Department of Mines
Western Australia

ANNUAL REPORT
1985/86

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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 period July 1985 to June 1986, together with reports from officers controlling Divisions, and tables and diagrams showing progress of the Mining Industry.

D.R. KELLY
Director General of Mines

Perth, 1986

CONTENTS

With an accompanying volume ''Digest of mineral production and other statistics 1985/86.''

HIGHLIGHTS

● In January 1986 oil production commenced from the Harriet Oil Field and is now averaging 1 300 kilolitres per day. Although small by world standards, the field is expected to have a life of 10 years and will contribute significantly to WA's energy needs.

Drill floor view of well-test flare during development of the Harriet Field.

● The North West Gas Development Agreement for the $9.8 billion liquefied natural gas phase of the North West Shelf Project was announced in August 1985. This is probably the largest single project yet undertaken in Australia. The 20-year sale and purchase agreement between the joint venturers and Japanese utilities requires annual exports to reach six million tonnes by the mid-1990s. Start up is expected in October 1989.

● Iron ore royalties exceeded $100 million in one year for the first time as a result of a combination of a favourable exchange rate and finalization of royalty payments from previous years.

● Construction of a new synthetic rutile plant was commenced by AMC near Geraldton; the North Capel ilmenite upgrade plant of Westralian Sands was nearly completed and is expected to begin production in early 1987.

● May 19, 1986 marked the centenary of the declaration of Western Australia's first goldfield — the Kimberley Goldfield — now better known for its diamond production. To commemorate this event, "A Century of Gold" was adopted as the theme for Western Australia Week beginning June 1.

● Some 21 new gold mines commenced operations during the year. Most are small to medium sized open-cut mines working lower grade ores from around previously worked higher grade lode systems but the Paddington (2 800kg gold per year) and Harbour Lights 2 500kg gold per year) mines are notably larger.

- Gold production reached its highest level since 1910 achieving an annual production value of $707 million. Gold is now third after iron ore and alumina on the State's table of annual value of mineral production.

- The most significant new gold discovery announced during the year was that near Boddington, only 100km southeast of Perth. With a potential annual production of over 5 000kg of gold this will become one of the largest gold producers in the State.

- Construction of Mineral House stage 2, to provide centralized accommodation for Departmental staff currently located in five separate external locations, began in October 1985. By June 1986 the elevator core and two service cores were half complete.

- The total annual value of iron ore production approached $2 billion (Aus $1 965 666 843), despite a 4 million tonne reduction in ore shipped.

- State royalty revenue at $163 million was some 24 per cent higher than in the previous year. The increase was almost entirely due to two commodities, iron ore and petroleum products.

- Uranium mineralization, described as "highly promising" by discoverer CRA, was found some 60km south of the Telfer gold mine and 50km southeast of the Nifty base metal prospect, at a locality named Kintyre. This further enhances the prospectivity of the Paterson Province.

- The plant to treat ore from the Argyle AK1 diamondiferous lamproite pipe was commissioned on 1 December 1985. Diamond production rose from 5.6 million carats in 1984/85 to 17.5 Mcts in 1985/86 and is expected to increase to around 25 Mcts annually within the next few years.

Tertiary cone crushers and screens at the Argyle Mine treatment plant (November 1985 photo, reproduced with permission of Argyle Diamond Mines Pty Ltd).

GOLD — Centenary of discovery in W.A.

The first commercial find of gold in Western Australia was made on 14 July 1885 at Hall's Creek in the Kimberley District, and the Kimberley Goldfield was proclaimed in the following year, on 19 May 1886. This discovery, and the dramatic rush that followed, marked the beginning of our gold-mining industry, which was to transform Western Australia over the next 15 years from an impoverished colony into a wealthy State. The centenary of the industry in 1985 coincides with a time when gold is again the most buoyant element in our mining industry, with expanding exploration and production, and excellent prospects for the future.

The Kimberley gold story began with the exploring expedition of Alexander Forrest in 1879. He traversed the district from west to east into the Northern Territory, and on reaching the Pine Creek gold-mining settlement commented to the manager of the mine, Adam Johns, on similarities between the rocks at Pine Creek and some of those seen by his party in the Kimberleys. This inspired Johns to mount an expedition to the area, with his mate Phil Saunders as leader, the others selected for the party being James Quinn, and Crawford (an Aborigine).

Saunders and Johns chartered a cutter from Port Darwin to Cossack, arriving there on 26 July 1881. The party found some signs of gold at Nickol River, 19 miles south west of Roebourne, and on the Ashburton River, but neither find was considered payable. They also found copper mineralisation at Whim Well (now Whim Creek) and Balla Balla, before returning to Roebourne and setting out for the Kimberleys on 11 April 1882.

During their journey through the Kimberleys in August-September 1882, Saunders' party observed signs of gold at several localities, the best being in the headwater tributaries of the Ord River, in the general vicinity of the present Halls Creek. However, there was a lack of water in this area to allow adequate panning for gold, and by that time Johns had become seriously ill, and was barely able to see or walk. He developed a form of paralysis, and it became imperative to push through to the Northern Territory as rapidly as possible so that he could be treated. Consequently Saunders was unable to prove whether the gold he had found in the East Kimberley was workable.

The news of Saunders' find reached the press, and the Colonial Secretary in Perth telegraphed him to obtain confirmation. Saunders replied by telegram dated 19 November 1882 from Yam Creek in the Northern Territory, announcing that he had "found gold on head watershed of Ord River, not payable. Believe payable gold exists, auriferous country extends north west and south east of Forrest's track".

Saunders' telegram aroused considerable interest in the Government, and there was debate as to the best means of following up his report of gold. One suggestion was that the Government should secure the services of a geologist to accompany the survey team that was to visit Kimberley in the following winter. The other was that Saunders lead a prospecting expedition to the area, and the Colonial Secretary wrote asking if he was prepared to do so. He responded with a detailed proposal for a party to prospect throughout the Kimberley. The reaction to this proposal is not recorded, but it seems clear that his plans involved a greater expenditure than the Government was willing to incur. It was instead decided to secure the services of a geologist to accompany the Kimberley survey party, and Edward T Hardman was selected for this purpose.

Hardman was born on 6 April 1845 at Drogheda, Ireland. He graduated in mining from the Royal College of Science, Dublin, and was appointed as a geologist in the Geological Survey of Ireland in 1870. When the need arose for a temporary Government Geologist to be appointed to Western Australia, the Colonial Office chose Hardman for the position. He arrived in Perth in March 1883, just in time to join a new Kimberley survey party led by John Forrest.

This survey was confined to the West Kimberley district, and Hardman found no positive signs of gold there. The following year (1884) he participated in H F Johnston's survey, which covered an extensive area from the West to the East Kimberley. Hardman panned traces of gold in many watercourses in parts of the East Kimberley, distributed over about 230 km along the Elvire, Panton, Ord, Mary, and Margaret Rivers. He claimed that the auriferous country covered an area of some 5 000 km^2, and found the most encouraging indications along the headwaters of the Elvire River, where there were also many potentially auriferous quartz veins.

In his report on the 1884 expedition, Hardman complained that he had received little assistance in his work, as the surveying aspect of the expedition had priority. "But had I had even two men to assist me, and render me independent, for a few days at a time.I believe I should now be able to report definitely as to the existence of payable gold in Kimberley, whereas I can at present only point to the strong probability of this".

Hardman's report and accompanying maps aroused great interest, and several prospecting parties set out for Kimberley in early 1885. One of these, with Charles Hall as leader, accompanied by John Slattery, Alexander Nicholson, Joseph McCague, John Campbell, and August Pontt, left Roebourne for Derby in February 1885. From Derby they headed due east for the headwaters of the Ord River, and on 14 July 1885 obtained their first payable gold (about 10 oz in nuggets) at what they named Hall's Creek. Hall and Slattery then left the rest of the party and returned to Derby, where on 8 August 1885 they formally reported the discovery to the Government Resident, Mr Fairbairn, before proceeding to Perth to inform the Colonial Secretary.

The discovery of payable gold by Hall's party was in an area shown on Hardman's map near the head of the

Elvire River, where Hardman recorded finding widespread traces of gold in alluvium, associated with many potentially auriferous quartz veins. It is not certain whether Hall had access to Hardman's map of the area, although this does seem probable, in which case it should have led him directly to the area of the discovery.

As soon as the Hall's Creek discovery became known the Kimberley gold rush began, well before the goldfield was formally proclaimed on 19 May 1886. The rush of prospectors from the southern parts of Western Australia, the eastern colonies, and New Zealand, reached its peak in mid-1886. Most arrived by sea at Derby, and then had to embark on a slow and hazardous trip of nearly 600 km to Halls Creek, commonly travelling all the way on foot. Others landed at Wyndham, and although their overland trip was shorter (about 400 km), the track was rougher and harder on men, horses, and equipment. Others again arrived overland through the Northern Territory, from as far away as Victoria.

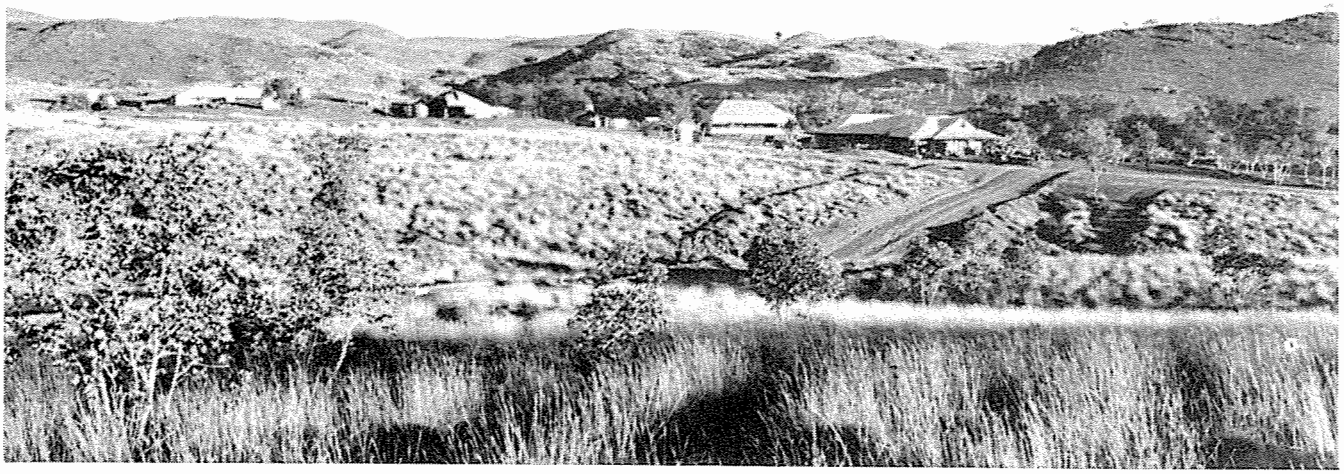
Of the estimated 6 000 to 8 000 men who arrived at the ports, many were ill-prepared for the remainder of the journey to Halls Creek, and had to turn back because of illness, fatigue, the breakdown of overloaded carts, or the death of their horses. Equipment and stores were often jettisoned beside the track, so that most people arrived at the gold diggings with inadequate equipment and stores for a prolonged stay. The majority of those who joined the rush had no previous experience in gold prospecting. They were ill-prepared for the privations of life in the outback Kimberley, far from the comforts of home. There were also many clashes with the Aborigines, commonly with spearing of diggers followed by reprisal raids on the blacks.

Illness and disease at the diggings were rife, and the First Warden, C D Price, who arrived on 3 September 1886, reported that "great numbers were stricken down, in a dying condition, helpless, destitute of either money, food, or covering, and without mates or friends, simply lying down to die." Further, on 10 December 1886, he reported that "a large number of deaths have occurred lately, fever, dysentry, scurvy, and general debility....being the cause."

By early 1887 the rush had virtually ceased, and by February the numbers of men on the field had dwindled to about 600. However, Warden Price maintained that there was still a bright future for the goldfields through underground mining of gold-bearing reefs. He stated in his annual report that "there is every reason to expect a prosperous future at no distant date." Price said further that "the whole of the miners are enthusiastic in the praise of Mr Hardman; ....every case when he has marked on his plan that auriferous deposits would be found....the result has proved the correctness of his opinion. Nowhere else have they found more than colours. I am sure it would be gratifying to Mr Hardman did he know in what estimation his plans and report are held by practical miners and how desirous they are to obtain them."

However, despite the early promise of several underground mines, Halls Creek never prospered. The mines did not live up to expectations, as the ore petered out at depth. The peak year for gold production was 1887, amounting to 4 474 ounces, and from 1890 the field went into steady decline, with production falling to 892 ounces in 1896 (the figures quoted being for unrefined gold bullion). Total production to 1896 was 23 373 ounces (unrefined), compared with a total to 1985 of only 30 763 fine ounces (refined), or about 38 500 bullion ounces (unrefined). This is a mere 0.04 percent of the State's total gold production to 1985.

Even though the Kimberley field was never more than a minor gold producer, its discovery and development marked the foundation of our gold-mining industry, and as such, constitutes one of the turning points in the history of Western Australia. The Kimberley gold rush drew world attention to the colony and its gold prospects; many of the diggers who joined this rush afterwards moved on to take part in the successive major gold discoveries at Southern Cross and the Pilbara (1888), the Murchison (1891), Coolgardie and Dundas (1892), and Kalgoorlie (1893), which were to have such a profound effect on Western Australia's economy.

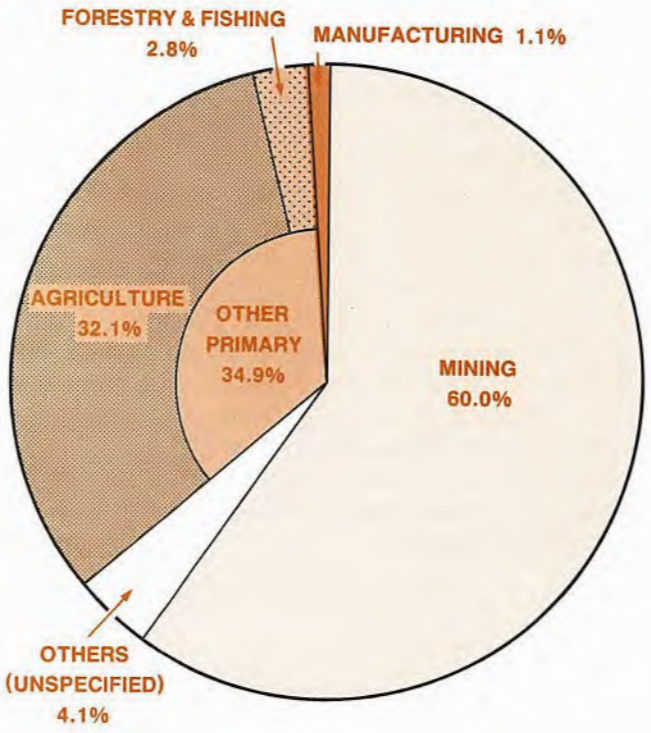


Halls Creek, photographed in the 1950s just before the new township some 13 km away was occupied. (Battye Library photo 1585B/1; reproduced with permission of West Australian Newspapers Ltd.)

The mining and mineral processing industry

Performance and outlook

Much has been said and written recently regarding the dramatic down-turn in the price of Australia's export-commodity prices and the unfavourable balance of trade. In the case of Western Australia, while there have been major down-turns, most notably in nickel and tin-tantalum, these have to a certain degree been offset by significant rises in gold and mineral sands and by the benefits of the devaluation of the Australian dollar. It is very important for the State that mineral exports remain comparatively healthy as they now make up about 60 percent of W.A.'s total overseas exports.



It is significant that the value of mineral production in W.A. reached $5 235 million, passing the $5 billion mark for the first time.

The current depressed metal and mineral commodity prices have resulted from a combination of a fall in the rate of growth in demand and an increase in the supply of many commodities. Fundamental changes are occurring which may be separate from the normal cyclical nature of supply and demand within the minerals industry, an industry which has failed to take part in World economic recovery. The major industrial nations such as Japan and the United States have, apparently, reached that level of maturity where economic growth is more in the services sector and and less in the metal-consuming manufacturing sector. At the same time many of the developing countries are (hopefully temporarily) so crippled by debt that their growth has been stalled. Additionally, a growing trend is for lighter, thinner, and stronger products to do the same work as the heavy metal products of the past, together with significant substitution of nonmetal 'high technology' products, such as optic fibre for copper wire in the communication industry.

These major changes mean that this State's already highly efficient mining industry will need to become even more competitive if it is to maintain its share of World markets.

The problems of the mining industry within Australia have been aggravated by the woefully inadequate returns on investment. Recent figures, for 1984/85, produced by the Australian Mining Industry Council show that from each dollar of sales, approximately 39 cents was paid to suppliers, 19 cents to employees as wages, 17 cents to Government in tax, royalties and fees, 13 cents on depreciation, 7 cents on interest on borrowings and only 4.6 cents to shareholders.

The industry can only overcome its immediate problems by significant rationalisation and cost-cutting. An example of this during the year has been the closure of the higher-cost mines at Kambalda, and increasing production from the more efficient shafts.

Another important need is for investment in new technology and secondary mineral processing to increase the 'value added' to the industry's and thus the State's exports. An excellent example of this is the investment in synthetic rutile and zirconia plants.

Labour and government also have an important part to play in helping to maintain the viability of the industry, by accepting and aiding in changes to practices, charges, and regulations which impose unnecessary costs and hinder flexibility.

A matter of considerable concern to the Department is the increasing, and often unreasoned, pressure being exerted by some conservationists on mineral exploration and mining operations. No doubt there is a need for adequate safeguards to ensure that any damage to the environment resulting from mining is minimized. However, any activity by Man will have some effect on the environment, and this has to be accepted as a trade-off for economic development. The environmental consequences of mining activity are clearly less than those of agriculture, the pastoral industry, and urban development; moreover, mining disturbs only 0.01 percent of the land surface of Australia, much less than the other activities mentioned. The mining industry has become increasingly aware of its responsibilities in environmental protection, and it has played a leading role in the last 15 years in developing restoration and rehabilitation techniques.

There are hopeful signs that the community, industry, and responsible conservationists are moving towards the middle ground on environmental issues, which will allow development to proceed with appropriate, but not excessive, measures to protect and rehabilitate the environment.

While there will undoubtedly be some tough and unpleasant economic times in the short term, the medium- to long-term outlook is considerably more optimistic. The mining industry should emerge leaner and more efficient and ideally situated to capitalise on the growth of the World's developing economies, most notably in the newly industralising countries of Asia. The population composition and numbers in these countries means that they will eventually consume more metal per unit of growth than, and offset the decline in usage in, the developed countries. It is in these markets that the industry's and thus the State's future prosperity lies.

Mineral exploration and development

Minerals. Expenditure on mineral exploration within Western Australia during 1984/85 (the last period for which full figures are available), increased by 2.5 percent to $189.8 million (around half of the total Australian expenditure). By far the most significant expenditure was on gold, which at $111 million represented almost 60 percent of the total.

Several significant new mines began production during 1985/86. Notable are Paddington (2 800 kg of gold per annum) and Harbour Lights (2 500 kg of gold per annum). Production of the Kambalda gold operations rose to 4 300 kg per annum.

The most significant new discovery announced during the year was that of Boddington, which, with a potential production of over 5 000 kg per annum, may in three years be the largest producer in the State, and indicates a likely new gold province away from historically important areas.

Although base metal exploration declined to $32.9 million it was concentrated on a number of major projects including shaft sinking and metallurgical test-work at Golden Grove, extensive drilling on the Pillara/Blendevale area, where reserves of 19.5 million tonnes at 7.5 percent Zn and 2.3 percent Pb were announced, and major exploration near Nifty in the Throssell Range/Rudall River area. In this latter area a Special Agreement Act to cover exploration represents a significant new initiative.

Diamond exploration was greatly reduced; however, at the end of the year, hard-rock mine production commenced from the Argyle diamond pipe.

During the year exploration for platinum group elements increased significantly, especially in the Lamboo Complex and in West Pilbara. In the latter area highly anomalous values were returned from drilling in the Munni-Munni complex.

Interest in mineral sands revived, and plans were announced for a number of secondary processing plants. A number of potentially significant discoveries were made of several other commodities. These include: CRA's Kintyre uranium prospect, in the Paterson Province; Union Oil Development Corporation's apatite-bearing carbonatite at Mt Weld (over 100 million tonnes of medium-grade phosphate ore); the Union Oil/West Coast Holdings Brockman rare-earth-element deposit; and the Western Ventures NL/CRA Hill River coal prospect.

Mineral exploration expenditure during 1986 is expected to remain about the same, at around $180 million. Exploration priorities will also remain similar with the greatest emphasis on gold but greater interest will be shown in exploration for potential underground mines.

Oil and gas. In 1985/86, 29 exploration wells were drilled compared with 81 in 1984/85. This decrease is a reflection of the general economic downturn and particularly the falling oil price in the first half of 1986. Most drilling was concentrated in the offshore Carnarvon and onshore Canning Basins. An encouraging pointer to future activity is the increased seismic acquisition, particularly offshore, when compared with the previous period. Total line distance of 29 083km (13 440km in 1984/85) is an increase of 105 percent, with offshore lineage increasing by 160 percent.

No major discoveries were made during the year although some successful extension test drilling was completed. The most significant wells drilled in the year were Goodwyn Nos. 7 and 8 which confirmed the presence of a section in the Goodwyn Field with a very high condensate to gas ratio. A highlight of 1986 was the start of oil production from Harriet, Western Australia's first offshore oil field.

The most significant event of 1985 was the announcement of the "North West Gas Development Agreement" for the $9.8 billion liquified natural gas phase of the North West Shelf Project, probably the largest single project ever undertaken in Australia. Start-up is expected in October 1989 and annual exports are expected to reach 6 million tonnes by the mid-1990s.

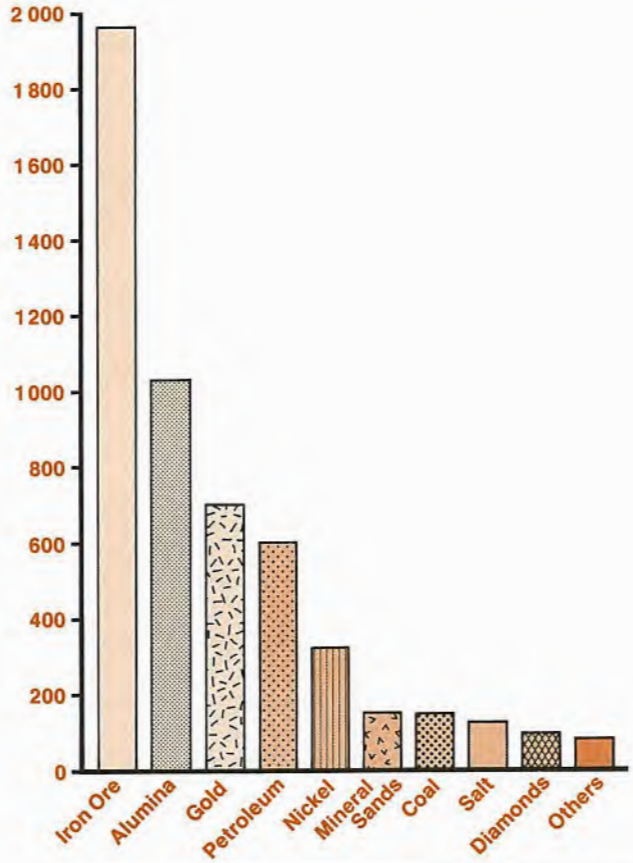
Mineral production

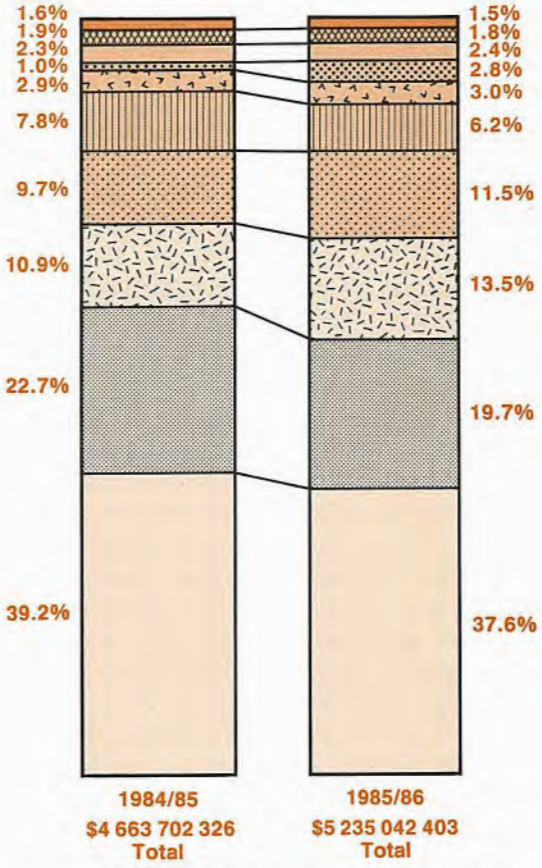
The level of production in most mineral industries in the State showed an increase in 1985/86 compared with that of the previous year (see accompanying table). Two notable exceptions are the iron ore industry, and the basic titanium and zircon products from the mineral sands industry. Shipments of the iron ore were 2 million tonnes, 2.2 percent down on the previous year, but in value terms, primarily as a result of exchange rate variations, the figures show over 10 percent increase. In mineral sands, whilst ilmenite and leucoxene output declined, the high titanium product rutile significantly increased, and improved prices in the industry resulted in a 17 percent increase in overall value.

All major commodities, except nickel, showed an overall increase in value terms, resulting in a total mineral production in Western Australia of $5 235 million in 1985/86; up 12 percent on the $4 664 million of 1984/85, and passing $5 billion for the first time. The depressed state of nickel prices gave a marginal reduction in overall value compared with 1984/85 even though production was about 4.5 percent higher.

MINERAL EXPLORATION AND MINING DEVELOPMENTS IN WESTERN AUSTRALIA 1985/1986

VALUE OF MINERAL PRODUCTION
1985/86





Mineral	Units	Production		Factor
		1984/85	1985/86	
Alumina	Mt	5.3	5.4	+1.02
Base metals: (primary)				
Copper conc.	Kt	48.5	44.5	−1.02
Zinc conc.	Kt	42.4	75.9	+1.79
Silver	t	36.4	33.3	−1.1
Coal	Mt	3.7	3.8	+1.03
Diamond	Mcts	5.6	17.5	+3.13
Gold	t	37.4	46.1	+1.23
Silver	t	7.9	7.2	−1.09
Gypsum	Kt	545.2	348.6	−1.56
Iron ore	Mt	89.3	85.5	−1.04
Mineral sands:				
Ilmenite	Kt	1 188	1 108	−1.07
Leucoxene	Kt	19.6	19.0	−1.03
Rutile	Kt	73.5	71.8	−1.02
Zircon	Kt	362.3	349.0	−1.04
Monazite	Kt	16.6	18.0	+1.08
Nickel conc.	Kt	486.5	455.2	−1.07
Nickel ore	Kt	—	45.9	—
Copper	t	3 424	3 484	+1.02
Cobalt	t	449	515	+1.14
Palladium	Kg	461	420.5	−1.1
Platinum	Kg	81	94.5	+1.17
Silver	Kg	346	716	+2.07
Petroleum:				
Oil	ML	1 216.5	1 430.2	+1.18
Natural gas	Mm^3	1 759.6	2 756.1	+1.57
Condensate	Kt	94.9	293.1	+3.09
Salt	Mt	4.8	4.8	1.0
Silica sand	Kt	404.6	377.0	−1.07
Talc	Kt	182.6	133.3	−1.37
Tin, tantalum, lithium:				
Tin concentrate	t	569.1	679.1	+1.19
Tantalite conc.	t	68.9	143.4	+2.08
Spodumene conc.	Kt	8.5	12.6	+1.48

Iron ore again dominated with 38 percent of total value of the State's production; with alumina, gold, petroleum products and nickel following in that order with 20, 13, 12 and 7 percent respectively, as depicted in the accompanying figure. The individual values of output of the remainder of the mineral industries are some $200 million or more below the nickel industry, being valued at $160 million or less. Further information on these is detailed in the Supplementary Statistical Digest.

Gold, petroleum products (natural gas, condensate and crude oil) and diamond have been the main growth areas, reflecting the buoyancy of the gold industry, new developments in oil, primarily with the Harriet project and progressive expansions in relatively new projects of the North West Shelf Gas (for natural gas and condensate) and Argyle diamonds. Gold production increased by a further 20 percent to match its previous years redevelopment and resulted in a number of new projects being realised. The Argyle diamond project moved into the major AK-1 pipe operating stage in December 1985, resulting in output increasing from an annual level of 6M carats per annum to around 25M carats per annum. The massive North West Shelf Project continued its gradual expansion through its phase of domestic gas production, whilst oil developments, committed in the period of high oil prices in 1985, came on stream at the beginning of the major fall in oil prices.

Gold and diamond production should continue to expand in the coming year, but the difficult market situations in iron ore, alumina and nickel will decide the trends of these commodities. Apart from continuing

development of the North West Shelf Project it is difficult to predict developments in petroleum in the present highly depressed price arena.

Royalties

State royalty revenue continued to increase in 1985/86, achieving $163 million in 1985/86, some 24 percent higher than the previous year. This increase was almost entirely attributable to two commodities, iron ore and petroleum products.

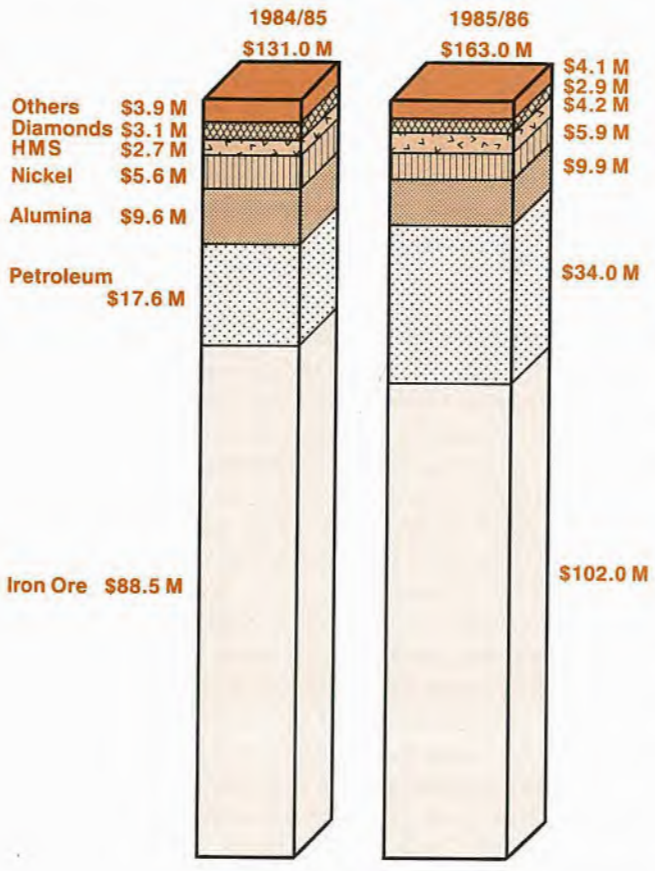
Revenue from the iron ore industry, at $102 million, exceeded $100 million for the first time, as a result of a combination of favourable exchange rate and finalisations of royalty payments from previous years.

Royalty revenue increased significantly over the past three years due to new developments in the petroleum industry , and this situation continued in 1985/86 with the exploitation of the Harriet oilfield, and a smaller new development in the Canning Basin. A most significant event in the year has been the Agreement between the State Government and Western Australian Petroleum Pty Ltd (Wapet) to enter into a profit-based resource rent royalty arrangement, and a parallel Agreement between State and Commonwealth Governments for the sharing of royalty revenues, as a replacement of the two-tier State royalty and Commonwealth excise systems. This new arrangement became effective from 1 July 1985 and the transitional arrangement from the old wellhead/ad valorem royalty system has resulted in an apparently large crude oil revenue increase to the State, which, however, will show adjustment in the subsequent year. Petroleum revenue almost doubled in 1985/86 from $17.5 million to $34.0 million.

Nickel, alumina, mineral sands, and diamond were the other major royalty earners, and only the buoyant mineral sands industry showed any significant increase in payments in 1985/86. The accompanying figure shows the distribution of royalty income for the last two years.

The independent inquiry into mineral (including petroleum) revenues in Western Australia continued throughout the year, and the final report with analysis on the existing system of royalty collection and recommendations on alternatives should be presented to Government in early 1986/87 fiscal year.

ROYALTY REVENUE



Commodity reviews

Iron ore

The value of iron ore production was Aus$1 965 666 843. It is expected to exceed Aus$2 000 million in a single year for the first time, next year. This years level made up about 38 percent of the State's total value of mineral production and again dominated the overall mining industry scene. A continuing favourable Aus$ to US$ exchange rate considerably assisted in this achievement, as, in actual shipment terms, the total level was down by nearly 4 million tonnes from the previous year to 85.5 million tonnes.

The improvements in the World steel industry being detected and forecast a year or so ago did not continue to any great degree and, more significant to the Western Australian iron ore industry, there was little detected improvement in Japan. The Western Australian iron ore industry being predominantly export-oriented is very dependent on movements in the world steel industry where, in respect to iron ore supplies, increasing competition and oversupply have dominated the scene for a number of years. Whilst there does not appear to be much potential for any increase in shipments to Japan, there have been encouraging signs for new markets opening for Australian iron ore in China, Taiwan, Republic of Korea, and possibly in Eastern Bloc countries such as Rumania, plus other smaller markets in South East Asia and the Middle East. Additionally there have been signs of increasing penetration of the Western European market.

Following on from the difficult price negotiating position of the past four to five years, the 1986 settlements again indicated the strength of a buyers market, with first the Pilbara producers settling on 5.5 to 5.9 percent price cuts with European consumers and then just recently 4 to 4.5 percent reduction for Japanese shipments.

Industrial relations in the Pilbara have been relatively stable and there has been little interruption on shipments. Earlier in the year Mt Newman Mining found itself with insufficient stocks at the port to maintain its demand for loading, resulting from depletion of stocks due to industrial action in the previous year. Consequently Hamersley Iron and Goldsworthy Mining picked up additional shipments to BHP's steelmaking operations in the Eastern States. The Western Australian Iron Ore Industry Consultative

Council, set up to monitor the status of the industry, to encourage dialogue between all parties, and generally to seek to promote a climate of good industrial relations, is considered to have had a positive influence in this area.

Hamersley Iron continues to be the largest producer with shipments of 35.8 million tonnes from Tom Price and Paraburdoo; this was 1 million tonnes below last year's total, but still slightly above forecast levels. Mt Newman Mining, on the other hand, shipped 27.09 million tonnes, slightly less than forecast due to the shortage of shipping stocks early in the year as noted above. The completion of major dredging works at Port Hedland allowed a record 230 000 DWT vessel to be loaded by Mt Newman Mining.

The dredging is one of several major capital works programmed by Mt Newman. Mt Whaleback pit restrictions have limited operating capacity to 32 million tonnes per annum. With the redevelopment plans over the next year or so the company should have an operating ability of at least 35 Mtpa. This will involve $340 million investment over two years. Also in 1985/86 the company has been studying potential development plans for supplementing production from the Eastern Satellite Orebodies.

A significant movement in ownership in the year has resulted in BHP increasing its share to a controlling interest of 85 percent in Mt Newman Mining, 10 percent remaining with the Japanese trading houses, and 5 percent with BP Minerals. This follows a pattern set in the previous year by CRA, when it assumed full control of Hamersley Iron.

Hamersley Iron's plans for development, with the Government of the Peoples Republic of China, of the Channar deposits to the south, have not progressed as hoped 12 months ago, and discussions on these proposals have been "on-off" in nature over the year.

However, other projects are being pursued for possible usage of both the Hamersley and Newman railways. CRA has joined CSR in its Yandicoogina project; and BHP is showing interest in promoting development of its options over the Yandicoogina area.

A third project, McCamey's Monster in the Ophthalmia Range east of Newman, is being advanced by Hancock Mining Ltd. McCamey's Iron Associates has divided its areas up among the partners (Consolidated Goldfields, BHP, Hancock Mining) to allow Hancock Mining to "go it alone" with development. The plan is seen as development at an initially low level of five million tonnes per annum to serve Hancock Mining's commitment, reported to be to supply 53 million tonnes of iron ore to Rumania over a long-term period under a barter arrangement. Other major projects in the Hamersley Range, namely Goldsworthy's Mining Area C, Robe River's West Angelas deposit and Hancock/CRA's Marandoo, have shown little advance during the year.

Shareholding changes of Robe River Iron Associates has resulted in Peko-Wallsend increasing its control to 50.9 percent by buying out the Cleveland Cliffs Inc share. Production level during the year was as forecast at 14 million tonnes and, although the operations are to a large extent reliant on Japan (through significant Japanese shareholdings), economics, particularly in transportation costs, has made the ore attractive to Europe, and increased supplies to China and South Korea have also been achieved.

The other major Pilbara producer, Goldsworthy Mining Associates, at Shay Gap — Sunrise Hill, increased its output by almost half a million tonnes to five million tonnes in 1985/86. The perpetual short-term extension to the 'northern areas' operations seems to be continuing, with upgrading of facilities to treat lower grade ores being planned for longer term development. No imminent development plans are known for the company's major Mining Area C reserve to the south.

BHP's Cockatoo Island operation in the West Kimberley region has finally shipped its last remaining stockpile ore and development of the island for tourism is being investigated. The adjacent Koolan Island operation is being expanded to maintain the supply to BHP's steelworks in the Eastern States, whilst retaining its high-grade export tonnages. This effectively gives an increase of 50 percent on production capacity, but reduces the remaining reserve life to only seven years. Shipments from the Yampi Sound operations in 1985/86 totalled just under four million tonnes.

The Southdown magnetite prospect, in the South West of the State, near Albany, has been providing speculative interest, without any real definitive exploration being undertaken. A major drilling programme had commenced at financial year-end to delineate what has been described as a very significant geophysical anomaly extending over a considerable strike length.

Bauxite/alumina

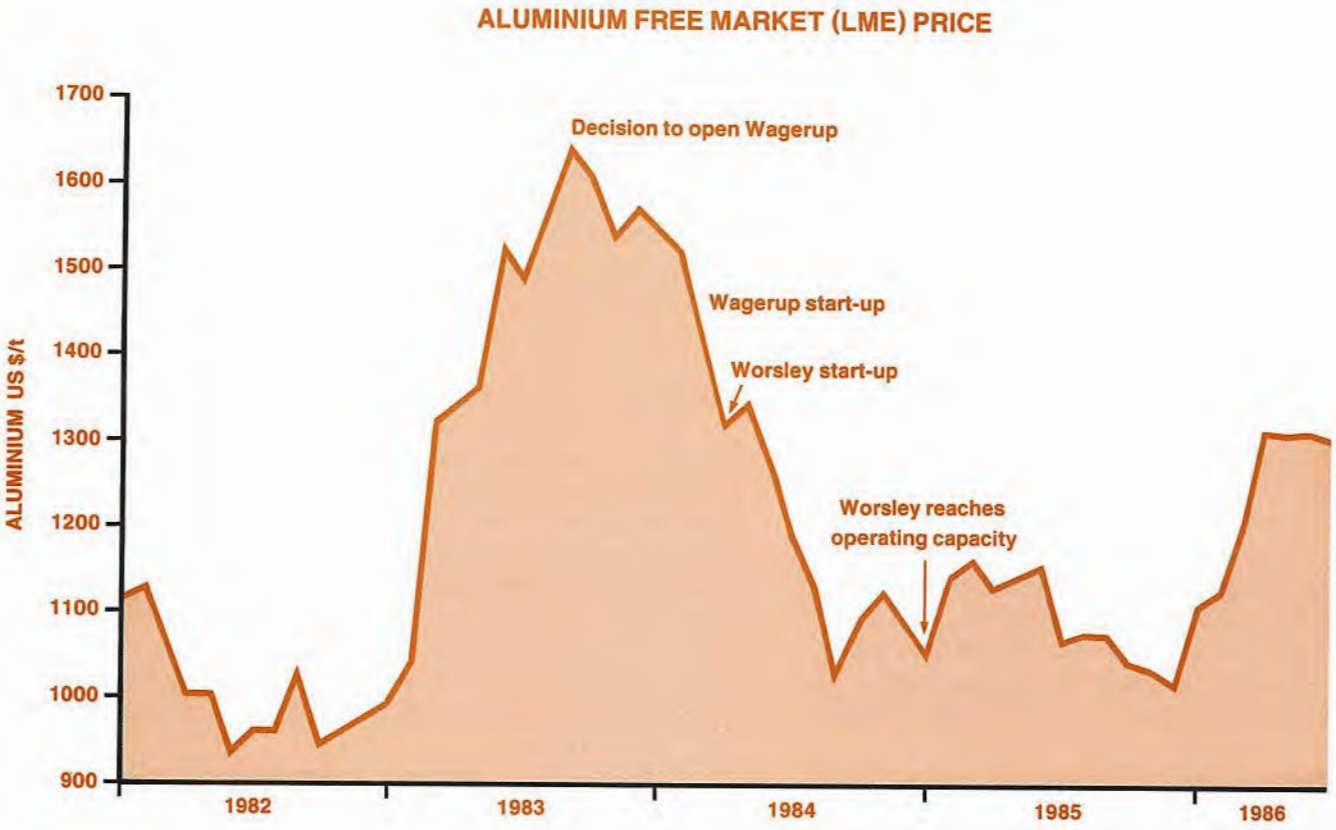
The depressed alumina market continues to influence the short- to medium-term planning by both Alcoa and Worsley Alumina. Alcoa's Kwinana refinery's alumina production has been reduced by 30 percent, with a proportional reduction in the amount of bauxite mined at Jarrahdale. The Pinjarra and Wagerup refineries, also owned by Alcoa, have maintained normal production. All three Alcoa refineries are paying close attention to quality controls in the refining process.

Alcoa and the State Government are re-examining the 25-year mining strategies for Del Park and Huntley bauxite deposits, in the face of increased mining costs, the concerns of the Dwellingup community, and the declaration of the Lane Poole Reserve. Trials of the "Dosco" continuous miner show promise that this new technology could replace the need for extensive blasting and trucking.

Worsley Alumina has completed its second year of mining at Saddleback and refining at Worsley. The company now has a fully integrated bauxite mining and refining system, after some initial problems with winter mining.

During 1985/86, 21.0 Mt of bauxite was mined by the two companies from five mine sites. A total of 5.4 Mt of alumina was refined from this material. This represents a 3.7 percent increase in alumina production over the previous financial year.

Average monthly freemarket prices for aluminium declined during the latter part of 1985. In November a low



of US$1 015/t was reached. This was followed by a sharp increase late in December and this trend continued until March, 1986 when a peak of US$1 316/t was attained. Since that time prices have remained relatively stable with a marginal decline to US$1 302/t in June of that year.

In contrast to the recent increase in price of aluminium, prices for alumina have continued to decline. At the beginning of the 1985/86 financial year, the Australian Bureau of Statistics average export price for alumina stood at Aus$215/t. By the end of the first quarter 1986, the average export price had declined to Aus$174/t. However, a worldwide trend is recognised for spot price movements of alumina to lag behind those for aluminium by a considerable period.

Alcoa of Australia continues to be the major world supplier of alumina to the free market in an industry formerly dominated by fully integrated aluminium producers.

Gold

Extensive exploration and project development in the State's gold mining industry were continued during 1985/86, and indications are that gold will continue to be amongst the most sought-after commodities in the mining industry for at least the remainder of the decade. Currently 500 to 600 companies and prospectors produce gold in the State, and an everincreasing number of companies, with gold as the prime exploration target, are being "floated".

Gold ($707 113 630) lies third, after iron ore and alumina, on the State's table of value of mineral production in 1985/86. Gold production has increased dramatically since 1980, and is at its highest level since 1910. In order to achieve this production, the ore tonnage being mined is about four times as large as was required back in 1910.

	Ore treated (tonnes)	Total gold (kg)	Recovered grade g/t
1910	2 930 601	44 235.980	15.1
1980	1 883 737	11 232.943	6.0
1982	3 452 504	20 756.754	6.0
1984/85	8 352 003	37 424.545	4.5
1985/86	11 469 920	46 072.127	4.02

In terms of the world gold-mining industry, Western Australia has recorded the highest percentage increase in gold production of any major producer since 1980.

Seven new gold mines commenced operations in 1984/85; this number increased to 21 during 1985/86, and a further 23 gold mines are expected to come on-stream in 1986/87. The majority of these mines are operations in previously abandoned mining areas; most are small- to medium-sized open-cut mines in oxidized, lower grade haloes around the previously worked higher grade lode systems. Many of the new mines will have a life of about 4 to 10 years; additional and replacement production should continue to increase at least to the end of the decade. If the gold price continues on its present trend, many of the shallow open-cut mines may be able to extend development to greater depths and prolong their presently limited lives. In addition, major expansions are planned for well-established open-cut mines at Telfer and Kalgoorlie

in the forthcoming year. Looking further ahead, the Boddington mine should commence operations in 1987/88. Boddington is important as it is a major "greenfields" discovery and, at an anticipated production of over 5 000 kgpa, has the potential to be the State's second largest producer after Telfer.

Much of the gold industry is speculative, and its success is determined by the gold price and international currency markets. Gold mining and exploration in Australia has historically been stimulated by its exemption from direct taxation. The possibility of the removal of this exemption is strongly opposed by those in the industry and by the Western Australian government, all of whom see that the imposition of a direct tax would remove much of the exploration incentive and would cause the closure of more marginal operations. Although such factors make predictions for the industry very difficult, the general outlook must be seen as excellent.

Nickel

The 1985/86 financial year has been disastrous for the nickel industry world-wide. Although demand remained relatively stable at an annual rate of around 550 000 tonnes, and producer inventories fell to approximately the equivalent of three months supply, the nickel price fell dramatically. From a peak of US$2.50 a pound in early 1985 the free market price fell to US$1.80 a pound in June 1986. This fall severely effected even the highly cost-efficient Western Australian nickel industry and has resulted at the end of the period in the closure of mines by Western Mining Corporation.

Capital expenditure on the Agnew mine was almost $300 million. When the mine opened, in 1979, the nickel price in 1985 Aus. dollar terms was $4.00 a pound, and the company was able to make an operating profit in its first year of operation. The fall in the price since that time, has meant that, when depreciation is included, the company has made a loss in each subsequent year of operation.

The Agnew deposit remains one of the World's major nickel sulphide deposits and it is anticipated that the mine should become profitable once price and market conditions have improved sufficiently.

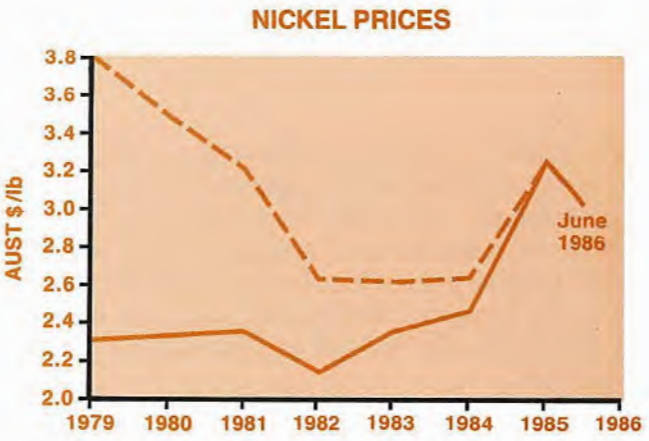
In the case of Western Mining Corporation (WMC) the company was forced to reduce production costs by closing a number of its higher cost mines. Of the eleven operating mines at Kambalda, five (Wannaway, Mt Edwards, Jan, McMahon and Hunt) were closed, together with the South Windarra open-pit near Laverton. In a statement made at the time of the closure the company cited increased costs, including higher wages, the fringe benefits taxes on employee housing, and the high level of industrial stoppages at Kambalda, as contributing factors, in addition to the lower prices.

Some 200 of the 1 500 employees at Kambalda had to be retrenched as a result of the closures, although WMC was able to transfer some of the personnel to increased shifts on the other mines.

The five mines have each been placed on a care and maintenance basis. Each has significant remaining reserves and can be re-opened when economic conditions allow. By increasing nickel production from a number of the remaining mines, the company hope to be able to keep the decrease in total nickel production to as little as 10 percent.

One brighter aspect for nickel during the year was the recommissioning, in December, of the Metals Exploration Nepean mine. Reserves at this mine totalled some 250 000 tonnes of 2.7 percent nickel at the time of re-opening, sufficient for just over two years production. Output is treated at the Kambalda concentrator under a life-of-mine agreement.

Current predictions are that the relatively tight demand and supply situation developing in the market should see an effective increase in price of around 10 percent by the end of 1986. If this price can be sustained or further improved through 1987 then the Western Australian industry, the competitiveness of which has been aided by the effective devaluation of the Australian dollar, should be in a much healthier position through the coming year. The increase in value of related gold production should be of further assistance to WMC's integrated Kambalda and Windarra nickel mining operations.



Mineral sands

The mineral sands industry has been one of the bright spots in the Western Australian mining scene for 1985/86.

The industry has seen significant increases in demand and greatly improved prices for virtually all of its products. While, for a number of technical reasons relating to individual mining operations, ilmenite and leucoxene output declined slightly, the output of rutile increased significantly, and this, together with the higher prices, saw a 17 percent increase in the value of the State's production.

