net profit was \$58.1 million.

Large investments in the State's alumina industry in recent years have provided modern plants with large capacities. It is therefore critical that demand continues to improve. At present, returns on investment are exceptionally low and Alcoa quoted a figure of 2.5 per cent for the year.

ALUMINIUM FREE MARKET (LME) PRICE



The State Government supports the concept of an aluminium smelting industry being established in the South West of the State. Accordingly, there was considerable effort expended during the year in advancing all aspects of the proposal including investigations into coal supplies for power generation and the possible location of smelter facilities.

### Nickel

As with iron ore, the world nickel industry continued to suffer from the world recession in the steel industry. However there was a sharp climb in price from about US\$1.60/lb in early December 1982 to around US\$2.45/lb by late March 1983. This trend did not continue and there was a gradual decrease to US\$2.10 - \$2.20/lb by year end.

Western Mining Corporation, the State's main nickel producer, maintained its production levels by stringent cost control, operating in cost-efficient and higher grade areas at Kambalda, and offsetting losses from nickel operations by increasing gold output. This company also renewed a contract for 15 000 tonnes per year contained nickel for 10 years with the Japanese Sumitomo Metal Company. This represents about 30 per cent of Kambalda's production. As a result of these moves, Western Mining has now become the third biggest nickel producer in the world.

Also in 1983, Western Mining purchased Shell's 50 per cent share of the Windarra operation, near Laverton.

Seltrust/MIM's Agnew operations also maintained production, even though the sole customer, Amax Nickel Inc., temporarily closed its U.S. refinery over June and July. Substantially reduced production costs and the devaluation of the Australia dollar could not sufficiently counter-balance low nickel prices and consequently the Agnew operation incurred losses for 1983. Nickel yields and production levels improved in the second half of the year.

Operations at Metals Exploration's Nepean mine were suspended in February 1983 and the mine was

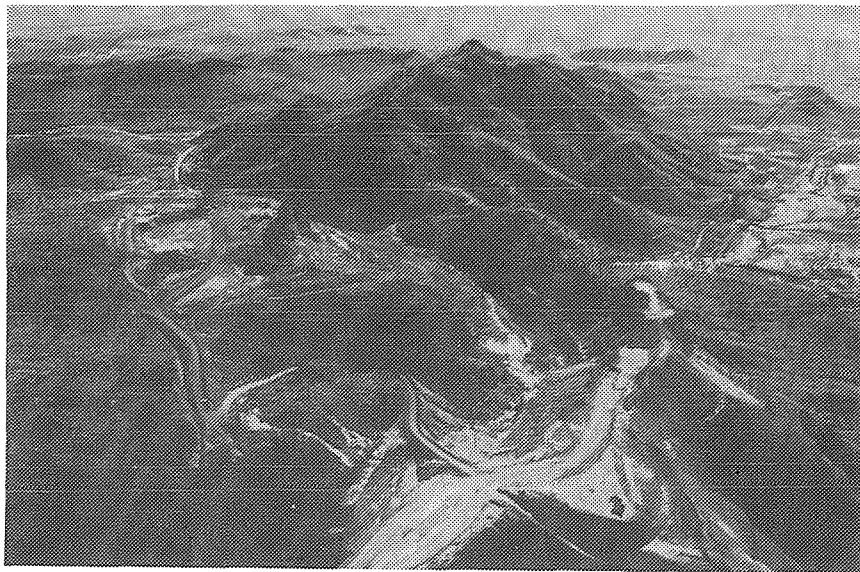
placed on care-and-maintenance awaiting improvements in the market. A reserve of 2 years extractable ore remains.

## Gold

While exploration and development of most mineral commodities were curtailed by the continuing world recession, in the gold industry substantial exploration activity resulted in a number of significant finds and increased production from expansion of existing operations. A number of the larger companies operating in several commodities have increased their production of gold, and both large and small companies have switched their exploration efforts from other minerals to gold.

The rapid rise in the price of gold through 1982 continued into the early part of 1983 when the US\$500/oz barrier was broken in February. The price then stabilized at around US\$400-420/oz for much of the year and towards year end dropped further to between US\$380 and 400/oz. These prices are considered adequate to sustain interest in gold, although further drops of US\$40-50/oz could adversely affect some existing operations and new developments.

The most significant mining development during the year was the continued increase in production of



Aerial view of the Argyle diamond pipe where work is in progress to remove 20 million tonnes of overburden before commercial mining of the pipe ore begins in 1986.

Western Mining Corporation's Kambalda gold operations. This compensated for the financial plight of the company's nickel operations. Output doubled from the previous year to make Kambalda the third most important gold centre in the State. In 1982 production had already increased five-fold on 1981.

On the Golden Mile, North Kalgurli began open-cut operations to supplement its established underground production and Paringa commenced production from underground and open-cut operations.

Telfer and Mt Charlotte remain as the largest gold-mining operations.

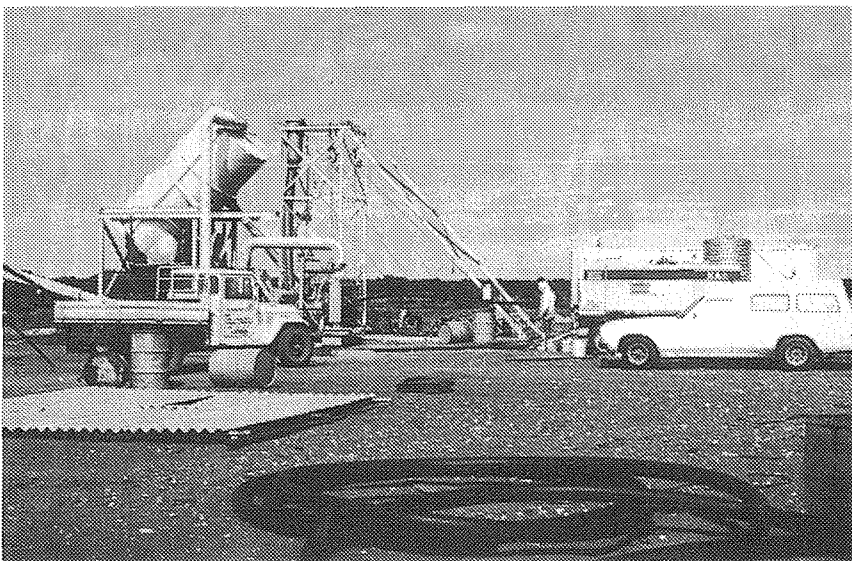
## Diamond

Commercial production of diamonds officially commenced from alluvial deposits at Argyle in the East Kimberley on 1 January, 1983. In the first year of operation just over 1 million tonnes of alluvial ore was processed for a recovery of 6.2 million carats of diamonds.

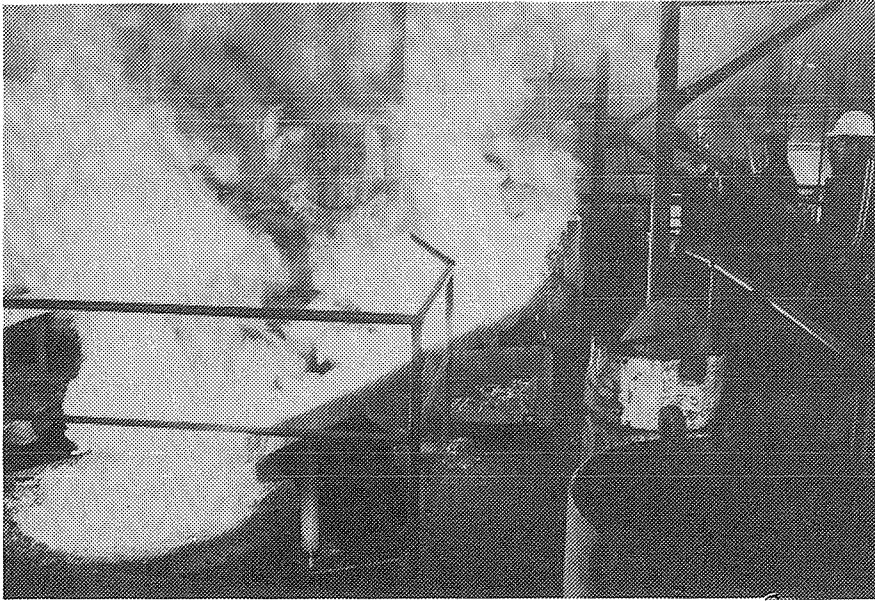
The first sale was made in April, 1983 after which regular monthly sales of 95 per cent of production were made to the De Beers-controlled Central Selling Organisation. Northern Mining Corporation sold its 5 per cent share of the production on the open market, via a Belgian sales agency.

The known alluvial resources will be exhausted by early 1986, by which time the major project on the AK-1 diamond pipe at Argyle will have commenced. Development work, such as pre-production stripping and preparation for plant construction, began in November. The proposed level of output of 25 million carats per year from the pipe will make the operation more than double the size of the largest current operation in the world, and will add about 40 per cent to world natural diamond supplies, although largely as industrial stones.

The discovery of such a major deposit and progression to commercial production have stimulated fur-



Surface installation for shaft sinking using hydraulic lift technique at the Harbour Lights gold mine near Leonora.



Tapping molten tin from the Greenbushes Tin N.L. tin smelting furnace at Greenbushes.

ther diamond exploration interest in the State over the last 5 years and there is a long-term potential for other major finds.

#### **Tin, tantalum, lithium**

Although there was an improvement in the world demand for tin in 1983 large stocks have built up around the world, and the International Tin Council will maintain export controls for the foreseeable future. However, if demand remains strong, there may be a gradual cut-back in these trading restrictions through to 1986.

As a result of the export restrictions, Greenbushes Tin Ltd, the dominant producer in the State, continued to operate at about one-third of capacity. However Greenbushes tin production operations regained profitability as a result of a 20 per cent increase in the market price for tin in the first half of 1983.

Over the past few years there has been an almost total lack of demand for tin's co-product tantalum, and mining has been directed towards zones of high tin concentration.

Tantalite stocks at Greenbushes amounted to almost 2 years of production by mid-1983 and inventories were valued at \$7.1 million. However, a successful bid in mid-year to supply 54 430 kg of concentrate to the U.S. General Services Administration Strategic Stockpile,

although at marginal prices, provided a big boost to the company's immediate cash flow by reducing the inventory by about \$4.2 million.

The development of the major underground resource, which could ultimately lead to Greenbushes being a world leader in the tantalite industry, was slowed when negotiations with a potential joint-venture partner were broken off at the end of 1982. However, with improving tantalite demand and price towards year end, the company was close to raising sufficient capital on its own to commission the project by 1985.

Furthermore, hardrock lithium reserves of 11 million tonnes at 1.9 per cent extractable  $Li_2O$  associated with the tantalite could make Greenbushes a world-ranking lithium producer. Some concentrate shipments have commenced.

#### **Oil and gas**

The Blina oilfield in the Canning Basin began production in September as the second producing oilfield in the State, some 16 years after the start of Barrow Island. The Sundown Field, also in the Canning Basin, is likely to be brought into production early in 1984, whilst the offshore Harriet Field in the Barrow Sub-Basin could also be producing from next year.

The high discovery rate, one in six wildcat wells drilled, provides en-

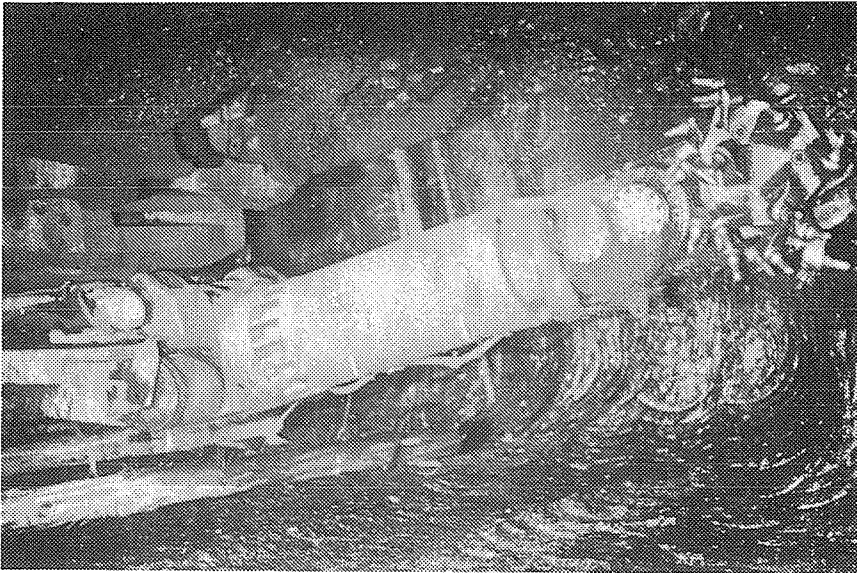
couragement for future exploration in the Carnarvon and Canning Basins; whilst the major discovery during the year by BHP at Jabiru, in Commonwealth Territorial waters, has heightened interest in the Bonaparte and Browse Basins. Oil exploration is extremely important in view of the gradually declining Barrow Island production (3 350 kL per day in 1982 compared to 6 500 kL per day in the early 1970s). In addition the identified oil resource is small, and currently 51 per cent of the State's energy needs are met by imported oil.

The gas situation is very different. At present the production comes chiefly from Dongara, supplemented by Woodada and Barrow Island. Production was about  $1.1 \times 10^9 m^3$  in 1983. The major North Rankin Field on the North West Shelf is on schedule to begin production in mid-1984. Resources of this and nearby fields are very large, adequate to serve long-term domestic needs and to allow substantial quantities of gas to be exported as liquified natural gas (LNG). Ultimate production from the North West Shelf natural gas project will be 6 million tonnes of LNG, 1.4 million tonnes of condensate and 640 000 tonnes of liquified petroleum gas (LPG) per year.

#### **Other minerals**

The State's **heavy mineral sands** industry, centred on Capel and Eneabba, has shown a reversal of the general improvement experienced in 1980-82. Most producers recorded decreased sales and revenues in the year, whilst marginally remaining in profit. Only rutile showed increased sales on 1982 levels, reflecting the greatly improved prices in this commodity. A 30 per cent rise over a 6 month period resulted from a general depletion of Eastern States stocks. In the latter part of the year there was a slight increase in prices for all products except zircon, providing a better outlook for 1984.

**Coal** for domestic power generation is mined at Collie. The two coal producers recorded increased profits



Mechanical coal cutter, Western Collieries, Collie.

for the year and production, which was again slightly up on the previous year, totalled 4.0 million tonnes. Exploration for coal elsewhere in the State declined overall, with most activity confined to the Vasse Shelf south of Busselton, and the Hill River area midway between Perth and Geraldton.

The State possesses significant **uranium** resources at Yeelirrie and Lake Way near Wiluna, Manyingee Hill south of Onslow, and Cundeelee to the east of Kalgoorlie. In view of the Commonwealth Government's review of the Australian uranium industry, which resulted in withdrawal of approvals to negotiate sales contracts, no development and little exploration progress was made in Western Australia during the year.

Teutonic Bore, to the north of Leonora, is the only primary producer of **copper** and **zinc** in the State. Increased demand and prices for these commodities, and **silver**, resulted in an improved performance in 1983.

Evaluation work continued on the State's largest copper-zinc deposit at Golden Grove, where a reserve of 40 million tonnes has been identified in two prospects, Gossan Hill and Scuddles. At the latter, approval has been given for shaftsinking, bulk sampling, and metallurgical testing programmes collectively costing \$20 million.

In September, Western Mining Corporation announced encouraging early-stage exploration results on mineralization at their Nifty copper prospect, 200 km east of Marble Bar. The possibility of establishing an open-cut operation is currently being evaluated.

Western Australian **salt** production, all from the North West, is largely exported to Japan and Taiwan. One salt producer (Lake MacLeod) experienced quality control problems leading to loss of sales and Government assistance was required to keep that project in operation. Demand improved in the latter part of the year.



Gypsum from Southern Asiatic Enterprises' Lake Cowan deposit being loaded from port stockpile onto conveyor at Esperance.

The AMP Society became a 35 per cent shareholder in Agnew Clough's Shark Bay solar salt and **gypsum** operation. This is the largest gypsum operation in the State and mainly supplies the export market. A second major gypsum export project by Southern Asiatic Enterprises Pty Ltd began in mid-1983 on Lake Cowan, near Norseman. Gypsum is being shipped through Esperance, and operating levels of about 350 000 tonnes per year (equivalent to the Shark Bay capacity) were being achieved by year end.

A host of other industrial minerals are produced chiefly for the domestic market, although silica sand and attapulgite are notable export-oriented commodities.

## State Government inquiries and initiatives

### Mining Act 1978/81 review

During 1983 there were many conversions from existing 1904 Act titles to Mining Act 1978 tenements and, although the transition process will continue for several years, the bulk of the conversion has now been effected.

Industry was able to make its submission on the operations of the first 2 years of the Act through the Mining Act Inquiry set up in July.

As well as this review of the Act itself, arrangements were made for management consultants to examine the departmental registry function and procedures for tenement processing early in 1984.

These initiatives are aimed at continuing the effectiveness of legislation to promote the mining industry of the State.

#### **Mineral revenues review**

The Government has initiated an independent study into State revenue from the whole of the minerals and petroleum industries. The study will include a review of royalties, tenement rentals and other forms of government fees, charges or subsidies for services and infrastructure.

There has been a call for public submissions and the study will commence in 1984. A final report with firm recommendations is scheduled within a 9-month period.

#### **Radiation protection in the mineral sands industry**

A Code of Practice on Radiation Protection in the Mining and Processing of Mineral Sands was prepared by a Committee comprising representatives of the Mines Department, Public Health Department, Australian Workers' Union, and the W.A. Chamber of Mines. This was incorporated in the Regulations to the Mines Regulation Act in January 1983. The regulation requires that mining or processing of a radioactive substance in the course of mineral sands mining operations shall be conducted in compliance with the Code. A further public inquiry into certain aspects of the Code was initiated during the year.

An interim committee on mine radiation safety with representatives from the same organizations has been meeting to establish the best method of radiation safety control in the mining and processing of radioactive mineral sands and uranium. It is expected that a Mine Radiation Safety Board, similar to the Ventilation Board, will be established under the Mines Regulation Act.

#### **Aboriginal land-rights inquiry**

A written submission was made to the Aboriginal Land Inquiry giving the Mines Department's views on land rights in relation to the Mining and Petroleum Industries. The Department put the view that major extensions of certain forms of land rights beyond existing Aboriginal Reserves could be detrimental to the mining and petroleum industries. As these industries are of vital importance to the economic welfare of Western Australia, it would not be in the interests of the people of the State for the continuing growth of these industries to be significantly inhibited through land-rights legislation. The Department considers that access by mining and petroleum companies to land awarded under such legislation should be maintained.

#### **Mines Department**

The total establishment of the Mines Department at year's end was 812 positions, comprising 618 Public Service, 4 contract, 43 Ministerial and 147 wages positions. In addition there

were 15 part-time wages employees engaged as cleaners and gardeners at the various outstations.

There was an increase in establishment of 19 positions during 1983 attributable to two factors: under the new Government, personnel in the Minister's office were grouped with the Department; and 12 new Public Service positions were created.

These positions comprise 2 in the Executive Division, 4 in the Computer Services Branch, 3 in the Geological Survey, and 3 in the Government Chemical Laboratories.

During the year there were 60 vacancies advertised, compared with 39 in 1982.

In addition to the increase in staff, a number of employment schemes commenced during the year. These included the Wage Pause and Community Employment Programmes. Through these programmes funding was approved for the employment of up to 26 persons to carry out specific project work to assist the Department to computerize various activities including the Mining Tenement Information System, the Records Management System, Geological Survey reporting, and Surveys and Mapping recording.



Installing the OPTI COPY process camera in the Surveys and Mapping Division photo-process laboratory, Mineral House.

## THE YEAR OF 1983

● On July 11, 1983 the Government approved the constitution of a Committee of Inquiry into Aspects of the Mining Act 1978. Solicitor Michael W. Hunt was appointed Chairman of the Committee which includes representatives from the mining and rural industries and the Mines Department. The Committee considered 23 formal written submissions and completed its meetings and public hearings in December.

● The State Government acquired a 5 per cent interest in the Argyle diamond venture, by the purchase of Northern Mining.

The first commercial sale of Argyle diamonds to De Beer's Central Selling Organisation, consisting of 200 000 carats of gem and industrial stones, was completed in April.



An assortment of 2-carat uncut diamonds produced from alluvial deposits at Argyle showing a range of colours, shapes and qualities.

● Electrolytic Zinc Co. of Australia Ltd announced the awarding of a contract to Thyssen Mining Construction of Australia Pty Ltd for the sinking of a 4 m diameter shaft to 370 metres on the Scuddles orebody at Golden Grove.

● Peel-Harvey Estuary studies, assisted by the Government Chemical Laboratories, showed that more than half the paddocks sampled in the catchment area required no further applications of superphosphate fertilizers for maximum production in the 1983 season. This information revealed a real chance to reduce the amount of phosphorus reaching the estuary, one of the causes of objectionable algal blooms.

● Western Mining Corporation announced the discovery of the Nifty copper orebody in the Throssell Range, 200 km east southeast of Marble Bar. Detailed drilling to assess the full potential and to permit open-pit design studies was being undertaken.

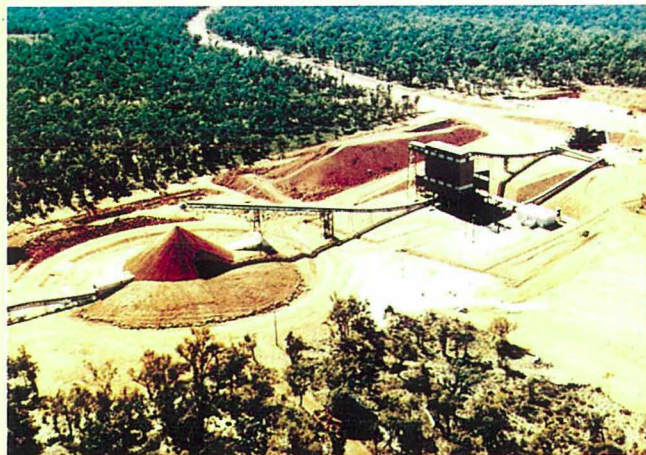
● Mining tenement applications increased dramatically from 2 968 in 1982 to 13 434 in 1983. Almost 11 000 of the applications were for prospecting licences and the Kalgoorlie and Leonora centres between them received 5 631 of these.

● Ministerial Temporary Reserve 5487H — which had been created in 1971 over State Forests in the South West of the State to help restrict the spread of “die-back” disease — was cancelled. Exploration under stringent protective conditions may now be undertaken in this area with the consent of the Minister for Forests.

● Alcoa of Australia announced a return to full production at the two operating alumina refineries (Kwinana and Pinjarra) in W.A.

● Special Act Mining Lease 258SA for bauxite exploration was granted on August 16, 1983 to the Worsley Joint Venturers. The lease contains an area of over 10 000 square kilometres and extends from north of York to south of Collie.

● Worsley Alumina commenced bauxite production at Boddington and commissioned the 51km overland conveyor between the quarry and the alumina refinery.



Bauxite stockpile being established at the head of the conveyor to Worsley Alumina Pty Ltd refinery at Worsley.



Trenching prior to burial of the 28.5 km-long pipeline linking the Blina oil production field to the Erskine storage depot on Great Northern Highway.

- Commercial production began at Blina in the Canning Basin. This was the first new producing oil field since the discovery of Barrow Island in 1967.
- The Dangerous Goods (Road Transport) Regulations were passed by both Houses of Parliament in December, to become operational on January 1, 1984.
- A surveillance survey of the most widely used pesticides was undertaken by the Government Chemical Laboratories as a result of concern expressed by the Primary Industry Association about the quality of pesticide formulations. The survey showed that the great majority of pesticides were within acceptable tolerance of their registered active constituent content.
- Development drilling commenced on the North Rankin Platform and the pipeline to transport the gas from Dampier to Perth is complete. The first gas from the North West Shelf is expected to reach Perth in the middle of 1984.



Digging the trench for the Dampier-Perth Gas Pipeline.

- A new process called laser scanning has been used successfully to reproduce out-of-print coloured 1:250 000 geological maps. Laser scanning is a much faster and cheaper process than the re-preparation of original material.
- In 1983, 70 petroleum exploration wells were drilled compared with 67 in 1982. This is a record for the second successive year.
- In 1983 there were 5 oil discoveries in the Barrow Sub-basin and 1 in the Canning Basin, and 2 gas discoveries in the offshore Carnarvon Basin. These gave an excellent success ratio of about 1 in 6 wildcat wells drilled.



Flaring gas during testing at Wilcox No.1 discovery well in the offshore Carnarvon Basin (Woodside Offshore Petroleum Pty Ltd photo).

- The 'CONTAM', mine contamination computerized records system was implemented for the Mining Engineering Division, and the analysis and design phases of the Mining Tenement Information System were completed.
- Griffin Coal Mining Co. Ltd discovered Permian Coal near Boyup Brook. The size of the resource has not yet been delineated.

- A 3-month amnesty from prosecution was declared to encourage people with illegally held explosives to contact the Explosives Division, who would arrange for the safe destruction of the explosives.
- Western Mining Corporation Ltd announced the commencement of a \$7 million, 4.6 metre diameter shaft to a proposed depth of 870 metres at the Foster mine, Kambalda.

- The State Batteries treated a record 177 049 tonnes of tailings in 1983. This substantially exceeded the previous record of 112 318 tonnes treated in 1936.

- Legislation came into effect in March to allow blood and urine to be taken from drivers suspected of being affected by drugs. Of the 61 cases examined, drugs were detected in 45 by the Government Chemical Laboratories.

- In December Roberts Construction Ltd commenced the sinking of a 4.5 m diameter shaft to a planned depth of 272 metres on Australian Consolidated Minerals Ltd's Golden Crown Leases at Day Dawn.

- On February 19, 1983, Special Act Mining Lease 259SA for diamond mining was granted to the Ashton Joint Venturers. The lease comprises an area of 13 620 hectares including the AK-1 kimberlite pipe.

- At Argyle, work commenced on the stripping of 19 M tonnes of waste material to expose the AK1 kimberlite pipe. Construction of a 3 M tonne/annum treatment plant and associated facilities also commenced.



Aerial view of Limestone Creek alluvial diamond mining area on which will be located the 3 million tonne per year treatment plant for AK-1 pipe ore.

- Agnew Mining Company completed the commissioning of the winders on the No 1 Shaft at the Agnew Nickel Mine.

- Kalgoorlie Mining Associates announced that the Chaffers Shaft would be refurbished to the 26 level to permit access to the whole of the western lode system above that level. The Chaffers Shaft is the deepest shaft on the Golden Mile (1 146 metres) and has been closed down since 1976.



Typical mining operation in weathered pegmatite at Greenbushes (Greenbushes Tin N.L. photo).

- Greenbushes Tin Ltd made a successful bid to supply 54 430 kg of tantalite to the U.S. General Services Administration Strategic Stockpile.

- Greenbushes Tin NL exported their first shipment of spodumene (lithium ore) concentrates.

- Output of gold from Western Mining Corporation's gold operations at Kambalda doubled from the previous year making it the third most important gold centre in the State.

- Metana Minerals NL recovered 5 000 ozs of gold from alluvial ore at Nullagine during the mine's first 9 months of operations.

- Buoyant gold prices led to intensified exploration, development and expansion in production in the gold industry. There was strong activity in the stock market and many major mining companies diversified into gold.



Aerial view of Paranga Gold treatment plant commissioned in 1983. (Gold Resources Pty Ltd photo).



## CONTINUOUS MINERS

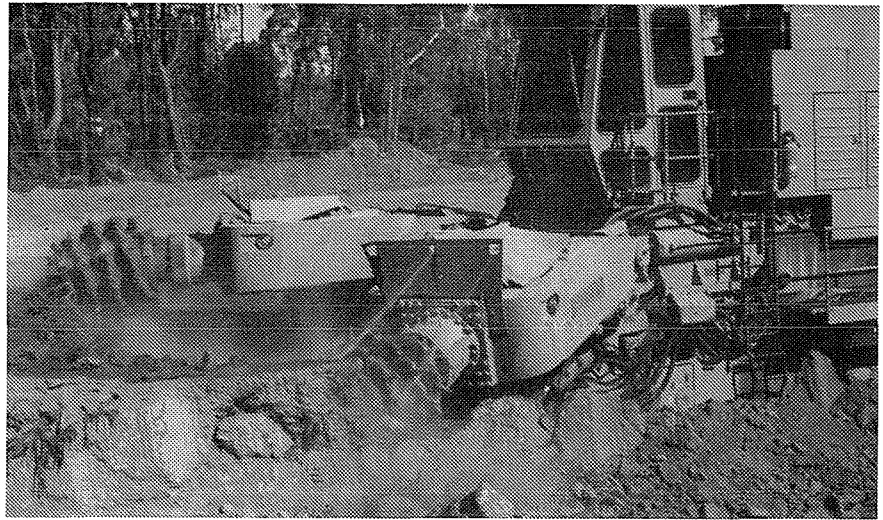
Continuous mining machines were introduced into the underground operations of the Collie Coal Mines in 1979, and into the bauxite operations of Alcoa of Australia in 1982.

The first continuous miner at Collie was a Dosco Dinthead, which went into service in the Western No.2 Colliery in 1979. The aim was to increase production, lower unit costs, and at the same time improve the stability of the roof and pillars by avoiding blasting. Encouraging results have led to the system being expanded and a further five Voest Alpine AM50 Roadheaders have since been purchased.

Both types are electrically powered, self propelled crawler mounted units. The Dosco utilizes a large mat cutter chain, whereas each Alpine AM50 is fitted with a fully articulated cutter boom on which is mounted a rotating cutting head studded with tungsten carbide picks.

As the coal is mined it travels over a bridge conveyor to transfer conveyors (which are extendable) on to the main conveyor system. Thus the coal is transferred from the face to the surface stockpiles in one continuous operation.

Mining is by the Bord and Pillar method with bords (headings) ranging in width from 5.0 to 6.5 metres. Large panels (or blocks) of coal measuring approximately 400 metres by 400 metres are developed by driving four parallel driveages to form the primary haulage, ventilation and access ways. A panel is then progressively mined by a continuous miner operating alternately in twin parallel bords. Because each bord is fitted with its own extendible conveyor, bridge conveyor, ventilation and power systems it is only necessary to shift the continuous miner when mining is to be transferred from one bord face to the next. This is done after each 11 or 16 metres of advance (depending on the machine being used) to permit the extension of the



Dosco 3000 Continuous Miner, mining bauxite at the Jarrahdale operations of Alcoa Australia Ltd.

conveyor system.

Although these types of continuous miners cannot match the long wall variety used in some other countries considerable increase in output per man shift has resulted since their introduction. Each Alpine AM50 has an average production of 200 tonnes per shift and is capable of considerably more, but production is dictated by the clearing capacity of the bridge conveyors. Current investigations to improve bridge conveyor design should result in greater production capabilities in the future.

Continuous miners are also useful in above ground operations. In the bauxite mining operations of Alcoa of Australia the company is understandably restricted in the use of explosives where the safety of people and property could be at risk. As a consequence blasting is not undertaken within 400 metres of a townsite boundary or farmhouse, and an alternative mining method had to be found which would not endanger, or unduly annoy local residents. The manufacturer of Dosco continuous miners has designed and built the Dosco 3000 specifically for this task and the unit is now operating successfully.

This crawler mounted machine features hydraulically driven, twin

cutting heads mounted on fully articulated, independently controlled booms. A portable diesel generating unit supplies power through a trailing cable to the electrically driven hydraulic pumping system.

Unlike its counterparts in the underground coal mining industry, the Dosco 3000 is not constrained by height limits, and the operator is located in a centrally mounted cabin overlooking the cutting heads.

Otherwise the principle of operation is basically the same, with the broken ore being picked up and fed to the rear of the machine by a conveyor positioned beneath the main structure. Powerful jets of water are directed at the cutting heads. The water suppresses the dust, keeps the tungsten carbide picks cool and allows them to rotate within their own sockets ensuring even wear.

The Dosco 3000 is achieving a bauxite production of approximately 310 tonnes per hour and although production costs are higher than conventional drilling, blasting and loading, it is mining a valuable ore reserve which may otherwise have been lost.

Continuing growth, changing technology and developments in the mining industry placed severe strains on the resources of the Mining Engineering Division during 1983. The problems will be compounded in 1984 with the commencement of several new mining operations.

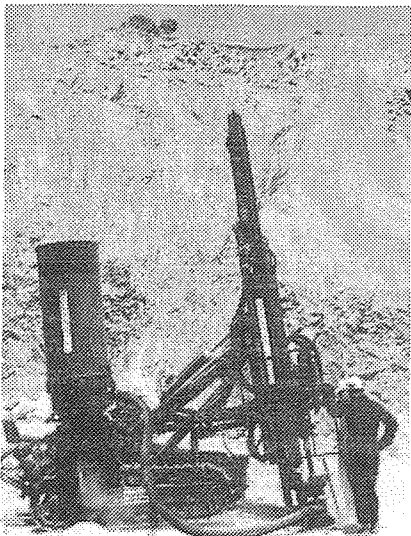
The value of production from mines (excluding petroleum) under the jurisdiction of Acts administered by the Division was \$3 311 million and the number of mine workers increased by 614 to 24 242.

Drilling Branch activities concentrated on the Statewide groundwater investigation programme and the drilling of 174 bores totalling 7 778 m was completed. Bore repair work, aquifer development and testing, thermal logging and borehole television scanning were also undertaken.

## Mining Activities

### Alumina

A revival of world aluminium production was reflected in a decision by *Alcoa of Australia (W.A.) Ltd* to return to full alumina production at its Kwinana and Pinjarra refineries.



Crawler mounted blast hole drilling rig fitted with dust collection system.

The company plans to bring the Wagerup refinery into production in the first half of 1984.

Bauxite mining at Jarrahdale, Del Park and Huntly minesites produced 14 016 503 t from 160 hectares of land. Processing of this ore resulted in 3 983 098 t of alumina.

Delays continued in the construction of the Worsley refinery and *Worsley Alumina Pty Ltd* had to defer its scheduled commissioning, again to the first half in 1984. Bauxite production commenced at the Tunnel Road minesite, Boddington, with 265 000 t being recovered from 3.3 hectares of land.

### Clays and shales

The continuing depressed state of the building industry again resulted in further decreases in the production of clays and shales.

*Midland Brick Co. Pty Ltd* remains the largest producer with 614 000 t.

### Coal

Production continued to expand with a record production of 3 952 768t being achieved. Of this, open-cut production accounted for 3 153 945 t.

*Western Collieries Ltd* provided 44 per cent of the market with a production of 1 736 439 t from its No's 2, 6 and 7 underground mines and the No.5 open cut.

At the Western No.2 mine the depletion of developed ore reserve resulted in a 21 per cent reduction in coal output to 474 784 t. Development of the western side of the mine continued.

Training facilities, incorporating mine rescue equipment to serve all underground mines, are being established on the surface at this mine.

Although operations at Western No.6 mine have concentrated on development of the mine, the use of four continuous miners greatly

assisted in a 48 per cent increase in coal production to 299 813 t.

The first coal production from Western No.7 mine came from a development heading in the Collie Burn No.2 seam on the 21st February. Since that date 24 260t of coal have been produced. A steel lined, 4 m diameter shaft provides the exhaust outlet for ventilation of the mine.

Annual production from Western No.5 open-cut mine remained static at 937 618t, but was restricted due to heavy rains in August/September.

*The Griffin Coal Mining Co. Ltd* achieved a total coal production of 2 216 328 t from its Muja and Chicken Creek open cuts.

At the Muja open cut the scheduling of mining operations is made difficult by a requirement to maintain a steady rate of production for power generation from a pit containing multiple seams of varying thickness. To overcome such problems the company operates a comprehensive, computerized mine planning programme. Precise machine and overburden stripping requirements are matched to daily coal production and exposure requirements. All mining equipment is fitted with two-way radio and its movements are controlled by a pit coordinator who is responsible for maintaining daily production targets.

Production from the Chicken Creek open-cut totalled 449 754t, the bulk of which was mined prior to 1 July. A decision to supply SEC needs from the Muja cut and only private industry needs from the Chicken Creek mine, came into effect on 1 July resulting in a production decrease to approximately 1 000 t/week. Most of the mine employees were transferred to the Muja cut.

The Company installed a treatment plant to treat the highly acidic mine water before it is discharged into the Collie River.

## Copper

On completion of open-cut mining at Teutonic Bore late in 1982, mechanized diesel mining of open stopes below the pit floor level was commenced. Mining is proceeding at a production rate well in excess of plant requirements with the aim of completing mining by August 1984. The plant will continue to treat stockpiled ore for a further 2 years.

Production from the mine totalled 359 000 t of Cu, Zn, Ag ore, but only 144 000 t were treated. Calculated metal content recovered in concentrates was: Cu, 4 860t; Zn, 11 474t; Ag, 26 176kg.

## Diamond

*Argyle Diamond Mines Pty Ltd* successfully completed its first full year of commercial production with a recovery of 6.2 million carats of diamonds from the treatment of 1.068 million tonnes of alluvial ore.

During the year the throughput capacity of the alluvial plant was doubled to 4 000 t/day.

In November site work commenced for the development of an open-cut mining operation on the AK-1 kimberlite pipe and an associated treatment plant and administrative facilities.

## Dimension stone and aggregate

Supplies of stone and aggregate used by the building and construction industries were mined from 28 different quarries throughout the State in varying quantities to meet specific local demands.

## Gold

The hectic activity associated with gold exploration and mine development in 1982 was sustained during 1983 resulting in a number of discoveries and the announcement of new mining projects. Gold production climbed to 23 881 kg valued at \$359.37 million.

**Pilbara Mining District.** *Newmont Holdings Pty Ltd* at Telfer dispens-

ed with contract mining in January and is now fully self reliant. Eleven Mt of overburden was stripped from the open cuts along with 487 000 t of mill-grade ore. Gold recovery totalled 4 450.75 kg.

Preparations were commenced for the establishment of a heap leaching process designed to treat 350 000 tpa of low-grade ore to maintain gold output on depletion of the high-grade reserves. Gold production from this source will commence in 1984.

*Metana Minerals N.L.* commenced gold extraction from an alluvial deposit near Nullagine and in 8 months treated 358 000 t for a recovery of 173.6 kg of gold.

*Golconda Resources Pty Ltd* recovered 114.5 kg from 47 000t of tailings from the Blue Spec mine.

The tailings re-treatment operations of *Comet Gold and Pilgan Mining Pty Ltd* produced a further 35 kg.

**Peak Hill Mining District.** The Horseshoe Lights open cut produced 322 000 t of ore for processing in cyanide solution leach dams. The construction of a carbon-in-pulp plant is planned for 1984.

Small operators mined alluvials and re-treated tailings to produce 211.3 kg from the district.

**Murchison Mining District.** A 40 per cent production increase at the Haveluck mine, owned by *Whim Creek Consolidated N.L.*, combined with improved gold recovery resulted

in a 63 per cent increase in gold output to 732.7 kg. Open-cut mining commenced on the old Phar Lap mine which is southeast of Meekatharra.

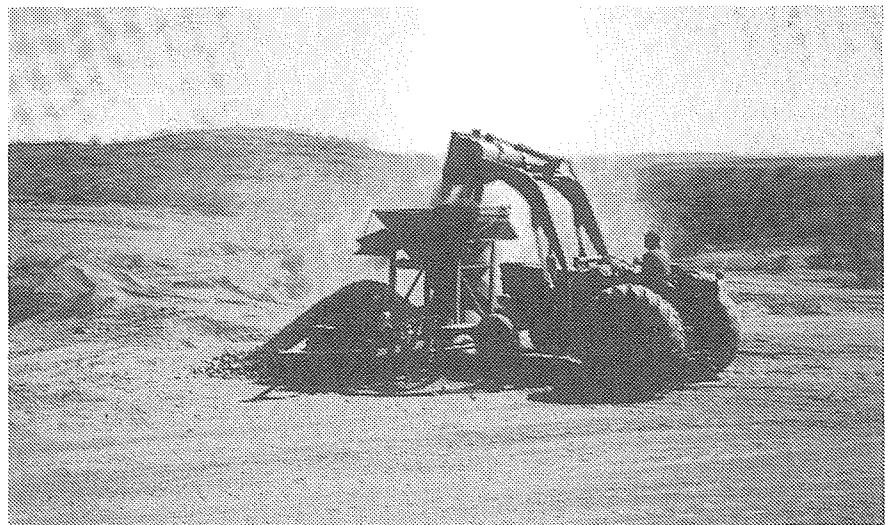
*Hill 50 Gold Mine N.L.* treated 87 000t of oxidized open-cut ore and 97 000t of underground ore from the Morning Star and Lou-Ann mines. The Hill 50 main shaft was dewatered to 253 m, the shaft and headframe refurbished and a 90 kW double drum winder installed. Mine development work to intersect the Saturn orebody was commenced.

A number of small companies and prospectors were active in the district and jointly accounted for a reported recovery of 227 kg of gold.

**Yalgoo Mining District.** Ore treated from the Rosemary, Carnation and Daffodil mines produced 57.6 kg of gold.

**Mt Margaret Mining District.** The Lancefield gold mine operated by WMC Ltd remained the major producer in the district with the mining of 209 893 t of ore. Sinking of the Evers shaft was terminated at 395 m because of ground support problems following the intersection of talc chlorite schist at 334 m. An extensive exploratory drilling and mine development programme continued throughout the year.

The Tower Hill gold mine, Leonora is now owned and operated by the *Forrest Gold Company* - a



Typical alluvial goldminer with dryblower in the Ashburton Mineral Field.

division of CRA Services. The company plans to mine and treat 200 000 tpa from an open-cut mine which was brought into production in November. Processing of ore through a carbon-in-pulp plant will commence early 1984.

At the *Sons of Gwalia N.L.* a CIP plant installed to re-treat approximately 6 Mt of tailings was commissioned in September. The plant is to be expanded to treat oxidized ore from a planned open cut on the mine.

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

Commencement of open-cut mining by *Edjudina Gold Mines Pty Ltd* at the old Porphyry gold mine was the highlight of the year in this district. Work commenced on the construction of a \$6 million treatment plant which will be commissioned in 1984.

Elsewhere in the district, a number of small surface and underground mines were in production and a number of tailings re-treatment plants were operational.

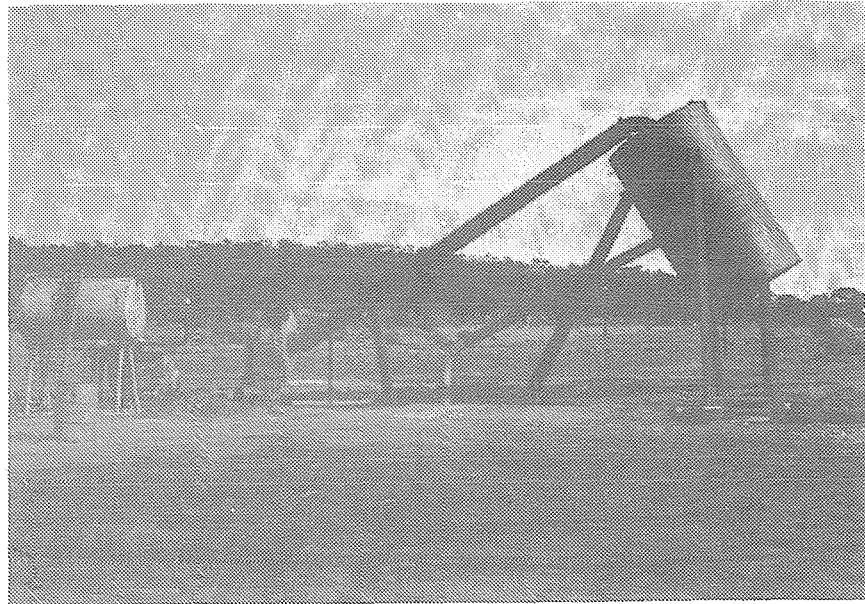
#### **Broad Arrow Mining District.**

The operations of *Western Mining Corporation Ltd* at the Sand King and Missouri open-cuts produced 70 610t of ore at 6.68 g/t. At Grants Patch a 200 t/d carbon-in-leach plant was constructed by *Ora Banda Gold Mining Pty Ltd* to treat ore from the Wentworth open cut.

Tailings re-treatment plants were operated by *Nonda Pty Ltd*, *Arrowville Pty Ltd* and another is under construction at Vettesberg by J. Granich and Son.

**East Coolgardie Mining District.** This district centred on the Golden Mile, continues as the main source of gold in the State.

*North Kalgurli Mines Ltd* almost doubled production with a 60 per cent increase from underground sources and a 330 per cent increase from its open-cuts to a total of 406 000 t. Mine development totalled to 1.2Mt. The bottom of the Croesus shaft was cleaned out and the Eclipse shaft refurbished to the 5 level; mine ventilation has been improved.



Vacuum lift mounted on prospecting show, to raise ore from underground.

*Kalgoorlie Mining Associates* continued to expand their gold mining operations in Kalgoorlie with a marked increase in production from Fimiston leases. The Cassidy shaft sink had reached 1 075 m by the end of the year and the shaft is expected to be completed in June 1984. This \$60 million investment will give access to the deep ore reserves.

Total underground development on KMA mines was 10 848 m; ore production was 1.123 Mt and gold recovery amounted to 5 831 kg.

During 1983 the company commenced refurbishing of the Chaffers shaft from the surface to the 26 level, constructed a CIP plant at the Oroya Mill and commenced construction of a \$1 million administration building at Fimiston.

*Gold Resources Pty Ltd* completed construction of the treatment plant at the Paringa mine ahead of schedule and designed throughput capacity was achieved by May. Underground production progressively increased to 12 000 t/period in August. The commissioning period has been completed and full scale production is in progress.

The pit at *Western Mining Corporation's* Great Boulder open cut has now been expanded into the Horseshoe leases of KMA. Ore from these leases is to be treated at the Oroya plant while Great Boulder ore will continue to be treated at Kam-

balda. Ore mined was 410 000 t at a grade of 5.1 g/t.

A number of small mines and tailings re-treatment plants operated throughout the year and two new open-cut operations may result from extensive exploration drilling programmes.

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

During 1983 there was considerable gold mining activity in the Kambalda area, the Victory mine of WMC Ltd being the largest producer. All ore is taken from long hole open stopes in the Victory and Defiance orebodies now that the open cut has been completed.

A considerable number of small operations covering a wide range of mining techniques operated throughout the district. However, a shortage of treatment facilities restricted production from some mines.

#### **Yilgarn Mining District.**

*Marvel Loch Gold Mines* achieved significant progress with a trebling of ore production compared to 1982. A total of 56 000 t were treated with considerable stocks left. In December open-cut mining commenced on an orebody discovered between the Marvel Loch and Exhibition shafts.

#### **Dundas Mining District.**

*Central Norseman Gold Corporation Ltd* recorded a significant drop in production during the year as the

Princess Royal open cut and underground operations approached the end of mineable ore reserves. Development of the Ajax mine has proved disappointing and only 12 500 t of ore was produced.

The Company treated 175 827 t for a recovery of 2 054.7 kg of gold.

*Australis Mining N.L.* is establishing itself as a medium-sized operation as it progressively transfers from tailings retreatment to primary ore production from the Mt Henry open cut. A 60 t/h crushing plant was installed at Mt Henry during the year.

### Gypsum

The gypsum industry continues to expand, particularly in the south of the State. *Southern Asiatic Enterprises Pty Ltd* exported nearly 200 000 t from Lake Cowan through the Port of Esperance but Gypsum production from Useless Loop was more than halved to 163 590t. A further 76 000t was obtained from other sources.

### Iron Ore

Production of 74.984 Mt was lower than 1982 output of 3.198 Mt.

*BHP Minerals Ltd* closed its Koolyanobbing mine in August after railing 314 000 t to Kwinana for shipment to the Eastern States.

Mining continued on Koolan and Cockatoo Islands with shipments of 2.53 Mt from Koolan and 0.475 Mt from Cockatoo. The Cockatoo pit is nearing the end of its economic life and mining is expected to cease in 1984.

*Cliffs Robe River Iron Associates* continued mining from Mesas L and N in the Eastern Deepdale area and 13 Mt were exported through Cape Lambert. Dredging of the shipping channel and wharf area at Cape Lambert was commenced to permit ships of 220 000 dwt to leave the port fully loaded.

*Goldsworthy Mining Ltd* mined and exported 4.87 Mt from the Shay Gap and Sunrise Hill minesites.

*Hammersley Iron Pty Ltd* shipped 31.3 Mt of ore mined from their Tom Price and Paraburdoo open cuts. Ore



Loading iron ore from the bottom bench (below sea level) at Cockatoo Island — Dampier Mining.

and waste mined at Tom Price totalled 36 Mt of which 14.2 Mt was direct shipping ore and 10 Mt was low-grade ore used as feed to the heavy media concentrator. At Paraburdoo, 18.9 Mt of material was mined for a production of 10.3 Mt of direct shipping ore.

*Mt Newman Mining Co. Pty Ltd* suffered severe production losses as a result of industrial disputes, which, combined with the depressed state of the steel industry resulted in ore production being nearly half of the 1982 figure. Total ore and waste mined at Mt Whaleback was 49.7 Mt (86.2 Mt in 1982) of which 15.86 Mt was ore. Ore shipments were down by 6.2 Mt to 22.55 Mt.

### Mineral sands

Products recovered totalled 1 234 437 t from the treatment of 10.94 Mt of ore. Of this production, 1 149 388 t were sold for a return of \$83.088 million.

*Allied Eneabba Ltd* mined and treated 6.14 Mt of sands at its Eneabba minesite. At Narngalu 433 376 t of mineral products were recovered from the treatment of 539 669 t of concentrates.

*Associated Minerals Consolidated Ltd* severely restricted production from its operations during the year.

At Capel only 966 700 t of ore

were mined resulting in a recovery of 110 842 t of products. The production of synthetic rutile was restricted to the output of the smaller 'A' Plant.

At Eneabba mineral production for the year totalled 140 141 t.

*Cable Sands Pty Ltd* mined and treated 518 500 t of ore from their Capel leases. A further 187 000 t of tailings concentrates were re-treated for an overall recovery of 164 607 t of minerals. The secondary drier was converted from oil to coal firing completing the change over to the use of coal for all drying purposes.

*Westralian Sands Ltd* mined and treated 2.73 Mt of ore from its North Capel and Yoganup Extended minesites for a return of 385 471 t of mineral products.

### Nickel

The nickel market showed signs of recovery during the year but lower nickel prices counteracted the increased sales leaving the industry in a barely break-even situation.

*Western Mining Corporation Ltd* improved its nickel sales by approximately 30 per cent over 1982, but lower prices forced the company to maintain production from its higher grade stopes at Kambalda and introduce other cost cutting measures.

During the year, work was commenced on sinking the Foster shaft, which will be used for ore haulage from the lower levels of the Foster orebody. Foster shaft is to be 4.6m in diameter and will be sunk to a depth of 870 m.

Mine development has been restricted throughout the Kambalda nickel operations, particularly in lower grade areas, as a means of economizing on expenditure. Total development for the 11 mines was 27 843m. Ore production totalled 1 329 993 t and 374 738 t of concentrates were produced.

The company's Kalgoorlie nickel smelter treated 445 907 t of nickel concentrate and produced 50 890 t of nickel matte.

The Kwinana Nickel Refinery produced 29 461 t as nickel briquettes and powder.

The Windarra Nickel mine produced 393 015 t of ore of which 387 476 t were treated to produce a nickel concentrate for further processing at the Kalgoorlie Smelter.

The No.1 shaft of the *Agnew Mining Co Pty Ltd* is nearing full operational status, and when electronic systems are completed the skip system will be fully automatic and the cage winder will operate on command from the cage.

Level development from the shaft continued throughout the year and construction of an automatic skip loading station at the 11 level is well advanced.

Drilling of the No.1 ventilation shaft by the Hughes CSD 300 Rig ceased on the 12th February at a depth of 750.5 m, 279.5 m short of its planned depth. Agnew Mining decided to stop the drilling and complete this shaft after equipping the main shaft. A connecting rise has been put up from the 6 level to the bottom of the ventilation shaft.

Ore production from the Decline mine was 576 000 t, a 96 000 t improvement on 1982.

*Metals Exploration Ltd* closed down its Nepean mine in February after having produced only 10 569 t of ore for the year.

The mine has been placed on

care-and-maintenance and is being kept unwatered. Ore reserves remaining are quoted as 246 000 t at 3.2 per cent nickel.

### Salt

The bulk of the State's export salt production continued to come from Dampier, Lake Macleod, Port Hedland and Useless Loop. The year's production amounted to 3.868 Mt valued at \$59.7 million.

### Spodumene

The mining of spodumene ore and subsequent concentration is now an integral part of the operations of *Greenbushes Tin N.L.* at Greenbushes. The concentration plant, which was upgraded and expanded, treated 38 037 t of ore for a recovery of 3 985 t of concentrate. Shipments totalled 2 491 t valued at \$464 041.

### Talc

*Westside Mines Pty Ltd* at Mt Seabrook achieved a 4 000 t increase in production to 23 723 t.

*Western Mining Corporation Ltd Talc Joint Venture* have completed mining of the original orebodies first discovered at Three Springs. Future ore will be mined from Pit C which is on an orebody discovered some 400 m to the east of the earlier mine. Talc production was 141 136 t which was nearly double that of 1982.

### Tin and tantalite

*Greenbushes Tin N.L.* mined and treated 880 000 m<sup>3</sup> of pegmatite clays and produced 403 t of tin ingots and 78.49 t of tantalite concentrate. Production was limited by tin quota restrictions.

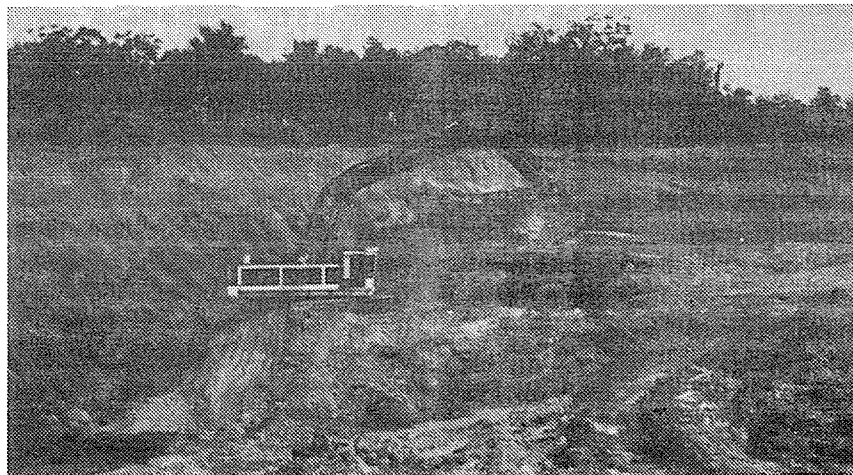
Elsewhere in the State tin/tantalite miners either suspended operations or operated at restricted outputs according to respective tin quotas.

### Operations

#### Kalgoorlie

The year 1983 was one of consolidation for the gold mining industry in the Kalgoorlie Inspectorate. Mine development and construction projects commenced in the previous 2 years resulted in a number of operations being re-established as significant gold producers. Several exploration projects resulted in the discovery of major gold deposits which will support medium to large open-cut operations.

Significant events in the year were the commencement of mining projects at Porphyry and Tower Hill. These, together with re-development activity on the Golden Mile and elsewhere, and plans for the re-treatment of many millions of tonnes of old tailings throughout the inspectorate, foreshadow a period of high productivity and stability in the gold mining industry.



Greenbushes Tin — mining in New Zealand Gully.

The acquisition of a group of mining tenements in the Jubilee area, some 50km north east of Kalgoorlie, by a subsidiary of the South African De Beers Group sparked a mini pegging boom for diamonds during August/September.

In the Officer Basin, PNC Exploration (Australia) Pty Ltd excavated 202 000 t of overburden to obtain a 10 t parcel of uranium ore for metallurgical testing from their uranium prospect.

## Perth

Perth based inspectors had a busy year, largely due to sustained gold mining activity in the Peak Hill, Murchison and Yalgoo Mining Districts.

The alumina industry came out of the doldrums with Alcoa returning to full production, but mineral sand and tin mining operations, along with aggregate, limestone and sand production remained in a depressed state.

At the end of the year sinking of two circular concrete-lined shafts had commenced. At Golden Grove, Electrolytic Zinc Co. of Australia Ltd and partners are sinking a 4.0 m diameter shaft to a planned depth of 370 m on a copper-zinc-silver orebody. At Day Dawn a 4.3 m diameter shaft is being sunk to a depth of 270 m for Australia Consolidated Minerals Ltd to develop gold ores discovered near the old Golden Crown mine.

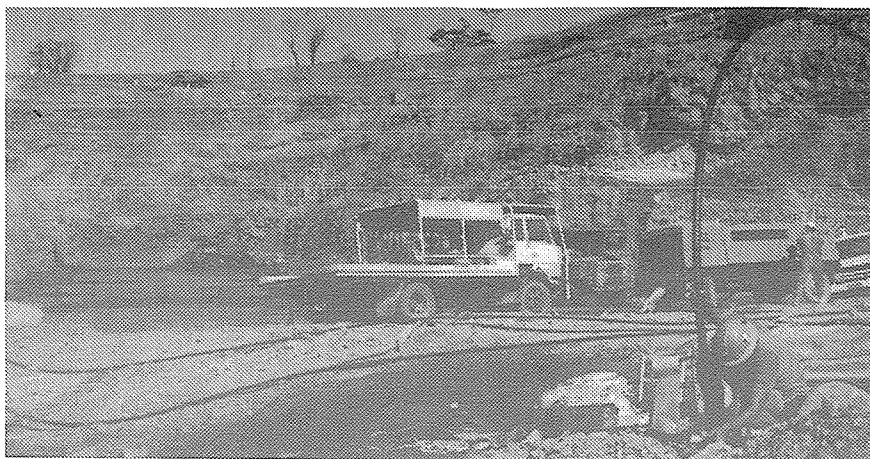
## Karratha

Iron ore mines continued to produce below capacity during 1983.

Gold production decreased in 1983, primarily as a result of lower grades at the Telfer mine.

Argyle Diamond Mines Pty Ltd completed its first full year of commercial diamond production. The State Government joined the venture with the purchase of a 5 per cent holding.

Salt production was severely affected by diminishing overseas markets and mothballing of the Lake Macleod minesite was averted only



Western Mining Corporation. Victory open cut — Kambalda. Charging stoping holes in cut floor.

after intensive negotiations between the company, the Western Australian Government and the mine workforce.

## Collie

Mining of Collie coal continues to expand and another year of record coal production was achieved. Three surface and three underground mines are now in production and between them have produced a total of 40.5 Mt, or 56.4 per cent of the total coal production of 71.9 Mt since commercial production commenced in 1898.

## Mining accidents

Six fatalities occurred as a result of mining accidents in 1983. Three were associated with underground nickel mining, two with underground gold mining and one occurred in an iron ore quarry. Details are on page 76.

The table below shows the accidents in the industry in the year and

they are segregated according to the mineral mined and processed. Further relevant statistics appear on page 75.

## Ventilation

Inspectors and officers of the Ventilation Sections continued to monitor dusts, gases and other workplace atmospheric contaminants throughout the mining industry. They also inspected underground diesel engine equipment and monitored engine exhaust gases and temperatures. Temperature and air flow surveys were made in a number of underground mines. However, the duration and frequency of inspections and the monitoring of atmospheric contaminants were severely restricted due to inadequate staffing.

Regular inspections and advice on the use of chemicals has increased the general awareness of their potential dangers. The wearing of

Mineral	Number of Persons Employed	Accidents		
		Fatal	Serious	Minor
Bauxite (alumina)	4 197	—	43	89
Coal	1 236	—	74	516
Diamond	200	—	6	19
Gold	2 968	2	148	352
Ilmenite, etc	647	—	9	49
Iron	10 795	1	137	428
Nickel	2 919	3	77	154
Salt	401	—	10	46
Tin/Tantalite	186	—	7	18
Copper, silver, zinc	159	—	3	9
Other minerals	288	—	—	3
Rock quarries	246	—	4	13
<b>TOTALS</b>	<b>24 242</b>	<b>6</b>	<b>518</b>	<b>1 696</b>

protective equipment is becoming more universal and storage and security of toxic chemicals have improved considerably.

In the past, powder monkey crews in iron ore quarries have been subject to excessive dust exposure. This problem has been virtually overcome by greater use of pressurized cabins on bobcats and a re-organization of work practices.

A summary of gravimetric dust samples taken in underground and surface mine workings is given in the accompanying table.

The Committee visited the mineral sands mines and was generally satisfied with their level of compliance with the Code.

All the mines have used measurements of radiation levels to properly mark out 'Controlled Areas' and to identify 'designated employees'. These employees are continuously monitored, individually, to determine the gamma and beta radiation levels to which they are exposed. Their radiation levels seldom exceeded the level permitted for the general public which is 10 per cent of

never exceeded.

The levels of radon and thoron daughters are barely within the limits of detection for simple instruments and thus cannot be accurately measured with them. Nevertheless, levels are well below their annual and derived limits.

Waste and tailings disposal are well regulated. Areas to be mined are surveyed to determine the pre-mining levels of radiation and, when restored, the level of radiation will not exceed this pre-determined level.

SUMMARY OF DUST SAMPLING RESULTS

	Total Dust		Respirable Dust		Positional
	-SOP	+SOP	-SOP	+SOP	
Kalgoorlie:					
Gold	16	2	220	69	7
Nickel	9	4	119	8	—
Other	10	5	2	—	—
TOTAL	35	11	341	77	7
Perth:					
Aggregate Quarries	4	—	45	25	—
Alumina	8	1	—	—	5
Attapulgate	4	5	3	—	—
Gold	—	—	58	10	—
Limestone	—	—	8	—	—
Manganese	1	1	—	—	—
Mineral Sands	55	3	12	1	6
Spodumene	9	—	7	1	—
Talc	9	17	1	—	—
Tin	5	—	—	—	—
Other	—	—	4	5	—
TOTAL	95	27	138	42	11
GRAND TOTAL	130	38	479	119	18

-SOP — Less than the Standard of Purity.

+SOP — Greater than the Standard of Purity.

## Radiation

This is the first year in which the mineral sands mines have been subject to regulation on radiation matters under the Mines Regulation Act. The Code of Practice on Radiation Protection in the Mining and Processing of Mineral Sands (1982) was incorporated into the Act in January 1983.

At the direction of Cabinet, the Interim Mine Radiation Safety Committee was convened to advise government on the implementation of the Code and the changes required to the Mines Regulation Act to set up a Mine Radiation Safety Board. This was nearing completion at the end of 1983.

the level permitted for a 'designated employee'. No employee received a 'dose equivalent' in excess of 50 per cent of the 'dose equivalent limit'.

Housekeeping standards are generally good, with a proper regard being shown towards dust and the cleaning of spillage. The practice of blowing down is not regarded as satisfactory, but until a viable alternative is found reliance is placed on the wearing of respirators. The methods used for evaluating measurements of monazite dust are still under consideration. However, even when the worst-case method of evaluation is applied, the 'derived limits' for dust containing thorium are only rarely exceeded. In terms of gross alpha count the derived limit is

## Machinery in mines

The resurgence in mine development activities in 1983 found the machinery inspection section unable to keep up with the workload. Significant projects being monitored by the section included the equipping of the Agnew No.1 shaft, the refurbishment of the Hill 50 main shaft and the Chaffers shaft in Kalgoorlie, commissioning of the Worsley and Wagerup refineries and shaft sinking projects at Foster, Golden Grove and Golden Crown mines.

The mechanical engineers undertook design reviews of machinery associated with the above as well as a number of small projects.

## Winding machinery accidents

Twenty six mishaps involving winders were reported. Seventeen were of a minor nature with no significant damage or potential danger to persons. But of the remaining 9 which resulted in more serious damage, 3 were due to hang-ups; 3 to overwinds; 2 to derailments in an underlay shaft; and 1 was caused by a full skip fouling the wall plates.

## Electrical inspections

Special Inspectors of Mines (Electrical) carried out 626 inspections covering 336 mining operations.

Thirty three minor electrical accidents were reported.

The Inspection Branch of the State Energy Commission has undergone a re-organization and now has Special Inspectors of Mines (Elec-



tricity) stationed in Perth, Collie, Albany, Geraldton, Kalgoorlie and Port Hedland.

### Prosecutions

Three prosecutions were conducted during the year and all resulted in convictions.

One workman was found to be in breach of Regulation 8.24(1) in that he failed to install a ventilation system to remove blasting fumes from a development heading and was fined \$50.00

Another workman was fined \$40.00 for entering a working place containing blasting fumes contrary to the provisions of Regulation 8.25.

A third workman was prosecuted for firing outside the prescribed firing times contrary to Regulation 7.30(2) and was fined \$100.00

### Rehabilitation

During 1983 the mining industry was the subject of a number of adverse media reports relating to environmental damage. Land damage has occurred on a number of small areas as a result of gold prospecting activities utilizing dozers in conjunction with metal detectors and dry blowers, but tighter controls are now being implemented to curb unnecessary damage by such activities. Damage caused by highly mobile, illegal miners remains the greatest problem.

The mining industry has expended large sums of money on studies to determine ways and means of protecting the environment, and even larger sums on rehabilitation of mined areas. It is one of the few industries, outside Government, which employs a considerable number of highly trained people to deal with environmental problems.

Iron ore miners in the Pilbara and West Pilbara regions continued their efforts to rehabilitate waste dumps and areas damaged by mining activities. The Mt Newman Mining company continued with its slope stabilization programme using 'Moonscaping Techniques' and dur-

ing 1984 plans to place a greater emphasis on mine rehabilitation as a dust control measure. Re-vegetation of the borrow pits excavated for the construction of the Ophthalmia Dam progressed well with encouraging results.

Hammersley Iron continued experiments on slope stabilizing techniques at Mt Tom Price along with their efforts to speed up and improve germination rates of local flora.

Gold mining open-cut operations in and around the Golden Mile at Kalgoorlie created new problems because of the formation of large waste dumps of oxidized rock. Endeavours were made to contain dust by covering the surfaces of the dumps with fresh, clean rock. The planting of trees and other vegetation is to follow.

Alcoa continued to spend large sums of money on rehabilitation and during 1983 rehabilitated 283 hectares of mined land, some 123 hectares more than was mined during the year. The number of bauxite minesites which have been successfully rehabilitated is increasing.

Mineral sands miners at Eneabba and Capel now rehabilitate the refilled mining pits progressively as mining advances.

Greenbushes Tin continued with its overall programme to rehabilitate present and old workings but progress was restricted during 1983 as a result of production cutbacks.

Coal mining rehabilitation is now being undertaken (on a systematic basis) by both the companies mining at Collie. Emphasis was placed on back-filling of open cuts and contouring of external waste dumps to control erosion, facilitate vegetation planting and to blend in with back-fill in the pits. In addition, care was taken to identify acidic waste and ensure that it was buried well below the surface.

The Mines Department continued to finance a programme of covering old waste dump areas containing hot coal ash with a thick layer of soil. During the year \$22 452 was spent on similar works bringing total expenditure to \$94 000 over the past 10 years.

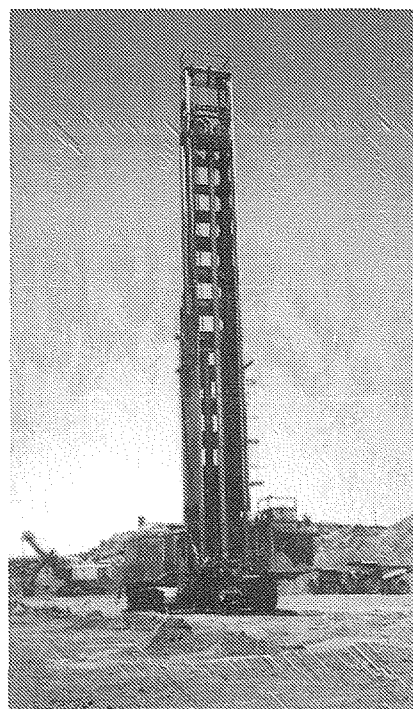
### Drilling

The Drilling Branch was responsible for drilling 7 778 m in 174 bores, the development of aquifers in 170 bores and the testing of aquifers in 10 bores. Repair work was undertaken on 7 bores and 17 bores were subject to thermal logging. Five bores were sidewall cored and perforated and the borehole television camera was used to scan 35 bores. Branch personnel supervised the contract construction of 3 bores.

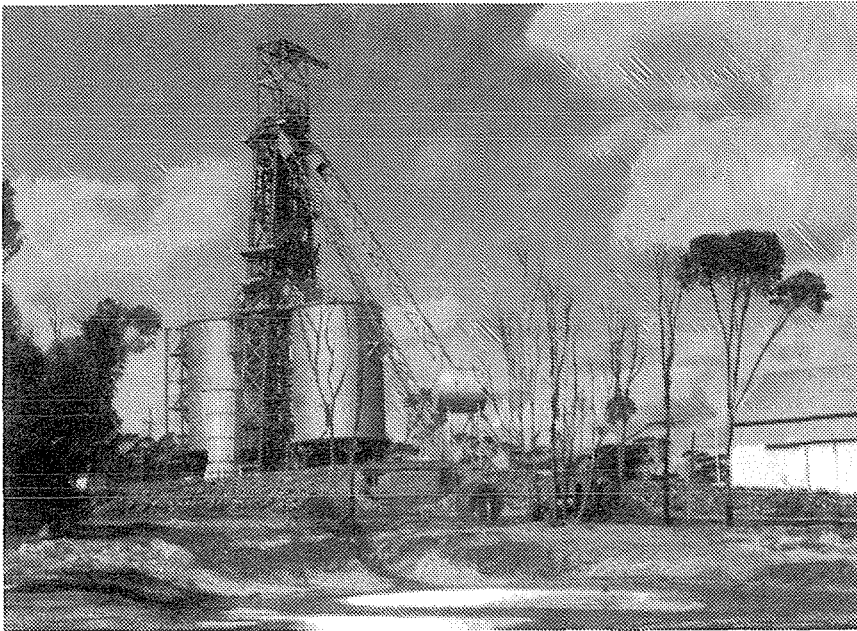
Demand for the services of the borehole T.V. scanning equipment appears to be stabilizing at about 35 jobs per year. The unit again travelled to Geelong in Victoria, this time to examine the extent of damage to a major water supply bore following the dropping of a pump.

The Statewide Groundwater Investigation Programme by the Geological Survey of Western Australia continued as follows.

Three of the planned 4 bores on the Harvey Deep Line were completed; work was completed on the Harvey Shallow Line, and drilling commenced on the Busselton Shallow Line. This latter project is to provide information on stratigraphy and groundwater conditions to a projected depth of



6OR drill at Newman.



Western Mining Corporation. Kambalda Nickel operations — Otter-Juan Headframe.

100m in areas between Capel and Dunsborough.

Drilling commenced along the Fortescue and Robe River flood plains to provide stratigraphic and groundwater information between the North West Coastal Highway and the coast.

The Geological Survey of Western Australia and the Department of Agriculture have commenced a joint programme of research into land salinization in the Winchester catchment and Lake Toolibin areas. The Branch completed a programme of rotary and core drilling designed to provide soil and water samples. The completed bores will provide future monitoring points for water level and quality.

Near Collie, a drilling programme designed to provide a means for monitoring the groundwater response to forest clearing, and known as the Lemna Catchment Job, was completed during the year.

The Branch commenced one other programme during the year. This consisted of 3 experimental Multi-Port Piezometer Bores, 1 at Fremantle and 2 at Del Park near Dwellingup. The work is aimed at developing a method of monitoring groundwater quality and water level at a number of different depths below ground level. Normal practice at present requires a separate bore for each

depth to be monitored. The aim of the Multi-Port System is to be able to monitor 10 or more depths in one bore.

A summary of drilling and associated work is tabulated on page 74.

#### Ventilation Board

The Ventilation Board is a statutory body appointed under Section 23C of the Mines Regulation Act 1946-74. Its purpose is to deal with all matters connected with the safety, protection and health of persons working in or about mines insofar as those matters relate to ventilation or environmental atmospheric control.

The Board has set its primary aim as being — 'To prevent mine workers from suffering damage to lungs due to the presence of atmospheric contaminants in the working places'. To this end the Board, with the assistance of the Mining Engineering Division, introduced a computerized system for the recording of atmospheric contaminant sampling known as CONTAM. This system replaced MINDUST which dealt only with dust. The new programme will provide a statistical record of all sampling carried out under the requirements of Part 8 of the Regulation to the Mines Regulation Act.

The Board produced a document titled 'Guidelines for the Evaluation of Atmospheric Contaminants in the Mining Industry' to ensure conformity of sampling procedures and practices and to provide the greatest possible benefits from the information gained. Copies were issued to all participating mining companies.

Throughout the year the Board continued to work in close liaison with the inspectorates and the mining companies. Visits were made to mines in the Kalgoorlie, Pilbara and South West regions by Board members to discuss problems with mine management and familiarize themselves with company operations.

#### Board of Examiners — Certificates of Competency

Certificates of competency issued for management and supervisory positions under the Mines Regulation Act and the Coal Mines Regulation Act during 1983 are detailed on pages 77 and 78.

#### Staff

The State Mining Engineer, Mr J.K.N. Lloyd retired on 15th December 1983 after serving 32 years with the Mines Department.

District Mining Engineer, B.J. van der Hoek was appointed to the position of Regional Mining Engineer — Karratha Inspectorate and Mr D. Collie is to transfer from Karratha to Perth as Regional Mining Engineer. Both officers will take up their new duties, early in 1984.

At the end of the year a vacancy for a District Mining Engineer in the Perth Inspectorate remained unfilled.

## STATE BATTERIES—early history

The present State Battery system was initiated by the Goldfields Act of 1895 (Amendment Act, 1898), which sought to enable prospectors to test their prospects and obtain a cash flow during the development period. Financial provision was made in 1898 for the construction of Public Batteries (as they were then known) and the first Superintendent of Public Batteries was appointed early in the same year.

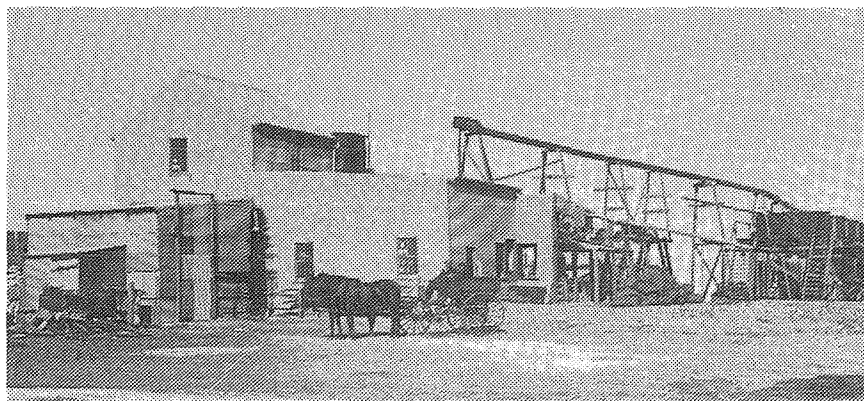
Sites were selected at Lennonville, Tuckanarra, Mulline, Mount Ida, Leonora, Yerilla and Yalgoo for the construction of the first State Batteries. Privately owned batteries at Norseman and Bulong were purchased by the Department of Mines. By 30 June, 1899 these nine batteries had been erected or acquired at a total cost of £ 39 883 11s 7d and 6 923 tons of ore had been crushed.

The average cost of crushing was 15 shillings and 2 pence per ton, and the price charged for crushing was 15 shillings per ton. In the few cases where the yield of gold did not pay crushing charges, the gold recovered was accepted as payment. Five of the batteries ran at a profit of 2 or 3 shillings per ton, two batteries broke even, and two batteries ran at a loss. Early problems contributing to these losses included the difficulty and cost of acquiring sufficient water, the extra expense of condensing 'very dense' (saline) water, and expensive management.

Seven of the batteries consisted of 10 head stamps of between 750 and 1 000lbs in weight. At Yalgoo, a modular type was erected consisting of five single boxes, one stamp in each. At Bulong, 20 heads were in operation. This made a total of 95 head of stamps.

Regulations introduced in 1903 further governed the use and operation of the State Battery system. A

minimum charge was established for small tonnages and State Battery managers were empowered to refuse ore considered too low in grade to pay crushing charges, unless a deposit was paid in advance. Where payment for crushing was not made on completion of treatment, sufficient gold could be retained to pay for the amount due.



Meekatharra State Battery in its early days.

The process of cyanidation was gradually introduced, beginning with a cyanide plant at Norseman in 1900 followed by Mulline, Mt Ida and Lennonville. The 1903 regulations provided that, where no cyanide plant had been erected at a battery, any person who wished to remove the tailings that were the proceeds of his crushing was to remove them immediately after the crushing was completed or they would be regarded as abandoned tailings. Where a cyanide plant had been erected at a battery, tailings from ore crushed at that battery would be treated, although tailings considered unsuitable for cyanide treatment could be refused by the Manager. The price for the cyanidation of tailings was 10 shillings per ton. The tailings were sampled and assayed by the manager, so that the value of fine gold from the tailings could be ascertained. A sample retained by the owner of the tail-

ings could be privately assayed should he dispute the Manager's assay. Where these two results differed by more than 6 grains, a third sample was sent to the Government Assayer in Perth whose assay result was considered final. The cost of this referee assay was borne by the party whose assay differed most widely from the Government Assayer's result.

The intended purpose of State Batteries was to enable prospectors and small mine owners of a district to prove their mines by working trials and to eventually obtain treatment plants of their own. Although in practice many miners continued to use the facility long after the trial stage was passed, many substantial gold mining areas had their beginnings with State Batteries such as Peak Hill, Sandstone, Meekatharra, Norseman and Leonora, with some in operation today. The latest new find at Coolgardie is the most recent example of the benefits of the subsidized State Battery system for exploration and development.

From its inception in 1898, the State Batteries System reached a peak number of 40 plants in 1913. In 1983, 15 plants were still operating. Peak production was in 1938, when 108 996 tons were treated for a return of 50 427 ounces of fine gold.

The numerical values used in this article have not been decimalized because of the difficulty of establishing a dollar equivalent for the 1898 pound Sterling. In that year above ground wages at a mine were £ 3 10s 0d per 48 hour week and underground wages were £ 4 10s 0d per 47 hour week. The gold price was £ 4 4s 11½d per ounce. 1 ton = 1.016 tonne, 1 pound = 0.45 kilogram, 1 troy ounce = 31.1 grams, 1 grain = 0.065 gram. There are 24 grains to a pennyweight and 20 pennyweights to an ounce.

# STATE BATTERIES

E. J. GREEN, SUPERINTENDENT

The average gold list price for 1983 as advised by the Gold Producers Association Ltd was \$469.75 which was an increase of \$99.00 on the previous year's average of \$370.75. Recent practice of the State Batteries has been to keep charges to a reasonable figure without incurring too great a loss or subsidy. This policy has been maintained by the revenue production from tailings treatment, both by State Battery and contract allocation.

The accompanying table summarizes the treatment of a record tonnage of tailings in 1983.

The previous record tailings treatment was in 1936 when 112 318 tonnes (110 543 tons) were treated.

The 1983 carbon-in-pulp assessment is shown in the table.

The carbon-in-pulp method of tailings treatment, while more than halving traditional treatment costs, does require a substantial capital input. In searching for an alternative, test operations have been carried out at Menzies on large (4 000 tonne) heap leaching systems to reduce both capital and operating costs. Unfortunately the system only applies to permeable material, and from early work it appears that both the carbon-in-pulp and heap leach systems will be required to enable the wide variety of tailings to be treated.

The expenditure on general upgrading of State Batteries and facilities for 1983 is itemized in the adjoining table.

The Kalgoorlie installation has been upgraded with a new feed bin service which is scheduled for start-up in early 1984, and the old mill building will be re-clad.

The environmental aspect of this area should be improved by the more attractive design of future housing installations and the erection of fencing, together with the planting of many trees by the State Batteries and the Goldfields Dust Abatement Committee.

The completion of a carbon-in-pulp plant at Meekatharra should double production from this battery.

Buildings were upgraded at the Boogardie State Battery and the old type horizontal converted gas engine

changed over to a diesel - electric generator system.

A new manager's house was installed at Leonora. Arrangements have been made for housing improvements at other areas in 1984.

## TAILINGS TREATMENT 1983

	Tonnes	Value of extracted gold paid to	
		State Batteries \$	Prospectors \$
State Battery vat treatment	15 760	257 059	116 252
State Battery CIP treatment	57 559	604 154	262 370
Contract allocations	03 730	251 844	79 914
Other revenue	—	2 340	—
<b>TOTAL</b>	<b>177 049</b>	<b>1 115 357</b>	<b>458 536</b>

## CARBON-IN-PULP 1983 ASSESSMENT

Location	Tonnes Treated	COST		INCOME			Profit (Loss) \$
		\$	\$/t	State Batteries \$	Paid to Prospectors		
					kg Gold	\$	
KALGOORLIE	26 075	327 099	12.5	256 133	1.733	28 564	(42 402)
COOLGARDIE	20 914	287 726	13.7	183 277	8.464	125 908	21 459
MEEKATHARRA	10 569.6	116 334	11.0	164 744	7.271	107 898	156 308
<b>TOTAL</b>	<b>57 558.6</b>	<b>731 159</b>	<b>12.7</b>	<b>604 154</b>	<b>17.468</b>	<b>262 370</b>	<b>135 365</b>

## EXPENDITURE ON UPGRADING 1983

Facility	\$
Kalgoorlie feed bins	41 731
CIP Meekatharra	113 806
Managers house Leonora	41 905
Water supplies	17 773
Reclad Kalgoorlie mill	24 539
Housing maintenance	7 964
Engineering maintenance	9 505
Electrical maintenance	1 352
Boogardie office and shed, conversion to a.c. power	18 318
Ball mill additions	15 600
Production emergencies	12 272
Fencing & dust control	8 831
Erco Crusher	7 000
Compressor Kalgoorlie	7 960
Analytical AAS Kalgoorlie	6 185
Marble Bar 5 head	1 229
Marble Bar managers house	600
Stamp modification investigations	568
Minor works	448
<b>TOTAL</b>	<b>\$337 586</b>



Assay Department, Kalgoorlie State Battery.

## Operations

### Crushing gold ores

One twenty (20) head, seven ten (10) head and six five (5) head mills crushed 33 247.2 tonnes of ore made up of 311 separate parcels; an average of 106.9 tonnes per parcel.

The bullion recovered amounted to 271.9916 kilograms estimated to contain 231.1913 kilograms of fine gold equal to 6.95 grams per tonne of ore. The average value of tailings after amalgamation was 3.09 grams per tonne, giving an average value of ore received of 10.05 grams per tonne; in addition 224 smelts produced 416.3961 kilograms of bullion estimated to contain 353.9367 kilograms of fine gold.

In total 585.128 kilograms of fine gold was produced compared to 338.53 kilograms of fine gold in the previous year from amalgamation and smelting activities in the State Batteries.

The gross cost of crushing 33 247.2 tonnes of ore was \$68.60 per tonne. In 1982, 32 947.2 tonnes of ore were crushed at the gold plants for a cost of \$61.08 per tonne. This year the nett cost of crushing (after payment by prospectors) was \$56.48 per tonne compared with \$51.03 per tonne in 1982.

### Cyanidation

State Batteries at eight individual battery locations treated 73 319 tonnes

of tailings by vat, carbon-in-pulp and heap leaching methods for a production of 79.351 kilograms of fine gold, of which 11.345 kilograms were paid out to prospectors. The remaining gold was sold for State Batteries. The average content was 1.80 grams per tonne before cyanidation and the residue 0.72 grams per tonne giving a recovery of 59.9 per cent.

In addition a total of \$30 412.5 was collected for the contract stripping of 30 batches of carbon which produced 65.183 kilograms of bullion estimated to contain 58.6647 kilograms of fine gold.

The carbon-in-pulp plants at Kalgoorlie, Coolgardie and Meekatharra treated 57.559 tonnes of the total tonnes treated for a production of 53.429 kilograms of fine gold at a treatment cost of \$12.70 per tonne.

The vat treatment plants treated a total 15 760 tonnes at a treatment cost of \$25.09 per tonne.

The gold production was made up as follows:

	kg
Amalgamation gold (fine)	231.1913
Smelt gold (fine)	353.9361
Cyanidation gold (fine)	79.351
C.I.P. strip gold (fine)	58.6647
Total	723.1437

### Treatment of ore other than gold

The Northampton battery crushed a scheelite sample of 26.16 tonnes to produce 0.156 tonnes of saleable concentrate.

### Value of production

The estimated value of production from the State Batteries in 1983 and the total since their inception, excluding the value of gold tax paid to the Commonwealth is shown in the accompanying table.

### State Battery Inspectors Report

During 1983, 26 days have been spent in plant inspection with 11 Batteries being visited, some more than once where problems were evident. The only plants not inspected were Northampton, Yarri, Laverton and Ora Banda.

VALUE OF PRODUCTION FROM STATE BATTERIES

	1983 \$	Since inception \$
Gold	10 921 503	81 027 507
Other metals		
Silver	2 357	14 770
Tin (concentrate)		515 385
Tungsten (concentrate)	945	98 619
Copper (ores for agricultural use)	—	11 932
Lead and zinc (concentrate)	—	1 650 865
Tantalite (colombite concentrate)	—	207 030
Garnet (concentrate)	—	131 001
Other metals Total	3 302	2 629 602
Grand Total	10 924 805	83 657 109

Head Office duties prevented the more frequent inspection of the Batteries. As seven new managers have been appointed over the last three years, which is over half of the total number of managers, closer supervision is needed to maintain the service at a high degree of competence. More time will be spent in the field on Battery inspection in 1984.

### Operations

The number of tonnes crushed, the hours run and the 'duty' (productivity per 5 head mill unit) are shown in the accompanying table.

Plants showing a 'duty' of less than 0.75 will receive special attention to upgrade production during 1984.

### Safety

Since the re-appointment of the State Batteries Inspector in 1981, accident statistics have shown a vast improvement. In 1982, 36 accidents resulted in the loss of 178 man days, compared with 23 accidents and 50 man days lost in 1983. Staff are to be congratulated and every endeavour will be made to further reduce this statistic.

### Organization

#### Battery man power

During 1983 an average of 113 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 of a monthly average of 85 wages staff and 28 ministerial appointments. Due to the fluctuating supplies of ore to be treated the total number of personnel employed ranged between 104 and 115.

### Staff

In 1983 the following promotions and transfers were made:

Mr T. Broadbent promoted to Foreman and transferred from Boogardie to Coolgardie; Mr G.



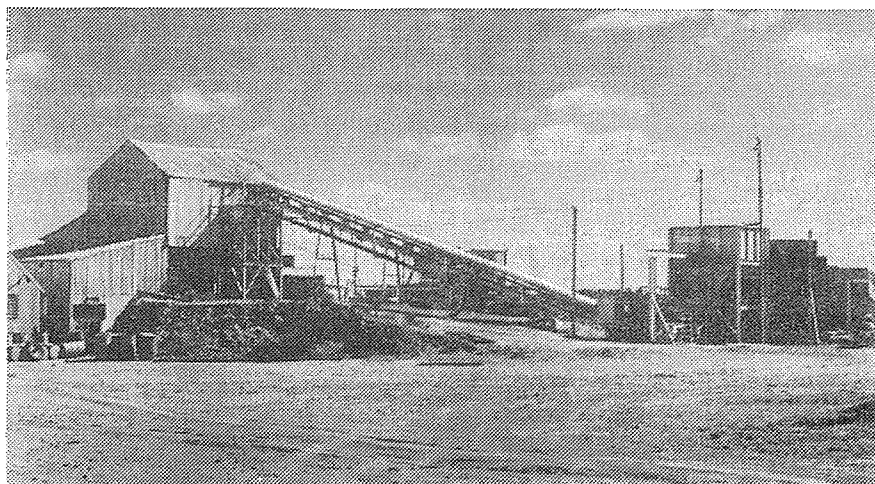
Kalgoorlie stripping plant.

STATE BATTERY OPERATIONS 1983

Battery	Total tonnes	Mill hours run	'Duty' (Tonne per hour per mill of 5 stamp capacity)
Boogardie	1 798	2 425	0.74
Coolgardie	4 359	5 362	0.85
Kalgoorlie	5 101	6 512	0.78
Laverton	1 442	1 491	0.97
Leonora	4 725	6 301	0.75
Marble Bar	3 257	3 378	0.96
Marvel Loch	4 406	8 187	0.54
Meekatharra	1 091	2 153	0.51
Menzies	1 697	2 896	0.59
Norseman	1 727	2 220	0.78
Ora Banda	1 413	1 621	0.87
Paynes Find	1 287	1 514	0.85
Yarri	760	1 014	0.75
Over all plants	33 243	45 104	0.74

Scegghi promoted to Foreman, Leonora and Mr J. Lee promoted to Foreman, Yarri; Mr C. Hodgson Foreman, Meekatharra promoted to

Manager and transferred to Menzies. Other transfers were Foreman K. Scegghi, Leonora to Boogardie, Foreman J. Piggott, Paynes Find to Meekatharra, Foreman L. Boyle, Menzies to Paynes Find. Manager transfers were Mr R.H. Dellar, Leonora to Marvel Loch, Mr M. Spain, Marvel Loch to Leonora, Mr J. Duperouzel, Meekatharra to Coolgardie and Mr D. Elsegood from Coolgardie to Meekatharra.



Yarrie State Battery.