The increase in importance of the chloride route to TiO_2 pigment production has seen an increase in demand for the high TiO_2 feedstocks, natural and synthetic rutile, and has resulted in rapid price increases for these commodities. These price rises have been instrumental in encouraging two of the Western Australian producers, Associated Minerals Consolidated (AMC), and Westralian

Sands Limited, to dedicate a proportion of their ilmenite resources for synthetic rutile production. This has reduced the availability of ilmenite, derived mainly from the younger strandline deposits, for the production of pigment by the sulphate route. These younger strandline deposits are slowly becoming depleted and the pigment industry, recognising this potential shortage, has increased the price of ilmenite.

The end-user markets for titanium products are pigments in paints, paper and plastics, titanium metal and welding rods. These uses are related to the growth of high technology markets rather than heavy industry and the high demand is therefore considered likely to continue through this decade. Zircon, which is produced as a by-product of titaniferous mineral mining has been subject to some contraction of supply World-wide, as synthetic rutile has substituted for natural rutile mining. This factor, together with the recovery of United States and Japanese foundry-sand markets has seen a firming of prices for zircon. These prices seem likely to further improve through 1986 and beyond.

Some rationalisation has occurred within the industry during the year, with the successful takeover of Allied Eneabba by the Renison Goldfields subsidiary, Associated Minerals Consolidated. The Cable Sands Pty Ltd also constructed a new dredging operation at Minninup.

A particular feature of the mineral sand industry is the high degree of secondary processing of minerals that takes place within the State, greatly increasing the value and importance to the State's economy. The start of construction of the Narngulu (AMC) and Capel (Westralian Sands) synthetic rutile plants during the year has been particularly important. ICI Australia announced during the year a proposal to build a plant at Kwinana to produce a wide range of zirconia-based powders and chemicals for use in the ceramics industry. A number of studies into the feasibility of building plants to produce rare-earth elements from monazite are also being conducted.

The increase in the price of the various mineral sand commodities has seen a big upsurge in exploration for minerals sands. Exploration programmes are being conducted in the Carnarvon Basin and in the Scott Coastal Plain, as well as in the more traditional areas. The successful float of a new company, TiO_2 Corporation NL, which raised $15 million to explore and develop the Jurien and Cooljarloo deposits in the northern part of the Perth Basin, is of particular note.

Diamond

The year was a particularly significant one in the history of Western Australian diamond production as December saw the commencement of hard-rock production from the Argyle AK-1 pipe. This development will increase production to approximately 25 million carats annually, and will bring the State into the 'major league' of World diamond producers.

Large-scale bulk sampling and pilot production of alluvial diamond-bearing deposits, on the lower part of

Smoke Creek and Limestone Creek, was continued by the Afro-West and Gemex/Freeport joint ventures. These diamonds were originally derived from the AK-1 pipe but, because of the natural attrition processes that have taken place, the deposits contain a higher proportion of gem quality diamond than AK-1. The joint venturers of the Gemex-Freeport deposits plan to complete a feasibility study by October 1986. If the decision is made to go to full production, this should commence at a minimum of 1 million tonnes per annum in late 1987. Preliminary negotiations for marketing the production have been held with dealers in Australia, Antwerp, London and New York.

Aerial oblique of the Argyle AK1 open-cut mine with treatment plant in the middle distance. (August 1985 photo, reproduced with permission of Argyle Diamond Mines Pty Ltd.)

Tin, tantalum, lithium

The tin industry went through a major upheaval in 1985/86 with a suspension of trading between October 1985 and April 1986 and, on trading resumption, prices were cut drastically. The International Tin Council, through its stockpile release mechanism, had provided market and price support and, through the export quota system, trade and prices were maintained to allow reasonable operating levels. However, the debt problem of the Council led to the collapse in its activities on price control and export restrictions have been lifted.

The suspension of trading was primarily a result of world indicator prices disappearing, notably the tolling price in Penang. However, Greenbushes Limited, the prime producer and trader in the State, is an integrated producer through to tin metal, not reliant on toll pricing, and as a result has continued to sell throughout the year, but at significantly reduced prices. Metal prices were between Aus$15 000 and 16 000/tonne in mid-1985 and had increased to Aus$18 000/tonne just before the collapse. Subsequently prices dropped to $11 000 to 11 500/tonne and for the last quarter, with the resumption of trading, have been in the range of $8 500 to 9 000/tonne. Greenbushes' production is currently 40 to 50 tonnes of metal/month selling primarily to the domestic market; this is a level some 25-30 percent above the quotas applied for the last three years. With the closure of the Australian Tin Smelting smelter at Sydney, the Greenbushes smelter is the only operating tin smelter in Australia.

To compound the industry's problems, tantalum, which a year ago was being forecast to emerge from its depressed price situation, in fact continued to show a steady drop from US$30-40/lb Ta_2O_5 through 1985 to a level of US$18-25/lb in the last four months of the period. While Greenbushes has responded with significantly reduced production, shipments have just about doubled over those of the previous year, allowing large local inventory levels to be reduced. Additionally, the company's development of a tantalite tailings retreatment plant has allowed lower cost tantalum to be produced. This, together with the long-term future in the investment in the underground, hard-rock, operation and associated plant, is seen to be a springboard for Greenbushes to quickly react to the potential improvement in the market. This major development is about $3 million away from completion and such completion has had to be delayed because of the very difficult overall marketing situation operating in the industry at present. The stringent cost-cutting measures introduced by the company are envisaged to achieve only debt servicing and a breakeven on operations, with deferment of all capital investment.

Increasing diversity of mined and manufactured product is a feature of the Greenbushes operation. Spodumene is the third commodity produced by the company. Production in 1985/86 was maintained slightly higher than in the previous year at 12 690 tonnes supplying the speciality glass-ceramics market. With commencement from January 1986 of mining a high-grade spodumene zone of 4 percent Li_2O (with low Fe_2O_3 content), the company anticipates an additional outlet for bulk shipments to the glass market without the need for concentration. A feasibility study on a lithium carbonate plant was completed during the year, but with the current depressed economic situation the joint venturers have been unwilling to commit themselves to development.

Overall, Greenbushes has implemented measures to counter the extremely difficult financial situation by deferring its development plans, concentrating mining operations on high-grade areas of the orebody, and reorganising staff. The company anticipates such action will allow the operation to continue, whilst many other operations elsewhere have already foundered.

Elsewhere in the State, only small quantities of tin concentrate are produced in the Pilbara.

Base metals

Exploration for new base metal deposits continued during the year albeit at a reduced level in view of depressed commodity prices. Most of the current activity is centred in the Kimberley region where significant carbonate-hosted mineralization has been defined in a number of areas.

The most promising base metal project in the State at present is the Blendevale carbonate-hosted deposit in the West Kimberley, owned jointly by BHP and Shell. Preliminary reserve estimates have been announced as 19.5 Mt at an average of 7.5 percent Zn and 2.3 percent Pb with minor amounts of Cd and Ag. The proposed sinking of a decline to further evaluate the deposit has been

temporarily postponed due to the present uncertain investment climate.

All operations have ceased at Teutonic Bore and the mine was closed in early 1986 after the sale of mine and other equipment. With this closure no base metal mine currently is operating in Western Australia. However, significant reserves of copper and zinc with minor silver and gold have been delineated for the Scuddles copper-zinc deposit at Golden Grove. Following the sinking of a shaft and diamond drilling, a reserve of 10.6 Mt was announced, comprising 1.3 Mt at 5.1 percent Cu, 1.7 percent Zn, 44.4 g/t Ag and 1.3 g/t Au, plus 9.3 Mt at 15.8 percent Zn, 108.1 g/t Ag, 1.3 g/t Au and 0.5 percent Cu, in two massive sulphide bodies. A further 4.0 Mt of stringer ore containing 2.9 percent Cu and 10.1 g/t Ag have also been defined. Metallurgical testing of samples is continuing.

WMC is continuing exploration at and in the vicinity of the Nifty deposit in the Throssell Range area. Of note, in relation to this exploration, is the passing by both Houses of Parliament of a Special Agreement Act with WMC. This creates large Special Exploration Licence which frees the company from normal relinquishment requirements for a period of five years in return for greatly increased expenditure commitments.

Exploration is continuing in the Bangemall Basin area following the discovery of significant lead and silver mineralization at the Amoco/Geopeko Jillawarra prospect.

Uranium

Occurrences of uranium mineralization throughout the State are numerous, widespread, and of varied type. Potentially economic deposits, however, are more limited in number and unlikely to be fully developed in the near future, mainly due to political considerations and the anti-uranium mining lobby.

One noteworthy development during 1985-86, however, was CRA's announcement of the discovery of uranium mineralization at Kintyre, which they described as "highly promising". Kintyre is located in the Paterson Province, some 60 km south of the Telfer goldmine and about 50 km southeast of WMC's Nifty base metal discovery; there is encouragement, therefore, that in this remote part of the State may be a largely undiscovered major mineral province.

Oil and gas

In January 1986 Harriet Oil Field, the State's first offshore producing oil field commenced production and is now averaging about 1 300 kilolitres (kL) per day. The development of this field was completed in record time — only 9 months from the first construction to the first shipment. Facilities consist of a production platform (two more satellite platforms are to be added), a 6.5 km pipeline to Varanus Island where storage tanks were built, and another undersea pipeline 3 km long to an offshore loading point. It is expected that the field will have a total life of about 10 years and, although it is small by world standards, it will make a significant contribution to Western Australia's energy needs.

Another small field to come on production was West Terrace that was discovered in early 1985. This discovery was made by Home Energy Company Ltd and the oil has been added to the small Blina/Sundown production and trucked to Broome for shipment to Kwinana. The three small fields are now contributing about 250 kL per day towards the State's total energy needs.

Barrow Island continues to be the major oil producer supplying about 90 percent of the total oil produced in the State, about 3 200 kL per day. Other recent oil discoveries in the vicinity of Barrow Island, such as South Pepper, Chervil, and Talisman, are considered to be uneconomic at present because of the current low price of oil. However, it is possible that the discovery made by West Australian Petroleum Pty Ltd in early 1985 at Saladin could be developed in 1987 if appraisal wells planned for late 1986 are successful. The State's total recoverable crude oil reserves are estimated to be 14.97 x 10^6 kL of which 95 percent occur in the Carnarvon Basin.

Recoverable reserves of gas on the North West Shelf are estimated to be 534.13 x 10^9 m^3 with a further 64.93 x 10^6 kL of condensate. Export of LNG to Japan is expected to commence in October 1989.

Coal

Production of coal for domestic power generation amounted to 3.765 Mt in 1985/86, a slight increase from the 1984/85 figure of 3.7 Mt although output in the first part of 1986 has declined to a rate below 3.2 Mt per year. This general decline, which was evident in 1984, is associated with the increased use particularly for power production of natural gas from the North West Shelf.

Very little exploration for coal is taking place. Evaluation of resources in the Wilga and Boyup Brook Basins south of Collie, and in the Hill River and Margaret River areas in the Perth Basin is continuing.

Other minerals

A small increase of 3 percent in shipments of *salt* was achieved during 1985/86 by the four northwest coast producers, raising the level of exports to 5 Mt pa. During the year Agnew Clough continued to export *gypsum* from Useless Loop at Shark Bay. Reserves at Useless Loop are likely to be depleted this year and a decision will be made as to whether the gypsum operation should be moved to a large deposit on the Peron Peninsula. A loading facility, of increased capacity, would have to be constructed near the site. Southern Asiatic Enterprises also continued to export smaller quantities of gypsum from Lake Cowan. Exports from both companies were to South East Asia where an extremely competitive market situation prevails. Ten smaller producers currently supply the domestic market. The quantity of gypsum mined in 1985/86 was 38 percent less than in the previous year.

Other significant export products included *talc, silica sand* and *attapulgite.* On the local scene there were notable increases in the quantity of *fireclay* and other raw materials produced for the building and construction industry. *Garnet sand* production also increased. Many other industrial minerals are mined for the domestic market, though not in large quantities.

Conservation and rehabilitation

In April 1985 the Hon Minister for Minerals and Energy established a work party to examine conservation and rehabilitation in the Western Australian Mining Industry.

At about the time that the work party was being set up, the land Resources Policy Council (LRPC) was also established to advise the Government on land-resource policy matters. One of the issues referred to it was that of rehabilitation and landscaping following mining development. It was thought appropriate that the work party reports would be forwarded to the LRPC and that the LRPC would be represented on the work party.

The work party, with Dr P E Playford, (Assistant Director General of Mines) as Chairman and Mr John Clarke (Mines Department) as Secretary, had a representative from each of the following organisations:

Association of Mining and Exploration Companies
Pastoralists and Graziers Association
Chamber of Mines
Land Resource Policy Council
Department of Conservation and Environment
Department of Agriculture
Department of Conservation and Land Management
Mining Engineering Division, Mines Department
Geological Survey Division, Mines Department

The agreed terms of reference for this inquiry were to examine and report on:

1. the status of conservation and rehabilitation regulation and practice on the Western Australian mining industry;
2. enviromental standards that should be achieved by the industry;
3. measures required to ensure that these environmental standards are met;
4. whether it is desirable to predetermine end uses for mined areas after rehabilitation, and if so how this can be acheived;
5. the extent of illegal mining, its environmental consequences, and measures needed to eliminate this practice.

The work party agreed that the gold mining industry should be first to be examined because of the current high level of gold exploration and development over widespread areas of the State.

Areas in the Eastern and Murchison Mineral Fields were examined on the ground and from the air, and by November 1985 a "Report on Conservation and Rehabilitation in the Gold-Mining Industry" had been submitted to the Hon Minister for Minerals and Energy. The recommendations in the report were endorsed by the Minister and in due course by the WA Chamber of Mines. The Minister is at present having legislative provision made to curb illegal mining and will appoint additional Mines Inspectors to police this aspect and monitor rehabilitation generally. The cost of these additional inspectors is being shared by industry through a small increase in tenement rentals suggested by the Chamber of Mines.

The Committee will next examine the heavy mineral sands industry.

Experimental rehabilitation on top of a tailings dump south of the Golden Mile has successfully reduced wind erosion and the resulting dust nuisance.

Mines Department

The total establishment of the Mines Department at the end of the 1985/86 year was 833 positions comprising 640 Public Service, 2 Contract, 48 Ministerial and 143 wages positions. In addition there were 15 part-time wages employees engaged as cleaners and gardeners at the various outstations.

This represents a net increase in the establishment of 10 positions over the 12-month period from the 823 positions at the end of June 1985. There was an increase of 14 Public Service positions, a decrease of 5 contract positions, an increase of 3 Ministerial positions, and decrease of 2 wages positions.

The net increase of 10 positions were as follows:—

— five in the Mining Engineering Division, Radiation Secretariat for environmental and occupational safety;
— one in the Government Chemical Laboratories, Forensic Science Branch for drug detection and analysis;
— one in the Petroleum Division, Administration and Titles Branch to further the processing of concession areas;
— one in the Corporate Services Division, Executive Branch to improve financial and human resource management;
— one in the Royalties and Statistics Branch for the assessment and collection of state revenue;
— one in the Explosives and Dangerous Goods Division at the Kalgoorlie Explosives Magazine for management and safety purposes.

Forty vacancies were advertised during 1985/86 compared with 67 during 1984/85.

Three additional persons were employed during the year, through funding made available by the Community Employment Programme, for specific projects including chemical data card compilation, hydrogeology reports encoding and water analyses transcribing.

In addition, the Department's computerisation program was supported by three consultants.

MINING ENGINEERING — A new structure

The plans made (during 1984-85) for restructuring of the Mining Engineering Division (MED) were approved early in 1986, and the first phase of the necessary staff expansion, which is scheduled over a three year period, will take place in 1986-87.

The general Divisional structure is shown in the accompanying oprganisation chart. The organisation of the new branch, Research and Technical Services (RTS), is given in greater detail. Essential features of the restructure are:

— The Deputy Director (Deputy State Mining Engineer) position becomes a line rather than a staff position.
— Greater functional responsibility for the activities in their branches is assigned to Branch Heads, who are now titled Assistant Directors, and a fourth Branch (RTS) is established.
— Administrative and clerical support staffing is being increased to allow the Division and its technical staff to function effectively.
— The Research and Technical Services Branch is being formed, incorporating some existing and a number of additional staff, to provide technical back-up to all branches of the Division, and to the Department, and to provide a service and co-ordinate activities with appropriate groups in the industry.
— Additional staff will be appointed to the Inspectorates to cope with the very great growth of the industry, particularly in the Kalgoorlie region.

The need to expand the resources of the Division and to restructure it to meet the current and future demands on its services was recognised with the rapid and sustained expansion of the industry in size, spread, and complexity, and the increasing demand for further emphasis on occupational health and safety and greater care for the environment.

A total of thirty one additional staff will be engaged over three years, deployed at Perth, Kalgoorlie, Collie and Karratha. Eleven are administrative and clerical support staff, five are environmental specialists and fifteen are engineering and technical.

The Assistant Director Coal Mining (State Coal Mining Engineer) has been appointed, and a District Mining Engineer will be recruited for the Collie Inspectorate.

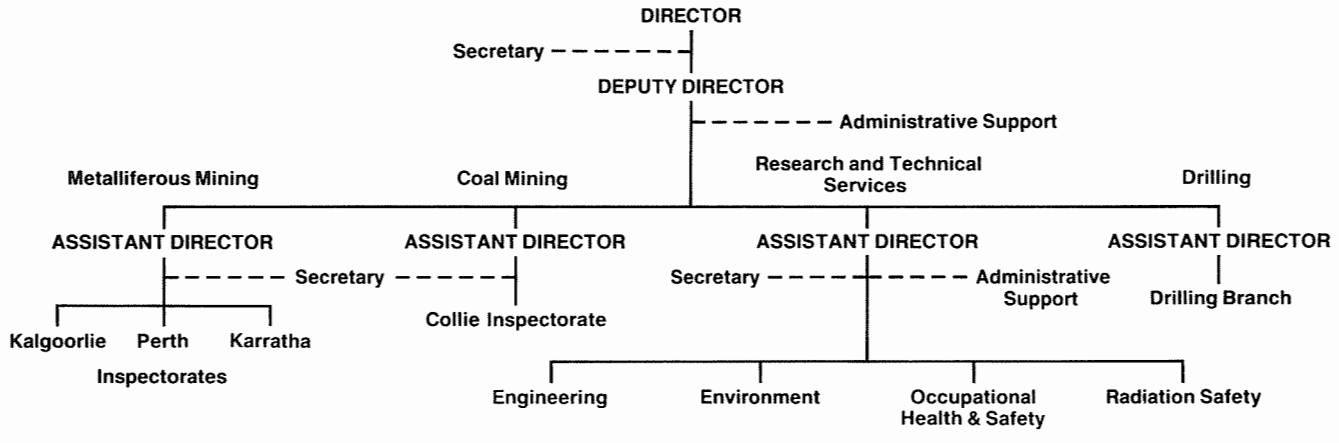
The Assistant Director to head the RTS Branch will be appointed as soon as possible. The RTS Branch will comprise four sections, Engineering, Environment, Occupational Health and Safety, and Radiation Safety.

The position of Manager, Environment and Rehabilitation will be filled during the latter part of 1986, completing the senior appointments in the Branch.

The main objectives in setting up the RTS Branch are summarised:

— provide technical advice and service to the Inspectorates, research specific problems, set up data bases and compile reports;
— prepare Departmental responses on mining issues and advice to Government;
— undertake research and forward planning on occupational safety, health and welfare; maintain contact with other authorities interstate and overseas on current developments and standards;
— maintain records and statistics and disseminate information for Divisional and industry use;
— assist in compilation and revision of legislation and in developing and formulating policy;
— provide advice and assistance on environmental and rehabilitation matters and control of these aspects of industry operations;
— advise and assist where needed on plant design, methods and equipment; and
— promote training and application of standards and codes of safe practice.

Strong support from the Minister for Minerals and Energy, and the Arts, The Hon. David Parker, and from the Chamber of Mines, have enabled this initiative to be implemented at a critical time, and the Divisional staff look forward to the challenges of their future tasks with enthusiasm.



J. M. TORLACH, STATE MINING ENGINEER

The gold mining sector of the industry has continued to expand throughout the year and the level of activity in other areas was generally sustained, with shipments of iron ore from the Pilbara maintained at a high level. Further reference to expansion of activity is contained in the body of the report.

Staffing problems in the Division referred to in the 1984/85 report have been recognised, and the action taken to remedy the situation is described in the feature story on the Mining Engineering Division. These initiatives, coupled with a return to full planned strength, will allow for provision of an effective service to the industry.

Notwithstanding the problems associated with rapid growth and geographical expansion, the overall safety performance in the industry has continued to improve, although there is still considerable scope for further reduction in the frequency and severity of disabling injuries.

More effort is being applied to improvement in specific areas of occupational health and safety, some of which are referred to in the report, and the establishment of the Research and Technical Services Branch will give impetus to more effective performance in this field.

It is appropriate to acknowledge the efforts of the Divisional staff over this past year, who have all sustained a good performance in the face of difficulties of which it is useless to complain, and to ask for the same level of support in the year ahead.

Mining activities

Alumina

Alcoa of Australia Ltd continued production of bauxite from its mines at Jarrahdale, Del Park, Huntley and Willowdale. This ore was processed at Kwinana, Pinjarra and Wagerup refineries. In late 1985 alumina production at Kwinana was cut by 30 percent because of low demand.

Worsley Alumina Pty Ltd mined bauxite at its Tunnell Road minesite which is linked by conveyor belt to the refinery at Worsley 55 kms away.

Attapulgite

Mallina Holdings excavated and stockpiled attapulgite-bearing clay from its Lake Nerramyne minesite and this was treated at Narngulu to produce attapulgite.

Clay shale and limestone

Clay was produced from several pits in the Shire of Swan with Midland Brick Pty Ltd the largest producer.

Cockburn Cement was the largest producer of limestone. In addition to cement and lime manufacture, limestone was produced from several quarries for use in road and groyne construction.

Coal

Production from the three underground and three opencut mines totalled 3.77 million tonnes; 2.93 million tonnes came from the open cuts, with Muja accounting for 2.1 million tonnes of this. The largest underground producer was Western No. 6 with 416,000 tonnes.

Towards the end of the year arrangements were in hand to commence opening up another open-cut mine that will be known as Western No. 3 Open Cut. It is located in the same general area as a former mine of this name which operated between 1954 and 1958, the most important seams being the Ewington 2, Moira Upper-Split, Stockton Upper-Split and Wallsend. The opening of Western No. 3 Open Cut will give Western Collieries Ltd the required flexibility to optimise the stripping ratios between No. 5 and No. 3 mines.

At Muja Open Cut Griffin Coal commenced a controlled programme of cable bolting the West wall. If the technique is proven successful the overall slope angle of the West wall may be safely increased thereby reducing the incremental stripping ratio in that area of the mine.

At Western No. 6 underground mine an experimental underground panel is to be extracted by the 'Wongawilli' total-extraction system. Development of the panel has commenced and depressurisation of the aquifers above the panel via surface boreholes is progressing.

Copper-zinc

The Teutonic Bore mine ceased operations in late 1985 with the mill placed on care and maintenance. Joint Venturers in the Golden Grove project, Electrolytic Zinc, Amax, Esso and Aztec, continued work on the feasibility of the project.

Diamond

Initial overburden stripping by contractors at the Argyle Diamond Mines Pty Ltd was completed in August 1985, enabling the company to commence its mining programme in October. The treatment plant which was under construction during this phase was commissioned on 1 December 1985, treating all ore mined from the AK-1 pipe.

Mining of alluvial deposits was completed in October and the plant placed on care and maintenance. During its period of operation the alluvial plant recovered 17.3 M carats of diamonds.

The workforce operates on a commuter basis, returning to Perth for fourteen days break after each two weeks working on site.

Dimension stone and aggregate

Supplies of stone and aggregate used in the building and construction industry were mined from numerous small quarries to meet local requirements. Demand for these

products was strong as a result of an increase in construction activity much of which is related to the America's Cup defence.

Gold

Many new gold mines commenced production in 1985/86, most being open-cut operations.

Gold production for the year ended 30 June, 1986 was 46 t valued at $707.11 million compared with 37 t valued at $508.89 million for the previous twelve months.

Some of the highlights of the year were:

— the opening of the Mt. Percy open-cut mine and treatment plant at the northern end of the Golden Mile. The first gold was produced in October 1985;
— the official opening of Pancontinental's open-cut mine and treatment plant at Paddington which will develop into one of the largest gold mines in Australia;
— completion of construction of a treatment plant and commencement of underground production from Australian Consolidated Minerals' Golden Crown mine at Day Dawn near Cue in the Murchison Mineral Field. The first gold was poured on 7 April 1986;
— the opening in May 1986 of the Westonia open-cut goldmine operated by Australian Consolidated Minerals in the Yilgarn Mineral Field. The mine is located over the old Edna May workings that produced 11,000 kg of gold between 1911 and 1947;
— the commencement of production in February 1986 from Austwhim Resources' Cork Tree Well open-cut gold mine;
— commencement of a $33 million construction programme to expand gold treatment facilities at Newmont Holdings Ltd Telfer operation, allowing the company to increase throughput of low grade ore;
— development of Newmont Holdings Pty Ltd New Celebration gold mine 30 km south of Kalgoorlie was at an advanced stage at the end of the period with production anticipated to commence in early 1987;
— the official opening of the Brunswick Oil N.L. Galtee Moore goldmine and treatment plant in March 1986;
— commencement of site works for the Boddington gold mine located 120 km southeast from Perth.

Gypsum

Production of gypsum continued at Norseman, Lake Seabrook, and Lake Brown in the Kalgoorlie Inspectorate, and at Lake Hillman near Kalannie in the Perth Inspectorate. Gypsum is used in cement manufacture and for agricultural purposes.

Iron ore

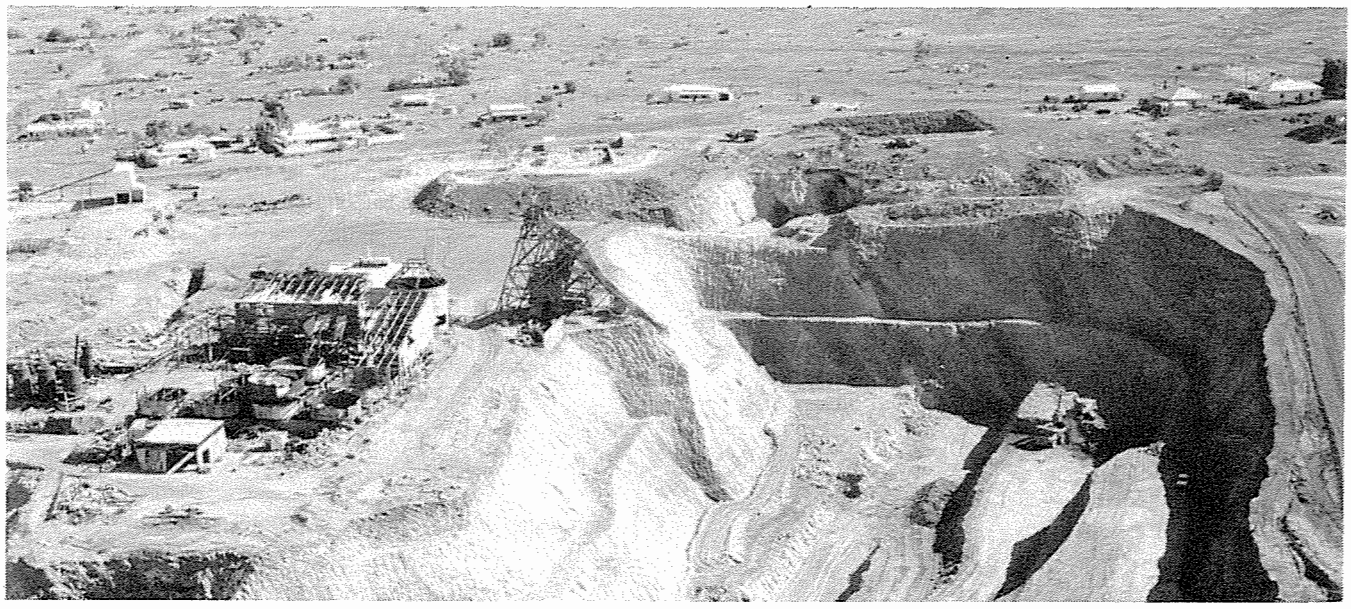
Shipments from North West ports were 84.7 million tonnes in 1985/86 compared with 92.2 million tonnes in 1984/85. The last shipment of iron iron from stockpiles at Cockatoo Island was made in May 1986. BHP Minerals Ltd's operation at Koolan Island continued and it is envisaged that production levels prior to the Cockatoo Island closure will be maintained.

Robe River Iron Associates was formed in April 1986 following Peko Wallsend Ltd taking a controlling interest in Cliffs Robe River Iron Associates. Mining was concentrated in the Eastern Deepdale area at Mesas L and N.

Goldsworthy Mining Ltd produced ore from the Shay Gap and Sunrise Hill minesites. Tests were carried out with a pilot heavy-media separation plant at Finucane Island to establish the viability of upgrading low grade ores from Area B.

Hamersley Iron Pty Ltd produced ore from minesites at Tom Price and Paraburdoo. Eight winzes up to 50 metres in depth were sunk in the Channar deposit to obtain bulk samples for metallurgical testing.

Preliminary site works were commenced at Mt Whaleback, in conjunction with Mt Newman Mining Co Pty Ltd's normal production operations, for the construction of an in-pit waste crushing and conveying system.



Sons of Gwalia open-cut gold mine showing the headframe and remains of plant from the old deep mine.

Mineral sands

The demand for mineral sand products was strong throughout the year compared with most other mining products. The Renison Group, the parent company of Associated Minerals Consolidated Ltd (AMC), took over Allied Eneabba and has amalgamated AMC and Allied mining operations at Eneabba.

A new synthetic rutile plant at Geraldton was commenced by AMC. Westralian Sands Ltd was well advanced in the construction of its Ilmenite Upgrade plant at North Capel with production scheduled to commence in early 1987.

Nickel

The two main producers of nickel, Western Mining Corporation Ltd (WMC) and Agnew Mining Company Pty Ltd (Agnew), continued their operations.

The depressed market price of nickel resulted in WMC placing five of their underground operations at Kambalda on a care and maintenance basis. Production at Kambalda now comes mainly from the Otter, Juan, and Long Shaft orebodies. The Kambalda operations experienced a seven-week industrial dispute during the year.

At their Windarra operation, WMC closed the South Windarra open-pit and concentrated on underground operations where some difficulties were experienced with ground conditions.

Agnew reduced production targets in order to mine higher grade ore in a selective mining programme. However, ore treatment suffered from poor metallurgical performance and metal recovery fell. Development for stoping trials was commenced off the main shaft in an area where test-work showed the ore to have better metallurgical characteristics.

The Nepean mine was re-opened early in the year and a two-year production programme was commenced.

The Kalgoorlie nickel smelter of WMC continued to treat concentrates from Kambalda, Windarra, Agnew and, later in the year, from Nepean. Production was curtailed somewhat due to an industrial dispute at Kambalda, the effect of which was also felt at the Kwinana nickel refinery.

Salt

Dampier Salt (Operations) Pty Ltd continued production at Dampier and commissioned a new re-wash plant to remove impurities from their product. Leslie Salt Company continued operations at Port Hedland.

Production from Shark Bay Salt J.V. operations at Useless Loop was adversely affected by cyclonic rains which flooded the evaporation pans.

Small quantities of salt were mined at Pink Lake and Lake Deborah in the Kalgoorlie Inspectorate.

Spodumene

Greenbushes Tin N.L. cut production and worked higher grade alluvial material due to depressed market conditions.

Talc

Western Mining Corporation Ltd continued to expand production during the year at their Three Springs operations, with a third open-pit being developed.

Tin and tantalite

Due to depressed market conditions, Greenbushes Tin N.L., the major producer, cut back production further and worked higher grade alluvial ore.

Goldrim Mining Australia Ltd in joint venture with Bamboo Creek Holdings Ltd re-treated tailings at Wodgina during the early part of the year. A similar re-treatment operation was conducted by Endeavour Resources Ltd at Marble Bar. The Pilgangoora operations of Pilgan Mining Ltd remained on care and maintenance.

Vermiculite

Vermiculite Industries Pty Ltd produced a small tonnage of vermiculite from their Young River open-cut operation near Esperance. Demand for this product is expected to continue to grow due to difficulties with overseas supply.

Operations

Kalgoorlie

The number of operating gold mines in the Inspectorate increased again in 1985/86. On 30 June 1986, 136 significant mining ventures were in operation, the majority of them producing gold, compared with only 59 in 1980.

The increased activity has been largely brought about by improvement in the technology of gold extraction by the cyanide leaching and carbon-in-pulp techniques, coupled with the sustained higher price for gold and improved methods of selective mining in open-cut practice. Operations are predominantly open cut, but underground mining is being evaluated at some operations, following on from open-cut extraction. New underground mines have also commenced.

Continuance of the current rate of expansion in the gold mining industry will depend to a great extent on the result of a Federal Government inquiry on the imposition of a tax on income from gold mining. Such a tax probably will have a deleterious effects on a mining industry already affected by the fringe benefits tax.

While the gold sector is enjoying major expansion, the same cannot be said for the nickel mining operations which have been adversely effected by a severe decline in world nickel prices.

In October 1985 BP Minerals' copper, silver, zinc mine at Teutonic Bore closed when economic reserves were mined out.

Karratha

Iron ore markets remained firm during the year with shipments from North West ports exceeding 84.7 million tonnes.

The last shipment of stockpiled iron ore at Cockatoo

Island was made in May 1986 and control of the Island is to be handed over to a promoter of tourism.

The resurgence in gold production was evident with several small projects commencing operation and a major producer commencing an expansion programme.

Activity in tin and tantalite mining was almost nil due to the continuing depressed state of the market.

Major exploration for diamonds continued in the Kimberley adjacent to the Argyle diamond project and to a much lesser degree in the Karratha and Nullagine areas.

Perth

Alumina producers were adversely affected by falling world prices and rising costs, while the mineral sands sector saw an improvement in the market for some of its products. Gold mining activity increased, and the crushed stone and construction material industry benefitted from projects related to the America's Cup, particularly in the metropolitan area.

The tin and tantalite markets remained depressed throughout the year.

Collie

Production of coal from the Collie Basin mines during 1985/86 remained static at 3.77 Million tonnes. Coal consumption for domestic power generation has declined due to increased gas production from the N.W. Shelf, and stockpiling of some coal commenced in March 1986. The local Collie Inspectorate for the three underground mines and three open-cut mines continues with one Senior Inspector of Mines and a Workman's Inspector of Mines.

Mining accidents

Eleven fatalities occurred as a result of mining accidents in the twelve months ended 30 June 1986. Seven of the eleven fatalities occurred underground, four in nickel mines and three in gold mines. Of the four surface fatalities, three were associated with gold mining and one with iron ore mining. Three of the seven underground fatalities involved rockfalls, and two men were suffocated in one accident at a nickel mine.

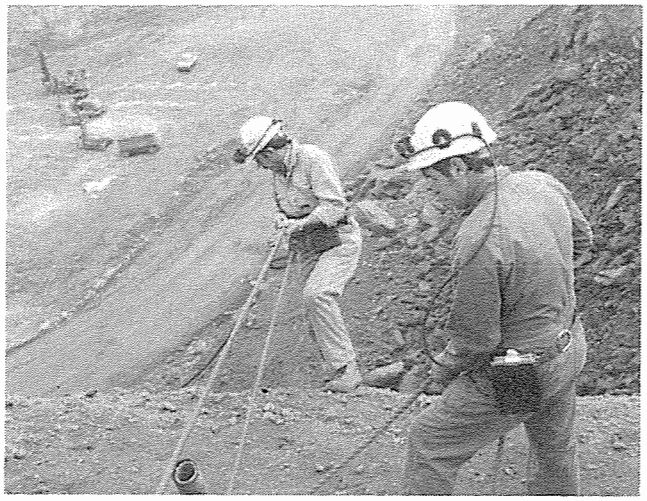
A summary description of fatal accidents is included at the end of the Division's report.

In 1985/86, 493 serious and 1733 minor accidents occurred compared with 521 serious and 1898 minor accidents in 1985.

The Division is pleased to note that the total number of lost-time injuries per thousand employees in the metalliferous mining industry has halved each ten years since 1965, from 273 per 1,000 in 1965 to 142 in 1975 and to 72 in 1985.

Accident statistics for 1985/86 are given in the Supplementary Statistical Digest.

The Division is well advanced in the development of a computer-based system for collation and analysis of data related to lost time injuries in the mining industry. The system, known as AXTAT, will be operational in early 1987 and will provide inspectors with information enabling them to focus their attention on the agencies and places of injury that are most cause for concern.



Inspector of Mines Dennis Johnson prepares to descend an open-cut face at the North Kalgurli mine to gain access to old workings.

Ventilation

Kalgoorlie

The Ventilation Section was understrength for most of the year, with only three Ventilator Officer positions filled, following the resignation of one of the officers.

Routine inspections were made of underground and surface operations, dust and gas samples were taken, diesel engines for use underground were tested for issue of permits, and blood or urine samples arranged for some assay laboratory and goldroom personnel.

A summary of the 373 dust samples collected and tested for standard of purity (SOP) are set out in the table below.

	Total Dust		Respirable Dust	
	−SOP	+SOP	−SOP	+SOP
Gold	24	12	186	24
Nickel			118	6
Other			2	1
TOTAL	24	12	306	31

SOP Standard of Purity
\+ greater than
− less than

In addition to the above, fifteen dust samples were taken in assay laboratories and tested for lead content. None exceeded the required SOP.

A series of seminars throughout the mineral Fields areas was held on the safe use of sodium cyanide, following the detection of high levels of HCN gas in some areas of carbon-in-pulp and carbon-in-leach gold treatment plants.

Work conditions in 76 of 1 051 workplaces were found to be unsatisfactory during routine underground inspections. In general these conditions were caused by one of the following:

— ventilation not installed;
— ventilation too far from the workplace;
— recirculation of airflows.

During the year, 76 diesel permits were issued, bringing the number of underground diesels operating in the Inspectorate to 711.

Perth and Karratha

The Ventilation Section based in Perth comprises two Special Inspectors of Mines (Ventilation) who are required to cover all mines in the Perth and Karratha Inspectorates. The coverage is not satisfactory, however the situation will improve with the appointment of a third inspector to be based in Karratha in late 1986.

Routine inspections were made of underground and surface operations, with dust and gas samples taken.

Perth. A summary of SOP results from dust sampling from the Perth Inspectorate is shown below.

In addition to the above, 53 samples were taken of gases and vapours. Four exceeded the SOP.

Fifty one samples were taken for heavy metals and fifteen exceeded the SOP. All the samples exceeding the standard of purity were of silver in the gold refining process.

Karratha. Fifty four samples were taken in the Karratha Inspectorate as summarised below.

In addition to these samples, two samples for lead fume in an assay laboratory, and one hydrogen cyanide gas sample from a gold treatment plant, were below the SOP.

Collie

With the increasing number of roadheader-type continuous miners in the underground production panels and the corresponding decrease in blasting, more attention is being given to allaying airborne dust. More attention is being given to the optimal use of water sprays, and gravimetric sampling will receive greater emphasis in the coming year.

Precise gas chromatograph analyses of air samples from each mine's main return airways registered typical concentrations of methane and carbon monoxide at 4ppm and 2ppm respectively.

Notwithstanding the absence of methane and near saturation of the ventilating current, it has been generally accepted that there exists the possibility of explosion and/or fire underground. Consequently, a committee representing the companies, unions and Mines Department is presently studying the various facets of flameproofing and progressive stages of eliminating naked-light mine practices.

Noise and vibration

A new section consisting of a mechanical engineer and three workplace inspectors was in place by 1 August 1985. The primary function of this section is to administer the Noise Abatement (Hearing Conservation in Workplaces) Regulations 1983 on mines.

The mechanical engineer is situated in the Perth office, with a workplace inspector based at each of the Division's three regional offices in Perth, Kalgoorlie and Karratha.

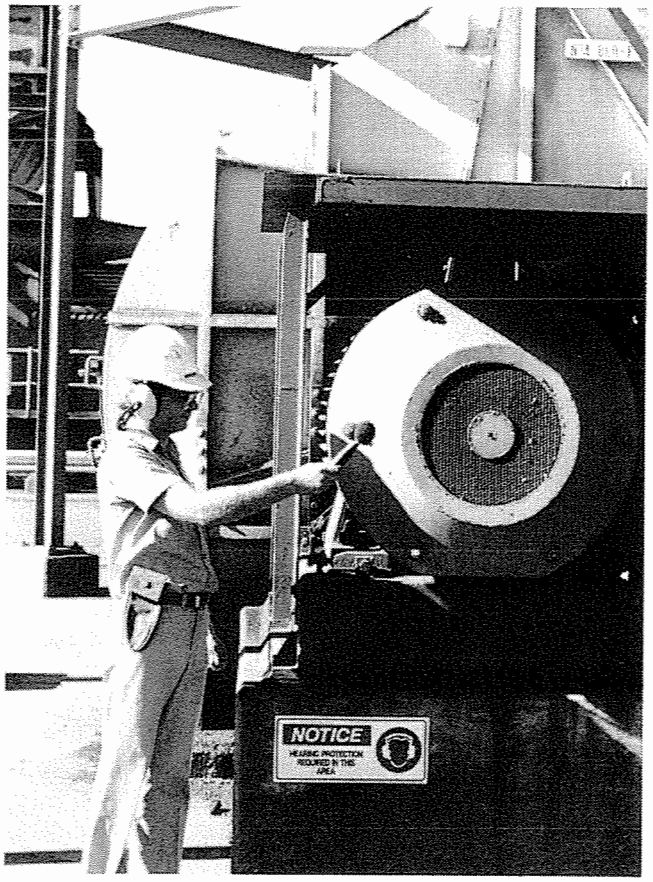
Inspections of workplaces progressed satisfactorily and 127 noise survey reports were submitted by mining companies before 30 June 1986. A further nine reports were completed by the workplace inspectors for small mining companies which lacked the capacity to complete their own noise survey.

Most mining companies were well advanced in matters of employee education, noise hazard warning notices, use of hearing protection, and audiometric testing.

In addition to the occupational health aspect, the noise and vibration section were actively involved in blast monitoring in response to complaints by members of the public living close to mines and quarries, particularly in the Perth metropolitan area.

Material being Produced	Total Dust		Respirable Dust		Fibres	
	−SOP	+SOP	−SOP	+SOP	−SOP	+SOP
Aggregate quarries	15		71	13		
Attapulgite	10	1			5	
Bauxite	21	1				
Gold	8	3	25	4		
Limestone	14		2			
Mineral sands	62	5	4			
Spodumene	3		1			
Talc	7	6			2	
Miscellaneous	8	1	2	2		
Total	148	17	105	19	7	

Material being Produced	Total Dust		Respirable Dust		Fibres	
	−SOP	+SOP	−SOP	+SOP	−SOP	+SOP
Aggregate quarries			2	3		
Gold	1	1	13	2		
Iron	14	5	9		4	
Total	15	6	24	5	4	



Measuring noise level of a ventilation fan motor at a Kalgoorlie gold mine.

Radiation

Mineral sands operations were inspected for radiation safety purposes by Special Inspectors of Mines (Radiation) employed by the Radiation Health Branch of the Health Department. Six inspections were made at the various minesites.

A Radiation Safety Section within the Mining Engineering Division has been formed as a result of a decision by Government on the recommendations of the Winn Report on Radiation Safety in the Mineral Sands Industry. Establishment of this section will relieve industry demands on the Radiation Health Branch except when there is a need for in-depth expertise, and close liaison with this Branch will continue.

The new section comprises an executive officer (physicist), a mining engineer, and a field officer, with supporting clerical staff. The section will advise Government and Industry on radiation safety matters on mines and, by regular inspection, ensure that mineral sands mining companies operate within the requirements of the code of practice on radiation protection, particularly with respect to 'designated workers'.

The mineral sands industry employs approximately 900 persons with about 100 of them as 'designated workers'. (A designated worker is one who regularly works in an area where radiation levels could exceed 0.3 of the stipulated derived limits or may receive an annual dose equivalent in excess of the public limit.)

The Interim Mines Radiation Committee continued to function throughout the year and its role will be taken over in 1986/87 by the Mines Radiation Safety Board as recommended in the Winn Report. The Board will have an independent chairman, Dr Phillip Jennings, Associate Professor of Physics at Murdoch University.

A training course for Radiation Safety Officers was conducted by WAIT-AID Ltd with assistance from industry and the Radiation Health Branch. Successful completion of this course was a pre-requisite for appointment as Radiation Safety Officer.

Mineral sand operations achieved general compliance with the Code of Practice and a reduction in dust concentrations. However one company's sampling programme has shown elevated levels of alpha activity in airborne dust and a more rigorous sampling programme will be undertaken to investigate the matter further.

A new standard for alpha concentrations of 0.8 Bq/m3 is being phased in throughout the mineral sands industry. The previous limit was 2.7 Bq/m3 and a much greater effort will be required by companies to comply with the new limit.

Machinery on mines

Seven Special Inspectors of Mines (Machinery) seconded from the Department of Occupational Health Safety and Welfare (formerly Department of Industrial Affairs) carried out statutory inspections on mines.

The secondment system will end in 1986/87. Thereafter, Department of Occupational Health, Safety and Welfare inspectors will inspect classified machinery on surface on mine sites and Mines Department inspectors will inspect general and mobile machinery on surface (including winders) and all machinery underground. The handing over of inspections of classified machinery will enable greater emphasis to be placed on safe operation of mobile equipment, underground haulage systems and general machinery.

A mechanical engineer was recruited in 1986 and is based in the Kalgoorlie Regional Office, improving the capacity of the Inspectorate to keep up with the increasing demands of industry.

Significant projects reviewed and approved included upgrading of the Golden Crown haulage system, North Kalgurli haulage appliances, Paget Goldmine haulage system, Bellevue shaft-sink project, and haulage systems for Lindsay's Reward Goldmine, Foster Shaft and Albert Shaft.

Several transportable headframes and proprietary hoists were assessed and approved for use on mines, and design aid was given to various small mining ventures and prospectors.

The senior mechanical engineer, was appointed chairman of a committee to prepare an Australian Standard dealing with the safe use of winders. He is very well equipped in terms of knowledge and experience, and by position, to handle this task.

Winding machinery accidents

Twenty incidents involving winders and hoists were

reported during the year. Fourteen were of a minor nature with no significant damage or potential danger to personnel. The remaining six which resulted in more serious damage, were caused by:

— faulty limit switch at the brace;
— unsecured material in the cage;
— rope failure during tipping;
— winder drum shaft failure;
— non-compliance with the regulations;
— overloading of cage floor beam.

All the incidents were investigated and appropriate remedial action was taken to prevent or minimise recurrences.

Electrical inspections

Special Inspectors of Mines (Electricial) carried out 729 inspections of mining operations during the year. As a result of these inspections 130 letters detailing defects were issued to mine managers.

A total of 71 submissions by mining companies, mainly relating to approval of electrical installations and appointment of electrical supervisors, were processed.

No fatal accidents involving electricity were reported. A total of 28 electrical incidents were reported of which 8 warranted investigation.

Inspection procedures were revised to include routine testing of safety interlocks on high voltage switching cubicles following an electical accident on an iron ore mine.

Two fires on mining leases were investigated. Neither was attributed to electrical cause. Six warnings were issued relating to unlicenced, unauthorised, or sub-standard electrical work.

A mining company, a contracting company, and two employees were prosecuted for breaches relating to electrical worker's licences.

Prosecutions

Fourteen persons were prosecuted for offences against the Mines Regulation Act and Regulations. All were found guilty.

Five contractor's employees were prosecuted for failing to wear safety helmets in an open-cut excavation in breach of Regulation 4.3(1). Each was fined $100.

A miner was prosecuted for failing to ensure that there were no misfires in the mine workings toward which he was advancing. He was fined $100 for breach of Regulation 7.24(4).

Two mining company employees were each fined $100 for failing to wear safety helmets in breach of Regulation 4.3(1)

A miner was fined $50 for failing to obtain the consent of his supervisor to fire an obstruction in an orepass at a time other than those prescribed in Regulation 7.30(2).

A locomotive driver was fined $100 for two breaches of Mines Regulations arising from an incident in which a locomotive struck the rear of a train.

A miner was fined $60 for three breaches of the Mines Regulations relating to an incident in which he drove an unauthorised motor vehicle underground.

A miner was fined $100 for drilling into a butt in breach of Regulation 7.24(2).

A contractor's employee was fined $40 for not wearing a safety helmet in a quarry excavation.

An underground supervisor was fined $40 on each of two offences related to firing at other than times prescribed in Regulation 7.30(2)

Charges against a further eight offenders against the Mines Regulation Act Regulations were still to be heard at the end of the year.

Rehabilitation

Gold Mining

The Work Party on Conservation and Rehabilitation in the Mining Industry, set up by the Hon Minister for Minerals and Energy, reported in November 1985 on the gold mining industry which was generally perceived to be the segment most requiring improvement in its environmental standards.

The Work Party made a number of recommendations on measures required to ensure that environmental standards are met. Among these were:

— an environmental management unit should be established in the Mining Engineering Division to formulate environmental objectives, assess environmental proposals submitted by operators, supervise the implementation of approved proposals, and enforce the environmental provisions of the Mining Act;
— tenement holders not subject to State Agreements should be required to submit written environmental proposals detailing the nature of any significant surface disturbance to be undertaken and the planned rehabilitation measures. Such operations should not be allowed to commence until written approval is obtained from designated Mines Department staff following any necessary consultation; and
— administrative procedures should be developed to enable the Mines Department to require a bond for any operation, if it is considered necessary. Such a bond would be available to the Department to finance remedial work in the event of rehabilitation conditions not being met.

Other significant recommendations include:

— the desired end use of land following mining to be clearly defined, so that appropriate rehabilitation procedures can be formulated;
— establishment of regional mining environmental advisory committees so that community-based objectives and standards are formulated.

Following appropriate changes in membership, the Work Party will examine the mineral sands industry.

Mineral sand mining

At the Wonnerup townsite, some 10 km northeast of Busselton, tailings from one of the original mineral sands mining operations in conjunction with a natural mineral sand present a problem due to high concentrations of

monazite that give rise to levels of radiation emission above acceptable limits. The old townsite has once again become a focal point for residential development and it is necessary that radiation levels be reduced before human habitation can be permitted.

The Mines Department has undertaken the role of co-ordinating a mining operation over the area which is planned for commencement during the first quarter of 1987. Following mining, the land will be returned to the respective owners in a stabilised condition having been planted with cover grasses, shrubs and trees. The rehabilitated land will have acceptable levels of radiation and be available for development and habitation.

View of open pit at Cable Sands Mine, Prouse's farm, south Capel operating in 1981.

View of same area in 1986 after the pit has been filled, topsoil spread, and pasture established.

Collie rehabilitation

At Western No 5 Open-Cut mine rehabilitation work continued on a wide scale at various locations. Following contouring and drainage establishment the slopes were successfully seeded by hydro mulching technique. A total of 51 hectares were completed during the year bringing the total rehabilitation area to date to 250 hectares.

At Griffin Coal's Muja open-cut mine considerable effort was given to rehabilitation work including the successful seeding of profiled slopes by helicopter. A total of 22 hectares were completed and this will be extended to 48 hectares during the coming year.

Remedial work in combatting the heating of fine coal in the old Co-operative Mine area continued.

Drilling

In the 1985/86 fiscal year, the Drilling Branch drilled 83 bores totalling 8 024 metres, and controlled the drilling by contractors of 42 bores totalling 1 620 metres. Eighty-three aquifers were developed and aquifer testing was carried out on 30 bores.

In addition, Television Camera Scanning was carried out on 44 bores, 192 sidewall cores were taken, and 360 perforations were made in bore casings using shaped charge explosives.

The work was entirely related to groundwater investigations for assessment of the State's groundwater resources and for specific land-use research projects such as land salinisation.

Contract drilling was supervised in the East Kimberleys for drought relief of grazing properties. A contractor was also engaged to construct pollution-monitoring bores at a number of land-fill rubbish tips in the Perth area.

This year techniques and equipment for the control of high-pressure flammable gases and liquids were introduced into the deep drilling operations, to allow drilling of bores with potential high-pressure gas hazards. The deep drilling operations are a specialised variation of the general procedures used to drill oil and gas wells. Considerable savings are made by using a "double tube" completion which allows monitoring of two aquifers instead of having to drill a separate bore for each aquifer.

The "multiport" construction method for monitoring shallow bores, which has been experimental for two years, has now been successfully developed and is in common use for specialised land-use projects.

Development work is in progress on the "slug" method of testing acquifers, and shows promise of reducing costs considerably on projects suited to its use.

Change-over of the borehole electronic recording gear from analogue to digital (to allow direct interfacing with computers) is under consideration. If effected, this should, greatly reduce the time required to analyse aquifer tests.

The borehole television scanning service continues to be in demand, and is continually improved as new technology becomes available.

Work has commenced on changing the Branch accounting and stores system from manual to computer operation as financial analysis indicates this should save its installation costs in two years of operation.

A summary of drilling and associated work appears in the Supplementary Statistical Digest.

Ventilation Board

The Board met on eight occasions in 1985/86 to exercise its functions under the Mines Regulation Act.

Board membership was increased from seven to nine persons and now comprises:

Mr J M Torlach	State Mining Engineer, Department of Mines, Chairman;
Dr F Heyworth	Principal Medical Officer, Department of Occupational Health Safety and Welfare, Medical Expert;
Dr P Psaila-Savona	Medical Co-ordinator, Occupational Health, Health Department, Medical Expert;
Mr H Jones	Chamber of Mines nominee, Employer's Representative;
Mr P Lockyer	Chamber of Mines nominee, Employer's Representative;
Mr J Beckwith	Australian Workers Union nominee Employee's Representative;
Vacant	Trades and Labour Council nominee, Employee's Representative;
Mr D Collie	Principal Mining Engineer, Department of Mines;
Mr I Loxton	Regional Mining Engineer, Department of Mines.

A paper, entitled "Mining the Marra Mamba Orebody — Evaluation of Possible Health Risks", was written at the request of the Board by Dr Heyworth and Senior Mining Engineer Mr R A C Williams following expression of concern by workers in the iron ore industry.

A working group including board members and representatives of employers and employees in the iron ore industry was established to examine the possible effects of dust on workers in the Marra Mamba orebody.

The working group endorsed the view that such workers are at no greater risk than those where hematite is mined.

Rapid expansion in the gold mining industry has resulted in a proliferation of new gold recovery plants and a significant increase in the use of sodium cyanide. A series of half-day seminars was conducted in Perth and at six regional mining centres Kalgoorlie, Meekatharra, Mt Magnet, Leonora, Marvel Loch and Marble Bar. The seminars were held to inform management and employees of the dangers and protective measures required when cyanide is used. The seminars were attended by more than 300 people who showed a high level of interest in the subject.

(Left to right) Ian Loxton and Oscar Williams (Mining Engineering Division) with J Genovese (Govt Chemical Laboratories) and Dr F Heyworth (Dept of Occupational Health and Safety) at a seminar on safe handling of cyanide.

Initial steps were taken to amend dust sampling strategy to make it more representative of conditions on mines.

Regulations dealing with ventilation on mines in Part 8 of the Mines Regulation Act, Regulations were updated.

Staff

C Kirwin was appointed Noise and Vibration Officer, Perth on 1 July 1985.

M J Brown was appointed Noise and Vibration Officer, Karratha on 1 July 1985.

S B Bremen was appointed Ventilation Officer, Kalgoorlie on 1 July 1985.

B Johnson was appointed Machinery Inspector, Karratha on 22 July 1985.

A McDonald was appointed Noise and Vibration Office, Kalgoorlie on 29 July 1985.

M A Bohm was appointed Ventilation Officer, Kalgoorlie on 29 July 1985.

D Lenigas, Ventilation Officer, Kalgoorlie resigned on 21 February 1986.

J C Spreadborough was appointed Mechanical Engineer, Kalgoorlie on 3 February 1986.

J A Cedro, District Mining Engineer, was transferred from Kalgoorlie to Perth on 17 February 1986.

R J Lea, District Mining Engineer, was transferred from Perth to Karratha on 27 March 1986.

A Sheppard, Mining Engineer, was transferred from the Ventilation Section to the Radiation Section on 17 April 1986.

P J Acton was appointed Clerk, Radiation Section on 24 April 1986.

M L Mahajan was appointed District Mining Engineer, Kalgoorlie on 28 April 1986.

M Ralph was appointed Radiation Field Officer, Perth on 30 June 1986.

The positions of State Coal Mining Engineer and Regional Mining Engineer which have been vacant for a lengthy period will be filled in early 1986/87.

Board of Examiners — Certificates of Competency

Certificates of Competency issued for management and supervisory positions under the Mines Regulation Act and Coal Mines Regulation Act during the year 1985/86 are tabled below:

Metalliferous Mining Certificates of Competency issued July 1985 to June 1986

First Class Mine Managers

183 SUCKLING, I.M.
184 HOLLY, D.R.
185 GROSE, F.T.
186 KING, A.H.
187 BUCKLAND, K.G.
188 CANNINGS, W.R.
189 RONALD, W.I.
190 BLAKE, W. R.

191 MORTIMER, R.R.
192 GILLETT, L.J.
193 MYERS, P.A.
194 GREEN, S.W.
195 ROWLANDS, A.T.
196 BERGIN, N.K.
197 MILLS, G.J.
198 MENEGHINI, J.P.
199 BRUCE, P.F.
200 HEATHER, S.J.
201 GREENWOOD, J.B.

Underground Supervisors

A369 ALLSOPP, P.J.
A370 McKINSTRY, J.D.
A371 CHUK, A.M.
A372 TURTON, A.D.
A373 POWELL, S.J.
A374 HEWITT, G.P.
A375 DARVENIZA, P.
A376 HEATHER, S.J.
A377 SMITH, M.W.
A378 BERGIN, J.H.
A379 GILLMAN, S.J.
A380 ANDERSON, J.S.
A381 KLYNSTRA, J.
A382 SOKOLENKO, V.J.
A383 ZOLEZZI, M.A.
A384 CLARKE, B.H.L.
A385 DEKKER, M.
A386 NICHOLS, R.J.
A387 DEATH, A.R.
A388 McGRATH, A.J.
A389 HOCKLEY, N.H.
A390 HILLS, S.A.
A391 RIDGE, S.L.J.
A392 DODDS, A.G.
A393 EYERS, G.C.
A394 HINE, M.A.
A395 WOODALL, D.G.
A396 CONLAN, G.R.F.
A397 HENDRYCH, G.
A398 DEATH, P.
A399 RUSSELL, D.S.
A400 TERBEEKE, C.J.
A401 DOWNIE, C.R.
A402 LUMSDEN, W.R.
A403 O'ROURKE, M.L.
A404 RODAN, M.F.
A405 JOLLEY, K.W.
A406 de VRIES, J.C.
A407 RANCLAUD, L.C.
A408 THOMAS, L.E.
A409 MALEY, N.P.G.
A410 BOX, D.R.
A411 VALENTINE, D.R.
A412 PATTERSON, D.H.E.
A413 PTSCHELINZEW, P.K.
A414 SCHOCH, F.G.
A415 HOWELL, R.J.
A416 WOTHERSPOON, J.
A417 FLORANCE, R.W.
A418 BOYD, J.C.
A419 WILLIAMS, D.L.
A420 LYDON, M.I.A.
A421 MURPHY, J.G.
A422 BURSTON, S.A.
A423 RANKIN, D.R.
A424 BOWEN, N.R.
A425 HUSTON, R.W.
A426 MOKOS, P.P.
A427 ROSE, D.M.
A428 HARDWICK, R.J.
A429 BOWRON, A.M.
A430 CARROLL, I.R.
A431 NICHOLLS, D.R.C.
A432 GALVEZ, M.A.
A433 SPANJAARD, C.A.M.
A434 JORDINSON, R.

Quarry Managers

101 TIPPER, R.G.
102 ROLLO, N.E.
103 CORNWELL, P.J.
104 WOODWARD, G.A.
105 DUNLOP, J.
106 OLIVER, R.G.
107 SNOWDEN, R.
108 WRIGHT, P.R.
109 GLOYNE, M.J.

Restricted Quarry Managers

150 CARUSO, P.F.
151 SELLWOOD, G.S.
152 SCANLAN, J.D.
153 LEE, R.J.
154 STOJKOV, K.J.
155 GEORGE, R.St.J.
156 ADAMS, B.J.
157 FERRARO, J.M.
158 FOSTER, D.A.
159 TOOVEY, D.L.
160 SCHAPEL, R.J.
161 CLEMENTS, M.J.
162 DANKS, K.
163 O'CONNOR, P.
164 CHAMBERLAIN, K.
165 CARTER, P.
166 BERKHOUT, P.
167 PRICE, G.
168 FRANKLIN, G.
169 SCANLON, T.
170 BELL, K.C.
171 WOOLFORD, C.
172 WHEATLEY, K.J.
173 COLLINS, M.
174 DIXON, R.G.
175 MARLAND, D.H.
176 CHAMBER, R.D.
177 WATTS, H.R.

Authorised Mine Surveyors

078 WRIGHT, V.C.D.
079 MARSHALL, A.J.
080 DUNNE, J.M.
081 BACHER, A.V.
082 ROGAN, J.F.

Coal Mining Certificates of Competency Issued July 1985 to June 1986

First Class Mine Managers

52 BLACKFORD, G.D.
53 OLSEN, P.G.
54 SANDERSON, PR

Deputy

115 GADECKI, S.
116 HUGHES, R.J.

Open Cut Mine Managers

16 McGUCHIN, G.R.

Authorised Coal Mine Surveyor

06 SMITH, R.T.

Deputy (Open-Cut)

22 BANKS, B.J.
23 DOWNS, D.H.
24 HARROLD, B.W.

Summary description of fatal accidents reported during the 12 months ending 30 June 1986

Name Occupation Date of Accident	Mine details and remarks
B A Langley Miner 3/7/85	Kalgoorlie Mining Associates, Kalgoorlie Lake View. The deceased was struck by a rock in the 11/110 cut-and-fill stope.
U F Koslowski Track Maintenance Workshop Foreman 18/10/86	Mt Newman Mining Co Pty Ltd, Newman. The deceased was crushed between the front of a four-wheel-drive vehicle and a railway re-sleepering machine in a railway plant maintenance workshop.
B A Redman Geologist 23/10/86	Kia Ora Gold Corporation NL, Marvel Loch Gold Mine. The deceased was standing on top of a hung up ore pass which gave way causing him to fall down the ore pass.
G Venturini Underground Supervisor 7/11/86	Metals Exploration Ltd, Nepean Mine. The deceased fell down a ventilation rise in a stope.
A L N Miller Pipe Fitter (Contractor) 11/12/86	Brunswick Oil NL, Galtee More. The deceased fell approximately 4.7 metres from a cable tray on to a concrete floor.
D E Taylor Miner 11/12/85 E J Potts Miner	Agnew Mining Company Pty Ltd. Agnew Mine. Both men were suffocated due to a major depletion of oxygen in 1443 level, number 2 stope, caused by oxidation of sulphide ore. Potts went into the stope seeking material for a ventilation stopping. Taylor who went into the stope later, succumbed, presumably trying to rescue Potts.
R M Matheson Scraper Driver (Contractor) 18/12/85	Western Mining Corporation Ltd, Kalgoorlie Gold Operations, Morrison open-cut, Fimiston. The deceased was driving a scraper which overturned.
M L O'Rourke Miner 19/2/86	Western Mining Corporation Ltd, Kambalda Nickel Operations, Jan Shaft. The deceased was struck by a rock in a gig rise between 1300 and 1200 levels.
K J Nazzari Miner 21/3/86	Central Norseman Gold Corporation Ltd, Ajax Shaft. The deceased was struck by a fall of rock in the 10/1200 stope.
A T Anderson Driver (Subcontractor) 11/6/86	North Kalgurli Mines Ltd. Surface, near Croesus open cut. The deceased was assisting in the removal of a 60 tonne haul truck from a low loader when a jack slipped causing the truck to drop. Mr Anderson was crushed between the front tyre and a wooden chock.

STATE BATTERIES — An early appraisal

So far as can be determined, Mr A Montgomery, MA, FGS, was born on 10 January, 1862. He joined the Mines Department in 1902, on a salary of £700 per year, as Mining Engineer, a position he filled until his retirement in 1929. Executive Council approved his extended service to the age of 67 years.

His first function was to investigate the proposed erection of a State Battery (copper) on the Phillips River Goldfield. He was active in the early establishment of the first School of Mines at Coolgardie, opened in early 1903, and the Kalgoorlie School of Mines, opened in late 1903.

The following philosophical comments are editorially extracted from his 1904 Annual Report as State Mining Engineer.

"Under Part IV of the Mining Act, the extension of the State Battery system continued during 1904 on the same lines as the preceding year. It may be useful to make a few remarks on one aspect of the State Battery question which has on several cases lately been brought into prominence. This is a demand that the State batteries should from the first be furnished with plant for the most complete and economical treatment of the tailings, both sands and slimes, in order that the owners of small mines may realise the greatest possible percentage of the value of their ore, and raises important questions as to the proper functions and objectives of a State battery, and how far it should be managed on strictly commercial lines. The primary object of State batteries, I take it, is to enable the prospectors and small mine owners of a district to prove their mines by working trials, and put them in a position to have them opened up on a more extensive scale, so that they may eventually get batteries of their own. No mine of any magnitude can be content for a long time to cart its ore, perhaps several miles, to a small State battery, and in a healthy and progressive field the natural growth of the mines ought from time to time to result in the erection of their own batteries, leaving the State one free to crush for prospectors and little developed mines, or even rendering it unnecessary altogether. The State battery under such circumstances might show a heavy loss if considered purely as a commercial concern and yet have been a great national benefit in bringing about the establishment of a flourishing field. Its first objective is served when the mines become strong enough to do without it, and from this point of view it is seen to be an essentially temporary means of encouraging the early stages of the development of a district.

"Its primary function being of a temporary nature it is hardly reasonable to demand that the equipment should be of the costly character of a permanent mill, and the question of the class of plant to be provided narrows itself down to that which will reasonably serve the objective of bringing the mines to the self-supporting stage. There are two ways by which this stage may be achieved: by the introduction of sufficient capital to open the mine and furnish it with a battery; or by raising enough gold from the mine itself to permit progressive expansion of the mining operations and purchase of machinery.

"For the introduction of outside capital the first necessity is proof of the value of the mine, and this is furnished most conclusively by crushings at the State battery. For the purpose of proving mines sufficiently to to justify capital being put into them, assays of the tailings from the amalgam process should show their value quite satisfactorily, without the need for the battery to provide expensive slimes treatment appliances.

"But as the prospector has to make his living from the proceeds of the crushings, it is always almost necessary that the treatment should go further than amalgam and include the cyaniding of the sands, as otherwise the returns are insufficient to enable him to cover expenses. For the case where the mine owner is trying to develop his mines as he goes along, he wants every penny he can make from the ore to enable him to extend his operation. If there were many mines or prospectors in a district a good argument might be made for equipping the State battery very completely, even at the risk of loss, as additional revenue due to the success of even one good mine would compensate the State for considerable loss on the battery. In actual practice, the need for completing the slimes equipment of the State batteries in order to enable small mine owners to extend their operations is so seldom visible as to be quite negligible in most cases.

"So far as testing and proving prospective mines is concerned, therefore, there is rarely any good reason why the State mills should carry the treatment further than amalgamation, followed by cyaniding of the sands. But now we come to the second function of these batteries, which is to provide treatment facilities for small mines which have no plant of their own. This becomes of more importance in many districts than the original objective of testing and proving the reefs. Small parties of working miners take up reefs and work them to make a living out of the gold raised, without any special intention of doing anything towards more extensive development. In such instances the State battery is simply a "Custom Mill", and there is little reason why the general body of taxpayers should contribute to their support at all. Being simply worked for the purpose of making a living, the reefs should be entirely self-supporting, and State battery erected to afford the crushing facilities should make charges on ordinary commercial principles, to recoup not only working expenses, but also interest on the cost of erection and profit sufficient to cover redemption of capital cost. The amount of plant erected should therefore be determined by the prospects of its being commercially profitable. When a large quantity of slimes has been accumulated, and the state of the district affords some guarantee that ample supplies of ore will be maintained, it might be good business to add filter press treatment of slimes to the mill equipment, but the question,

in my opinion, ought to be looked at mainly from a commercial point of view.

"It seems to me that a sharp distinction must be drawn between batteries erected in new fields for the purpose of proving them and hastening their development, and those that are put up, especially in settled districts where there are batteries already, simply to afford crushing facilities for a number of small owners. The extreme cases of each type are easily distinguished, but most of the difficulty of the question results from the fact that very many of the cases are a blending of both types, purely prospecting ventures of the first gradually becoming small working mines of the second, passing on into the desirable stage of becoming independent concerns with their own machinery equipment for mining and milling. The plant provided should accordingly be opened and developed, and might legitimately be operated at a loss; whereas in the second instance the question should be decided on ordinary commercial principles.

"The most feasible method of confining encouragement to parties developing and extending their mines, with establishment of crushing facilities for those who are simply working for a day to day living, is to fix the ordinary rates for treatment at a figure which will pay for cost of the plant and interest on a redemption of the first cost of the plant, and give substantial reductions in the rates to such owners as are carrying out bona fide development work."

The original Menzies State Battery, located on Reserve 10253, operated over the period 1904 to 1915.

STATE BATTERIES

E. J. GREEN, SUPERINTENDENT

The average gold list price for 1985/86 financial year, as advised by the Gold Producers Association Ltd, was $476.50 per oz which was an increase of $54.50 on the previous year's average of $422.00.

Recent practice of the State Batteries has been to keep charges at a reasonable level yet at the same time to endeavour to contain the loss, i.e. the subsidy, to industry. This has been possible by the revenue gained from tailings treatment, both by State Batteries and allocation to contractors.

The table below shows the tailings treated during the 1985/86 financial year. While tonnes treated by heap leaching are lower than the previous year, the values extracted are higher for the period.

TAILINGS TREATMENT 1985/86

State Batteries	Tonnes treated	Value of extracted gold paid to:	
		State Batteries $	Prospectors $
HEAP LEACH TREATMENT	35 500	539 820	215 728
CIP TREATMENT	53 243	602 338	132 275
CONTRACT ALLOCATIONS	128 143	174 082	—
OTHER REVENUE	—	1 190	—
TOTAL	216 886	1 317 430	348 003

State Batteries' carbon-in-pulp (CIP) treatment is necessary in some areas of fine clay-type ores and this activity is continuing at Meekatharra, Coolgardie, and Kalgoorlie to enable revenue production from this type of tailings. In addition, a transportable type CIP unit is almost ready for assembly. This unit is programmed for Ora Banda and Leonora where further clay-type tailings are evident. Future additions of a jaw-crusher and ball mill would make this a complete transportable plant.

The expenditure on general upgrading of State Batteries for the 1985/86 period is itemized in the following table.

EXPENDITURE IN UPGRADING 1985/86

Facility	$
Assay plant relocation	60 000
Heap leach plant and equipment	58 000
Manager's house, Coolgardie	55 000
Mobile carbon-in-pulp plant	162 030
Noise abatement modifications	91 316
Vehicle garage	60 000
Engineering maintenance	18 464
Electrical maintenance	2 761
Housing maintenance	6 037
Water supplies	11 515
Carbon strip facility extensions	14 249
Forklift	13 779
Carbon reactivation kiln	18 350
Assay equipment	13 647
TOTAL	585 148

Operations

Crushing gold ores

One 20-head, seven 10-head, and five 5-head mills crushed 23 986 t of ore, made up of 253 separate parcels, averaging 94.8 t per parcel.

The bullion recovered amounted to 191.971 kg estimated to contain 163.173 kg of fine gold equal to 6.80 g/t of ore. The average grade of tailings after amalgamation was 2.68 g/t, giving an average grade of ore received of 9.48 g/t; in addition smelts produced 58.459 kg of bullion estimated to contain 49.688 kg of fine gold.

In total 212.861 kg of fine gold was produced in 1985/86 from amalgamation and smelting activities in the State Batteries, compared with 519.678 kg of fine gold in the previous year.

In 1985/86 the gross cost of crushing 23 986 t of ore was $101.35/t, compared with 1984/85 ore crushed at the gold plants totalling 28 755.5 t for a cost of $85.91/t.

The nett cost of crushing (after payment by prospectors) was $87.29/t compared with $74.36/t in 1984/85.

Cyanidation

In 1985/86 State Batteries at nine individual battery locations treated 88 743 t of tailings by CIP and heap-leaching methods for a production of 90.444 kg of fine gold, of which 31.32 kg were paid out to prospectors, the remaining gold was sold for revenue. The average gold content was 1.85 g/t before cyanidation and the actual recovery of completed and part completed installations was 54.9 per cent. Of the total of 35 000 heap-leachings tonnes installed, 8 600 t were still being treated.

In addition a total of $9 814 was collected for the contract stripping of batches of carbon which produced 20.574 kg of bullion estimated to contain 17.488 kg of fine gold.

The CIP plants at Kalgoorlie, Coolgardie, and Meekatharra treated 53 243 t of the total tonnes treated for a production of 49.392 kg of fine gold at a treatment cost of $18.78/t, compared with $11.89 in 1984/85.

The heap-leaching plants treated a total 35 500 t at a treament cost of $9.12/t, compared with $11.12 in 1984/85.

The production of gold was made up as follows:

	1984/85 kg (fine)	1985/86 kg (fine)
Amalgamation gold —	222.238	163.173
Smelt gold —	219.744	49.688
Cyanidation gold —	99.67	90.444
C.I.P. strip gold —	18.935	39.221
	558.611	342.526

CARBON-IN-PULP ASSESSMENT 1985/86

Location	Tonnes treated	Cost		Income				Profit (Loss) $
		$	$/t	State Batteries $	Paid to Prospectors		Total $	
					Kg Gold	$		
Coolgardie	17 101	350 414	20.49	185 161	6.431	69 689	254 850	(95 564)
Kalgoorlie	23 787	372 148	15.64	251 218	3.802	48 562	299 780	(72 368)
Meekatharra	12 355	277 551	22.46	165 959	0.492	6 310	172 269	(105 282)
TOTALS	53 243	1 000 113	18.78	602 338	10.725	124 561	726 899	(273 214)

Other metal production

Silver to the value of $2 646 was recovered as a by-product of refining Battery gold.

No other metals were recovered during the period.

Value of production

The estimated value of gold and other metal production from the State Batteries in 1985/86, and the total since their inception excluding the value of gold tax paid to the Commonwealth is shown in the accompanying table.

VALUE OF PRODUCTION FROM STATE BATTERIES

	1985/86	Since Inception $
Gold	5 248 027	103 864 811
Other Metals		
Silver	2 646	21 952
Tin (concentrate)		515 385
Tungsten (concentrate)	—	98 619
Copper (ores for agricultural use)	—	11 932
Lead and zinc (concentrate)	—	1 650 865
Tantalite (columbite concentrate)	—	270 030
Garnet (concentrate)	—	131 001
Other Metals Total	2 646	2 636 784
GRAND TOTAL	5 250 673	106 501 595

Research and development

Development of a hydraulic stamp system instead of the age-old cam system has reached the stage where a prototype unit is ready to be forwarded to Kalgoorlie for further test work.

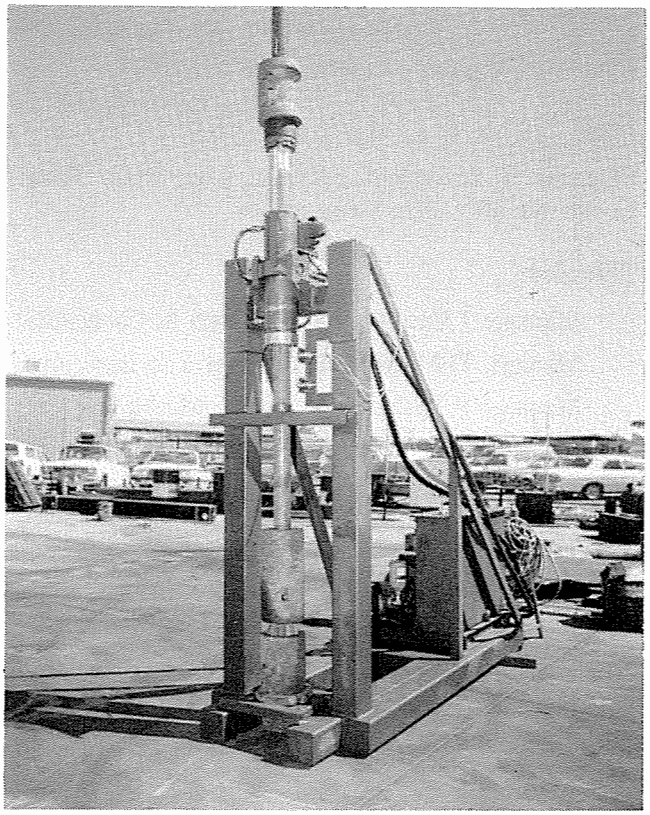
Installation of this operation will reduce noise level and hopefully maintenance.

Test work on recovery of gold from spent carbon, in conjunction with the Government Chemical Laboratories (Engineering Chemistry Laboratory), indicated many difficulties in this field that have not been resolved. The main problem after ignition of the spent carbon was extraction of the gold from material in which as little as one percent of unburnt carbon retained most of the soluble gold.

Further test work with the Government Chemical Laboratories and the Kalgoorlie State Batteries indicated the potential of Thiourea for extraction of refractory gold material.

The inconsistency of extraction, and high chemical consumption and costs, gave little hope for a practical operation at this stage of knowledge.

The method however should be examined for each individual ore system, as its potential is dependent on the compatibility of the ore characteristics with the extraction reactions, and because of its environmental acceptance.



Prototype hydraulic stamp developed and tested at the Kalgoorlie State Battery.

State Battery Inspector's Report

Forty two days have been spent on field inspections during the year 1985/86.

Considerable upgrading has been carried out on Batteries by State Batteries engineering staff, during the past few years, and have resulted in all batteries being in the best operating condition they have achieved in the last 35 years.

Work carried out and still under progress in relation to the Noise Abatement Act has resulted in greater comfort and protection for all battery staff.

STATE BATTERY OPERATIONS 1985/86

Battery	Total tonnes	5 Stamp Mill Hours Run	"Duty" (tonnes per hr per mill of 5 stamp capacity
BOOGARDIE	1 504	1 443	1.04
COOLGARDIE	3 244	4 846.5	0.67
KALGOORLIE	5 576	6 640.5	0.84
LAVERTON	607	942	0.64
LEONORA	3 290	5 293.5	0.62
MARBLE BAR	1 557	2 071.5	0.75
MARVEL LOCH	3 495	5 908	0.59
MEEKATHARRA	403	501.75	0.80
MENZIES	749	1 135	0.66
NORSEMAN	1 618	2 119.5	0.76
ORA BANDA	432	336	1.28
PAYNES FIND	1 359	1 612.5	0.84
YARRI	152	181.5	0.84
OVERALL TOTALS	23 986	33 031.25	0.73

Noise surveys of all batteries carried out by BMA staff has identified problem areas, and all staff have been tested for hearing loss. Most long-serving staff have suffered some hearing loss and progression of this loss should be eliminated by proper control under the Act.

Staff

Manager T Broadbent resigned from State Battery Coolgardie after eight years service.

Transfers

Manager J Edwards; Marvel Loch to Coolgardie.

Manager D Elsegood; Meekatharra to Laverton

Manager P Tucker; Laverton to Marble Bar.

Manager R Bell; Marble Bar to Meekatharra.

Manager B Wade; Norseman to Leonora.

Manager M Spain; Leonora to Norseman.

Foreman J Lee; Kalgoorlie to Acting Manager Marvel Loch.

Foreman G Sceghi; Leonora to Meekatharra.

Foreman J Piggott; Meekatharra to Manager Ora Banda.

Safety

Nine time-loss accidents and ten no-time-loss accidents resulted in 35 man-day-loss recorded. This is a big improvement over previous year when 15 time-loss and 15 no-time-loss accidents resulted in 146 man-day-loss.

Fourteen of the nineteen accidents recorded were at Kalgoorlie State Battery. Eight of these accidents occurred in the engineering workshop area. Management supervision in this area must be improved to reduce accidents.

Organisation

During 1985/86 a monthly average of 99 men were employed at State Batteries throughout the State. This figure does not include the Superintendent, State Batteries.

The average number employed is drawn from a staff ceiling of 32 Ministerial officers and 83 wages staff.

Due to fluctuating supplies of ore to be treated the total number of personnel employed ranged between 94 and 107.

State Batteries — Vale

First November 1986 will see the end of 88 years of Mines Department operation of State Batteries. It is hoped that under the new control the concept of helping exploration and development through State Batteries will continue.

Under the new arrangement a potential for a freedom in finance, production and marketing will be available as was never before known at State Batteries. It is hoped that emphasis and service will still be directed towards those "battlers" who deserve the help.

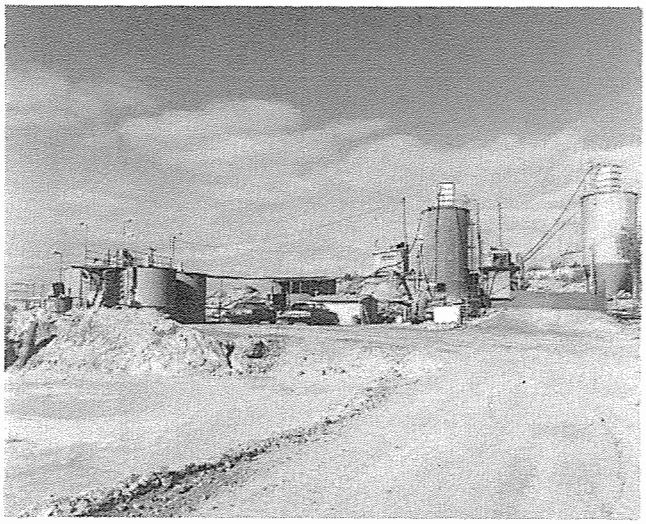
Mr E J Green, Superintendent State Batteries, in a personal message foreshadowing his retirement after nine years, said:

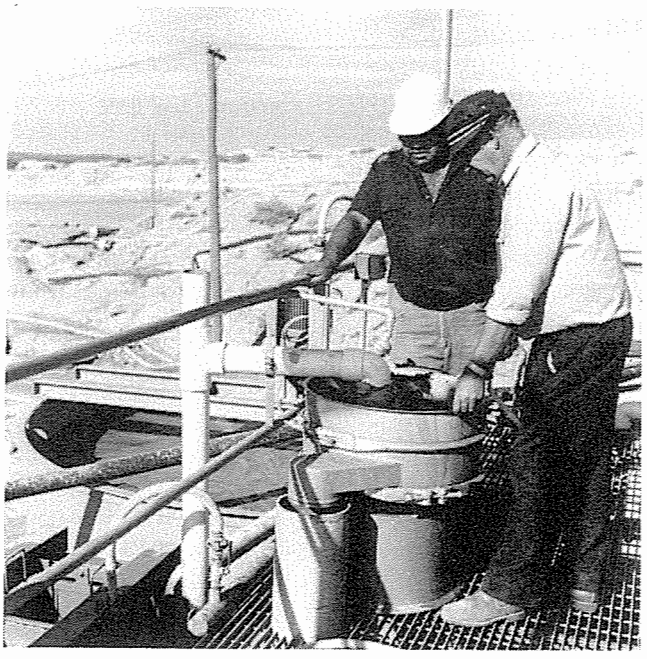
"State Batteries have the honour of being the oldest continuous gold production system in Australia and it is with regret and trepidation that many dedicated staff see the changing circumstances.

"Some staff members, with over thirty years service, know State Batteries as a life-time position. To these, and to many others behind in service but not in dedication, 'I dips me lid'.

"These men, their wives and families, after living in conditions way below their status, earned the respect of many shires and towns of the Outback.

"It is with regret that I retire from State Batteries after a mere nine years. These nine years were however the best nine in forty years of production in the Mining Field, and I am happy to have been associated with such a team."





On the eve of transfer of State Batteries to WA Development Corporation, many improvements have been made to the Kalgoorlie Battery.
Left: New coarse ore feed bins installed.
Top: New store and engineering shop built.
Above: A new continuous C-I-P plant constructed and old pachuca-type tanks (on right of picture) used as digestion surge tanks.
Middle Right: Close-up of newly installed C-I-P plant.
Right: Leading cyanide hand Monty Allison and cyanide manager Cliff Solly checking transfer of loaded carbon.

WITWATERS RAND-TYPE GOLD — Is there a deposit in Western Australia

One of the primary functions of the Geological Survey is to provide a geological database that can be used in the development of conceptual models for the discovery of new mineral deposits, particularly those that need geological theory for their detection because they are completely buried — the so-called "blind" deposits. One method in this approach is to match the diagnostic geological characteristics of a certain class of deposit found elsewhere in the world, with the regional geology of the State. The chances of finding another Broken Hill, or Zambian copper belt or a Witwatersrand, are significant if the geological conditions are right.

The giant Witwatersrand Goldfield, itself a largely blind deposit, is one of Nature's geological mysteries as well as being the world's largest single geological source of gold. Most gold deposits of the world, including those that we are familiar with in Western Australia, are described as epithermal or hydrothermal. That is, they formed from hot fluids circulating through volcanic rocks, early in the crustal forming process. These fluids could either have been related to the volcanism, or to metamorphic dewatering when the rocks were buried, heated, and folded. The resultant deposits occur in complex, impersistent veins and lodes in deformed and highly altered rock.

By contrast, the Witwatersrand deposits are described as palaeoplacers, as they occur on extensive horizons in beds of quartz-pebble conglomerate that were deposited by ancient rivers pouring into a shallow sandy basin. All the constituents of the Rand "reefs", including the gold, show evidence of having been deposited grain by grain in an alluvial fan environment. This is not to deny the possible role of circulating hydrothermal systems, because the palaeoplacers have been modified. The ultimate gold source is also still a mystery.

Three other features characterize this type of deposit. Firstly, the host sedimentary rocks relate to an episode of crustal stabilization when the development of the very old and highly mobile granite-greenstone terrains gave way to a more stable crustal regime characterized by extensive marine sedimentary cover sequences and confined tectonic belts.

Secondly, some unusual features of the reefs suggest that the period during which they formed was one of unusual surface chemical conditions very different from those of the present day, and characteristic of that time. These features include a relative abundance of detrital grains of pyrite and uraninite, minerals which do not survive long exposure to atmospheric oxygen, and also the presence of enigmatic carbonaceous traces of early life forms.

Thirdly, similar auriferous or uraniferous quartz-pebble conglomerates of varying economic importance, are also known from Canada, USA, Ghana, India, and Brazil, where they all fall in the time band of 2.8 to 2.4 billion years before present.

Sedimentary sequences containing weakly auriferous quartz-pebble conglomerates of the required age, and indicative of crustal stabilization, were deposited in the early phases of the Hamersley Basin sequence on top of the ancient greenstones of the Pilbara in Western Australia. They are known to occur in the Chichester and Hamersley Ranges, and in isolated basins near Nullagine and Marble Bar, but despite extensive exploration over the last two decades (with some encouraging results), no geological analogue of the Witwatersrand deposits has been found.

However the search for a possible analogue takes on a new meaning with recent work in both subcontinents. Recent precise isotopic age dating has shown that the bottom of the Hamersley Basin sequence has the same age as the sequence that covers the Witwatersrand Basin, and that strikingly similar sedimentary sequences can be recognized. Moreover there is emerging evidence that the Hamersley and Transvaal Basins could be the ruptured parts of a once larger basin, torn apart by an early period of continental drift.

If a Witwatersrand-type gold deposit exists in Western Australia, then it is likely to be buried beneath the extensive cover of basalt, shale, dolomite, and iron-formations of the Hamersley Basin. Its detection will require a complete understanding of the sedimentological and tectonic evolution, and the geophysical characterization of the Hamersley Basin, a project that is now under way by the Geological Survey.

The prize for discovering another Witwatersrand is immense, for the Rand has yielded 40 500 tonnes of gold, and has a current annual output of nearly 700 tonnes. By comparison, Western Australian historical production is 2 300 tonnes, with a present annual production of 50 tonnes — more than an order of magnitude in difference.

Conglomerate in the Hardey Sandstone, low in the Hamersley Basin succession, and a possible host to Witwatersrand-type gold deposits.

A feature of the year was the incidence of administrative changes that required input from staff at all levels, with resulting encroachment on time for which other productive uses had been planned.

While planning is not new in managing the Division, the requirement to prepare a formal Corporate Plan with defined objectives and completion targets is taking much longer than expected. It has already been recognized as a useful exercise in that initially some 127 projects (operations that will be completed in less than 5 years) and 45 sub-programmes (operations lasting more than 5 years) were found to be in progress and the danger of undertaking too much work became evident.

The preparation of Position Data Forms for all staff, as required by the Public Service Board, also demanded close attention as it was evident that the information supplied in these forms would be used directly as a means of assessing Service-wide salary "broadbands".

Planning for eventual reaccommodation in the enlarged Mineral House complex proceeded despite basic disagreement with the Office of Government Accommodation on the amount and type of working space required for geologists to efficiently perform their duties.

A project that has claimed significant time from several sections is the compilation of Memoir 3, "The Geology and Mineral Resources of Western Australia". It began in 1983 as a revision of Geological Survey Memoir 2, "The Geology of Western Australia" (published in 1975 and reprinted in 1983), always with the intention of including an account of the mineralization and with better illustration throughout. For various reasons, few of the thirty authors were able to begin compilation until this year, during which roughly half of the text has been written.

Although to date no commercial organization has accepted the invitation to fund particular Geological Survey activities, a number of overseas universities have arranged for Geological Survey staff members to supervise post-graduate research students on field projects in Western Australia. In this way overseas research grants are largely spent in Western Australia, the services of specialist investigators come free-of-charge to the Geological Survey and our knowledge of the geology of particular areas is advanced, for the relatively small outlay involved in supervisory time and logistic support. Where the aim is to produce a thesis (typically for a doctoral degree) the Survey generally has first rights to publication.

In this way Miss C. Brown, from Imperial College, University of London, is examining the Mount Barren Group and related rocks on the southern margin of the Yilgarn Block. The purpose of the study is to understand the structure and tectonic evolution of the metasedimentary rocks in this area that are related to the Albany-Fraser orogen. Dr J Myers, Supervising Geologist, Precambrian Geology Section shares the Supervision of the project with Dr S. White of the University of London. It is expected that field work will be completed in 1987 and the thesis presented in 1988.

Doctoral candidates Miss V. Pedone and Mr B. Ward, both from the State University of New York, have been engaged for the past two field seasons on investigating diagenesis and dolomitization respectively in the Canning Basin Devonian reef complexes under the joint supervision of Professor W. Meyers (S.U.N.Y.) and Dr P. Playford, Assistant Director General of Mines. It is likely that the results of their work, together with those from other studies recently completed by external investigators, will be combined with current work by Geological Survey personnel to produce a comprehensive publication on the Devonian reef complexes.

In a project commenced in 1984, Mr M. Cornelius of the University of Leoben (Austria) investigated the origin and mineral potential of layered mafic complexes in the Western Gneiss Terrain under the joint supervision of Prof. E. Stumpfl and Dr R. D. Gee, Deputy Director, Geological Survey Division. The field work, now completed, involved mapping and sampling of all known occurrences of xenoliths and other remnants of mafic and ultramafic bodies between Tallering Peak and Yornup in Western Australia.

Dr B. Simonson of Oberlin College in Ohio U.S.A. commenced a study of the Wittenoom Dolomite, one of the lower units of the Hamersley Group, in the Hamersley Range and Ophthalmia Range areas. The aim of the study is to establish the palaeoenvironment of the Wittenooim Dolomite which should illuminate depositional conditions of the stratigraphically adjoining banded iron formations. It is planned to publish Dr Simonson's work as a Geological Survey Bulletin after field work is completed in 1987.

There was further interaction with other organizations when Dr D. Groves (University of Western Australia) and Dr M. Etheridge (Bureau of Mineral Resources) were invited to assist with the supervision of a Geological Survey project aimed at determining the structural evolution of the host rocks for the gold mineralization on the "Golden Mile" at Kalgoorlie.

Operations

Some of the more important projects undertaken by the Division are described in the following sections.

Basement, Minerals, and Geotechnics Branch

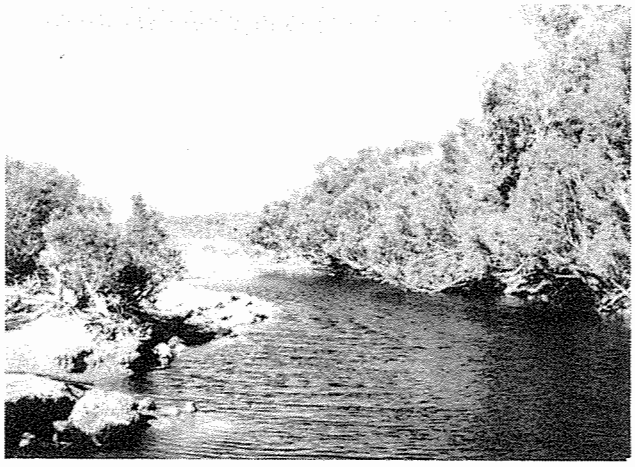
Precambrian Geology Section. A considerable amount of report writing and map compilation was done for projects, the field work for which was completed in the previous year or earlier this year. These included the Ashburton Fold Belt, Sylvania Inlier, Balfour Downs, Boorabbin, and Widgiemooltha 1:250 000 sheets remapping, 1:100 000

mapping on Yilmia, Lake Lefroy, Cowan and Kalgoorlie Sheets, and the Murchison Metallogenic project. The Murchison Metallogenic Project has included contributions from other sections and will lead to a comprehensive bulletin in which the evolution of the greenstones, granitoids and gneisses of the Murchison Province will be described.

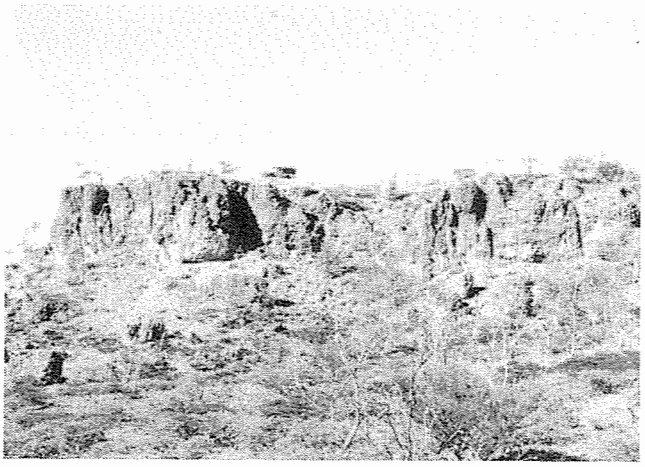
Field work in the Ophthalmia Range area to establish the relationships between the Sylvania Inlier, Ophthalmia Range Fold Belt, Turee Creek Syncline, and Ashburton Fold Belt was completed during the period. As a spin-off from this project a paper on the structural geology of the Mount Whaleback iron ore mine was prepared; reporting and map compilation for the main project will continue into 1987.

Remapping of the Robertson 1:250 000 sheet area is nearly completed. In rocks previously mapped as part of the Bangemall Group, a new sequence has been recognized in the southeastern part of the Sheet and named the Savory Group. The Savory Group unconformably overlies the Bangemall Group, is very extensive, and contains glacigene rocks that may be compared with those in the Amadeus Basin some 700 km to the east.

Bogged in the bed of Savory Creek.



Spring-fed pool in Savory Creek.



Breakaway showing laterite cap-rock overlying boulder beds at the point where the newly discovered glacigene sediments of the Savory Group were first positively identified.

Striated quartz boulders from the glacigene unit in the Savory Group.

Studies within the northern section of the Western Gneiss Terrain progressed satisfactorily with additional field work completed, 165 whole-rock chemical analyses received from Government Chemical Laboratories, some Sm/Nd and zircon geochronology carried out at WAIT and Australian National University respectively, and a report completed on the Manfred Complex.

In the Kimberley region field work commenced on a project designed to determine the geological evolution of the King Leopold Fold Belt. In the first year of mapping part of the northwestern sector was completed, and samples collected for subsequent geochronology, geochemistry and petrological studies.

As a follow-on to the surface and sub-surface geological mapping of the Golden Mile and its environs, a study of the structural evolution of this economically important area was commenced. By an understanding of the deformation history of the Golden Mile, a detailed setting of the different types of gold mineralization should be obtained.

In addition to these field projects, most staff members were also involved with writing sections for Precambrian parts of Geological Survey Memoir 3 — The Geology and Mineral Resources of Western Australia.

Mineral Resources Section. The *Exploration Data Subsection* received 2 059 new exploration reports (volumes) in the 1985/86 year (cf. 1 709 in 84/85) bringing the total number of volumes to 17 921 relating to 4 763 projects. During the year, with assistance from a Community Employment Programme team, a further 927 exploration reports on 164 projects were microfilmed on 64 film rolls taking the open file system to a total of 5 588 reports on 1 990 projects. WAMEX and AESIS databases were updated accordingly. Industry requests for information from reports not yet microfilmed numbered 103, resulting in the release of an additional 660 volumes on 83 projects.

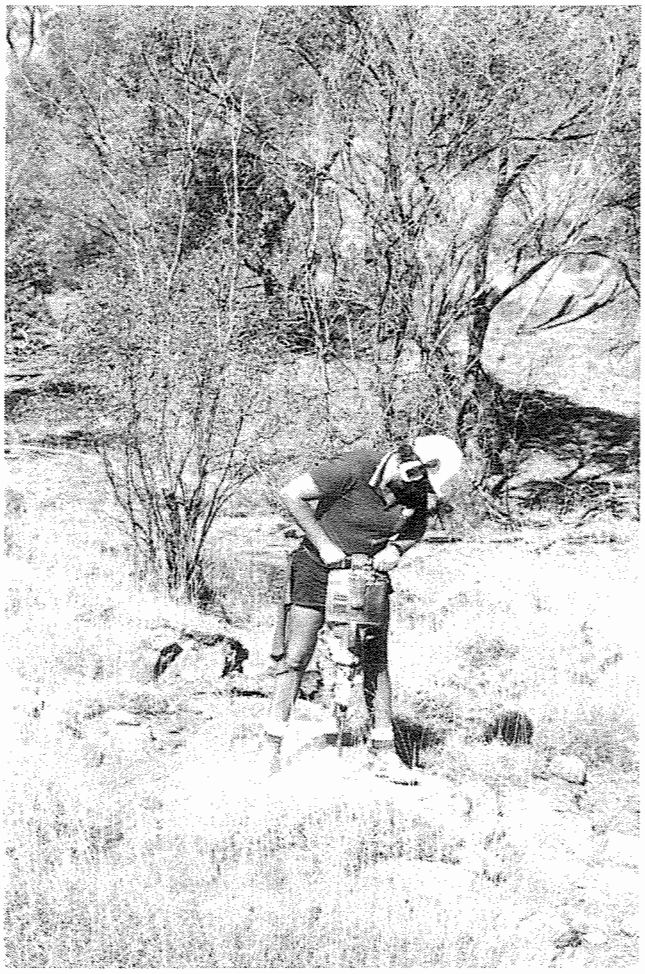
In the *Mineral Economics Sub-section* the Senior Geologist (Mr W. Preston) continued to be seconded to the Royalties and Statistics Branch. A temporary replacement (Mr A. Heath) was engaged mainly to prepare a databank of current and proposed mining operations. With the assistance of another temporary geologist (Ms S. Churchward) who prepared and keyed-in much of the data, and Miss M. Nash who designed the storage/retrieval programme using FOCUS software. MININFORM is now operative and complete for gold. For several other important mineral commodities data has been collected but not yet taken up on computer. This will be progressed as staff become available.