## GROUNDWATER FOR THE NEXT CENTURY

Western Australia has vast areas with low or irregular rainfall, high evaporation rate and no permanent surface water. Groundwater is the sole water supply source over 75 per cent of the State's area, and in 1983 provided about 40 per cent of the total volume of water consumed. The progressive assessment of groundwater resources over the whole State is an important task of the Hydrogeology Branch of the Geological Survey Division.

The potential for groundwater accumulation can be assessed by considering the geology of a region in conjunction with rainfall records. Generally areas with a high rainfall and underlain by porous (sedimentary) rocks offer the best potential for usable groundwater supplies. Least prospective are those areas with a low rainfall underlain by non-porous crystalline rocks. Based on these broad parameters the State may be divided into 19 groundwater provinces as shown on the accompanying map. However, the assessment of actual resources depends ultimately on detailed recording and evaluation of results from borehole drilling (or well-sinking operations).

The accompanying table shows known groundwater resources in Western Australia. The Perth Basin has the largest resource of domestic quality (potable) groundwater but the

Canning Basin has a greater total resource when water of all salinities is included. In the Yilgarn Province, which includes the goldfields and much of the wheat belt, a combination of soil salinity and low rates of groundwater infiltration and movement has severely restricted both the groundwater resource and its development. Fortunately in the goldfields, extensive groundwater exploration has located substantial yields of saline groundwater, probably adequate for foreseeable mining development needs. Useful small supplies of fresh water also occur locally.

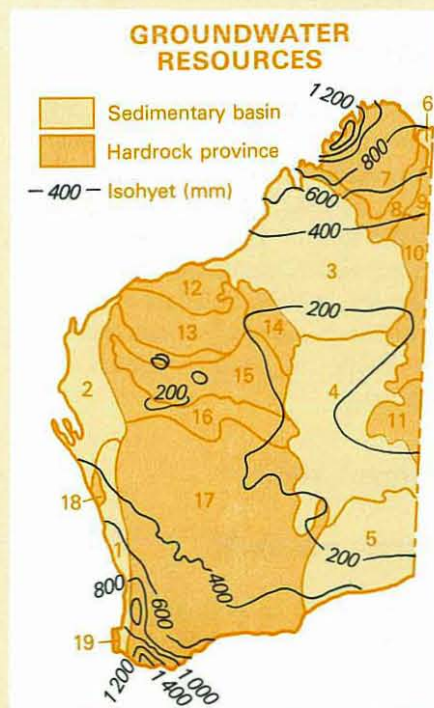
The most intensively investigated province is the Perth Basin, where thick sediments contain both deep confined (artesian and subartesian) groundwater and unconfined (near surface) groundwater. Current usage of both types amounts to about 18 per cent of the known resource. There is considerable scope for the continued expansion of Perth and other major town water supplies well into the next century.

In the Pilbara, Hamersley and Northampton Provinces a relatively high utilization up to 16 per cent is current but elsewhere the level is below 5 per cent and the rate of increase of demand is small.

Identification of intake areas (which must be protected against

pollutants), calculation of recharge rates or of permeability (to determine safe yields) and control of abstraction rates are only some of the factors important in the management of groundwater. The Hydrogeology Branch, and other government departments, investigate and monitor these factors in sensitive areas.

In most areas, Western Australia has substantial resources of groundwater to meet foreseeable water supply needs into the next century. There could also be a useful surplus of new developments in the future.



Province Type	SEDIMENTARY BASINS									HARD ROCK PROVINCES									
Province Name	Perth	Carnarvon	Canning	Officer	Eucla	Bonaparte	Kimberley	Halls Creek	Ord	Sturt	Musgrave	Pilbara	Hamersley	Paterson	Bangemall	Capricorn	Yilgarn	Northampton	Leeuwin
Diagram designation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
TOTAL RESOURCE (GL/y) (million kilolitres/year)	1 625	146	2 430	51	34	192	740	116	58	77	28	100	326	34	232	106	1 027	9	7
FRESH WATER RESOURCE (GL/y)	1 126	66	809	19	14	74	726	102	40	19	7	42	118	17	100	35	271	2	2.5
Currently used % of total	17.9	3.8	0.2	<0.1	0.6	0.3	0.1	3.0	1.0	<0.1	0.1	16.4	10.1	0.3	<0.1	2.5	3.1	11.0	1.4

The increasing demand for professional geological advice from many sectors of government and industry noted in 1982, further accelerated in 1983.

Much of this demand can now be met by review and reinterpretation of the large body of existing geological data that has accrued from traditional Geological Survey field mapping and research activities, supplemented by exploration data supplied by companies under statutory requirements of the Mining Act.

The trend for more staff to be occupied on data manipulation and applied geology, to the detriment of the traditional research role, has been recognized with concern for some years. Continued vigorous research is necessary if knowledge of the geology and mineral resources of the State is to be advanced.

Approaches to Government to provide the additional staff needed to correct the imbalance were partially successful in November 1983 when approval in principle (subject to availability of funds) was obtained to restructure and increase the Geological Survey Division permanent staff from 99 to 124. The approval followed an examination of the Division's work functions by the Public Service Board which coincided with a review of the professional staff salary classifications. It is expected that when the additional positions are phased in, hopefully over the next 3 years, the salaries offered will attract suitable applicants and the Division will be able to meet the new demands for services without affecting its important research role.

### **Mineral and petroleum exploration activity**

After reaching a nadir in 1982 the tempo of mineral exploration in Western Australia picked up appreciably in the latter part of 1983.

The improvement was due largely to continued interest in gold and, to a lesser extent, diamonds, but was also influenced by the announcement of an important copper find in the Throssell Range. The increased exploration activity was reflected in the larger numbers of tenement applications received; applications for exploration licences rising from 898 in 1982 to 1 964 in 1983; and those for prospecting licences increasing from 1 794 to 10 671 in the same period.

Gold exploration was concentrated mainly in the traditional mining centres and much was directed at the discovery or evaluation of low-grade ores amenable to open-cut mining. Such deposits included several along Kalgoorlie's Golden Mile, and those of Harbour Lights, Sons of Gwalia and Tower Hill at Leonora. New underground operations proposed during the year include those at Golden Crown and Big Bell near Cue, and Bellevue at Lawlers. In addition, most mines at Kalgoorlie engaged in extensive subsurface development, including the sinking of the Chaffers shaft at Mt Charlotte.

The various new gold developments initiated or proposed during 1983 may, if the price of gold stays at current levels, result in the State's present production of about 22 tonnes per year rising to around 28 tonnes in 1984 and possibly to 35 or 40 tonnes per year before the end of the decade.

Regional exploration for gold was concentrated mainly on various conglomerate units within the Archaean and Proterozoic rocks of the northwest of the State, and on those parts of the Eastern Goldfields greenstone belts where the geology is concealed by salt-lake deposits.

The search for base metals in Western Australia received a considerable boost in September 1983 when Western Mining Corporation announced the discovery of a probably mineable copper deposit in the Throssell Range on the eastern

margin of the Pilbara Block. The find focussed attention on the Middle Proterozoic Yeeneena Group and resulted in a large number of exploration licence applications covering that unit and possible correlatives or extensions. Late in 1983 the joint-venture partners exploring the Golden Grove prospect south of Yalgoo announced their intention to sink a shaft on the Scuddles deposit. On the debit side, interest in the carbonate-hosted lead-zinc deposits of the East Kimberley region declined during the year, the Sorby Hills camp being closed. However, high levels of activity continued on lead-zinc exploration in the Canning Basin.

Development plans for the Yeelirrie uranium deposits were shelved, and some other uranium exploration projects were suspended or abandoned. Nevertheless, work continued on two of the more encouraging discoveries, namely Manyingee south of Onslow, and Cundelee east of Kalgoorlie.

The continued depressed state of the iron and steel industry, as evidenced by the closure of the Koolyanobbing mine, gave operators little incentive to increase their already large reserves of ore. Exploration was generally confined to that required to maintain existing tenements.

Mining of alluvial diamond deposits shed from the AK-1 kimberlite pipe commenced during 1983. Work began on the Upper Smoke Creek area, and later extended to Limestone Creek. Mining of the kimberlite itself should get under way in late 1985.

Interest in diamond exploration continued at a reasonably high level, with considerable attention being given to the Kimberley Plateau. A minor diamond 'rush' to the Jubilee area north of Kalgoorlie has so far produced no significant results.

Improved demand for tantalum and lithium during 1983 encouraged Greenbushes Tin Ltd to resume



development of its underground pegmatite resource.

The possibility of platinum occurring within the State attracted some attention and a number of exploration programmes were carried out, particularly in the Kimberley region. The application of LANDSAT imagery to mineral exploration gained increased favour during 1983, with some consultants specializing in providing sophisticated interpretations of the satellite data by means of computers.

Coal exploration continued to decline during the year although a moderate amount of activity prevailed in the Hill River area and south of Busselton. Many companies applied to the Department requesting that their Coal Mining Leases (or applications) be converted to Exploration Licenses as this was regarded as the more appropriate type of tenement for exploration purposes. There was a big reduction in tenement holdings across the lignite-bearing ground in the Bremer and Eucla Basins.

A highlight of the year as far as coal was concerned was the discovery, by the Griffin Coal Mining Co. Ltd, of Permian coal near Boyup Brook. The basin has not been delineated fully and the size of the resource has not been reported.

CRA and Western Coal and Uranium continued to carry out extensive exploration programmes in the Hill River area where the target is Jurassic coal similar to that occurring at Eneabba. CRA and the Bond Corporation have been actively exploring in the northern half of the Vasse Shelf, south of Busselton, where Permian coals of a higher rank than those at Collie are present below a cover of Mesozoic and younger sedimentary rocks.

In the Bremer and Eucla Basins, activity was largely confined to infill drilling on known lignite deposits, together with associated laboratory testing.

The Geological Survey carried out a review of Collie coal reserves during the year, based on recently acquired data supplied by the two operating companies. Demonstrated reserves now stand at 492 million ton-

nes, an increase of 120 million tonnes over the previous assessment. Potential open-cut coal comprises 81 per cent of the total reserves.

The Survey also provided geological support for the Aluminium Smelter Task Force which is examining all issues related to possible construction of an aluminium smelter and associated power station in the Bunbury area.

Continued oil discoveries in the Carnarvon and Canning Basins have highlighted petroleum exploration activity in the past 12 months.

In the offshore Carnarvon Basin a number of significant fields were discovered.

Wesminco took over as operator of permit WA-149-P from Mesa Australia Ltd and found oil in the Lower Cretaceous Barrow Group in South Pepper 1, North Herald 1 and Chervil 1 wells. An oil column was also encountered in South Chervil 1, drilled 5km southwest of Chervil 1.

In permit WA-192-P just northeast of Barrow Island, Australian Occidental encountered good oil shows in the Barrow Group in Bamba 1 and 2 wells. A major discovery was made in the permit in the Harriet 1 well, located about 17 km northwest of Barrow Island; maximum flows of 634 kL/day of oil and  $57 \times 10^3 \text{m}^3/\text{day}$  of gas were recorded from the Barrow Group during drill-stem tests.

In permit WA-28-P, also in the Carnarvon Basin, Woodside's Wilcox 1 is a potential gas-condensate producer from the Triassic Mungaroo Formation.

In the onshore Canning Basin within permit EP 129, Home Energy's discoveries continued with a significant discovery of oil in the Permian Grant Formation in the Sundown 2 well. This well was drilled as an extension to Sundown 1 (drilled in 1982) which detected good oil shows in the Grant Formation, although initially spudded to test Devonian carbonates. The discovery enhances the prospectivity of the Permian Grant Formation sands and other post-Devonian clastics on the Lennard Shelf.

Similarly, the large oil find by

BHP's Jabiru 1 well in Commonwealth territory of the Bonaparte Basin has stimulated considerable exploration interest, and it is expected that exploration activity in this basin and the adjoining Browse Basin will increase significantly in that area.

In all, 70 wells were drilled in 1983, three more than the number drilled in the previous record year. Despite early prediction to the contrary, drilling activity remained high in Western Australia during 1983.

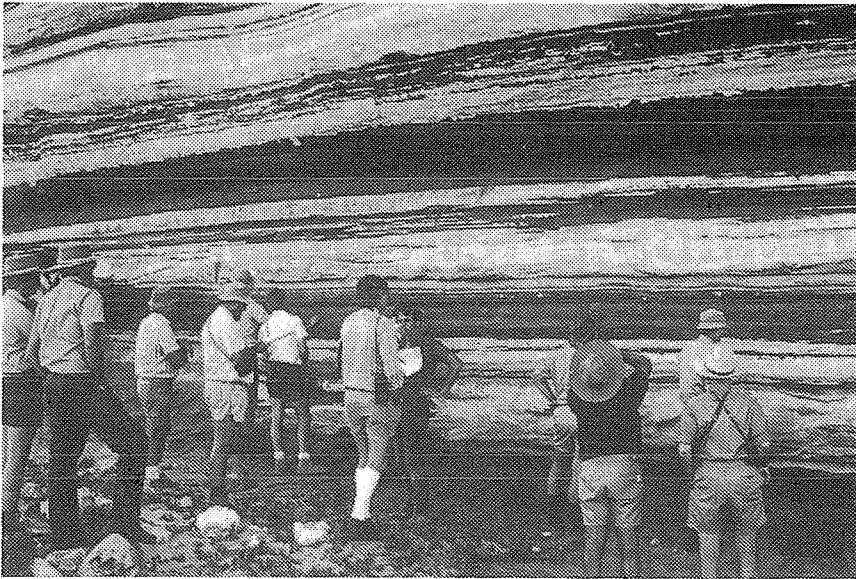
## Operations

It was evident during the year that the amount of exploration data lodged by companies under the statutory requirements of the Mining Act was greatly exceeding the capacity of the Mineral Resources Evaluation Section to check and record, index, microfilm and release this information. Loss of certain key personnel and increased reporting requirements under the 1978 Mining Act worsened the situation.

It was recognized that a long-term solution to this problem must include the introduction of electronic data processing (EDP) to speed up the indexing and retrieval stages of the process. Design of an EDP system, linked with the Mineral Tenement Information System (MTIS) being developed elsewhere in the Department, was undertaken in co-operation with the Computer Services Branch of the Administrative Services Division.

However, the involvement of Geological Survey staff in the EDP system design and data input required that search services to industry had to be further curtailed. It is hoped to restore these services next year when extra staff are made available and the EDP system is at least partly operational.

A geological excursion attended by 18 people was conducted on the Ajana sheet area from April 18 to 21. Following lectures on the night of April 18, the remaining 3 days were



Examining an outcrop of Tumblagooda Sandstone at Red Bluff during the Ajana Sheet geological excursion.

spent visiting locations of geological interest in the Murchison River valley, the coastline near Kalbarri and Gregory, and lead mines north of Ajana.

In May Dr A.F. Trendall and Dr R.D. Gee attended, by invitation, the 34th Dahlem Conference in Berlin, with the title 'Earth history: how smooth, how spasmodic'. The conference topic was originally proposed by Dr Trendall after attending the 23rd (1980) conference on mineral deposits. Subsequently however, by agreement of the 48 participants, the published proceedings of the 34th conference will appear under the title 'Patterns of change in Earth Evolution'. The Dahlem Konferenzen (*sic*), which began in 1974 as workshops for interdisciplinary communication, were conceived by Dr Silke Bernhard. They are now funded by the Science Foundation of German Industry, the German Organization for Promoting Fundamental Research, and the Senate of the City of Berlin. Dr Trendall, who prepared a discussion paper entitled 'The Archaean-Proterozoic transition as a geological event — a view from Australian evidence', acted as moderator of discussion Group 3, co-chairman (with Prof. H.D. Holland, Harvard University) of plenary sessions, and co-editor of the workshop report volume. Dr Gee

contributed to discussions of Group 4.

As the selection of participants for the Dahlem Conferences is based on international scientific reputation alone, the attendance of two staff members complimented the professional standing of the Geological Survey Division.

#### Hydrogeology Branch

Systematic deep and shallow drilling to determine the hydrogeology of the Perth Basin continued in 1983. The results of this and earlier investiga-

tions were applied, in particular, to the evaluation and management of confined and unconfined groundwater resources for the (Perth) Metropolitan Water Authority.

Aquifer evaluations, salinity studies, dewatering operations, country town water supplies, surface (Peel Inlet) and underground pollution investigations, groundwater recharge, groundwater census, artesian monitoring network, effects of bauxite mining, and clear-felling (for woodchip production) on groundwater, and major and minor hydrogeological investigations were some of the projects undertaken on a statewide basis by the Branch in 1983.

In accordance with the policy of the State Government, the existing water responsibilities of the Public Works Department and Metropolitan Water Authority are to be amalgamated within an integrated Western Australian Water Authority. It has been established in principle that this Authority will continue to rely on the Hydrogeology Branch of the Geological Survey for advice and service in relation to groundwater matters.

#### Engineering and Environmental Geology Branch

Environmental geology maps at 1:50 000 scale were commenced in the

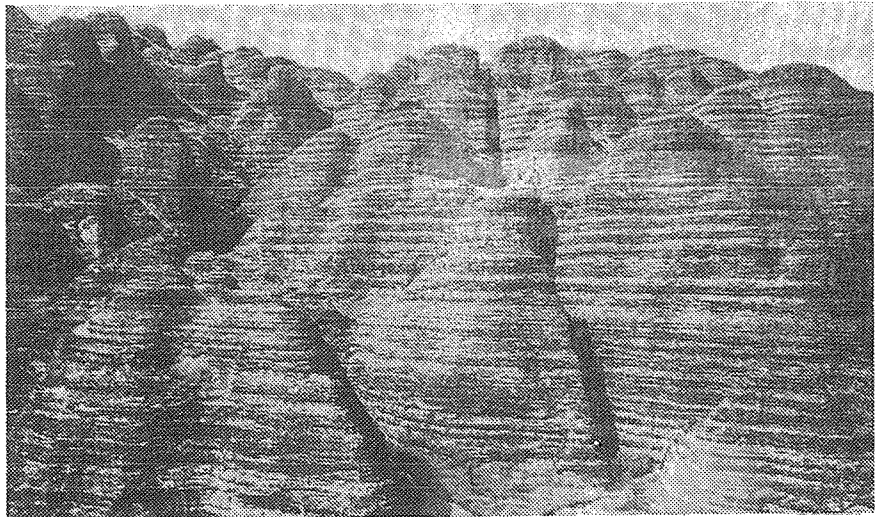


In 1983 engineering geology investigations were conducted on the Ahoy Tunnel, constructed for the Point Peron waste disposal project.

Perth Metropolitan and Collie regions. Other work was concerned mainly with the appraisal and review of environmental-geology aspects of proposed developments in sensitive areas. An engineering geologist was stationed at the Harding River dam-site in the Pilbara region to advise on geological problems during the construction phase. Most of the projects undertaken by the Branch are at the request of other government departments who are increasingly aware of the value of geological advice in their wide-ranging activities.

### Regional Geology Branch

Although compilation of systematic 1:250 000 scale geological maps of the State was completed in 1982, it was only late in 1983 that all of the map sheets could be produced in printed form. Of the 163 sheets covering the whole State, 144 have been printed in full colour at some time since 1962. The other 19 are available as preliminary black and one colour prints or as dyelines. Progress towards printing these sheets in full colour with explanatory notes is indicated later under the heading 'Publications'. Some of the earlier sheets are now out of print but, having achieved excellent reproduction of multi-coloured geological maps with a laser-scan 4-colour printing process, it is now possible to reprint



'Beehive' hills approximately 60m high formed by weathering of Devonian sandstones at the Bungle Bungle Range, Ord Basin.

earlier editions at a much lower cost.

There has been steady progress in remapping Balfour Downs, Cue, Boorabbin, and Widgiemooltha sheets.

Other projects include: remapping of parts of Wyloo, Edmund and Turee Creek sheets for reinterpretation of the geology of the Ashburton Trough; detailed mapping of the Sylvania Dome; and examination of the Western Gneiss Terrain on the western margin of the Yilgarn Block (in the course of which isotopic age determinations have shown that zircons recovered from an orthogneiss near Mt Narryer rank with the oldest terrestrial rocks identified elsewhere in the world).

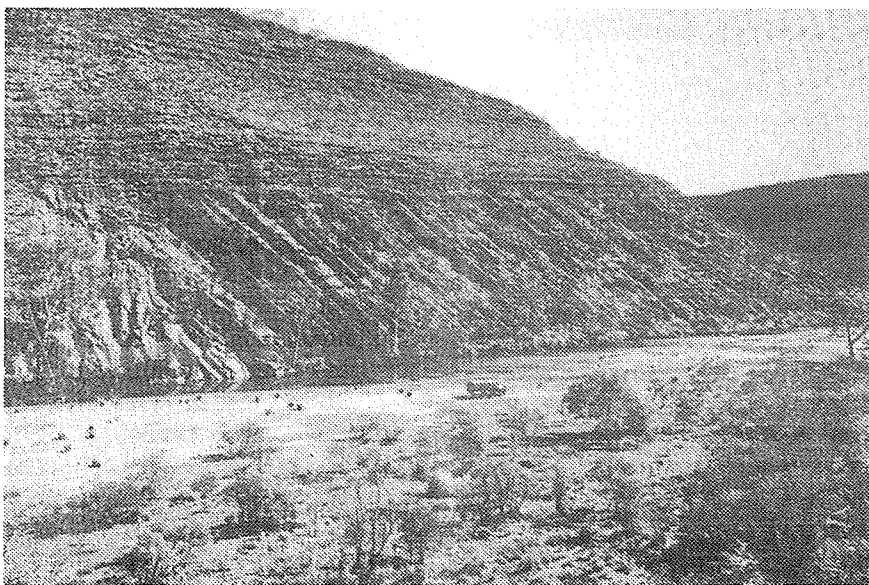
### Sedimentary Geology Branch

In addition to the continued accessioning, indexing, and preparation of data packages on released company exploration data the following projects were conducted: a review of coal reserves in the Collie Basin and a study of trace elements in Collie coal; mapping of Carnarvon, Bonaparte and Ord Basins (fieldwork completed); and studies of sedimentary basins designed to establish and formalize stratigraphy, structure, depth to basement and further guides to petroleum potential.

### Mineral Resources Branch

In an effort to achieve better access to and faster release of company exploration data, design of a computer based electronic data processing index/retrieval system was commenced by the Evaluation Section of the Branch. This will establish a new and significant geoscience data base when data input is complete and the Department's computer mainframe is installed in 1984.

Other Branch projects commenced or continued during the year included: the Darling Range bauxite study, in which increasing attention was directed towards the influence of parent rock composition on bauxite occurrence; a study of the Murchison Province to establish the regional stratigraphy of layered Archaean rock successions; a review of the



The Top Camp Unconformity. Flat-lying Bangemall Group rocks overlying steeply dipping Wyloo Group rocks at Fords Creek.



Examining wall-rock re-exposed after dewatering the Narlarla lead-zinc open cut on the northern region of the Canning Basin.

mineral potential of the Carnarvon Basin; mapping of an area of approximately 1 000 km<sup>2</sup> centred on Kalgoorlie-Boulder to establish the regional geological setting of the 'Golden Mile' mineralization; field examination and research on carbonate-hosted lead/zinc deposits in the Bonaparte and Canning Basins; and preliminary fieldwork and geochemical sampling of rocks with potential for platinoid metals throughout the State.

#### Common Services Branch

The **Palaeontology Section** commenced or continued studies on Permian invertebrates, stromatolites (Precambrian to Recent), Cretaceous macrofossils, palynology of Collie Basin sedimentary rocks and late Jurassic and Cretaceous palynology of the Perth Basin. A major palynological study of Devonian rocks of the Canning Basin continued.

The **Geochemistry Section** conducted geochemical investigations on Jeerinah Shale/Marra Mamba Iron Formation, Weeli Wolli Formation, Collie coal (trace elements), rocks from the Mt Clement gold prospect area, surface laterite and basement rocks from the Mt Saddleback area, and volcanic rocks from the Pilbara region.

The **Petrology Section** co-operated with various research workers at the W.A. Institute of Technology on a number of projects requiring isotopic age determinations using galena, Rb/Sr and Sm/Nd techniques; investigated regional metamorphic patterns in the Southern Cross province (central Yilgarn Block); and conducted petrological examination of mafic rocks from the Fraser Range, kimberlitic and lamproitic rocks from statewide localities, and a wide variety of other rocks submitted by other Branch officers.

The **Geophysical Section** conducted ground radiometric surveys at Wonnerup and Minninup, seismic refraction surveys at six widespread locations, resistivity surveys at two locations and geophysically logged some 163 boreholes. An appreciable amount of time was spent developing geophysical programmes on the available computer graphic system and testing the salinity of water samples submitted by the public.

The **Technical Information Section** in addition to meeting specific requests from the public for technical information, edited 49 publications to varying stages of completion, 22 of which were in the printer's hands at the year end. This resulted in publication of 12 records, 1 bulletin (The Geology of the Pilbara Block and its Environs), and 13 geological

maps with explanatory notes. Memoir 2 (The Geology of Western Australia) and the map sheet Mineral Deposits of Western Australia were reprinted. Public enquiry remained at a steady level but staff requisitions for drafting services increased. A terminal (with printer) for access to AUSINET, INIS and DIALOG information networks was installed in June, allowing interrogation of a large worldwide selection of reference data bases.

Members of the public visiting the **Library** totalled 4 143 of whom 1 118 made use of the microfilm reading and printing facilities. Staff loans totalled 7 732 and 766 interlibrary loans were arranged.

## Organization

### Staff

Mention has already been made of the approved proposals for expansion of the Division's staff and of the professional staff salary reclassifications.

The greatest staff turnover was in clerical and general officers and, although appointments matched transfers and resignations, the changeover from experienced to inexperienced staff was disruptive.

Geophysicist Mr D.L. Rowston retired on 30 September after 21 years continuous service with the Division. Dr M. Middleton was appointed as Senior Geophysicist in the Sedimentary Geology Branch, but at the end of 1983 there were still two senior positions vacant in this Branch. In the Hydrogeology Branch two vacancies created through resignations were quickly filled.

### Accommodation

There was no change in accommodation during 1983. The anticipated move of the Regional Geology Branch to another building did not eventuate, but this relocation may take place in 1984. It will provide much-needed space for the exploration data sections of the Mineral Resources and Sedimentary Geology Branches.

## Publications

The following publications were issued during 1983.

Bulletin 127. Geology of the Pilbara Block and environs; by A.H. Hickman.

Memoir 2. The Geology of Western Australia (reprinted).

Geological maps in colour at 1:250 000 scale with explanatory notes for sheet areas:

Ajana — SG 50-13

Belele — SG 50-11

Broome — SE 51-6

Byro — SG 50-10

Collie — SI 50-6

Glenburgh — SG 50-6

Kirkalocka — SH 50-3

Moora — SH 50-10

Ninghan — SH 50-7

Port Hedland — SF 50-4

Yaringa — SG 50-9

Yarrie — SF 51-1

Kalgoorlie (SH 51-9) and Mount Ramsay (SE 52-9) maps were reprinted in colour using a laser-scan 4-colour separation process.

Records:

1982/1 Operations 1981 and programme 1982 of the GSWA;

1982/7 Explanatory notes on the Mt Barker/Albany 1:250 000 geological sheet, W.A.; by P.C. Muhling and A.T. Brakel;

1982/8 Gravity traverses across the Warriadar Belt; by L. Kevi;

1982/9 Explanatory notes on the Winning Pool/Minilya 1:250 000 geological sheet, W.A.; by R.M. Hocking, S.J. Williams, I.H. Lavaring and P.S. Moore;

1982/10 Statistical assessment for prospecting purposes of the trace-element composition of caprock ironstones in the northeast Pilbara; by R. Davy and A.H. Hickman;

1983/1 Summary of progress of the G.S.W.A. during 1982, and plans for 1983;

1983/2 Wells drilled for petroleum exploration in W.A. to the end of 1982; by A.E. Cockbain and R.P. Iasky;

1983/3 A geochemical study of the Mt McRae Shale and the upper part of the Mt Sylvia Formation in core RD1, Rhodes Ridge W.A.; by R. Davy;

1983/4 Petroleum exploration in W.A. in 1982; by A.E. Cockbain and R.P. Iasky;

1983/5 Explanatory notes on the Kennedy Range 1:250 000 geological sheet, W.A.; by R.M. Hocking, S.J. Williams, P.S. Moore, P.D. Denman, I.H. Lavaring, and W.J. E. van de Graaff;

1983/6 The Piccaninny Structure - a cryptoexplosive feature in the Ord Basin, East Kimberley; by G.M. Beere;

1983/8 Geology and mineral deposits of the Leonora-Laverton area northeastern Yilgarn Block, Western Australia; by J.A. Hallberg;

Urban geological maps in colour at 1:50 000 scale:

De Witt/Picard

Harvey/Lake Preston

WAMPRI Report 1. The Flash Smelting of Nickel Sulphide Concentrates.

WAMPRI Report 2. Carbon-in-pulp Gold Processing Technology.

In press:

Bulletin 128. Geology of the Bangemall Group; the evolution of a Proterozoic inter-cratonic sedimentary basin; by P.C. Muhling and A.T. Brakel.

Bulletin 129. Stromatoporoids from the Devonian reef complexes, Canning Basin, Western Australia; by A.E. Cockbain.

Bulletin 130. Biostratigraphic studies from the Proterozoic Earraheedy Group, Nabberu Basin, Western Australia; by K. Grey.

Mineral Resources Bulletin 14. Nickel mineralization in Western Australia; by R.J. Marston.

Report 12. Professional papers 1982.

Geological maps in colour at 1:250 000 scale with explanatory notes for sheet areas:

Barlee — SH 50-8

Bencubbin — SH 50-11

Bremer Bay — SI 50-12

Jackson — SH 50-12

La Grange — SE 51-10

Mount Phillips — SG 50-2

Newdegate — SI 50-8

Pemberton/Irwin Inlet — SI 50-10/14

Pender — SE 51-2

Sandstone — SG 50-16

Shark Bay/Edel — SG 49-8/12

Wooramel — SG 50-5

Youanmi — SH 50-4

In preparation:

Bulletin 131. Geology of the eastern part of the Nabberu Basin; by J.A. Bunting.

Report 13. Economic potential of the lower Fortescue Group and adjacent units in the southern Hamersley Basin: a study of depositional environments; by D.F. Blight.

Report 14. Professional papers 1983 Manuscript. Geology of the Gascoyne Province; by S.J. Williams.

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

Corrigin — SI 50-3

Dumbleyung — SI 50-7

Hyden — SI 50-4

Kellerberrin — SH 50-15

Mt Barker/Albany — SI 50-11/15

Perenjori — SH 59-6

Records:

1983/7 Current studies on fossils of Western Australia. With a supplement: bibliography of the palaeontology of Western Australia 1975-1982; by S.K. Skwarko and J. Backhouse.

1983/9 Explanatory notes on the Wooramel 1:250 000 geological sheet, Western Australia; by P.D. Denman, R.M. Hocking, P.S. Moore, I.R. Williams and W.J. E. van de Graaff.

1984/3 An orientation study of trace and other element composition of some Collie coals; by R. Davy and A.C. Wilson.

1984/5 Analysis of a pumping test from the Darling Range, eastern Collie area, Western Australia; by M.W. Martin.

Papers in outside publications:

Ahmat, A.L., 1983, Structure, stratigraphy and mineralisation potential of the anorthositic Windimurra gabbroid, Yilgarn Block, Western Australia: Geol. Soc. Australia Sixth Australian Geological Convention, Canberra. Abstract Series, No.9, pp.265,266.

- Allen, A.D., 1983, Chloride variations in unconfined groundwater from the Swan Coastal Plain, near Perth, Western Australia: Water Research Foundation of Australia, Water Quality Seminar, Murdoch University Perth 1983, Seminar Papers, pp.50-58.
- Cargeeg, G.C., McFarlane, D.J., and Smith, R.A., 1983, Regional survey of groundwater quality in Perth, Western Australia: Water Research Foundation of Australia, Water Quality Seminar, Murdoch University, Perth 1983, Seminar Papers, pp.44-49.
- Cockbain, A.E., 1983, Petroleum developments in Western Australia during 1982: APEA Journal 1983 v.23 pt 2 pp.31-34.
- Cockbain, A.E., 1983, Western Australia: petroleum developments in 1982: PESA Journal No.3 pp.41-44.
- Commander, D.P., 1983, Hydrogeology of the Eneabba area, Western Australia: Univ. West. Australia Geol. Dept M.Sc. Thesis (submitted 1981).
- Commander, D.P., 1983, Groundwater exploration and development in the western Fortescue valley, North West Australia: Australian Water Resources Council Conference Series No.8 v.3, pp.21-28.
- Davidson, W.A., and Jack, P.N., 1983, Water nitrates — occurrence and health aspects in Western Australia: Water Research Foundation of Australia, Water Quality Seminar, Murdoch University, Perth 1983, Seminar Papers, pp.59-63.
- Davy, R., 1983, A contribution on the chemical composition of Precambrian iron-formations *in* Trendall, A.F., and Morris, R.C. (Editors) Iron Formation: Facts and Problems: Elsevier, New York, pp.325-343.
- Davy, R., Butt, C.R.M., and Ballinger, T.A., (Editors), 1983, Geochemical exploration in arid and deeply weathered environments: Assoc. of Exploration Geochemists Australian Regional meeting Perth, Abstracts volume 67 pp.
- Fletcher, I.R., Wilde, S.A., Libby, W.G., and Rosman, K.R.J., 1983, Sm-Nd model ages across the margins of the Archaean Yilgarn Block, Western Australia — II; southwest transect into the Proterozoic Albany-Fraser Province: Jour. Geol. Soc. of Australia, v.30, No.3, pp.333-340.
- Froude, D.O., Ireland, T.R., Kinny, P.D., Williams, I.S., Compston, W., Williams, I.R., and Myers, J.S., 1983, Ion microprobe identification of 4100-4200 Myr old terrestrial zircons: Nature, v.304 pp.616-618.
- Grey, K., and Jackson, M.J., 1983, A re-assessment of stromatolite evidence for the correlation of the Late Proterozoic Neale and Ilma Beds, Officer Basin, Western Australia: Bur. Min. Resour. Aust. (BMR) Jour. of Australian Geology and Geophysics v.8 p.359.
- Jaques, A.L., Lewis, J.D., Gregory, G.P., Ferguson, John, Smith, C.B., Chappell, B.W. and McCulloch, M.T., 1983, The ultrapotassic diamond-bearing rocks of the West Kimberley Region, Western Australia: Geol. Soc. Australia Sixth Australian Geological Convention, Canberra, Abstract Series No.9 pp.286-287.
- McCulloch, M.T., Jaques, A.L., Nelson, D.R., and Lewis, J.D., 1983, Nd and Sr isotopes in kimberlites and lamproites from Western Australia: an enriched mantle origin: Nature v.302, no.5906, pp.400-403.
- Moore, P.S., and Hocking, R.M., 1983, Significance of hummocky cross-stratification in the Permian of the Carnarvon Basin, Western Australia: Jour. Geol. Soc. of Aust. v.30, No.3 pp.323-331.
- Playford, P.E., 1983, Geological research on Rottneest Island *in* Bradshaw, S.D. (Editor) Research on Rottneest Island: Jour. Roy. Soc. West. Australia v.66, pt 1, pp.10-15.
- Trendall, A.F., 1983, The Hamersley Basin *in* Trendall, A.F. and Morris, R.C. (Editors) Iron Formation: Facts and Problems: Elsevier, New York, pp.69-129.
- Trendall, A.F., and Morris, R.C., (Editors), 1983, Iron Formation: Facts and Problems: Elsevier, New York (Developments in Precambrian Geology Series No.6) 558 pp.
- Fletcher, I.R., Williams, S.J., Gee, R.D., and Rosman, K.J.R., 1983, Sm-Nd model ages across the margins of the Archaean Yilgarn Block, Western Australia; Northwest transect into the Proterozoic Gascoyne Province: Jour. Geol. Soc. of Australia v.30, pp.167-174.

In May 1983 a team of divers completed the 'tie-in' of the submarine pipeline which will be the vital artery in the North West Shelf Development Project taking gas from the offshore platform to the shore. The divers had been working for several weeks in hyperbaric conditions at a sea depth of 125 metres and living in a cramped compression chamber on the diving support vessel at a similar pressure.

The discovery of petroleum and mineral deposits offshore has required operators, designers and constructors to adapt and extend the technology needed for the recovery of these deposits. As the techniques for drilling in deep water have evolved, the methods for recovery of deep water deposits have followed closely behind. Nowhere has the technology advanced more rapidly than in the diving industry.

Research conducted by private companies and various naval research laboratories has resulted in working dives being carried out in excess of 350 metres sea water depth and simulated dives in excess of 600 metres. The problems associated with depth involve the development of the correct breathing gas mixtures to maintain the correct partial pressure of oxygen. Helium is a light inert gas introduced with oxygen to prevent nitrogen building up in the body of the diver. This nitrogen build-up is the main cause of bends and of nitrogen narcosis with its symptoms of euphoria and reduced mental and physical function leading to loss of consciousness. The other practical problem with deep water diving is the decompression procedure. For a dive of 30 minutes duration at the depths of 100m, 200m and 300m the approximate decompression times are 3 hours, 12 hours and 10 days.

It was the realization that the body becomes saturated with gas at pressures corresponding to depth that led to the use of saturated diving systems. Once the body is saturated with an inert gas at a given pressure

it can stay saturated for a long period and still only require one decompression cycle to return to atmospheric pressure. This means that a diver may be kept under pressure in a surface compression chamber for long periods of time and transported to the work place by means of diving bells without change of pressure.

The work place on the submarine pipeline was the seabed adjacent to the North Rankin 'A' Platform where the end of the pipeline laid by the pipe lay-barge was to be connected to the riser pipe installed on the platform. In this operation the divers first had to level the seabed in order to position a working mud mat. On the mud mat the tie-in spool piece approximately 60m long and weighing 20 tonnes was supported in alignment with the riser connection at the platform and the pipeline at the other end. Once in correct position an underwater welding habitat was lowered over the pipeline/riser con-

nection. The habitat was sealed around the ends of the riser pipe and tie-in spool piece and the habitat was dewatered to provide a dry environment. Working in a dry helium/oxygen atmosphere the divers accurately aligned and cut the pipes to allow a short length of pipeline (pup-piece) to be positioned. The pipe ends were bevelled and diver/welders welded the one inch thick steel, one metre diameter pipeline. The joints were non-destructively tested by radiography. The procedure was repeated at the pipeline end of the tie-in spool piece.

During the operation, Cyclone Jane approached the area and it was necessary for the work to be interrupted. However, because of the saturation diving system, the diving support vessel was able to leave the area with the diving team still under pressure, ready to resume underwater operations when the weather conditions allowed the vessel to return.



Diver approaching welding habitat.

## Exploration and development

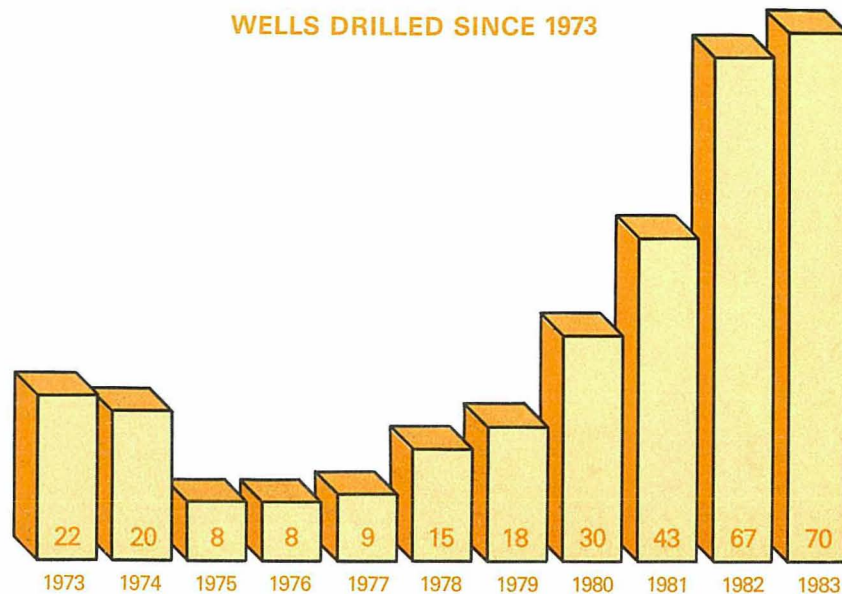
For the second successive year a record number of exploration wells were drilled (70 compared to 67 in 1982) even though total penetration was down from 151 948 metres in 1982 to 125 741 metres in 1983. This decrease was due to the large number of shallow stratigraphic tests which were drilled. Seismic surveys dropped considerably in 1983 with a recorded coverage of 24 200 line kilometres compared to 56 372 line kilometres in 1982, a decrease of almost 60 per cent. This decrease is a matter of concern as it could adversely affect the number of exploration wells to be drilled in the next 2 or 3 years.

A list of the wells drilled in 1983 is shown in the table at page 84.

Of the total number of wells drilled, 6 were classed as oil discoveries and 2 as gas discoveries, to give a success ratio of about 1 in 6 based on new field wildcats. The most active areas for petroleum exploration were the offshore Carnarvon Basin and onshore Canning Basin where 76 per cent of the drilling and 68 per cent of the seismic work was carried out.

During 1983, four oil discoveries were made to the east and south of Barrow Island, in the Barrow Sub-basin of the Carnarvon Basin. Crude oil flowed from Barrow Group sandstones at varying rates during testing at Bambra No. 1, Harriet No. 1, North Herald No. 1 and Chervil No. 1 and additional wells will have to be drilled to determine the extent of these hydrocarbon accumulations. These discoveries are small but together they could contribute significantly to the reserves of the State. The highest flow rate was recorded at Australian Occidental's Harriet No. 1 where  $634 \times 10^3 \text{m}^3/\text{day}$  was recorded. At Chervil No. 1 a flow of  $328 \times 10^3 \text{m}^3/\text{day}$  was recorded and the rates at South Pepper No. 1 and North Herald No. 1 were 242 and  $301 \times 10^3 \text{m}^3/\text{day}$  respectively.

WELLS DRILLED SINCE 1973



In the Canning Basin oil was discovered at Sundown No. 2 by Home Energy in the Grant Formation (Permian/Carboniferous age). This, together with the discovery at Blina, indicates that prospects are excellent for finding small oil fields in this basin and that major discoveries are still a real possibility in this area.

Gas discoveries were also made in 1983 by WAPET at Central Gorgon No. 1 and by Woodside at Wilcox No. 1 (gas/condensate).

Blina Field, in Canning Basin, is the first new producing oil field since the discovery of the Barrow Island Field in 1967, excluding the minor production from Dongara which commenced in 1971. Commercial production began on 30 September, 1983 and the crude is currently being produced at about 110 kilolitres per day. The oil is degassed and dewatered on site and then transported via pipeline to the storage and loading terminal at Erskine on the Great Northern Highway. From there it is moved by road to Broome for storage and regular shipment by tankers to Kwinana Refinery.

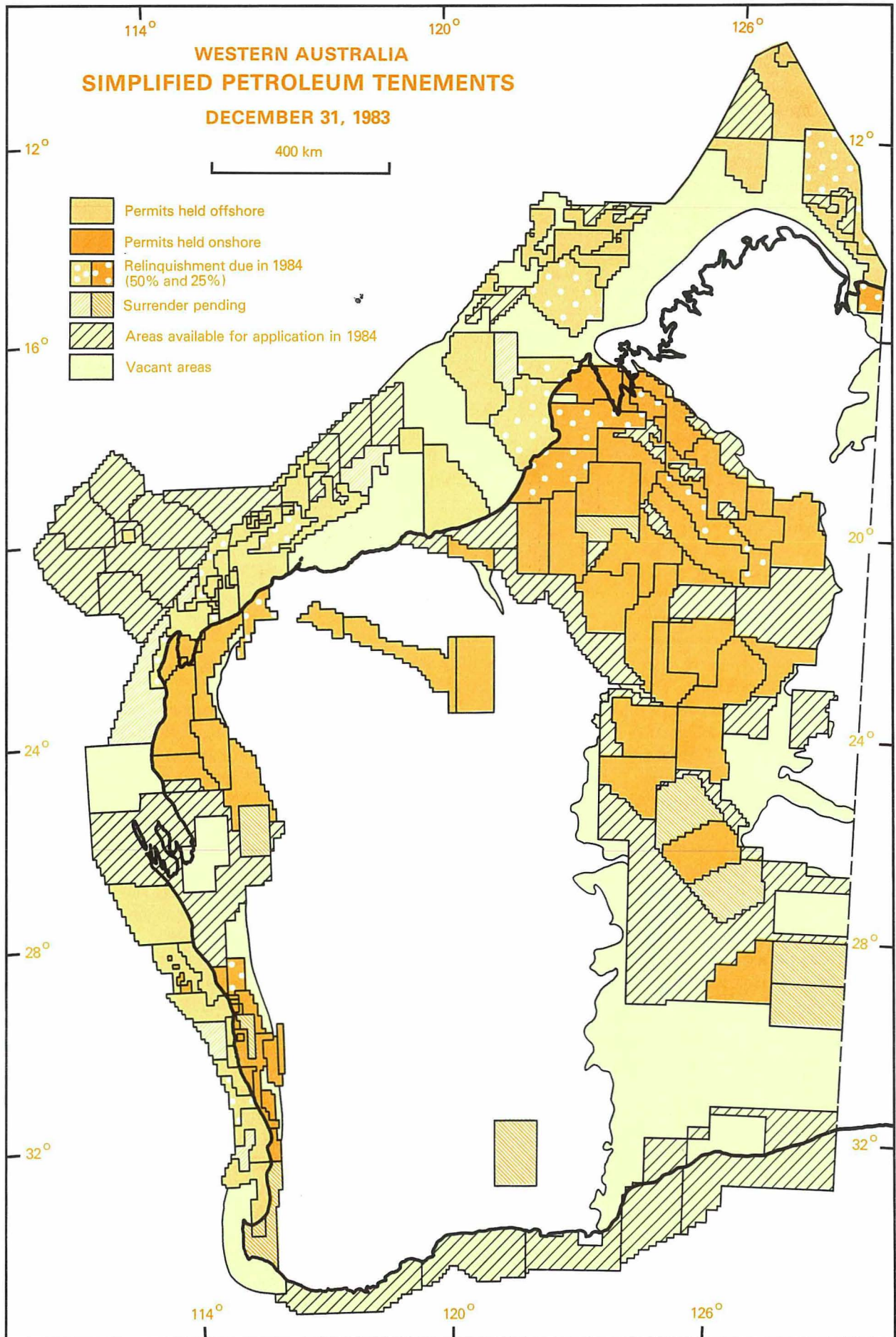
## Tenements

On 31 December, 1983 there were 112 permits to explore for petroleum in Western Australia including 43 offshore and 69 onshore. The permit area held comprises 1 024 544 square kilometres made up of 393 745 square kilometres offshore and 630 799 square kilometres onshore. An accompanying map shows, in simplified form, the petroleum tenements at the end of the year.