Mr P Harrison in the *Evaluation Sub-section* has gone as far as possible with the assessment of the potential for platinum group elements in Western Australia. Writing the results must await re-analyses of samples with anomalous results using a different analytical method. Meanwhile assessment of reserves, resources and potential for heavy mineral sands in Western Australia has been commenced at the request of the "Work Party on Conservation and Rehabilitation in the Mining Industry".

The *Economic Geology Sub-section* completed work on the Golden Mile project. The results will initially be presented in map form: a 1:25 000 scale map of the Kalgoorlie — Boulder mining area incorporating surface and subsurface sample information, together with company drilling information and recently acquired aeromagnetic data; and 1:50 000 scale maps of the Kalgoorlie region showing the mining area in its regional context. Subsequently a Report will be published. The solid geology map will be the most detailed map of the Kalgoorlie/Boulder area published since that of Mr K. J. Finucane in F. L. Stillwell's 1929 account of the geology and ore deposits of the Boulder Belt, Kalgoorlie (GSWA Bulletin 94).

In an investigation of skarn-hosted tungsten mineralization in the Nanutarra-Uaroo region, designed to confirm the geological setting of the deposits and identify source granitoids, field work and preliminary maps and sections have been completed; whole-rock analyses, remaining petrological examinations and report writing should be completed early in 1987.

To stimulate interest for gold in the Pilbara, a study of the potential for the occurrence in the Precambrian of Western Australia of gold-bearing conglomerates of Witwatersrand type was completed. Remarkable



Sampling granite in the vicinity of the Uaroo tungsten prospect.

lithological similarities can be demonstrated and several regions are identified as having subsurface potential for conglomerate-hosted gold deposits.

In common with previous years, considerable time was spent by all Section staff attending to requests for information on mineral exploration and development from a wide span of inquirers.

Engineering and Environmental Geology Section. The *Environmental Geology Sub-section* took over the project to review the bauxite deposits in the southwest of the State from the Mineral Resources Section when that section lost a key staff member through resignation. Little additional field work is required; to complete the compilation of a bulletin, draft text and plans are being prepared and integrated with mineralogical and chemical data.

A draft report on the limestone resources between Bunbury and Lancelin was compiled. It will be modified to include an assessment of the region's limesand resources.

As participants on the Collie Land Use Working Group, an interdepartmental fact-finding group recommending developmental policy in the Collie Coalfield, a draft report was completed in June 1986.

In the 1:50 000 scale environmental mapping programme the following sheets were compiled: Busselton, Capel, and Lake Clifton — Hamel; the Collie, Muja and

Mundaring sheets are also being drawn by the Surveys and Mapping Division. Preliminary work has commenced on Yallingup, Gleneagle, Karragullen, Jumperkine, Burekup and Broome — Roebuck Plains sheets.

The *Engineering Geology Sub-section* continued to provide geological advice on a wide variety of geotechnical problems involving the investigation and construction of engineering projects. These problems included location of quarry sites for road base and breakwater armour stone, studies of water tank foundations, school foundations, road and rail cutting stability, rail ballast rock, and causes of cracking of paved tennis courts.

Three reports on geological aspects relating specifically to existing dams or damsites were prepared, and a further four reports are in course of compilation.

Site investigations, including pitting, drilling, mapping, geophysics, and permeability testing, continued on the Harris River damsite. It is planned to have the results of this work ready by the end of 1986.

The Sub-section continues to monitor information on the Southwest Seismic Zone and liaise with other organizations likely to be concerned or be able to assist in the event of a damaging earthquake.

A draft of the section's contribution to a proposed publication "Geological background to the development of Perth" was completed.

Petrology Section. Routine petrological examinations during the period resulted in completion of 53 reports covering the determination of 1 728 samples.

Transfer of the rock and mineral data system to the Department's IBM mainframe computer was completed and tested satisfactorily. The system is now operational in batch update mode and can be interrogated either indirectly through the microfiche catalogue and indexes, or directly using a newly acquired terminal comprising keyboard, VDU and printer.

Bulletin 132, 'The kimberlites and lamproites of Western Australia', was completed and passed to the printer early in 1986. The aim was to have it printed in time for issue of the Fourth International Kimberlite Conference beginning in Perth on 11 August 1986. Mr J. Lewis, as a co-author of the Bulletin and Secretary of the Conference, became more heavily committed to these activities as the year progressed.

Considerable progress was achieved with the isotope geochronology sub-programme in conjunction with the WA Institute of Technology, and the Precambrian Geology and Mineral Resources Sections. Three techniques are used: rubidium/strontium; samarium/ neodymium; and lead isotopes.

The rubidium/strontium (Rb/Sr) geochronology programme includes: dating of ten suites of rocks from the northwestern part of the Western Gneiss Terrain; dating of seven rock suites from the Sylvania Dome; results from the Murchison Province; samples from the Muttabarty Hills; and specimens from plutons in the southeastern part of the Pilbara Block. Rb/Sr dating of biotite separated from suitable rocks has been conducted on rocks collected in the Murchison Province, the western and southwestern margins of the Yilgarn Block and the Mount Narryer area.

Samarium/neodymium dating progressed in the Manfred Complex and the Julimar complex (both in the Western Gneiss Terrain), other locations in the Western

Pump-testing groundwater at the Harris River damsite to determine permeability of foundation rocks.

Gneiss Terrain, the Murchison Province, southeast Pilbara plutons, basement rocks beneath the Fortescue River valley, and the Jimberlana Dyke.

Lead-isotope dating was conducted on samples from the Hamersley Basin and the Rudall Metamorphics, and on additional material from the Gascoyne Province and the Bangemall Basin.

Geochemistry Section. A number of projects, the results of some of which were published, were completed during the period.

A Report was published on the geochemistry and petrography of the Mount Edgar Batholith in the Pilbara area. In this the greater part of the Mount Edgar Batholith is shown to consist of a large mass of granodiorite within which some 20 plutons, with compositions ranging from quartz diorite to adamellite, are found. Most of the plutons fall within the compositional range of the main granodiorite mass. The Moolyella Adamellite is the exposed portion of a younger, sub-circular stock which underlies the known area of distribution of the cassiterite-bearing pegmatites of the Moolyella tin field. No other clear-cut mineralized granitoids were established, although individual anomalous samples have been found.

A Record (1985/6) was published of an investigation of a drill core (supplied by Hamersley Exploration Pty Ltd) that intersected the Roy Hill Shale Member of the Jeerinah Formation, topmost unit of the Fortescue Group, and the Marra Mamba Iron Formation, basal member of the Hamersley Group. Both the composition and mineralogy indicate that sedimentation was more or less continuous; the Roy Hill Shale contains beds that could be classified as iron formation and the Marra Mamba Iron Formation has bands of shale. The change of group name at that stratigraphic level is therefore of artificial convenience rather than a reflection of a depositional discontinuity.

Geochemical data on 964 samples of volcanic rocks from the Pilbara Block were published in the form of computer-output fiche in Bureau of Mineral Resources Record 1986/14. In another BMR Record (1986/6) determination of rare earth elements (REE) and high field strength (HFS) elements of the same samples showed three groups of volcanic rocks with distinctive common geochemical characteristics. These results supported relationships deduced from other investigations and fitted comfortably into established age relationships determined by geochronological dating.

Basins Fuel and Groundwater Branch

Hydrogeology Section. The aggregate depth drilled in the National Water Resources Assessment Programme was 5 860 m for the 12-month period to the end of June 1986. This comprised deep drilling along the Gillingarra Line (across the Perth Basin about 110 km north of Perth) and shallow drilling to test unconfined groundwater in the Cataby area (about 140 km north of Perth). In addition 2 563 m in aggregate of drilling was sited and logged for other projects such as drought relief on Kimberley region cattle stations, to gauge effects of bauxite mining on groundwater, and research on rehabilitation of salinized land in the North Stirling area.

Drilling on the Gillingarra Line resumed in September 1985 on Site 8 near the eastern edge of the Perth Basin. Palynological determinations showed for the first time in this area that there is a step fault block close to the main Darling Fault. The effect of this is that only poor-quality water is obtained near the scarp, as had been previously encountered in a deep bore near Moora but had not been properly understood at the time of drilling.

The Cataby shallow drilling project resumed in December 1985 after return of the rotary drill rig from more urgent work in the northwest of the State. Because of excessive time spent on Site 2 due to cavernous conditions, a change was made from rotary mud drilling to wireline coring since which progress has been good. Superficial sediments have been found to be thin in the northern part of the area but in the south there are substantial resources of unconfined groundwater, the quality of which is locally affected by swamps and lakes.

On the Fortescue River, coastal plain drilling at 31 sites, with subsequent test pumping and monitoring, has demonstrated that reasonable quantities of water of salinity about 400 mg/L exist in alluvium adjacent to the course of the Fortescue River. In a smaller programme (16 holes) near the mouth of the Robe River, abundant water of salinity between 600 and 700 mg/L was found. There are no immediate uses for these water resources which were originally envisaged as supplements for Dampier/Karratha supplies before the Hardy River Dam assumed that role.

In the Perth Basin, assessment of results from drilling 4 deep boreholes across the basin along each of two lines through Harvey and Binningup, showed that in the region between these lines, deep groundwater is likely to be brackish to saline with some quality improvement nearing the coastline to the west. Broadly, these two drill lines are thought to straddle the Harvey Ridge which separates good deep aquifer systems to south and north.

In the Kimberley Region, to alleviate drought conditions, 28 bore sites were located on 6 cattle stations in an attempt to obtain at each site a minimum supply of 55 m^3/day of water with less than 7 000 mg/L total dissolved salts. An aggregate of 1 100 m was drilled by private contractors for 10 holes that met the requirements, 3 dry

Lowering an air-driven pump into a shallow drillhole to obtain a pumped water sample.

holes, and 15 in which the water was too saline. This drilling programme was supervised by Mines Department personnel.

In the Broome area 1 738.5 metres of drilling was supervised as part of an investigation into available water supplies for horticultural and other developments. Results from this programme showed the need for reassessment of future land subdivisions and a groundwater management philosophy to cope with the large demands for groundwater in an area where a large saline intrusion has already occurred.

Also at Broome, Hydrogeologists provided on-site supervision for Mines Department drilling of a privately funded 500 m-deep artesian bore, and for W.A. Water Authority funded drilling of a series of monitoring piezometers in the townsite, Coconut Wells and Cable Beach areas.

After many years acting as consultants, first to the Laporte Effluent Advisory Committee, and more recently to the Department of Resources Development, the Section ceased to be directly involved with the ongoing problem of effluent disposal from the SCM Ltd titanium dioxide production plant at Australind. Private consultants have now taken over the task of monitoring existing soakage lagoons and recommending new sites, with the Geological Survey available to act in an advisory capacity if required.

Other minor projects on groundwater contamination included: assessment of the effects on groundwater at a proposed rubbish disposal site in the Mundaring Shire; monitoring of groundwater quality in the immediate vicinity of the Talloman and Fertal offal treatment sites; reviewing consultants' reports on a proposed caravan park site near Mundaring and a tannery site near Albany; and interpretation of monitoring results obtained to investigate alleged salinization of market garden wells and bores in the Coogee area following a dewatering programme in an adjoining area.

Additional or new groundwater supplies were sought at the request of the Water Authority of Western Australia for some 13 town supplies ranging in location from Wyndham through Nullagine, and Mandurah to Hopetoun. At Hopetoun it was necessary to first conduct a local census of bores and wells before selecting sites, drilling of which is still in progress. In all cases the required supply and quality was found.

At Derby, after study of available information on the major aquifer in the area, and examination of existing shallow seismic profiles, a drilling programme has been proposed for development of additional groundwater for both the town water supply and a proposed tourism development. Drilling should commence in early 1987 using W.A. Water Authority funds and Mines Department drilling equipment and personnel and geological supervision.

In studies of natural groundwater recharge, tritium from atmospheric nuclear testing that has contaminated rainfall in Perth since 1954 is used to identify vertical layering and horizontal movement of groundwater in the Gnangara Mound. Recharge rates were found to range between 13 and 43 per cent of annual rainfall with the highest rates near the crest of the mound. Tritium has not yet penetrated to the bottom half of the aquifer where groundwater movement is as slow as 2.2 to 5.5 metres per year. These bottom layers are also shown by carbon-14 dating to be about 2 500 to 3 000 years old. It is worth noting that the peak tritium concentrations in Perth groundwaters was about 30 units compared with groundwaters in Europe in which tritium concentrations around 600 units were fairly common.

On 1 July 1985 the Water Authority of Western Australia (WAWA) was formed to assume the duties previously undertaken by the Metropolitan Water Authority and the Country Water Supply Branch of the Public Works Department. Early in that amalgamation, the possibility of WAWA taking over all or some of the Hydrogeology Section staff was considered but eventually rejected. It has subsequently been arranged that four hydrogeologists spend all their time on WAWA work and the remaining Section professional staff spend the equivalent time of 3 others. Acting Senior Geologist A. Davidson was allocated the duties of a Liaison officer to whom all WAWA requests for hydrogeological advice and services were directed. In the 12 months June 1985 to May 1986 the liaison officer attended 255 meetings and handled 95 requests for information mainly from the Water Resources Planning Branch and the Water Resources Management Branch of WAWA. These requests covered groundwater investigations for reticulated supplies over widely scattered localities in the State, groundwater pollution studies, studies of effects of bauxite mining and woodchip operations on groundwater, participation in the development of the State Water Resources Information System, and interpretation of geophysical borehole logs run by the GSWA Geophysics Section.

Typical v-notch weir used to measure discharge rate when pump testing groundwater supplies.

Several long-term projects were advanced, but not as fast in some instances as had been hoped. These included manuscripts on the Geological Background to the Development of Perth; a bulletin on the Hydrogeology of the Perth Metropolitan Area; evaluation of artesian water in the Perth Metropolitan Area; a study of the Perth urban water balance; and completion of 1:5 000 000 and 1:2 500 000 state hydrogeological maps.

In the year, 13 farm inspections were made for the purpose of selecting favourable drill sites for groundwater,

Drilling the 500m-deep privately-funded artesian bore which produce a flow of 500m³ per day of slightly brackish water which will be desalinated for irrigation of horticultural land.

and personal, mail and telephoned inquiries on groundwater matters totalled 1 445. Apart from the number of inspections this was a comparable rate with a similar period last year.

Fossil Fuel and Phanerozoic Geology Section. The *Petroleum Resources Subsection* continued to accession, index, store and retrieve company exploration data supplied under the onshore and offshore Petroleum Acts. Early in the year the decision was made to abandon 35 mm roll film and adopt fiche as the microformat on which to release this information. Instead of grouping a number of reports on a roll of 35 mm-wide microfilm, reports are now on separate fiche and can be purchased individually. In the year 2 053 fiche were produced and it is hoped that, by bringing in an extra camera and possibly extra staff, the estimated backlog of 10 000 fiche can be reduced to a manageable size within 3 years.

To provide better information recovery of electric logs, seismic sections, and shot-point base maps, an agreement was entered into with Petroleum Information Energy Services Pty. Ltd whereby this company is to be progressively supplied with original-scale transparencies of the released logs, sections and maps so that they can copy and build a master set from which customers can purchase duplicates.

In addition, feasibility studies for the WAPEX information database were completed using FOCUS software. A specifically designed programme and appropriate data capture are now required before WAPEX can be operated as an index and retrieval system for petroleum exploration data in the same way as WAMEX works for mineral exploration data.

To assist with the assessment of undiscovered petroleum resources in the sedimentary basins of Australia by the Bureau of Mineral Resources, onshore well data were supplied to Dr D. Forman, who visited Perth for two weeks in May 1986 for this purpose. Pre-drill objective horizons and two-way-time seismic contour maps were provided for each well drilled.

The *Coal Resources Sub-section* has a similar responsibility for the accessioning, curation and subsequent release of coal exploration data. All coal reports are now placed on open-file in microfiche format. The resignation of Dr A.C. Wilson left the project on the coal resources and geology of the Collie Basin in abeyance pending the appointment of a replacement.

The *Basin Studies Subsection* completed compilation of two major studies: geology of the Carnarvon Basin and geology of the Bonaparte and Ord Basins.

The Carnarvon Basin work was based on the 1:250 000 scale systematic regional mapping, the individual sheets of which have been published over the last few years. Special emphasis has been placed on sedimentology and palaeogeography and a rationalization of the Permian stratigraphy has been achieved. Information from offshore exploration and drilling activities assisted greatly in achieving a good understanding of the geological history of the basin.

In the Bonaparte Basin Late Devonian reef complexes were mapped in detail for the first time although they are not nearly as well exposed as those in the northern part of the Canning Basin. In the Ord Basin Devonian sandstones and conglomerates comprising the scenically spectacular Bungle Bungle Ranges were closely studied. Although not a high priority target the Devonian rocks generally in these basins have some prospectivity for hydrocarbons. Complementing the study of onshore geology in the Bonaparte Basin, a regional study of the offshore part of the basin was commenced.

Dr M.F. Middleton was seconded to the Petroleum Division for 3 1/2 months to assist with petroleum reserves assessment. Mr G.M. Beere resigned from the Section during the year.

As mentioned earlier, field work by two State University of New York post-graduate students continued on research on the diagenesis and dolomitization of Devonian reef complexes in the northern Canning Basin.

Geophysics Section. In order to refine the regional Bouguer anomaly maps of the southwestern part of the Yilgarn Block, a project to establish about 300 additional gravity stations was started late last year, and, until suspended because of a staff shortage, 225 stations had been occupied and elevations and positions established. The purpose in providing closer spacing of gravity stations is to detect small areas of sedimentary rocks possibly preserved in shallow isolated basins above the hard rocks comprising the Yilgarn Block.

There was a considerable reduction in the number of boreholes logged electrically during the year. The total fell from around 300 in the previous 18 months to 108 in the 12 month period. All boreholes logged were drilled for water exploration.

The Binneringie Dyke, a feature with intermittent outcrop from near Williams extending in an eastnortheasterly direction for about 150 km to east of Kulin, apparently has a different magnetic polarity at one end from the other. To investigate this phenomenon eight traverses, each of up to 5 km length, were made across the dyke using a magnetic gradiometer. Magnetic susceptibility measurements and oriented samples were also taken at each site. A program has been written for computer-plotting of the traverse results which will then be interpreted.

To assist in regional structural interpretation of the greenstone belt passing through Southern Cross, detailed aeromagnetic data extracted from company exploration reports were used to enhance the Bureau of Mineral Resources published aeromagnetic base map of the region.

Much of the useful geophysical data available in the Division is now electronically catalogued. The catalogue of geophysical well logs now contains some 2 200 records. Seven parameters may be used on the search program which has been fully documented in Geophysical Report 2/85.

A comparable catalogue has been prepared for aeromagnetic data contained in company exploration reports. About 800 records, retrievable mainly by locality, are on magnetic tape that can be read by the Tektronix 4054 microcomputer.

Original aeromagnetic data tapes, submitted by exploration companies with their exploration reports, and tapes generated by the SIE borehole logging unit now total 76 reels. This is a growing archival requirement for which better accommodation is planned in the enlarged Mineral House complex.

Palaeontology Section. As an aid to stratigraphic correlation and palaeoenvironmental interpretation in the Glengarry and Earaheedy Sub-basins, over 100 samples of rocks containing stromatolites were collected, and a start made on systematic descriptions. It is expected that an understanding and classification of the stromatolites will help with correlations and in distinguishing between lithologically similar horizons in these sub-basins.

To assist with dating of Devonian reef complexes in the Lennard Shelf (northern Canning Basin) a biostratigraphic assessment of selected miospore assemblages was undertaken and at the end of the period was about two-thirds complete. Part of the sequence is older than originally anticipated.

Palynological determinations and correlations were undertaken on Permian surface and cored deep drillhole samples from the Collie Coalfield as part of a larger programme of mapping and reserves re-estimation on the field. A small amount of additional microscope work is expected to resolve some minor difficulties in applying palynostratigraphy to all sections of the basin.

In preparation for a study of the economically important Cretaceous rocks of the southern part of the Northwest Shelf a card index of data relevant to Foraminifera found in the Early Cretaceous of Western Australia was prepared. However, contrary to expectations, it appears that Foraminifera were not well represented in these rocks. Other microfossil groups (e.g. Ostracoda, Radiolaria and calcareous nannoplankton) are now being investigated as better correlative tools.

A bulletin "The palaeontology of the Permian of Western Australia" was completed. This work brings up to date, summarizes, and makes readily accessible, all that is known of the fossils found in the Permian of this State. It also contains papers on the Permian System, palaeogeography, climate, sediments, and correlation of the Western Australian Permian strata with those of other parts of Australia and overseas. It is planned to publish the work in five volumes.

In the period, 19 Palaeontological Reports were compiled and issued. They mainly comprised palynological determinations on core and cuttings from Perth Basin exploratory drilling for groundwater but also included studies on fossils from the Kimberley region and the Nabberu Province.

Support Services Branch

Publications and Information Section. There were the usual public inquiries on geological and economic mineralization matters bolstered by an unusually strong interest in gold prospecting. Seventeen publications were processed

through to the release stage as listed later.

Miss M. Nash, who is also divisional liaison officer with the Computer Services Section, utilized FOCUS software to develop MININFORM, a data storage and retrieval program designed to yield quick answers to questions on mineral resources and development in this State.

The booklet "An Overview of Mining in Western Australia" was updated on several occasions for specific purposes; it has proved to be a most useful work and it is intended to produce it in sufficient quantity to issue free of charge to all inquirers.

Library. Members of the public using the library during the year totalled 3 426 of whom 858 made use of the microfilm reader/printer facilities. Staff loans totalled 952 which included 481 inter-library loans; 401 inter-library loans were arranged at the request of other libraries.

The library obtained the facilities of a Telecom Computerphone and printer enabling direct on-line access to the Australian Bibliographic Network (ABN) and to the AUSINET and DIALOG networks.

Subject access to the library collection is being improved with the use of the AESIS Australian Thesaurus of Earth Science and Related Terms. The old in-house subject catalogue will be retrospectively revised to comply with the new terms.

In May 1986 a programme designed to gradually replace the M Series reference set of microfilm rolls was begun.

Regional offices

At the Karratha office Mr Commander supervised the end of test work on the water bores at the mouths of the Fortescue and Robe Rivers, completed the water bore and well census of the Marble Bar 1:250 000 Sheet and attended to several requests by the Main Roads Department for location of water supplies for road construction before leaving on transfer back to Perth in November, 1985. His successor, Dr A. Thorne, commenced duties at the Karratha office in April 1986 from where he will study the Fortescue Group.

After some 7 months on his own at the Kalgoorlie office, Dr Hunter was joined by Dr W. Witt early in July 1985 and late in October by Dr C. Swager. After completing the Boorabbin 1:250 000 sheet remapping and the Kalgoorlie 1:100 000 sheet mapping, Dr Hunter transferred to Perth in December 1985 upon which Dr Witt took charge of the office. After an initial orientation on mineralization on the Kalgoorlie 1:100 000 sheet area, Dr Witt then undertook detailed geological mapping of the Bardoc 1:100 000 sheet. Dr Swager assisted on this project until March 1986 when he commenced a structural study of the Golden Mile which will complement the detailed regional geology of the same area completed earlier from the Kalgoorlie office by Dr Keats.

Visiting Japanese group calibrating the radiometer during an investigation of the application of multispectral scanning techniques in the Eastern Goldfields.

Organization

Staff

There was no increase in the number of approved staff positions during the period and on 31 May 1986 a total freeze was placed on staff growth and replacement throughout the Service. Fortunately only five items (two geologists, Level 1, Assistant Librarian, Geophysical Assistant and Laboratory Technician) were affected by this measure and were consequently vacant at 30 June 1986.

Mr P. R. Dunn commenced as Assistant Director in charge of the Basement, Minerals and Geotechnics Branch on 23 September 1985. his arrival was most timely as a number of administrative matters (e.g. a staff reclassification, revised duty descriptions and responsibilities for all items, the requirement for a formalized corporate plan) had been seriously pressing existing members of the Directorate.

In February 1986, Dr Trendall, after negotiations and agreement with the Public Service Board, announced that on 1 September 1986, he would step down from the Directorship to become a Senior Principal Geologist within the Precambrian Geology Section of the Survey, to return to active geological investigations. This relinquishment of administrative responsibilities in favour of a return to mainstream geoscientific work is an arrangement practised with demonstrable advantage by the United States Geological Survey; it is believed to be new to the State Public Service.

Accommodation

In 1985/86 there was no need to increase office space for personnel. The accommodation of materials, particularly company reports on exploration for coal and petroleum (S series records) and other minerals (M series records), required numerous rearrangements within existing space in Mineral House and an extension of space adjoining the Precambrian Geology Section at 190 Hay Street.

With the recognized need to remove the Division's laboratories out of the Mineral House Complex, considerable time was spent investigating alternative locations at which to establish new laboratories. It had always been hoped that the laboratories could be re-sited

close to the professional staff for whom the sample preparation work is done. At the end of the year however, it was apparent that no such site would become available and that more remote locations would have to be considered.

Publications

Issued during 1985/86

Bulletin 128. Geology of the Bangemall Group; by P.C. Muhling and A.T. Brakel.

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

Report 14. Professional Papers for 1983 containing:

The hydrogeology of Lake Mariginiup, Perth, Western Australia; by J. Hall.

Carboniferous of Western Australia — a review; by A.E. Cockbain.

Palaeozoic stratigraphy of the Ord Basin, Western Australia and Northern Territory; by A.J. Mory and G.M. Beere.

Structural and stratigraphic relationships in the Archaean granite-greenstone terrain around Cue, Western Australia; by K.P. Watkins and I.M. Tyler.

The Fraser Complex — a major layered intrusion in Western Australia; by John S. Myers.

A Rubidium-strontium date from felsic volcanics within the Mount Roe Basalt of the Wyloo Dome; by J.R. de Laeter, D.B. Seymour and W.G. Libby.

Rubidium-strontium biotite dates in the Gascoyne Province, Western Australia; by W.G. Libby and J.R. de Laeter.

Upward-shallowing sequences in the Precambrian Duck Creek Dolomite, Western Australia; by A.M. Thorne.

Stromatolites in the Proterozoic Duck Creek Dolomite, Western Australia; by Kathleen Grey.

Stratabound axinite in the Weeli Wolli Formation and its occurrence in related dolerites; by R. Davy and M. Price.

Report 17. The Mount Edgar Batholith, Pilbara area, Western Australia. Geochemistry and petrology; by Richard Davy and J.D. Lewis.

Report 18. Late Devonian Sponges of Western Australia; by J. Keith Rigby.

1:250 000 coloured Geological Map series: Dumbleyung SI/50-7 (Map and Notes).

The Bureau of Mineral Resources compiled and issued the Sandstone SG/50-16 coloured geological map with Explanatory Notes.

1:50 000 Environmental Geology maps: Fremantle and Rockingham.

Records:

1985/4 Explanatory notes on the Dumbleyung 1:250 000 Geological Sheet, Western Australia; by R.J. Chin and A.T. Brakel.

1985/2 Review of petroleum exploration, development and production in western Australia to the end of 1984; by R.M.L. Elliott, R.P. Iasky, and K.A. Crank.

1985/5 Revised stratigraphic nomenclature in the Carnarvon Basin; by R.M. Hocking.

1985/6 The mineralogy and composition of a core which intersects the Marra Mamba Iron Formation and the Roy Hill Shale Member; by R. Davy.

1986/1 Summary of progress of the Geological Survey of Western Australia during 1985 and plans for 1986; by A.F. Trendall.

1986/4 Explanatory notes on the Kellerberrin 1:250 000 Geological Sheet, Western Australia; by R.J. Chin.

1986/6 Phanerozoic sedimentary basins of Western Australia and their petroleum potential; by A.E. Cockbain.

1985/1 Summary of progress of the Geological Survey of Western Australia during 1984 and plans for 1985.

In press at June 1986

Bulletin 132. The kimberlites and lamproites of Western Australia; by A.L. Jaques, J.D. Lewis and C.B. Smith.

Report 15. Geology of the Gascoyne Province; by S. Williams.

Report 16. Stratigraphy, structure, and economic geology of the Mount Monger area, Eastern Goldfields Province; by A.H. Hickman.

Report 19. Professional papers for 1984 containing:

Metamorphic patterns in the greenstone belts of the Southern Cross Province, Western Australia; by A.L. Ahmat.

Problematic microstructures in the Proterozoic Discovery Chert, Bangemall Group, Western Australia. Ambient grains or microfossils?; by Kathleen Grey.

Stromatolite evidence supporting a correlation of the Proterozoic Uaroo and Bangemall Group, Western Australia; by Kathleen Grey.

The mineral potential of layered igneous complexes within the Western Gneiss Terrain; by P.H. Harrison.

Liquid-waste disposal in Perth. A hydrogeological assessment; by K-J.B. Hirschberg.

Occurrence, distribution, and origin of smithsonite in the No.2 lead-zinc deposit at Narlarla, Western Australia; by C.R. Ringrose.

The sedimentology of a tide-influenced fan-delta system in the Early Proterozoic Wyloo Group on the southern margin of the Pilbara Craton, Western Australia; by A.M. Thorne and D.B. Seymour.

Age and stratigraphy of a sequence of metavolcanic and metasedimentary rocks in the Prairie Downs Deadman Hill area, southwestern margin of the Sylvania Dome; by I.M. Tyler.

Report 20. Geochronology of the Gascoyne Province; by W.G. Libby, J.R. de Laeter, and J.S. Myers.

Record 1986/3. Two-dimensional gravity modelling with the Tektronix 4054 graphic system; by L. Kevi.

Record 1986/5. Revised stratigraphic nomenclature for the onshore Bonaparte and Ord Basins, Western Australia; by G.M. Beere and A.J. Mory.

Record 1986/7. Explanatory notes on the Corrigin 1:250 000 geological sheet, Western Australia; by R.J. Chin.

1:250 000 coloured Geological Map Series:

Kellerberrin (SH/50-15), Corrigin (SI/50-3) and second edition Peak Hill (SG/50-8), Cue (SG/50-15).

1:50 000 Environmental Geology maps — Armadale, Perth, and Serpentine.

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OFFSHORE OIL — Western Australia's first field

Harriet Oil Field is the State's first offshore producing oil field. It commenced production in January 1986 and is now averaging about 1 300 kL of oil per day from five wells. The discovery well, Harriet-1, was completed on 1 December 1983, and the rapidity with which the field was placed on production is a credit to the developers, led by Bond Corporation, and all who participated in the construction of the production facilities. Harriet is also the first offshore oil field to be operated by an Australian company.

The field is located just 20 km northeast from Barrow Island and 120 km west from Dampier, near the Lowendal Islands. Onshore supporting facilities have been built on one of these islands known as Varanus Island.

The original Permit to Explore, WA-192-P, was granted in November 1981. Since then Bond and its partners have drilled 24 wells, and conducted about 10 850 line kilometres of seismic surveys, to make this permit the most intensely explored offshore permit in Western Australia in recent times. The discovery was made in November 1983 and this was followed by Harriet-2 through -6, of which only No. 2 was dry. The field was extended in area by the drilling of Lenita-1 -2 and -3, and two additional development wells, C-1 and C-2 were drilled at the planned location of the proposed satellite platforms B and C.

The oil zone is in Lower Cretaceous sandstones of the upper part of the Barrow Group. The sandstones are coarse grained deltaic sediments, which have excellent reservoir characteristics with porosities as high as 25 percent and permeabilities ranging up to 4 Darcys. The oil is trapped in a relatively simple structure on the northeast-trending Lowendal Fault with a possible stratigraphic component. Excellent flow rates have been recorded, up to 4 926 barrels of oil per day (783 kL/d).

The development of the field was completed in record time — only nine months from the first construction to the first shipment. The facilities consist of the production platform, a 6.5-km pipeline to Varanus Island where three storage tanks were built, and another undersea pipeline (3 km) to take the oil to tankers anchored offshore.

The design and construction contract for the production platform and associated facilities cost about $87 million, utilising mainly Western Australian suppliers, with most of the construction work taking place in Geraldton. The 'A' jacket structure built in Geraldton is the first offshore structure of its type to be built in Western Australia and weighed 725 tonnes during installation. The deck, also built in Geraldton, was installed fully equipped with production facilities. The installation of the deck and equipment constituted an Australian record offshore lift of 1 350 tonnes. The final weight of the complete offshore structure including remote flare is over 3 000 tonnes.

Two additional platforms are planned, Satellite platforms 'B' and 'C' which, when hooked up, can increase production to about 2 250 kL of oil per day. These are expected to be completed during the third quarter of 1986.

Strict environmental controls have been laid down by the Government for the island and marine areas for the protection of flora and fauna. The environmental management, monitoring, and rehabilitation program is as strict as that employed on nearby Barrow Island even though the Lowendals are a lesser class of reserve. All equipment and material taken to the island has to undergo quarantine procedures at Onslow and the number of vehicles and their use is restricted. All facilities have been located to minimise disruption to turtle nests and to mutton bird rookeries.

It is expected that the field will have a total life of about 10 years and although it is small by world standards, it will make a significant impact upon Western Australia's liquid fuel energy needs.

Varanus Island in the Lowendal Group showing storage tanks of the terminal for the offshore Harriet oilfield.

PETROLEUM

I. FRAZER, DIRECTOR

Exploration and development

In the period 1985/86, 29 exploration wells were drilled and 40 623 line km of seismic recorded at an estimated cost of $180 million. This represented a considerable drop in drilling (81 wells in 1984/85), mainly onshore (15 in contrast to 63 wells previously). The decrease is a reflection of the general economic downturn and, in particular, the falling oil price in the first half of 1986. However, it was encouraging that seismic acquisition increased, particularly offshore. The total line kilometres recorded represented a 105 percent increase over 1984/85 and a 160 percent increase for offshore seismic (29 084 km in 1985/86 versus 13 440 km in 1984/85). This seismic activity suggests that when the oil price recovers to a more stable figure drilling activity can be expected to increase again.

A list of wells drilled and geophysical surveys conducted in 1985/86 is shown in the tables in the Supplementary Statistical Digest.

No major discoveries were made during the year although some successful extension tests were drilled. As in the previous few years the most active areas for petroleum exploration were the offshore Carnarvon Basin (14 wells; 14 897 km of seismic) and the onshore Canning Basin (8 wells; 10 470 km of seismic), or 70 to 80 percent of the work undertaken.

Only one well drilled in this period could be classed as a discovery. This was Campbell-2 drilled by Bond Corporation, 1.38 km east-southeast from Campbell-1, designed to test the Campbell structure updip from the No. 1 well which was drilled by West Australian Petroleum Pty Ltd (WAPET) in 1979. The well has been classed as a suspended gas/condensate well after a drillstem test over the interval 2 212 - 2 214 m flowed gas at a rate of 7.8 MMCFD (220 x $10^3 m^3/d$) with condensate at 160 bopd (25 kL/day) through a half-inch choke.

Probably the most significant well drilled during the year was Goodwyn-7, classified as an extension test, which confirmed the presence of a reservoir section with a very high condensate-to-gas ratio. A similar ratio was also found at Goodwyn-8 drilled in May 1986. These results could significantly improve the economics of the multi-billion dollar North West Shelf Project.

Successful extension tests and development wells were drilled at Lenita-3 and Harriet C1 and C2, confirming the reserves in the Harriet oil field. A total of 27 development wells with a combined total of 40 065 m were drilled, including 18 on Barrow Island, 5 at North Rankin, 1 at Blina, 1 at Sundown, and 2 at Harriet.

A highlight of 1986 was the start of oil production from Harriet, Western Australia's first offshore oil field. Although not a large field by world standards it will make a significant impact on the State's energy requirements.

The announcement of the "North West Gas Development Agreement" for the $9.8 billion liquified natural gas phase of the North West Shelf Project, probably the largest single project ever undertaken in Australia, was the most significant event of 1985. The 20-year sale and purchase agreement between the joint venturers and Japanese utilities requires annual exports to reach six

Using Teleseis for seismic surveying in shallow water. This technique uses floating transmitters to beam the data from individual seafloor geophones to a recorder vessel in deeper water or a station on adjoining land.

million tonnes by the mid-1990s. Start-up is expected to be in October 1989.

Another development project which could start production, possibly in 1987, is the Saladin oil field in the Barrow Sub-basin, which was discovered by WAPET in early 1985. Appraisal wells are to be drilled late in 1986 and development will depend on the results of these and on commercial viability. A similar configuration to the Harriet field would be developed.

Tenements

At 30 June 1986, 88 permits to explore for petroleum existed in Western Australia, including 32 offshore and 56 onshore. The present area held comprises 756 111 km^2, made up of 284 893 km^2 offshore and 471 218 km2 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 1984/85 and 1985/86 is tabulated in the Supplementary Statistical Digest. At the end of the year vacant areas totalled about 750 000 km^2.

The number of applications for permits decreased slightly during 1985/86, and the area and number of permits held have dropped compared to the previous period (from 93 to 88). Permit surrenders, expiries, and cancellations have decreased from 20 to 14, and renewals increased from 4 to 11, resulting in just a 5 percent drop in the number of permits held. However six offshore permits were in the process of being surrendered at the end of the period. This situation reflects the current difficult economic climate.

Reserves

Estimated recoverable reserves for the State at 30 June 1986 were 14.97 x 10^6 kL of crude oil, 1 052 x 10^{9}m^3 natural gas, 98 x 10^6 kL condensate and 24.5 x 10^{6}m^3 liquid petroleum gas. The table in the Supplementary Statistical Digest shows details of these reserves.

The main changes to the oil reserves since 1984/1985 were the introduction of the Saladin Field and the upgrading of the Blina Field. There were only minor changes to the gas reserves (based on production adjustments).

Ninety-five percent of the State's oil reserves are located in the Carnarvon Basin, but at present only two fields in that basin, Barrow Island and Harriet, are producing oil. Oil is also produced in small quantities from the onshore Perth and Canning Basins. Carnarvon Basin gas reserves of more than 500 billion cubic metres represent the largest accumulation of potentially producible gas in the State at present. Large gas fields in the Bonaparte and Browse Basins and Exmouth Plateau are not economically viable at present because of water depth and lack of markets, but could be developed late in this century.

Development and production

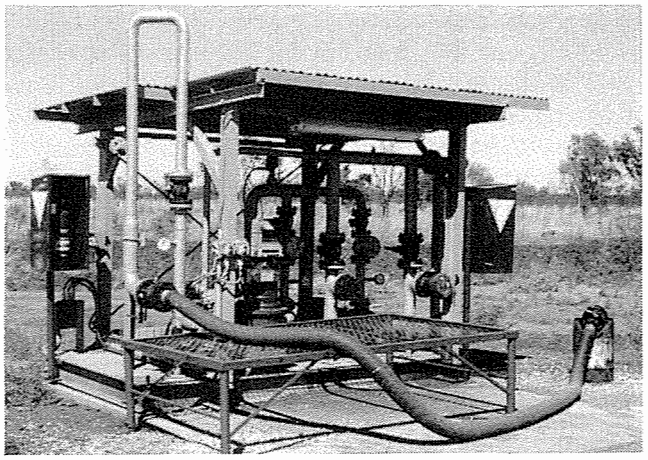
In Western Australia production of crude oil totalled 1 416 x 10m^3 kilolitres (kL), and production of gas 3 128 x 10^{6}m^3 for the year ending 30 June 1986. Oil was produced from Barrow Island, Blina, Sundown, West Terrace, and Harriet Fields as well as small amounts from Dongara and Mt Horner Fields, while gas and condensate were produced at North Rankin, Dongara, Mondarra, Yardarino and Woodada Fields. West Terrace and Harriet were the two newest fields to join the group.

Barrow Island Oil Field (West Australian Petroleum Pty Ltd). Barrow Island Field is located on a 233 km^2 island,88 km north from Onslow and 145 km west from Dampier. The first well was spudded in 1964, and since then 727 wells have been drilled. Production started in April 1967, and at the end of June 1986 a cumulative total of 34 107 x 10^3 kL of oil has been produced.

At least 27 different reservoirs are 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 percent of oil production, the Windalia Sandstone (97 percent), Muderong Shale (1.3 percent) and Cretaceous/Jurassic sandstones (1.2 percent).

During 1985/1986 WAPET drilled 20 wells, 18 of which were classed as development wells together with 2 extension tests both of which tested Muderong objectives. All the development wells were successfully completed as producers and the two extension tests are shut-in.

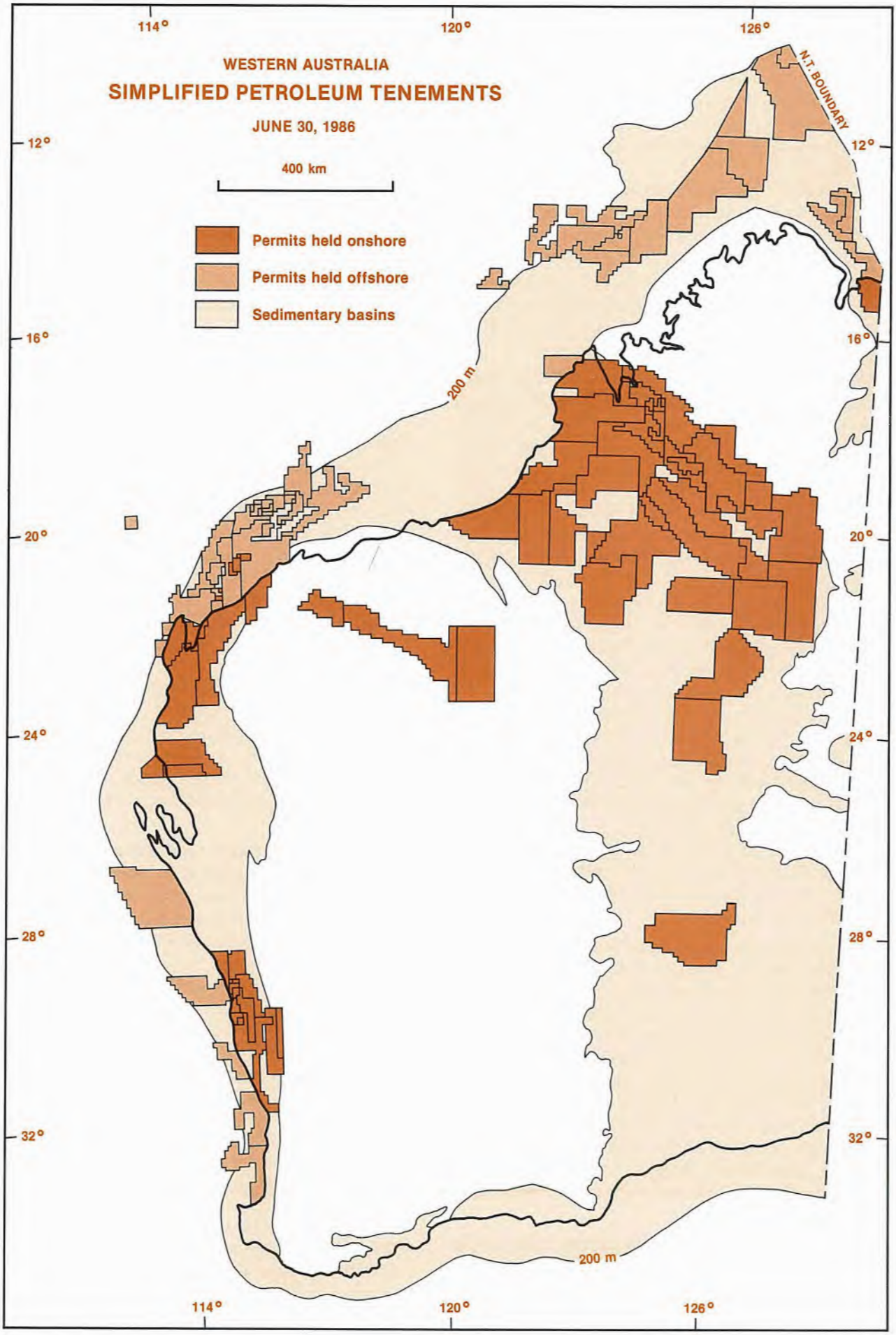
The status of the 727 wells drilled on Barrow Island to 30 June 1986, and the total production for 1985/86 and cumulative production, are shown in the Supplementary Statistical Digest.



Crude oil trucking terminal for the small Sundown oilfield.

Blina, Sundown, and West Terrace Oil Fields (Home Energy Company Ltd). Blina Field is located 105 km southeast from Derby in the Canning Basin. Six wells have been drilled in the field and all six wells are producing.

The oil was discovered in the Blina-1 well in 1981 and production started on 30 September 1983. Production, which comes from two main reservoirs, the Upper Devonian Nullara Limestone and the Lower Carboniferous Yellow Drum Formation, totalled 41.13 x 10^3 kL for 1985/86. Blina-5 was drilled in mid-1985 and was placed on production in August 1985, and Blina-6 which was drilled in August 1985 commenced production in mid-September 1985.


WESTERN AUSTRALIA
SIMPLIFIED PETROLEUM TENEMENTS
JUNE 30, 1986
400 km
Permits held onshore
Permits held offshore
Sedimentary basins
N.T. BOUNDARY
200 m
200 m
114°
120°
126°
12°
16°
20°
24°
28°
32°

Oil was discovered 26 km northwest from Blina where the Sundown-1 well encountered oil in several separate zones within Permo-Carboniferous sandstones of the Grant and Anderson Formations. Subsequently the well was completed in the "1100 sand" horizon. Three other wells have been drilled and two of these are now producing, one was a dry hole. Production commenced in July 1984 and the total produced during the year ending 30 June 1986 was 7.96 x 10^3 kL.

In late June 1985 oil was discovered at West Terrace-1 which was completed as a producer after a drillstem test conducted over a 3 m interval flowed oil at a rate of 122 kL/d through a 9.5mm choke. Production started on 21 June 1985 and to date 8.50 x 10^3 kL has been produced.

Disposal of oil from Blina, Sundown and West Terrace Fields totalled 52.508 x 10^3 kL to 30 June 1986 as tabulated in the Supplementary Statistical Digest.

Dongara, Mondarra, and Yardarino Gas Fields (West Australian Petroleum Pty Ltd). These fields are located about 320 km north from Perth and 65 km south from Geraldton in the northern part of the Perth Basin. Production from the Dongara Field began in 1971 and was followed by Mondarra in 1972 and Yardarino in 1978.

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

A total of 25 wells have been drilled in the Dongara Field and at present there are 9 gas producers, 1 oil producer, 3 oil and gas producers, 7 shut-in wells, 1 water source well and 4 abandoned wells. Gas produced at a rate of about 1 300 x 10^3m^3 per day was transported in a 36 cm diameter pipeline from Dongara to Pinjarra via Perth and Kwinana. The Mondarra Field, two gas wells and two abandoned wells, produced gas at a rate of 60 x 10^3m^3 per day. Yardarino Field produces a small amount of gas from one well only. Oil production from Dongara averaged about 25 kL per day for the year.

Disposal of gas from the Dongara, Mondarra and Yardarino Fields totalled 493 x 10^6m^3 for the year ending 30 June 1986. During the same period 8.61 x 10^3 kL of Dongara oil was disposed of.

Mt Horner Field (Barrack Energy Ltd). The Mt Horner Field is about 380 km north-northwest from Perth in the Perth Basin. The first well was drilled by WAPET in 1965 and since then five extension tests have been completed. Of these six wells, four are classed as suspended producers and two (Nos. 2 and 6) are plugged and abandoned. Production commenced in May 1984 and, in the year ended 30 June 1986, 263 kL of oil was produced.

At least three potentially productive units occur at Mt Horner: the Cockleshell Gully Formation, the Kockatea Shale, and basal Triassic sands.

During 1986 a workover program was commenced and is still in progress.

North Rankin Gas Field (Woodside Petroleum Development Pty Ltd). North Rankin Field is located 130 km north-northwest from Port Hedland off the coast of Western Australia. The first well, North Rankin-1, was drilled in 1971 and since then 5 extension tests and 11 development wells have been completed. Production started in July 1984 and, for the year ending 30 June 1986, 3 582 x 10^6m^3 of gas and 564 x 10^3 kL of condensate had been produced.

The main reservoir is in the Mungaroo Formation of Upper Triassic age. Gas is currently being produced at a rate of about 7 000 x 10^3m^3 per day and condensate at 1 200 kL per day. Total recoverable reserves of gas and condensate at North Rankin are estimated to be 225 x 10^9m^3 and 24.5 x 10^6m^3 respectively.

Disposal of gas from the North Rankin Field totalled 2 202 x 10^6m^3 for the period ending 30 June 1986. The amount of condensate disposed of during the same period was 379 x 10^3 kL.

In late 1985 an agreement was reached to sell LNG to Japan, to commence in October 1989. The 20-year agreement requires annual exports of 6 million tonnes by the middle 1990s.

Woodada Gas Field (Strata Oil N.L.). Woodada Field is 13 km northwest from the township of Eneabba in the Perth Basin. The discovery well was drilled in 1980 and since then 10 wells have been completed. Gas production commenced on 24 May 1982 and, for the year ending 30 June 1986, 61 011 x 10^3m^3 of gas were produced. The current production rate is about 180 x 10^3m^3 per day.

The main reservoir is in the Carynginia Formation of Early Permian age. Of the 11 wells drilled in the field 5 were gas producers, 4 were shut-in wells, and 2 were plugged and abandoned.

Gas was originally produced from Woodada -1 and -2 but in mid-April 1983 the rate at the No. 2 well fell to a sub-economic level and had to be shut-in. The number of wells producing gas peaked at six but by the end of June 1986 only three were on production. A reduced level of production is being maintained to prevent the field watering out.

Harriet Oil Field (Bond Corporation Pty Ltd). Harriet Field is located 20 km northeast from Barrow Island and 120 km west from Dampier, near the Lowendal Islands. This field, W.A.'s newest producing field, is discussed in some detail elsewhere in the Report.

Since the discovery well was drilled in 1983, 10 appraisal wells have been drilled, all of which have been successful except Harriet-2 which was plugged and abandoned. Production commenced on 18 January 1986 and at 30 June 1986 a cumulative total of 202.73 x 10^3 kL of oil had been produced.

The reservoir is in Lower Cretaceous sandstones of the upper part of the Barrow Group. Oil is currently being produced at a rate of about 1 300 kL per day.

Oil pricing and royalties

The price of Australian crude oil is regulated by the Federal Government through its customs and excise powers. From 1 January 1985 indigenous crude oil has been marketed through a partial allocation scheme which means that small

venturers producing up to 8 000 kL/d are required to dispose of all crude through allocation arrangements. Since 1978 all crude has been priced at import parity (IPP) with Middle East crudes (now a weighted average of several different oils).

The Import Parity Price has been through several adjustments because of the drop and fluctuations in world oil prices since early 1986, but as of 1 May 1986 the price for Western Australian crude delivered at Kwinana Refinery was set at:

Barrow Island oil	$117.81/kL
Harriet oil	$124.72/kL
Blina/Sundown oil	$115.29/kL

Prices as of 1 May 1985 were in the range of $271.63/kL to $285.53/kL.

Excise at various rates is levied on the import parity price of crude oil. Condensate which is blended with a crude oil stream is treated as parity oil. When marketed separately it may be sold at commercially negotiated prices and is not subject to excise levy. Oil is also classified as either "old", "new" or "intermediate" depending on when it was discovered. For example "old oil" is oil discovered prior to 18 September 1975. In addition to the levy payable to the Commonwealth the State receives royalty on the wellhead value at between 10 and 12.5 percent.

From 1 July 1984 a Resource Rent Tax (RRT) was introduced by the Federal Government for new developments outside existing licence areas in those offshore areas where the Commonwealth's Petroleum (Submerged Lands) Act applies. RRT is a levy of 40 percent which is imposed on income received from the sale of petroleum recovered. This levy is applied prior to company tax and is tax deductible.

In 1985 a "Resource Rent Royalty" (RRR) agreement was agreed to by WAPET, the State, and the Commonwealth to apply to Barrow Island oil field. This allows all costs including secondary recovery schemes to be deductible. The company obtains import parity price for its oil and pays a royalty based on profit of 40 percent. This is then split 25-75 percent between the State and the Commonwealth.

During 1985/86 total royalties paid on petroleum in W.A. were $29 947 637. This was derived from $25 479 038 paid on crude oil sales, $3 843 821 on natural gas sales and $624 778 for condensate (See tables in the Supplementary Statistical Digest). Annual royalties paid in 1984/85 totalled $17 555 802 including $13 621 418 for oil, $3 754 615 for natural gas and $179 769 for condensate.

Operations

Engineering

The Harriet Field development, which commenced in May 1985, continued at Geraldton where the 'A' platform jacket and deck were fabricated, and on Varanus Island, the longest island in the Lowendal group, where the oil storage and shipping facilities were being built.

The platform and deck were installed offshore in December and production commenced in January 1986. Satellite platforms 'B' and 'C' were fabricated at Jervoise Bay. 'C' platform was installed offshore in June 1986 and 'B' platform is expected to be installed in July 1986.

Platform preparations on the North Rankin 'A' have commenced for the improvement of the platform and flare tower foundations. The remedial work will consist of strengthening the soil beneath the tips of all 32 platform piles by injecting chemical grout. Next, half the piles are to be belled out to provide 4.5 m diameter concrete footings. The flare tower is to have four of its piles belled as well as being braced with permanent guy wires. The steel anchor boxes for the guys have been constructed at Geraldton and will be filled with 2 500t of iron-ore ballast after installation.

Although there is no evidence of scour, anti-scour mats are being installed around the base of the four corner jacket legs and all three flare tower legs to ensure the mud shoes continue to provide additional support.

Gas recycling has been proposed for the North Rankin 'A' platform whereby gas is stripped of its condensate and the 'dry' gas re-injected into the field.

Diving Safety

A scheme for commercial divers in petroleum-related operations, which came into force in August 1985, requires all divers who take part in these operations to be accredited by the Petroleum Division by November 1985.

The accreditation involves an assessment of the documentation related to training, experience, and medical fitness of the applicant. To 30 June 1986, 150 divers have been accredited.

The accreditation is categorised as follows:

A — shallow air (less than 20m);
B — deep air (20 — 55m);
C — surface orientated mixed gas (0 — 80m);
D — bell bounce; and
E — saturation.

Accidents

Figures relating to accident statistics in the petroleum exploration and production industry are shown in the Supplementary Statistical Digest.

Pipelines

A total of 326 work proposals relating to the Dongara-to-Pinjarra Natural Gas Pipeline from Government Departments, instrumentalities and other parties were processed during the year. This compared to 293 processed in 1984/85. There were 13 encroachments on the pipeline during the period, 11 by State Energy Commission and 2 by the Metropolitan Water Authority.

Organization

On 4 October 1985 Mr A J Sharp, Director of Petroleum Division retired, and Mr I Fraser took over as Director on 14 October 1985.

The position of Petroleum Engineer — Operations has remained vacant since the retirement of Mr Peter Hammett in January 1985.

TERRITORIAL SEA — Defining a boundary

Much attention is presently being given to the control and exploitation of the rich resources lying in and under the waters surrounding the continents. Conventions seeking to reach agreement on acceptable laws for the sea have met with some degree of success. Only recently in the history of mankind have nations turned their attention to ownership of the sea. Some of the very first claims made to the oceans were extreme. By the Papal Bulls of 1493, Spain and Portugal divided up the New World. Spain obtained the whole of the Pacific Ocean and the Atlantic Ocean in the vicinity of the Central Americas, while Portugal obtained the Indian and most of the Atlantic Ocean. The principle that the sea could not be made the property of any State was propounded in 1609 by Grotius, the founding father of modern international law, and by the beginning of the 19th Century the principle of freedom of the high seas had been established.

However the concept of the extent seaward of a State's sovereignty remained a contentious issue. In 1702 the Dutch jurist Bynkershoek wrote that the sovereignty of a State extended as far out to sea as a shot from a cannon would reach — at that time approximately one league (three nautical miles). Many other claims for this width to vary from that "cannon shot" are made to this day.

The first conference attempting to resolve the conflicts of widths and authority was held at the Hague in 1930. No agreement was reached. By the next conference, held in 1958 at Geneva, agreement on the width of the territorial sea was no further advanced. In fact, nine States now claimed the waters and subsoil of their continental shelves. The 1958 conference did not agree on territorial sea width but did adopt four important Conventions on the Law of the Sea (Australia has ratified them all). These included the Convention on the Territorial Sea and the Contiguous Zone, and the Convention on the Continental Shelf.

The Convention on the Territorial Sea established "the sovereignty of a State to extend beyond its land territory and its internal waters to a belt of sea adjacent to its coast described as the territorial sea" and "the normal base line for measuring the breadth of the territorial sea is the *low-water line* along the coast as marked on large scale charts officially recognised by the coastal State". It was further agreed, in cases where coastlines are deeply indented or if there is a fringe of islands, the method of straight baselines joining appropriate points may be employed. The waters on the landward side of the baseline are known as *internal waters* of the State and the breadth (not defined) of the territorial sea is measured outward from the baseline.

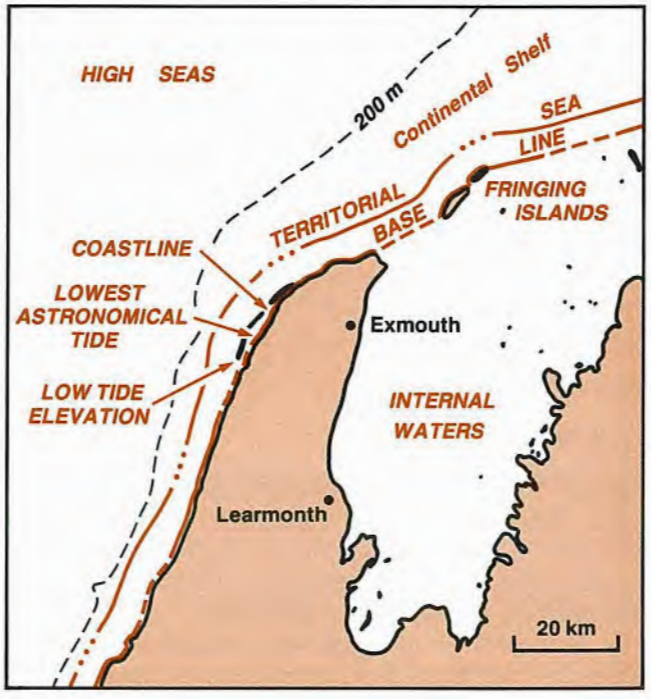
The Convention on the Continental Shelf establishes the rights of the coastal State to the natural resources of the seabed and subsoil of the continental shelf but does not affect the legal status of the superjacent waters as high seas, or that of the airspace above those waters.

The Convention establishes the continental shelf as being "outside the area of the territorial sea, to a depth of 200 metres, or beyond that limit, to where the depth of the superjacent waters admits of the exploitation of the natural resources of the said areas". Its boundary is essentially an advancing frontier fed by the rapidly expanding technology.

Australia, in association with its States, has agreed upon joint methods of administering its offshore rights, and by proclamation dated 9 February 1983 has defined the extent of its offshore claim. In particular it sets the breadth of its territorial sea as 3 nautical miles, being 5 556 metres, and the baseline as being the coastline defined by the Lowest Astronomical Tide (L.A.T. — the lowest low level). It also formally establishes the straight baselines enclosing the fringing islands such as the Dampier Archipelago, Abrolhos Group, Recherche Archipelago etc.

The use of L.A.T. and the offshore straight baselines are designed to set Australia's maritime boundaries as far from the land mass as possible and whilst the principles of the baseline are now established, their actual position is not. Most people would be aware of the wide range of sea-level around our coastline and in particular of the variations to the land, rocks and reefs exposed at low tide but covered at high tide.

The extent of this exposure depends upon many factors. The phenomenal 30 foot tides experienced on our North West and Kimberley coast, coupled with the very flat shelving mud and sand banks, cause a considerable horizontal variation to the actual coastline. The available maps are not consistent. All current land maps depict either mean high water or highest high water line whilst most hydrographic charts show mean low water rather than the line of lowest astronomical tide as has now been adopted.



SURVEYS AND MAPPING

W. R. MOORE, DIRECTOR

It can be noted with some confidence that the provision of maps of all kinds to support the various functions associated with an inventory of the earth's resources will remain an ever increasing need. Maps should not be looked upon as merely pretty pictures nor as simply a work of art — although properly constructed they can be both. Maps are an essential base for supporting a geographic or spatially distributed array of data which is thereby recorded and portrayed allowing that data to be read, exchanged, manipulated or further derived. Maps are media for collating, compacting and miniaturising large quantities of data.

The advent over the past few years of the principles of corporate planning has resulted in the major users and producers of map products within the Department having to critically review and forecast their present and future map and drafting requirements. This has highlighted these needs of the Department to be greater than previously understood and in fact, under present resources and structures, the current mapping needs of the Department will not be met by some considerable amount.

It is a serious matter that at this stage the Department still has some five hundred base plans remaining at imperial scales and not based on the Australian Map Grid.

Future planning is anticipated to define further the extent of this functional deficiency and hopefully point to some firm solutions. Failure to support existing maps and programmes can only result in a deteriorating base of data.

Surveying services

Surveys of 461 tenements were completed during the year, which is 267 fewer than last year although the average size of tenements surveyed has arisen from 71 hectares to 194.

Requests to locate prospecting licences accurately by survey continued at a high level. This trend was not anticipated and results from the high level of activity for gold exploration. A further contributing factor was a degeneration in the standard of pegging of tenements of recent time, resulting in substandard ground marks — in some cases completely omitted — together with poorly described and sometimes misleading descriptions of the tenement. It is hoped some recent cases of tenements being refused for inadequate pegging standards will have a salutary effect.

Alternative methods, using aerial photographs where appropriate, to provide reports to enable ground disputes to be resolved were applied with success.

The long-awaited review of the regulations under the Mining Act which relate to the surveying process were enacted during the year.

A minimum of levelling work for the Hydrogeological Branch was undertaken.

Geodetic survey and tenement control

An increasing demand for control informaion from the mining public and other government agencies was apparent during the year. Some 37 companies and individuals and 5 agencies obtained copies of relevant sheets of coordinates.

No major new control projects were initiated, as for previous years. The impending advent of the new Global Positioning System (GPS) surveying technique, which is predicted to revolutionise many of the traditional surveying modes, dictates such a pause in this field activity. Meanwhile any urgent call for connection of tenements will be handled on a local basis and as part of the normal surveying process.

Work to generate the coordinates of tenements for mapping purposes is progressing on a restricted basis due to lack of staff resources. Similar factors affect the preparation of new standard plans based on these coordinates and 85 maps were completed out of a projected programme for the year of 92.

Mining tenements

A high level of activity continued with respect to mining tenements and the public plans, as a consequence of the continuing interest in mining tenure and the level of mining activity. Tenements added to the public plans numbered 6 285, and 12 886 other dealings of assorted nature necessitated adjustment to the data on the plans.

The Department's developing computerised system for mining tenements (TENDEX) attracted a significant proportion of our resources during the year. Support for this activity diverted resources from other urgent functions. It is hoped a fully operational TENDEX will be of considerable support to maintenance of the public plans in the future. A part of this support was to capture data in more complete form about those tenements which cover multiple plans and also concerning Local Authorities which are affected. In addition, extensive validation of data previously captured from the traditional records has been necessary. A lesson to be learnt is that computerisation implies extreme precision in data capture and operational procedures. This lesson is being applied with all diligence.

The inability of our existing public plan operational support procedures to adequately and quickly reflect changes to land tenure originated within other Departments is of increasing concern. To help improve the situation pastoral lease variations are now obtained directly from the originating source in the Department Lands and Surveys and incorporated onto our plans as a weekly update. Determining the land tenure affected by mining tenements is an important function of the public plans. With the passage of time the variety of land tenure is increasing as is its quantity, and its capture in an accurate and timely manner is correspondingly important which is

becoming ever more critical with the current enhanced awareness of rights in land tenure by the community at large.

A case in point is the handling of the Environmental Protection Authority recommendations regarding proposals for reserving a large number of areas within the State. To facilitate its recommendations a series of plans was prepared at scale 1:1 000 000 to serve as a spatial index to these proposals.

Cadastral maps and plans

The sets of public plans in both Perth and the District Offices have been maintained with the replacement plans being progressively converted to cronaflex medium. This has proved to be very beneficial. The computer system PLANMON has proved of great assistance in monitoring the state of these plans, and in addition the system has been incorporated as a unique data file within the TENDEX system.

Replacing the old series cadastral maps over the Kalgoorlie region with AMG 1:50 000 scale maps, which was commenced in 1985, was extended when further enlargements were required. The programme will be completed by July 1986. A further similar programme for the old series cadastral maps in the Murchison, East Murchison and Yalgoo areas was commenced. Ninety-eight new maps were completed by the end of the year. The Kalgoorlie-Boulder area was remapped using two consolidated sheets at 1:10 000 to replace the previous five sheets.

A revision of the 1:100 000 maps of the Kimberley, West Kimberley, Ashburton and Gascoyne Mineral Fields is planned for the coming year.

Petroleum titles

The petroleum tenement map continued to be a valuable and popular publication. Additional maps and replacement maps in the 1:1 000 000 scale series are required but cannot be commenced due to lack of resources.

A proposal to incorporate the data on the State Petroleum Titles map with the information about the data on the Wells Drilled for Petroleum Map and to produce map products from such a data base by computer-aided techniques has been developed to the stage of funds being sought for implementation.

Geological maps and other publications

Fifteen major coloured maps were produced during the year. In addition, four two-colour maps were printed and one map was reprinted using the laser scanning process. A further 875 black and white diagrams and figures and 594 slides and overhead transparencies were prepared. This is more than for the previous year.

Completion of 1:250 000 geological series

On 29 October 1985 the geological map coverage of the State at the scale of 1:250 000 was completed when the last of the series — Kellerberrin SH/50-15 — came off the press at the Government Printing Office. A total of 163 maps based on the national sheet format for Australia has been published to achieve this target since the project commenced in 1954. This is 50 maps more than the next largest State of Queensland.

The W.A. Department of Mines (who produced 99 maps) and the Bureau of Mineral Resources (who produced 64 maps) were involved in the compilation of these maps. The Commonwealth provided the finance necessary for printing until 1977 when this assistance was withdrawn for maps prepared by State personnel. The Department financed 43 maps in the last seven years to complete the series. The production of this required a substantial investment of time, skill and money. A 1:250 000 scale geologic series map of average complexity is rarely published in colour in less than two years after field work ceases.

These maps were designed to provide government agencies, private mining companies and the public with geological information in a concise form having due regard for their scale of 1:250 000.

About 2 000 copies of each were printed, and each was accompanied by a set of explanatory notes.

Photographically recording progress on construction of Mineral House Stage 2.

Right: Sample checking for quality control during printing run of a coloured map at the Government Printing Office.

Reprographic services

The installation of an automatic film processor for processing colour and black-and-white film has extended the range of integrated photographic services now available within the Division. This has resulted in an improved quality and turn-around time of work.

The OPTI-COPY Process Camera continued to perform to maximum advantage with accuracy and speed of operation. This equipment enabled many functions to be better serviced such as a comprehensive programme of replacement plans for the outstations.

The demand for services of the photographic staff continued to increase.

Printing of maps

Quality printing to the exacting demands of multicolour geological maps was achieved by both the Government Printer and the firm of private map printers Mercury Walch Pty Ltd of Hobart. Without this private facility, which includes the colour separation and proofing functions in addition to printing, the number of maps printed each year would be considerably reduced.

Technical information services

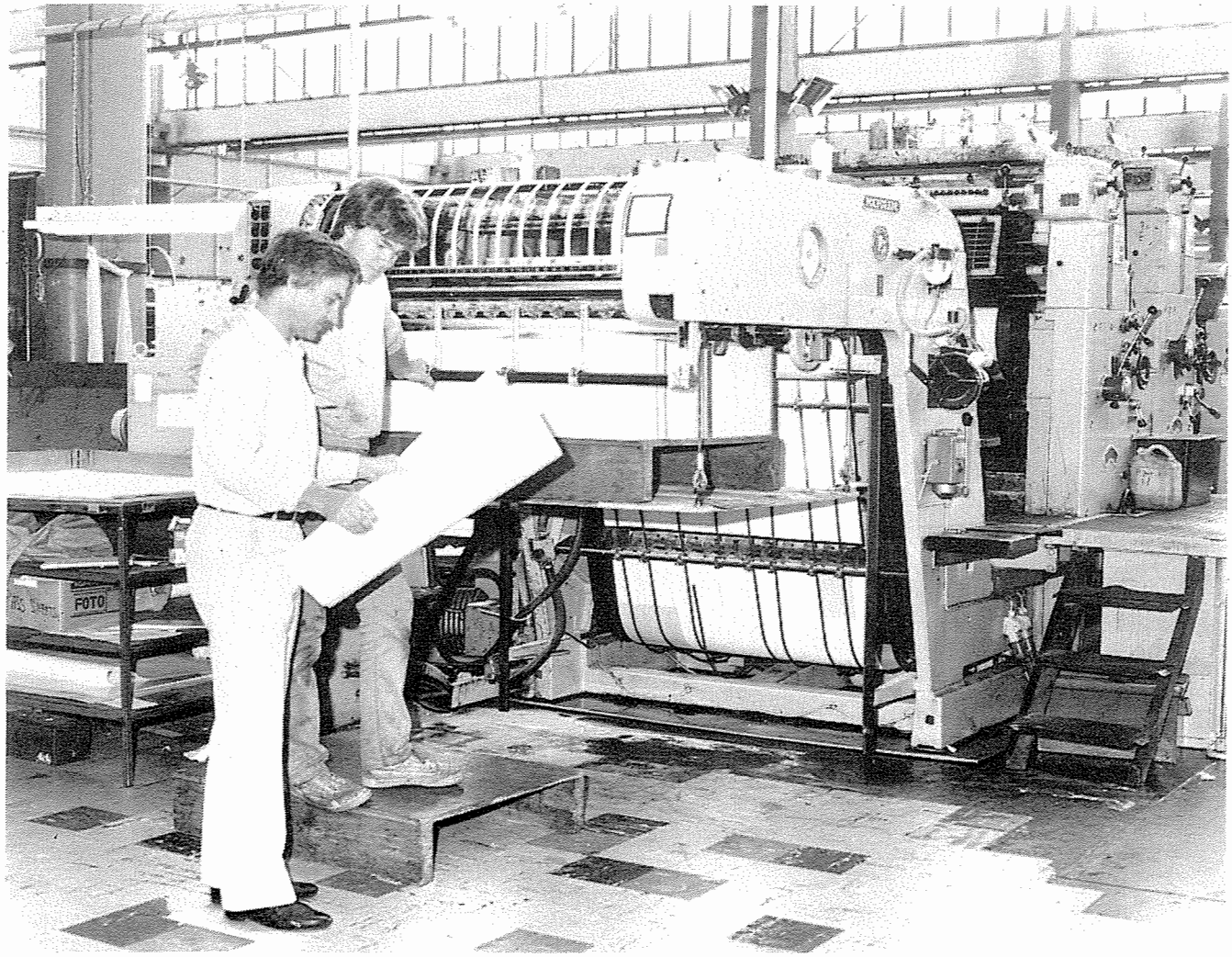
Supply of technical services by way of assistance with searching and sale of copies of maps and other documents continued at a high level, with sales of 16 570 copies of the public plans for a value of $62 833 being the principal component. Sales of other maps and plans amounted to $107 322. A policy of providing our maps at a discount of 33 1/3 percent to approved sales agencies was inaugurated in order to stimulate sales of maps.

Requests to view the plans of old or current underground workings increased, as did the number of plans lodged for the first time for new mines.

Microfilming of the survey plans and diagrams, and archival public plans, was temporarily suspended whilst the micro-film unit was out of operation due to renovation of the premises.

Lack of staff to carry out the necessary support functions also contributed to a backlog.

A deficiency felt for some time has been the lack of adequate plans of the old underground coal-mine workings at Collie. Detailed working plans exist but the scales are large and variable and the resulting sheets mostly



cumbersome and unwieldy. An inability to correlate these with the surface development such as townsites and the land tenure pattern has long been identified.

This year a coverage of plans at a uniform scale of 1:5 000 was prepared to cover the entire Collie Basin. The plans show the cadastral pattern together with the coal-mine workings as a transparency which overlays a formatted set of orthophoto maps of the Basin at scale 1:5 000. It is now possible to ascertain with ease and precision the details of what workings lie under which particular development on the surface. The information is of considerable assistance to the engineers, geologists, inspectors, and regional and town planning and development.

Promotional activity

In response to the policy to promote the corporate image and the impact of the Department's activities with respect to the mining industry and the community at large, the function of display, design and graphic presentation activity has increased, and, during the year, two positions of Graphic Designer were created by conversion from Drafting Assistant positions. This work provides a further dimension to the activities of the Division and is one that is likely to increase. Eleven displays were prepared.

Staff resources

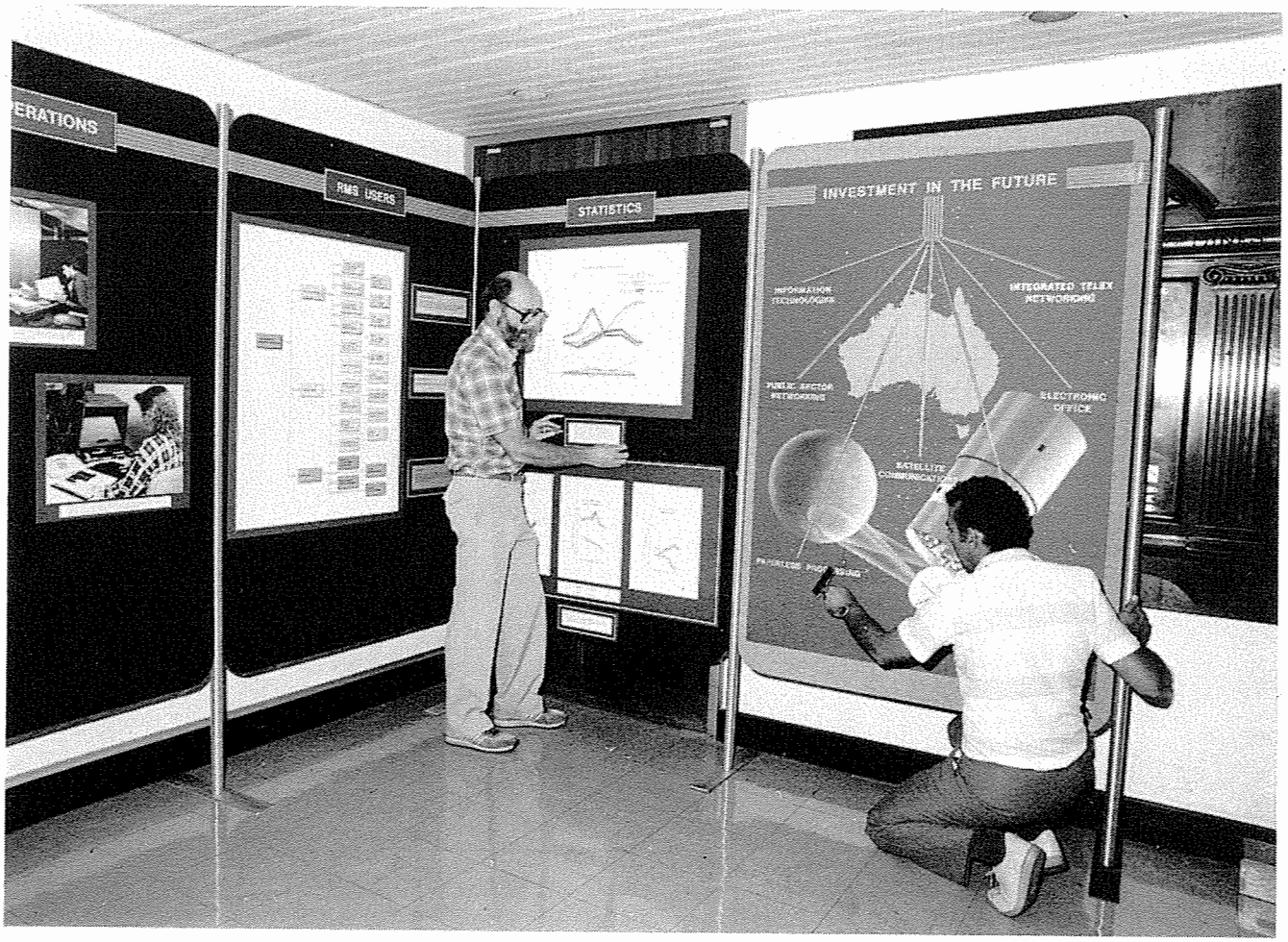
Total establishment numbers reduced by 2 to 129 despite increasing demands upon the Division to service increased activity flowing from increased strengths in other areas of the Department. However high levels of work output continued.

During the past twelve months, one draftsman was employed in a temporary capacity for the whole year as an Additional Assistant and approximately 600 hours were allocated to contract drafting services at a cost of $18 500. However, not all forms of drafting are adaptable to outside assistance, and a considerable amount of preparation, explanation, and supervision is necessary to achieve satisfactory results. Thus outside contracting is not always as economic or as efficient as in-house drafting, but is necessary in order to satisfy the increased demands being made on the Division.

It is expected that, subject to budget provisions, there will be an increase in the use of temporary and contract staff in the coming year to cope with the programme which is estimated to be two to three times the present capacity to achieve.

Other activities

Joint visits with officers of the Mining Registration



Trevor Dods and David Smart, graphic designers, put the finishing touches to a display illustrating a newly installed departmental records management system.

Division were made to inspect plans and operations at the offices in Mt Magnet, Cue, Norseman, Coolgardie, Kalgoorlie, Leonora, Kununurra, Broome and Marble Bar. These were undertaken by the various officers responsible for managing the dealings with each particular office or area and were the most comprehensive and rewarding undertaken to this stage. Valuable experience was gained, not only in plan reviews, outstation requirements, office procedures and outstation atmosphere, but more importantly in personal contact.

A working group convened by the Director and with representatives from the mining industry and the surveying profession reviewed the method of defining mining tenement boundaries. The report considered all aspects of pegging and description of tenement boundaries, including the advantages and disadvantages of using graticular sections, and made nine recommendations, the most important of which are that the principles of pegging tenements have much to commend them and should be retained for the smaller tenements, whilst boundaries of exploration licences could be defined along fixed intervals of latitude of longitude but the advantages and disadvantages need further evaluation as does the cost of conversion for the tenement maps. By comparison with boundaries described by distance and direction, graticular boundaries have an advantage of unambiguity but a disadvantage of inflexibility.

Mr W.R. Moore, Director, and Mr M.E. Sawyer, Senior Technical Officer, attended the 11th National Surveying Conference (Institution of Mining and Engineering Surveyors) in Perth during August 1985, and Mr P.A. Shaw attended a workshop on computer-assisted cartography initiated by the Chief Geological Cartographers Conference and held in the Bureau of Mineral Resources, Canberra in December 1985.

Mr E.J. Blake, Assistant Director General and Mr W.R. Moore visited the Department of Mineral Resources, New South Wales and the Department of Mines, Queensland in June 1986 for the purpose of investigating their systems and methods of operation with particular attention to their use of graticular sections.

LUPINS — An old crop with new potential

Markets

Success stories in agriculture are rare these days, but the development of the Western Australian lupinseed industry over recent years is nothing short of spectacular.

Lupinseed production went from 25 000 to 540 000 tonnes in the period 1980-85, making it the third most important crop in the State and WA the only significant exporter of this commodity in the world. Market research indicates demand is outstripping supply, even in the current economic climate.

The WA sweet lupinseed competes favourably with soybean in the compound feed trade in Europe and Asia, and now is entering additional markets for human consumption in Asia.

Alkaloids

A key factor in the growth of this industry has been the success of a lupin breeding programme by Dr John Gladstones at the WA Department of Agriculture which has resulted in low alkaloid (sweet) varieties for commercial production.

The Agricultural Chemistry Laboratory has assisted this work through the development of methods to accurately define the amount and types of alkaloid present at trace levels in sweet lupinseed. The analytical data have aided the plant breeder in selecting lupins with enough alkaloid in the plant to confer some natural insect resistance, but with low enough alkaloid in the seed for it to be commercially acceptable.

An important application of the analytical technology developed by the laboratory has been to monitor, for the last three years, the alkaloid level in lupinseed at 25 major receival points in the State.

The cumulative data establish that the average alkaloid content of WA sweet lupinseed is less than 0.02 percent, and well inside an upper limit of 0.05 percent under consideration by the European Economic Community (EEC).

Composition

Although lupinseed is a well-known stockfood in Europe it is totally new to feed compounders in South East Asia, who understandably seek detailed information on its chemical composition.

To meet this requirement the laboratory has conducted a comprehensive range of analyses on samples representative of the State crop over the past three seasons. The constituents determined include protein, fibre, fat, trace elements, amino acids, alkaloids and anti-nutritional factors.

This information has been documented in an internal report which has proved to be of particular value to the local feed formulation industry and to the Grain Pool in their promotion of lupinseed overseas.

Research

The lupin research programme of this laboratory originated in 1974 with the work of Jack Jago, recently retired Chief of the Laboratory and foundation member of the WA Lupinseed Technology Committee.

Research developments recorded this year were:

— The extraction and purification of two kilograms of alkaloids from a bitter variety of lupin (Fest) has been completed. The alkaloids will be used for toxicological studies by an independant world recognised body, the British Industrial and Biological Research Association (BIBRA). This work, commissioned by the Grain Pool will provide information essential for the use of lupinseed for human consumption.

— Chemically pure forms of some of the main lupin alkaloids, unavailable elsewhere in the world, are now prepared for use as analytical reference standards. These chemicals and a thoroughly proven methodology for analysis of lupin alkaloids have been supplied to four importing countries, Finland, Korea, Japan and USA enabling them to confirm in their own laboratories the low alkaloid status of WA lupinseed. Requests for this service are expected to increase as the lupinseed market expands and diversifies into uses for human consumption.

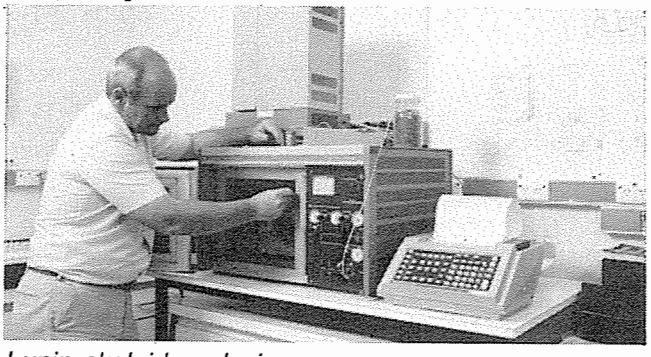
— A procedure has been developed for the automated extraction of alkaloid from lupinseed samples, significantly reducing the time required for this part of the analysis.

— Chemical analysis for anti-nutritional factors has confirmed the low level of these components in WA commercial lupinseed, compared to soybean products.

Research grants

The Rural Credits Development Fund financed the purchase of a capillary gas chromatograph in 1981 and, in 1986, funded the appointment of a chemist for 12 months to investigate anti-nutritional factors in lupinseed.

The Grain Research Committee of WA funded equipment in 1985 for the large-scale extraction of alkaloids for BIBRA and for the development of automation of the analytical procedure.



Lupin akaloid analysis.

GOVERNMENT CHEMICAL LABORATORIES

H. C. HUGHES, ACTING DIRECTOR

The expectations for 1985/86 were not fulfilled in a number of respects. In the last days of the previous year the Director, Mr Ron Gorman together with Mr Jack Jago, the Chief of the Agricultural Chemistry Laboratory, and Mr Noel Platell, the Chief of the Water Science Laboratory, all retired. Expectations for appointments to all of these senior positions and for an early announcement on the future of the Government Chemical Laboratories, following yet another review, did not materialise and at the close of the year 13 of the senior positions in the Laboratories were filled by acting staff.

Joint ventures

All staff are looking forward eagerly to a decision not only on the future programme for the Government Chemical Laboratories (GCL) but also for a decision on a new site for the Laboratories. A number of discussions at various levels were held during the year, on proposals to establish a new Laboratories complex to encompass potentially a Minerals Research Centre which would combine some projects of the Commonwealth Scientific & Industrial Research Organisation (CSIRO) and the Government Chemical Laboratories with the active collaboration with one of the tertiary institutions. Such a focus could lead to other joint efforts complementing those already in progress, with for instance, Western Australian Institute of Technology (WAIT) and Murdoch University, extending the co-operation which has taken place to an increasing extent in recent years between CSIRO, the tertiary institutions and the GCL. Some examples of such co-operation are:

- the announcement of a joint purchase of an electromicroprobe costing approximately $600 000, funds being supplied by CSIRO, the State Treasury and the State Energy Commission. This will be accessed by Mineral Science, Engineering Chemistry and Materials Science Laboratories.
- a joint programme between the GCL and Murdoch University School of Veterinary Studies, funded by the Western Australian Turf Club and the Western Australian Trotting Association, to examine the metabolism of drugs in racing horses.
- joint research with Murdoch and WAIT for the Australian Mining Industry Research Association (AMIRA) directed in part at the characteristics of activated carbon used in gold recovery processes.
- collaboration with WAIT and CSIRO under the auspices of Western Australian Mining and Petroleum Research Institute (WAMPRI) into the relationship between mineralogy, roasting and extraction of gold."
- discussions with CSIRO have been held on collaborative test work aimed at developing a CSIRO patent for the processing of monazite.

The foundations for such collaboration have been well laid. Additionally, the GCL continues to make use of the Scanning Electron Microscopes at CSIRO and the WAIT Physics Department, and closer physical proximity would enhance the ease of use of sophisticated and expensive instrumentation and joint facilities to all involved.

Of the utmost importance is that such collaboration continues to take place so that maximum value can be obtained, not only from expensive analytical equipment but also from the application of the expertise available from a variety of sources to investigate problems. The proposed Mineral Research Centre along with the GCL both sited on the campus at one of the tertiary institutions which has some common functions is designed to make maximum use of such available expertise and equipment. Similarly the functions of the various laboratories complement each other to produce an enormous fountain of expertise built up over many years.

Accommodation

The environmental problems associated with the operation of a chemical laboratory in the city were highlighted during the year when in-house problems arose. Workmen engaged in the building of Mineral House II expressed concern at the fumes generated by the Laboratories and, on one occasion, hydrogen sulphide emissions found their way into Mineral House I, much to the discomfort of the staff. This highlighted the problems already known to exist with the fume cupboards and it is pleasing to note that plans to upgrade and scrub the emissions prior to evacuation have been drawn up and the work is about to commence.

The old library has been converted to a laboratory for the physical evidence section of the Forensic Science Laboratory and was almost ready for occupation at the end of 1985/86. This will provide reasonable accommodation for this section which has occupied sub-standard conditions in an area originally intended for mineral analysis, is subject to the excessive noise of the adjacent rock crushing machines, and has been spread over a number of areas due to lack of laboratory space. These problems were exacerbated by large increases in workload.

The staff of all the Laboratories are eagerly looking forward to an early start on the planning of the new Laboratories, a decision having been made in 1984 that the existing site was to be vacated in five years. New laboratories would be particularly welcome as again the total number of sample receivals exceeded the previous year, this time by about 4 percent.

Finance and equipment

The creation of a new position in the Mines Department of Manager, Financial Services, has provided a new era of co-operation in relation to the financial management of the GCL. Advice and co-operation on preparation of budgets, and a general education in methods of dealing with the Treasury requirements, have brought about a better

appreciation within the GCL of its financial operation. The running down of reserve supplies and the failure to acquire funds for replacement of equipment resulted in Treasury approval for emergency funding to enable the Laboratories to maintain their services to client Departments throughout 1985/86. Although initially no funds were provided for replacement of major capital equipment, subsequent requests to Cabinet were successful in obtaining funds for a Mass Specific Detector costing $120 000 and a Fourier Transform Infra-red Spectrophotometer costing $100 000, replacing instruments that had become inoperable. Without these items much of the drug work for the Police, and a number of other important aspects of the GCL's work, would not have been possible.

Research

Research and investigation continued to be an important function of the GCL, and in a number of areas the GCL continues to enhance its reputation in various fields of chemistry. The feature article on lupins demonstrates world leadership in lupin chemistry research, and the close relationship with the Department of Agriculture in this field is leading to considerable economic benefit to the State. In a completely different field, the detection of the use of the narcotic analgesic buprenorphine (TEMGESIC) in both racing and trotting was an achievement since no detections of this drug, which is used at an extremely low dose rate, have been recorded elsewhere, even though the drug is believed to be extensively used.

These two examples highlight the need for continued research over a wide range of fields. They demonstrate, on the one hand, the importance of research to our economy in the form of exports and, on the other, need for continued surveillance of the use of drugs in the racing industry to keep the sport clean. This is important in retaining the confidence of the racing public because this industry is a big revenue earner for the Government.

The table below — "source and allocation of work received in 1985/86" — shows clearly the extensive range of Government Departments and Authorities serviced by the GCL in terms of consultancy, analysis, inspections, lectures and advisory work.

Agricultural Chemistry Laboratory

Work received by the laboratory continued at a record level of 51 000 samples for the year, despite a decrease of 4 500 soil samples from farms in the Peel-Harvey catchment area.

Research centred on the chemical evaluation of the State's major feed grains, the determination of anti-

SOURCE AND ALLOCATION OF WORK 1985/86 FINANCIAL YEAR

SOURCE	Laboratory								
	Agricultural Chemistry	Engineering Chemistry	Food and Industrial Hygiene	Forensic Science	Kalgoorlie Metallurgical	Materials Science	Mineral Science	Water Science	Total
DEPARTMENT OR AUTHORITY									
Agriculture Department	50 044	1	763			3	19	279	51 109
Building Management Authority	20		4			28	12	40	104
Conservation & Environment Department	254	2	103	1			1 211	3 278	4 849
Conservation & Land Management Department			80					43	123
Consumer Affairs Department			4			66	6	2	78
Education Department	29					48	5	1	83
Fisheries Department	690		1 072					13	1 775
Geological Survey of WA							986	485	1 471
Government Chemical Laboratories	91	43	20	40	35		358	71	658
Government Stores Department			4	45		1			50
Health Department	3		1 821	9		15	59	124	2 031
Homeswest			7	3		7	5	1	23
Housing & Construction Department (Commonwealth)								56	56
Hospitals			17						17
Leschenault Inlet Management Authority			54					52	106
Main Roads Department	6					2	34	16	58
Metropolitan Transport Trust							25		25
Mines Department	1		246		9	2	497	6	761
Occupational Health, Safety & Welfare Department			339			1	262	2	604
Peel Inlet Management Authority								80	80
Perth Mint							77		77
Police Department			15	5 769			327		6 111
Prisons Department				431	34				465
Resources Development Department							1	416	417
State Energy Commission		97	3						100
State Planning Commission								161	161
State Tender Board						82			82
Swan River Management Authority			6					181	187
Water Authority of WA	1		931	1	268	5	111	9 142	10 459
Waterways Commission			2					149	151
Other Departments (16)		1	4	2		12	12	11	42
PUBLIC									
Pay	247	139	103	8	3 181	218	153	755	4 804
Victorian Harness Racing Board				17					17
Western Australian Greyhound Racing Association				461					461
Western Australian Trotting Association				880					880
Western Australian Turf Club				1 974					1 974
Other (5)				25					25
TOTAL	51 386	186	5 692	9 669	3 527	490	4 160	15 364	90 474

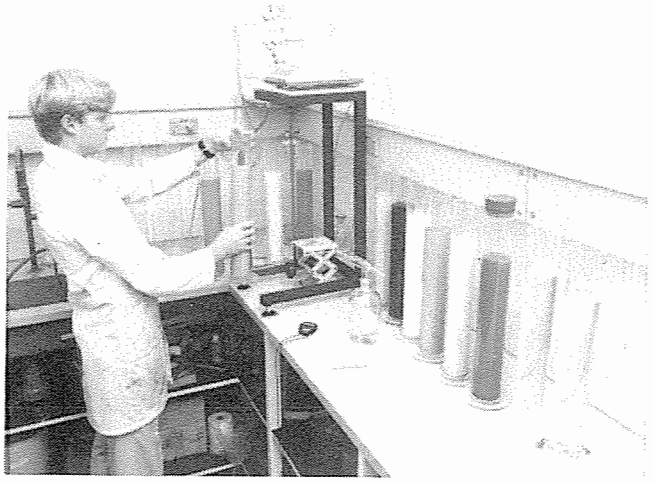
nutritional factors in lupinseed, the development of soil tests for assessment of phosphate and gypsum requirement of WA soils, and improvement of tissue analysis techniques for the diagnosis of boron toxicity in barley and molybdenum deficiency in wheat.

Analysis systems

The computer this year was put to more effective use in handling sample documentation, collection and calculation of data from autoanalysers, and printout of reports.

The combination of this, modern instrumentation and more efficient analytical procedures has enabled the laboratory to keep abreast of demand and double work output per person each five years in the last decade. Samples analysed per person/year have increased from 448 in 1975, to 1 024 in 1980, and to 1 969 in 1985.

Projections by the Department of Agriculture, on the requirement for chemical analysis as a component of their research programmes, indicate that the above increase in ouput will need to be maintained and possibly exceeded. In view of this, an investigation was conducted on the suitability of an Inductively Coupled Plasma Atomic Emission Spectrometer, courtesy of the Mineral Science Laboratory, to handle nutrient profile analysis on plant tissue and multi element determinations on fertilizers and gypsum. The results of the study were conclusive and leave no doubt that this type of instrumentation is essential if the projected requirements of the Department of Agriculture are to be met.



Soil testing.

Anti-nutritional factors

The 1985 crop of commercial sweet lupinseed (L. angustifolius) in WA was analysed for various anti-nutritional factors.

The amounts of phytate phosphorus and tannins were found to be low when compared with those of other commercial grains and are unlikely to reduce the nutritive value of sweet lupinseed.

The trypsin inhibitor activity of sweet lupinseed was comparable to that of wheat, and considerably lower than those of rye, triticale and soybean.

Significant amounts of oligosaccharides of the raffinose family (raffinose and stachyoze) were present in lupinseed. These sugars are largely responsible for the flatulent properties of legume seeds. However, the levels of these sugars are comparable to those present in other legume grains.

The variability in the contents of the anti-nutritional factors was relatively small over 58 sites in the lupin growing areas of the South West of WA.

A sample of WA sweet lupinseed was analysed for hydrogen cyanide liberated by decomposition of cyanoglucosides. The level of cyanide was much lower than the permitted maximum limit, contrary to a claim made in the press of an importing country.

Gypsum

Farmer interest in the use of gypsum to improve soil structure has continued at a high level as indicated by a 30 percent increase in requests for analysis of gypsum samples. As with previous years, approximately half of these contained more than 85 percent gypsum which previously was the level required to register gypsum for sale as "soil conditioner".

Gypsum application has resulted in a doubling of wheat yields on some soil types. This laboratory is working jointly with the University of WA and Department of Agriculture to define the mechanisms involved. Samples from trial sites on a range of soils throughout the wheatbelt were analysed to monitor physical and chemical changes that occur after gypsum applications and to establish its residual value.

Boron toxicity

A leaf disorder widespread in barley crops throughout the WA wheatbelt has been diagnosed as being due to boron toxicity. It occurs on heavy or sand over clay soils which form a large proportion of the medium to low rainfall barley growing area.

Plant samples have been analysed to examine the difference in boron uptake and degree of symptoms among nine varieties of barley. Soils have also been analysed to establish properties which may influence boron uptake. Plant tissue analyses will be used to determine the extent and severity of boron toxicity and the relationship between concentrations of boron in individual leaves and grain yield.

Engineering Chemistry Laboratory

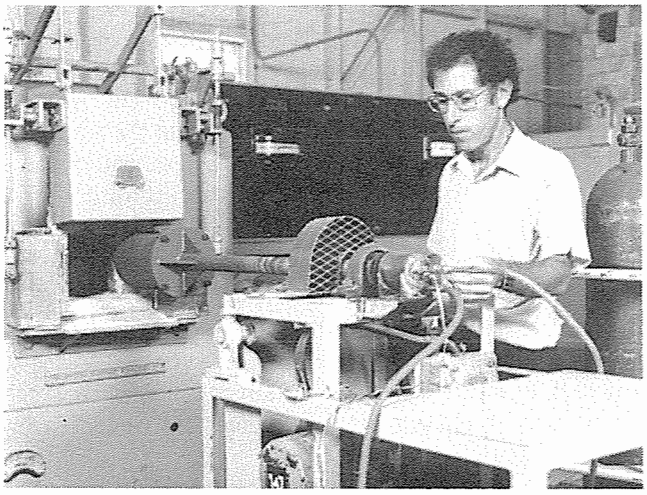
The sustained resurgence of activity in gold mining prompted research and development into aspects of that industry. The specific matter receiving attention is the activity of carbon used to adsorb gold in carbon-in-pulp (CIP) and carbon-in-leach (CIL) processes. Other minerals were examined for their potential for economic exploitation. Additionally, government and a variety of industries were assisted with technical advice and practical testwork.

Activated carbon

Granular activated carbons, commonly made from either

coconut shell or peat, are used to adsorb gold from solutions and pulps. The desirable characteristics of such carbons are resistance to abrasion, ability to adsorb and desorb gold and the capacity to be re-activated. Equipment has been set up to evaluate these characteristics. Active carbon is a powerful but non-specific adsorbent and, in practice, it adsorbs organic material and other metallic species so that the carbon's capacity for gold is reduced. Reactivation, as the term implies, restores the activity of the carbon and this is accomplished essentially by heating the carbon in controlled conditions of temperature and atmosphere.

Because of the apparent ease with which carbon can be reactivated, there are various different techniques and furnaces used in the industry. However, the methods applied are not always scientifically sound or based on quantitative evaluation of their efficacy. Data acquired by experiment, by visits to operating plants and furnace manufacturers and by association with the Murdoch-WAIT Gold Technology Group, are being accumulated towards a better understanding of the reactivation process and to establish a basis for advice to the industry. The rotary kiln simulator, which was designed and fabricated on-site, has proved to be very useful in this investigation.



Rotary kiln simulator.

It is also described as a rotary pot kiln and has been used in many projects. It will be supplemented soon by a Rintoul furnace which was obtained from the manufacturers by Murdoch University and will be sited at the GCL. In this unit the carbon is reactivated by heat generated when an electric current is passed through a column of carbon.