A summary comparison of permit dealings for the years 1982 and 1983 is tabulated on page 81. At the end of the year the area still available for application totalled more than 500 000 square kilometres.

There was a general decrease in permit applications during 1983 and the area and number of permits held have dropped compared to 1982. Permit surrenders, expiries and cancellations have doubled and renewals halved resulting in a 19 per cent decrease in the number of permits held. This reflects the current economic climate. During 1984 it is expected that several areas of high ex-





ploration potential, particularly offshore, will be advertised as being available for application.

### Development and production

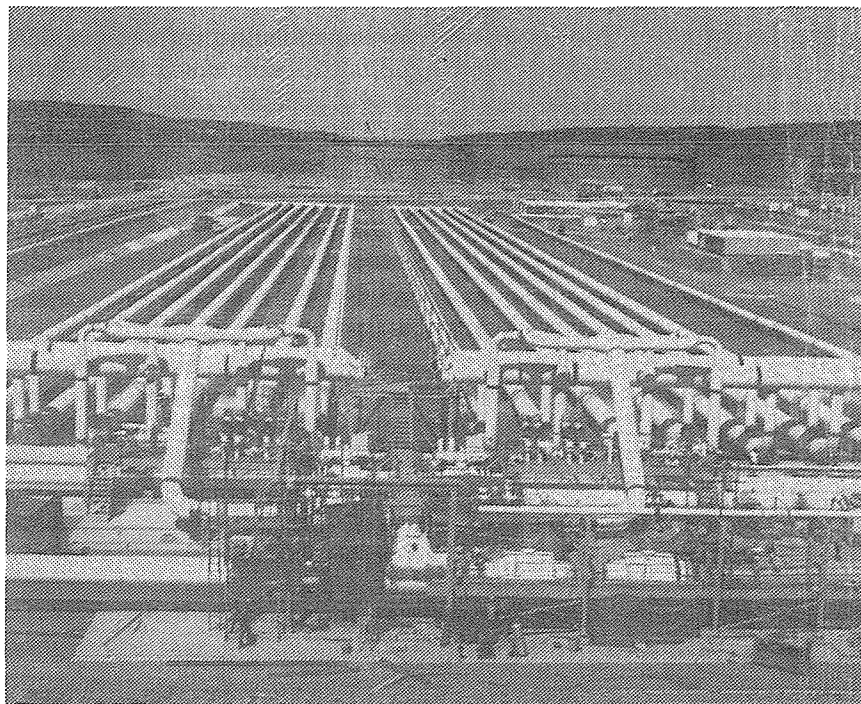
In Western Australia production of crude oil totalled 1 297 624 kilolitres and production of gas  $12.14 \times 10^6 \text{m}^3$  for the year ending 31 December, 1983. Oil was produced from the Barrow Island Field, Blina Field and a small amount from the Dongara Field, while gas and condensate were produced from the Dongara/Mondarra/Yardarino Fields and the Woodada Field. The North Rankin Gas-condensate Field has not yet commenced production but preparations are under way to transport the gas by pipeline to Perth for commercial sales in the latter half of 1984.

**Barrow Island Oil Field (West Australian Petroleum Pty Ltd).** Barrow Island Field is located on a 233 square kilometre island 88 kilometres north of Onslow and 145 kilometres west of Dampier. The first well was spudded in 1964 and since then 668 wells have been drilled. Production started in April 1967 and at the end of 1983 a cumulative total of 31 207 034 kilolitres of oil had been produced.

There are at least 27 different reservoirs producing or holding oil and/or natural gas in the field, but the four main producing pools are the Lower Gearle Siltstone, representing about 0.3 per cent of oil production, the Windalia Sandstone (97 per cent), Muderong Shale (1.3 per cent) and Jurassic sands (1.2 per cent).

During 1983 a total of 19 wells were completed, 17 testing Muderong objectives and 2 the Windalia Pool. Thirteen of these wells were classed as extension tests, 4 were new pool wildcats, and there were 2 development wells. Of the wells drilled in 1983, 13 were oil producers, 5 were suspended and 1 was plugged and abandoned.

The status of the 668 wells drilled on Barrow Island to the end of 1983 is shown in the table on page 81. A breakdown of annual and cumulative production for the reser-



Condensate slug catcher.

voirs of the field is shown in the table on page 82.

In the second half of 1984 WAPET plans to drill 14 wells to test Muderong Shale targets.

The commissioning of the new large power station commenced in 1983 was delayed by late delivery of fuel gas compressors. It is hoped that the station will be ready during the first quarter of 1984.

**Blina Oil Field (Home Energy Company Ltd).** Blina Field is located 105 kilometres southeast of Derby in the Canning Basin. The oil discovered in Blina No. 1 (1981) was substantiated by three extension wells. Oil production commenced on 30 September, 1983 and to the end of the year 16 321 kilolitres of oil has been produced.

The two main reservoirs at Blina are the Upper Devonian Nullara Limestone (80 per cent of production) and the Lower Carboniferous Yellow Drum Formation (20 per cent).

There was no disposal of oil for sale in 1983 and all the oil produced at Blina was stored at Erskine and in Broome. All four wells are currently producing, Nos. 1, 2 and 3 from the Nullara Limestone and No. 4 from the Yellow Drum Formation.

**Dongara, Mondarra and Yardarino (WAPET).** These three fields are located approximately 320 kilometres north of Perth and 65 kilometres south of Geraldton in the northern part of the Perth Basin. Production from the Dongara Field commenced on 25 October, 1971 followed by Mondarra Field in 1972 and Yardarino in 1978.

The four reservoirs in these fields are the Aranoo Member (Early Triassic), the Dongara Sandstone (Early Triassic), the Wagina Formation (Upper Permian) and the Irwin River Coal Measures (Lower Permian).

No development drilling was conducted by WAPET in the Perth Basin during 1983. However, a major acid stimulation programme was carried out: 8 Dongara wells (Nos. 2, 3, 10, 11, 12, 15, 23, 24) were successfully acid stimulated resulting in a marked increase in production.

A total of 25 wells have been drilled in the Dongara Field and at present there are 10 gas producers, 2 oil producers, 2 oil and gas producers, 7 shut-in producers, 1 water source well and 3 abandoned wells. Gas produced at a rate of about  $2.20 \times 10^6 \text{m}^3$  per day was transported in a 36cm diameter pipeline from



Helicopter pad on the Maersk Valiant (courtesy of Australian Occidental Petroleum Inc.)

Dongara to Pinjarra via Perth and Kwinana. The Mondarra Field, 2 gas wells and 2 abandoned wells, produced gas at a rate of  $0.08 \times 10^6 \text{m}^3$  per day, and the Yardarino Field produced gas at a rate of  $0.02 \times 10^6 \text{m}^3$  per day. Oil production from Dongara averages about 40 kilolitres per day.

In 1983, 3 wells were recompleted in the Aranoo Member: No. 21 which produced oil; No. 24 which produced gas and minor oil; and No. 25 which needs further work. In 1984, 3 wells are to be re-perforated and stimulated: Nos. 9, 14 and 16.

**Woodada Gas Field (Strata Oil N.L.).** Woodada Field is 13 kilometres northwest of the township of Eneabba, in the Perth Basin. The discovery well was spudded in 1980 and since then 8 wells have been drilled. Gas production commenced on 24 May, 1982 and to the end of 1983  $257 \times 10^6 \text{m}^3$  of gas has been produced. The current rate is about  $0.6 \times 10^6 \text{m}^3$  per day.

The main reservoir is in the Carynginia Limestone of Early Permian age. Of the total of 9 wells drilled in the field, 5 are gas producers, 3 are shut-in producers and one is plugged and abandoned.

Gas was initially produced from Woodada Nos. 1 and 2 wells but in mid-April 1983 the rate at the No. 2 well fell to a sub-economic level and

had to be shut-in. Since then a gas gathering system connects Woodada No. 8, East Lake Logue No. 1 and Indoon No. 1 wells, which are located in Primary Production Licence PL5, to the production facilities in PL4. The State Energy Commission is using Woodada gas to promote gas sales in the Perth area to maximize initial sales of North West Shelf gas on arrival later in 1984.

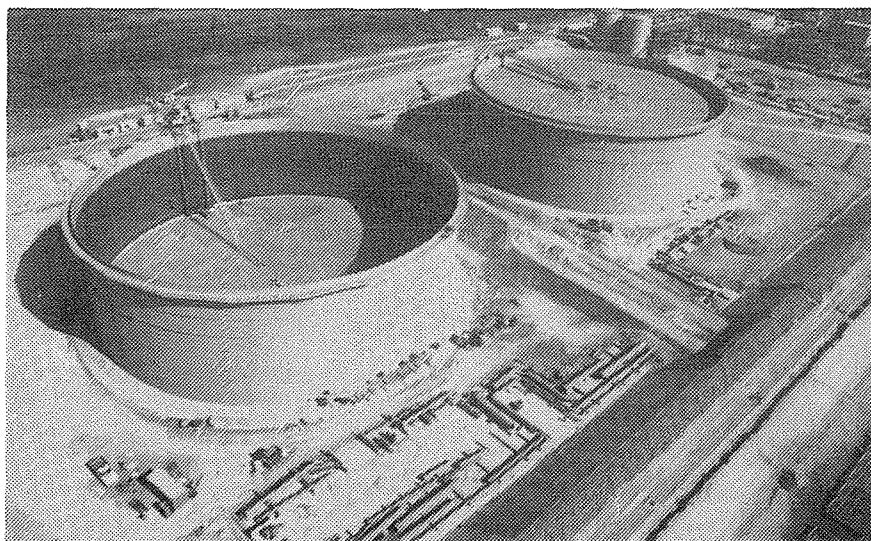
**North Rankin Gas - Condensate Field (Woodside Petroleum Development Pty Ltd).** North Rankin Field is located offshore 130 kilometres north-northwest of Dampier in 125

metres of water. The first well was spudded in June 1971 and a total of six appraisal wells have been drilled all of which are shut-in gas-condensate wells. The first development well, designated NRA 01/SE5 was started in 1983 from the North Rankin 'A' Platform. Over 30 development wells are expected to be drilled from the platform.

The main reservoir is in the Mungaroo Formation of Upper Triassic to Lower Jurassic age. Production is due to commence in mid 1984. Gas will be transported to Perth by a 1 250 kilometre pipeline where it will be re-directed to consumers by the State Energy Commission.

**Mt Horner Field (XLX N.L.).** Mt Horner Field is about 380 kilometres north-northwest of Perth in the Perth Basin. The first well, drilled by WAPET, was spudded in March 1965, and since then five wells have been drilled, the last, Mt Horner No. 6 in 1983. Of the 6 wells put down, 4 are classed as suspended oil producers and 2 (Nos. 2 and 6) were plugged and abandoned. Production is due to commence in early 1984.

There are at least three potentially productive formations at Mt Horner, the Cockleshell Gully Formation, the Kockatea Shale and basal Triassic sands.



Condensate storage tanks on the Burrup Peninsula.

## Reserves

The total recoverable reserves for the State at the end of 1983 are estimated with a probability of greater than 25 per cent to be at least  $13.54 \times 10^6 \text{m}^3$  of crude oil,  $85.90 \times 10^6 \text{m}^3$  of condensate,  $29.35 \times 10^6 \text{m}^3$  of liquid petroleum gas and  $1\,665.18 \times 10^9 \text{m}^3$  of natural gas. The table at page 82 shows details of these reserves.

The main changes to the oil reserves since 1982 are the addition of the small South Pepper Field and adjustments to the Barrow Island reserves. As far as gas reserves are concerned the main changes are the addition of the very large Scott Reef and Scarborough Fields, the large North Gorgon pool and several lesser fields - Brecknock, Brewster, Rankin, Spar, Central Gorgon and Barrow Deep. These fields also contributed additional condensate reserves.

It should be noted that all these fields are under constant review. For example the gas reserves of Dongara have been slightly reduced after a major review of the field.

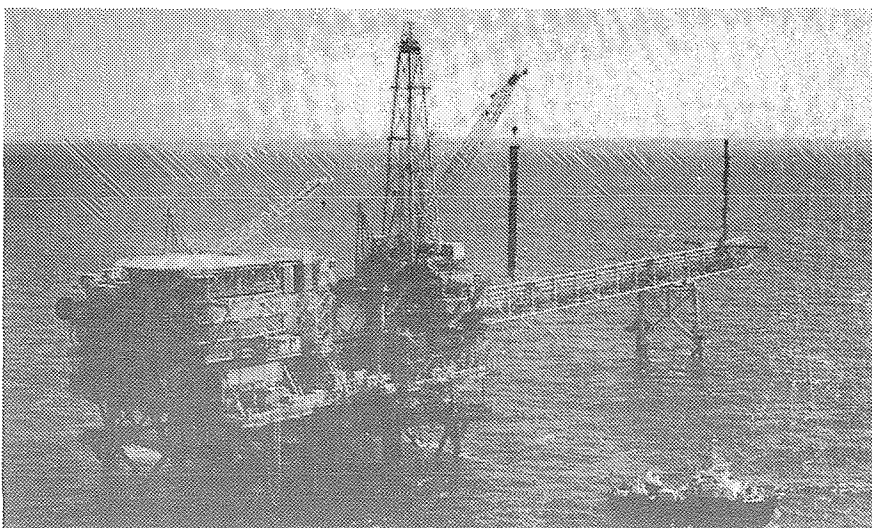
## Royalties

Total royalties paid on petroleum in 1983 were \$18 443 370 compared to \$14 188 870 in 1982, an increase of 23 per cent. This was derived from \$15 196 442 paid on crude oil sales, \$3 211 243 on natural gas and \$35 684 on condensate.

Royalty paid on Barrow Island crude during 1983 was \$15 081 487 an increase of \$3 088 086 or 20 per cent on 1982. The royalty rate at Barrow Island is 10 per cent of the value of the crude at the wellhead. WAPET also paid \$2 335 636 in royalties for the northern Perth Basin, including \$2 205 305 on gas, \$108 230 on oil and \$22 101 on condensate.

Royalties paid on gas and condensate at Woodada were \$1 005 938 and \$13 584 respectively. Hudbay Oil (Aust) Ltd was the operating company for Woodada Field until Strata Oil N.L. took over in May 1983.

Home Energy Company Ltd paid \$1 838 royalty on Blina production and Pacific Basin Exploration Pty Ltd \$4 887 on Mt Horner production test oil.



North Rankin A Platform (courtesy of Woodside Offshore Petroleum Pty. Ltd.)

A table showing royalty paid and disposal of petroleum for 1983 appears on page 83.

## Operations

### Engineering

The petroleum engineering (construction) section continued appraising the design, construction and installation of the pipelines and facilities for the North Rankin Gas Field, Woodada Gas Field and Blina Oil Field. A spur pipeline on the Dampier-Perth trunkline from Karratha to Port Lambert was also under construction.

Activities offshore continued. The North Rankin 'A' Platform was commissioned for life support on 24 January and can accommodate 320 persons living on board. The drilling equipment was commissioned on 19 September.

The final 'tie-in' joining the submarine pipeline from the onshore gas treatment plant to the offshore platform was completed by divers in May. After hydrostatic testing the pipeline was deballasted and dried in preparation for receiving gas.

At Woodada a field gas gathering system was constructed linking the wells at Woodada Nos. 4, 6 and 8, East Lake Logue No. 1 and In-noon No. 1 to the treatment battery at Woodada No. 1 and thence to the WANG pipeline.

At Blina an oil treatment battery

was constructed at Blina No. 1 location, and a 100 millimetre diameter pipeline 30 kilometres long was laid to a storage and loading facility at Erskine Ranges on the Great Northern Highway. The oil is trucked to Broome where a 110 000 barrel storage tank was constructed from which it is then shipped to Kwinana.

### Accidents

Figures relating to accident statistics in the petroleum, exploration and production industry are shown in the table on page 83.

### Pipelines

A total of 221 work proposals relating to the Dongara to Pinjarra Natural Gas Pipeline from Government Departments, instrumentalities and other parties were processed during 1983, compared with 227 in 1982.

There were 12 encroachments on the pipeline during the year, 2 by Telecom, 2 by the Metropolitan Water Board and 8 by the State Energy Commission.

## Organization

During 1983 there were 2 appointments, and 1 resignation and at the end of the year there was 1 vacancy: Assistant Director (Exploration). One professional appointment was made, that of Dr F. Jursa as the Reservoir Engineer.



# SURVEYS AND MAPPING

W. R. MOORE, SUPERINTENDENT

Western Australia is a large State, much of which is undergoing active exploration for minerals and petroleum. The task of mapping the State to meet the needs of the mining industry is therefore a formidable one. Staff numbers in the Surveys and Mapping Division were static in 1983 and it is a tribute to the staff that they have matched the increased demands placed upon them.

The functions of the Division include the survey of mineral tenements and the compilation of mineral tenement maps. As a consequence of the changeover to the new Mining Act many tenements need re-numbering and some boundaries will have new configurations. A programme is being implemented to replace the old, much modified tenement maps with new maps reflecting these changes.

For many years the basic scale of tenement maps was 1:50 000. The question of scale was recently reviewed because of the increased size of the new tenements. Under a revised policy the scale of 1:100 000 has been adopted for general coverage, with enlargements at scale 1:25 000 or 1:50 000 where clarification of detail is required. This will reduce the total number of maps and at the same time provide a suitable coverage.

Liaison with the Division of National Mapping has been established so that information gathered on our maps over the years will be incorporated by NATMAP on their revised second edition of the national 1:250 000 topographic series.

## Tenement surveys

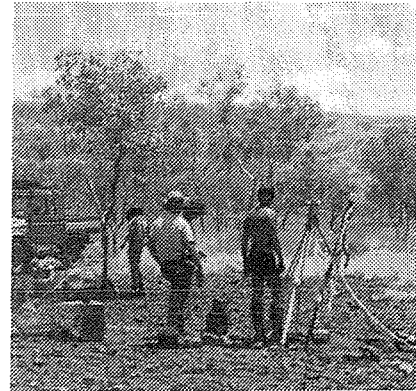
The initial hesitation shown by industry in taking up new ground under the new Act which was apparent in 1982 did not occur in 1983. As a consequence, the number of tenements requiring to be surveyed in 1983 rose considerably. The number of tenements actually surveyed in 1983 was 1 048, approaching the average over the past 4 years, and con-

siderably more than the 1982 total of 577 tenements surveyed. Field surveys were carried out at 125 localities throughout the State and were undertaken by 23 private survey firms on a contractual basis. The figures are shown in the Table below.

There remains a substantial backlog to calculate co-ordinates from existing field work. Likewise a large number of standard plans awaits preparation.

Approved leases awaiting survey totalled 2 251 at the end of 1983, which amounts to 2 years work not accounting for new tenements to be received. Cost of surveying has risen from \$472.00 per tenement in 1982 to \$555.00 in 1983. This 17.6 per cent increase in cost is attributed to increases in surveyors' charges and to the additional costs that result from widely dispersed surveys.

There is a significant number of requests from lessees for specific surveys to establish the actual position of tenements pegged under the old Act prior to their transition to tenements under the new Act. There are also many requests for surveys of 1978 Act prospecting licences and exploration licences because doubt exists about their position. Such surveys require the approval of the Warden or the Minister, and this legislative requirement causes complications and delays. The Department is thus not able to initiate quick surveys in disputed situations as required.



Survey party running a line along a mining tenement boundary, Kimberley Mineral Field.

Although the office work in arranging the surveys and co-ordinating the resulting information was carried out with a reduced staff level, a higher output was achieved. This is attributed to the better and more efficient accommodation occupied by the Survey Branch during the year.

## Control surveys and co-ordinate traversing

A control survey in an extensive area between Kurnalpi and Kookynie was commenced. When completed this will bring to a conclusion control projects of large magnitude. Most mineralized areas in the goldfields are now either in view of an established control point or within easy range of one. Future needs will be met by surveyors connecting new cadastral work directly to controlled points.

	1983	1982
No. of tenements surveyed	1 048	577
Cost per tenement	\$ 555	\$ 472
No. of field books lodged	186	135
Total boundary line run	4 274km	816km
Total traverse line run	1 652km	173km
Total area defined by survey	37 125ha	25 755ha
Distance travelled	70 749km	43 455km
Total value of cadastral surveys	\$ 581 353	\$ 395 052
Total value of geodetic surveys	\$ 91 844	\$ 64 828
Total value of special surveys	\$ 34 349	\$ 1 387
Total value of all surveys	\$ 707 546	\$ 461 267



Mining tenement corner with survey peg, rock-spits and the applicant's well-flagged post. Kimberley Mineral Field.

### **Petroleum tenements**

The level of interest in maps showing the position of petroleum tenements taken up or relinquished remained about the same as last year. The distribution of the tenement map on a quarterly basis to regular subscribers is an important function, and this Division has maintained its goal to prepare, print and distribute an up-dated map together with a full list of tenements and holders within 10 to 14 days of the end of each quarter.

### **Geological maps**

Preparation of geological maps embraced a range of techniques and complexities in both the drawing and the photographic processes, and expended most of the resources of the cartographic area. Eight full colour editions of regional geological maps at scale 1:250 000 were printed during the year together with two maps in the urban geology series. This represents a substantial output. In addition four sheets were completed as preliminary editions.

### **Reprints of maps — laser scanning.**

A concern for some time has been the need for reprinting out-of-print coloured geological maps particularly in the regional series. Most of these maps were printed long ago and much of the original reprostat is either not available or has deteriorated beyond use. A technique is now available whereby positives can be obtained by laser scanning an original copy and separating it into the four process colours from which printing plates can be prepared. The technique has previously been used in the printing trade but geological maps present a formidable task because of the number and variety of colours created by the use of screens and tints.

Two out-of-print maps, Kalgoorlie and Mt Ramsay, were selected for trial scanning and printing. The result is satisfactory although technically of a lower quality than the original map. Laser scanning is a much cheaper process than remaking the original reprostat.

**New maps.** An exciting development during the year was the design and

commencement of a new 1:50 000 map series to portray environmental geology. Initially the intention is to prepare nine sheets covering the metropolitan area. The series will show geology, geomorphology (including origin of landforms and slopes), hydrology, lithology, topography and cadastral details. Information will be shown on both sides of the paper. The first sheet, Muchea, will be printed during 1984.

### **Project and thematic maps**

A new map in the thematic (information) series was produced. This map portrays graphically the value, quantity and destination of mineral exports from Western Australia to the rest of the world. Five out-of-print maps in this series were reprinted.

### **Publication and display**

The demand for visual aids and other graphic artwork has increased, reflecting the expanding demand on Departmental officers to communicate the results of their work to industry and the public. Display work for slides and overhead projection

were prepared for local and overseas presentations, and a high standard of artwork was maintained.

A set of guidelines was prepared for the use of those in the Department who contemplate using this facility.

### **Cadastral plans**

Maps at scale 1:50 000 to cover a large part of the South West Mineral Field were adopted from the Forests Department, Town Planning Department and Lands and Surveys Department and re-formatted to our requirements. Maps at scale 1:50 000 in the West Pilbara, Pilbara and Peak Hill Mineral Fields are being systematically replaced by 1:100 000 scale mapping as new topographic material becomes available. The first full revision of 119 maps at scale 1:100 000 in the Kimberley and West Kimberley areas was completed.

### **Reprographic work**

Work commenced towards the end of the year to enlarge and re-arrange the laboratory layout to achieve better working conditions. The renovations will accommodate the new OPTICOPY process camera, and the improved arrangement of the existing equipment will be a considerable advantage.

The prevailing cramped conditions together with closure of certain units during renovations curtailed some of the photographic work, whilst processing of an urgent nature was contracted to outside sources.

### **Public plans**

During the year, 12 137 applications for mining tenements were added to the public plans. This is a sharp increase over the figure of 2 844 for 1982. A large number of these were replacement applications under the transitional provisions and a further significant number were prospecting licences. In addition there were many cancellations of tenements. As a result of these numerous additions and alterations, plans have become cluttered and need replacement. The

clerical mechanisms for notification of cancellations are inadequate and it is hoped computerization of the tenement system will improve this aspect.

The Division presently carries 1 741 plans in the system as against 1 757 in 1982. Plans replaced during the year totalled 244, compared with a past average of 266, whilst 55 new plans were inaugurated, compared with an average of 84. There is a large backlog awaiting adoption.

### **Technical information**

Public enquiries for both old and new tenements together with requests to inspect plans of mine workings were maintained at a high rate. There was a sharp increase in revenue from \$57 558.00 in 1982 to \$93 156.00 in this year, mainly from increased sales of copies of public plans and an increase of about 15 per cent in charges.

The Mine Plans and Research Section in its new location at 69 Adelaide Terrace presents a better facility for public contact and provides an improved service. There is a backlog in the filing and indexing of new plans of mining operations at the rate currently being received.

### **Cartographic computing**

The year has seen major changes in the Department's overall computing activities with the installation of data communications hardware and additional terminals with access to outside bureau facilities. In addition to computer applications within the Division other activities included software conversion from the PDP11/40 computer to the VAX 11/780 at the Land Information System Support Centre and participation in the Land Information System joint rural project. This project was initiated as a pilot study involving a number of Government Departments dealing with rural land management. Senior draftsman, Mr P. Shaw, of this Division was appointed part-time group manager and a geologist from the Hydrogeology Branch was appointed full-time group leader. The project involved the application of modern computer

graphics technology to develop a test data base covering part of the Wellington Dam catchment area, the Collie coal measures and the Lake Magenta area in the eastern wheat belt.

The project has provided significant experience in the application of current computer graphics technology to real world data and has demonstrated the need for careful design and strategic planning in implementing this technology.

### **Staff**

Total establishment numbers remained static at 131. It is some time now since Surveys and Mapping increased its staff numbers and more backlogs are anticipated unless numbers are increased. Some rationalization of duties and re-scheduling of priorities helped the work flow, and 2 283 hours of work were contracted out. If a realistic drafting service is to be provided to satisfy contemporary demands, this contract work should be extended.

### **Other activities**

Joint visits with officers of the Registration Division were made to inspect plans and operations in the Southern Cross, Collie, Bridgetown, Carnarvon and Cue offices. These visits assist in liaison and information flow between head office and the outstations.

Mr M. Harry, Photographic Technician, attended the Australian Photographic Industry Association Convention held in Melbourne in May 1983.

Mr G.R. Sharp, Chief Cartographer, attended the 12th Conference of Chief Cartographers in Darwin during September 1983.

The 12th International Conference of the International Cartographic Association is scheduled for Perth in 1984. This will be a major event in cartographic activity in Australia and for Western Australia in particular. Mr D.T. Pearce, Assistant Superintendent of this Division, continued his work towards the organization of this event.



## ASBESTOS—assessing the hazard

Much work has been done in recent years on assessing the asbestos hazard, particularly with respect to Wittenoom where blue asbestos was mined between 1933 and 1966. The television documentary 'Alice - A Fight for Life', shown in Western Australia during 1983 brought the public face to face with the hazard accompanying uncontrolled exposure to asbestos fibre. It created concern among people previously unaware that some everyday objects could create a hazard and it increased by a factor of four the examinations made by the Laboratories.

The hazard was first established in the mid 1920's and mesothelioma, the particular danger of blue asbestos (crocidolite), which differs from asbestosis and lung cancer, was observed in South Africa in the 1950's. The first documented case of mesothelioma outside South Africa

was reported in Western Australia in 1962 by Dr McNulty the current Commissioner of Public Health in this State.

Specialist mineralogists in the Mineral Science Laboratory use microscopy to assess fibre-bearing materials in a way similar to the assessment of other mineral based materials such as those containing quartz dust.

Samples assessed have come from a variety of buildings including hospitals, banks, post offices, office blocks, schools, private residences and demolition sites, and from industrial sites such as brake relining establishments and mines.

The anxiety felt by individuals has been shared by several unions and employers and urgent, out of hours, examinations have been made to avert industrial action.

Whenever asbestos materials are

disturbed there is a risk that fibre may be released into the air. Typically this risk is increased when efforts are made to remove the asbestos from ceiling insulation or industrial equipment. Such stripping operations are closely monitored and samples taken from measured volumes of air are compared with the constantly reviewed recommended upper limits set by the National Health and Medical Research Council.

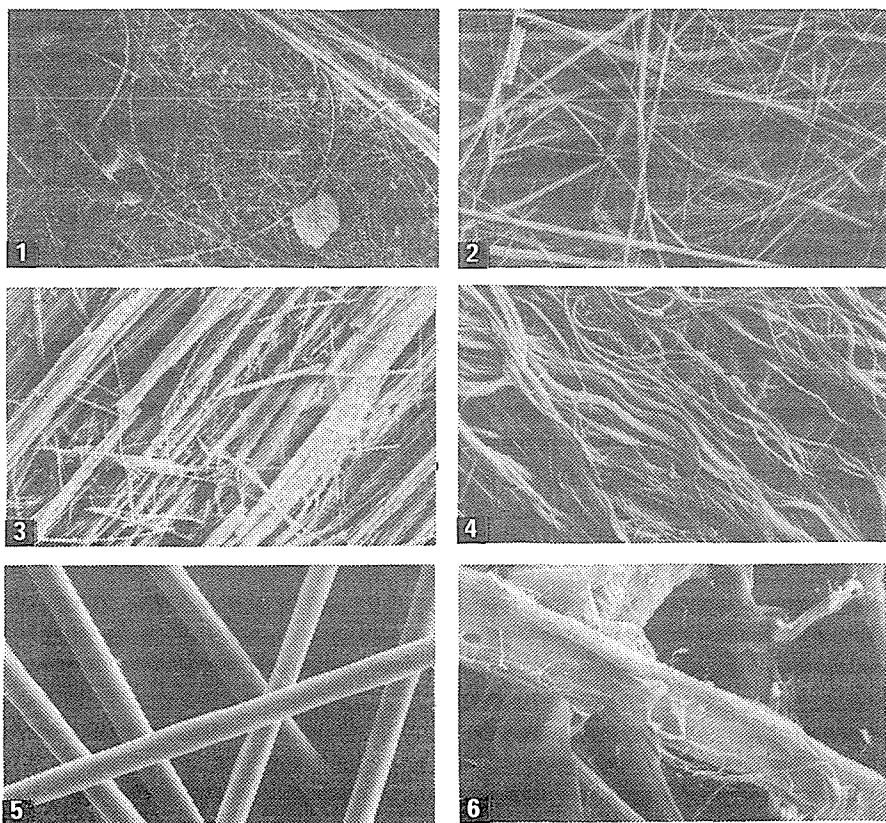
Currently these limits are set at 0.1 fibres of crocidolite, and 1.0 fibres of amosite or chrysotile asbestos per cubic centimetre of air breathed by a workers in a normal working shift.

In commercial applications asbestos usually occurs with some form of bonding agent and is often present in minor amounts associated with various other fibres and fillers. Fibres commonly encountered include glass, mineral wool, cellulose, cotton and synthetic polymers, from which asbestos must be distinguished. The fillers include portland cement, lime, gypsum, calcium silicate, quartz, basic magnesium carbonate and diatomaceous earth.

Identification of these materials is required to provide a complete assessment of the hazard and techniques such as X-ray diffraction and scanning electron microscopy are often employed.

Because concern regarding asbestos hazards has become so widespread large organizations, both government and private, have been encouraged to consider setting up their own monitoring systems. The expertise of the Laboratories is in growing demand for advice and for training to those entering this field.

The reported phasing out of asbestos from a wide range of products is unlikely to lessen the demand for asbestos analysis in the near future. Experience in overseas countries indicates that the demand may not have reached its peak, due to increasing publicity and concern.



Fibre types: (Magnification x 1000) Blue Asbestos: 1. Western Australia 2. South Africa. White Asbestos: 3. Amosite. 4. Chrysotile. Other: 5. Artificial. 6. Wood Cellulose.

# GOVERNMENT CHEMICAL LABORATORIES

R. C. GORMAN, DIRECTOR

As in every year for the past decade, 1983 was a year of rapid growth in the volume of work submitted by Departments. The 8 per cent increase this year was more manageable than the record increase of 24 per cent in 1982. Major growth areas have again been from the Department of Agriculture and the Department of Conservation and Environment (DCE). The latter's work on the Peel Inlet/Harvey Estuary problem has been the main source of increased submissions from the DCE, and this is liable to increase even further in 1984.

Altogether more than 69 000 samples were submitted for examination. (See table on page 57).

With staff numbers constant over the last 5 years the Laboratories can only deal with such a growth in the volume of work by continuing to automate procedures as funds are made available. In this respect approval to purchase an inductively coupled plasma arc spectrometer (ICP) was given in the 1983-84 budget and this instrument, when fully operational, is expected to make a major contribution to the Laboratories' performance.

The Scientific Co-ordinating and Advisory Committee which is responsible to Cabinet through the Minister for Minerals and Energy for overseeing the development of analytical laboratories within the Government service, met several times through the year. It came out in strong support for the Laboratories' proposals with respect to a new site, the need for increased staff for the Forensic Science Laboratory, and the purchase of major equipment.

A major unresolved concern in 1983 was the need for a decision on a new site for future development of the Laboratories. At one stage during the year consultant architects for Mineral House II were seriously considering the early demolition of the complete Administration area and Mineral Science Laboratory. With

such proposals imminent, a secured new site for future planning and development is essential.

## MWA-PWD merger

During the year the Merger Project Group examined the possibility of the proposed Water Authority of Western Australia taking over the water work that the Government Chemical Laboratories currently does for these two separate authorities. Although the work done for the Metropolitan Water Authority (MWA) had decreased over recent years due to the establishment of its own water supply laboratory, work for the Public Works Department on water has greatly increased. It was put to the Merger Group that the eventual taking over of the chemical work by the new Authority was not unreasonable. However since new laboratories did not exist to take on the staff to cope with the work, it was suggested that the transfer of this work should be on a gradual basis, as staff and facilities become available.

## Occupational health and safety legislation

A submission was made on the Public Discussion document on Occupational Health and Safety with respect to the role of these Laboratories. It was suggested that the Government Chemical Laboratories could serve the proposed Occupational Health and Safety Commission in the way it serves the various authorities responsible for health and safety at present. This would obviate the need to establish separate laboratory facilities and avoid an inefficient use of resources such as experienced staff, expensive equipment and background expertise, which are all in short supply. Also, other facilities for services

such as dust identification and monitoring and pesticide work need not be duplicated.

## Pesticides in perspective

Pesticide use has been under attack in the media during the past year. It has reached the stage at which certain pesticides with no scientific evidence against their safe use, to the knowledge of Government Chemical Laboratories, are being removed from the market because of misleading publicity; 2,4,5-T is a prime example of this. Yet all 2,4,5-T manufactured or sold in Western Australia in recent times has met the new stringent standard of have not more than 0.01 mg/kg of the impurity dioxin present. DDT is another pesticide that is slowly being removed from agricultural use mainly because of its bad publicity with respect to its persistence. It is well documented that any possible harm that DDT may have ever caused, is far outweighed by the benefits it has given. It is supposed to be the cause of reduction in bird life, yet if results of samples sent to these laboratories are any indication, it is clear that many more birds in Western Australia have been killed to determine their levels of DDT, than have been confirmed to have been killed by DDT.

Misuse or incorrect use of pesticides is certainly known to have caused problems and will continue to do so as long as people will not read and follow the usage and safety instructions that are required by law to be on all pesticide labels: a practice that is closely watched by local regulatory authorities.

The registration of pesticides relating in particular to safety is very closely watched in Western Australia, as it is in all other Australian States. The procedure used is equal to or better than that used in any other part of the world.

The misinterpretations of research findings of pesticides are often used to condemn useful and safe pesticides. It is necessary to realize that while, in principle, the use of pesticides may be undesirable, without their use modern agriculture and food production could not exist.

Monitoring of pesticide residues in the local environment over the past 20 years by these Laboratories has shown decreasing residues in all areas of commercial food production and the environment. However many examples of the misuse and misunderstanding of pesticides abound in non-commercial areas, such as in eggs from non-commercial poultry allowed to roam free in areas sprayed with persistent organochlorine pesticides.

Put into proper perspective pesticides properly used are a boon but incorrectly used can be harmful.

#### **Pesticide formulation quality**

Concern was expressed during the year by the Primary Industry Association over the quality of pesticide formulations, after an analysis by the Government Chemical Laboratories of one suspect sample showed it to be low in active constituent. As a result a surveillance survey of the most widely used and economically significant pesticides was undertaken. This survey showed, with the exception of 2,4-D ester samples, that the great majority of pesticides were within acceptable tolerance of their registered active constituent content.

The exception found with 2,4-D esters lay primarily in the out-of-date method of analysis given in Australian Standard AS1175-1976. The method in this standard is a general method and gives falsely high results, when compared with a modern specific gas chromatographic procedure. This finding was conveyed to the manufacturers and to the Standards Association of Australia. It is hoped that the standard will be revised in the very near future. One disturbing feature of the survey of 2,4-D esters was that several samples

of supposedly low-volatile esters were found to contain appreciable levels of volatile esters of 2,4-D. This could be of particular significance due to spray drift on to non-target crops which are susceptible to 2,4-D damage, such as tomatoes.

#### **Agricultural Chemistry Laboratory**

This Laboratory gives specialist support to the Department of Agriculture in investigations related to soil fertility, plant nutrition, fertilizers and crop and pasture quality.

Provision of chemical data required for evaluation of proposed solutions to environmental problems added to the sample numbers of the Agricultural Chemistry Laboratory which are about half that of the whole Laboratories.

#### **Peel-Harvey Estuary studies.**

Chemists made a substantial contribution to research programmes to solve the problems of algal blooms in the estuary.

Soil tests offered free to farmers in the catchment area showed that more than half of the paddocks sampled did not require further applications of superphosphate fertilizers for maximum production in the 1983 season. This information offered a real opportunity to reduce the quantity of phosphorus reaching the estuary via drainage by restricting fertilizer use.

Measurement of phosphorus in soil from leaching trials conducted by the Department of Conservation and Environment showed that many of the fertilized topsoils were able to desorb phosphate and that some soils had only a low capacity to hold phosphate at depth.

Estimation of the various forms of phosphate stored in the soils showed that half of the phosphorus stored in the top 10cm is present as organic phosphates. Study of the contribution of the organic fraction to the pool of phosphorus available to plants and to the amount of leachable

phosphorus is continuing, since it has been shown that losses of stored soil phosphorus by leaching into the estuary are as important as the losses from recently applied fertilizer.

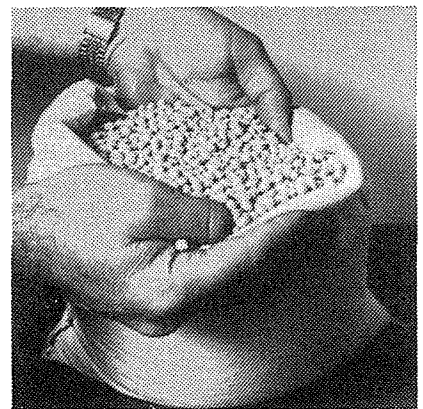
Laboratory studies of sediments taken from the estuary showed that maximum phosphorus release from sediments occurred at high pH, in the absence of oxygen, and in the presence of large amounts of organic matter and low amounts of phosphorus-retaining components. Although these conditions are not normal for the Peel-Harvey Estuary there is evidence that release of phosphorus available for algae growth does occur.

A review was made of techniques which prevent phosphorus release from sediments, including aeration, addition of nitrate or alum and raising the pH of estuary water, none of which appeared applicable to the Peel-Harvey system.

**Cereal grains and lupinseed.** The chemical composition of these products is required by stockfood formulators, overseas buyers and researchers in animal husbandry and nutrition.

A comprehensive survey was commenced of the composition of grains produced commercially and of other grains, not yet released to growers, which are the result of breeding programmes.

The composition of lupinseed from 26 rail sidings in Western Australia was shown to be relatively consistent for most of the 18 components analysed. There were signifi-



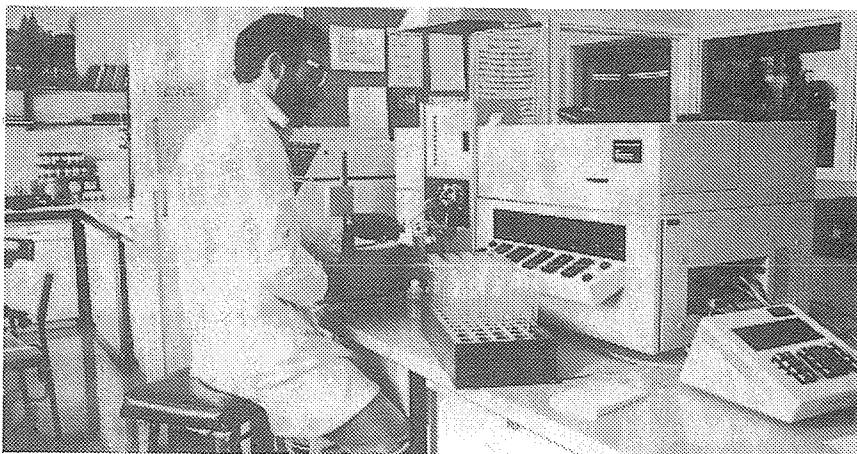
A sensitive method for analysis of the low levels of alkaloids in sweet lupin seed was developed.

cant differences in composition of breeding material due to variety and the region of production.

Alkaloid content of breeding material was made available to breeders in time for rejection of unsuitable lines.

**Analytical chemistry.** Development of analytical methods is necessary to keep abreast of changes and to maintain an efficient rate of work output.

Better use of staff time was achieved by expanding the use of the computer to record sample identification, to retrieve and calculate data



Measuring calcium, magnesium, copper, manganese and zinc in plants.

output from analytical instruments and to issue clients with a computer printout of results.

Improvements in methodology included the use of a kjeltec automatic nitrogen analyser instead of manual equipment, the use of high pressure liquid chromatography for amino acids analysis, chemistry of soils for earth dams, flow injection analysis for sulphur, effects of sample grinding on fibre analysis, fatty acids by capillary gas chromatography, potassium in soil extracts, molybdenum in wheat leaves.

### Engineering Chemistry Laboratory

Despite the continuing economic recession which restricted interest in most metal ores, projects covering a wide range of materials and processes were tackled during the year, and increased emphasis was given to innovative projects. A description of the more significant of these activities is given below.

**Gold.** The welcome upturn in gold mining activity led to an increase in sponsored testwork on gold ores. Facilities for testwork relating to carbon-in-pulp (CIP) technology were extended, and many technical enquiries were handled concerning details of conventional Merrill-Crowe, CIP and amalgamation processes.

**Fluidization.** Early in the year an officer spent 2 weeks working at the CSIRO Division of Mineral

ing polychlorinated bi-phenyls and a detailed evaluation and staff training programme in use of a clear perspex unit.