Phosphate rock

The pilot-scale rotary kiln was used on two occasions to calcine low-grade phosphate rock from Christmas Island. The process converts the phosphate to a soluble and hence available form, so that the product has potential as a fertilizer that can be directly applied to the soil. The calcined ore was tested by the Department of Agriculture.

Heavy mineral sands

Heavy mineral sands are commonly referred to as "beach sands" and they consist of several different mineral species which are recovered separately. Experience has been gained in the beneficiation of these minerals, in particular ilmenite and zircon, over many years. A significant contribution was made some years ago to the beneficiation of ilmenite to synthetic rutile and it is gratifying to note the recent expansion in the application of this process by two companies in WA. More work was done this year on the cleaning of iron-stained zircon and some work was done on the separation of kyanite.

Collaborative testwork

Many companies commissioned testwork of different degrees of complexity on various ores and minerals e.g. limestone, kaolin, gold ores, vanadium ore, diatomite, phosphate ore and spodumene. The mining industry still apparently is largely unaware of the facilities and expertise available to it for confidential testwork, albeit at a charge based on the actual cost of labour and materials plus an allowance for overheads. This contact with industry helps to ensure the relevance of research programmes initiated from within. The practical relevance of testwork is further ensured by collaborative research which attracts industry support. In this context, work sponsored by the AMIRA and WAMPRI is being undertaken in association with the Murdoch-WAIT Gold Technology Group, WAIT and CSIRO.

Food and Industrial Hygiene Laboratory

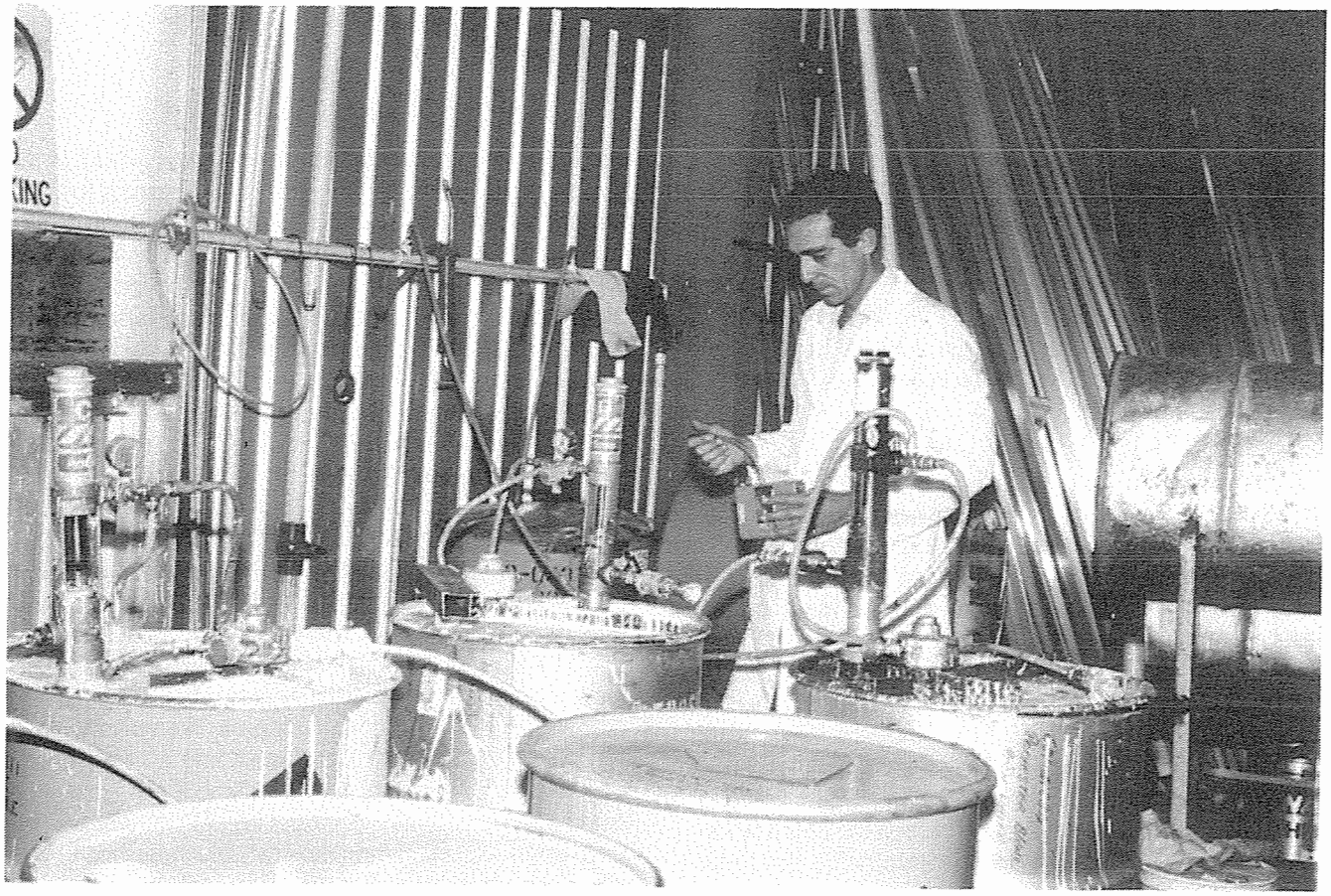
There has been an increased demand for laboratory staff to assist the other Divisions of the Mines Department and other Government Departments and Authorities in the area of occupational hygiene. The increase is in line with Government policy and is due partially to the increase in activity of the Occupational Health, Safety and Welfare Commission.

Minesite inspections and seminars

Resulting from the more economic recovery of gold using the CIP process there has been an upsurge in the use of this process in this State to treat ores and to retreat tailings. One of the major chemicals used in the CIP process is a solution of either sodium or potassium cyanide. The dangerous properties of cyanide have led to some potentially hazardous situations. This Laboratory has been involved, along with Mines Inspectors, in a large number of special minesite inspections with emphasis on cyanide problems. Mr J H Genovese of the Laboratory took part in a series of seminars organised by the Mining Engineering Division and held throughout the gold mining regions of the State, to alert and reinforce to the mining public the inherent dangers of cyanide and the measures to be taken for its safe handling and use.

Factory and industrial hygiene inspections

Prison Warders regularly practise firearm shooting at ranges attached to their prisons. At one prison concern was expressed regarding the concentration of lead fumes to which the warders were exposed. A series of tests was



Monitoring solvent concentration in air at a factory site.

carried out during a firing session and high levels of lead in the air were found. Recommendations were made for alterations to the ventilation system of the range which, when carried out, lowered the level of lead to which the warders were exposed to well below the threshold limit value.

The staff have been called upon to investigate and make recommendations on the storage, handling and use of chemicals in work places. During these investigations several cases of misuse of chemicals were encountered due to ignorance of their properties.

Pesticides

A farmer in the South West of the State applied DDT to his maize crop. When analysed the cobs complied with the maximum residue level (MRL) but the outer leaves were high in DDT levels. The leaves and some of the cobs were fed to cows. The resultant milk had an elevated DDT level but it did not exceed the MRL. The field drains into a river where marron deaths were reported. Marron are very susceptible to DDT.

The Health Department in conjunction with some Shire Councils undertook a survey of various vegetables offered for sale at the metropolitan and local growers markets for pesticide residues. This survey extended over a three month period and included beans, brussel sprouts, cabbage, carrots, cauliflower, celery, cucumbers, lettuce, potatoes, spring onions and tomatoes. Of all of the samples analysed only one sample exceeded the MRL. It is planned to repeat the survey, next time including fruit.

Colours in ceramic ware

Several ceramic vessels with large areas of yellow glaze were examined for extractable cadmium and lead. The amounts of cadmium and lead extracted were far above the amounts allowed by the appropriate British Standard. This glaze, after extraction with dilute acid, was badly crazed indicating that the glaze was of poor quality and/or had not been fired at a sufficiently high temperature.

Monitoring of Princess Royal Harbour for mercury

The problems in this Harbour of mercury originating from the phosphate fertilizer plant at Albany were outlined in the previous Annual Report. The ongoing survey of crustacea, fish, molluscs and sediments have not shown any significant decrease in the amount of mercury. It appears that the monitoring programme will need to continue for several years.

Forensic Science laboratory

The laboratory continued to provide a comprehensive analytical, advisory and support service in forensic chemistry to the Police and other departments. While there were general increases in all aspects of operation, the period under review was dominated by massive increase in cases submitted in connection with drugs and drug abuse.

Alcohol, drugs and driving

A total of 1 163 exhibits requiring analyses for alcohol or drugs were received from the Police Traffic Branch, 63 percent from sobriety cases and the remaining 37 percent from traffic accident victims.

The role played by alcohol in traffic deaths is highlighted by a comparison of drivers' blood alcohol concentrations in single vehicle versus multiple vehicle incidents. In the single vehicle accidents, alcohol could be considered to be the causative agent in 70 percent of cases whereas the deceased driver was considered impaired in only 20 percent of multiple vehicle incidents.

Toxicology and drugs

The escalating rate of increase in receival of heroin seizures from the Police Drug Squad (up 82 percent) was a trend that is of particular concern reflecting as it does the increasing proliferation of the drug in the community.

A grim reminder of the ultimate fate of many heroin users is supplied by the results of analysis of exhibits submitted by the Police Coronial Inquiry Section. During the year, deaths that were directly attributable to heroin abuse rose by 150 percent to 17, making it the major cause of drug-related deaths in Western Australia.

Overall there was a seven percent increase in cases submitted by the Coronial Inquiry Section for examination for drugs and poisons to assist in determining the cause of death. The number of drug cases received for the year from the Police Drug Squad and other sources rose by 36 percent.

Doping control in sport

The year has seen the establishment of a research programme jointly managed by this Laboratory and the Murdoch University School of Veterinary Studies. Under the programme, University staff are administering drugs of interest to horses, evaluating effects and collecting biological samples. The samples are then taken to the Laboratory so that techniques to detect the drugs and metabolites can be designed and thus enable basic data on drug kinetics in race horses to be established.

The West Australian Turf Club and the West Australian Trotting Association have jointly funded the programme and in addition have provided vital analytical equipment required to handle routine testing plus the work generated by the research programme.

Criminal investigations

A wide variety of examinations of material from crime scenes, victims and suspects were carried out during the year. The most common case types are fire debris, blood and urine, paint, glass, fibres, gunshot and explosive residues. In 1986, ten incidents involving explosives were examined. These analyses are usually aimed at determining the nature of the explosive used in the incident. A typical example is shown in the photo where the crane tower at the Observation City construction site was bombed. Laboratory analyses showed the presence of ethylene glycol dinitrate and nitroglycerine residues in the debris, typical of gelignite explosives.

Kalgoorlie Metallurgical Laboratory

The high sample throughput of 2 159 achieved in the previous twelve months has risen by 63 percent to 3 527 this year with bullion numbers being the main contribution. The primary emphasis has been on gold. With new plants opening and exploration remaining buoyant and contrary to last year's predictions the level of umpire work increased. The Laboratory has also become involved in custom milling arrangements with clients.

For the first time in almost three years the Laboratory has its full complement of staff and they are now settling into a team making the best use of their diverse talents.

Co-operation with the WA School of Mines

A cordial relationship with the WA School of Mines (WASM) has always been enjoyed, but 1986 has seen the start of efforts to forge closer ties and to undertake joint research projects. If current plans come to fruition the first joint project will commence in July 1986.

Access to the WASM mainframe computer has been achieved by linking the Laboratory into existing lines in the Metallurgy building and the School has generously made a terminal and a printer available on a short-term loan basis. The metallurgical staff are now building up experience in its use for CIP plant applications.

The Laboratory's assaying experience is being applied to a course to train fire assayers for the Papua New Guinea Government's Department of Minerals & Energy. The course has been organised by the WASM in conjunction with this Laboratory with funding provided by the Australian Development Assistance Bureau.

Metallurgical testwork

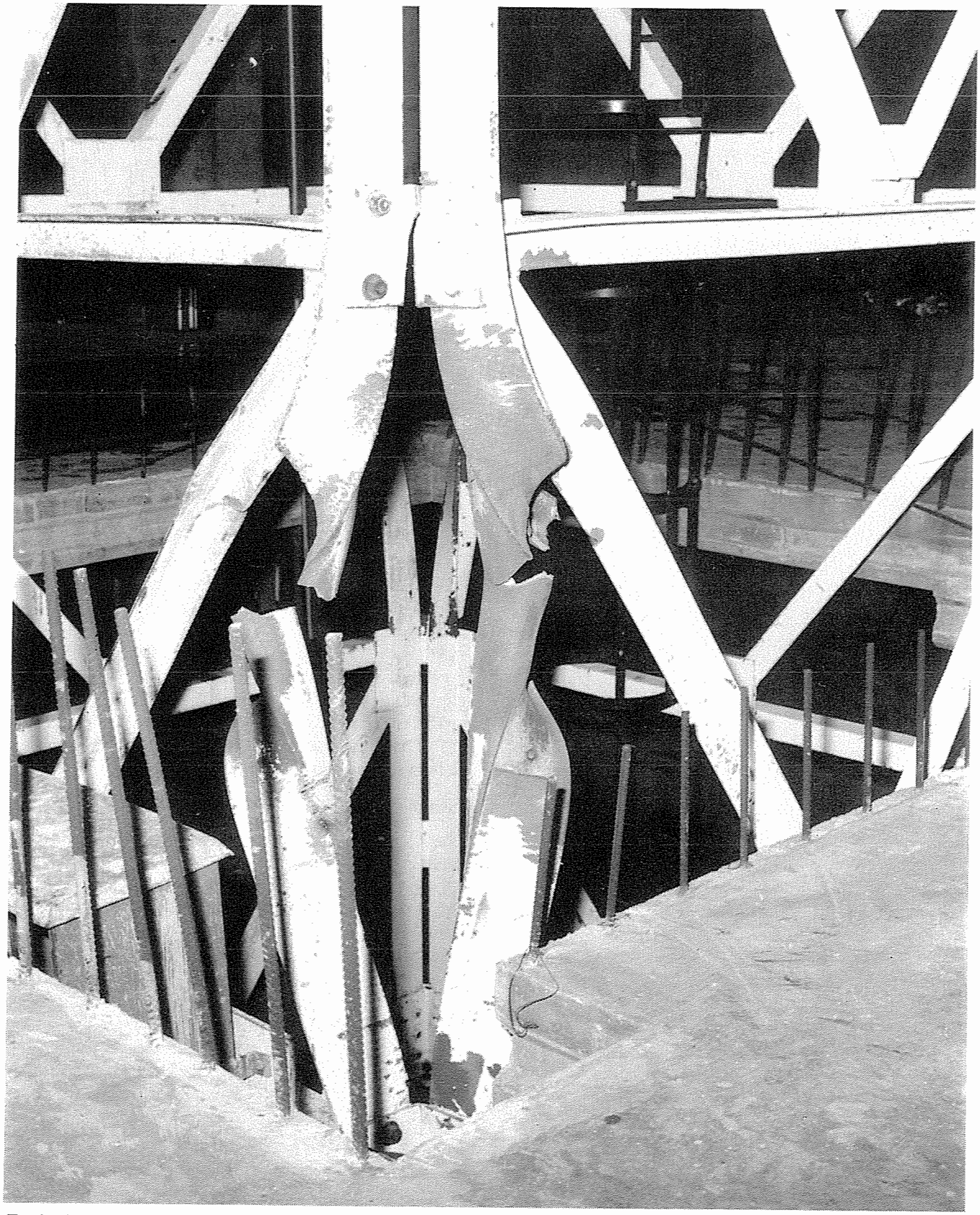
A number of ore parcels have been treated through the pilot plant and as the operating techniques are refined and the circuit is modified so its performance is steadily improving. Maintenance engineering support from Engineering Chemistry Laboratory has been important in this area and it is likely to become even more important as the equipment usage increases.

Gold stealing

There was a dramatic increase in the work for the Police Department Gold Stealing Detection Staff during the first six months of 1986. The WASM scanning electron microscope (SEM)has been a valuable tool in the early part of some of these investigations.

Materials Science Laboratory

Demand for technical advice and independent testing services resulted in a busy year for this group with 14 State department as well as Commonwealth and local government bodies and private clients utilising the laboratory's expertise during the year. Product quality assessment and failure analysis for small business and



Explosion damage resulting from bombing of a crane tower at the Observation City construction site.

consumers continued to be an important area. The laboratory is fulfilling a need for independent testing services in the WA community. Involvement with environmental impact matters continued to increase.

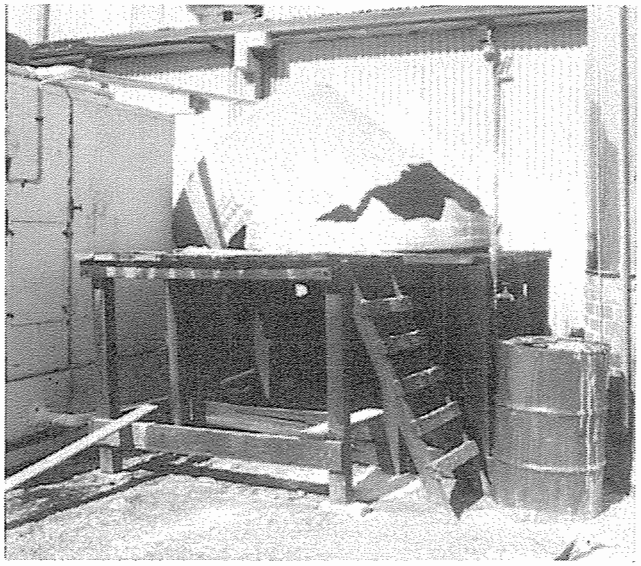
Investigational and industry support

Involvement in a wide range of consultative matters occurred including a major investigation into the

operational efficiency of the Hospital Laundry and Linen Service, and development of safe and effective cleaning chemical formulations for use by Government departments and hospitals.

A catastrophic failure in a glass reinforced plastic (GRP) tank used to store sulphuric acid was investigated. The reason for the failure was determined to be inadequate structural design and incorrect selection of materials for the GRP laminate.

Two examples of technical assistance to local industry were quality control testing for corrosion resistance of components produced by a local manufacturer for Defence Department contracts, and physical and chemical testing of a new industrial and underwater coating system for market development purposes.



Sulphuric acid spill resulting from collapse of an under-designed glass reinforced plastic tank.

Environmental

Technical appraisals of environmental impact assessment reports were conducted on three proposed new industries in the Kwinana area, a chlor-alkali plant, a sodium cyanide plant and a liquified petroleum gas production facility.

A critical review of environmental impact matters relating to a new mineral sands processing plant at Capel was undertaken and staff continued to be involved in appraisal of the environmental effects of converting the SCM Chemicals pigment plant at Bunbury from sulphate to chloride technology.

Materials in contact with potable water

In collaboration with Health Department and the Water Authority, testing and approvals procedures are being developed for materials such as coatings, plastics and repair systems for use in the State's water supply reservoirs and distribution network. The problems of consumer acceptance (tainting) and toxicity are being examined and tests developed to screen out products which contaminate the water supply.

Mineral Science Laboratory

The Laboratory's mineralogical and chemical expertise were utilised by some 20 Government departments and authorities to analyse and characterise rocks, minerals, building products, dusts and related materials. The associated advisory service has assisted investigations and helped solve problems related to exploration, mining, mineral processing, occupational health, forensic, environmental, consumer protection, building and construction programmes.

New technique

A recent major instrument purchase was commissioned in mid-1985. This instrument an inductively coupled plasma atomic emission spectrometer, more commonly known as ICP, has proved to be a valuable asset to the Laboratories.

The ICP is used to analyse solutions for a wide range of elements. The solutions are aspirated through a 6 000°C plasma. The solvent is vaporised and the soluble compounds broken down to atoms and ions which are excited by the intense heat of the plasma. These excited species emit characteristic spectra which allow the elements to be detected in a rapid sequential programme.

The ICP is being regularly used in many of the Laboratories' programmes including water resource evaluation, water pollution monitoring, contamination of food, evaluation of nutrient requirements of plants, monitoring of regulatory fertilizers, and analysis of geological materials and nuisance dusts. ICP offers a more efficient and cost effective alternative to the previously used procedures. The savings in resources is achieved because the ICP is run unattended at night and can determine six elements in a solution every two minutes.

Platinum

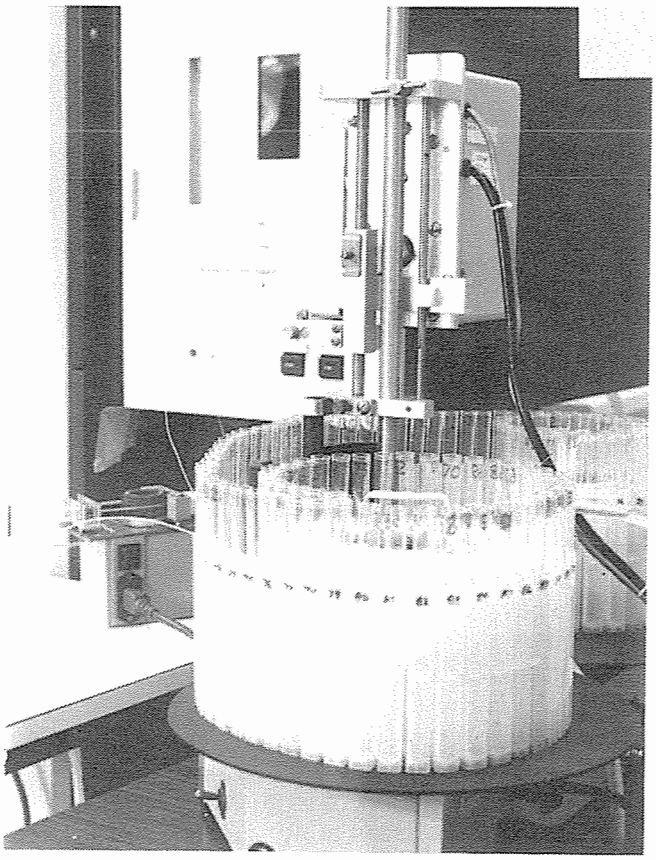
The Laboratory has recently developed procedures for analysing geological specimens for platinum group elements (PGE). As 80 percent of the western world's platinum comes from South Africa there is considerable exploration activity in Western Australia aimed at identifying economic deposits of these elements. The Laboratory has assisted the Geological Survey by analysing samples from many areas of Western Australia which have potential as a source of he platinum group elements.

The PGE, platinum, palladium, rhodium, iridium and ruthenium are collected in a nickel sulfide button after heating the ground sample and fluxes in a furnace at 1000°C.

The nickel sulfide button contains the PGE which are separated from the nickel and other elements by selective dissolution and ion exchange techniques. The PGE are determined by inductively coupled plasma atomic emission spectrometry and electrothermal atomic absorption spectrometry.

Perth sand

To most observers the sand around Perth looks the same except perhaps for some variation in colour. To a



Newly installed inductively coupled plasma spectrometer (ICP) used for automated analyses for a wide range of elements.

mineralogist, a geologist who has specialised in the study of minerals, the Perth sands provide valuable information about the geological history of the coastal region and can provide valuable evidence to assist Police solve crimes.

A series of sand samples have been collected from several transects across the Swan Coastal Plain between Perth and Wanneroo and subjected to detailed mineralogical analysis. Significant easterly trends have been found in the variations in the composition and amounts of the heavy mineral fractions including the black mineral ilmenite which is often naturally concentrated on beaches.

Some of these trends can be related to weathering and to the age of the dune systems and is enabling subdivisions of the dune systems to be made according to the composition of the sand. A detailed map of the dune systems will be produced once further samples from the southern metropolitan region have been characterised.

This study has also been of significant benefit to forensic investigations as it has resulted in improved assessments of sand and soil samples submitted by the Police. Minute quantities of sand can be matched with control samples and in many cases a district or locality from which the sand originated can be specified.

Fumes, dusts and fibres

Fumes, dusts and fibres can be a nuisance or a health hazard. The laboratory uses mineralogical and chemical techniques to identify, characterise and analyse these materials and thus identify the source and assess the potential health hazard.

Samples are collected from mining or mineral processing operations, other industries, and factories, by staff of the Laboratory, and by staff of other Divisions of the Mines Department and other Government Departments. Samples are also collected from residential areas and from areas such as market gardens.

Several major studies have been undertaken. Soil samples from the Fortescue Valley were examined to establish the extent of asbestos contamination from mine waste dumps in the Wittenoom Gorge. Public concern, caused by the appearance of blue fibres as far away as Millstream, was allayed when the particles were identifed as spinifex ash. Dust from mining the Marra Mamba iron formation and other bodies were examined for their fibre content. The complex mixture of gold refining fumes and dusts were also examined.

Water Science Laboratory

Water in public and private supplies, waste water from domestic and industry and environmental water estuarine, river and lakes — its study and understanding continues as the main thrust.

Sample turnover on various projects was maintained at the high level of 1984.

Organic contaminants in water have become a priority with the laboratory which has been constrained from activity in this vital area by a full commitment in conventional analyses and restricted access to equipment.

Water treatment

Another successful year was achieved in water treatment with a significant involvement at Australind, Northampton and Mundaring where quality upgrading for iron removal or more complete disinfection was applied.

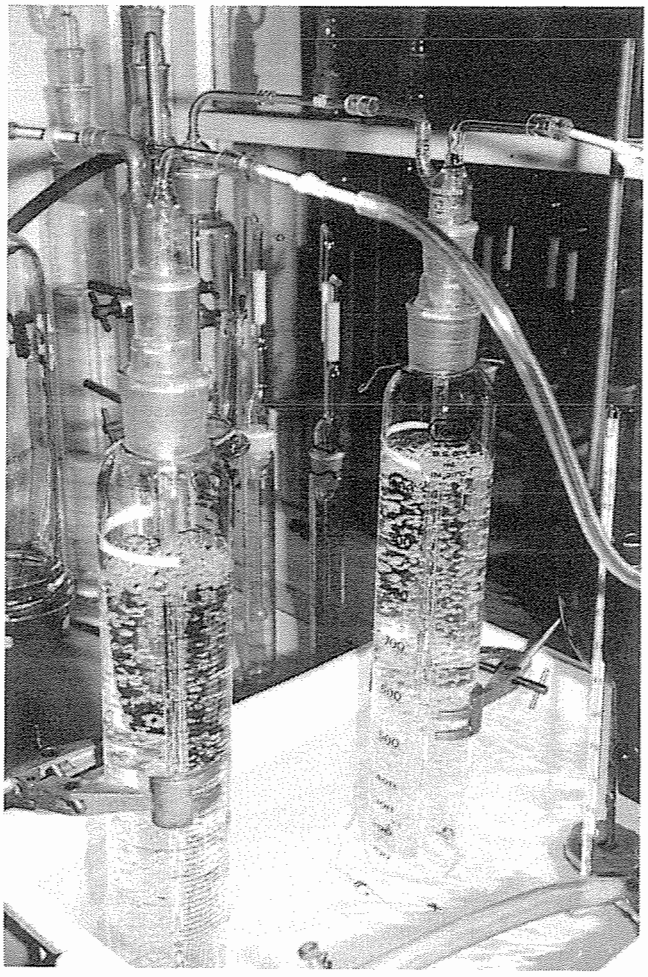
Amoebic meningitis prevention

Despite multipoint chlorination, amoeba continued to be isolated from the Mundaring water supply system until December 1985 when chloramination (chlorine plus ammonia) was introduced as the disinfectant. There have been no amoeba isolations since but a taste/odour problem has plagued the system from the outset of the chloramination treatment. Because of clear evidence of water/pipe wall interaction it was assumed that the taste resulted from such interactions and that with time it would go away. However by mid-April the taste was still widely reported.

It appears that the cause is iodoform resulting from a reaction between the naturally occurring iodide and organics under the milder oxidising action of the chloramines. Chlorine alone generated a suite of haloforms (chloroform and similar, so-called THM for trihalomethane compounds) but not iodoform. One of the reasons for using chloramination in many water utilities is that haloform production is largely eliminated. It is ironic that, while the usual haloform family was indeed practically absent under

the chloramination regime, the rarer iodoform appeared.

A simple solution has emerged. When the chlorine is added before the ammonia, iodoform and its medicinal, unpleasant taste is not formed.



Air stripping for taste/odour investigations.

Harding Dam

While the heavy draw on the ground water reserves at Millstream, supplying Karratha and other Pilbara towns, has influenced water storage only marginally, the Water Authority none the less saw the need for a surface supply, and the Harding Dam was constructed in the "dry" of 1983 and 1984 and filled in February 1985.

Careful planning failed to predict two problem areas which showed up in the early months, namely (i) a much greater chlorine demand than experienced with the organically pure Millstream water. Chlorine decay in surface waters is exponential but linear in purified ground water. (ii) a taste/odour. The taste is of the now widely reported, earthy, musty character for which the organic geosmin, a napthalene related compound, is responsible. It is seasonal, probably generated by blue-green algae and is more intense when the dam is thermally stratified from say August to March. While not the first demonstration of geosmin in a local water supply, it is the first to be so clearly associated with consumer reaction.

A water goblin

Work is progressing on an interesting phenomenon which occcurred in the small Rocky Gully catchment. Water from the dam, which supplies about 30 services, was found to produce a froth when boiled. Preliminary examination of the froth showed it to be a harmless cellulose material which has not as yet been positively identified. Such materials are used as stabilizers or emulsifiers in asphalt coatings, which have been used on the catchment area. However, run-off from the catchment collected since the problem arose has not contained this material.

Resource management

Grape growers in the Swan Valley used not irrigate crops at all. Some years ago they began to apply about 150 mm of water during the growing season (the old rule of thumb; 2 inches three times a year) and have more recently opted for regular watering at up to 500 mm annually. This practice has put the ground water resource under threat and caused significant salinity increases. Licensing and strict monitoring of all abstractions with quotas for each grower are imposed.

Trickle irrigation is encouraged since it can reduce water rates, compared to sprinkler application, by as much as 50 percent. However, iron in the water blocks the dispensers. A Department of Agriculture trial during the summer of 1984/85 and 1985/86 with appropriate controls, showed that our silicate treatment which complexes the iron and prevents the blockages, will contribute significantly to a resource preservation by allowing all users to switch to the more economical trickle technique.

Corrosion

Corrosion of the steel water pipeline to Kalgoorlie has been studied many times since failures as early as 1905 (within three years of the project completion) appeared to sound its doom. Much of the original locking bar main is still in service despite repairs and patchwork over long stretches. Leaks and minor bursts which still plague the system require constant vigilance by maintenance teams.

An effective life for the pipe was assured with cement lining of the main in the early thirties. In places where the lining is sound another fifty years life is predicted but there are many places where the lining-to-steel bond has been poor and shorter lifetime is inevitable. In attempting to forecast effective life emphasis is on two very different situations, bare steel and cement-lined.

Some consolation results from the lower corrosion rates expected with modified water treatment started in December 1985, but the $100 million plus replacement cannot be too far away.

Corrosion of copper in hot water systems has long been a problem in Perth but this problem is decreasing as it is recognised that corrosion does not occur when the water temperature is less than 60C. Apart from occasional stray current failures, corrosion of cold water copper pipes is rare; but an interesting case resulting in many pin hole (approximately 0.1 mm diameter) leaks per metre of 12 mm

diameter domestic cold water pipe occurred with water treatment on a home bore.

The treatment, for colour removal, used excess alum and soda which with an associated white deposit occluded the copper surface and caused the severe pitting. The whole service had to be replaced.

Publications and Lectures

The following publications and lectures were presented in 1985/86:

Agricultural Chemistry Laboratory Annual Technical Report No. 4, 1984.

Allen, D.G., 1986, Organic Phosphorus in Soils of the Peel-Harvey Catchment Area; GCL Report.

Avraamides, J., Field, R., George, J. and Graieg, O., 1986, A Laboratory Scale Rotary Kiln Simulator; Australasian Inst. Mining Metall. Proc., June 1986.

Beng, E.W., A Thin Layer X-ray Diffraction Technique Using 13 mm Filters for Determination of Respirable Alpha-Quartz; Proc. Aust. X-ray Analyt. Assoc. (W.A. Branch) 2nd Ann. Conf., Mandurah, October 1985.

Bollard, M., D'Antioni, M. and Allen, D., 1986, Extraction by Sodium Bicarbonate of P Applied to Sandy Soil as Superphosphate and Duchess Rock Phosphate and its Relationship to Subsequent Herbage Yields of Serradella and Subterranean Clover; Submitted to Aust. J. Exp. Agric.

Brennan, L.J., 1986, Coal in Western Australia; GCL Report of Investigations No. 31.

Campbell, N.T., Cannabis and Driving Offences; presented to The Aust. Forensic Sc. Soc. (W.A. Branch), Perth, 1985.

Campbell, N.T., Cannabis : Forensic Perspective of Cases in W.A.; presented to the 7th Aust. Int. Symp. on Forensic Sciences, Melbourne, 1986.

Clarke, R.M., Asbestos Fibre Counting; presented to Factory Inspectors from India, Perth, 1985.

Clarke, R.M. and Williams, I.R., 1986, Moolooite, a Naturally Occurring Hydrated Copper Oxalate from Western Australia; Mineralogical Magazine, 50, p. 295.

Coates, P., 1986, Consultant report to CSIRO on Australian Aid Project at an Animal Research Centre at Ciawi, Indonesia.

Ferguson, G.M., Urea Formaldehyde Foam Insulation, presented to the W.A. Polymer Group of Roy. Aust. Chem. Inst. 1986.

Harris, D. and Jago, J., 1985, Chemical Composition of Kernels and Hulls of Sweet Lupinseed from Western Australia; GCL Report.

Harris, D. and Jago, J., 1985, Chemical Composition of Sweet Lupinseed in W.A. (III); GCL Report.

Harris, D. Spadek, Z. and Baseden, S., 1985; Chemical Evaluation of Feed Grains; GCL Report.

Harris, D., Spadek, Z. and Baseden, S., 1986, Chemical Evaluation of Lupinseed as a Feed Grain; GCL Report.

Ingraham, D.J., Industrial Chemical Production, Trade and Uses in W.A., presented to the W.A. Chapter of Aust. N.Z. Assoc. Adv. Sci., 1985.

Jackson, M., Hancock, D., Schulz, R., Talbot, N. and Willis, D., 1986, Rock Phosphate, the Source of Mercury Pollution in a Marine Ecosystem at Albany; Marine Environmental Research, 18 (3), p. 185.

Lynch, B.F., Developments in Automotive Paint Microanalysis; presented to the 8th Aust. Int. Symp. on Forensic Sciences, Melbourne, 1986.

McLinden, V.J., Experiences in Relation to Drugs/Driving Offences; presented to the 8th Aust. Int. Symp. on Forensic Sciences, Melbourne, 1986.

Staunton, W.P., The Determination of Arsenic by Hydride Generation and ICP; presented at a Roy. Aust. Chem. Inst. seminar, Perth, 1986.

Staunton, W.P., Sample Introduction Methods in ICP-AES; presented at Inductively Coupled Plasma Atomic Emission Spectrometry School, Perth, 1985.

Talbot, V., Creigh, S. and Schulz, R., 1985, The Derivation of Threshold Mean Concentrations of Copper and Zinc in Sea Water to Protect the Edible Tropical Rock Oyster, Saccostrea cucullata from Exceeding the Health (Food) Standards, Department of Conservation and Environment Bull 212, July, 1985.

DANGEROUS GOODS — The Australian Transport Code

The Australian Code for the Transport of Dangerous Goods by Road and Rail was completed and approved by Australian Transport Advisory Council in 1980, and the Commonwealth launched the new Code at a two-day seminar held in Canberra in March 1980 that was attended by representatives from industry, commerce and state and federal departments who gave it strong support. It is unlikely that those gathered together on those two days realised the time that would pass before the Code was implemented by legislation in all States.

Nation and State

In considering transport in Australia it is necessary to review the interests of the Commonwealth and State governments. In 1901 the individual Australian States came together as a federation and, in doing so, legislative responsibilities for certain matters of common interest were transferred to the Commonwealth (Australian) Government, e.g. defence and external affairs. Since that time some other activities such as civil aviation have also become the Commonwealth's prerogative. However, transport generally, including licensing of vehicles and drivers, regulation of traffic and construction of highways, is a responsibility still retained by the States. Thus, to achieve uniformity throughout Australia on the transport of dangerous goods, each State or Territory must bring in uniform legislation.

This poses difficulties even when agreement has been reached by representatives of all States.

Transport procedures

The responsibility for complying with the Code is placed mainly on the person contracting with the consignor to transport the goods (the prime contractor), or with the consignor if he transports his own goods. The consignor normally is responsible for providing details of the goods being offered for transport, and for their correct marking and packaging. The prime contractor is then required to select and train his drivers, ensure the goods are correctly stowed, that the vehicles are correctly marked, and that equipment specified by the Code is provided.

Implementation difficulties

The difficulties in implementing the Code have largely occurred in two areas. The first of these is with packagings in that manufacturers have been slow to provide packagings which comply with the Code.

Drums and similar closed-head metal packagings have been made and approved, but plastic drums of 20-25 litres capacity that pass the performance tests are only now appearing. Combination packagings — inners within fibreboard or other outers — have been slow in gaining approval but progress on these is being made.

Furthermore, none of the existing open-top metal or plastics drums that have traditionally been used to transport paints and other viscous dangerous goods in liquid form have been able to pass the prescribed performance tests.

Despite these problems Australia is leading the world in the fabrication of approved packages. Where no suitable packagings exist, it has been necessary for the Competent Authorities Sub-committee to grant interim exemptions from full Code requirements, but package makers are rapidly filling all the gaps in the range of approved and tested packages.

The second problem is the difficulty of ensuring compliance with the actual transport requirements for dangerous goods in packages. While a specially designed road tanker or even a vehicle conveying a tank is an obvious target for inspection, it is not so evident whether vehicles conveying packages, particularly when covered by a tarpaulin, are carrying dangerous goods or not. In many cases non-compliance only comes to notice following an accident.

The safe transport of dangerous goods on vehicles such as this requires industry and regulatory authorities to work together in terms of the Australian Code.

However, large chemical firms are now writing the need to comply with the Code into their transport contracts. The larger transport companies are also moving to ensure their staff and drivers are aware of the Code's requirements. The provisions of the Code are harder to enforce against, or even bring to the notice of, those individuals who own their own vehicles.

Divisional Inspectors have paid particular attention to packages containing dangerous goods over the past twelve months. In the two and a half years since the code was promulgated via regulations in WA, substantial progress towards compliance by manufacturers of packages and consignors of dangerous goods has been made.

Acknowledgement. Thanks to Mr H. Blackmore, the Chief Inspector of Explosives and Dangerous Goods, NSW for permission to reproduce text from his publications on the Australian Situation.

EXPLOSIVES AND DANGEROUS GOODS

H. DOUGLAS, DIRECTOR

During the past year the Explosives and Dangerous Goods Division consolidated on its early work implementing the Dangerous Goods (Road Transport) Regulations, commenced some preliminary development work towards putting into effect the provisions of the Explosives and Dangerous Goods Act which relate to the storage of dangerous goods, and continued its monitoring of the more traditional areas — the storage and handling of flammable liquids and explosives.

Explosives

In response to the anticipated significant increase in the movement of explosives through Western Australian ports the Division has reviewed the latest publications from overseas and applied that knowledge to reassess the capacity of all Western Australian ports. This review included a comprehensive analysis of the risks involved in the movement of explosives through the Port of Fremantle.

These actions will allow the Division to assign capacities for ports to handle explosives, with a high degree of assurance that people in any way associated with the port will not be subjected to an unacceptable level of risk.

Activities at the Kalgoorlie and Baldivis Explosives Reserves have continued to be most satisfactory through the year with the respective Magazine Keepers monitoring vehicle movements and manufacture and storage operations.

At the suggestion of the Hon. Minister, arrangements were made with the State Energy Commission to construct a storage facility at Baldivis for capacitors containing PCBs. The facility consists of a securely fenced compound containing a fully enclosed shed which is connected to the electronics security system at the Reserve. The Division is implementing a fuel management protocol developed by forestry officers from the Department of Conservation and Land Management to ensure that the possibility of the PCB becoming involved in a fire is minimal.

An Explosives Manufacturing Plant, owned and operated by ICI Australia Operations Pty Ltd was commissioned into operation at the Department's Kalgoorlie Explosives Reserve in August 1985.

The new plant is the first in Western Australia to produce small-diameter cartridged explosives suitable for use as a replacement for gelignite for hardrock mining. It complements other less sophisticated plants operated by ICI, Johnsons Explosives Pty Ltd and CBS Explosives Ltd at various other locations throughout the State.

Dangerous goods

The active implementation of the Flammable Liquids Regulations and the monitoring of LP Gas distribution at service stations continued at a high level.

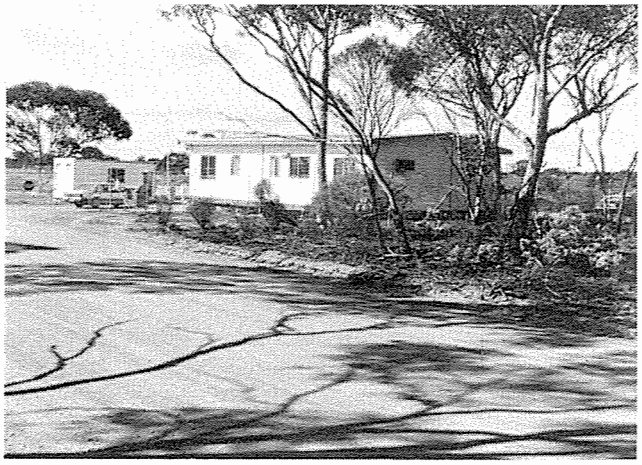
The expertise developed by the Division in many areas involving Dangerous Goods has resulted in the Division being consulted on safety matters associated with projects which will have significant inventories of dangerous goods such as:

— the new Perth Mint;
— a Chlor-Alkali manufacturing plant;
— a cyanide production plant; and,
— an LP Gas Stripping Plant.

The Division's responsibility continued to be directed towards such matters as spillage or leakage control and containment, fire protection and emergency training.

The Division also has a statutory involvement in monitoring the transport operations associated with the above plants, as significant quantities of LP Gas, cyanide, chlorine, and sodium hydroxide will be transported from the plants by road when they come into operation.

During the year the Division actively participated in the deliberations of the North West Shelf Technical Safety Committee which has been reviewing the means of optimising safety matters at the onshore processing facilities at the Burrup Peninsula.



The entrance to the Kalgoorlie Explosives Reserve. The Department has embarked on a tree-planting program to control dust in the region.

Accidents

A detailed summary of the accidents which occurred in 1985 has been prepared and distributed independently of this report. An interim review of dangerous goods accidents in early 1985 resulted in action being taken to require all vehicles carrying dangerous goods in packages to be fitted with substantial, well-fitting restraining devices (i.e. gates). This action resulted in a significant decrease in accidents involving packaged dangerous goods in the latter half of 1985, and the trend appears to be continuing into 1986.

1985 also saw the demise of the Western Australian Transport of Dangerous Goods Advisory Committee (TDGAC) which was subsequently incorporated into the State Counter-Disaster Advisory Committee. The SCDAC is a broadly based committee responsible for ensuring that

The effects of accidents such as this can be minimised by implementing the good planning of the Transport Emergency Assistance Scheme (TEAS).

appropriate steps have been taken to plan, as far as practicable, for any emergency which may develop in Western Australia. The Division's part on the Advisory Committee is primarily because of its involvement with and knowledge of dangerous goods throughout the State.

Interstate activities. The transport of dangerous goods necessitates high-level interaction with other Australian States. The Division has ensured that its transport regulations are administered in harmony as far as practicable with the Australian Code for the Transport of Dangerous Goods by Road and Rail by actively participating in the Competent Authorities and Drafting Sub-committees.

Initiatives taken by Western Australia have led other Australian States in the area of the marking of packages with emergency contact details and the restraining of packages on vehicles. The next edition of the Australian Code will contain enforceable requirements consistent with recent amendments to the Western Australian Regulations on both subjects and industry is already acting on an Australia wide basis to ensure that packages containing dangerous goods are marked appropriately.

The acquisition of a personal computer by the Division in the latter part of the year facilitated the ability of the Division to exchange and share its work load with our counterpart divisions in Victoria and New South Wales. In this manner, all three States may avoid duplicating work and allocate their inspectoral resources most productively.

The Division also continued its involvement in the drafting and implementation of the requirements of various Australian Standards including those related to:

- the storage and handling of LP Gas, Flammable and Combustible Liquids, and Chlorine;
- explosives storage;
- portable plastics and metal fuel containers; and
- tanker vehicle standards for flammable liquids, LP Gas and toxic and corrosive cargoes.

Risk management

In tune with overseas thinking on the means of controlling major hazards, the Division has become more aware of the need to put increasing responsibility on to plant management to require reviews of operational procedures to ensure that the probability of a serious, dangerous event is very remote and that the effects of any such event are limited so far as practicable.

Inspectors are participating in training schemes for quantitative risk analysis techniques to gain a better understanding of the procedures used to quantify the degree of hazard which may be associated with those activities which are regulated by the Explosives and Dangerous Goods Act. This training is in anticipation of applying a philosophy of risk management in the implementation of regulations, part of which is the acceptance that a society completely free of risk is impossible and our aim must be twofold:

- the setting of criteria of risk which are acceptable to the general public and
- the management of installations which generate major hazards so that the risks to the community are no greater than the predetermined criteria.

Having presented an overview of operations during the past 12 months the following ten detailed articles provide a more detailed account of selected activities of the Division during 1985-86.

Liquefied petroleum gas

There are approximately 2 500 storage facilities for LP Gas in Western Australia other than cylinders connected to domestic reticulation systems. About 1 100 of these are on premises licenced to store flammable liquids and therefore come under the control of this Division which applies the requirements contained in Australian Standard 1596-1983.

Government approval has recently been given to Wesfarmers Kleenheat Gas to build a $70 million liquefied petroleum gas stripping plant at Kwinana. The proposed plant will extract LP Gases (butane and propane) from natural gas piped from the Burrup Peninsula via the SEC WA pipeline.

Associated with the extraction plant will be 2 large refrigerated storage tanks to store LP Gas for export and two pressurized vessels for domestic product.

Water fire protection at the tanker loading facility at Kleenheat's Kwinana LP gas installation. This protection meets the requirement of Australian Standard 1596.

Proposed regulations. There is currently no regulatory body in this State with the authority to administer safety controls on LP Gas facilities not associated with flammable liquid storage. To rectify this anomaly an approach has been made to Cabinet to introduce regulations enabling this Division to control the storage and handling of LP Gas in Western Australia.

The proposed regulations would be based on Australian Standard 1596, SAA LP Gas Code, and appropriate international codes or industry codes of practice and would include:

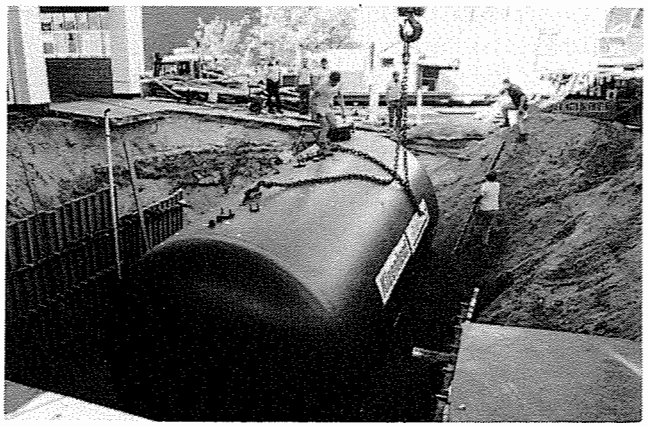
- tank design, construction and installation,
- filling operations, both bulk and cylinder (including automotive),
- storage depot installations,
- fire protection and other hazard mitigators,
- penalties and licensing.

The implementation of these regulations will also provide the Government with a formal means for monitoring public safety issues associated with the proposed LP Gas Stripping Plant at Kwinana both during and after construction.

Recent developments. Following a two year trial period the Division approved LP Gas self-serve operations at service stations and distributed a set of rules for use by Industry.

Divisional approval was given for a proposal to install the first underground tank for LP Gas at a service station in Western Australia, following a comprehensive review. The approval followed extensive consultation with other involved Government departments, and a review of the corrosion protection facilities which included:

- coating the surface of the tank,
- suppressed current cathodic protection and
- an external corrosion allowance of 3 mm.



The first underground LP gas tank on a Western Australian service station. Demand for LP gas at this site could not be met using above-ground storage because there was insufficient area to enable compliance with separation distances prescribed in the Australian Standard.

Prosecutions

Steps have been taken to amend the Explosives and Dangerous Goods Act to the effect that, when prosecuting an offence against the Act, proof that a container was at a particular time labelled, branded or marked as containing particular dangerous goods will be deemed as proof also that the container contained those goods.

The following table summarises prosecutions during the year.

	Outstanding from 84/85	Initiated 85/86	Pending	Won	Lost	Withdrawn
Explosives	1	3	2	1	—	1
Flammable liquids	1	2	—	2	—	1
Dangerous goods	8	6	5	6	2	1

A proposed prosecution of several parties involved in a leakage from these tanks was withdrawn because it could not be proved that the tanks contained chlorine.

Baldivis Explosives Reserve

The Baldivis Explosives Reserve is located approximately midway between Rockingham and Mandurah, and some four kilometres east of the Mandurah Road, in an area of State pine forest known as the 'Peel A' plantation. Joint tenancy of the forest exists between the Departments of Conservation and Land Management, and Mines.

Co-operation and liaison between officers of the two departments has been close since the occupation of the Reserve by Explosives Division in October 1984 and this was to prove invaluable on the afternoon of Monday, 20 January 1986.

On that day at approximately 1300 hrs, a heavy pall of smoke was spotted to the northeast of the forest and Reserve. A Reserve employee was immediately despatched by the Officer in Charge to locate the fire and a fire crew was placed on alert (this being standard procedure for fires within three kilometres of State forests). At 1310 hrs a request for assistance was received by the Explosives Division officer in charge from the Rockingham Shire Council Chief Bush Fire Control Officer via two-way radio communication. The standby fire crew comprising the officer in charge and two others was immediately despatched to an area one kilometre northeast of the Reserve on Baldivis Road.Conditions for fire fighting were adverse, with temperatures in the high thirties and very hot and gusty northeast winds directing the fire towards the Reserve. It later transpired that no less than six roadside verge fires had been lit by an arsonist along the Baldivis Road.

In addition to the Reserve fire unit from Explosives Division, the fire was attended by some 18 fire units and crews, supplemented by the Channel Nine rescue helicopter for spotting purposes.

The fire was eventually brought under control after six hours when a fortuitous wind change assisted fire crews and directed the fire away from the Reserve and forest area. Crews were then deployed in mopping up operations and extinguishing flare-ups during the night.

Reserve staff were stood down from fire duties at 0800 hrs the following day after some eighteen hours in the field, though continuous surveillance was conducted by Shire and volunteer units for a further three days. The fire had devastated an area of some fifteen square kilometres but fortunately, despite the relative density of residences and stock in the area, the only perceivable damage was to bush, pasture and fences. The offending arsonist has never been identified; however, the incident confirmed the value of pre-planning for such emergencies. In this case, the Reserve and forest were not directly threatened and the Reserve Staff were pleased to assist their local community.

Import and export of explosives

Despite the publicity given to the destructive and illegal use of explosives, it is a fact that thousands of tonnes of explosives are transported and used safely every day.

But the transport of explosives was not always so safe. Gunpowder has been transported and widely used for hundreds of years and has always been a problem.

From its invention in the 1860's the transport of blasting oil presented dire problems — especially in freezing cold weather. World-wide, blasting oil was regarded as an ultra-sensitive, powerful product. Its power was demonstrated in Sydney about 1866 when 150 kilograms exploded killing 15 people and causing great damage.

Fortunately Alfred Nobel, in 1867, was able to develop Dynamite based on nitroglycerine but prepared in a solid form which made transport demonstrably safer.

All such explosives were originally brought into WA in non-ferrous spark-proof containers and, to safeguard city areas, remote areas were chosen for explosives wharves.

The improvement in explosives formulations and the availability in recent years of a good road and rail connections with the Eastern States have enabled explosives to be transported in large road vehicles and rail wagon loads. Further, with the construction of a high technology explosives factory at Kalgoorlie, in WA, explosives are now being exported through WA ports whereas in the past all explosives were imported. Each wharf is now individually assessed to determine its capacity for explosives.

The safe transhipment of explosives is now taking place in both directions, both import and export, and little mention has been made by the media of the controlled safe transport of explosives.

This container was packed at an isolated part of the Baldivis Explosives Reserve, and stored under electronic surveillance pending loading on board ship using modern handling techniques to minimise the exposure of port facilities.

Dangerous goods, packaging

The major requirements of the Regulations in the area of packaged dangerous goods relate to the use of packages manufactured to specific material and strength specifications. Detailed marking requirements are also prescribed to enable approved packages to be identified in the field.

During 1984 the Inspectorate personnel have devoted most of their time to the inspection, approval and licensing of bulk transport equipment. This period enabled production and testing of packages to be undertaken by the industry. Approved packages became readily available towards the latter half of 1985, and the Inspectorate then concentrated on enforcing the packaging requirements of the Regulations.

An initial survey of the major dangerous goods distributors, and discussions with company managers, enabled specific problem areas to be identified and helped establish an effective, comprehensive inspection program. All known chemical formulators and distributors within Western Australia were subsequently visited and their attention was drawn to all deficiencies. Further inspections and general field observations have shown that all companies are moving rapidly towards full compliance.

Approved packages are marked according to their type in a codified form which is in accordance with United Nations specifications. The marking enables inspectors to establish on site: whether a package is approved; where it was approved; the year of manufacture; the package type and material of construction; whether it may be used for solids or liquids; the density of product it may carry; the pressure rating if applicable; and the group(s) of dangerous goods the package may contain.

Frequent periodic monitoring will continue to be a routine activity of the Inspectorate in conjunction with inspections of the transport and storage of dangerous goods. Overall, industry has acknowledged the need for high standards in packaging and detailed labelling for dangerous goods, and a high level of co-operation has been achieved in this area.

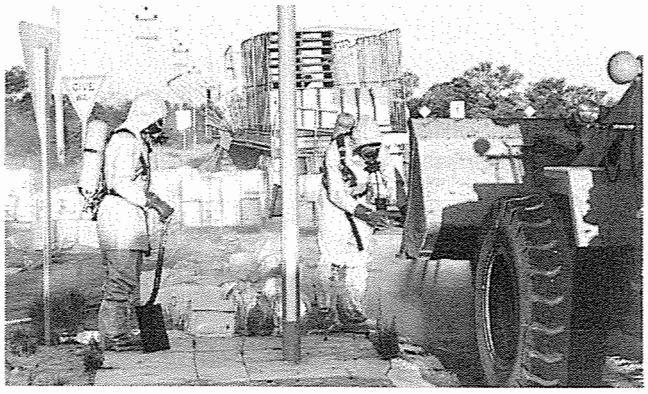
Approved packaging and labelling as shown, now gives precise information on the dangerous goods contained within and assurance that the package is suitable for its purpose.

Pesticides conveyance

Pesticides are extensively used in Western Australia to protect food crops and properties from damage by insects and pests. A significant number of the 1 450 registered pesticides formulations are transported by road throughout the State.

Random checks, conducted by Divisional Inspectors, of vehicles at major transport depots, have revealed that the majority of the operators are transporting pesticides in accordance with the requirements of the Dangerous Goods (Road Transport) Regulations 1983.

Protective clothing. The Division consulted the Pesticides Section of the Department of Agriculture on type of protective clothing and equipment that are recommended for drivers handling packages of pesticides and, as a result of that consultation, Divisional guideline documents were prepared and distributed to industry.



Firemen wearing protective clothing and self-contained breathing apparatus clean up a roadside spillage of pesticides. (Courtesy of Community Newspapers.)

Bulk conveyance. The road transport of bulk diluted pesticides in pest control operators' vehicles was reviewed following a request from the pest control industry.

Results of the review indicated that only 6 out of the 86 permissible pesticides used by these operators would be classed as Dangerous Goods when carried in the diluted form. Further examination of these six pesticides revealed that they have very limited application in the field and are rarely transported in bulk. Pest control operators have subsequently been given general exemption from having their vehicles licensed under the Dangerous Goods (Road Transport) Regulations 1983.

The Division has continued to liaise with the Health Department in updating the list of Registered Pesticides in WA.

Fireworks

The fireworks highlight of the year, was the 96 FM STEREO Sky Show when an estimated 175 000 people viewed the largest fireworks display ever staged in Western Australia. This display synchronised music with 1 300 kg of fireworks displayed over Perth Water, using shells up to 300 mm diameter firing up to 350 m into the air.

Sixty fireworks displays in all were held this year and, while not all were as complex as the Sky Show, all required review by the Explosives Division Inspectorate to ensure the highest degree of public safety. Inspectors assessed the suitability of proposed sites many of which required relocation to ensure adequate safety distances. These sites ranged from barges on the river through breakwaters and country ovals to stadiums such as Subiaco Oval and Gloucester Park. Part of this review by the Division included inspection of displays, a direct result of which was the banning of one fireworks item that was considered to be too unpredictable and a threat to public safety.

Sparklers were again placed on the banned list as a direct result of irresponsible use during an 18-month trial period from July 1984. The ban was inevitable after incidents of fires and injuries to the public demonstrated that a small minority of people with mischievous intent could be quite dangerous playing with what was intended to be a hand-held firework.

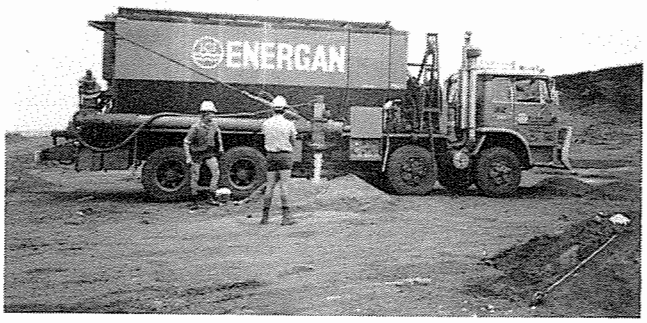
Theatres, nightclubs and bands used a total of 1 330 pyrotechnic special effect pieces throughout the year to supplement on stage performances. One such production recreated battle scenes from the American Civil War.

An International Fireworks Competition planned for the Americas Cup promotions, will bring to Perth the world's leading pyrotechnicians, making scenes such as this a common sight over metropolitan skies. (Photo courtesy of West Australian Newspapers Ltd.)

Explosives mixing vehicles

Ammonium nitrate/fuel oil (ANFO) mixing vehicles have for many years provided an efficient, cost effective means of producing bulk blasting agents for use in large mining operations. Improvements in explosives technology have resulted in the development of energized ANFO mixtures consisting of ammonium nitrate prill mixed with an emulsion phase, giving the explosive a greater strength and improved water resistance. This year has seen more mining companies adopt this technology and a corresponding increase in the number of competing suppliers.

Mining companies may elect to have the explosive delivered direct to the blast hole by the explosives company, or to purchase the technology and base emulsion while choosing to mix the explosive themselves.



Direct loading of boreholes with explosive — Goldsworthy Mining, Shay Gap.

Safety advantages derive from both methods of operation because the production of an explosive is on-site from non-explosive ingredients and is delayed until immediately prior to use. Costs associated with production are also minimized as no explosives are produced in excess of that required for immediate use. Furthermore production of the explosive can be tailored to the site conditions depending on the geologist's report. Hard rock may require a more dense product hence a greater proportion of emulsion to prill. Similarly the water resistance of the explosive can be improved by adjusting the mixing ratio or by incorporating a gassing agent or crosslinking agent.

Fifteen mobile mixing units were operating throughout the State in 1985/86. Testing programmes undertaken by the Division have monitored the performance and handling characteristics of the explosives produced to ensure that they remain sufficiently insensitive while being mixed so as to not present a hazard to the mining personnel. This requirement is met when the explosive fails to detonate after initiation from a No.8 detonator. Current work is aimed at ensuring bulk explosives produced from mixing vehicles continue to meet this criterion.

B Trains

The concept of B trains is new in W.A. and already it is making strong inroads into the field of transporting dangerous goods. B Trains are employed by one transport company to convey dangerous goods, and several other companies are seriously considering their use.

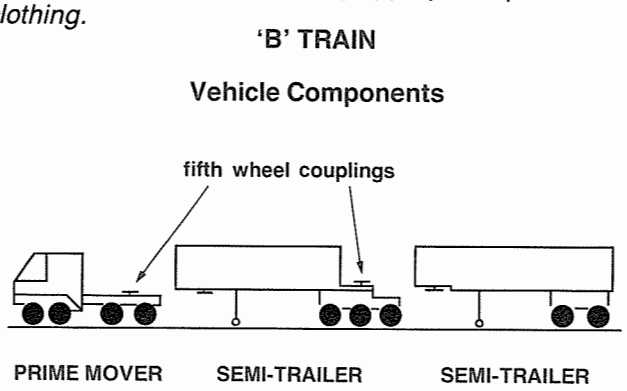
B trains consist of a prime-mover hauling two semi-trailers connected through two fifth wheels without the use of a drawbar.

The absence of a drawbar gives the driver a much more direct feel of the behaviour of both trailers. This effectively increases the stability of the unit making it comparable to that achieved from a single semi-trailer. B trains also offer a more economic means of transport from the increased payloads as they can incorporate more axle groups than any other unit of comparable length.

The first B trains were developed in Canada. In early 1983, feasibility trials were commenced in W.A., and for a period of two years, they were used to carry general cargo in freight containers. No adverse reports were received during this period and they have now been approved by the MRD for use on prescribed routes and under specified conditions.

Unlike roadtrains, B trains do not require any special permits or endorsements from this Division. Both trailers may be used to transport Dangerous Goods provided they fully comply with the Regulations. Periodic inspections are carried out on the vehicles and their associated tanks to ensure that adequate safety standards are maintained.

A typical B Train ready for loading with concentrated sulphuric acid. Emergency Information Panels are in place and the driver is wearing appropriate protective clothing.



Clerical operations

The clerical staff continued to perform a variety of functions, including licensing, records, finance management, word processing, purchasing, and the organisation of training courses. The use of microfiche to optimise limited storage space, is being assessed for some ten thousand cancelled files accumulated since the Division's records were isolated from the Department's filing system in 1969.

Computers. A considerable amount of time and effort was expended on developing the computerised licensing system. Now in its third year of operation, the system has resolved many of the minor problems encountered during the initial phase-in period, but the practical use of the system, especially over the last twelve months, has identified the need for additional functions and further modifications. Rather than undertake piecemeal changes it has been decided that a complete review of the whole system was warranted and this is now under way.

Throughout the year records staff continued to utilise the computerised records management system. This system now maintains information on hundreds of files that are created each year for a multitude of subjects.

Authorisation of explosives. During the year a record number of 45 new explosives were tested and authorised for use in Western Australia. Three explosives were deleted from the list of authorised explosives.

Regulations. Amendments to adjust prescribed fees and charges were made to all Regulations. Additional amendments were made to the Dangerous Goods (Road Transport) Regulations to:

— require the licensing of drivers of vehicles conveying dangerous goods in bulk;
— incorporate emergency contact information into the marking requirements for packages;
— require the fitting of gates to tray top vehicles when carrying dangerous goods in packages;
— prescribe improved methods of loading packages;
— require consignors to provide emergency procedure guide cards.

Driver licensing. The requirement for drivers of vehicles conveying dangerous goods in bulk to be licensed resulted in a heavy workload for the staff involved in processing the initial influx of applications. Each application was accompanied by four supporting documents, all of which required thorough checking. Over 1 200 licences were issued during the first three months of operation.

Staff. There was a high incidence of staff movements in the latter half of the year, including the secondment of the Senior Clerk to the Corporate Executive Division for three months. As a consequence, more time than usual was directed towards the training of replacement and relief personnel.

TENDEX — Tenement information on computer

The phased introduction into the Mining Registration Division of a computerised mining tenement index system (TENDEX) commenced in November 1985 and should, when fully operational, lead to significant improvement in public access to mining tenement information and more effective Divisional administration.

TENDEX holds data about mining tenements and their holders, shires, public plans, and survey instructions. Examples of reports that are available are:

— all tenements held by a person or company;
— all tenements granted or due to expire in a district during a particular month;
— all live tenements situated within the boundaries of a Shire;
— the name and address of the holder of a particular tenement.

All tenements applied for under the Mining Act, 1978 are recorded in TENDEX, together with all leases that were granted under the Mining Act, 1904 and which, under the Transitional Provisions of the 1978 Act, are deemed to be mining leases under that Act.

About 38 000 tenements were recorded as at June 1986, and various procedures have been developed to ensure that data are maintained as accurately as possible.

Development of the system has reached the stage where on-line enquiries are available to Divisional staff in Perth. It is anticipated that, by late 1986, the system will have been developed to the stage that it will be used by counter staff in Perth to serve public enquiries.

It is also planned to utilise TENDEX to provide Shires with information regarding tenement holders for rating purposes. One of the main improvements will be the removal of the need for regular advices to be sent to Shires throughout the year regarding tenement transfers, change of status, change of address etc.

Apart from advices of new tenement grants, which will continue to be sent as they occur, it is expected that Shires will be provided with a single list of current tenements and their holders, at the end of each financial year. Rate notices will then be issued for the ensuing financial year.

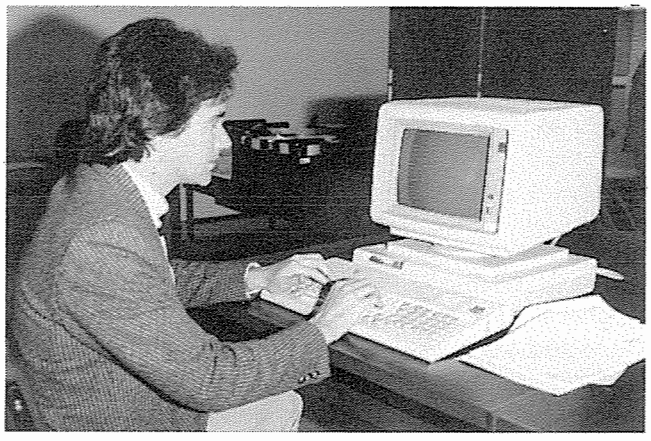
The resultant time savings and increases in efficiency in both Shire offices and the Division should be significant, mainly because the administrative burden of maintaining the cumbersome manual tenement base lists will be greatly reduced or removed.

A further benefit of TENDEX is the computerisation of the Division's tenement holders' address list. Of particular benefit to the public is the following:

— the Division can effectively cater for a request from a tenement holder that notices/correspondence relating to certain of that holders' tenements be forwarded to a project manager appointed pursuant to a joint venture or option agreement;
— notices of intention to forfeit tenements for non payment of rent or other breaches of conditions will be sent to the current address of the holder, as all change of address notifications are recorded in TENDEX immediately upon receipt.

The development and expansion of TENDEX will be an on-going process including the future use of computer terminals at some of the Division's outstation offices, depending on the reliability of power supply and communications. The Kalgoorlie Mining Registrar's office will be the first outside Perth to have direct access to the system; a terminal and printer will be installed in that office in July 1986.

The Division is confident that TENDEX will prove to be an effective tool in improving service to the public and in the general administration of mining tenements in this State. The capacity of TENDEX to streamline procedures and data maintenance and to pinpoint developing trends or problem areas will enhance the Division's ability to respond to future challenges and industry requirements.



Tendex computer terminal being operated by a staff member in the Division's Perth office.

MINING REGISTRATION

W. PHILLIPS, DIRECTOR

Introduction

1985/86 has been a year of transition for the Division, with the new structure initiated in June 1985 getting into full swing. Staff have responded well to the concept, and now have a wider knowledge base and range of skills that is reflected in an improved service to the public.

A factor that has, however, negated this improved service to some extent has been the higher than usual staff turnover due to several resignations of long-serving staff members leaving to accept positions in the mining industry and the inherent high level of temporary staff in the Division during this period.

Nevertheless, the benefits of increased efficiency are reflected in the fact that finalization of tenement applications increased by 4.3 percent from 82.75 percent in 1984/85 to 87.05 percent in 1985/86.

The total area covered by in-force mining tenements as at 30 June 1986 was 17 496 124 hectares of the State's area of 252 763 300 hectares. This represents a decrease of approximately 5 percent in the area held under mining tenements as at 30 June 1985 (18 414 443 hectares). Details of the different types and numbers of mining tenements held in the various Mineral Fields/Districts and a yearly comparison of total areas held from 1982 to 1986 can be found in the Statistical Supplement.

Operationally, the Division has made good progress during the year in more effectively carrying out its role of vetting the large numbers of operations reports lodged, this resulting mainly from the establishment of more precise evaluation criteria and improved procedures.

It should be stressed that a tenement holder's performance in fulfilling expenditure commitments is a major factor taken into account when consideration is being given to any subsequent application by a holder for an extension of the term of a prospecting licence or for a mining lease in place of a prospecting licence.

Amendments to the Mining Act

On 31 January 1986, the Mining Act Amendment Act 100/85 was proclaimed, bringing into effect many of the recommendations of the 1983 Mining Act Inquiry.

These important changes affect most areas of the Act and as an aid to their appreciation, the Division has produced an information pamphlet which explains their implications and is available at the Division's Head Office and outstations.

Effective 1 July 1986 fees and charges were increased by varying amounts, with mining tenement application fees and rentals increasing by approximately 16 percent.

Further amendments to the Mining Act and Regulations are expected to be enacted later in the year.

Tenement applications

Tenement applications received in the last and previous year are as follows:

Application type	1984/85	1985/86
Prospecting Licences	2 968	4 636
Exploration Licences	462	1 075
Mining Leases	505	676
Miscellaneous Licences	137	117
General Purpose Leases	31	30
	4 103	6 534

The 1985/86 figure represents an approximate 53 percent increase on applications received during the previous twelve months.

Prospecting Licence extensions

The number of applications received for extensions of term of Prospecting Licences rose sharply for the 1985/86 year to 3 483 and represents an increase of 207 percent on the previous year.

However, problems and delays are arising with the processing of these applications as some tenement holders are not strictly adhering to expenditure and reporting requirements which is one of the main criteria when these applications are being considered.

Final expiry of non-mining titles

The year 1986 is the last in which holders of Miner's Homestead Leases and other non-mining 1904 Mining Act titles may apply to convert their holdings to Land Act tenure. Consequently the Division is currently processing large numbers of these applications and it is envisaged that most holders will have applied for conversion before expiry of these tenements on 31 December 1986. However, at the time of writing there were still 74 of these tenements for which conversion applications have not been received.

Operations and reporting

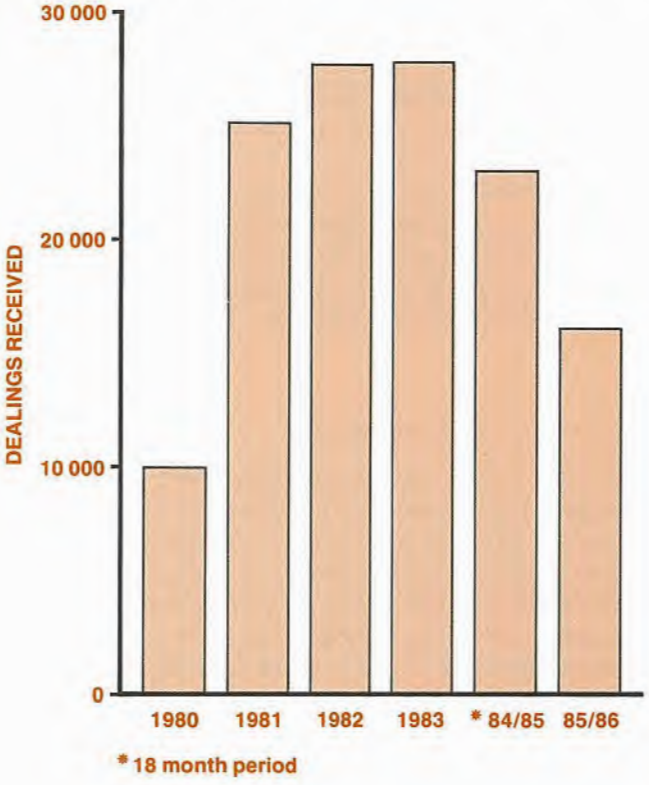
A total of 13 120 reports on operations were lodged for the period 1 July 1985 to 30 June 1986; this figure is similar to the number received the previous year.

The number of applications for exemption from labour and expenditure conditions received for the same period dropped to 1 936 from 5 066 applications received during 1984/85 and approximately 10 000 received in 1983. This continuing trend to fewer exemption applications, together with the decreasing numbers of tenements in force (ie. 18 668 on 30 June 1985; 17 412 on 30 June 1986), indicates that consolidation of adjoining groups of tenements into larger tenements is continuing.

Dealings

Dealings received in 1985/86 totalled 16 086, which is a similar total to that for the previous 12 months. However this steady figure would appear to contrast with the present number of mining tenements in force which, as indicated, dropped during 1985/86. This is due to the fact that such areas as Murchison and Kalgoorlie have seen a significant upsurge in development resulting in a number of gold operations commencing during 1985/86. This activity has had a marked effect on the volume of caveats, agreements, and transfers being lodged for registration against mining titles. Consequently, although mining tenement numbers have declined recently, the volume of dealings received remains constant.

Irrespective of the decline in tenement numbers and the stable volume of dealings, dealings received during this past year are well short of numbers recorded for the years 1981, 1982 and 1983 when receivals exceeded 25 000 annually; this is depicted in the accompanying diagram.



Mining activity

Kalgoorlie and Leonora outstations continued to receive the most tenements applications during the year, with the bulk being prospecting licences. The total number of applications received in Kalgoorlie was 1 470 and in Leonora 1 252, with these figures reflecting the continuing interest in gold prospecting in those areas.

During 1985/86 the Kimberley and Pilbara Mineral Fields were the main areas attracting applications for exploration licences; almost half of tenement applications received at the Kununurra Office were for exploration licences (136). This figure is an indication of the continuing diamond exploration in this area.

The South West Mineral Field, although not a major source of tenement applications, continues to attract a large proportion of exploration licences. However due to the incidence of private property, State Forests, National Parks, etc, applications listed in the Warden's Court at Perth are, in the main, inherently more complex than applications dealt with in the outstations. Consequently, delays often occur in the finalization of applications in the South West Mineral Field.

However, even though workloads of most outstations and their Warden's Courts remain high, the speed of applications determination at these office remains at a satisfactory level.

Gold production

Numerous gold mining projects either commenced or continued in operations during the year, some examples of which are shown as follows:

— in the Cue area, Australian Consolidated Minerals Ltd has commenced underground gold mining on the Golden Crown Lease at Day Dawn. Also in this area, Metana Minerals NL are currently producing from their openpit operation at Reedys, and during the past year they have uncovered more profitable values which could be mined in the coming year;
— Mt Magnet has seen the opening of the Galtee More openpit gold mining operation owned by Brunswick NL;
— the "go ahead" for the Boddington Gold Project, situated near Boddington approximately 120 km south from Perth, was given with the granting of five mining leases to the Worsley Joint Venturers. Full production from the mine, which has the potential to become one of the country's largest goldmines, is expected to be reached in 1987.

Prior to this approval the Joint Venturers were required to submit an Environmental Review and Management Programme covering rehabilitation and environmental matters, and this was subsequently received and approved by the Environmental Protection Authority.

Mining and the environment

Access to land is of paramount importance to the mining industry's future; however, the whole question of maintaining such access for mineral exploration and mining is a difficult one given the often conflicting views of sectional interest groups.

The importance to the State of both mining and environmental conservation is recognised by the relevant authorities which are attempting to develop a system of multiple land use in which each land user accepts certain restraints or conditions on their use of the land in order to accommodate other users.

The mining industry itself has a responsibility in ensuring that wherever possible mining is a temporary land use. There are, however, some mining operations where

poor environmental management and lack of genuine efforts to rehabilitate mined areas have resulted in mining being seen by the public as a final land use.

These problems are not limited only to some large scale mining projects, but also occur as a result of operations carried out on some prospecting licences.

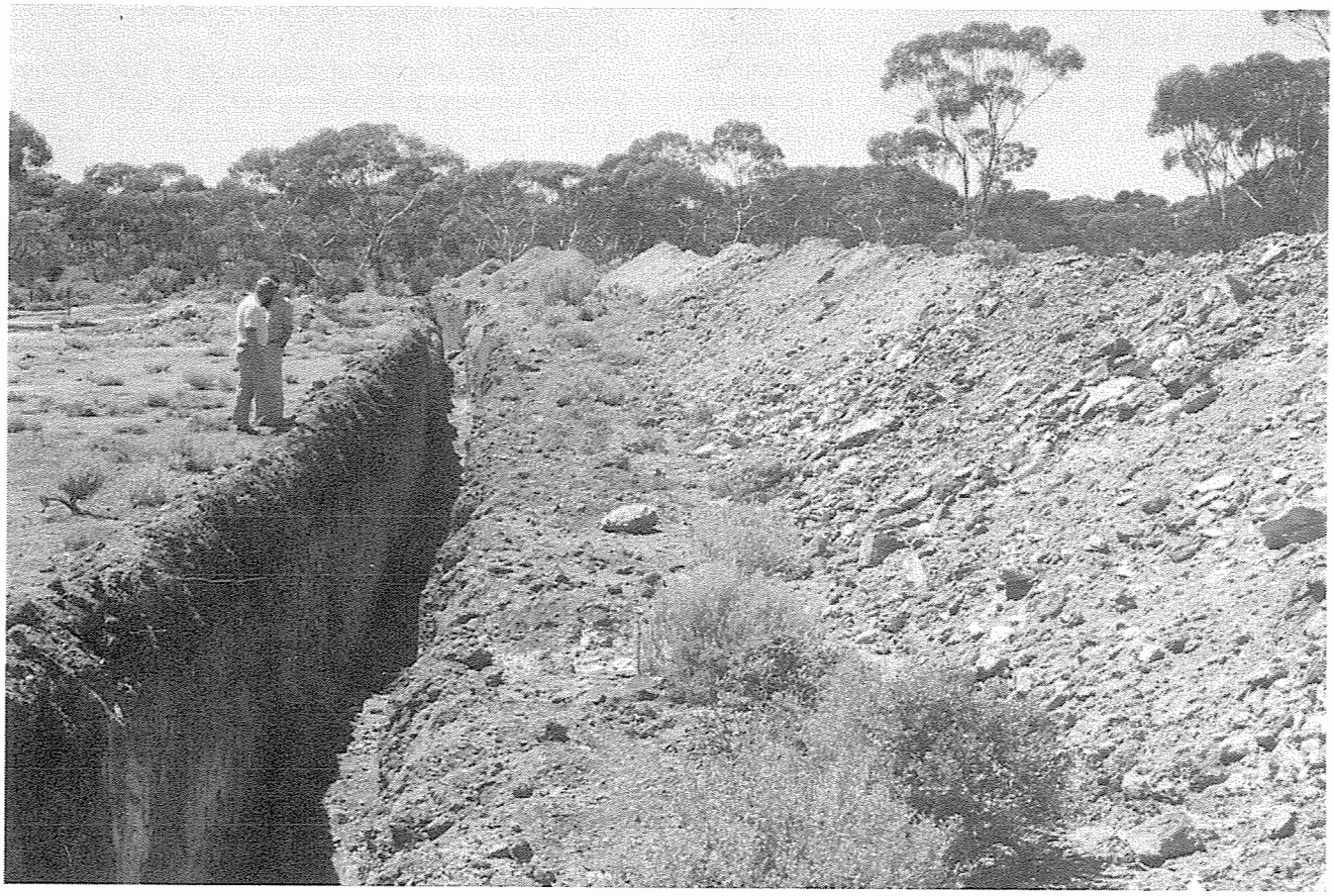
While it must be stressed that most prospecting licence holders operate on their tenements in a responsible manner, some holders through ignorance or design consider their licences to be pseudo-mining titles. Upon such tenements mining operations are carried out which are often environmentally damaging, particularly to pasture and vegetation, and which are rarely followed by any serious efforts to rehabilitate the ground.

In order to contribute towards a resolution of the problem to the satisfaction of all affected parties, the Mining Registration Division has, in concert with other relevant Divisions, formulated appropriate protective and rehabilitative conditions which are now imposed upon the grant of all prospecting licences, exploration licences and mining leases.

Organisation

Established staff numbers for the Division remain at 50 for Head Office and 39 for Outstations.

Due to restructure limitations imposed on the Division in Perth the appointment of temporary officers increased to 26 per cent of total staff, mainly brought about through the resignation of permanent officers enticed into the mining industry.



A four metre-deep costean where surface rehabilitation is an obvious need upon completion of mining operations.

RECORDS MANAGEMENT — A year of change

The Records Services Branch took a significant step forward in information technology on 14 May 1986 with the end to the implementation phase of a computer based Records Management System (RMS) and the official cessation of the parallel running of manual operations.

The major objectives of the computerised Records Management System were to improve efficiency, and eliminate time-consuming tasks and information gaps, in the management and movement of departmental records. These basic goals have been achieved.

The main component of RMS is a powerful data base that is essentially a register of key reference details pertaining to the 140 000 departmental files managed by the system. These details include file reference numbers, titles, storage locations etc. that are maintained in a current state. The basic function of the data base is to determine (identify) which file holds the particular information being sought.

Another noteworthy component of RMS is the tracking facility. The use of modern barcode technology enables the Tracking Facility to quickly and accurately capture file movements and maintain these data. From an information management point of view this facility holds the essential records of movement of files within the Department (files out and files in) and thus provides the current location of all information sources identified by the system.

The system also provides various reports and statistics that assist with the management of information. Some of these include: incomplete recorded actions, illegal file movements, bring-ups, and missing files.

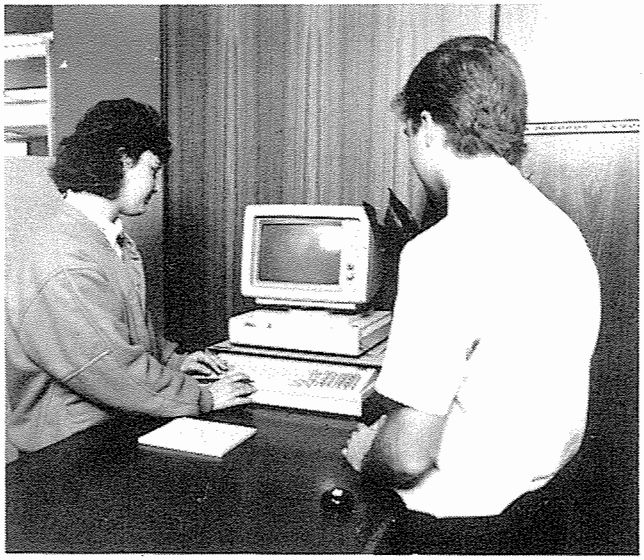
The effort involved in fully implementing RMS has been extensive. Departmental officers planned, co-ordinated and supervised the project (36 person-months) and two Commonwealth Employment Programs were required to uptake and input data (180 person-months). These contributions represent a substantial investment by the Department in the future direction of management of its information sources.

As a result of these efforts Records Services Branch functions are now operating at significantly improved levels of efficiency and effectiveness.

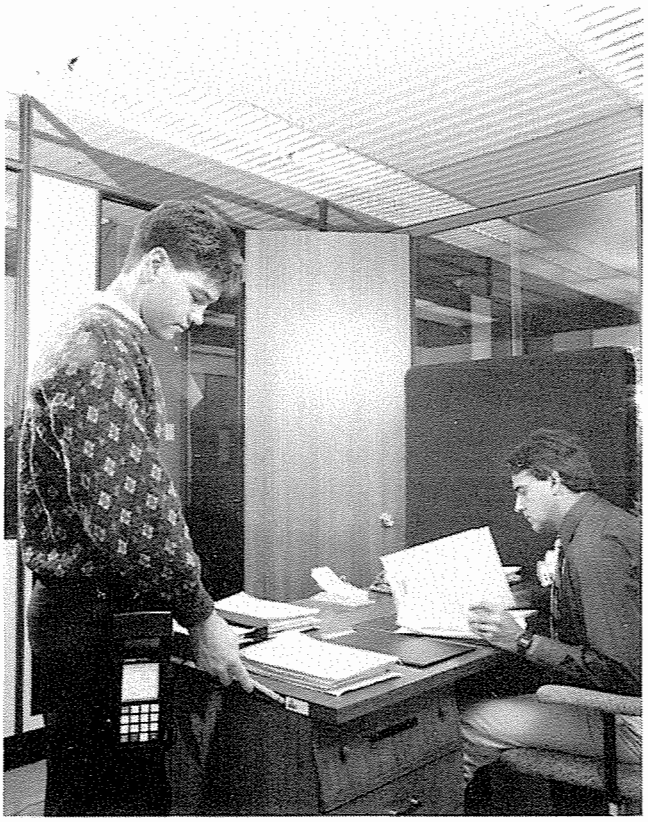
Backlogs are no longer a common occurrence and search lists are negligible and at times non-existent, resulting in shorter turnaround times in file requests and prompt distribution of mail. These significant benefits in information management are passed on to all Divisions of the Department.

Since the concept of introducing a computerised Records Management System there has been a close, efficient and effective working relationship between Records Services, Computing Services and Management. This has lead to a strong bond in the endeavour to ensure the successful implementation of the system.

The co-operation of other Divisions must also be noted.



Locating filed information using the Records Management System.



Using barcode technology, the location of files throughout the Department is checked in a weekly file audit.

CORPORATE SERVICES

A. MISTILIS, ACTING DIRECTOR

The 1985/86 year has been a year of change for the Corporate Services Division.

Following planning for the reorganisation of the Administrative Services Division, an organisational structure necessary for the delivery of corporate services to the Department was submitted to the Public Service Board in July 1985.

The changing nature of the services provided by the previously titled Administrative Services Division has necessitated the reorganisation of existing resources.

With current demands to improve the efficiency and effectiveness of Government services, greater emphasis is being placed in areas relating to financial management, computerisation, allocation of human resources, planning and research.

During the year, approval was granted by the Public Service Board for retitling of the Division and the creation of some aspects of the reorganisation. In this regard a Manager, Financial Services, was appointed during the year and at 30 June 1986 negotiations with the Board for the creation of the Human Resources and Management Services Branches were completed and the Department is now waiting for official confirmation.

The reorganisation has been negotiated on the basis of abolishing, reclassifying and retitling existing positions in a manner that has minimised the financial impact.

As in previous years, there has been a constant rearrangement of priorities and redeployment of personnel because the available human resources are not sufficient to service essential areas.

Systems (Internal) Audit

The sole Internal Auditor of the Department conducts an independent, post-operative appraisal function as a service to management. The areas of coverage include Departmental revenue and expenditure, stores, personnel and related operations, and any financial, accounting, and supply activities arising from particular functions of the Department.

The area of coverage must remain limited as only one staff member is allocated to this function.

Personnel Services Branch

The Personnel Services Branch is responsible for the human resource management function within the Department and corresponding interaction with the Public Service Board, Office of Redeployment and Retraining and Office of Industrial Relations.

In last year's Annual Report, the overview provided for this Branch stated that the Public Service Board was in the process of planning the phased delegation of a number of its functions and the implementation of new initiatives to Departments.

Recognising the impending additional responsibilities and workload, a proposal for restructuring the Branch was submitted to the Public Service Board. The restructure involved the creation of a mix of management and clerical positions, and a final decision in respect to this matter is still awaited.

Apart from the traditional routine work which continues, the functions and new initiatives that have been delegated and are being implemented respectively are:

— recruitment (advertising and filling of vacancies);
— staff performance (appraisal) management system;
— occupational health, safety, and welfare;
— classification determination (broadbanding);
— equal employment opportunity management plan;
— personnel information management system.

With regard to classification determination, the preliminary determination of all positions within the Department as at 1 November 1985 was received on 4 June 1986, and a final determination will be issued following discussions between the Board and senior management of the Department to resolve concerns.

Financial Services Branch

In September 1985, the Department appointed a Manager, Financial Services to head the newly created Financial Services Branch.

Further restructuring is currently before the Public Service Board to segregate the Branch into three distinct sections with the following functions:

— Finance and Planning — financial analysis, costing, planning, and budgetary development;
— Accounting Services — co-ordination and control of the traditional accounts function, and development of management accounting system;
— Coal Mine Worker's Pension Section.

During the year a rolling capital works replacement programme was developed for plant and equipment in the Government Chemical Laboratories, and a justified request for $1.667 million was included in the Department's Mining Development Capital Works Programme for 1986/87.

A microcomputer was installed in the Branch during the year and the system has been interfaced with the Treasury Department's Government Accounting System. The facility will enable the computerisation of several functions within the Accounting Services area and when the Finance and Planning section is established, will be vital to the development of budgetary procedures and financial planning techniques within the Department.

Coal Mine Worker's Pensions Section

Coal Mine Worker's Pensions. During the 1985/86 period the Coal Mine Workers (Pensions) Act was amended to allow those beneficiaries receiving a fortnightly pension the

option to commute their pension to a lump sum. In December 1985, 411 pensioners accepted the commutation leaving 13 remaining on a fortnightly basis.

Other amendments made at this time were:

— benefits for dependents of single mineworkers;
— deletion of the section of the Act which prohibited benefits being paid to beneficiaries of mine workers whose death arose from an intentional self-inflicted injury;
— incorporation of relevant elements from the Commonwealth Sex Discrimination Act referring to gender.

Under the other provisions of the Act there were 20 lump-sum payments made to eligible beneficiaries.

In May 1986 the Government Actuary's triennial valuation of the fund was received. The Actuary reported an improvement in the Fund and the full impact of his findings are being analysed by the Coal Mine Workers Pensions Tribunal.

Mine Worker's Relief. The final stage of the wind up of the Mine Worker's Relief Fund took place on 1 May 1984.

The Mine Worker's Relief Board was formally dissolved in September 1984 and the State Government Insurance Office was charged with administering the residue of the Fund.

The Mine Worker's Relief Act will continue to be administered for those beneficiaries who established their entitlement prior to 1 May 1984.

Miner's Phthisis Act. Seven persons were receiving benefits under the Act.

Coal Mining Industry Long Service Leave Act. The Act provides for long service leave to be paid to all coal mine industry workers in Western Australia. In conjunction with the Commonwealth Government, funds are collected and recouped to mining companies for long service leave taken by coal mine industry workers. The Act currently covers 1 272 coal mine industry workers.

Management Services Branch

The activities of the Management Services Branch continued to be directed mainly in two areas: accommodation, and broadbanding.

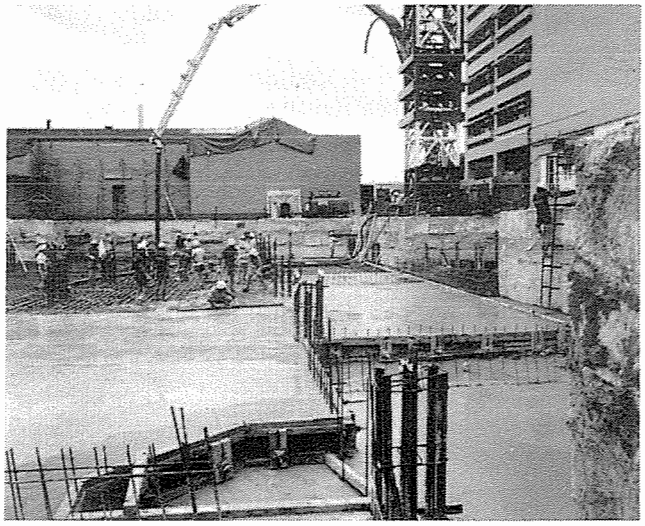
Following the massive exercise to complete the Position Data Forms (PDFs) in the first phase of the broadbanding initiative, most forms had to be revised more than once after scrutiny by, and discussions with, officers from the Public Service Board. The preliminary determination published by the Board will undoubtedly see further revisions to the PDFs.

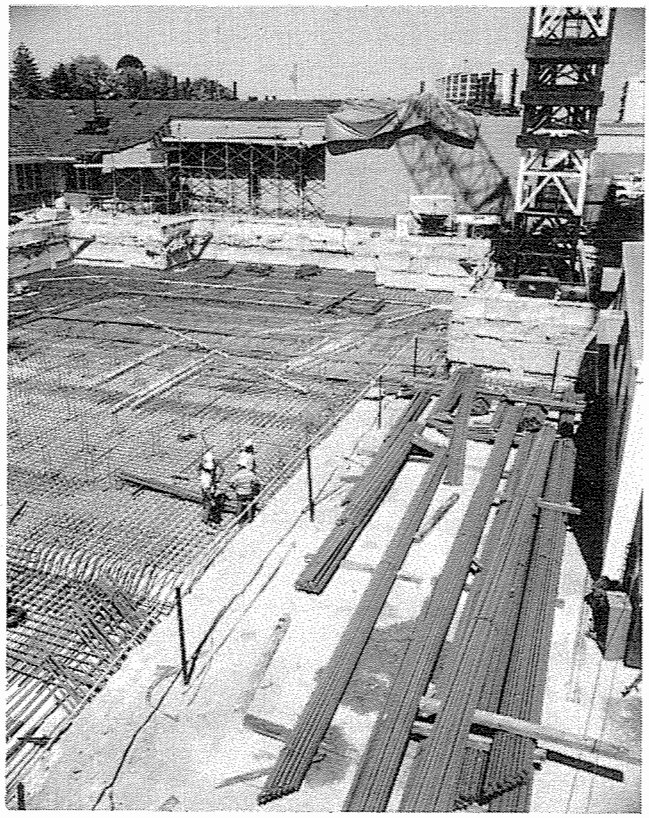
A significant increase in workload associated with the construction of the new Mineral House stage II was evident in the period under review. Planning for, and review of, a variety of facilities had to be co-ordinated eg. electronic security system, laboratories, computing, car parking, foyer etc., as well as space requirements and colour schemes.

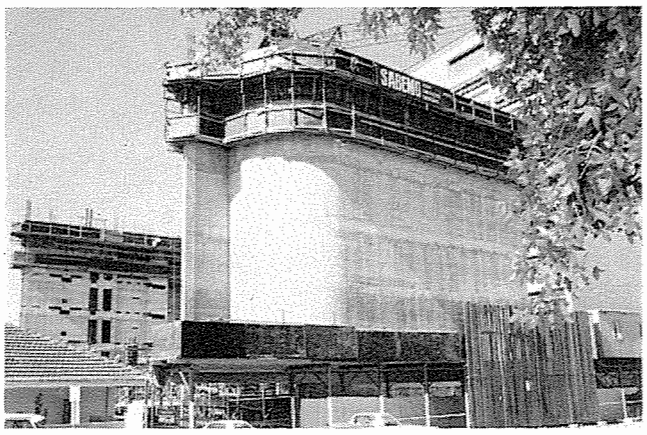
Planning associated with the refurbishment of Mineral House stage I will occupy a significant amount of time in the next financial year, as will the fitting out and phased occupation of the complex which is expected to be complete by mid-1987.

Other notable achievements include:

— the installation of a new electronic PABX and approval for an expansion of the system to cater for the increase in telephone requirements when the Complex is fully occupied;
— approval for the construction of an additional floor in the Kalgoorlie Regional Office;
— approval for an upgrade to the fume cupboards and effluent disposal from the Government Chemical Laboratories.







Progress on construction of Mineral House Stage 2.

Top left: Site preparation — October 1985.
Left: Constructing diaphragm wall on foundation perimeter — October 1985.
Top: Excavating below ground level — early December 1981.
Above: Setting basement reinforcements.
Top right: Pouring basement concrete — December 1985.
Middle right: Slip-forming elevator shafts — May 1986.
Right: Slip-forming service cores.

Information Services Branch

Records Services Section. The Records Services Section was further vitalised by the full implementation of the computerised Records Management System (RMS). All manual operations (with the exception of historical searches) officially ceased in May 1986.

A major culling of expired mining tenement files took place, resulting in about 79 000 files being transferred to secondary storage in Beaufort Street.

As usage of these files decreases, they will be progressively passed on to the State Repository at Dianella. Microfilming of these files will be carried out at a later date.

Due to constraints in Mineral House accommodation a file storage area was re-established in Confederation House to accommodate some 16 000 low access files.

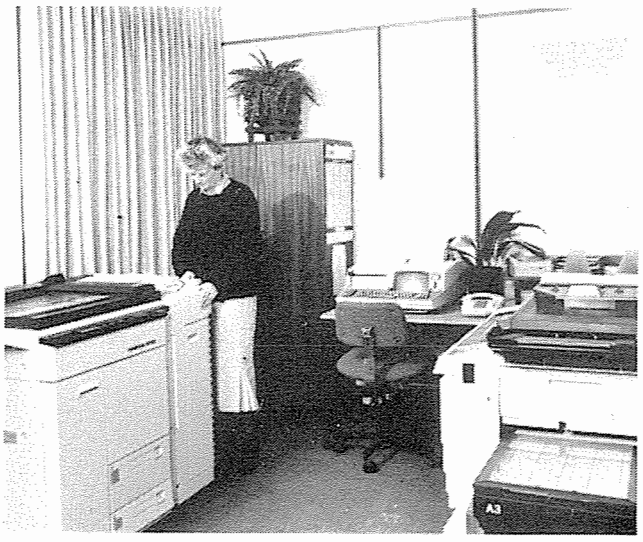
During the 1985/86 year, 8 356 files were created, compared with 6 721 for the previous year. Items of correspondence received for placement on file numbered 78 915 for the year, a little less than the 84 326 for 1984/85.

Staff resources remained constant but it was necessary to utilise 1 720 hours of overtime for work related to computerisation as well as for clearing backlogs in various ongoing operations. This compares with a total of 2 673 hours for the previous year.

The Branch is appreciative to those Divisions/ Branches which played an active role in assisting one of the trainees involved in the Youth Traineeship Scheme. Co-ordinated by this Branch, the officer gained valuable experience in a diverse range of office procedures.

The telex machine was replaced by Telecom's latest electronic unit (Telex 2000) which is actually a microcomputer with a VDU. The photocopy machines were also upgraded during the year. This new equipment will assist the Branch in meeting the extra demands experienced in the the telex and photocopy services.

As the use of keyboards increased, job rotation training, together with the correct use of ergonomic furniture, has enabled staff to avoid the occurrence of any repetitive strain injuries (RSI).



Newly installed Telex and photocopy machines.

With the implementation of modern technology the morale of staff within the Branch has risen significantly as the individuals observe and recognise the valuable improvements that have resulted from their own efforts and the team as a whole.

Word Processing Section. Following funding approval for an enhancement of the operating system from FDOS to Gemini, a new central processor called Series 8000-3 was purchased and installed. Consequent modifications had to be made to a number of terminals to enable them to be connected to the new processor, and in addition new cabling had to be laid.

It was imperative that the word processing system was updated as the original Wordplex 4 CPUs had long since reached full capacity and standalone units were proliferating. Half the terminals were running on FDOS and half on Gemini and the two operating systems were incompatible. The efficiency of the operators diminished as they could not be equally proficient on both types of screens and therefore flexibility in their deployment was limited. Documents typed on FDOS could not be edited on a terminal using Gemini and vice versa. Supervisors had two sets of housekeeping routines to perform. The terminals could not 'talk' to each other.