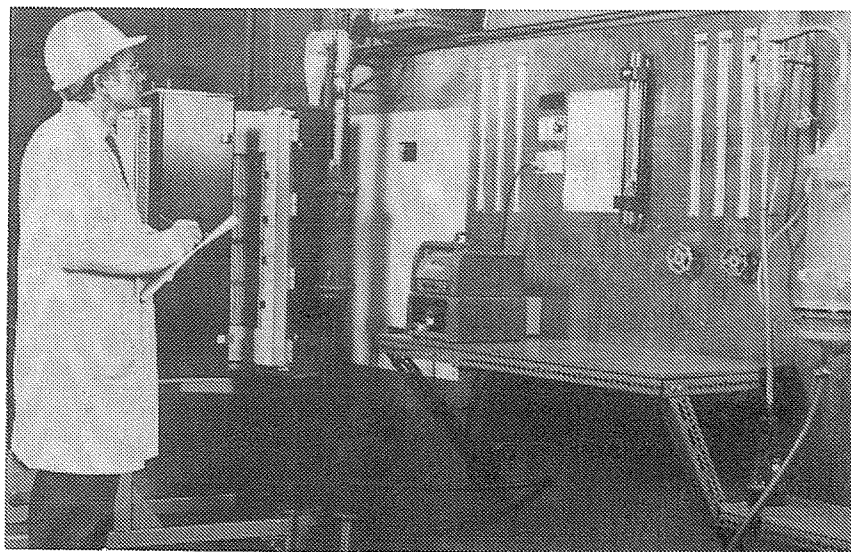
**Tungsten.** In addition to pilot scale flotation work on a scheelite ore, a new hydrometallurgical technique developed for extraction of tungsten from low-grade tailings led to a project on samples provided by the State Batteries, and to publication of a technical paper.

**Rare earths.** Western Australia is a major world producer of the rare earth minerals monazite and xenotime. A project to upgrade commercial concentrates by further removal of gangue minerals and to investigate the possibility of producing super-concentrates enriched in particular rare earths is continuing slowly. A significant problem in this regard is the difficulty of obtaining accurate (as opposed to repeatable) analyses of individual rare earths with presently available instrumentation, and significant help in this regard has been given by the Mineral Science Laboratory.

### Food and Industrial Hygiene Laboratory

There has been a sustained increase in the volume of industrial hygiene work undertaken by this Laboratory. This is probably due to the greater awareness of industrial health pro-

Engineering in Melbourne and the Division of Fossil Fuels in Sydney on aspects of fluidized bed technology. The expertise acquired was subsequently used in several projects including the attempted neutralization of acid vapours resulting from complete incineration of liquids contain-



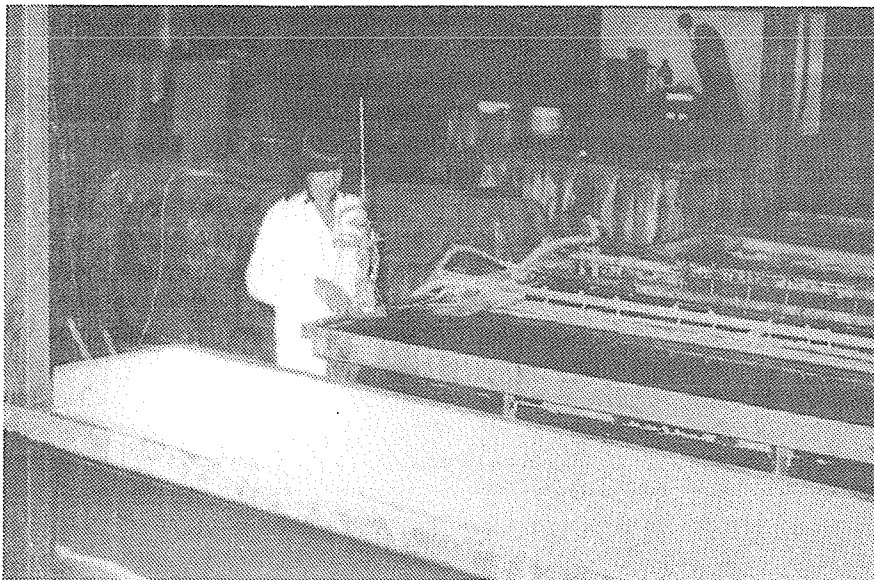
Fluidised bed apparatus.

blems by both employees and employers. In the pesticide area there is a similar increase in the samples handled which has resulted in the automated gas chromatographs working at near capacity.

**Foods.** Both the Department of Agriculture and the Public Health Department submitted samples of filled milk products for identification.

Filled milk is a product from which the butter fat in the milk is removed and replaced with a vegetable oil. Filled milk is prohibited under the Dairy Industry Regulations. Several of the samples submitted were found to be filled milk and the Department of Agriculture successfully prosecuted a supplier.

The National Health and Medical Research Council has recommended that apricot, nectarine and peach kernels for human consumption should contain less than 5mg/kg hydrogen cyanide. Samples of apricot kernels purchased by the Public Health Department from various health food shops contained up to 2 000 mg/kg of hydrogen cyanide.



Sampling mist from electroplating bath.

**Minesite inspections.** In conjunction with inspectors of the State Mining Engineers' Division inspections were made of 16 minesites this year. Recommendations made last year regarding high mercury contamination in a gold room have since been

implemented and the problem is now under control.

**Tractor cabs.** There has been concern that farmers using boom sprays to treat crops with various pesticides may be adversely affected by spray from the booms contaminating the air of the tractor cabs. Preliminary investigations have been made by sampling the air outside the cabs and inside cabs fitted with air filters. Results from these tests do not indicate that the farmers are exposed to significant quantities of pesticide sprays. The farmers are more likely to be at risk from exposure to pesticides by improper attention to personal hygiene while handling the concentrate and servicing spray equipment.

**Pesticides.** As a result of publicity given by the Department of Agriculture to the possible contamination of eggs from free-ranging-poultry in orchards on areas treated with organochlorine pesticides, 45 samples of eggs were received this year. The samples were from properties having a known

history of pesticide usage or where the owners did not know of the previous pesticide treatments and wished to establish whether excessive levels of pesticides were present in the eggs. Dieldrin and/or heptachlor were found in levels above the Max-

imum Residue Limit in 60 per cent of the samples submitted. These results emphasize that poultry must not be kept on any area where organochlorine pesticides have ever been used.

### Forensic Science Laboratory

The promise of additional staff in 1984 was welcomed by the staff who again in 1983 bore the brunt of increased demands by the police on both advisory and analytical services in connection with many aspects of criminal activity.

**Alcohol, drugs and driving.** In March legislation came into effect which permits blood and urine to be taken from suspected drug affected drivers. Since then 61 cases have been examined for the presence of drugs. Of these, drugs were detected in 45, the most commonly encountered being the benzodiazepines (Valium, Serapax etc), cannabis derivatives and the barbiturates.

In 17 cases the concentration of the drug found in the blood was sufficient to explain the condition of the driver. In other cases the drug was detectable only in the urine which does not lend itself to ready interpretation, or the drug was such that there is insufficient knowledge about its effects at the levels found. In such cases, however, the presence of the drug is corroborative evidence in the prosecution. Experience since March suggests the legislation has been justified.

Analysis of blood taken from fatal traffic accident victims in 1983 showed that 55 per cent of drivers of motor vehicles had blood alcohol levels in excess of 0.08 per cent including 44 per cent greater than 0.15 per cent.

**Toxicology and drugs.** The continuing trend to develop drugs of greater potency enabling smaller doses to be prescribed has forced toxicology laboratories to apply modern technological advances to detect and identify drugs which might be present in the body in trace amounts even though a fatal overdose of the drug had been administered. As a result

there have been major transformations in the approach to toxicological analyses in recent years.

A significant but disturbing trend in 1983 was the increase to 11 in the number of heroin associated deaths. Reasons for this trend probably lie not only in the increased usage of heroin but in the concentration of the heroin used. Analysis of heroin seizures this year generally revealed a marked increase in the concentration of active drug within the seizures. Heroin users, who may be accustomed to using the drug containing 10-15 per cent diacetyl morphine may unwittingly find themselves injecting the drug three or four times more concentrated.

**Doping control in sports.** Analysis of blood and urine samples in connection with doping control programmes by equine and greyhound racing authorities yielded 11 positive reports. Of special interest were the detections, in separate cases, of the use of the narcotic analgesic fentanyl and the illicit drug cocaine, each of which was encountered for the first time.

**Criminal investigations.** Paint flakes from hit-run accidents and flammable residues from suspected arson incidents were the largest contributors to a wide range of materials submitted for examination to assist the police in their criminal investigations and to provide expert scientific evidence for prosecution in the Courts.

Scientific assistance given to the police was extended during the year to include a wider training programme for detectives and officers from the Scientific Branch of the Western Australian Police.

### **Kalgoorlie Metallurgical Laboratory**

The Laboratory's first full year in its new building coincided with a strong resurgence in the gold mining industry. There was a marked increase in the number of sponsored investigations which were almost exclusively related to gold. Bullion assaying also



Remains of a telephone box examined for traces of explosive.

increased dramatically, rising to 20 per month by the year's end.

Metallurgical testwork for North Kalgurli Mines Ltd has continued and since August payment testwork has been undertaken on parcels of ore custom milled by Gold Resources Pty Ltd in their Paringa Plant. The standard free milling and refractory testwork methods developed from North Kalgurli Mines were successfully applied to the Gold Resources ores. This umpire role is likely to expand in the new year.

**Carbon-in-pulp.** With carbon-in-pulp firmly established for gold processing many of the sponsored investigations related to activated carbon. The

standard test for gold absorption on carbon became the reference point for several clients setting up carbon regeneration facilities.

A method for the determination of platinum involving classical fire assay followed by A.A.S. analysis was successfully applied to 150 samples for the Geological Survey Division.

### **Materials Science Laboratory**

Activities continued to span a wide range of interests including provision of technical information and advice for Government and industry, and maintenance of testing and evaluation facilities for industrial chemical products and processes.



Scene of wilful damage where scientific techniques were used to assist Police investigations.

**Building materials and paints.** Floor coverings and related materials continued to be a major area of activity and a total of 50 samples including carpets, vinyls, ceramic materials and adhesives were examined. Most of this work was undertaken for various Government Departments requiring quality assessment, testing for compliance with specifications and suitability for use in specific applications. Fourteen samples were submitted by the Bureau of Consumer Affairs arising from customer-supplier disputes and two were found to be substantiated.

Tender Board and random check samples of paint were tested for compliance with specifications. It was noticeable that disputes between Government Departments and private contractors over types of paint used or number of coats increased during the year probably reflecting difficult times in the building industry generally and the very keen competition for Government business which can lead to compromising of specifications by contractors.

Work on the marine anti-fouling paint testing raft at HMAS Stirling (Garden Island) continued.

Following on from a Department of Agriculture project to investigate chemical means of overcoming water repellent soils in Western Australia, a systematic investigation

of surfactant materials was carried out. Several blends of commercially available surfactants were developed which showed great promise in bench scale tests. Field trials by Department of Agriculture will be carried out in 1984.

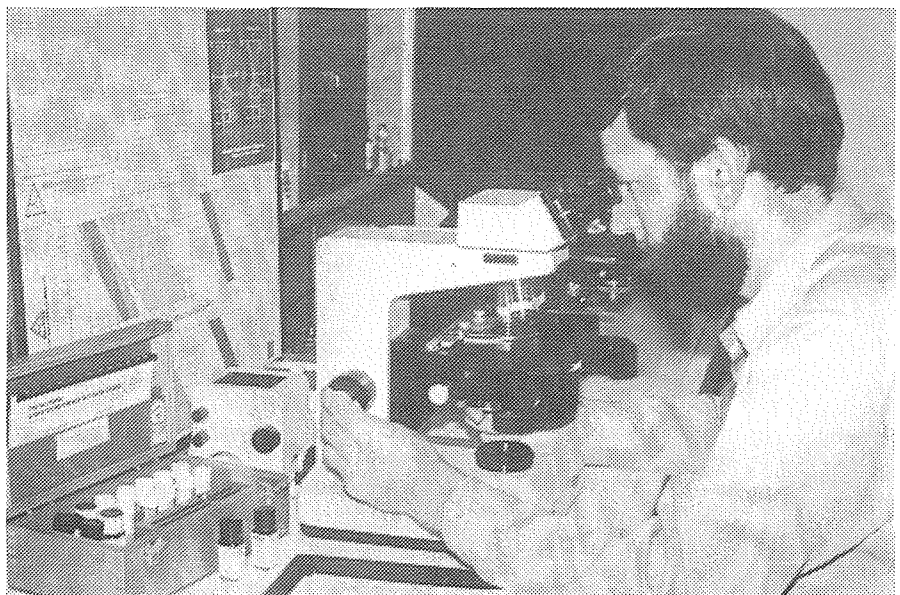
### Mineral Science Laboratory

Along with the normal involvement with work related to the mineral resources of the State, the past year has seen increased demand on the expertise of the Mineral Science Laboratory for its application in solving problems in the occupational

health, consumer protection and building and construction areas. This, together with the expansion of programmes by the Geological Survey of Western Australia, has resulted in an increase of over 40 per cent on sample submissions from the previous year.

**Health hazards.** The involvement of the Laboratory in providing assessments of materials and advice to other Government Departments and the public on the possible health hazards associated with asbestos is the subject of an earlier report. Not the least important of these investigations were those associated with children, such as the airborne fibre concentrations during roofing operations at the Applecross High School, and fibre concentration in soils at a proposed children's recreation camp at Point Samson.

The laboratory tested metallic and plastic jewellery designed for children's wear which had been reported as likely to contain toxic materials. The products are attractive in appearance, particularly to a child, and could readily be placed in the mouth. Chemical tests on the metallic jewellery found leachable lead present at a level approximately 80-100 times the upper limit recommended by the Standards Association of Australia for children's toys. The plastic jewellery tested was found to be free of toxic materials.



Analysis of dusts and fibres using optical microscope.

**Buildings.** The Bureau of Consumer Affairs and several other Government Departments have presented problems associated with building operations, in most cases to determine whether a fault can be attributed to workmanship or materials used.

Several occurrences of metal tarnishing and corrosion point to the necessity for internal brick walls to be neutralized and washed free of acid following brick cleaning operations.

A newly laid concrete driveway developed surface popping within a few weeks of being constructed, due to the reaction between the alkalis of the cement and certain components of the aggregate. This resulted in the formation of cones approximately 2cm in diameter and 4mm deep. From 1 to 2 cones had appeared per square metre of concrete. Some organizations submit samples of aggregate for chemical and petrological examination to check on the possibility of such adverse reaction.

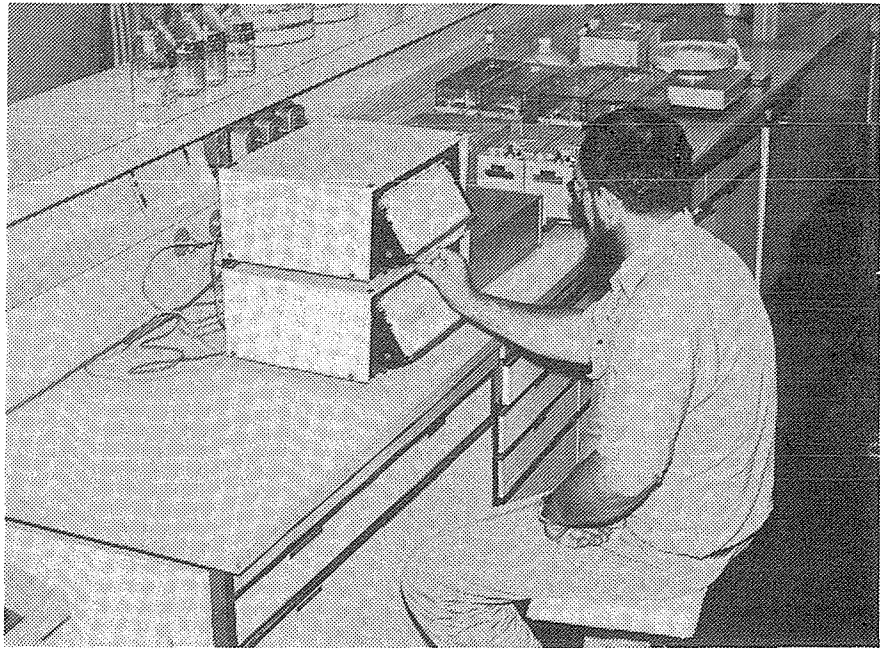
Other faults examined included failed cement renders and mortars.

**Environmental.** A mineralogical study of sands from areas previously used for an ilmenite treatment plant was made to assess the sands' environmental significance. The handling of a potential hazard due to radiation depended on the type of mineral, local concentrations and potential for commercial retreatment.

## Water Science Laboratory

Despite the 10 per cent increase in sample receivals during 1983 to about 13 000, following a 24 per cent increase during the previous year, the Water Science Laboratory had by the end of the year reduced its backlog of samples to less than 1 000. This improved output was achieved mainly through organizational improvements and computerized automated techniques.

**Water supply treatment.** Most of the investigations were related to treatment for iron and/or manganese removal and these investigations were



Automatic analyser unit.

at both laboratory and field scale. Treatment involving a combination of alkali addition, potassium permanganate addition, aeration and chlorination was ineffective only in the case of an organically complexed iron-bearing water at Gingin. Country town supplies for which successful treatment processes were recommended during 1983 included Australind, Busselton, Eneabba, Moora, Northampton and Ravenswood.

**Peel Inlet/Harvey Estuary.** Receivals of water and leachate samples in connection with research associated with land treatment and fertilizer application options in the Harvey River catchment area more than doubled during 1983 to almost 2 000 samples. The object of this research is to restrict phosphorus input to the Harvey River as a means of prevention of the current spate of 'nodularia' blooms (blue green algae or cyanobacteria). These blooms have regularly occurred during the past 4 years between the months of October and January and caused serious eutrophication of the Harvey Estuary. A research project undertaken during the year showed that a wall of crushed limestone across the Harvey River would not be a feasible method of removing phosphorus.

## Laporte effluent sand dune disposal.

The continued disposal of this effluent in an area, whose neutralizing capacity is becoming depleted in both the shallow and deep aquifers has required increases in sampling frequency and numbers of samples. The selection of sites for disposal by either lagoon or bore, and the type and quantity of effluent to be discharged into them, is the joint responsibility of various Government departments and private consultants. Close co-ordination is necessary during this transitional stage where options including acquisition of a larger disposal area, pipeline to sea disposal or industrial treatment are being debated. Staff members are still involved in steering committees for research programmes to further study the iron fixation mechanism in relation to land disposal techniques.

**Country sewage plants.** 1983 saw the completion of the first year of regular 3 monthly analysis of raw, treated and final effluent from all Public Works Department country sewage plants. The results generally showed that the inorganic nitrogen status of final effluents from plants in the north of the State was much lower than their counterparts in the south. This has been attributed to the lush growth of algae in the warmer northern treatment ponds.



## Organization

To comply with the standard procedure in the Public Service, and now within the Mines Department, of calling the first subdivision within a Department a Division, the names of our various laboratories were changed from Division to Laboratory in 1983.

At the same time, because of the changing emphasis of work within what was the Industrial Chemistry Division this laboratory was renamed the Materials Science Laboratory.

The Laboratories now consist of six laboratories on the Plain Street site, the Engineering Chemistry Laboratory at Bentley and the Kalgoorlie Metallurgical Laboratory at Kalgoorlie.

## Staff

With strong support from the Police Department, the Commissioner of Police and the Minister of Police, approval was obtained at the end of the year for three new staff for the Forensic Science Laboratory. Crime is very much a growth industry and the increased staff for forensic work in 1984 will be a welcome relief for the staff of this laboratory, who have been carrying a very great case load until now.

Early in the year Dr E.B.J. Smith, Chief of the former Industrial

Chemistry Division retired after 14 years in that position. Dr Smith, a former Rhodes Scholar with extensive experience in industry and with a wide knowledge particularly in paints and plastics, will be greatly missed. Mr D.J. Ingraham was appointed in June as the Chief of this renamed Materials Science Laboratory.

## Accommodation

Additional laboratory space is an urgent requirement and long term further development on the current site is not justified.

Two possible sites, one at South Perth near the Department of Agriculture and WAIT and the other in Graylands/Floreat Park near the CSIRO are both suitable and either would be satisfactory.

During the year the older parts of the Plain Street building have been repainted and refurnished. The Public Works Department day-labour staff have done a very good job and have been very helpful in causing a minimum of inconvenience.

## Equipment

The following major pieces of equipment were purchased during the year: a Tecator Kjeldahl nitrogen analyser; an autosampler for a Hewlett Packard 5880 gas chromatograph;

an Oliver air table; a plate-screen-plate electrostatic separator; a Beckman portable mercury meter; a Miran infrared gas analyser; a Hewlett Packard pyroprobe; a high pressure diamond cell; a Beckman organic carbon analyser.

## Other activities

**Publications and lectures.** The following publications and lectures were presented during 1983.

Priddis, C., 1984, Capillary Gas Chromatography of Lupin Alkaloids: *Jour. of Chromatography* 261. p.96-101.

Marshall, R.E., 1983, Hydrometallurgical Extraction of Tungsten from Low Grade Residue Dump: *Proc. Aus. I.M.M.* No.297, p.47-50.

Brennan, L.G., Field, R.V., George, T.J.F., and Marshall, R.E., *in press*, Chemical Beneficiation of Zircon Concentrates in Western Australia: *Int. J. Min. Proc.*

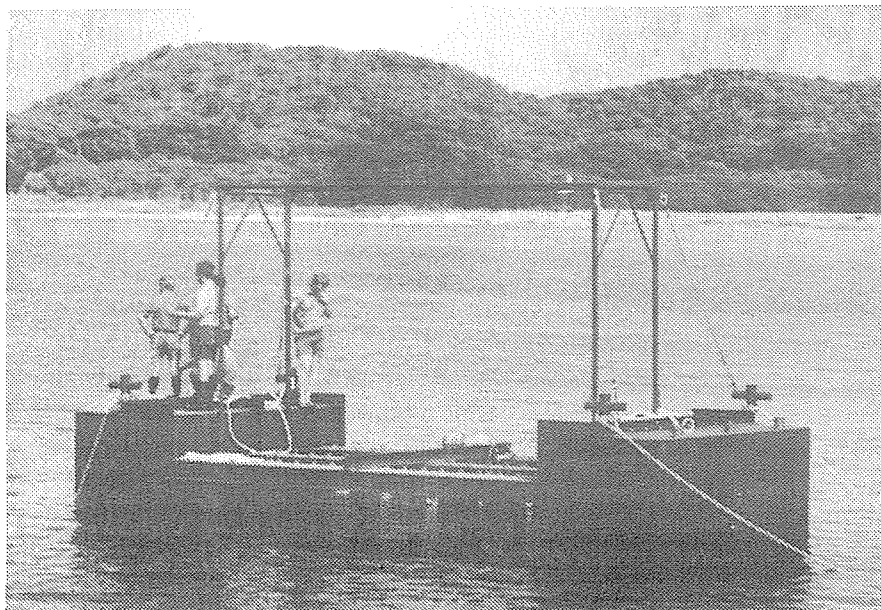
Dickson, J., Peet, R.L., Duffy, R.J., Hide, D.F., and Williams, D.E., 1983, Heptachlor Levels in Bone Marrow of Poisoned Cattle and Horses: *Australian Veterinary Journal* 60, P.311.

Challinor, J.M., 1983, Forensic Applications of Pyrolysis Capillary Gas Chromatography: *For. Sci. In.* 21, p.269-285.

"Chromatographic Methods for Establishment of Heroin Signatures as an Aid to Law Enforcement" Hansson, R. and Tranthim-Fryer, D., presented to 1st Asian Pacific Congress on Legal Medicine and Forensic Science, Singapore 1983.

"Analysis and Comparison of Glass Fragments" Lynch, B.F., Van Riessen, A. (WAIT), and Terry, K. (WAIT) presented to 1st Asian Pacific Congress on Legal Medicine and Forensic Science, Singapore 1983.

"Applications of X-ray induced X-ray Fluorescence in a Scanning Electron Microscope in Forensic Science" Lynch, B.F., Van Riessen, A. (WAIT), and Terry, K. (WAIT), presented to 8th Australian International Forensic Science Symposium Perth, 1983.



Antifouling paint testing at Garden Island.

“The Failure by Growth of White Precast Concrete Panels” Clarke, R.M., and Pitman, F. (PWD), presented to the Concrete Symposium of the Institution of Engineers Australia, Perth 1983.

“Nitrates in Western Australian Waters” Jack, P.N. and Davidson, A. (Geol. Survey) presented to Water Research Foundation Symposium, Murdoch University, 1983.

**Committees.** Representation on over 40 technical committees by various staff members has continued to be an important contribution of the Laboratories. The functions of these committees cover the fields of environment, health, computing, foods, water quality, waste disposal, analytical chemistry, pesticides, poisons, effluents, chemical safety, paints, detergents, oils, cleaning pro-

ducts, registration of laboratories and many other aspects. The advice given by staff at these committees is a very important function and one that is becoming more readily appreciated by all Departments.

**SOURCE AND ALLOCATION OF WORK 1983**

SOURCE	Laboratory								Total
	Agricultural Chemistry	Engineering Chemistry	Food and Industrial Hygiene	Forensic Science	Kalgoorlie Metallurgical	Materials Science	Mineral Science	Water Science	
DEPARTMENT OR AUTHORITY									
Agriculture Department	33 820	20	2 402			2	3	148	36 395
Alcohol & Drug Authority				11					11
Conservation & Environment Department	545		34			28	5	2 022	2 634
Consumer Affairs Bureau			13				18	6	37
Corrections Department				106					106
Education Department	38					1	9		48
Fisheries & Wildlife Department			3					17	20
Forests Department			14			1			15
Geological Survey of W.A.	80				286		1 908	536	2 810
Government Chemical Laboratories	100	178	21	76	28	11	238	14	666
Hospitals			37					2	39
Industrial Affairs Department			15			2	45		62
Leschenault Inlet Management Authority			8					71	79
Main Roads Department					1	2	74	26	103
Metropolitan Regional Planning Authority								47	47
Metropolitan Water Authority			243			1	20	1 700	1 964
Mines Department			291		12	1	770	8	1 082
National Parks Board								44	44
Office of North West							17		17
Peel Inlet Management Authority								119	119
Police Department			14	4 727	10		55	1	4 807
Public Health Department	11	2	3 277	29		27	1 284	198	4 828
Public Works Department	48	5	153			48	28	7 132	7 414
State Energy Commission			3	7		26	62		98
State Housing Commission			1			10	4	5	20
State Tender Board						26			26
Swan River Management Authority			6					443	449
W.A. Greyhound Racing Association				428					428
W.A. Trotting Association				762					762
W.A. Turf Club				1 584					1 584
Other Authorities (11)	1		9	8		19	10	1	48
PUBLIC									
Free					21		14		35
Pay	496	166	88	19	931	37	186	427	2 350
TOTAL	35 139	371	6 632	7 757	1 289	242	4 750	12 967	69 147

## WOODMAN POINT EXPLOSIVES RESERVE

When James Stirling brought the first settlers to the Swan River Colony 155 years ago, it was from Cockburn Sound and Garden Island that he founded the new Colony. From a temporary settlement on Garden Island numerous crossings were made to the mainland and the nearest landing place became known as Woodman Point.

Thomas Woodman was the Purser on HMS Success and his name was given to that point of land, separating Jervoise Bay from Owen Anchorage, which years later was to become the site of the Quarantine Station and the Woodman Point Explosives Reserve.

It is recorded that in the early years of the Colony a sailor was killed by an explosion of gunpowder at Woodman Point; this probably occurred in the course of landing supplies from ships anchored in Cockburn Sound. Only a very small quantity of explosives was used within the Colony prior to 1890 but soon after, mining created a demand and greatly increased usage of explosives in Western Australia.

Mining explosives were stored at first in the hulk of an old ship outside Fremantle Harbour and this was still in use for bulk storage when the Government Analyst and Chemist,

Mr E.A. Mann, became the first Inspector of Explosives in 1895. Magazines were then constructed on an area of land adjacent to the smelting works at Robb Jetty, in Owen Anchorage.

At the turn of the century mining in Western Australia had become a major industry and explosives were essential tools in underground workings. All supplies were imported by ship and had to pass through the Robb Jetty magazines before being conveyed by rail to the mines. Authorities in Fremantle, however, considered the Robb Jetty magazines too close for comfort and claimed they were a potential danger to the community.

There were frequent complaints about the Robb Jetty magazines and in 1902 efforts were made to select an alternative site. A meeting of interested parties, including the eight importers of explosives, was held to discuss the matter. The Minister for Mines, Mr H. Gregory, was present together with Mr E.A. Mann, Sir George Shenton and others. They discussed proposed sites at Bayswater, Chidlow, Guildford and at Case Point, said to be 13 miles (21km) south of Fremantle.

The Minister then drew attention to Woodman Point and all agreed it

would be suitable if the land could be obtained. At that time it was leased by the Fremantle Race Club who accepted £1 000 (\$2 000, a substantial sum in those times) as recompense for past improvements and surrender of the 99 year lease.

No great haste was shown to move the Robb Jetty magazines to the new area and in June 1903 the Surveyor-General, Mr Harry Johnston, instructed an officer called Mr Wigglesworth to "hurry the matter on". Within a month from that time the air was shattered by the explosion of a magazine at Robb Jetty. There was general alarm in South Fremantle and Beaconsfield; the blast was heard and felt for several miles towards Perth, and the event, which undoubtedly did much to hurry Mr Wigglesworth, is remembered by some Fremantle residents to this day.

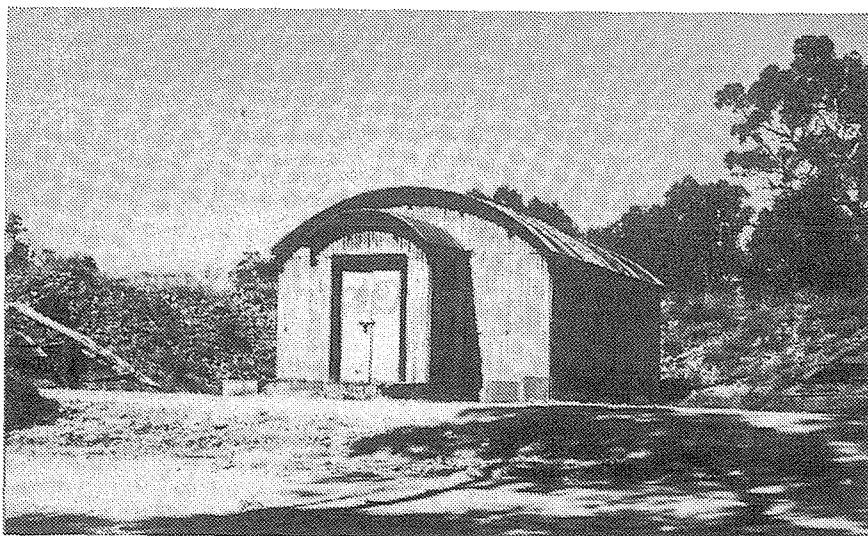
In August 1903, the new Reserve was surveyed by Surveyor Reilly of Rockingham and by September the fencing and staff quarters had been erected. By January 1904, the magazine buildings were moved from Robb Jetty and re-erected within the new Reserve where they still stand on the present site, having served the needs of the mining industry for over 80 years.

Woodman Point Explosives Reserve has certainly fulfilled its purpose to the mining industry of Western Australia and the land, an area of some 121 hectares with its clean shelving beach front, is now more valued for park and recreation purposes.

Accordingly, on 24 October 1983, Cabinet announced that the Reserve was to be re-located within 12 months to a new site at Baldvis which, coincidentally, is close to the Case Point area originally considered by the Minister for Mines in 1902 as an alternative to the Woodman Point location.

---

(Acknowledgement for historical research to G A Greaves, Chief Inspector of Explosives, 1968-1974)



One of the oldest magazines at the Woodman Point Explosives Reserve.

# EXPLOSIVES AND DANGEROUS GOODS

H. DOUGLAS, CHIEF INSPECTOR

September 1983 saw the gazettal of the Dangerous Goods (Road Transport) Regulations; the result of 5 years work on numerous drafts, reviews and amendments by such groups as the Western Australian Transport of Dangerous Goods Advisory Committee, more than 80 sections of private industry, the Ministers and Cabinets of three Governments and the active and continual participation of the Divisional staff.

Following gazettal of the Regulations, Explosives and Dangerous Goods Inspectors commenced actively advising industry on the requirements of the Regulations. The process was interrupted when the Regulations were disallowed by the Legislative Council but was resumed after a period of intense consultation. Minor amendments as authorized by the Interpretation Act 1918, resulted in the Regulations being passed into Law by resolution of both Houses of Parliament on 7 December, 1983 to become operative 1 January, 1984.

The Honourable Minister for Mines formally opened the 18th Australasian Conference of Chief Inspectors of Explosives in Perth on 10 October. Delegates from all Australian States, the Northern Territory, the Australian Capital Territory and New Zealand attended with the aim of resolving common problems facing authorities enforcing regulations pertaining to explosives and to achieve uniformity in the application of policies which affect industry in the fields of transport, use and manufacture of explosives.

For several months officers from the Explosives Division worked with Westrail staff to draw up a consolidated set of rules applicable to the conveyance of explosives by rail in Western Australia which reflected the latest developments in this field.

A significant change was made in the Division's policy on the conveyance of fuel by road train when approval was given to Clan Contracting to carry crude oil in road trains



C.S.B.P. personnel load a tanker with sulphuric acid.

on a regular basis from Home Energy's Erskine Range Terminal to a storage terminal in Broome.

At the request of interested parties in the industry, the Division reviewed the statutes applicable to persons performing cutting and welding work on tanks used to convey flammable liquids.

As a result of several accidents which caused injury to children who misused explosives they had found, the Minister declared a 3 months amnesty from prosecution for any person illegally in possession of explosives. The aims of the amnesty were two-fold:

- to enable people to hand over explosives for which they had no further use so they could be disposed of safely, and,
- to encourage people to think about any explosives they may have acquired and retained over the years and to arrange for the destruction of those explosives.

The amnesty concluded late in December and resulted in some 650 explosives items being collected by the Explosives Inspectors for destruction.

## Operations

### Legislation

In March the Explosives and Dangerous Goods (Classification of Dangerous Goods) Amendment Order 1983 was gazetted. This amendment was necessary to update the Schedule of Dangerous Goods.

**The Dangerous Goods (Road Transport) Regulations 1983.** These were gazetted in September and were subsequently disallowed by the Legislative Council. Following amendments to various sections, they



Cases of deteriorated explosives like this one are destroyed by burning.

were finally passed through both Houses of Parliament in December.

**The Flammable Liquids Regulations.** Amendments were made to adjust the licence fees and charges and to delete those sections which are now covered under the Dangerous Goods (Road Transport) Regulations 1983.

**Explosives Regulations.** These were amended to adjust prescribed licence fees and charges. The explosives Austin Delay Primer Delays, Austin Delay Primers, Detadrive Boosters, Detonating Cord Primers, Du Pont Special Detonating Cord, Power Plus Primers and Primacord were added to the list of authorized explosives.

#### Explosives reserves

**Woodman Point.** As indicated in the feature story, the long awaited transfer of the Woodman Point Explosives Reserve to Baldivis is coming to fruition; Cabinet has agreed to financing arrangements to allow construction of the new Reserve. A total of 2 668 explosives vehicles passed through the Reserve during the year.

**Kalgoorlie.** The explosives storage capacity of the Kalgoorlie Explosives Reserve increased by 60 tonnes with the installations of two new magazines. Periodic surveys were made of the area adjacent to the reserve where the dumped detonators were found in 1982 and further action was taken to hasten the destruction of these detonators.

#### Inspectoral activities

**Licensed premises.** The rationalization of fuel storage locations continued through 1983 and the number of premises licensed to store flammable liquids decreased from 4 754 to 4 594.

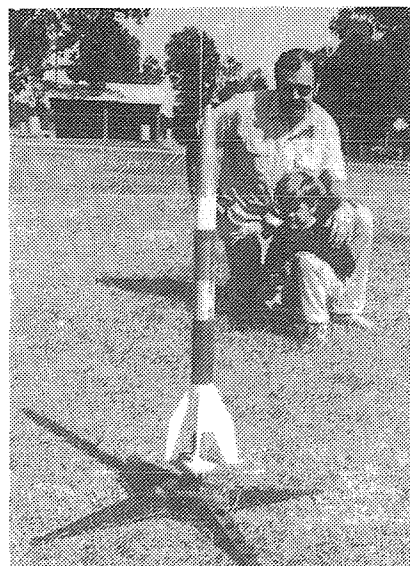
The number of magazine licences also decreased: Mount Newman Mining Company replaced a number of old magazines with a single magazine of 50 tonnes capacity and the downturn in oil exploration resulted in several companies not licensing or using their portable magazines.

Overall the number of licences and permits issued for the control of explosives throughout the State increased by 2.6 per cent over 1982.

**Shotfirer training.** The most significant training exercises conducted by the Division were:

- seven inservice and night school classes for aspiring shotfirers;
- familiarization exercises for the farming community in the Albany area to increase participants' awareness of the agricultural applications of explosives and safe handling procedures.

A total of 200 applicants sat the examination for a shotfirer's permit; 181 permits were issued and 19 candidates failed the exam.



Model Rocket enthusiasts are able to purchase rocket propellants after establishing their bona fides and obtaining a permit from the Division.

#### EXPLOSIVES LICENCES AND PERMITS

	1982	1983
Import	6	5
Manufacture	9	6
Blasting Agents	406	380
Storage Mode A	37	34
Storage Mode B	7	8
Magazine (1 000 kg)	45	45
Magazine (5 000 kg)	47	50
Magazine (no limit)	87	78
Sell	26	32
Convey	86	94
Portable magazines	108	95
Storage of detonators	1	1
Shotfirers permits	1 727	1 836
Fireworks displays	35	43
Entry permits	60	52
<b>TOTALS</b>	<b>2 687</b>	<b>2 759</b>

#### Explosives found, stolen, destroyed.

The Inspectors continued to provide a service to the public by collecting old or deteriorated explosives and arranging their destruction. A total of 100 kilograms of gelnite, 450 detonators, 880 distress flares, 2 kilograms of black powder, 50 oil-well cartridges and several kilograms of sundry fireworks were collected and destroyed by Inspectors at various locations in the State.

Several instances of theft were reported and instructions were given for the standard of storage to be upgraded.

**Analysis and testing.** Regular testing

of prilled ammonium nitrate (7 samples), safety fuse (8) and nitro glycerine based explosives (297) continued through the year, all samples tested were satisfactory and approved for use.

A total of 350 Asahi photo electric testers were examined and approved for use. The AECI LT-02 earth leakage tester and AECI BO-01 digital ohmmeter were also approved after testing.

After initial examination interim approval, for 12 months, was given for the use of:

- the Magnadet Type 2 Exploder;
- the Reo BM175-10ST Sequential Blasting Machine; and

— The PACCS Exploder; pending satisfactory reports from operators using these items in the field.

A mains firing box submitted by a country shire council did not comply with the requirements of Australian Standard 2187 and was not approved for use in Western Australia.

Field tests were conducted on 11 different explosives to assess their suitability for authorization, use in Western Australia or to monitor their performance over an extended period. Most samples were also submitted to the Government Chemical Laboratories for analysis. No explosive tested behaved in an unsatisfactory manner and none was rejected for use in Western Australia.

**Explosives import and export.** The movement of explosives by ship to S.E. Asia and Yampi Sound using suitably modified freight containers progressed to become a regular feature during the year. Approximately 200 tonnes of high explosives and 100 000 detonators were exported through West Australian ports in this manner. All aspects of each shipment were closely supervised by the Division and all ports co-operated well allowing exports to proceed safely and efficiently.

Entry permits for the import of unauthorized explosives were issued on 49 occasions throughout the year, mainly for specialist charges for use

in oil exploration and production. Incorrect and misleading labelling on many packages from overseas is creating a hazardous situation for people who must handle these items in transit, so all consignments received in Western Australia were inspected on arrival and required to be appropriately labelled before they were released. Action is being taken through the Australasian Conference of Chief Inspectors of Explosives and the Department of Aviation to rectify this situation.

**Dangerous Goods (Road Transport) Regulations.** Prior to the gazettal of the Regulations approximately 1 000 vehicles had been assessed for their suitability as flammable liquid carriers. In the 3 months following gazettal, these vehicles were again inspected and most transport companies and dangerous goods carriers were advised of licensing requirements. Whilst ensuring that vehicle standards were maintained inspections were made on the bulk containers and, where these were satisfactory, approval plates were issued.

**Road train operations.** Permits to convey flammable liquids by road train were given to 13 operators during the year. Until recently this Division insisted that all fuel conveyed by road train, other than that on the tractor or a semi-trailer, be of flash-point greater than 60°C (i.e. diesel fuel). However the accident record

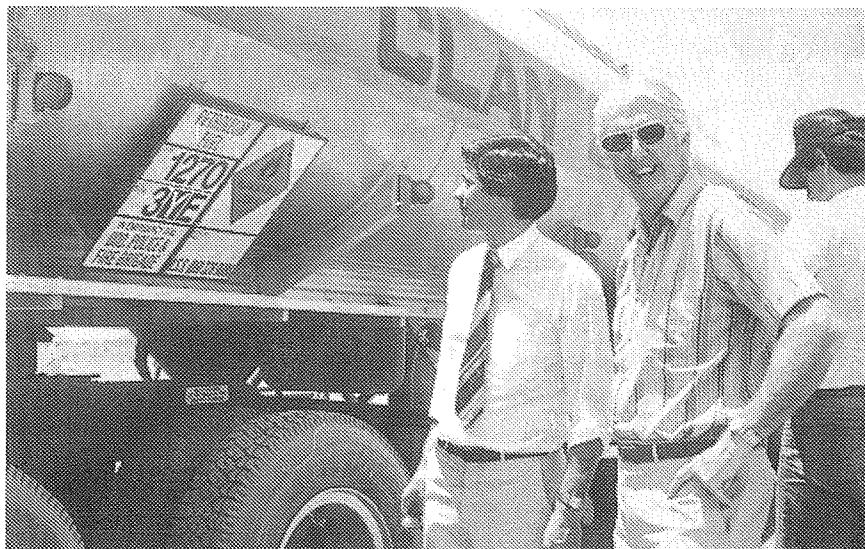
for road train operations is very good and specific approval, on a trial basis, has been given to a company to convey crude oil with a flash point of 3°C over a section of the Great Northern Highway. All aspects of this operation have been inspected and continue to be monitored. The information gained will be used to assess future applications for the use of road trains for low flash point products.

**Rail conveyance of explosives.** The increased movement of explosives into Australia in freight containers gave impetus to the use of such containers for interstate movement of explosives. Explosives Inspectors worked with officers from Westrail and their counterparts in the Eastern States through the Chief Inspectors Conference to develop working guidelines for the conveyance of explosives by rail in freight containers and there was a significant increase in the quantity of explosives moved by this method in 1983.

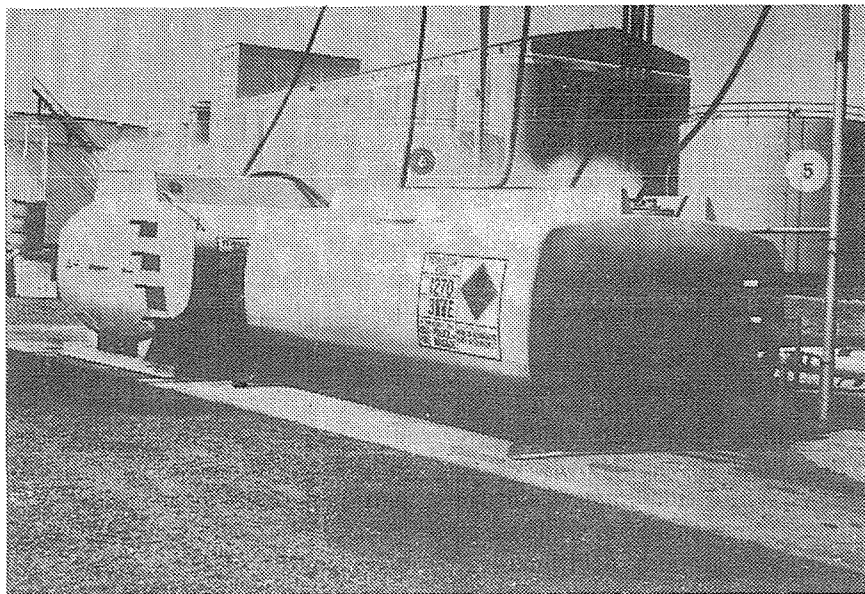
The principal advantage of this procedure is a reduction in the number of times the explosives must be handled and a concomitant increase in security. As a typical example, a container may be packed and locked in Victoria and delivered to a mine in Collie in the same condition. Transfers of individual packages at rail junctions in South Australia and onto road vehicles at Kewdale or Robb Jetty are no longer necessary.

**Hot work.** Welding and cutting operations may only be safely performed on tanks and tanker vehicles after the explosion risk has been reduced by extensive degassing. Typically two to three accidents per year are reported in which a container (drum or tank) has exploded while being cut or welded.

In an attempt to reduce the number of accidents, the Division has issued guidelines in accordance with Australian Standard 2017 for tank repairers and is maintaining a register of operators to facilitate regular inspections during 1984. The Explosives Inspectors will maintain a closer involvement with tank degassing and repair procedures.



The Hon. Minister for Mines and the Director General of Mines with a roadtrain operated by Clan Contracting for conveying crude oil from the Blina oil field.



Flammable liquid tanks being degassed with steam prior to any hot work being carried out.

**Flameproofed machinery.** Industrial fork lift trucks at 21 bulk fuel and paint depots were inspected during the year to ensure compliance with the Australian Standard and that the vehicles could safely work in hazardous locations.

Officers from the Division also worked closely with several local companies who were developing the expertise to modify forklift vehicles to operate in hazardous locations. Before the Division involved itself in this area, almost all vehicles were modified in Sydney or imported from overseas.

#### Accidents and incidents

**Explosives.** A spate of separate accidents and near misses in which school children sustained finger and eye injuries while playing with detonators resulted in the Hon. Minister declaring an amnesty to encourage people to search their possessions and hand in any explosives they might find. Following the publicity of the accidents and the amnesty, no further incidents of this type were reported.

A young man lost a hand and sustained injuries to his face and ear when a stick of gelignite exploded prematurely as he prepared to throw it into some water.

A man in a caravan was killed when a quantity of explosive

detonated in Kalgoorlie. As the man had legal access to explosives and there were no suspicious circumstances, the case was considered to be a suicide.

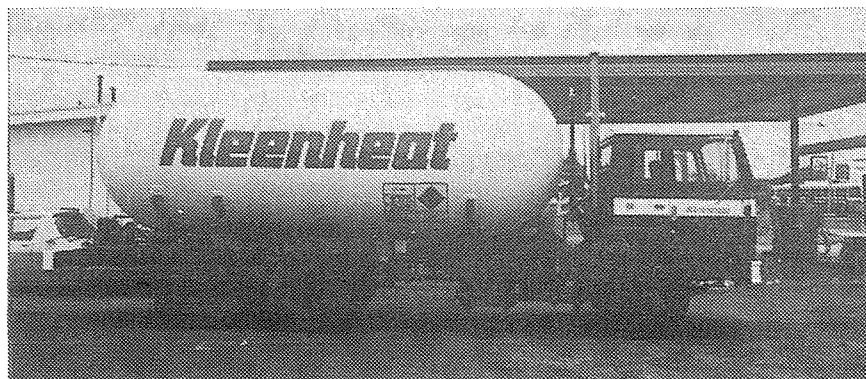
The mother of a young baby found her child chewing on a piece of plasticized explosive the child's father had kept at the conclusion of a construction job in which he was involved. The baby seemed to suffer no ill effects and was released from hospital after a medical examination. The remaining explosive was safely disposed of by a qualified shotfirer.

**Dangerous goods.** Thirteen accidents involving flammable liquids were reported to the Division in 1983 and, as in previous years, these included a significant number in which people ignored or were unaware of very basic safety precautions. Typical examples of this were:

- two fires occurred in separate incidents when petrol was being used for washing purposes. In one instance a man was seriously burned;
- a man was hospitalized with burns after he tried to start a fire with petrol;
- a man sustained burns and a tanker vehicle was destroyed following a fire which occurred during the filling of an underground tank. In this case the tanker operator was not using close coupled fittings to the underground tank and this allowed a large quantity of fuel vapour to generate at ground level, with disastrous results;
- static electricity is believed to have been the source of ignition of a fire which occurred when a man poured petrol from a plastic container into a metal drum. No plastic container has been approved to hold petrol in Western Australia;
- dispensing equipment was damaged by fire at a service station when the driver of a vehicle lit a cigarette while the vehicle was being refuelled.

All other incidents reported were either beyond the ambit of the Flammable Liquids Regulations or the presence of flammable liquids was incidental to the accident. (For example, a tanker vehicle inadvertently ran off the edge of a road and overturned when its wheels sank into the sandy verge).

The Division became more actively involved in investigating ac-

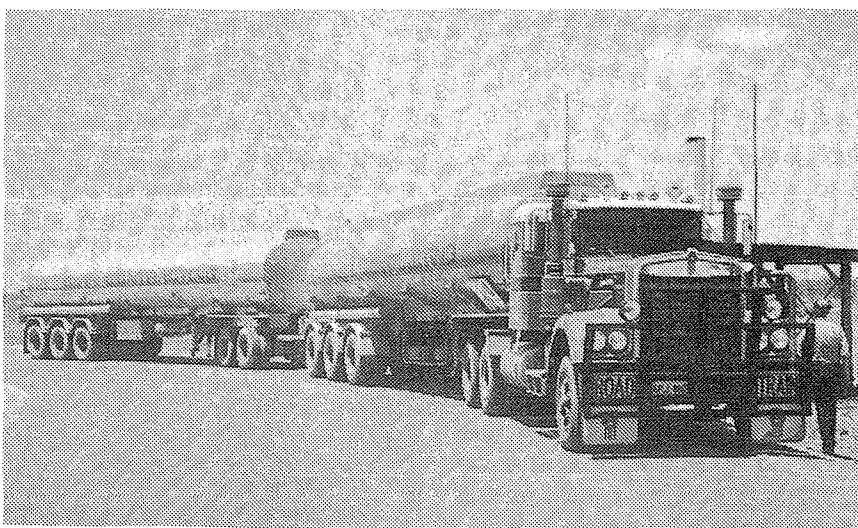


An LPG tanker arrives at a service station to deliver product.

idents involving chemicals in transit as a result of the gazettal of the Dangerous Goods (Road Transport) Regulations. Typical of these accidents were:

- two people in a four-wheel drive vehicle were killed when they turned in front of a sulphuric acid tanker on a country road. The nature of the load on the tanker vehicle was of sufficient interest to generate significant publicity although it was not pertinent to the accident. No product was lost when the tanker overturned and no blame was attached to the driver of the tanker;
- a man was killed when a panel van exploded soon after he entered it to drive to work. The man was a refrigeration mechanic and the van contained cylinders of LP gas, acetylene and oxygen. It is believed that one or more of the gas cylinders leaked, filling the van with a mixture of flammable gases which were ignited by the electrical system of the vehicle;
- 28 tonnes of prilled ammonium nitrate were spilled on and near the Northwest Coastal Highway when the rear trailer of a road train overturned. The trailer was badly damaged but no injuries resulted from the accident;
- a man was hospitalized for several days after a small quantity of cyanide was spilled when an Intermediate Bulk Container fell from a forklift vehicle while being loaded onto a semi-trailer. The I.B.C. was being handled contrary to the conditions prescribed in the Dangerous Goods (Road Transport) Regulations which had no legal standing at the time of the accident.

**Prosecutions.** Two companies and two private individuals were successfully prosecuted for a total of six breaches of the Flammable Liquids Regulations. These offences included storage without licence and irregular transport and delivery procedures. The police were successful in



Roadtrain operated by Clan Contracting transports crude oil from the Blina Oil well in the West Kimberley area of Western Australia.

the prosecution of a person found to be unlawfully in possession of, and storing explosives contrary to the requirements of the Explosives Regulations 1963.

## Organization

**Staff.** At 31 December the staff of the Explosives and Dangerous Goods Division remained at 28: 12 inspectorial, 8 clerical and 8 Reserve security personnel.

Mr G. Spencer was appointed to the position of Officer in Charge of the Woodman Point Explosives Reserve following the resignation of Mr T. Deacon.

**Training.** The Deputy Chief Inspector attended a two week Introductory Atomic Energy Course at Lucas Heights in Sydney. The course provided valuable information in matters associated with the safety requirements for the transport of radioactive materials.

Intra-divisional training sessions were held on tanker vehicle inspections, interpretation of the new Dangerous Goods (Road Transport) Regulations and containerization of explosives.

**Lectures.** Inspectors continued to fulfil requests to deliver lectures to interested parties on various aspects of the Dangerous Goods (Road Transport) Regulations.

**Other activities.** The Chief Inspector was actively involved on several interstate committees which affect the operations of this Division. These included the Standards Association of Australia Committees ME/15 (LP Gas), ME/17 (Storage of Flammable Liquids) and AU/17 (Tanker Vehicles for Dangerous Goods); the ATAC Advisory Committee on the Transport of Dangerous Goods by Road and Rail and, the Australian Association of Port and Marine Authorities.

Other committees, which met in Western Australia and in which the Chief Inspector participated, were the West Australian Transport of Dangerous Goods Advisory Committee; the Environmentally Hazardous Chemicals Committee and its Emergency Procedures Subcommittee which is drafting the West Australian Transport Emergency Assistance Scheme and the Interdepartmental Fire Protection and Public Safety Review Committee.



## BREAKING TRADITIONAL LINKS

Up until November 1970 the records for mining tenements were maintained in calf-bound, interleaved registers. Particulars of the tenement application, and its subsequent determination together with dealings affecting the tenement were maintained in hand-written form. Many of the lease registers are testimony to the painstaking pride that Mining Registrars took in the dying art of copperplate script.

During the 1969/1970 period an unprecedented level of exploration activity took place, commonly referred to as the 'nickel boom'. The 68 000 mining tenement applications received during this period had a devastating affect on the administrative procedures and staff resources of the Mines Department, in particular the Registration Division.

It became clear that the method of recording mining tenements had to be streamlined, and in 1970 W.D. Scott and Co., Management Consultants, were commissioned to implement a new tenement register system.

The consultants' report highlighted the facts that the majority of mining tenements being applied for were mineral claims, and the details on the original application form were the same as those required for the tenement register. It was therefore logical to adopt the application form as part of the register, with standard proforma pages to record the subsequent financial and conveyance transactions together with other dealings and encumbrances affecting the title.

Although this system alleviated the labour intensive task of register compilation, a considerable number of hand-written registers still had to be prepared and maintained for the various other leases and miscellaneous purpose tenements.

In October 1980 a review of the Mines Department's functions was carried out by Access Computer Con-

sultants to assess the potential for computer based developments and to identify the areas which would benefit from automation. The consultants' report provided the catalyst for development of a Mining Tenement Information System (MTIS).

In January 1981, a detailed feasibility study was conducted to assess the viability of implementing such a system. This study identified a need for a tenement information system which could ultimately incorporate the legal, graphical and geological elements of a tenement. The system also needed to interface with the Land Information System (LIS) being developed by the Department of Lands and Surveys which shows other types of land use.

A pilot system was developed to enable further evaluation of the proposed tenement information system. Basic information was extracted from a sample of 500 tenements of various types from the Cue and Day Dawn Mineral Fields.

Two staff provided by the Registration Division collected tenement information for the pilot system and advised on the types of statistical reports, control functions and enquiries which might be required of the system.

The pilot project demonstrated how the MTIS could greatly reduce the diversion of staff from their primary function of providing expedient grant of title for exploration.

In August 1983, an EDP Seminar was conducted by the Department for the mining industry. The Department's future computerization strategy was described.

The Registration Division presentation canvassed the proposed MTIS Tenement Register sub-system and its relationship to the legal register. Initially information would be limited to mining tenements under the Mining Act 1978, together with the repealed Act leases deemed to continue in force. This would provide a framework for a tenement information system to eventually replace the manual registers presently maintained by the Division.

In the near future the hand-written registers which are a traditional link with the past, will be replaced by the electronic medium of computer technology. Regional Mining Registrar's Offices will have direct communication lines for tenement register maintenance and industry will have much greater access to information.

The image shows a page from an early hand-written register, numbered 55. It contains a tenement application form with handwritten entries. The form includes fields for 'Tenement No.', 'Area', and 'Applied for'. The handwritten text reads: 'Mt. Egerton from a single side of 1/2 of 1/2 corner of 1/2 of 1/2 section 22 base to 22' and '18 acres'. Below the form is a list of names and amounts:

Name	Amount
Kelly Thomas	300
Neale Percy	300
Gonnaughton Judith	200
Ryash Thomas	200
De. Bernales Claude	200

A red stamp is visible over the list, reading 'FORGOTTEN FOR THE...'. The page is framed by a decorative border.

An early hand-written register.

The pressures experienced by the Registration Division in 1982 increased in 1983 as the tempo of new tenement peggings and the conversion of expiring 1904 Act tenements to substitute 1978 Act titles accelerated rapidly.

Procedures developed for the new Act needed modification in many cases as a result of working experience, and at the same time procedures required under the 1904 Act had to be maintained for those tenements not yet transitioned.

The introduction of the 1978 Act, and the amendments to the prospecting licence provisions in late 1982, have had major effects on the role of the Division. These effects include:

- a shift from a centralized Head Office application system to a local processing by Mining Registrars. Of the total applications received in 1983 over 80 per cent were prospecting licences which are determined by the local Warden; and

- a new role examining Reports on Operations filed for all mining tenements.

To meet the increased pressures on the Division, short term measures were taken. Staff were temporarily reallocated from other duties, there were interim structure modifications and overtime was allocated on selective tasks and in critical areas including Outstations.

A decision was taken to engage management consultants to undertake in early 1984, a review of the Department's Registry function and the current systems and procedures for processing mining tenement applications.

The year ahead looms as one of further change for the Division, with amendments to the Mining Act contemplated as a result of the 1983 Mining Act Inquiry. In addition the introduction of a computerized Mining Tenement Information System will have an impact on the day to day registration procedures.

## Branch reports

### Applications Branch

Trends established in the preceeding year for applications in substitution of 1904 Act tenements due to expire at the end of 1983, and applications for new ground in the traditional gold districts continued to increase. Mining Registrars at Kalgoorlie and Leonora received the bulk of the applications for Prospecting Licences.

A total of 13 434 tenements were applied for in 1983 for a total area of 23 437 922 hectares, and the accompanying diagram reflects the quarter by quarter activity during the past 2 years.

Tenement determinations for the year comprised 8 702 old Act applications and 7 504 applications for 1978 Act tenements as shown in the diagram overleaf.

Of all the applications received in 1982 which was the first year of operation of the Mining Act 1978, 98 per cent have now been finalized and special circumstances apply to those still outstanding.

The following further information on mining tenements appears in the Statistical Digest:

- a table showing applications made in 1982 and 1983 by tenement type and mineral field; and

- a graph showing the number and area of mining tenements applied for and inforce during the last decade.

### Dealings Branch

A total of 27 776 dealings were received in 1983, comprising the types shown in the diagram overleaf.

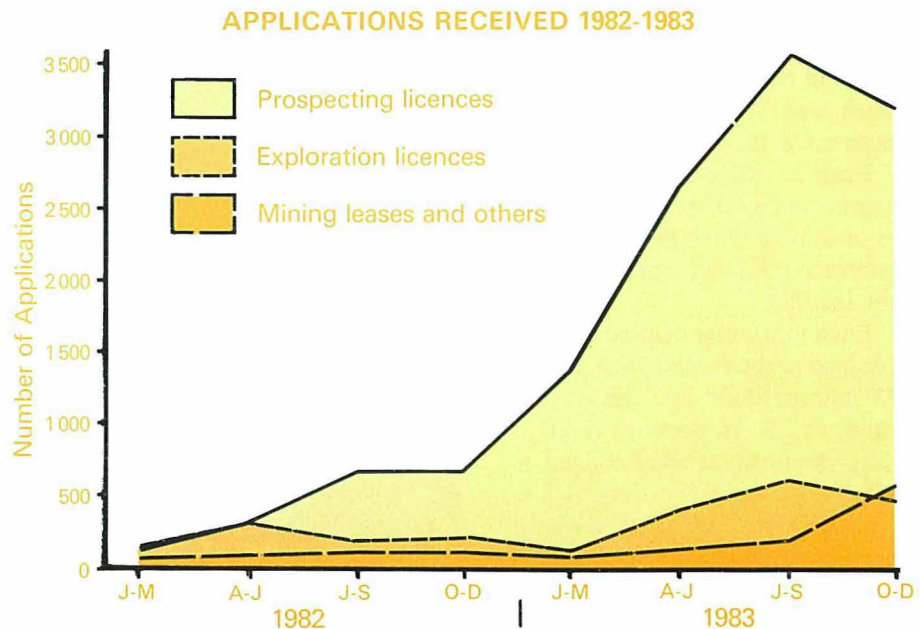
Regarding the 1983 receipts:

- approximately half were lodged at the Perth Office, and the remainder lodged at the Division's 14 Outstation offices;

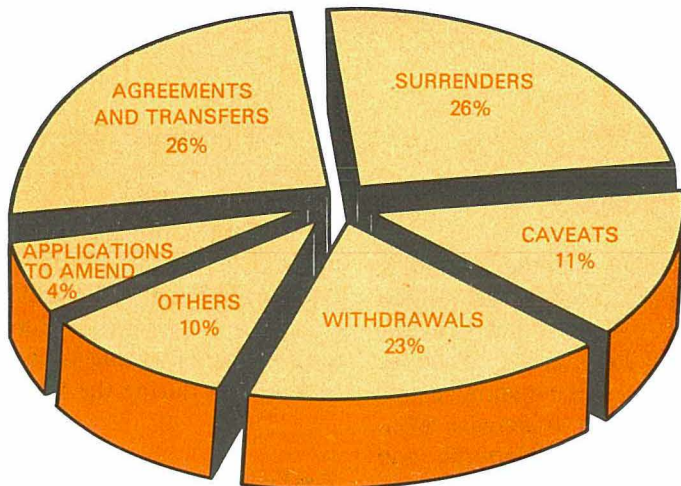
- the 6924 agreements and transfers lodged for Ministerial consent and registration represented a significant increase on the 4 710 such dealings received in 1982; and

- this is the third consecutive year in which the annual dealings intake has exceeded 25 000.

Throughout the year the Branch



### DEALINGS RECEIVED IN 1983



Notices of intended forfeiture were issued for 1 289 mining leases due to the lessees' failure to lodge reports, and this resulted in 145 leases being forfeited.

Applications for exemption from labour or expenditure commitments were received as follows:

1904 Act	—	6695
1978 Act	—	3272

continued to receive and process applications to transition existing homestead leases and other non-mining titles of the 1904 Act to appropriate Land Act titles.

Senior officers of the Branch assisted the executive of the Division in dealings concerning a number of State Agreement Acts, including the issue of Special Act Mining Lease 258SA for bauxite exploration to the Worsley Joint Venturers.

#### General Branch

The continuing transition of old 1904 Act titles to 1978 Act tenements throughout the year was reflected in the 658 tenement applications received at Perth in 1983, compared with 288 for 1982.

In most instances this conversion process involved a refund of unused survey fees or pre-paid rental and the Branch was kept busy processing vouchers for these refunds.

Branch officers provided approximately 18 000 photocopy searches of mining tenement registers in response to the 2 183 search requests made in 1983.

Each year more dealings are being lodged at the Perth office, and in 1983 almost half of the record number of 27 776 dealings received by the Department were lodged at Perth.

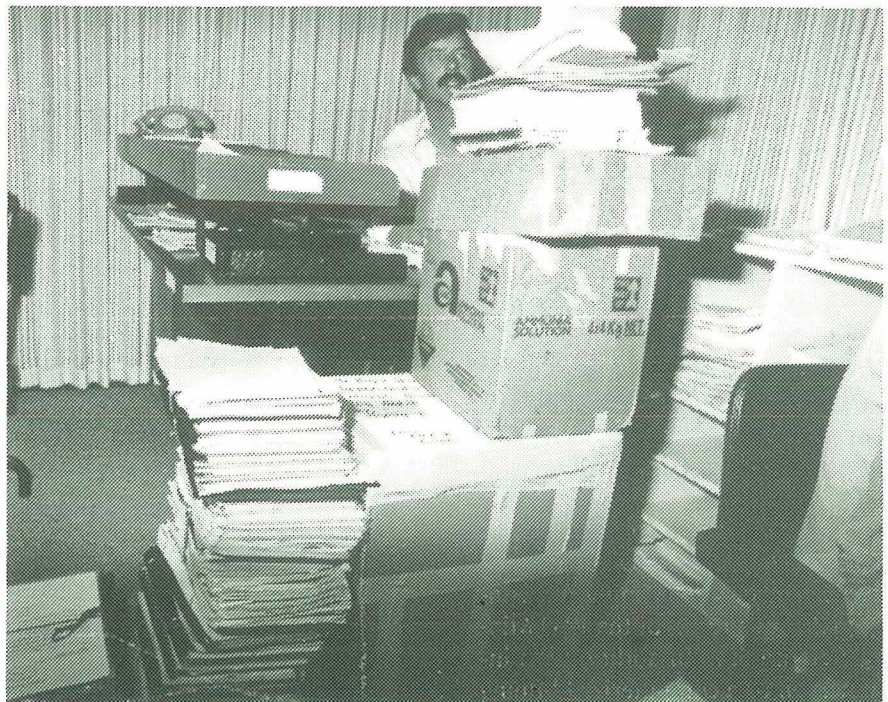
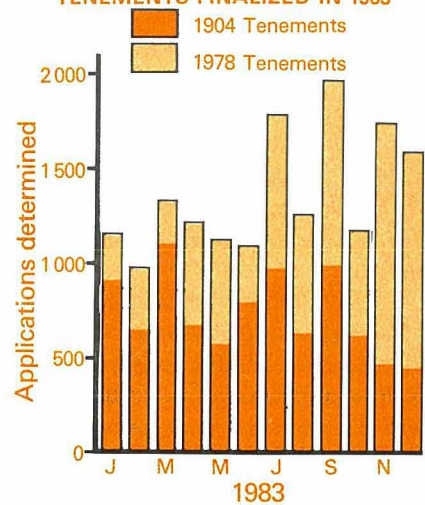
Collections by the General Branch of royalties and other general revenue exceeded \$103 million for the year.

#### Operations Branch

An informal Operations Branch was created in March 1983 to carry out the Division's role in the exemption and reporting provisions of the Mining Act.

Over 6 000 reports were filed during this first year of reporting under the new Act and many of these were defective in some way. Processing these reports was most onerous and inadequate staff resources led to significant delays.

### TENEMENTS FINALIZED IN 1983



The 'inward tray' in the Operations Branch.

**Petroleum branch**

Despite the decline in the total area held under exploration permits during 1983 due to surrender, cancellation, expiry and relinquishment upon renewal, a high level of activity was maintained in the Petroleum Branch. The overall number of dealings received for processing actually exceeded the number received in 1982.

During 1983 legislation was proclaimed embodying the new offshore arrangement between the States and the Commonwealth and although the system is presently running smoothly, the full effect is not likely to be realized until the first of the renewals for the existing permits are dealt with later in 1984. Close liaison is being

maintained with the Commonwealth Department of Resources and Energy on a day to day basis on matters concerning the Joint Authority. Members of the Petroleum Branch have established an agreeable and co-operative working relationship with their Commonwealth counterparts. It is anticipated that further improvements to the Petroleum legislation will be introduced late in 1984.

The high level of work being maintained over recent years and the urgency with which petroleum matters need to be dealt, has placed an increasing strain on the Petroleum Branch and it is struggling to cope with its workload in an efficient manner. It is hoped that a review of the Branch will be undertaken early in

1984 to devise a means of alleviating the situation.

**Organization**

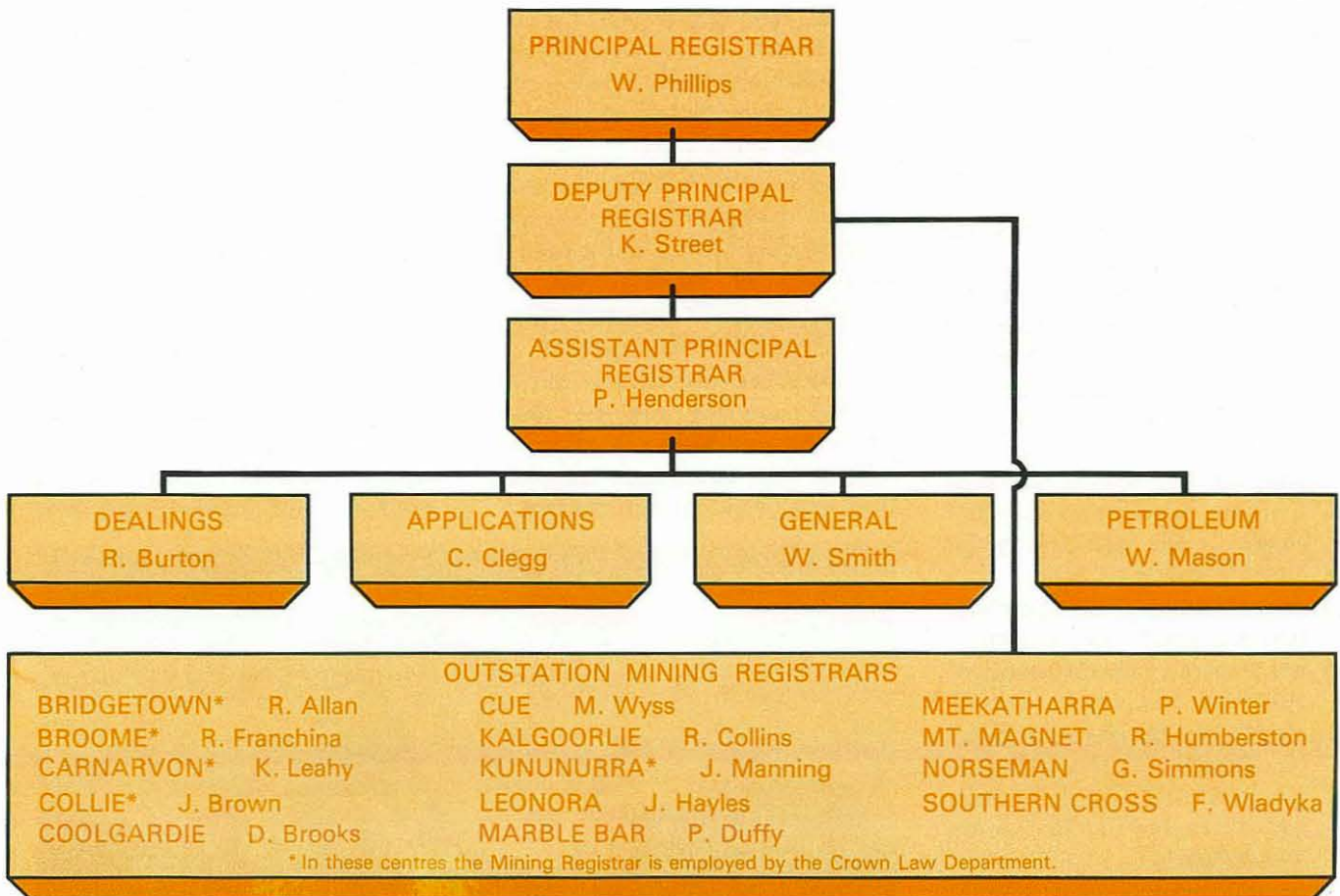
**Staff**

Establishment staff numbers for the Division remained at 55 for Head Office and 39 for Outstations. However additional part-time temporary staff were engaged during the year in the Kalgoorlie and Leonora offices.

Crown Law Department staff in Broome, Kununurra, Carnarvon, Bridgetown and Collie continued to carry out duties on the Division's behalf.

A diagram showing the senior staff placements in the Division is shown below.

**REGISTRATION**



# MINERAL ROYALTIES

Mineral resources are non-renewable and often scarce and it can be argued that the depletion of these resources should carry a cost.

Mineral royalties are a price or cost paid by the miner to the owner to obtain the proprietary right to mine those minerals.

Except in rare cases where mineral rights belong to the land owner by grants in title, minerals in this state generally belong to the Crown, and most mineral royalties are, therefore, paid to the State Government.

The nature of mineral royalties has been clouded in recent times. Some sections of the community would appear to regard it as a Government revenue source akin to taxation, which can be arbitrarily increased; whilst some sections of industry seem to regard it as a peripheral cost which can be set aside in difficult times: both of these approaches disregard the historical origins and basic philosophy of mineral royalties that they are a payment for the minerals.

The Department of Mines has been involved in a number of studies on the subject of mineral royalties. From these studies, four main factors emerge as desirable features in respect of any royalty system. It should:

- (1) have an impact which is equitable on all mining companies and at the same time keep a proper balance between a fair royalty to the State and the industry's ability to pay;
- (2) have minimum effect on exploration and production decisions;
- (3) not involve undue difficulties of collection, and compliance costs should be kept as low as possible. Therefore, it should be simple, easily understood and easily administered by the Government and industry;
- (4) be designed to provide revenue certainty.

No royalty system performs better than all others in all of the above

respects and a compromise between objectives is required when selecting a system.

A royalty based on tonnage mined takes no account of ore grade and other cost factors differing from mine to mine. This is likely to reduce incentive to mine lower grade ore and, if set too high a value, will discourage mining investment and exploration. Its main advantage is its ease of administration. Such a royalty is appropriate for producer-user minerals such as low value construction materials and is usually reserved for this purpose.

An ad valorem basis royalty is based on the value of the product. It is preferable to the tonnage royalty because it takes into account price fluctuations for the mineral, and the grade or relative value of the ore. It does not take into account the cost of production, which may differ between mines, and it may reduce the incentive to mine higher cost ore and discourage exploration.

Ad valorem royalties are more difficult to administer than the tonnage royalty because of the need to identify fair prices, but are significantly easier than systems involving a profit-related concept.

Royalties collected on a profit-related concept can be more equitable, and have less effect on mining and exploration decisions than unit or ad valorem systems.

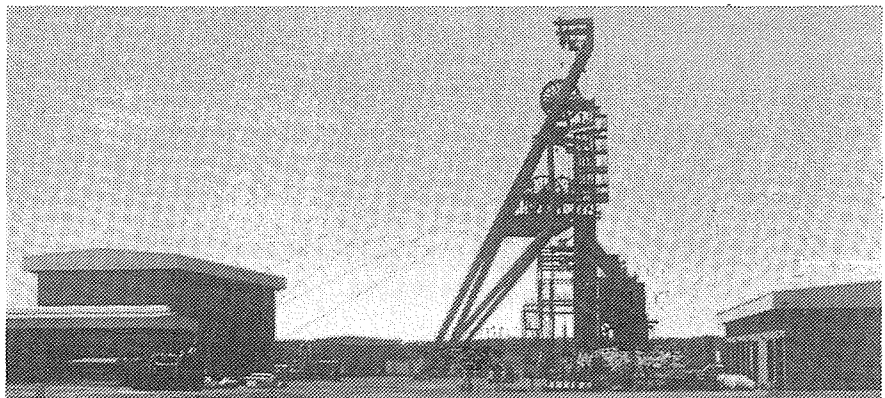
Major disadvantages of any profit-related royalty system are the uncertainty of royalty revenue yield and the problems of administration.

Profit-based royalties may be wrongly regarded by some as a form of taxation. Also they rely on an acceptable definition of profit which in turn depends on the allowable extent of expenditure deductions.

To date, Western Australia has mainly collected mineral royalties by using unit charge per tonne of production, or the ad valorem approach, or a combination of the two (i.e. ad valorem with unit per tonne as a minimum), and these methods are easy to administer. Less so, will be the profit-based royalty coupled with minimum ad valorem basic royalty recently established for the Argyle diamond mining operation. Here a narrow definition of profit and specific permissible expenditure deductions have had to be negotiated before the royalty can be calculated.

Royalties are continually reviewed by the Department of Mines to identify any problem areas, and can be adjusted by Government to suit particular industries or mines if a review shows that a change is warranted.

Selection of a royalty system is a decision based on the consideration of many factors. Each system has good and bad points, but disadvantages can be minimized by selecting a system to suit a particular situation.



The Agnew nickel mine. Royalties of \$4 million were collected on all nickel production in 1983.

# ADMINISTRATIVE SERVICES

A. MISTILIS, ADMINISTRATIVE OFFICER

## DEPARTMENT OF MINES CONSOLIDATED REVENUE FUND SUMMARY

	1981/82	1982/83	Estimated 1983/84
	(million dollars)		
<b>Revenue</b>			
Royalties	81.330	102.454	110.600
Other	13.755	15.218	16.066
Total	95.085	117.672	126.666
<b>Expenditure</b>	16.152	19.305	21.490

During 1983 the resources of the Administrative Services Division were fully extended in supporting the Executive and the Operational Divisions of the Department in their efforts to respond to the requirements of the new Government, especially in the areas of planning, staff and finance.

The thrust during 1983 was towards forward planning and improving the management of the Department's single most important resource - staff. This prompted a re-examination of the structure of the Administrative Services Division so that it could best serve the needs of the Department and Government.

The structure that presented itself as most appropriate recognized the broad service areas to be provided by the Administrative Services Division and it is under these headings that the activities in 1983 will be discussed — Financial, Personnel, Information, Management, Computer, Miscellaneous and Royalties and Statistics.

## Financial

### Accounts Branch

The difficulties resulting from the combination of the senior position of accountant with the position of Chairman, Coal Mine Workers' Pensions Tribunal continue to compound each year with the increase in financial activity due to the growth in value of revenue and level of expenditure. Steps are being taken to reconstitute separate positions to enable each of these important areas to be properly served.

The Consolidated Revenue Fund results for 1982/83 may be compared with those of 1981/82 and those estimated for 1983/84 as shown in the accompanying Table.

All Divisions of the Department received accounting advice from the

Accounts Branch particularly State Batteries, the Drilling Branch and also the Western Australian Mining and Petroleum Research Institute.

## Personnel

### Personnel and Staff Branch

The Personnel and Staff Branch already hard pressed, found it impossible to cope with the new Government's staff management requirements. During the year the office had to be supported by stationing a relieving clerk almost full time in the Branch and by the commencement of overtime to cope with work generated by 812 established positions and 26 additional staff allocated to the Department under various employment schemes.

Even with this level of support the Branch was not able to contribute to the emerging initiatives of human resource management such as Executive Identification and Development, Management Training and Development, Performance Appraisal, Corporate Planning, Computerized Personnel Information Management System and Review of the existing classification structure. These initiatives had to be covered by other stop-gap measures.

The importance of human resource management cannot be overstated. Of an estimated overall expenditure for 1983/84 of \$21.490 million about two-thirds represents salaries exclusive of amounts for associated overheads. It is therefore necessary that greater attention be given to this area.

## Information

### Records Branch

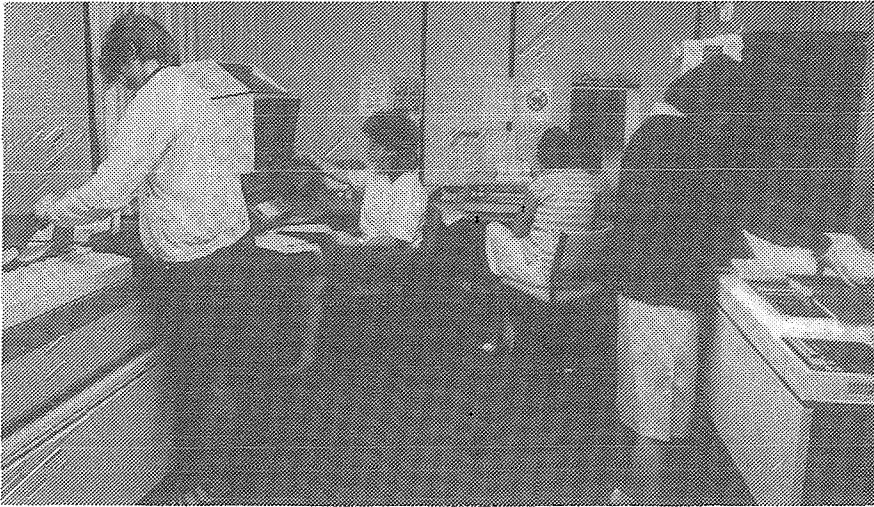
1983 was a year of pressure, with insufficient staff to meet the workload. A total of 12 920 files were created in the year, compared to 4 234 files created during 1982. Regular overtime was worked in the last quarter of 1983 to reduce backlogs.

The workload of the Records Branch is largely dependent on the rate of mining tenement applications lodged. During the year the number of tenements applied for was about four times greater than the 1982 level, resulting in severe demands for Records Branch services including the receipt, processing and storage of documents.

To meet the demands placed on the Branch the Department has brought forward the implementation of a computerized Records Management System developed for use in Government. It is anticipated that the initial data capture for this system will be completed during 1984.

### Typing Services

The Typing Services Branch went through a period of consolidation, review and adjustment during 1983. A post-implementation review of the word processing system was conducted in late February. On the basis of data collected over a 5 week period, the review showed that since 1982, typing output has increased by more than half without an increase in staff.



The new photocopying centre 7th Floor Mineral House.

The recommendations of the post-implementation review include the upgrading of the existing word processing system, the introduction of new equipment into the Mining Engineering Division and the Government Chemical Laboratories and the restructuring of the Typing Services.

The post-implementation review was forwarded to the Government Computing Policy Committee for information and approval to acquire additional equipment. As an interim measure the Committee approved additions to the system resulting in an increase in storage capacity by a factor of five, and the installation of a further two screens and a printer. A non-screen based Olivetti word processor was placed in the Mining Engineering Division to cope with the increase in typing work there.

Staff were sent for advanced word processing courses, seminars and talks on word processing. Four typists passed the Public Service Board Efficiency examination. So far 42 per cent of typists have obtained this certificate.

Many new applications were put on the word processing system. These included the rent forfeiture list, quarterly report on petroleum tenements, distribution lists for petroleum reports and annual reports, directory of petroleum and mining tenement companies, and a reviewable list of mining company addresses.

With the implementation of the recommendations in the review the

Department can look forward to further improvements in the standard and level of typing services and information processing. Future attention will be directed to Branches located away from Mineral House and to the outstations.

With the forthcoming installation of a mainframe computer, new possibilities of interfacing the word processors with the computer will be examined with a view to improving productivity.

## **Management**

### **Management Services Branch**

Personnel training and management received increased attention during 1983. Divisions of the Department were canvassed to determine their training needs. This resulted in the organization of in-house courses on time management, and written communication and dictation training given by the Australian Institute of Management and other private training organizations. Work also commenced on implementing a more systematic approach to staff development and training.

In 1984 the important personnel work commenced within the Branch will move to the Personnel Services area.

Accommodation matters were again a major area of operation. The Branch helped the Department to upgrade existing and additional accommodation. This included the

establishment of a Departmental photocopying centre which also provides telex, microfilm reading and binding facilities.

A major survey of the Department's Records Branch was undertaken and improvements made.

The Management Services Officer continued to provide secretarial support to the Mines Department Computer Co-ordinating Committee and assisted with the evaluation of tenders received for a new Departmental Computer System.

Significant areas of activity in 1984 will include a review of Departmental functions (including the employment of consultants to review the Registration function), commencement of the preparation of a corporate plan, assistance with the implementation of a computerized Records Management System and new budgeting procedures.

The further improvement of Departmental accommodation will require an additional officer and approval for this will be sought. Steps will continue during 1984 to achieve recognition of Departmental accommodation needs and to bring about a long term solution.

### **Systems Audit**

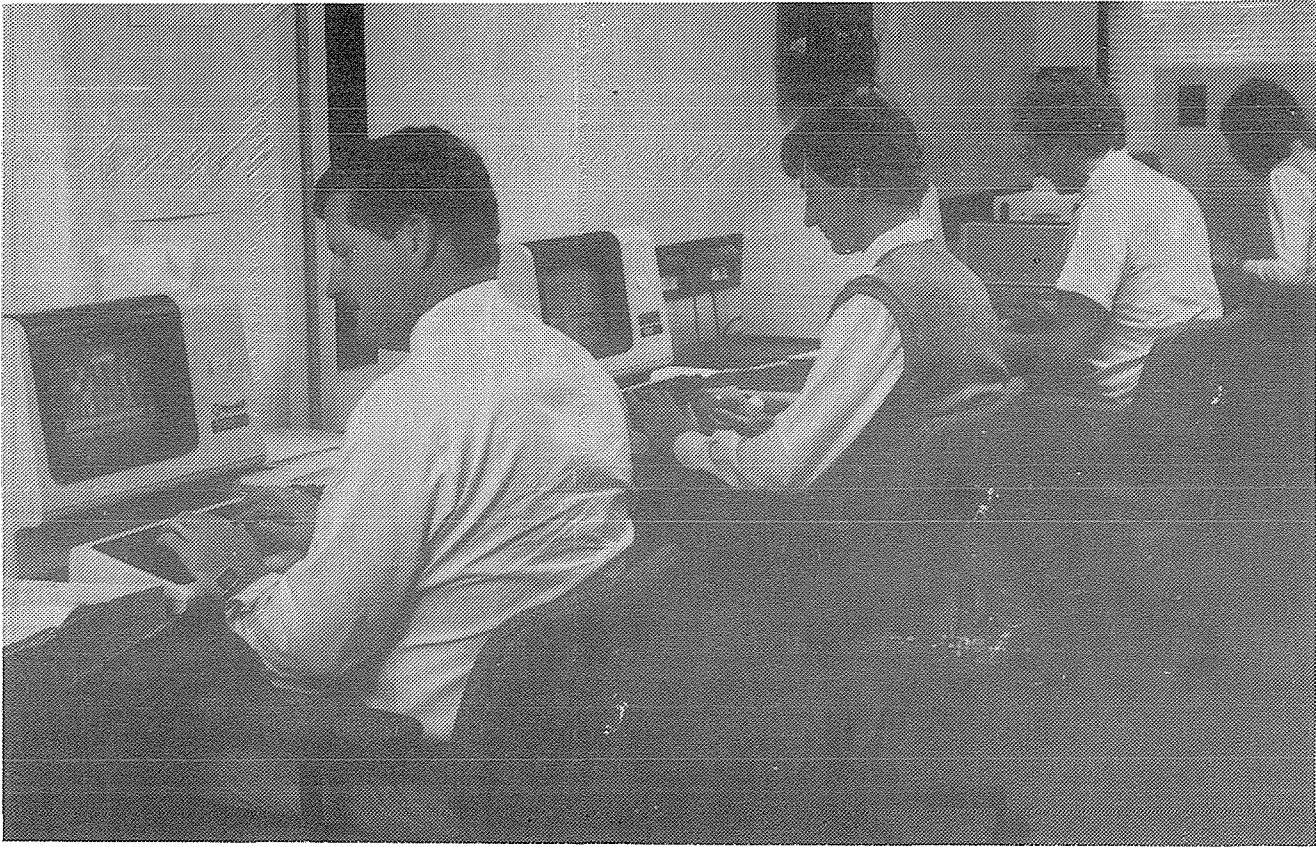
The main role of this branch is to review financial management and other methods of carrying out the Department's functions and to report on the effectiveness of accountability control points within these systems. Where necessary, methods of improvement are recommended.

## **Computer**

### **Computer Services Branch**

In 1983 a Systems Analyst arrived to join the Manager Computer Services, and four newly created computing positions are expected to be filled by January, 1984.

In June the branch moved to the 7th Floor of Mineral House. A terminal and computer room were provided, and the latter will house a new computer by mid 1984.



Systems development and data take-up operations in the new computer terminal room.

In the 1983/84 budget funds were allocated to provide a Departmental computer system and to replace the obsolete Government Chemical Laboratories PDP 11/40. Tenders were called in late 1983 for both the above and equipment is expected to be installed by mid 1984, to replace a variety of bureaux used by the Department.

Major projects undertaken were conversion of non laboratory systems from the Government Chemical Laboratories computer to Land Information System hardware, implementation of the 'CONTAM' Mine Contamination System, and commencement of the Mining Tenement Information and Explosives Licencing Systems. In 1984 additional staff and accommodation will be sought.

## Miscellaneous

### Coal Mine Workers Pensions

During the year amendments to the relevant legislation were made with

the view of streamlining the Coal Mine Workers Pensions Act. There were 34 lump sum payments made to eligible beneficiaries and fortnightly payments continued to be paid to 466 pensioners.

### Mine Workers Relief

Under the Mine Workers Relief Act lump sum payments continued to be made to beneficiaries during 1983 prior to the winding down of the fund in April-May 1984.

### Miners Phthisis Act

Only eight persons were receiving benefits through the Act.

### Coal Mining Industry Long Service Leave Act

The Act currently covers 1 273 coal industry workers in Western Australia.

## Royalties and Statistics

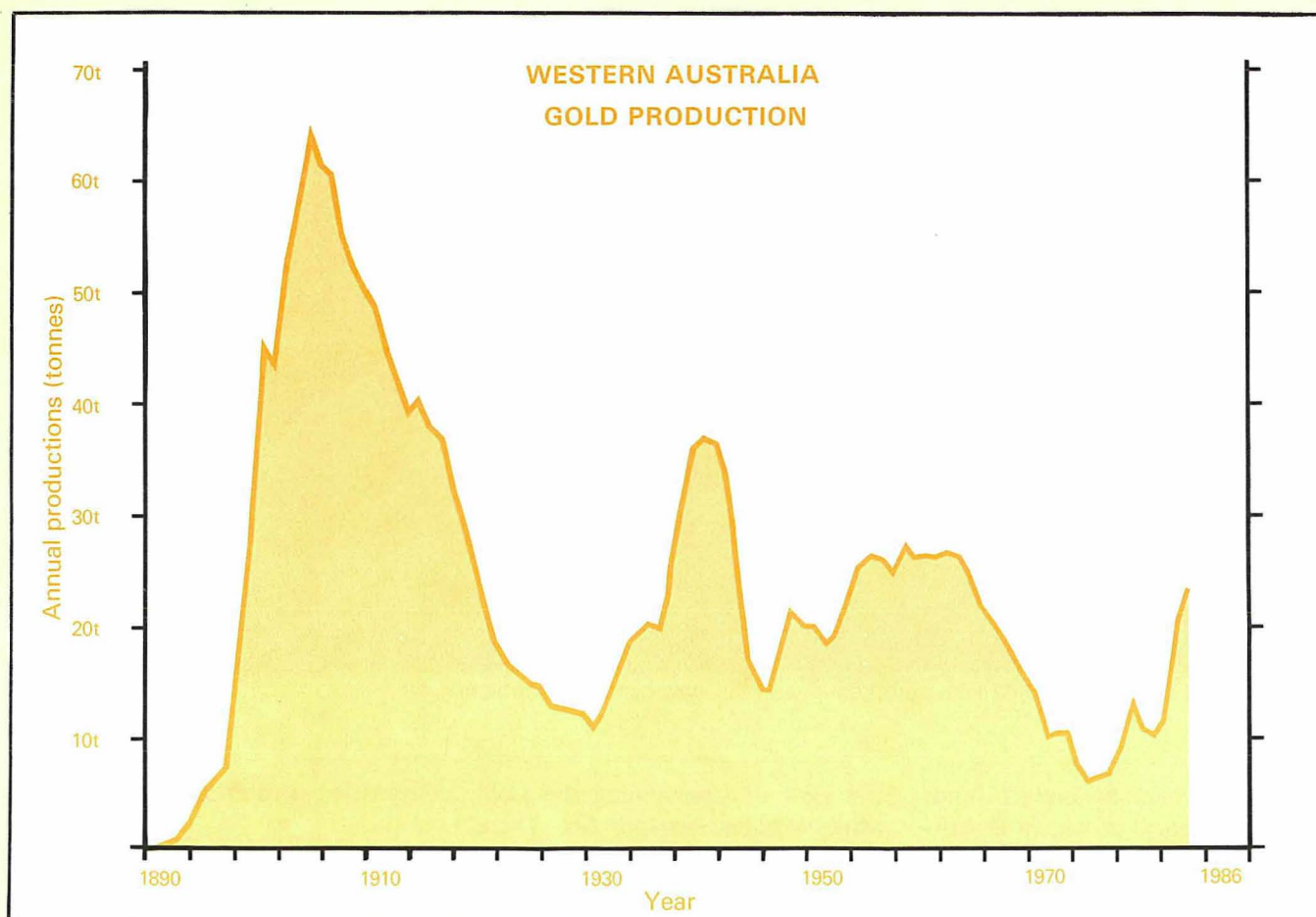
Annual royalty collections have increased markedly over the past 15 years. The Branch assessed and collected \$105.734 million as royalties on mineral production in 1983 compared to \$12.69 million in 1969. Royalty revenue is expected to rise to \$165 million in the year 1985/86.

The Branch also collected, compiled and published production figures of mineral commodities with a total value of \$3 666.69 million for 1983. Tables summarizing this production are shown in the statistical digest.

The need for the creation of a senior position to advise on and administer royalty policy was recognized and the appointment of a Royalties Administrator will be made early in 1984.



## GOLD PRODUCTION IN WESTERN AUSTRALIA SINCE 1886



Gold has played an important role in the development of Western Australia. The diagram above shows the variation in annual gold production since earliest recording in 1886.

The wealth and influx of population resulting from the rich finds in the Eastern Goldfields late in the 19th Century, established Western Australia on a sound financial basis for the first time. Again in the 1930's, rising gold production cushioned Western Australia's economy from the worst effects of the Great Depression.

Until 1963 gold production value

exceeded that of all other minerals and gold retained the highest individual production value until 1966 when iron exceeded it.

State annual gold production reached a 20th century low in 1974 when only 6 630.96 kg was produced; but this reached 23 880.92 kg in 1983, responding over the past few years to higher, but somewhat variable gold prices.

Western Australia's annual gold production by far exceeds that from all other States combined, and the Newmont Holdings Pty Ltd goldmine at Telfer is at present the

annually most productive gold mine in Australia.

Gold totalling 2 270 tonnes has been produced in Western Australia. It may be interesting to note that if it was all melted and formed into a solid cube, then the cube would have sides measuring 4.9 metres, or, if formed into a slab the size of a doubles tennis court, it would be about 45cm thick.

At the Perth Mint end of 1983 buying price of \$428.20 per oz the present day value of all the gold produced in the State would be \$31 256 348 000.

# STATISTICAL DIGEST

## CONTENTS

	Page
<b>MINING ENGINEERING DIVISION</b>	
Drilling carried out by Mines Department in 1983.....	74
Serious accidents for 1983.....	75
Fatal and serious accidents showing districts and cause.....	76
Summary description of fatal accidents reported during 1983.....	76
Certificates of Competency issued 1983.....	77
<b>STATE BATTERIES DIVISION</b>	
Schedule No.1. Number of gold ore parcels treated — tonnes crushed — gold yield by amalgamation and head values for the year ending 1983.....	79
Schedule No.2. Details of extraction — tailings treatment by State Batteries in 1983.....	79
Schedule No.3. Direct purchase of tailings by State Batteries in 1983.....	79
Schedule No.4. Statement of receipts and expenditure for milling at State Batteries.....	80
Schedule No.5. Statement of receipts and expenditure for cyaniding at State Batteries in 1983.....	80
<b>PETROLEUM DIVISION</b>	
Summary comparison of Exploration Permit Dealings (1982-1983).....	81
Barrow Island — well completion status by reservoir on 31st December, 1983.....	81
Petroleum production during 1983.....	82
Summary of identified recoverable reserves at 31st December, 1983.....	82
Disposal of petroleum 1983.....	83
Accident statistics relating to the petroleum exploration, production and pipeline industry during 1983.....	83
Wells drilled or drilling at the end of 1983.....	84
<b>REGISTRATION DIVISION</b>	
Tenements applied for — 1982/1983.....	85
Mining tenement summary 1974 to 1983.....	85
<b>ADMINISTRATIVE SERVICES DIVISION</b>	
Average number of men employed in mining operations in Western Australia during 1983.....	86
Quantity and value of minerals produced during 1982 and 1983 in Western Australia.....	87
Comparison of royalties collected in 1982 and 1983.....	88
Production of gold and silver from all sources showing in kilograms the output as reported to the Department of Mines during the year 1983.....	89
Quantity and value of minerals reported during the year 1983.....	90

**MINING ENGINEERING DIVISION**  
**Drilling Carried out by Mines Department in 1983**

Place	Purpose	Type of Work	Number of Bores	Meterage
Harvey Deep	Groundwater Investigation	Rotary drilling Developed Abandoned	4 3 1	2 079.5
Harvey Shallow	Groundwater Investigation	Rotary drilling Developed Pump Tested	16 16 4	393.10
Busselton Shallow	Groundwater Investigation	Rotary drilling Developed	40 40	2 089.5
Fortescue Flood Plain	Groundwater Investigation	Rotary drilling Developed Pump tested Abandoned	29 28 1 1	807.8
Robe River Flood Plain	Groundwater Investigation	Rotary drilling Developed Pump tested Abandoned	18 17 1 1	585
Winchester Catchment	Land salinization research and groundwater monitoring	Core and rotary drilling Developed Abandoned	43 42 1	1 073.4
Lake Toolibin	Land salinization research and groundwater monitoring	Core and rotary drilling Developed Pump tested	11 11 2	276
Lemon Catchment	Monitoring groundwater response to forest clearing	Rotary drilling Developed Pump tested	10 10 1	298.5
Fremantle Del Park	Experimental multi-port piezometer bore	Rotary drilling Developed	3 3	125.1
Various	MWA. pull and reset packer string		1	50
Various	Groundwater Investigation	Thermal Logging Repairs to bores	17 5	
Various		Supervision of contractors	3	
Various	Various	TV camera scan Long and sidewall core Perforate	35 5 5	
		Total		7 777.9

### Serious Accidents for 1983.

Class of Accident	Inspectorate				Totals	
	Perth	Karratha	Kalgoorlie	Collie	1983	1982
<b>Major injuries (exclusive of Fatal)—</b>						
<b>Fractures:</b>						
Head	—	—	1	—	1	2
Shoulder	—	1	—	—	1	2
Arm	3	4	3	1	11	10
Hand	2	3	8	1	14	19
Spine	2	—	2	—	4	1
Rib	1	2	2	—	5	7
Pelvis	—	—	2	1	3	2
Thigh	—	—	—	—	—	—
Leg	1	1	6	—	8	13
Ankle	1	1	3	—	5	6
Foot	—	4	4	1	9	10
<b>Amputations:</b>						
Arm	—	—	—	—	—	1
Hand	—	—	—	—	—	—
Finger	2	2	5	—	9	10
Leg	—	—	—	—	—	1
Foot	—	—	—	—	—	—
Toe	—	—	—	—	—	1
Loss of eye	—	—	—	—	—	—
Serious internal	1	—	1	—	2	—
Hernia	4	2	2	1	9	13
Dislocations	—	1	2	—	3	—
Other Major	—	1	4	—	5	11
<b>Total major injuries</b>	<b>17</b>	<b>22</b>	<b>45</b>	<b>5</b>	<b>89</b>	<b>109</b>
<b>Minor injuries—</b>						
<b>Fractures</b>						
Finger	5	7	16	—	28	27
Toe	1	3	4	1	9	7
Head	1	5	7	—	13	11
Eyes	7	3	5	—	15	20
Shoulder	—	6	1	6	13	17
Arm	4	5	10	2	21	18
Hand	8	25	29	7	69	73
Back	16	45	31	27	119	136
Rib	—	1	2	2	5	7
Leg	14	14	33	10	71	68
Foot	5	18	15	9	47	34
Other Minor	1	8	5	5	19	20
<b>Total minor injuries</b>	<b>62</b>	<b>140</b>	<b>158</b>	<b>69</b>	<b>429</b>	<b>438</b>
<b>Grand Total</b>	<b>79</b>	<b>162</b>	<b>203</b>	<b>74</b>	<b>518</b>	<b>547</b>

NOTE: The Perth, Karratha and Kalgoorlie Inspectorates comprise the following Mining Districts.

PERTH — South West, Greenbushes, Collie, Northampton, Yalgoo, Murchison Mining Districts, 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, Naberu and Phillips River Mining Districts.

### Fatal and Serious Accidents Showing Districts and Causes, 1983.

DISTRICT	Explosives		Falls		Shafts		Fumes		Miscellaneous underground		Surface		Total	
	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious
Kimberley												6		6
West Kimberley												1		1
Pilbara												65		65
West Pilbara											1	72	1	72
Peak Hill												17		17
Gascoyne												5		5
Murchison				2		1				5		4		12
Yalgoo										1		1		2
East Murchison			1	2		2				3		6	1	13
Mount Margaret				2		2				5		4		13
North Coolgardie												1		1
Broad Arrow												1		1
East Coolgardie	1			10		4						17	1	103
Coolgardie		3	1	12		1			1	26		8	2	50
Yilgarn				1					1	5		1	1	7
Dundas				1						11		3		15
South West												56		56
Greenbushes												5		5
Collie				4						38		32		74
Total for 1983	1	3	2	34		10			2	166	1	305	6	518
Total for 1982	1	2	2	19		7				169	3	350	6	547

### Summary Description of Fatal Accidents Reported during 1983

Name Occupation Date of Accident	Mine/Details and Remarks
L.H. Head Mechanical Loader Operator 21/4/83	Marvel Loch Gold Mines, Francis Furness Shaft. Mr Head was apparently endeavouring to free a "hung-up" ore pass when he fell into the pass when he fell into the pass and was buried in a run of ore. Death was due to crush asphyxia.
S.E. Omond Miner 24/2/83	North Kalgurli Mines Ltd, Main Shaft, Fimiston. Mr Omond was lowering a water hose down a borehole which was servicing a rise. During this operation a rise cut was fired causing fatal head injuries.
A.J. Greenwood Jumber Operator 22/6/83	Agnew Mining Company, Main Decline, Agnew. Death was due to multiple injuries sustained in a rock fall from the wall of No. 4 millhole, 1166 stope.
B.J. Nicholas Miner 25/8/83	Western Mining Corporation Ltd, Otter-Juan, Kambalda. Death was due to laceration of the right lung and contusion of the brain sustained when he fell from the 534/7 footwall rise onto broken dirt.
R.W. Cream Underground driller 1/9/83	Western Mining Corporation Ltd, Fisher, Kambalda. The deceased sustained fatal injuries when struck by a fall of rock from the back of the 1208/1 drive.
P.J. Johnson Refrigeration Mechanic 29/10/83	Hamersley Iron Pty Ltd, Paraburdoon. Mr Johnson was crushed when the vehicle in which he was sitting was run over by a haul truck.

## Metalliferous Mining Certificates of Competency issued 1983

### First Class Mine Managers

		Certificate Number			Certificate Number
Hutton	R.C.	151	Bilbe	P.R.	157
Phillips	J.B.	152	Trotter	K.	158
Bannister	K.R.	153	Turner	R.N.	159
McKinney	D.	154	Hill	G.A.	160
Wilson	C.J.	155	Ellison	C.	161
Ross	K.D.	156	Sandercock	I.H.	162

### Underground Supervisors

		Certificate Number			Certificate Number
Young	R.J.	A239	Fermo	E.C.	A271
Corn	A.	A240	Frewen	W.K.	A272
		(Restricted)	Goodwill	N.S.	A273
Minter	B.W.	A241	Hegde	A.S.	A274
Andrews	A.W.	A242	Howley	M.	A275
Hanlon	W.	A243	Hulmes	M.R.	A276
Bergin	N.K.	A244	Hunter	R.M.	A277
Proctor	T.H.	A245	King	A.H.	A278
King	A.H.	A246	Lambert	B.T.	A279
		(Restricted)	Mayes	G.W.	A280
Rodan	B.B.	A247	McHugh	A.	A281
		(Restricted)	McMahon	T.R.	A282
Teague	K.T.	A248	McMillan	S.A.	A283
Connell	T.J.	A249	Nilsson	K.K.	A284
		(Restricted)	Otway	B.J.	A285
Nilsson	K.K.	A250	Patterson	W.S.	A286
		(Restricted)	Ralph	S.R.G.	A287
Farley	R.M.	A251	Ring	J.	A288
Hunter	R.M.	A252	Rumbold	P.M.	A289
		(Restricted)	Scoble	F.L.	A290
Adams	J.J.	A253	Shaw	J.H.	A291
		(Restricted)	Simpson	M.A.	A292
Eaton	R.	A254	Studley	T.	A293
		(Restricted)	Thornett	G.R.	A294
Bagely	M.	A255	Tynan	P.J.	A295
		(Restricted)	Vayro	I.R.	A296
Adams	J.J.	A256	Walker	R.D.	A297
Bell	J.A.	A257	Ward	N.C.	A298
Bloomfield	S.M.	A258	Watts	K.M.	A299
Bedy	S.G.	A259	Sokolenko	V.J.	A300
Braddock	J.M.	A260			(Restricted)
Brune	O.M.	A261	Not issued		A301
Bryson	S.E.	A262	Cox	J.	A302
Butler	G.	A263	Adam	N.M.	A303
Cowan	A.D.	A264	Rowe	D.G.F.	A304
Corn	A.	A265	Milazzo	M.F.	A305
Cook	C.M.	A266	Russell	A.J.	A306
Charman	P.A.	A267			(Restricted)
Cunningham	P.T.	A268	Whalley	M.	A307
Doyle	P.R.	A269	Allom	A.R.	A308
Donaldson	J.A.	A270			(Replaces No.111)

### Quarry Managers

		Certificate Number			Certificate Number
Leith	D.B.	64	Land	K.R.	73
Sandercock	I.H.	65	Gray	F.E.	74
Curnow	P.J.	66	Hollier	G.R.	75
Campbell	F.R.	67	Soo	S.P.K.	76
Grubb	A.W.	68	Ward	A.J.	77
Bannister	K.R.	69	Hegde	A.S.	78
Morris	B.D.	70	Mumby	C.C.	79
Obara	M.	71	Buttenshaw	G.	80
Talbot	D.J.	72	Harris	M.	81

### Restricted Quarry Managers

		Certificate Number			Certificate Number
Stevens	G.L.	108	Lossie	J.M.H.	114
McKoy	J.C.	109	Waller	M.J.	115
Pratt	G.W.	110	Sampson	M.L.	116
Felder	P.G.	111	Stone	A.S.	117
Kershaw	A.H.	112	Little	K.M.	118
Beahan	W.J.	113			

### Coal Mining Certificates of Competency issued 1983

		Certificate Number			Certificate Number
<b>First Class Mine Manager</b>			<b>Third Class (Deputy)</b>		
Lockhart	R.T.	11	Farmer	G.J.	103
Clayton	G.W.	12	Lunardi	P.A.	104
Donegan	C.B.	49	Peters	L.H.	105
		(Reciprocal)	Sherwood	B.L.	106
<b>Second Class Mine Manager</b>			<b>Deputy (Open Cut)</b>		
Hetherington	C.J.	20	Truscott	K.J.	17
			Chapman	M.J.	18

### Authorized Mine Surveyors Certificates issued 1983

		Certificate Number
Soord	C.A.	64
Thompson	B.	65
MacDonald	T.J.	66

## STATE BATTERIES DIVISION

### Schedule No. 1

#### Number of Gold Ore Parcels Treated—Tonnes Crushed—Gold Yield by Amalgamation and Head Values for the Year Ending 1983

Battery	Smelt Bullion kilograms	Number of Parcels Treated	Yield by Amalgamation			Amalgamation Tailings Content Fine Gold Kilograms	Contents of Ore-Fine Gold	
			Tonnes crushed	Bullion Kilograms	Estimated Fine Gold Kilograms		Kilograms	Grams Per Tonne
BOOGARDIE	10.5061	14	1 798	13.4153	11.4029	7.3072	18.7101	10.40
COOLGARDIE	17.3982	43	4 539.6	31.3829	26.6760	13.6491	40.3251	8.88
KALGOORLIE	189.1500	53	5 101.5	25.9080	22.0217	10.6181	32.6398	6.40
LAVERTON	0.6730	20	1 442	19.4987	16.5738	9.2719	25.8457	17.92
LEONORA	32.2815	29	4 725	24.9096	21.1730	12.3758	33.5488	7.10
MARBLE BAR	134.7940	21	3 257	66.1690	56.2435	17.3676	73.6111	22.60
MARVEL LOCH	3.2634	33	4 406.7	23.3747	19.8685	10.7172	30.5857	6.94
MEEKATHARRA	18.5880	12	1 091.5	13.0396	11.0835	2.7276	13.8111	12.65
MENZIES	9.3401	13	1 697.9	11.7646	9.9998	4.0334	14.0332	8.26
NORSEMAN	—	17	1 727	7.5775	6.4408	3.6835	10.1243	5.86
ORA BANDA	0.6142	26	1 413.5	10.3887	8.8303	5.8522	14.6825	10.38
PAYNES FIND	1.2376	15	1 287.5	18.812	15.9901	3.2390	19.2291	14.93
SANDSTONE	—	—	—	—	—	—	—	—
YARRI	—	15	760	5.750	4.8874	2.0653	6.9527	9.14
	417.3961	311	33 247.2	271.9916	231.1913	102.9079	334.0992	10.05

Average per parcel.....106.9 tonnes

Average yield by Amalgamation (fine gold).....6.95 grams per tonne

Average Tailing (fine gold).....3.09 grams per tonne

### Schedule No. 2

#### Details of Extraction—Tailings Treatment by State Batteries in 1983

Battery	Estimated Tonnes	Head Value		Tail Value		Calculated Recovery		Actual Recovery	
		Grams Per Tonne	Total Content Kilograms	Grams Per Tonne	Total Content Kilograms	Kilograms	Per Cent	Kilograms	Per Cent
Coolgardie (C.I.P.)	20 914	1.75	36.5995	.60	12.5484	24.0511	65.7	18.173	49.4
Kalgoorlie (C.I.P.)	26 075	1.37	35.7227	.39	10.1692	25.5535	71.5	19.880	55.65
Kalgoorlie (Vat)	1 300	2.16	2.808	.54	0.6985	2.109	75.1	2.073	73.8
Leonora (Vat)	4 400	2.99	13.145	0.72	3.187	9.958	75.7	9.703	73.8
Marvel Loch (Vat)	3 000	1.91	5.717	.46	1.376	4.341	75.9	4.136	72.3
Meekatharra (C.I.P.)	10 570	2.09	22.090	.52	5.4962	16.5938	75.1	15.376	69.6
Menzies (H/Leach)	3 600	2.3	8.280	1.04	3.753	—	—	4.527	54.6
Part Treated					(calculated)				
Norseman (Vat)	760	3.53	2.6864	1.51	1.1474	1.539	57.3	1.509	56.2
Ora Banda (Vat)	2 700	1.99	5.376	0.50	1.344	4.032	75.0	3.974	73.9
	73 319	1.80	132.4246	0.54	39.7197	92.7049	70.0	79.351	59.9

### Schedule No. 3

#### Direct Purchase of Tailings by State Batteries in 1983

Battery	Tailings Purchased Tonnes	Initial Payment \$	Gold Paid to Prospectors Kilograms
Boogardie	87.3	119.84	5.063
Coolgardie	931.4	3 312.07	10.477
Kalgoorlie	347.8	1 153.69	1.329
Laverton	134.1	498.54	.060
Leonora	226.8	618.49	1.132
Marble Bar	1 667.1	5 558.70	—
Marvel Loch	302.1	675.27	2.033
Meekatharra	101.7	291.32	6.654
Menzies	460.3	1 145.01	2.255
Norseman	220.5	348.70	1.068
Nullagine	—	—	.362
Ora Banda	122.8	1 015.45	3.290
Paynes Find	361.8	798.59	—
Yarri	89.1	246.41	—
	5 052.8	15 782.08	33.723



**Schedule No. 4**  
**Statement of Receipts and Expenditure for Milling at State Batteries in 1983**

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	1 798	50 664.11	29 600.06	42 2877.04	122 541.21	61.15	26 745.10	30 932.55	180 218.86	100.23	31 417.85	17.48	—	148 801.01
Coolgardie	4 539.6	40 567.75	87 889.71	57 832.61	186 290.07	41.03	11 222.97	43 487.11	241 000.15	53.08	48 790.35	10.75	—	192 209.80
Kalgoorlie	5 101.5	87 812.76	103 982.88	74 541.74	266 337.38	52.20	26 806.25	68 433.74	361 577.37	70.87	81 825.05	16.04	—	279 752.32
Laverton	1 442	21 151.09	35 714.90	21 348.38	78 214.37	54.24	12 480.88	15 643.23	106 338.48	73.75	25 946.37	18.00	—	80 382.11
Leonora	4 725	21 390.71	75 588.24	26 861.67	123 840.62	26.20	13 993.26	35 162.41	172 996.29	36.62	61 397.91	13.00	—	111 598.38
Marble Bar	3 257	23 085.05	99 186.95	35 523.28	157 795.28	48.44	13 579.55	29 84190	201 216.73	61.78	33 115.53	10.17	—	168.101.20
Marvel Loch	4 406.7	27 595.11	105 637.67	42 076.99	175 309.77	39.78	15 662.00	39 912.58	230 884.35	52.40	34 020.74	7.72	—	196 863.61
Meekatharra	1 091.5	44 203.49	90 104.26	40 713.15	175 020.90	160.34	4 098.92	19 976.84	199 096.66	182.41	10 080.00	9.24	—	189 016.66
Menzies	1 697.87	21 220.26	92 460.93	32 810.63	146 491.82	86.27	5 858.70	22 242.79	174 593.31	102.83	23 566.75	13.88	—	151 026.56
Norseman	1 727	24 318.35	63 402.03	24 621.44	112 341.82	65.05	5 828.67	21 632.16	139 802.65	80.96	18 410.99	10.66	—	121 391.66
Ora Banda	1 413.5	21 997.65	30 731.40	39 626.93	92 355.98	65.33	6 454.74	13 445.76	112 256.48	79.42	18 072.50	12.79	—	94 183.98
Paynes Find	1 287.5	14 873.58	39 112.42	18 197.81	72 183.81	56.06	5 739.15	16 475.79	94 398.75	73.32	13 586.48	10.56	—	80 812.27
Sandstone	—	—	—	2 610.07	2 610.07	—	25.60	355.58	2 991.25	—	4 400.00	—	1 408.75	—
Yarri	760	337.61	32 959.06	20 240.30	53 536.97	70.44	4 340.73	12 004.32	69 882.02	91.95	6 425.00	8.46	—	63 457.02
Head Office	—	—	—	—	—	—	—	—	—	—	12 942.00	—	12 942.00	—
Cue	—	—	—	—	—	—	—	—	—	—	3 064.40	—	3 064.40	—
Sub Total	33 247.17	399 217.52	886 370.51	479 282.04	1 764 870.07	53.08	152 836.52	369 546.76	2 287 253.35	68.80	427 061.92	12.85	17 415.15	1 877 606.58
Northampton	26.16	20 946.63	16 372.49	9 785.27	47 104.39	1 800.62	478.03	1 409.71	48 992.13	1 872.79	261.60	10.00	—	48 730.58
Total	33 273.33	420 164.15	902 743.00	489 067.31	1 811 974.46	54.45	153 314.55	370 956.47	2 336 245.48	70.22	427 323.52	12.84	17 415.15	1 926 337.16

**Schedule No. 5**  
**Statement of Receipts and Expenditure for Cyaniding at State Batteries in 1983**

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	—	—	—	—	—	—	—	—	—	—	3 695.34	—	3 695.34	—
Kalgoorlie	1 300	—	82 296.57	26 205.79	108 502.36	83.46	788.12	3 270.18	112 560.66	86.59	3 133.78	2.41	—	109 426.88
Laverton	—	—	—	—	—	—	—	—	—	—	267.77	—	267.77	—
Leonora	4 400	—	33 028.97	39 373.04	72 402.01	16.45	1 154.83	8 624.34	82 181.18	18.68	148 978.78	33.86	66 797.60	—
Marvel Loch	3 000	—	20 189.02	23 010.48	43 199.50	14.39	8 505.52	10 468.96	62 173.98	20.73	43 100.17	14.37	—	19 073.81
Menzies	3 600	—	18 177.83	26 544.34	44 722.17	12.42	2 491.34	21 911.40	69 124.91	19.21	29 918.09	8.31	—	39 206.82
Norseman	760	—	849.88	7 122.26	7 972.14	10.48	198.00	1 961.77	10 131.91	13.34	1 377.47	1.82	—	8 754.44
Nullagine	—	—	—	—	—	—	—	—	—	—	916.37	—	916.37	—
Ora Banda	2 700	—	28 197.05	20 292.74	48 489.79	17.95	1 552.94	9 251.53	59 294.26	21.96	25 671.64	9.51	—	33 622.62
Sub Total	15 760	—	182 739.32	142 548.65	325 287.97	20.64	14 690.75	55 488.18	395 466.90	25.10	257 059.41	16.31	71 677.08	210 084.57
Coolgardie C.I.P.	20 914	—	97 638.47	92 822.46	190 460.93	9.10	4 093.36	93 171.53	287 725.82	13.76	183 277.54	8.77	—	104 448.28
Kalgoorlie C.I.P.	26 075	25 395.75	111 945.34	123 067.81	260 408.90	9.98	5 882.93	60 807.98	327 099.81	12.55	256 132.83	9.83	—	70 966.98
Meekatharra C.I.P.	10 569.6	—	21 904.69	62 082.76	83 987.45	7.94	6 963.54	25 383.51	116 334.50	11.01	164 743.90	15.59	48 409.40	—
Sub Total	57 558.6	25 395.75	231 488.50	277 973.03	534 857.28	9.29	16 939.83	179 363.02	731 160.13	12.71	604 154.27	10.50	48 409.40	175 415.26
Special Agreements	—	—	—	—	—	—	—	—	—	—	254 183.78	—	254 183.78	—
Sub Total	—	—	—	—	—	—	—	—	—	—	254 183.78	—	254 183.78	—
Total	73 318.60	25 395.75	414 227.82	420 521.68	860 145.25	11.73	31 630.58	234 851.20	1 126 627.03	15.36	1 115 397.46	15.21	374 270.26	385 499.83

**PETROLEUM DIVISION**  
**Summary Comparison of Exploration Permit Dealings (1982-1983)**

	1982		1983	
	No.	Area (km <sup>2</sup> )	No.	Area (km <sup>2</sup> )
<b>AREA ADVERTISED</b>				
Onshore	1	82	6	40 432
Offshore	—	—	10	113 300
Totals	1	82	16	153 732
<b>PERMITS GRANTED</b>				
Onshore	9	89 033	4	33 859
Offshore	6	39 861	—	—
Totals	15	128 894	4	33 859
<b>PERMIT APPLICATIONS (pending at year end)</b>				
Onshore	2	325	—	—
Offshore	2	16 760	2	16 760
Totals	4	17 085	2	16 760
<b>PERMITS HELD</b>				
Onshore	79	791 519	69	630 799
Offshore	59	635 247	43	393 745
Totals	138	1 396 766	112	1 024 544
<b>PERMITS SURRENDERED</b>				
Onshore	7	96 770	9	124 585
Offshore	3	68 820	9	127 099
Totals	10	165 590	18	251 684
<b>PERMIT RENEWALS</b>				
Onshore	14	45 525	3	32 822
Offshore	—	—	3	17 390
Totals	14	45 525	6	50 212
<b>PERMITS CANCELLED</b>				
Onshore	1	15 200	3	28 171
Offshore	—	—	4	54 221
Totals	1	15 200	7	82 392
<b>PERMITS EXPIRED</b>				
Onshore	—	—	2	11 823
Offshore	—	—	3	60 182
Totals	—	—	5	72 005

**Barrow Island—Well Completion Status by Reservoir on 31st December, 1983**

Horizon/Pools	On Production	On Injection	Shut In			Abandoned (3)	Total
			Producers (1)	Injectors	Miscellaneous (2)		
Tertiary Carbonates (4)	—	8	1	—	—	—	9
Early Cretaceous — Gearle	5	—	7	—	1	—	13
Windalia Radiolarite	—	—	1	—	—	—	1
Windalia Sandstone	327	181	48	16	5	5	582
Muderong	28	—	9	—	—	1	38
Flacourt (Oil)	1	—	—	—	—	—	1
Flacourt (Water Source)	6	—	4	—	—	1	11
5500' to 6200' sands	—	—	3	—	—	—	3
Late Jurassic	2	—	4	—	—	—	6
“Other Jurassic”	—	—	—	—	1	1	2
Middle Jurassic	—	—	3	—	—	—	3
<b>Totals</b>	<b>369</b>	<b>189</b>	<b>80</b>	<b>16</b>	<b>7</b>	<b>8</b>	<b>669</b>

- (1) Shut-in producers includes wells where attempts to obtain commercial production have been unsuccessful.  
(2) Miscellaneous includes wells cased but currently perforated plus wells completed in the water leg for observations.  
(3) Abandoned wells are fully plugged and abandoned.  
(4) Includes salt water disposal.

NOTE: Recompleted wells are included in horizon/pool of current completion.

## Petroleum Production During 1983

Field or Reservoir	No. of Producing wells at 31.12.83	Production for Year 1983						Cumulative Production					
		Gas (10 <sup>3</sup> m <sup>3</sup> )	Condensate (kL)	LPG (kL)	Natural Gasoline (kL)	Oil (kL)	Water (kL)	Gas (10 <sup>3</sup> m <sup>3</sup> )	Condensate (kL)	LPG (kL)	Natural Gasoline (kL)	Oil (kL)	Water (kL)
Barrow Island													
Gearle	5	1 551	—	—	—	2 497	6 890	18 484	—	—	—	79 680	25 520
Windalia	327	103 813	—	3 398	7 604	1 144 742	1 159 567	2 547 388	—	46 482	54 866	30 324 116	11 405 560
Muderong	28	20 696	—	—	—	118 031	101 408	72 825	—	—	—	439 360	262 369
Flacourt	1	473	—	—	—	2 316	—	808	—	—	—	4 618	—
Early Cretaceous	—	—	—	—	—	—	—	96 050	—	—	—	16 639	44 103
Late Jurassic	2	2 002	—	—	—	4 878	1 478	161 974	—	—	—	340 455	448 076
Middle Jurassic	—	11 828	—	—	—	270	121	65 033	—	—	—	1 674	558
<b>Total Barrow</b>	<b>363</b>	<b>140 363</b>	<b>—</b>	<b>3 398</b>	<b>7 604</b>	<b>1 272 734</b>	<b>1 269 464</b>	<b>2 962 562</b>	<b>—</b>	<b>46 482</b>	<b>54 866</b>	<b>31 206 542</b>	<b>12 186 186</b>
Northern Perth Basin													
Dongara	14	872 372	2 237	—	—	10 699	18 598	9 242 070	35 939	—	—	115 114	103 823
Mondarra	2	19 464	286	—	—	—	374	566 009	7 874	—	—	—	5 361
Yardarino	1	8 455	228	—	—	—	16 925	111 303	586	—	—	1 858	27 515
<b>Total N. Perth (Wapet)</b>	<b>17</b>	<b>900 291</b>	<b>2 751</b>	<b>—</b>	<b>—</b>	<b>10 699</b>	<b>35 897</b>	<b>9 919 382</b>	<b>44 399</b>	<b>—</b>	<b>—</b>	<b>116 972</b>	<b>136 699</b>
Woodada	5	173 421	1 260	—	—	—	2 800	256 621	2 017	—	—	—	3 500
Mt Horner	—	—	—	—	—	49	—	—	—	—	—	354	—
Canning Basin													
Blina	4	—	—	—	—	13 072	—	10	—	—	—	16 352	—
Sundown	—	—	—	—	—	1 070	—	—	—	—	—	1 070	—
<b>Grand Total</b>	<b>389</b>	<b>1 214 075</b>	<b>4 011</b>	<b>3 398</b>	<b>7 604</b>	<b>1 297 624</b>	<b>1 308 161</b>	<b>13 138 575</b>	<b>46 416</b>	<b>46 482</b>	<b>54 866</b>	<b>31 341 290</b>	<b>12 326 385</b>

## Summary of Identified Recoverable Reserves at 31st December 1983

	Oil (10 <sup>6</sup> m <sup>3</sup> )		Gas C <sub>1</sub> +C <sub>2</sub> (10 <sup>6</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> +C <sub>6</sub> (10 <sup>6</sup> m <sup>3</sup> )	
	P1	P2	P1	P2	P1	P2	P1	P2
<b>PRODUCING FIELDS</b>								
Carnarvon Basin								
Barrow Island	9.22	9.84	0.82	0.85	0.05	0.05	0.06	0.06
Perth Basin								
Dongara	0.06	0.06	1.90	1.90	—	—	0.01	0.01
Mondarra	—	—	0.06	0.08	—	—	neg	0.01
Yardarino	—	—	neg	neg	—	—	neg	neg
Woodada	—	—	0.35	0.51	—	—	0.01	0.01
Canning Basin								
Blina	0.36	0.36	—	—	—	—	—	—
<b>Total</b>	<b>9.64</b>	<b>10.26</b>	<b>3.13</b>	<b>3.34</b>	<b>0.05</b>	<b>0.05</b>	<b>0.08</b>	<b>0.09</b>
<b>UNDEVELOPED FIELDS</b>								
Angel	—	—	22.80	43.60	—	—	5.35	10.23
Brecknock	—	—	2.82	54.20	—	—	0.17	5.26
Brewster	—	—	—	55.00	—	—	—	—
Barrow Deep	—	—	0.60	8.03	—	—	0.01	0.27
Goodwyn	0.17	0.17	63.10	86.00	8.70	11.10	4.77	17.17
Central Gorgon*	—	—	1.38	37.37	—	—	0.01	0.40
Gorgon*	—	—	3.75	45.75	—	—	0.01	0.16
North Gorgon*	—	—	9.13	106.88	—	—	0.14	1.67
Rankin	—	—	5.66	5.66	—	—	0.83	0.83
North Rankin	—	—	201.00	235.00	15.80	18.20	19.23	22.10
South Pepper	0.18	1.93	—	—	—	—	—	—
Scarborough	—	—	170.00	550.00	—	—	—	—
Spar	—	—	1.93	7.04	—	—	0.22	0.79
Scott Reef	—	—	24.00	300.00	—	—	2.70	20.00
Tern	—	—	40.00	49.00	—	—	—	—
Tidepole	0.96	1.18	13.03	17.21	—	—	2.26	2.99
Tubridgi	—	—	1.08	2.16	—	—	—	—
West Tryal Rocks*	—	—	8.25	58.94	—	—	0.55	3.94
<b>Total</b>	<b>1.31</b>	<b>3.28</b>	<b>568.53</b>	<b>1 661.84</b>	<b>24.50</b>	<b>29.30</b>	<b>36.25</b>	<b>85.81</b>
<b>Total Reserves</b>	<b>10.95</b>	<b>13.54</b>	<b>571.66</b>	<b>1 665.18</b>	<b>24.55</b>	<b>29.35</b>	<b>36.33</b>	<b>85.90</b>

P1 probability 75%; P2 probability 25%. \*Excludes inerts

NOTE: Other undeveloped fields under review include: Wilcox, Dockrell, Eaglehawk, Egret, Petrel, North Herald, Chervil, Bamba, Harriet, Sundown, Mt Horner.

## Disposal of Petroleum 1983

Field	Gas Sold (10 <sup>3</sup> m <sup>3</sup> )	Oil Sold (kL)	LPG Sold (kL)	Natural Gasoline Sold (kL)	Condensate Sold (kL)	Water (kL) Injected	Cumulative Water (kL) Injected	Royalty Paid \$
Barrow Island	17 638*	1 249 919	2 879**	7 604***	—	3 784	68 166	15 081 487
Dongara, Mondarra, Yardarino	900 291	10 699	—	—	2 751	—	—	2 335 636
Woodada	173 421	—	—	—	1 333	—	—	1 019 521
Mt Horner	—	49	—	—	—	—	—	4 887
Blina, Sundown	—	—	—	—	—	—	—	1 838
<b>Total</b>	<b>1 091 350</b>	<b>1 260 667</b>	<b>2 879</b>	<b>7 604</b>	<b>4 084</b>	<b>3 784</b>	<b>68 166</b>	<b>18 443 369</b>

\* Field Fuel

\*\* 865 kL blended with crude

\*\*\* Blended with crude

NOTE: There was no disposal of oil for sale from Blina or Sundown in 1983.

## Accident Statistics Relating to the Petroleum Exploration, Production and Pipeline Industry during 1983

Nature of Injury				Agency of Injury			
	Onshore	Offshore	Total		Onshore	Offshore	Total
Head	4	13	17	Machinery in Operation	4	5	9
Eye	6	20	26	Vehicles	1	0	1
Trunk	35	60	95	Hand Tools	4	7	11
Arm	13	16	29	Power Tools	1	5	6
Hand	11	33	44	Manual Handling	25	25	50
Leg	11	29	40	Harmful Contacts	4	14	18
Foot	7	22	29	Persons Falling or Striking	18	75	93
Occupational	0	0	0	Objects Falling or Flying	13	41	54
Other	0	0	0	Other	14	18	32
Magnitude of Injury	Onshore	Offshore	Total	Time Factor	Onshore	Offshore	Total
Minor	51	137	188	Manhours Exposure	909 200	2 682 950	3 592 150
Serious	33	53	86	Manhours Lost	13 420	33 330	46 750
Fatal	0	0	0				

## Wells Drilled or Drilling at the end of 1983

WELL NAME	COMPANY	TENEMENT	TYPE	RIG	WELL SPUDDED	RIG RELEASED	TOTAL DEPTH (m)	STATUS ON DEC 31
<b>EXPLORATION WELLS</b>								
CARNARVON BASIN								
North Gorgon #1	WAPET	WA-25-P	NFW	Ocean Prospector	23.09.82	13.02.83	4 500	P & A, gas well
South Pepper #1	Mesa	WA-149-P	NFW	Glomar Main Pass III	9.11.82	11.01.83	2 550	Susp oil & gas well
Pasco #4	WAPET	WA-23-P	EXT	Cobot 750	20.11.82	13.02.83	2 170	P & A, oil shows
Bambra #1	Occidental	WA-192-P	NFW	Maersk Valiant	21.11.82	24.02.83	3 666	P & A, oil shows
Wilcox #1	Woodside	WA-28-P	NFW	Energy Searcher	28.11.82	27.03.83	4 024	P & A, gas/cond well
Barrow Y35M	WAPET	PL 1H	EXT	OD & E - H35	18.12.82	2.01.83	1 300	Susp oil well
Barrow Y25M	WAPET	PL 1H	EXT	OD & E - H35	3.01.83	17.01.83	1 274	Susp oil well
Serrurier #1	ESSO	WA-155-P	NFW	Key Biscayne	8.01.83	12.02.83	1 625	P & A
Barrow Y44M	WAPET	PL 1H	EXT	OD & E - H35	18.01.83	29.01.83	1 260	Oil well
Barrow X62M	WAPET	PL 1H	EXT	OD & E - H35	31.01.83	9.02.83	1 271	P & A
Barrow AA72M	WAPET	PL 1H	NPW	OD & E - H35	10.02.83	24.02.83	1 326	Susp oil well
Bluebell #1	WAPET	WA-25-P	NFW	Ocean Prospector	15.02.83	10.05.83	4 605	P & A
Arabella #1	Occidental	WA-192-P	NFW	Maersk Valiant	25.02.83	22.03.83	2 209	P & A
Barrow X81	WAPET	PL 1H	EXT	OD & E - H35	25.02.83	6.03.83	1 243	Susp oil well
Barrow X86M	WAPET	PL 1H	NPW	OD & E - H35	7.03.83	17.03.83	1 276	Susp oil well
Barrow L42M	WAPET	PL 1H	EXT	OD & E - H35	1.04.83	14.04.83	986	Oil well
Emma #1	Occidental	WA-192-P	NFW	Maersk Valiant	4.04.83	2.05.83	2 352	P & A, oil shows
Barrow L63M	WAPET	PL 1H	EXT	OD & E - H35	15.04.83	29.04.83	981	Oil well
Myanore #1	Avon Eng.	EP 137	NFW	Dril Tech DH-1	28.04.83	5.05.83	175	P & A, gas shows

Continued next page

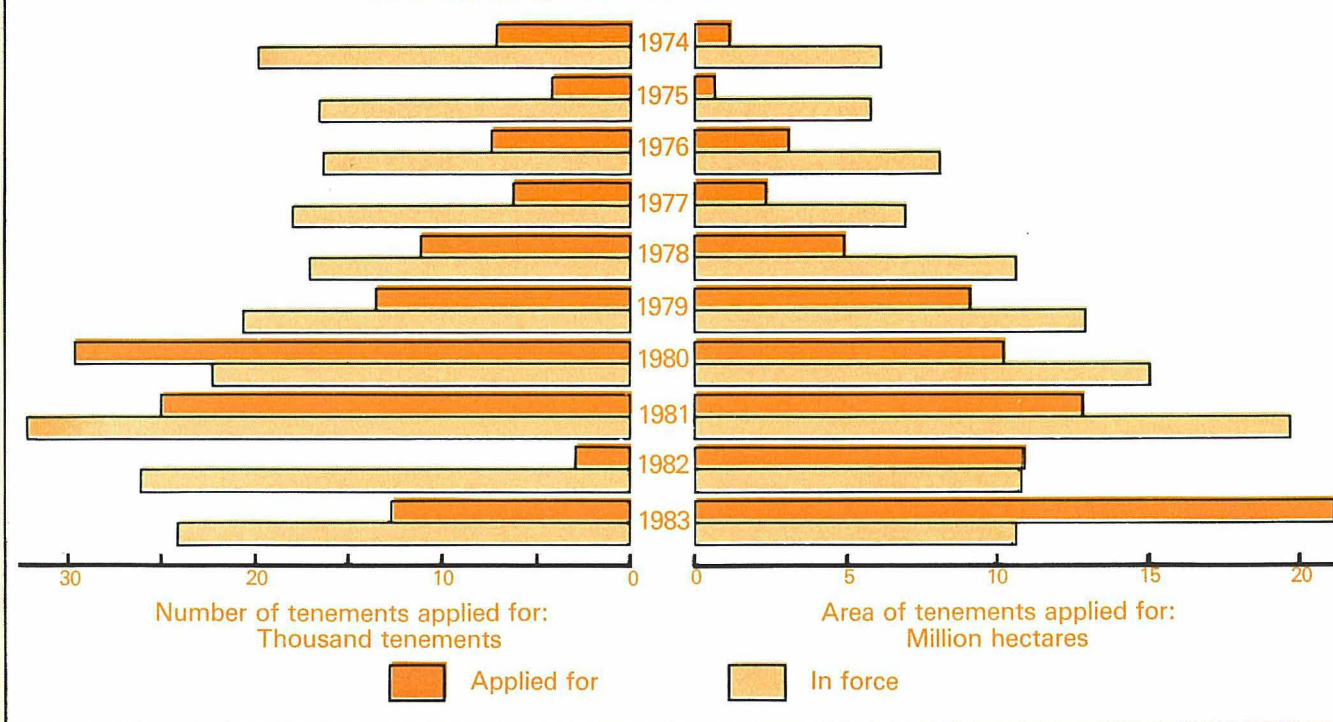
## Wells Drilled or Drilling at the end of 1983 (Continued)

WELL NAME	COMPANY	TENEMENT	TYPE	RIG	WELL SPUDDED	RIG RELEASED	TOTAL DEPTH (m)	STATUS ON DEC 31
<b>EXPLORATION WELLS</b>								
Bambra #2	Occidental	WA-192-P	NFW	Maersk Valiant	3.05.83	9.09.83	4 591	Susp, oil shows
Murnda #1	Avon Eng.	EP 137	STR	Dril Tech DH-1	7.05.83	17.05.83	252	Susp, gas shows
Barrow F12M	WAPET	PL 1H	EXT	OD & E - H35	12.05.83	22.05.83	946	Oil well
Central Gorgon #1	WAPET	WA-25-P	NFW	Ocean Prospector	13.05.83	2.09.83	4 598	P & A, gas well
Weelawarren #1	Pan Pacific	EP 110	NFW	Dril Tech DH-1	21.05.83	31.05.83	553	P & A
North Herald #1	Mesa	WA-149-P	NFW	Glomar Main Pass III	21.05.83	29.06.83	2 600	Susp. oil well
Barrow F42M3	WAPET	PL 1H	EXT	OD & E - H35	23.05.83	3.06.83	948	Oil well
Bounty #1	Marathon	WA-191-P	NFW	Regional Endeavour	23.05.83	3.08.83	3 524	P & A
Barrow 081	WAPET	PL 1H	EXT	OD & E - H35	5.06.83	10.06.83	810	P & A
Barrow U63	WAPET	PL 1H	NPW	OD & E - H35	11.06.83	17.06.83	810	Oil well
Garden Mill #1	Golden West Hyd	EP 166	STR	Dril Tech DH-1	16.06.83	24.06.83	555	Conv. water well
Barrow Y53M	WAPET	PL 1H	EXT	OD & E - H35	17.06.83	26.06.83	1 250	Oil well
Barrow Y54M	WAPET	PL 1H	EXT	OD & E - H35	27.06.83	5.07.83	1 245	Oil well
Chervil #1	Mesa	WA-149-P	NFW	Glomar Main Pass III	30.06.83	12.08.83	2 661	Susp. oil & gas well
Barrow Y43M	WAPET	PL 1H	EXT	OD & E - H35	6.07.83	16.07.83	1 255	Oil well
Barrow Y63M	WAPET	PL 1H	EXT	OD & E - H35	16.07.83	25.07.83	1 225	Shut-in
Georgette #1	Occidental	WA-192-P	NFW	Maersk Valiant	10.09.83	2.10.83	2 392	P & A
Flores #1	Occidental	WA-192-P	NFW	Maersk Valiant	2.10.83	19.10.83	2 119	P & A
South Pepper #2	Mesa	WA-149-P	NFW	Glomar Main Pass III	6.10.83	31.10.83	1 300	P & A
Harriet #1	Occidental	WA-192-P	NFW	Maersk Valiant	20.10.83	30.11.83	2 711	Susp. oil & gas well
South Chervil #1	Wesminco	WA-149-P	NFW	Glomar Main Pass III	1.11.83	2.12.83	2 282	Susp. oil & gas well
Judy #1	Occidental	WA-192-P	NFW	Maersk Valiant	1.12.83	16.12.83	2 021	P & A
Basil #1	Wesminco	WA-149-P	NFW	Glomar Main Pass III	4.12.83	27.12.83	2 347	P & A
Harriet #2	Occidental	WA-192-P	NFW	Maersk Valiant	18.12.83		(878)	Drilling
<b>CANNING BASIN</b>								
Kambara #1	ESSO	WA-109-P	NFW	Key Biscayne	23.10.82	2.01.83	3 147	P & A
La Grange #1	BP	WA-142-P	NFW	Regional Endeavour	9.11.82	5.01.83	3 260	P & A
Hangover #1	Home	EP 129	NFW	National 370	21.04.83	12.05.83	1 655	P & A
Perindi #1	ESSO	WA-109-P	NFW	Key Biscayne	10.05.83	12.06.83	1 867	P & A, oil shows
Sundown #2	Home	EP 129	EXT	National 370	16.05.83	12.06.83	1 965	Susp. oil well
Katy #1	Home	EP 129	NFW	National 370	20.06.83	16.07.83	1 952	P & A
Cycas #1	IEDC	EP 102	NFW	National 80 UE	21.06.83	22.08.83	3 019	P & A
Halgania #1	WMC	EP 143	STR	Coremaster 600	17.08.83	5.09.83	500	P & A
Pearl #1	Home	WA-117-P	NFW	Glomar Main Pass III	18.08.83	1.10.83	2 203	P & A
Hakea #1	IEDC	EP 103	NFW	National 370	22.08.83	18.09.83	1 703	P & A
Nita Downs #1	Sydney Oil	EP 142	NFW	National 110	4.09.83	30.09.83	1 849	P & A
Caladenia #1	WMC	EP 225	STR	Coremaster 600	5.09.83	13.09.83	296	P & A
Santalum #1	WMC	EP 225	STR	Coremaster 600	14.09.83		296	P & A
Santalum #1A	WMC	EP 225	STR	Coremaster 600		14.10.83	629	P & A
Olios #1	Gulf	EP 294	NFW	National 80 UE	1.10.83	2.11.83	1 962	P & A
Cow Bore #1	Gulf	EP 114	NFW	National 110	17.10.83	23.12.83	2 940	P & A
Aristida #1	WMC	EP 143	STR	Coremaster 600	18.10.83		216	P & A
Aristida #1A	WMC	EP 143	STR	Coremaster 600		21.11.83	734	P & A
East Crab Creek #1	Gulf	EP 114	NFW	Houston 5000	27.10.83		(1 218)	Drilling susp.
Goodenia #1	WMC	EP 225	STR	Coremaster 600	21.11.83	1.12.83	163	P & A
Eremophila #2	WMC	EP 225	STR	Coremaster 600	1.12.83	6.12.83	360	P & A
Eremophila #3	WMC	EP 225	STR	Coremaster 600	7.12.83	16.12.83	464	P & A
<b>PERTH BASIN</b>								
East Lake Logue #1	Hudbay	EP 100	NFW	Cooper LT 750	16.12.83	28.01.83	2 430	Susp. gas well
Peron #1	Hudbay	EP 100	NFW	Cooper LT 750	1.02.83	26.03.83	2 600	P & A
Rockingham #1	Phoenix	EP 204	NFW	Cooper LT 750	16.05.83	1.06.83	1 563	P & A water well
Depot Hill #1	Mesa	EP 23	NFW	IDFCO H1700	20.06.83	17.07.83	2 473	P & A
Diamond Soak #1	Pancontinental	EP 111	NFW	IDFCO H1700	25.09.83	10.10.83	1 722	P & A
Mt Horner #6	XLX	EP 96	EXT	Cardwell KM250	30.09.83	2.11.83	1 850	P & A
Leander Reef #1	Diamond Shamrock	WA-162-P	NFW	Regional Endeavour	8.11.83		(3 234)	Drilling
Greenough #1	Balmoral	EP 201	NFW	Failing 2 500	5.12.83	11.12.83	445	P & A
<b>OFFICER BASIN</b>								
Kanpa #1A	Shell	EP 178	NFW	PDSA - 840E	4.01.83	24.06.83	3 803	P & A
<b>BROWSE BASIN</b>								
Caswell #2	Woodside	WA-34-P	NFW	Energy Searcher	1.04.83	6.11.83	5 000	P & A, oil shows
Echuca Shoals #1	Woodside	WA-35-P	NFW	Energy Searcher	8.11.83		(3 605)	Drilling
<b>DEVELOPMENT WELLS</b>								
<b>CARNARVON BASIN</b>								
Barrow L78M	WAPET	PL 1H	DEV	OD & E - H35	18.03.83	31.03.83	990	Susp. oil well
Barrow L84M	WAPET	PL 1H	DEV	OD & E - H35	30.04.83	12.05.83	948	Susp. oil well
North Rankin A 01/SE5	Woodside	WA-1-L	DEV	North Rankin A Platform	3.11.83		(3 080)	Drilling
<b>PERTH BASIN</b>								
Woodada #8	Strata	EP 100	DEV	IDECO H1700	22.08.83	18.09.83	2 271	Gas well

## REGISTRATION DIVISION Tenements Applied for — 1982/1983

Mineral Field	No.	Prospecting Licences		Exploration Licences		Mining Leases and Other	
		1982	1983	1982	1983	1982	1983
Greenbushes	01	—	—	1	—	1	14
West Kimberley	04	12	15	35	99	18	29
Ashburton	08	17	158	45	14	1	19
Gascoyne	09	28	80	26	32	3	6
Collie	12	—	—	—	—	—	3
Coolgardie	15	97	750	16	29	34	84
Kunanalling	16	52	255	3	15	9	4
Murchison	20	101	294	20	12	7	9
Day Dawn	21	17	75	5	1	1	3
Broad Arrow	24	113	788	2	12	13	29
Bulong	25	13	319	6	9	2	10
East Coolgardie	26	67	603	4	10	33	41
Kanowna	27	49	299	8	17	8	9
Kurnalpi	28	74	240	25	100	6	3
Menzies	29	78	262	3	15	5	12
Ularring	30	27	296	—	5	1	11
Yerrilla	31	35	292	3	21	17	22
Lawlers	36	7	351	6	34	3	13
Mt Malcolm	37	115	1 080	9	32	20	37
Mt Margaret	38	84	391	13	26	11	38
Mt Morgans	39	50	471	16	39	13	15
Niagara	40	39	239	2	7	6	4
Pilbara	45	116	542	60	288	20	63
Nullagine	46	84	278	17	72	2	22
West Pilbara	47	42	135	78	76	5	11
Meekatharra	51	64	330	13	31	20	20
Peak Hill	52	12	15	41	49	6	23
Wiluna	53	16	225	12	41	6	22
Black Range	57	27	135	13	13	1	27
Mt Magnet	58	36	155	16	6	13	21
Yalgoo	59	56	221	27	50	3	12
Dundas	63	37	244	54	33	16	59
Northampton	66	9	5	—	—	—	2
Warburton	69	—	2	41	15	1	1
South West	70	44	287	64	89	13	189
Phillips River	74	1	42	39	10	2	16
Yilgarn	77	113	576	16	36	13	35
Kimberley	80	39	312	105	285	17	51
<b>Total</b>		<b>1 771</b>	<b>10 822</b>	<b>847</b>	<b>1 623</b>	<b>350</b>	<b>989</b>

### MINING TENEMENT SUMMARY 1974 to 1983



**ADMINISTRATIVE SERVICES DIVISION**  
**Average number of men employed in mining operations**  
**in Western Australia during 1983**

Company	Location	Above Ground	Below Ground	Total
<b>ALUMINA</b>				
Alcoa of Australia	Jarrahdale/Kwinana	1 626	—	1 626
	Del Park/Huntley/Pinjarra	1 545	—	1 545
Worsley Alumina	Wagerup	299	—	299
	Worsley	552	—	552
				4 022
<b>COAL</b>				
Griffin Coal Mining Co Ltd	Collie	473	—	473
Western Collieries Ltd	Collie	344	346	690
				1 163
<b>COPPER-SILVER-ZINC</b>				
Seltrust Mining Corporation Pty Ltd	Teutonic Bore	140	20	160
				160
<b>DIAMOND</b>				
Argyle Diamond Mines Joint Venture	Kimberley	128	—	128
				128
<b>GOLD</b>				
Central Norseman Gold Corp.	Norseman	236	167	403
Gold Resources Pty Ltd	Boulder	74	52	126
Great Boulder Mines (WMC)	Boulder	12	—	12
Hill 50 Gold Mines N L	Mt. Magnet	107	71	178
Horseshoe Lights Gold Mines	Horseshoe	16	—	16
Kia Ora Gold Corporation	Marvel Loch	36	44	80
Kalgoorlie Lake View—Boulder	Boulder	262	331	593
Kalgoorlie Lake View—Mt. Charlotte	Kalgoorlie	27	169	196
Newmount Pty Ltd	Telfer	213	—	213
North Kalgurli Mines Ltd	Boulder	112	137	249
WMC Great Boulder Holdings	Kambalda	37	31	68
WMC Great Boulder Holdings	Windarra	31	57	88
WMC Sand King	Ora Banda	10	—	10
Whim Creek Consolidated	Meekatharra	33	—	33
All other operators	State generally	929	174	1 103
				3 368
<b>IRON ORE</b>				
BHP Minerals Ltd	Yampi	541	—	541
Cliffs Robe River	Pannawonica/Cape Lambert	1 260	—	1 260
Goldsworthy Mining Ltd	Pilbara/Port Hedland	983	—	983
Hammersley Iron Pty Ltd	Tom Price-Paraburdoo/Dampier	3 663	—	3 663
Mt Newman Mining Co Ltd	Newman/Port Hedland	3 473	—	3 473
				9 920
<b>MINERAL BEACH SANDS</b>				
Allied Eneabba Pty Ltd	Eneabba	199	—	199
Cable Sands Pty Ltd	Capel	74	—	74
Associated Minerals Consolidated Ltd	Eneabba	77	—	77
	Capel	108	—	108
Westraillian Sands Ltd	Capel	170	—	170
				628
<b>NICKEL</b>				
Agnew Mining Company Pty Ltd	Leinster	217	83	300
Western Mining Corporation	Kambalda	719	673	1 392
	Kalgoorlie	361	—	361
	Kwinana Refinery	445	—	445
	Mt Windarra	197	130	327
				2 825
<b>PETROLEUM-CRUDE OIL</b>				
West Australian Petroleum Pty Ltd	Barrow Island	136	—	136
	Dongara	9	—	9
Strata Oil N L	Woodada	7	—	7
				152
<b>SALT</b>				
Dampier Salt Ltd	Dampier	189	—	189
	Lake McLeod	104	—	104
Leslie Salt Co	Port Hedland	49	—	49
Shark Bay Joint Venture	Shark Bay	59	—	59
				401
<b>ALL OTHER MINERALS</b> (including Rock Quarries)				
		720	—	720
				720
<b>TOTAL:</b>		<b>21 002</b>	<b>2 485</b>	<b>23 487</b>

Open cut workers classed as above ground.

## Quantity and Value of Minerals Produced During 1982 and 1983 in Western Australia

Minerals	Quantity Unit	1982		1983		Increase or decrease for year compared with 1982	
		Quantity	Value \$	Quantity	Value \$	Quantity	Value \$
Alumina	Tonne	3 676 385	647 822 717	3 983 098	745 084 355	+306 713	+97 261 638
Barytes	Tonne	6 643	281 749	—	—	-6 643	-281 749
Building Stone	Tonne	4 273	96 304	2 951	120 773	-1 322	+24 469
Clay	Tonne	242 971	337 440	219 712	387 811	-23 259	+50 371
Coal	Tonne	3 702 197	87 460 645	3 952 768	99 640 822	+250 571	+12 180 177
Cobalt (by-product of nickel mining)	Tonne	534	5 314 179	477	3 169 424	-57	-2 144 755
Construction Materials							
Aggregate	Tonne	7 836	32 070	5 033	17 486	-2 803	-14 584
Gravel	Tonne	5 470	30 635	60	240	-5 410	-30 395
Rock	Tonne	109 307	218 616	72 474	144 945	-36 833	-73 671
Sand	Tonne	21 673	54 371	125 405	343 272	+103 372	+288 901
Sandstone	Tonne	50	1 250	—	—	-50	-1 250
Copper (by-product of nickel mining)	Tonne	3 390	2 899 106	3 456	4 228 393	+66	+1 329 287
Copper Concentrates	Tonne	61 373	12 491 102	35 745	7 284 455	-25 628	-5 206 647
Diamond	Carat	—	—	6 539 544	68 978 807	+6 539 544	+68 978 807
Felspar	Tonne	1 914	79 613	3 551	35 507	+1 637	-44 106
Garnet Sands	Tonne	3 266	222 726	2 657	92 967	-609	-129 759
Gold	Kilogram	20 757	247 418 210	23 881	359 374 810	+3 124	+111 956 600
Gypsum	Tonne	426 543	4 070 915	439 444	5 500 499	+12 901	+1 429 584
Iron Ore	Tonne	78 182 395	1 495 065 014	74 983 543	1 546 325 341	-3 198 852	+51 260 327
Limestone	Tonne	514 252	1 659 214	345 481	1 686 993	-168 771	+27 779
Manganese	Tonne	74	1 852	—	—	-74	-1 852
Mica	Tonne	300	84 241	173	45 591	-127	-38 650
Mineral Beach Sands							
Ilmenite	Tonne	1 075 861	34 285 775	881 346	25 149 796	-686 831	-9 135 979
Monazite	Tonne	16 236	6 823 064	12 877	5 485 523	-3 359	-1 337 541
Rutile	Tonne	80 199	21 823 610	86 203	20 645 888	+6 004	-1 177 722
Leucoxene	Tonne	15 318	3 047 564	10 193	1 842 513	-5 125	-1 205 051
Zircon	Tonne	297 105	29 324 196	272 391	29 964 159	-24 714	+639 963
Nickel Concentrates	Tonne	457 785	332 138 957	494 007	288 621 810	+36 222	-43 517 147
Nickel Ore	Tonne	98 187	19 411 692	19 399	2 919 743	-78 788	-16 491 949
Palladium (by-product of nickel mining)	Kilogram	416	1 112 023	449	1 963 478	+33	+851 455
Platinum (by-product of nickel mining)	Kilogram	74	933 357	52	863 905	-22	-69 452
Petroleum — Crude Oil	Kilolitre	1 278 000	258 602 636	1 260 801	300 712 136	-17 199	+42 109 500
Petroleum — Natural Gas	10 <sup>3</sup> M <sup>3</sup>	881 154	36 018 694	1 052 738	54 528 779	+171 584	+18 510 085
Petroleum — Condensate	Tonne	2 552	NA	3 170	NA	+618	NA
Salt	Tonne	3 442 159	47 673 788	3 868 254	59 706 681	+426 095	+12 032 893
Semi Precious Stones	Kilogram	6 676	39 907	15 514	73 784	+8 838	+33 877
Silica Sand	Tonne	122 905	115 768	292 003	458 499	+169 098	+342 731
Silver	Kilogram	50 307	10 832 182	25 596	11 077 227	-24 711	+245 045
Spodumene	Tonne	—	—	2 492	464 041	+2 492	+464 041
Talc	Tonne	92 182	NA	164 859	NA	+72 677	NA
Tanto/Columbite Ores & Concentrates	Tonne	20	464 754	272	6 753 268	+252	+6 288 514
Tin Concentrates	Tonne	720	6 275 268	775	7 621 570	+55	+1 346 302
Vanadium	Tonne	167	971 300	—	—	-167	-971 300
Vermiculite	Tonne	429	7 040	56	840	-373	-6 200
Zinc Concentrates	Tonne	101 787	18 709 900	26 455	5 373 969	-75 332	-13 335 931
Totals			3 334 253 444		3 666 690 100		+332 436 656



## Comparison of Royalties Collected in 1982 and 1983

Mineral	Royalty collected		Increase or decrease compared with 1982
	1982	1983	
Aggregate	2 775.50	1 251.70	- 1 523.80
Alumina	5 500 745.27	6 708 516.32	+ 1 207 771.05
Amethyst	2 344.31	5 531.33	+ 3 187.02
Baryte	326.90	—	- 326.90
Building Stone	1 918.79	254.00	- 1 664.79
Chalcedony	1.65	—	- 1.65
Clay	75 993.99	57 786.15	- 18 207.84
Coal	431 029.09	738 422.40	+ 307 393.31
Cobalt	74 400.41	50 772.03	- 23 628.38
Copper	164 462.77	624 097.46	+ 459 634.69
Diamond	—	2 035 244.72	+ 2 035 244.72
Emerald	—	1 841.21	+ 1 841.21
Felspar	2 991.02	209.35	- 2 781.67
Garnet Sand	11 588.85	4 282.10	- 7 306.75
Gold	34 038.57	72 142.92	+ 38 104.35
Gravel	1 737.50	265.50	- 1 472.00
Gypsum	31 887.91	194 216.64	+ 162 328.73
Ilmenite	499 500.73	542 205.70	+ 42 704.97
Iron Ore	67 959 246.04	68 996 584.66	+ 1 037 338.62
Leucoxene	43 243.25	49 979.01	+ 6 735.76
Limestone	210 773.31	142 556.18	- 68 217.13
Magnetite	—	50.55	+ 50.55
Manganese	184.10	—	- 184.10
Mica	5 086.69	2 279.59	- 2 807.10
Monazite	16 516.31	122 255.89	+ 5 739.58
Moss Opal	109.54	2.47	- 107.07
Natural Gas	1 983 827.15	3 211 243.05	+ 1 227 415.90
Natural Gas (condensate)	27 725.27	35 685.63	+ 7 960.36
Nickel	5 033 875.75	3 968 209.42	- 1 065 666.33
Ochre	5.25	—	- 5.25
Oil (crude)	10 865 289.56	15 196 441.55	+ 4 331 151.99
Palladium	7 485.00	10 487.75	+ 3 002.75
Platinum	7 908.73	10 487.75	+ 2 579.02
Rock	31 720.45	16 192.61	- 15 527.84
Rutile	343 134.11	661 662.56	+ 318 528.45
Salt	241 968.97	324 040.98	+ 82 072.01
Sand	4 611.54	22 874.63	+ 18 263.09
Silica Sand	47 266.91	108 597.81	+ 61 330.90
Silver	86 187.90	131 582.58	+ 45 394.68
Spodumene	—	1 225.17	+ 1 225.17
Talc	23 477.96	75 970.00	+ 52 492.04
Tanto-Columbite	43 728.28	78 561.28	+ 34 833.00
Tin	53 833.03	247 045.33	+ 193 212.30
Vanadium	4 740.67	—	- 4 740.67
Vermiculite	195.80	42.00	- 153.80
Xenotime	1 000.79	1 761.05	+ 760.26
Zinc	186 619.28	538 524.75	+ 351 905.47
Zircon	594 561.67	742 613.55	+ 148 051.88
Totals	94 760 066.57	105 733 997.33	+ 10 973 930.76

**Production of Gold and Silver from all Sources Showing in Kilograms the Output as Reported to the Department of Mines during the Year 1983**

Goldfield	District	District						Goldfield						
		Alluvial Kg	Dollied and Specimens Kg	Ore Treated Tonnes	Gold Therefrom Kg	Total Gold Kg	Silver Kg	Alluvial Kg	Dollied and Specimens Kg	Ore Treated Tonnes	Gold Therefrom Kg	Total Gold Kg	Silver Kg	
West Kimberley		—	—	—	—	—	—	—	—	—	—	—	—	—
Kimberley		—	—	—	—	—	—	6.934	.410	—	.197	7.541	.045	—
Pilbara	Marble Bar	38.319	15.343	546 364.00	4 428.829	4 482.491	172.290	—	—	—	—	—	—	—
	Nullagine	1 79.423	4.003	642.00	104.108	287.534	.033	217.742	19.346	547 006.00	4 532.937	4 770.025	172.323	—
West Pilbara		—	—	—	—	—	—	7.828	.623	—	1.951	10.402	.922	—
Ashburton		—	—	—	—	—	—	21.561	2.081	200.00	.369	24.011	.010	—
Gascoyne		—	—	—	—	—	—	.123	.990	412.00	3.974	5.087	—	—
Peak Hill		—	—	—	—	—	—	20.685	2.528	289 753.00	492.630	515.843	.797	—
East Murchison	Lawlers	.943	.021	—	—	.964	—	—	—	—	—	—	—	—
	Wiluna	5.661	2.440	105.00	5.996	14.097	.030	—	—	—	—	—	—	—
	Black Range	5.402	3.599	521.00	121.839	130.840	.045	12.006	6.060	626.00	127.835	145.901	.075	—
Murchison	Cue	34.107	9.685	483.00	1.738	45.530	—	—	—	—	—	—	—	—
	Meekatharra	49.380	4.858	352 813.00	742.727	796.965	.576	—	—	—	—	—	—	—
	Day Dawn	1.630	—	1 440.00	11.215	12.845	.157	—	—	—	—	—	—	—
	Mt Magnet	12.171	5.023	230 832.00	1 082.561	1 099.755	136.516	97.288	19.566	585 568.00	1 838.241	1 955.095	137.249	—
Yalgoo		—	—	—	—	—	—	2.646	1.956	4 929.00	75.472	80.074	9.982	—
Mt Margaret	Mt Morgans	1.825	2.998	918.00	16.288	21.111	.007	—	—	—	—	—	—	—
	Mt Malcolm	15.556	6.388	9 578.00	74.032	95.976	.681	—	—	—	—	—	—	—
	Mt Margaret	14.334	6.551	93 953.00	1 082.465	1 103.350	.172	31.715	15.37	104 449.00	1 172.785	1 220.437	.860	—
North Coolgardie	Menzies	1.510	.552	1 723.00	34.844	36.906	.485	—	—	—	—	—	—	—
	Ularring	—	—	6 702.00	20.892	20.892	.638	—	—	—	—	—	—	—
	Niagara	.853	.069	360.00	6.815	7.737	—	—	—	—	—	—	—	—
	Yerilla	1.714	—	402.00	2.897	4.611	—	4.077	.621	9 187.00	65.448	70.146	1.123	—
Broad Arrow		—	—	—	—	—	—	1.897	.120	87 985.00	463.707	465.724	.882	—
North East Coolgardie	Kanowna	3.780	.820	276.00	19.043	23.643	—	—	—	—	—	—	—	—
	Kurnalpi	4.576	.163	298.00	1.997	6.716	.208	8.356	.983	574.00	21.020	30.359	.208	—
East Coolgardie	East Coolgardie	26.000	4.304	1 884 815.00	8 805.465	8 835.765	1 208.758	—	—	—	—	—	—	—
	Bulong	.173	1.509	594.00	15.162	16.844	—	26.173	5.813	1 885 409.00	8 820.27	8 852.613	1 208.758	—
Coolgardie	Coolgardie	5.364	3.993	593 913.00	3 659.519	3 068.876	370.573	—	—	—	—	—	—	—
	Kunanalling	9.670	—	645.00	6.654	16.324	.046	15.034	3.993	594 558.00	3 066.173	3 085.200	370.619	—
Yilgarn		—	—	—	—	—	—	3.759	2.741	61 142.00	452.119	458.619	160.620	—
Dundas		—	—	—	—	—	—	.459	.596	252 119.00	2 165.481	2 166.46	475.192	—
Phillips River		—	—	—	—	—	—	.023	.095	—	—	.118	—	—
South West Mineral Field		—	—	—	—	—	—	—	.367	4 270.00	7.013	7.380	—	—
Northampton Mineral Field		—	—	—	—	—	—	—	—	—	—	—	—	—
State Generally		—	—	—	—	—	—	5.508	4.294	—	—	9.802	—	—
Outside Proclaimed Goldfield		—	—	—	—	—	—	—	—	—	—	—	—	—
Totals								483.814	89.120	4 428 187.00	23 307.89	23 880.23	2 539.665	—

### Quantity and value of minerals reported during the year 1983

Mineral and Producer	Centre	Goldfield or Mineral Field	Quantity Tonnes	Metallic Content	Value \$
<b>Alumina</b>					
Alcoa of Australia (W.A.) Ltd	Del Park	South West	2 561 130		479 171 322
Alcoa of Australia (W.A.) Ltd	Jarrahdale	South West	1 421 968		265 913 033
			3 983 098		745 084 355 (l)
<b>Coal</b>					
Griffin Coal Mining Co. Ltd.	Muja	Collie	2 216 328		50 084 465
Western Collieries Ltd	Western	Collie	1 736 440		49 556 357
			3 952 768		99 640 822 (e)
<b>CONSTRUCTION MATERIALS</b>					
<b>Aggregate</b>					
Calsil Ltd	Port Hedland	Pilbara	1 739		6 608
D.C. McAulley	Onslow	Ashburton	210		2 730
J. Stove	Roebourne	West Pilbara	3 084		8 148
			5 033		17 486 (c)
<b>Gravel</b>					
R.G. Harvey	Kununurra	Kimberley	60		240 (c)
<b>Rock</b>					
Specified Services Pty Ltd	Mt. Regal	West Pilbara	72 474		144 945 (c)
<b>Sand</b>					
Calsil Ltd	Port Hedland	Pilbara	3 177		12 026
Clackline Refractories Ltd	Clackline	South West	53		106
Cottiers Pty Ltd	Port Hedland	Pilbara	2 435		33 306
Specified Services Pty Ltd	Maitland	West Pilbara	14 234		28 334
Jones D.	Derby	West Kimberley	180		900
Marathon Roofing Pty Ltd	Jandakot	South West	52 962		52 064
The Readymix Group (W.A.)	Karratha	West Pilbara	23 882		128 246
The Readymix Group (W.A.)	Widgiemooltha	Coolgardie	25 183		76 808
The Readymix Group (W.A.)	Turner River	Pilbara	3 328		11 482
			125 405		343 272 (c)

**BUILDING STONE****Quartz**

Snowstone Pty Ltd	Mukinbudin	South West	2 503	112 815
<b>Quartzite</b>				
House R.P.	Toodyay	South West	448	7 958
			2 951	120 773 (a)(c)

**CLAYS****Cement Clay**

Bell Bros. Pty Ltd	Armadale	South West	20 082	50 205
--------------------	----------	------------	--------	--------

**Fire Clay**

Midland Brick Co. Pty Ltd	Bullsbrook	South West	151 644	181 971
Clackline Refractories Ltd	Clackline	South West	910	1 820

**White Clay — Ball Clay**

Bristile Ltd	Goomalling	South West	994	11 500
Bristile Ltd	Jarrahdale	South West	44 766	134 298

**Kaolin**

Universal Milling Co. Pty Ltd	Mt. Kokeby	South West	169	1 014
-------------------------------	------------	------------	-----	-------

**Alunite**

R.C. Sadlier Pty Ltd	Lake Chandler	Yilgarn	1 147	7 003
			219 712	387 811 (a)(c)

**COBALT**

(Metallic by-product of Nickel Mining) (g)

Western Mining Corporation	Kambalda	Coolgardie	426.176	2 703 814
Agnew Mining Co. Pty Ltd	Leinster	East Murchison	50.905	465 610
			477.081	3 169 424 (f)

**COPPER**

(Metallic by-product of Nickel Mining) (g)

Western Mining Corporation	Kambalda	Coolgardie	3 115.757	3 856 323
Agnew Mining Co. Pty Ltd	Leinster	East Murchison	340.593	372 070
			3 456.350	4 228 393 (f)

**COPPER CONCENTRATES (G)**

Selstrust Mining Corporation Pty Ltd	Teutonic Bore	Mt. Margaret	35 745	7 284 455 (b)
--------------------------------------	---------------	--------------	--------	---------------

Mineral and Producer	Centre	Goldfield or Mineral Field	Quantity Tonnes	Metallic Content	Value \$
<b>DIAMOND</b>					
Argyle Diamond Mines Pty Ltd	Kununurra	Kimberley		Carats 6 539 544	68 978 807 (b)
<b>FELDSPAR</b>					
Snowstone Pty Ltd	Mukinbudin	South West	3 297		31 320 (a)
Universal Milling Co. Pty Ltd	Londonderry	Coolgardie	254		4 187
			3 551		35 507 (a)
<b>GARNET SANDS</b>					
Target Minerals N.L.	Port Gregory	South West	2 657		92 967 (a)
<b>GOLD</b>					
			Ore Treated Tonne	Kg.	
Newmont Holdings Pty Ltd	Telfer	Pilbara	543 854	4 370.883	65 775 734
Kalgoorlie Lake View Pty Ltd (Mt Charlotte)	Kalgoorlie	East Coolgardie	829 956	3 740.008	56 281 939
Western Mining Corp.	Kambalda	Coolgardie	569 390	2 517.108	37 878 989
Kalgoorlie Lake View Pty Ltd	Boulder	East Coolgardie	367 240	2 075.316	31 230 631
Central Norseman Gold Corp.	Norseman	Dundas	184 387	2 054.796	30 921 833
North Kalgurli Mines Ltd	Boulder	East Coolgardie	401 595	1 570.527	23 634 256
Western Mining Corp.	Lancefield	Mt. Margaret	93 505	960.596	14 455 639
Hill 50 Gold Mines N.L.	Mt. Magnet	Murchison	180 951	881.577	13 266 513
Great Boulder Mines — WMC	Boulder	East Coolgardie	129 775	721.146	10 852 248
Whim Creek Consolidated N.L.	Meekatharra	Murchison	345 658	702.523	10 571 998
Gold Resources Pty Ltd	Boulder	East Coolgardie	141 179	595.972	8 968 553
Kia Ora Gold Corp.	Marvel Loch	Yilgarn	54 661	378.477	5 695 555
Western Mining Corp. — Sand King	Ora Banda	Broad Arrow	79 284	376.387	5 664 103
Horseshoe Lights Gold Pty Ltd	Horseshoe	Peak Hill	269 667	316.004	4 755 422
Western Mining Corp. (ex Nickel Mining)	Kambalda	Coolgardie	—	274.789	4 135 194
Minor Producers		State Generally	237 065	*2 344.814	35 286 203
			4 428 167	*23 880.923	359 374 810
* Includes alluvial, dollied and specimens, gold obtained from tailings treatment, gold contained in exported gold bearing material.					
<b>GYPSUM</b>					
Agnew Clough Ltd	Shark Bay	Gascoyne	163 590		2 817 640 (b)
E.M. & E. J. Fitzgerald	Hines Hill	South West	3 035		3 642 (a)
H.B. Brady Pty Ltd	Lake Brown	Yilgarn	23 158		57 896 (a)
McAndrew R.W.	Yelbini	South West	14 862		46 290 (a)
P.F. & R.S. Nixon	Lake Hillman	South West	778		3 839 (a)
Southern Asiatic Enterprises Pty Ltd	Norseman	Dundas	199 454		2 209 651 (b)
Swan Portland Cement Ltd	Lake Hillman	South West	11 848		285 206 (c)
West Australian Plaster Mills	Yellowdine	Yilgarn	22 719		76 335 (a)
			439 444		5 500 499
Plaster of Paris reported as manufactured during the year. 33 133 tonnes from 47 754 tonnes of Gypsum by 2 companies.					

**IRON ORE**

**Ore railed to Kwinana**

B.H.P. Minerals Ltd	Koolyanobbing	Yilgarn	*282 608	Av. Assay Fe% 63.00	3 108 688 (n)
---------------------	---------------	---------	----------	------------------------	---------------

**Ore Shipping Interstate**

Mt. Newman Mining Co. Pty Ltd	Mt. Whaleback	Peak Hill	4 342 523	64.00	77 486 104 (b)
B.H.P. Minerals Ltd	Cockatoo Island	West Kimberley	475 256	68.78	5 227 926 (b)
B.H.P. Minerals Ltd	Koolan Island	West Kimberley	318 854	66.84	3 507 394 (b)

**Ore exported overseas**

B.H.P. Minerals Ltd	Koolan Island	West Kimberley	2 215 960	67.00	49 159 239 (b)
Mt. Newman Mining Co Ltd	Mt. Whaleback	Peak Hill	18 203 684	63.00	410 746 062 (b)
Hamersley Iron Pty Ltd	Mt. Tom Price	West Pilbara	31 272 604	63.12	676 631 632 (b)
Cliffs W.A. Mining Co. Pty Ltd	Pannawonica	West Pilbara	13 001 535	57.27	211 132 764 (b)
Goldsworthy Mining Ltd	Mt. Goldsworthy	Pilbara	4 870 519	62.29	109 325 532 (b)

74 983 543	1 546 325 341
------------	---------------

\* Includes 281 658 tonnes shipped interstate.

**LIMESTONE**

(For building, burning and agricultural purposes)

Bell Bros. Pty Ltd	Wanneroo	South West	38 717		38 717
Bell Bros. Pty Ltd	Wanneroo	South West	984		984
Bellombra V.	North Wanneroo	South West	2 068		20 680
Swan Portland Cement Ltd	Wanneroo	South West	44 546		267 053
Swan Portland Cement Ltd	Wanneroo	South West	53 820		318 506
Swan Portland Cement Ltd	Jandakot	South West	167 814		903 063
Swan Portland Cement Ltd	Yanchep	South West	1 664		8 835
Wolfe S.H.	Bornholm	South West	513		2 808
Unspecified Producers	—	South West	26 440		117 432
Specified Services Pty Ltd	Cleaverville	West Pilbara	8 915		8 915

345 481	1 686 993 (c)
---------	---------------

**MICA**

Pilbara Mica Corporation Pty Ltd	Pippingarra	Pilbara	173		45 591 (b)
----------------------------------	-------------	---------	-----	--	------------

**MINERAL BEACH SANDS**

**Ilmenite (g)**

Associated Minerals Consolidated Ltd	Capel	South West	93 275	Av. Assay ThO <sub>2</sub> 55.00	} 25 149 796 (b)
Cable Sands Pty Ltd	Capel	South West	254 362	54.99	
Western Mineral Sands Pty Ltd	Capel	South West	124 351	54.00	
Westralian Sands Ltd	Yoganup	South West	155 778	55.00	
Allied Eneabba Pty Ltd	Eneabba	South West	223 928	60.15	
Associated Minerals Consolidated Ltd	Eneabba	South West	19 708	60.00	
			871 302		

**Upgraded Ilmenite (g)**

Associated Minerals Consolidated Ltd	Capel	South West	10 044	92.00
--------------------------------------	-------	------------	--------	-------

Mineral and Producer	Centre	Goldfield or Mineral Field	Quantity Tonnes	Metallic Content	Value \$
<b>Rutile (g) (h)</b>					
Allied Eneabba Pty Ltd	Eneabba	South West	58 987	TiO <sub>2</sub> Tonnes 56 424	13 791 208
Associated Minerals Consolidated Ltd	Eneabba	South West	27 306	25 938	6 854 680
			86 203	82 362	20 645 888 (b)
<b>Leucoxene (g) (h)</b>					
Associated Minerals Consolidated Ltd	Capel	South West	158	TiO <sub>2</sub> Tonnes 142	33 600
Westralian Sands Ltd	Yoganup	South West	9 981	8 984	1 793 943
Cable Sands Pty Ltd	Capel	South West	54	49	14 970
			10 193	9 175	1 842 513 (b)
<b>Monazite (g) (h)</b>					
Cable Sands Pty Ltd	Capel	South West	702	TiO <sub>2</sub> Units 3 921	301 860
Westralian Sands Ltd	Yoganup	South West	1 403	8 455	554 419
Associated Minerals Consolidated Ltd	Capel	South West	781	5 076	321 739
Allied Eneabba Pty Ltd	Eneabba	South West	9 649	61 495	4 167 375
Associated Minerals Consolidated Ltd	Eneabba	South West	342	2 207	140 130
			12 877	81 154	5 485 523 (b)
<b>Zircon (g) (h)</b>					
Cable Sands Pty Ltd	Capel	South West	9 824	ZrO <sub>2</sub> Tonnes 6 400	1 074 942
Westralian Sands Ltd	Yoganup	South West	34 258	22 266	3 679 394
Associated Minerals Consolidated Ltd	Capel	South West	9 395	6 595	1 063 704
Associated Minerals Consolidated Ltd	Eneabba	South West	77 779	51 333	8 789 568
Allied Eneabba Pty Ltd	Eneabba	South West	141 135	91 510	15 356 551
			272 391	178 104	29 964 159 (b)
<b>NICKEL CONCENTRATES</b>					
Western Mining Corporation	Kambalda	Coolgardie	344 181	Av. Assay Ni% 11.81	196 558 488
Western Mining Corporation	Carnilya Hill	East Coolgardie	27 685	12.53	17 000 724
Agnew Mining Co. Pty Ltd	Leinster	East Murchison	78 436	14.25	56 514 967
Western Mining Corporation and Shell Co. of Australia	Windarra	Mt. Margaret	43 705	8.67	18 547 631
			494 007		288 621 810 (o)
<b>NICKEL ORE</b>					
Metals Exploration Ltd	Nepean	Coolgardie	19 399	Av. Assay Ni% 3.40	2 919 743 (c)
<b>PALLADIUM (g)</b>					
(Metallic by-product Nickel Mining)				kg	
Western Mining Corporation	Kambalda	Coolgardie		449.398	1 963 478 (f)

**PLATINUM (g)**(Metallic by-product Nickel Mining)  
Western Mining Corporation

Kambalda

Coolgardie

kg  
52.480

863 905 (f)

**PETROLEUM****Crude Oil**West Australian Petroleum Pty Ltd  
West Australian Petroleum Pty Ltd  
Home Energy Company Ltd  
Pacific Basin Exploration Pty LtdBarrow Island  
North Perth Basin  
Blina  
Mt. HornerAshburton  
South West  
West Kimberley  
South West

Kilolitres

1 249 919

10 757

—

125

298 329 613 (m)

2 361 968 (q)

—

20 555 (q)

1 260 801

m<sup>3</sup>10<sup>3</sup>

879 561

173 177

300 712 136

41 783 962

12 744 817

**Natural Gas**West Australian Petroleum Pty Ltd  
Strata Oil N.L.North Perth Basin  
WoodadaSouth West  
South West

1 052 738

Tonnes

2 191

979

54 528 779 (p)

N.A.

N.A.

**Condensate**West Australian Petroleum Pty Ltd  
Strata Oil N.L.North Perth Basin  
WoodadaSouth West  
South West

3 170

**SALT**State Total  
Reported to Mines  
Department

3 868 254

59 706 681 (r)

**SEMI-PRECIOUS STONES****Amethyst**

Soklich F.

Gascoyne

Gascoyne

kg

15 463

73 751

**Moss Opal**

Soklich F.

Norseman

Dundas

51

33

73 784

**SILICA SAND**Australian Glass Manufacturers  
Ready Mix Group (W.A.)  
Bell Basic Industries Ltd  
Western Mining CorporationLake Gnangara  
Jandakot  
Jandakot  
Douglas LakeSouth West  
South West  
South West  
East Coolgardie

26 741

38 168

85 718

141 376

112 079

N.A.

N.A.

346 420

292 003

458 499 (c)

**SILVER**Seltrust Mining Corporation Pty Ltd  
By-Product of Gold Mining  
By-Product of Nickel Mining

Teutonic Bore

Mt. Margaret

kg

21 407.747

3 839.626

348.901

9 719 086

1 229 362

128 779

25 596.274



Mineral and Producer	Centre	Goldfield or Mineral Field	Quantity Tonnes	Metallic Content	Value \$
<b>SPODUMENE</b>					
Greenbushes Tin N.L.	Greenbushes	Greenbushes	2 491.71	Li <sub>2</sub> O <sub>2</sub> Tonnes 174.23	464 041 (b)
<b>TALC</b>					
Three Springs Talc Pty Ltd	Three Springs	South West	141 136		N.A.
Westside Mines N.L.	Mt. Seabrook	Peak Hill	23 723		N.A.
			164 859		N.A.
<b>TANTO-COLUMBITE ORES AND CONCENTRATES (g)(h)</b>					
				Ta <sub>2</sub> O <sub>5</sub> kg	
Greenbushes Tin N.L.	Greenbushes	Greenbushes	160.30	72 261	4 029 994
Goldrim Mining Australia Ltd	Wodgina	Pilbara	5.26	2 190	119 959
Kincora Pty Ltd	Western Shaw	Pilbara	27.22	7 731	426 275
Pilgan Mining Pty Ltd	Pilgangoora	Pilbara	79.64	32 317	2 177 040
			272.42	114 499	6 753 268 (b)
<b>TIN CONCENTRATES</b>					
				Sn Tonnes	
Greenbushes Tin N.L.	Greenbushes	Greenbushes	491.98	344.40	5 000 556
D.N. & L.E. Hart	Abydos	Pilbara	4.39	2.93	36 370
Endeavour Resources Ltd	Moolyella	Pilbara	216.17	157.62	2 005 550
Kincora Pty Ltd	Western Shaw	Pilbara	62.30	44.38	579 094
			774.84	549.33	7 621 570 (b)
<b>VERMICULITE</b>					
Vermiculite Industries Pty Ltd	Young River	Phillips River	56		840 (a)
<b>ZINC CONCENTRATES</b>					
Seltrust Mining Corporation Pty Ltd	Teutonic Bore	Mt Margaret	26 455	Zn Tonnes 13 158	5 373 969 (b)

VALUE OF MINERALS .....\$3 307 315 290

VALUE OF GOLD.....359 374 810

TOTAL .....\$3 666 690 100

REFERENCES:

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 prices 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 of nickel containing products.

(p) Nominal price at well head.

(q) Nett well head value.