A phased approach was adopted in 'going live' starting on 28 April 1986 and concluding on 19 May 1986. There were some problems in the initial couple of weeks, but these have since been solved and the system is running efficiently and displaying the benefits anticipated.

Currently there are 21 terminals connected directly (or indirectly) to the new central processor and a further 6 are expected to be connected when all Divisions are housed in the Mineral House Complex in mid-1987. Then the full advantages of a centralised word processing system will be realised.

Computer Services Branch

The twelve months from July 1985 to June 1986 has seen steady and consistent progress made against the targets outlined in the Department's 1985/86 Information Technology Plan. The following summary provides an outline of the major achievements:

— TENDEX is an on-line system information service on more than 35 000 tenements, providing details on tenement holders, survey register data, renewals etc;
— RMS is a Departmental Records Management System including file tracking and an in-house developed back-up system, the full implementation of which was completed in the 1985/86 year;
— AXTAT is a Requirements Study carried out in conjunction with the Mining Engineering Division on a system which will monitor and report on accidents and injuries that occur in the mining industry. The primary objective of this system currently under development will be the improved safety and health of workers in the industry;
— WAPEX is a Requirements Study for a petroleum exploration data base — scheduled for development in

1986/87 — which will provide rapid access to petroleum information abstracted from comprehensive technical reports;

— ROCKMIN is the conversion of a data base of rock and mineral information from the Department of Computing and Information Technology based NCR computer to the in-house IBM system.

During the year the Department commissioned a Capacity Plan that identified its computing needs, both in hardware and software, for the next three years. Carried out by Departmental computing staff with assistance from DOCIT consultants and SCP Pty Ltd, the plan highlighted the computer based requirements for more advanced information systems. An upgrade to existing hardware, software and staff resources was recommended to handle the increasing and more complex systems requirements of the Department of Mines and Industry.

Considerable work was completed on the planning for provision of essential text and data processing services for the new Mineral House Complex. On occupation, Departmental staff should have access to the existing application systems on a cabling network based on 'state of the art' local area networking.

The period 1986/87 will be highlighted by the continued development of the Departmental Mining Tenement Information System, of which TENDEX has already been developed, as a 'front-end'.

Key priorities will be to maintain the existing levels of service and where possible to provide an improved information service to the Department and Industry.

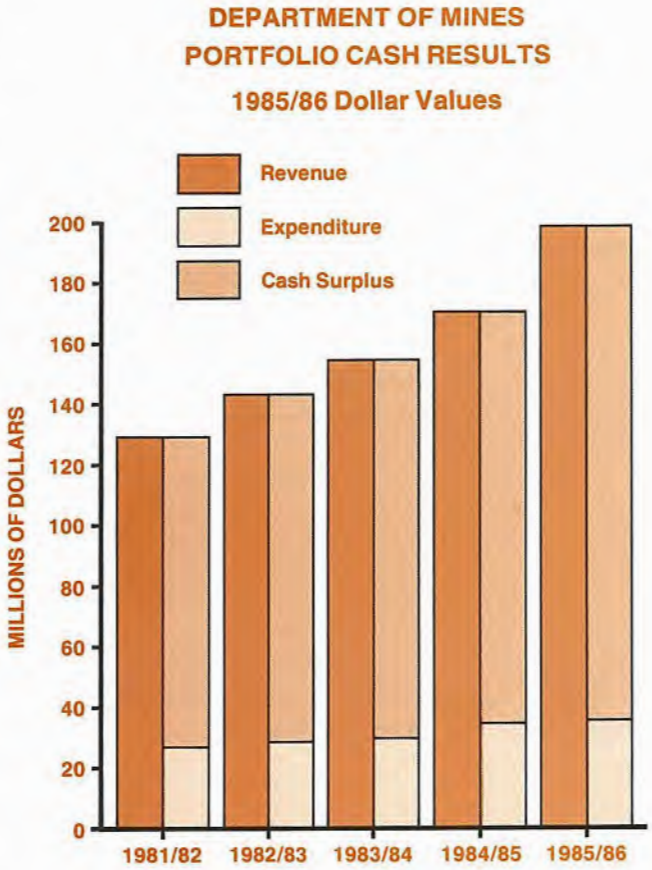
Financial Summary

Operations of the Department during 1985/86 resulted in a cash surplus of $163.126 million. This result was derived from:

	$ Million
Mines Department (Surplus)	165.216
State Batteries (Deficiency)	−2.090
	163.126

The accompanying table provides a summary of the finances on a cash basis as compared with 1984/85.

The figure presents a graphical representation of the cash results of the Department (including State Batteries) over the last five years.



Revenue

An analysis of the Department's revenue collection from mining activities in 1985/86 as compared to the previous year is shown in the accompanying table.

The increase in Leases and Other Rents was due to increased tenement applications and additional fees collected on the sale of interests in the North West Shelf Gas Production Licences.

The increase in Departmental revenue collections includes reimbursements from the State Development Fund for expenditure on the Argyle Social Impact Study Group and the East Kimberley Impact Project.

In addition, Chemical Laboratories revenue received a boost as a result of increased analyses for the private sector.

CASH SUMMARY (ACTUAL $ VALUES)

	Mines Department			State Batteries		
	1984/85 $M	1985/86 $M	Variation %	1984/85 $M	1985/86 $M	Variation %
Revenue	156.746	196.877	+25.6	1.596	1.652	+3.5
Expenditure	28.054	31.661	+12.9	3.804	3.742	−1.6
Cash Results	128.692	165.216	+28.4	−2.208	−2.090	+5.3

REVENUE — MINING (ACTUAL $ VALUES)

	1984/85 $M	1985/86 $M	Variations	
			$M	%
Royalties	130.977	162.982	+32.005	+ 24.4
Leases and other rents	22.338	28.406	+ 6.068	+ 27.1
Departmental revenue	1.405	3.279	+ 1.874	+133.4
Chemical Laboratories	0.643	0.758	+ 0.115	+ 17.9
Explosives	0.714	0.706	− 0.008	− 1.1
Miscellaneous revenue	0.669	0.746	+ 0.077	+ 11.5
TOTALS	156.746	196.877	+40.131	+ 25.6

Royalties. As shown in the table above, 1985/86 royalty receipts increased by 24.4 percent over the 1984/85 total.

Iron ore royalties increased as anticipated during the financial year with the more significant variations for individual iron ore producers being the result of different shipment levels and adjustments either for long standing disputes or on finalisation of returns.

A significant increase in royalties from crude oil was largely due to the commencement of operations of the new Harriet oilfield and the introduction of a new Resources Rent Royalty on petroleum products from Barrow Island.

Lower market prices for nickel, a difficult market for alumina and a lengthy dispute involving diamond sales had an adverse effect on royalty collections on those minerals.

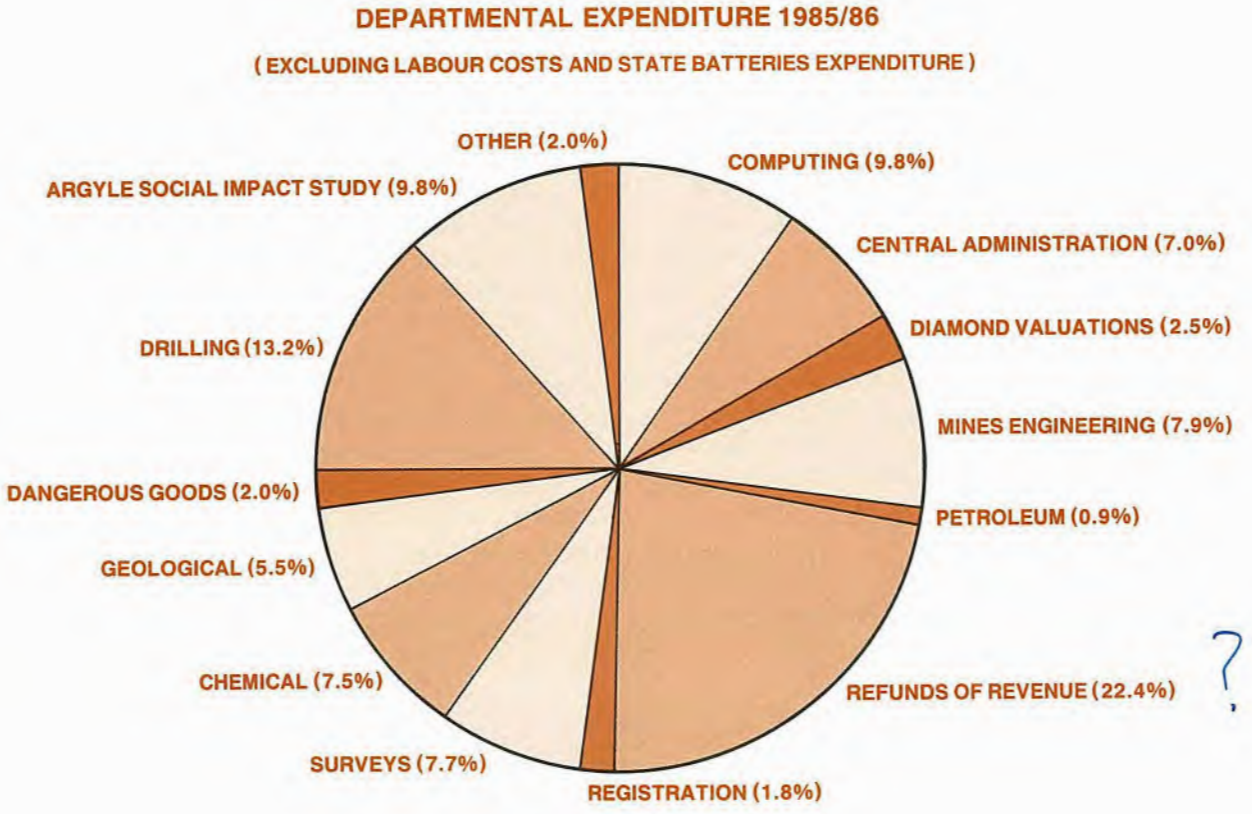
Mineral sand royalties increased significantly as a result of improved prices and demand.

Expenditure

The tables below provide an analysis of total expenditure by the Department on Mining and State Batteries activities respectively in 1985/86 as compared to 1984/85. The Figure graphically represents the percentage break up of expenditure, excluding labour costs, on mining operations during 1985/86.

Increased expenditure relating to Chemical Laboratories was a result of additional equipment required for the Forensic Laboratory and for an increase in consumable supplies.

The increased expenditure in Registration of Mining Titles can be attributed to a refund to WAPET for royalty adjustments from previous years.



EXPENDITURE — MINING (ACTUAL $ VALUES)

ITEM	1984/85 $M	1985/86 $M	Variations	
			$M	%
Salaries	17.151	19.063	+1.912	+ 11.1
Central Administration				
Other Staffing Costs (1)	1.200	1.405	+0.205	+ 17.1
Communications	0.142	0.138	−0.004	− 2.8
Services and contracts (2)	1.359	1.597	+0.238	+ 17.5
Consumable supplies	0.112	0.127	+0.015	+ 13.4
Maintenance of plant, equipment etc.	0.035	0.030	−0.005	− 14.3
Purchase of plant, equipment etc.	0.033	0.020	−0.013	− 39.4
Grants, subsidies and transfer payments	0.007	0.011	+0.004	+ 57.1
Other services				
Mines Engineering	0.792	0.909	+0.117	+ 14.8
Petroleum-administration and engineering	0.052	0.103	+0.051	+ 98.1
Registration of Mining Titles (3)	2.016	2.772	+0.756	+ 37.5
Surveys and Mapping	0.918	0.884	−0.034	− 3.7
Chemical Laboratories	0.603	0.864	+0.261	+ 43.3
Geological Surveys	0.700	0.633	−0.067	− 9.6
Control of Dangerous Goods	0.291	0.227	−0.064	− 22.0
Exploratory drilling	1.344	1.513	+0.169	+ 12.6
Special projects	0.060	0.185	+0.125	+208.3
Iron ore (Goldsworthy Nimingarra) Agreement Act	1.239	—	−1.239	−100.0
Argyle Social Impact Study	—	1.130	+1.130	—
East Kimberley Impact Assessment	—	0.050	+0.050	—
TOTALS	28.054	31.661	+3.607	+ 12.9

(1) 1985/86 Includes payroll tax ($0.887m), workers compensation ($0.234m)
(2) 1985/86 Includes computing ($1.12m), diamond valuation ($0.29m)
(3) 1985/86 Includes refunds of revenue ($2.57m)

EXPENDITURE — STATE BATTERIES (ACTUAL $ VALUES)

ITEM	1984/85 $M	1985/86 $M	Variations	
			$M	%
Salaries	0.096	0.111	+0.015	+15.6
Central Administration				
Other staffing costs	0.195	0.168	−0.027	−13.8
Communications	0.023	0.024	+0.001	+ 4.3
Services and contracts	0.048	0.043	−0.005	−10.4
Consumable supplies	0.008	0.004	−0.004	−50.0
Maintenance of plant, equipment etc.	0.002	0.001	−0.001	−50.0
Purchase of plant, equipment etc.	0.005	0.004	−0.001	−20.0
Other services				
Milling and tailings treatment	3.427	3.387	−0.040	− 1.2
TOTALS	3.804	3.742	−0.062	− 1.6

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COVER ILLUSTRATION

Aerial view of the Argyle Pipe, looking north, before mining began. The superimposed diagram shows a perspective view of the outcrop of the pipe (within broken line) and the diagrammatic vertical cross section shows the pipe and the rocks that it intrudes.

The oldest rock shown (horizontal rule) in the section is the Revolver Creek Formation consisting of Lower Proterozoic sandstone, siltstone and shale. This is unconformably overlain by Middle Proterozoic Hensman Sandstone (diagonal rule). Shortly after deposition these sediments were intruded by the Argyle lamproite pipe (open triangles), with consequent generation of contact and fault breccias (solid triangles).

Photograph by courtesy of Conzinc Rio of Australia Exploration; section adapted from Geological Survey Bulletin 132, Figure 23.

SUPPLEMENT TO ANNUAL REPORT

DIGEST OF MINERAL PRODUCTION AND OTHER STATISTICS 1985/86

DEPARTMENT OF MINES
WESTERN AUSTRALIA

DIGEST OF MINERAL PRODUCTION AND OTHER STATISTICS 1985/86

Supplement to the
Department of Mines
Annual Report

53775-1

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DRILLING BRANCH 1985/86

Summary of Drilling and associated work

Job name	Purpose	Type of work	No.of Bores	Drilled (metres)
Broome Horticultural	Groundwater investigation	Rotary drilling	2	388
Broome (Keelindi)	Groundwater investigation (Private bore)	Rotary drilling	1	500.7
Fortescue Coastal Plain	Groundwater investigation	Rotary drilling	2	71.5
Gillingarra	Groundwater investigation	Rotary drilling	9	5006.5
Robe River Coastal Plain	Groundwater investigation	Pumping tests		
Cataby Shallow	Groundwater investigation	Rotary drilling	16	828.0
Yarragil	Effects on bauxite mining	Rotary drilling	17	349.4
Del Park	Effects on bauxite mining	Rotary drilling	12	230.0
North Stirlings	Salinity studies	Rotary drilling	24	650.3
Isotope studies Collie & Dwellingup	Effects on bauxite mining	Cable tool drilling (Contractor)	4	132.9
Multiports (Various)	Waste disposal monitoring	Cable-tool drilling (Contractor)	10	393
Kimberley Drought Relief	Drought relief	Rotary percussion drilling (Contract)	28	1094.5
Maringee Farm	Salinity studies	Slug testing	13	
Harvey Deept & Gillingarra	Groundwater investigation	Deviation survey	5	
Cowaramup	Groundwater investigation	Site preparation	8	
Manyingee	Uranium mining	Tool recovery Bore cleaning) Packer) Placement)	1 2	
Various	Groundwater investigation	Pumping tests	17	
Various	Various	T.V. borehole scans	44	
TOTAL				**9644.8**

SERIOUS ACCIDENTS FOR 1985/86

Class of Accident	Inspectorate				Totals	
	Perth	Karratha	Kalgoorlie	Collie	1985/86	1984
MAJOR INJURIES (exclusive of fatal) -						
Fractures:						
Head			2		2	3
Shoulder	1				1	3
Arm			2		2	5
Hand		5	3	3	11	11
Spine			1		1	1
Rib		1	3		4	6
Pelvis	1				1	-
Thigh	1					-
Leg	1	1	4		6	11
Ankle			3	1	4	4
Foot	1	3	3		7	10
Amputations:						
Arm			1		1	1
Hand						-
Finger	1	1	5		7	9
Leg						-
Foot			2		2	1
Toe	1				1	-
Loss of eye						-
Serious internal						2
Hernia	1	3	1		5	10
Dislocations						2
Other major	7	7	1		15	13
Total major injuries	14	21	31	4	70	92
MINOR INJURIES						
Fractures:						
Finger	6	8	18	1	33	31
Toe	1	1	2		4	9
Head	1	6	1		8	16
Eyes	4	4			8	16
Shoulder	9	5	5	2	21	16
Arm	8	12	7	3	30	20
Hand	8	31	8	1	48	52
Back	31	57	31	15	134	131
Rib	4		3	1	8	3
Leg	10	23	23	2	58	70
Foot	11	13	5	2	31	37
Other minor	22	8	7	3	40	28
Total minor injuries	115	168	110	30	423	429
GRAND TOTAL	129	189	141	34	493	521

FATAL AND SERIOUS ACCIDENTS SHOWING DISTRICTS AND CAUSES, 1985/86

District	Explosives		Falls		Shafts		Fumes		Miscellaneous underground		Surface		Total	
	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious	Fatal	Serious
Kimberley												11		11
West Kimberley												7		7
Pilbara											1	52	1	52
West Pilbara												96		96
Peak Hill												27		27
Gascoyne												4		4
Murchison				2		1				5	1	18	1	26
East Murchison				1					2	4		7	2	12
Mount Margaret				3						2		10		15
North Coolgardie												2		2
Broad Arrow												4		4
East Coolgardie		2	1	5						33	2	15	3	55
Coolgardie				10					2	21		8	2	39
Yilgarn				1					1	2		5	1	8
Dundas			1							5		1	1	6
South West								2				89		91
Greenbushes												4		4
Collie										19		15		34
Total for 1985/6		2	2	22		1		2	5	91	4	375	11	493
Total for 1984/5	-	1	3	35	-	15	-	1	3	125	4	344	10	521

SUMMARY OF FATAL AND SERIOUS ACCIDENTS IN 1985/86

Mineral	Number of persons employed	Accidents		
		Fatal	Serious	Minor
Bauxite (alumina)	4 931	-	50	166
Coal	1 237	-	34	442
Diamond	752	-	11	15
Gold	4 498	6	134	284
Mineral sands	959	-	11	70
Iron	11 466	1	164	543
Nickel	2 957	4	65	112
Salt, gypsum	544	-	9	42
Tin, tantalite	196	-	4	10
Copper, silver, zinc	59	-	-	2
Other minerals	208	-	4	15
Rock quarries	301	-	7	32
TOTALS	28 108	11	493	1 733

G O L D

Company	Mine Location	Tonnes Mined		Tonnes Treated	Gold Produced kg
		Ore	Waste		
Newmont Holdings	Telfer			851 211	4 938.86
Metana Minerals	Nullagine			86 858	33.03
Bamboo Creek Gold	Bamboo Creek			35 086	315.89
Whim Creek Consolidated Limited	Meekatharra	498 099	1 953 700	498 099	1 072.2
Blue Bird Gold Mines Ltd	Meekatharra	533 254	1 759 423	239 490	550.5
Peak Hill Gold Mine	Peak Hill	23 106		19 106	10.0
Brunswick NL	Lennonville	87 000	2 670 000	85 800	295.0
Mineforce	Various	29 500		29 500	16.5
Woodford Well NL	Day Dawn	350 950		350 950	104.9
Hill 50 Gold Mines NL	Mount Magnet	234 359	610 170	234 359	1 224.7
Central Murchison Gold	Mount Magnet	83 275	1 728 564	124 427	316.9
Horseshoe Lights	Horseshoe Lights	386 006	4 576 495	397 642	1 661.5
Spear Syndicate	Peak Hill	81 136		81 136	30.5
KMA Mt Charlotte	Kalgoorlie	791 470		825 472	2 858.994
Fimiston	Fimiston	580 396	1 809 356	668 155	4 046.623
North Kalgurli	Fimiston	413 809	2 434 534	599 627	2 380.3
WMC Kalgoorlie Gold Operations	Great Boulder	22 674		21 354	118.96
	Sand King	16 693		20 693	109.86
	Lady Bountiful	21 110	10 630 000		
" Great Boulder Gold Operations	Lancefield	256 002	5 779 349	254 450	1 176.46
	Kambalda	710 647	3 980 284	710 121	3 482.64
Gold Resources	Fimiston	137 496	2 277 868		
C.K.G.M.	Kalgoorlie			43 334	156.437
ARM Broad Arrow J.V.	Broad Arrow	42 000	1 007 506	42 000	89.0
Pancontinental	Paddington	971 450	3 128 270	809 605	2 335.226
BHP Gold Pty Ltd	Ora Banda	163 814	2 069 107	143 814	405.7
West Coast Holdings	Hawkins Find	116 209	658 400	108 544	112.0
	Eureka Open Cut	33 846	910 220	31 548	93.0
Wiluna Dumps Project	Wiluna Tailings			1 203 851	496.68
Golconda Management	Tailings Treat			159 577	154.706

GOLD continued

Company	Mine Location	Tonnes Mined		Tonnes Treated	Gold Produced kg
		Ore	Waste		
Forsayth NL	Lawlers	280 594	566 271	75 018	305.719
Queen Margaret	Lawlers Tailings	280 594	566 271	317 323	664.766
Great Victoria	Marvel Loch	110 441	1 899 791	316 437	1 000.798
Marvel Loch Gold	Marvel Loch	411 156	1 005 385	274 657	1 116.60
Nevoria Gold Mine	Marvel Loch	344 609	743 294	335 408	798.155
Mt Percy	Kalgoorlie	377 806	4 767 524	352 411	773.3
Undaunted Gold Mine	Marvel Loch	6 397		6 397	73.38
(ASM) Westonia Gold Mine	Westonia	386 000	1 307 000	72 000	189.0
Copperhead Gold Mine	Bullfinch	30 420	450 000	19 920	89.393
Australis Mining	Norseman	7 822		89 423	127.6
Central Norseman G.C.	Norseman	306 401	1 683 794	303 014	3 619.489
R J Washer Operations	Southern Cross	2 200	1 000	51 479	32.85
Sons of Gwalia NL	Gwalia	502 610	1 400 315	503 133	1 935.4
Harbour Lights Mining	Leonora	628 851	4 594 957	624 066	1 977.118
Tower Hill Gold	Leonora	231 865	786 435	234 204	585.09
Austwhim Resources	Cork Tree Well	98 551	539 225	69 774	185.4
Woodford Wells NL	Yundaga			82 484	95.55
United Goldfields Corporation	Grosmont	18 800	200 500	54 118	117.197
Brilliant Tindals J.V.	Coolgardie	88 000	1 420 000	74 000	131.0
Elders Resources Ltd	McPherson's Find	15 269	900 000	15 269	120.09
Edjudina Mines	Edjudina	242 309	2 012 373	252 700	885.00
Sundry Producers *	Various	478 637	439 907	53 878	1 461.313

* Small producers and companies which did not wish to have their data published

M I N E R A L S A N D S

Company	Centre	Tonnes Mined	Tonnes Concentrate	MINERALS PRODUCED (TONNES)							
				Ilmenite			Leucoxene	Monazite	Rutile	Xenotime	Zircon
				Standard	Secondary	Upgraded					
Cable Sands Pty Ltd	CAPEL	1 199 409	158 518								
	WAROONA	638 851	98 633								
	BUNBURY		257 151	183 927	20 377		4 548	656		67	10 778
Westralian Sands Limited	CAPEL	4 040 000	559 600	400 584	23 000		23 591	2 222			31 836
Associated Minerals Consolidated Limited	CAPEL	905 613	160 000	103 524	5 078	55 457	2 993	410		5	10 129
	ENEABBA NORTH	6 025 919	629 686	169 109				4 125	42 084		135 833
	ENEABBA SOUTH	6 944 646	539 554								
	NARNGULU			202 070							
TOTALS		19 754 438	2 145 991	1 059 214	48 455	55 457	31 132	16 726	79 198	72	344 010

B A U X I T E - A L U M I N A

Company	Tonnes Mined	Tonnes Treated	Tonnes Alumina Produced
Alcoa of Australia Ltd	15 940 006	15 546 787	4 371 624
Worsley Alumina Pty Ltd	3 950 000	3 867 457	1 058 631
TOTAL	19 890 006	19 414 244	5 430 255

S A L T

Company	Location	Tonnes Produced	Tonnes Shipped
Dampier Salt	Dampier	1 928 000	1 787 306
	Lake MacLeod	617 000	826 986
Leslie Salt	Port Hedland	1 434 000	1 605 412
Shark Bay Joint Venture	Useless Loop	610 304	594 434
TOTALS		4 589 304	4 814 138

G Y P S U M

Company	Location	Tonnes Produced	Tonnes Shipped
Shark Bay Gypsum	Useless Loop	150 317	157 578
Southern Asiatic	Norseman	30 000	17 850
H B Brady & Co	Lake Brown	28 649	-
CSR Gyprock	Lake Seabrook	52 076	-
Small Producers	Various	74 488	-
TOTALS		335 530	175 428

T I N, T A N T A L I T E, S P O D U M E N E

Company	Location	Tonnes Mined Treated	Concentrate Produced		
			Tin (Cassiterite)	Tantalite	Spodumene
Greenbushes Tin Ltd	Greenbushes	1 548 242	617.86	94.63	10 204
Greenbushes Tin Ltd	Greenbushes	82 945			
Goldrim Mining (Aust) Ltd	Wodgina	8 246	2.72	2.82	
Endeavour Resources Ltd	Marble Bar	181 664	64.45	1.61	

O T H E R M I N E R A L S

MINERAL Company	Location	Tonnes Mines	Tonnes Treated	Tonnes Concentrate Produced
ATTAPULGITE				
Mallina Holdings	Lake Nerramyne Narngulu	34 951	18 202	8 844
GARNET				
Target Minerals	Port Gregory	21 765		
Garnet Millers Aust.	Narngulu		21 765	8 080
KAOLIN				
Greenbushes Tin Ltd	Greenbushes			2 586
ALUNITE				
Chandler Clay	Chandler	4 050	4 050	

SCHEDULE NO. 1

NUMBER OF GOLD ORE PARCELS TREATED, TONNES CRUSHED, GOLD YIELD BY AMALGAMATION AND HEAD VALUES FOR 1985/86

Battery	Smelt bullion (kg)	Yield by amalgamation				Amalgamation tailings content fine gold (kg)	Contents of Ore - fine gold	
		Number of parcels treated	Weight crushed (tonnes)	Bullion (kg)	Estimated fine gold (kg)		Weight (kg)	Grade (g/t)
Boogardie	9.731	13	1 504	4.958	4.215	2.300	6.515	4.33
Coolgardie	11.832	40	3 244	54.322	46.175	15.110	61.285	18.88
Kalgoorlie	8.876	47	5 576	48.228	40.993	11.645	52.638	9.44
Laverton	0.087	10	607	3.524	2.996	1.440	4.436	7.30
Leonora	5.656	19	3 290	16.460	13.989	9.843	23.832	7.24
Marble Bar	1.423	17	1 557	9.024	7.670	5.301	12.971	8.33
Marvel Loch	3.624	35	3 495	16.008	13.606	7.858	21.464	6.14
Meekatharra	16.169	10	403	4.136	3.516	1.086	4.602	11.42
Menzies	0.487	12	749	5.088	4.325	1.928	6.253	8.34
Norseman	0.395	16	1 618	10.123	8.603	3.966	12.569	7.77
Ora Banda	-	12	432	2.471	2.100	1.010	3.110	7.20
Paynes Find	0.177	17	1 359	16.327	13.878	2.418	16.296	11.99
Yarri	-	5	152	1.302	1.107	0.453	1.560	10.26
Totals	58.457	253	23 986	191.971	163.173	64.358	227.531	9.48

Average per parcel 94.8t;Average yield by amalgamation (fine gold) 6.80g/t; Average tailing (fine gold) 2.68g/t

SCHEDULE NO. 2

DETAILS OF EXTRACTION - TAILINGS TREATMENT BY STATE BATTERIES 1985/86

Battery	Estimated tonnes	Head value		Tail value		Calculated Recovery		Actual recovery	
		Grams per tonne	Total content (kg)	Grams per tonne	Total content (kg)	(kg)	Per cent	(kg)	Per cent
Coolgardie (CIP)	17 101	2.19	37.476	0.43	7.390	30.086	80.3	17.403	46.4
Kalgoorlie (CIP)	23 787	1.52	36.106	0.49	11.677	24.429	67.6	20.566	57.0
Meekatharra (CIP)	12 355	1.74	21.478	0.76	9.429	12.049	56.1	11.423	53.2
Boogardie (H/leach)	1 500	1.30	1.950	0.26	0.390	1.560	79.8	1.560	79.8
Coolgardie (H/leach)	4 000	2.20	8.800	0.90	3.600	5.200	59.1	5.200	59.1
Kalgoorlie (H/leach)	1 000	1.50	1.500	0.56	0.560	0.940	62.7	0.940	62.7
Leonora (H/leach)	6 000	1.56	9.360	0.47	2.820	6.540	69.9	6.540	69.9
Marble Bar (H/leach) - part treated	4 200	3.67	15.414	2.09	8.778	6.636	43.1	6.636	43.1
Marvel Loch (H/leach)	6 400	1.60	10.240	0.33	2.112	8.128	79.4	8.128	79.4
Marvel Loch (H/leach) - part treated	4 400	1.90	8.360	1.38	6.072	2.288	27.4	2.288	27.4
Menzies (H/leach)	2 000	1.40	2.800	0.60	1.200	1.600	57.1	1.600	57.1
Yarri (H/leach)	6 000	1.86	11.160	0.50	3.000	8.160	73.1	8.160	73.1
Totals	88 743	1.85	164.644	0.64	57.028	107.616	65.4	90.444	54.93

SCHEDULE NO. 3

DIRECT PURCHASE OF TAILINGS IN 1985/86

Battery	Tailings purchased (tonnes)	Initial payment ($)	Gold paid to prospectors (kilograms)
Coolgardie	853.0	5 597.23	11.435
Kalgoorlie	174.0	511.82	3.934
Laverton	92.8	274.09	1.599
Leonora	821.7	2 752.24	4.333
Marble Bar	514.8	1 157.70	2.897
Marvel Loch	330.0	1 269.52	4.003
Meekatharra	50.4	242.61	0.492
Menzies	3.0	4.88	0.488
Norseman	333.0	724.56	0.447
Ora Banda	49.0	120.58	0.540
Yarri	55.8	127.00	1.153
Totals	3 277.5	12 776.23	31.321

SCHEDULE No. 4

STATEMENT OF RECEIPTS AND EXPENDITURE FOR MILLING 1985/6

Battery	Tonnes	EXPENDITURE							RECEIPTS		Profit	Loss
		OPERATIONS		ADMINISTRATION								
		Stores and wages $	Cost per tonne $	Head office $	Assays $	Total administration $	Gross expenditure $	Gross cost per tonne $	Total receipts $	Rec per tonne $	$	$
Boogardie	1 504	122 300.09	81.32	32 272.83	2 496.64	34 769.47	157 069.56	104.43	16 780.70	11.16		140 288.86
Coolgardie	3 244	225 997.73	69.67	69 609.75	5 385.04	74 994.79	300 992.52	92.78	39 532.31	12.19		261 460.21
Kalgoorlie	5 576	346 494.21	62.14	119 649.81	9 256.16	128 905.97	475 400.18	85.26	107 607.01	19.30		367 793.17
Laverton	607	75 765.48	24.82	13 025.01	1 007.62	14 032.63	89 798.11	147.94	8 451.50	13.92		81 346.61
Leonora	3 290	226 402.76	68.81	70 596.82	5 461.40	76 058.22	302 460.98	91.93	43 302.10	13.16		259 158.88
Marble Bar	1 557	124 536.79	79.98	33 410.11	2 584.62	35 994.73	160 531.52	103.10	14 020.00	9.00		146 511.52
Marvel Loch	3 495	191 553.13	54.81	74 995.71	5 801.70	80 799.41	272 350.54	77.92	47 641.25	13.63		224 709.29
Meekatharra	403	118 887.17	95.00	8 647.57	668.98	9 316.55	128 203.72	318.12	3 908.95	9.70		124 294.77
Menzies	749	81 777.75	09.18	16 072.04	1 243.34	17 315.38	99 093.13	132.30	6 679.00	8.92		92 414.13
Norseman	1 618	131 396.52	81.21	34 719.04	2 685.88	37 404.92	168 801.44	104.33	21 769.70	13.45		142 031.74
Ora Banda	432	83 303.61	92.83	9 269.86	717.12	9 986.98	93 290.59	215.95	4 085.00	9.46		89 205.59
Paynes Find	1 359	95 360.89	70.17	29 161.42	2 255.94	31 417.36	126 778.25	93.29	11 821.25	8.70		114 957.00
Yarri	152	52 686.93	46.62	3 261.62	252.32	3 513.94	56 200.87	369.74	1 520.00	10.00		54 680.87
Head Office	-	-	-	-	-	-	-	-	10 073.37	-	10 073.37	-
Total	23 986	1 876 463.06	78.23	514 691.59	39 816.76	554 508.35	2 430 971.41	101.35	337 192.14	14.06	10 073.37	2 093 779.27

STATE BATTERIES SCHEDULE NO. 5
STATEMENT OF RECEIPTS AND EXPENDITURE FOR CYANIDATION 1985/6

Battery	Tonnes	EXPENDITURE							RECEIPTS		Profit	Loss
		OPERATIONS		ADMINISTRATION								
		Stores and wages $	Cost per tonne $	Head office $	Assays $	Total administration $	Gross expenditure $	Gross cost per tonne $	Total receipts $	Rec per tonne $	$	$
HEAP LEACH												
Boogardie	1 500	5 066.30	3.38	2 175.00	840.00	3 015.00	8 081.30	5.39	17 385.33	11.59	9 304.03	-
Coolgardie	4 000	41 972.71	10.49	5 800.00	2 240.00	8 040.00	50 012.71	12.50	56 192.59	14.05	6 179.88	-
Kalgoorlie	1 000	8 057.96	8.06	1 450.00	560.00	2 010.00	10 067.96	10.07	26 086.83	26.09	13 018.87	-
Laverton*	-	2 335.20	-	-	-	-	2 335.20	-	1 272.87	-	-	1 062.33
Leonora	6 000	31 016.46	5.17	8 700.00	3 360.00	12 060.00	43 076.46	7.18	98 325.85	16.39	55 249.39	-
Marble Bar	4 200	20 456.91	0.49	6 090.00	2 352.00	8 442.00	28 898.91	6.88	82 203.48	19.57	53 304.57	-
Marvel Loch	10 800	64 449.11	5.97	15 660.00	6 048.00	21 708.00	86 157.11	7.98	111 218.29	10.30	25 061.18	-
Menzies	2 000	10 512.86	5.26	2 900.00	1 120.00	4 020.00	14 532.86	7.27	19 017.93	9.51	4 485.07	-
Ora Banda*	-	14 499.35	-	-	-	-	14 499.35	-	6 824.47	-	-	7 674.88
Paynes Find*	-	5 053.64	-	-	-	-	5 053.64	-	40 186.09	-	35 132.45	-
Yarri	6 000	48 965.84	8.16	8 700.00	3 360.00	12 060.00	61 025.84	10.17	78 481.58	13.08	17 455.74	-
SUB TOTAL	35 500	252 386.34	7.11	51 475.00	19 880.00	71 355.00	323 741.34	9.12	537 195.31	15.13	219 191.18	8 737.21
C.I.P												
Coolgardie	17 101	201 156.68	11.76	142 930.16	6 327.37	149 257.53	350 414.21	20.49	185 161.45	10.83	-	165 252.76
Kalgoorlie	23 787	164 535.01	6.92	198 811.75	8 801.19	207 612.94	372 147.95	15.64	251 217.79	10.56	-	120 930.16
Meekatharra	12 355	169 716.91	13.74	103 263.09	4 571.35	107 834.44	277 551.35	22.46	165 959.05	13.43	-	111 592.30
SUB TOTAL	53 243	535 408.60	10.05	445 005.00	19 699.91	464 704.91	1 000 113.51	18.78	602 338.29	11.31	-	397 775.22
SPECIAL AGREEMENTS	-	-	-	-	-	-	-	-	175 274.48	-	175 274.48	-
Totals	88 743	787 794.94	8.88	496 480.00	39 579.91	536 059.91	1 323 854.85	14.92	1 314 808.08	14.82	394 465.66	406 512.43

* Carry over from 1984/85

WELLS COMPLETED IN 1985/86

Well	Type	Tenement	Company	Rig	DATES			Total depth (m)	Status
					Spud	Total depth	Rig release		
				DEVELOPMENT WELLS					
CANNING BASIN									
Blina 6	Dev	PL 6	Home	TSM 6000	01.07.85	11.07.85	18.07.85	1 260	O PROD
Sundown 4	Dev	PL 8	Home	National 370	05.07.85	18.07.85	28.07.85	1 800	O PROD
CARNARVON BASIN									
Barrow Q64A	Dev	PL-1H	Wapet	H 35	05.07.85	08.07.85	09.07.85	781	O PROD
Barrow Q65A	Dev	PL-1H	Wapet	H 35	10.07.85	13.07.85	14.07.85	778	O PROD
Barrow Q67A	Dev	PL-1H	Wapet	H 35	15.07.85	21.07.85	23.07.85	802	O PROD
Barrow P61A	Dev	PL-1H	Wapet	H 35	23.07.85	27.07.85	28.07.85	795	O PROD
Barrow Q84A	Dev	PL-1H	Wapet	H 35	29.07.85	31.07.85	01.08.85	770	O PROD
Barrow L17A	Dev	PL-1H	Wapet	H 35	02.08.85	04.08.85	06.08.85	785	O PROD
Barrow L18A	Dev	PL-1H	Wapet	H 35	07.08.85	11.08.85	13.08.85	800	O PROD
Barrow P81A	Dev	PL-1H	Wapet	H 35	14.08.85	17.08.85	18.08.85	790	O PROD
Barrow Q85A	Dev	PL-1H	Wapet	H 35	19.08.85	22.08.85	23.08.85	790	O PROD
Barrow Q87A	Dev	PL-1H	Wapet	H 35	24.08.85	26.08.85	28.08.85	800	O PROD
Barrow P71A	Dev	PL-1H	Wapet	H 35	28.08.85	31.08.85	01.09.85	763	O PROD
Barrow Q78A	Dev	PL-1H	Wapet	H 35	02.09.85	04.09.85	05.09.85	764	O PROD
Barrow Q77A	Dev	PL-1H	Wapet	H 35	06.09.85	09.09.85	10.09.85	786	O PROD
Barrow Q76A	Dev	PL-1H	Wapet	H 35	11.09.85	15.09.85	16.09.85	785	O PROD
Barrow Q75A	Dev	PL-1H	Wapet	H 35	17.09.85	19.09.85	20.09.85	787	O PROD
Barrow Q55A	Dev	PL-1H	Wapet	H 35	21.09.85	23.09.85	24.09.85	785	O PROD
Barrow Q56A	Dev	PL-1H	Wapet	H 35	25.09.85	27.09.85	28.09.85	785	O PROD

Well	Type	Tenement	Company	Rig	DATES			Total depth (m)	Status
					Spud	Total depth	Rig release		
Barrow Q53A	Dev	PL-1H	Wapet	H 35	29.09.85	01.10.85	03.10.85	790	O PROD
Harriet C1	Dev	WA-192-P	Bond	Maersk Valiant	20.09.85	01.10.85	06.10.85	2 000	O SUSP
Harriet C2	Dev	WA-192-P	Bond	Maersk Valiant	06.10.85	23.10.85	29.10.85	2 263	O SUSP
North Rankin A08/NE2	Dev	WA-1-L	Woodside	NRA Platform	03.08.85	13.11.85	30.11.85	4 553	GC SUSP
North Rankin A09/NW4	Dev	WA-1-L	Woodside	NRA Platform	30.11.85	27.01.86	08.02.86	4 058	GC SUSP
North Rankin A10/NW5	Dev	WA-1-L	Woodside	NRA Platform	21.02.86	30.03.86	03.04.86	3 279	GC SUSP
North Rankin A11/NW3	Dev	WA-1-L	Woodside	NRA Platform	07.04.86	19.05.86	01.06.86	3 760	GC SUSP
				EXPLORATION WELLS					
BONAPARTE BASIN									
Crane 1	NFWO	WA-147-P	WMC	Glomar Robert F Bauer	28.03.86	25.04.86	02.05.86	2 855	P & A
IBIS 1	NFWO	WA-147-P	WMC	Glomar Robert F Bauer	03.05.86	17.05.86	23.05.86	1 475	P & A
BROWSE BASIN									
Browse Island 1	NFW	EP 302	Santos	Bourne 5000 R	15.05.86	26.05.86	27.05.86	406	P & A
CANNING BASIN									
Percival 1	NFW	EP 225	WMC	Cooper 350	23.05.85	16.07.85	19.07.85	2 448	P & A
Sunup 1	NFW	PL 8	Ampol	National 370	21.06.85	01.07.85	03.07.85	1 500	P & A
Kennedia 1	NFW	EP 101	Ampol	National 80E	01.07.85	14.08.85	18.08.85	3 382	P & A
Cudalgarra 2	EXT	EP 164	SOC	National 370	03.08.85	29.08.85	04.09.85	1 550	P & A
Dodonea 1	NFW	EP 143	WMC	Cooper 350	09.08.85	25.09.85	28.09.85	2 215	P & A
Jumjum 1	NFW	EP 104	Esso	National 110	20.08.85	18.09.85	21.09.85	2 600	P & A
Mangaloo 1	NFW	EP 102	IEDC	National 80E	25.08.85	26.11.85	08.12.85	3 100	P & A
Juno 1	NFW	EP 231	Royal	Bourne 5000R	08.09.85	25.09.85	28.09.85	1 750	P & A
Lukins 1	NFW	EP 129	Home	National 370	20.10.85	03.11.85	05.11.85	1 675	P & A
Patience 1	NFW	EP 205	SOC	National 370	12.01.86	29.01.86	03.02.86	1 868	P & A

Well	Type	Tenement	Company	Rig	DATES			Total depth (m)	Status
					Spud	Total depth	Rig release		
CARNARVON BASIN									
West Barrow 2	EXTO	WA-64-P	BHP	Regional Endeavour	21.04.85	24.07.85	05.08.85	3 437	P & A
Talisman 2	EXTO	WA-191-P	Marathon	Margie	02.05.85	20.06.85	02.07.85	2 326	P & A
Wilcox 2	EXTO	WA-28-P	Woodside	Energy Searcher	02.06.85	15.08.85	21.08.85	4 117	GC SUSP
Unknown Hill 1	NFW	EP 41	Ampol	National T-32	13.06.85	11.07.85	14.07.85	1 544	P & A
Barrow P74M	EXT	PL 1H	Wapet	H 35	24.06.85	02.07.85	05.07.85	1 050	O SUSP
Fennel 1	NFWO	WA-149-P	WMC	Glomar Main Pass III	27.06.85	07.07.85	11.07.85	1 561	P & A
Lenita 2	EXTO	WA-192-P	Bond	Maersk Valiant	29.06.85	26.07.85	09.08.85	2 335	O SUSP
Calypso 1	NFWO	WA-191-P	Marathon	Margie	04.07.85	07.08.85	15.08.85	2 843	P & A
Chinty 1	NFW	EP 110	Esso	National 110	15.07.85	01.08.85	06.08.85	1 673	P & A
Lenita 3	EXTO	WA-192-P	Bond	Maersk Valiant	10.08.85	30.08.85	17.09.85	2 181	O SUSP
Goodwyn 7	EXTO	WA-5-L	Woodside	Energy Searcher	23.08.85	18.09.85	09.10.85	3 446	GC SUSP
North Herald 2	EXTO	WA-149-P	WMC	Glomar Main Pass III	29.08.85	05.09.85	12.09.85	1 300	O SUSP
Alum 1	NFWO	WA-149-P	WMC	Glomar Main Pass III	19.09.85	07.10.85	10.10.85	2 650	P & A
Barrow G73M	EXT	PL 1H	Wapet	H 35	04.10.85	11.10.85	13.10.85	980	SHUT IN
Barrow G53M	EXT	PL 1H	Wapet	H 35	14.10.85	20.10.85	22.10.85	966	SHUT IN
Santo 1	NFWO	WA-155-P	BHP	Maersk Valiant	31.10.85	16.11.85	23.11.85	1 883	P & A
Midway Hill 1	NFW	EP 41	Ampol	National 370	09.01.86	20.01.86	27.01.86	1 319	P & A
Campbell 2	EXTO	WA-192-P	Bond	Maersk Valiant	31.01.86	16.02.86	01.03.86	2 796	GC SUSP
Lefroy Hill 1	NFW	EP 41	Ampol	National 370	31.01.86	27.02.86	04.03.86	1 512	P & A
Orpheus 1	NFWO	WA-192-P	Bond	Maersk Valiant	02.03.86	20.03.86	28.03.86	2 383	P & A
Roberts Hill 1	NFW	EP 41	Ampol	National 370	05.03.86	16.03.86	21.03.86	1 265	P & SUSP
Plato 1	NFWO	WA-192-P	Bond	Maersk Valiant	30.03.86	21.04.86	28.04.86	2 808	P & A
Goodwyn 8	EXTO	WA-5-L	Woodside	Margie	04.04.86	13.05.86	29.05.86	3 197	GC SUSP
PERTH BASIN									
Wittecarra 1	NFWO	WA-196-P	BHP	Regional Endeavour	15.09.85	25.10.85	06.11.85	2 890	P & A

GEOPHYSICAL ACTIVITY COMPLETED DURING 1985/86

Survey	Tenement	Company	Contractor	Vessel/crew	Dates		Kilometres recorded
					Start	Finish	
BONAPARTE BASIN							
Tidal Flats Gravity Survey	EP 126	Moonie	Wongela	-	04.10.85	07.10.85	347
Tidal Flats Aeromagnetic Survey	EP 126	Moonie	Geoterrex	-	11.10.85	14.10.85	1 012
B - 1/85 MSS	WA-199-P	Bond	GSI	Magnificent Creek	17.11.85	12.01.86	5 277
BROWSE BASIN							
Capella MSS	WA-200-P	Marathon	Western	Western Odyssey	02.01.86	27.01.86	1 502
Whimbrel MSS	WA-201-P	Ampol	GSI	Eugene McDermott II	27.01.86	16.02.86	2 481
Leveque MSS	Vacant	GSI	GSI	Eugene McDermott II	20.02.86	23.05.86	2 716
CANNING BASIN							
Shell 308 SS	EP 308	Shell	SSL	421	25.03.85	17.07.85	790
Bongabinni SS	EP 142/225	WMC	Geosystems	204	22.04.85	07.10.85	1 030
1985 Fitzroy Basin (Phase 1) SS	EPS 101	IEDC	Western	785	01.05.85	23.05.85	221
					11.10.85	12.10.85	
1985 Fitzroy Basin (Phase III) SS	EP 103	IEDC	Western	785	03.06.85	15.06.85	551
					02.07.85	09.10.85	
1985 Sturt SS	EP 216	Pontoon	GSI	1852	16.06.85	17.08.85	600
					24.10.85	06.11.85	
1985 Fitzroy Basin (Phase II) SS	EP 102	IEDC	Western	785	25.06.85	29.08.85	404
1985 Fitzroy Basin (Phase IV) SS	EP 314	IEDC	Western	785	30.06.85	01.09.85	154

Survey	Tenement	Company	Contractor	Vessel/crew	Dates		Kilometres recorded
					Start	Finish	
EP 316 1985 Amoco Canning Basin SS	EP 316	Amoco	Geosystems GSI	205 1853	15.07.85	02-05-86	2 423
EP 312 1985 Amoco Canning Basin SS	EP 312	Amoco	GSI	1853	15.07.85	16.01.86	175
Quonga SS	EP 306	Pet Securities	SSL	421	11.08.85	20.08.85	197
EP 170 Lake McLernon SS	EP 170	ESP Interior	Norpac	NV02	04.08.85	13.09.85	332
Carnegie SS	EP 309	Pontoon	GSI	1852	20.08.85	21.10.85	546
EP 142 Twin Buttes SS	EP 142	Wainoco	SSL	421	22.08.85	12.09.85	137
1985 Dampier Shelf SS	EP 114	Bridge	Western	785	15.10.85	13.02.86	811
Anna Plains 1985 SS	EP 142	Wainoco	SSL	421	15.09.85	02.10.85	206
Auld SS	EP 232	Churchill	Geosystems	204	15.10.85	15.12.85	501
EP 311 1985 Amoco Canning Basin SS	EP 311	Amoco	Geosystems GSI	205 1853	02.10.85	23.03.86	324
Meda (2) 1985 SS	EP 129	Home	Norpac	NV02	20.11.85	22.11.85	24
Radi Hill SS	EP 315	Alliance	Petty Ray	6150	22.11.85	10.01.86	350
1985 Skinners Pool SS	EP 306	Pet Securities	Norpac	NV02	23.11.85	16.12.85	256
Cardong SS	EP 231	OCA	Petty Ray	6316	10.01.86	11.02.86	379
EP 313 1986 Amoco Canning Basin SS	EP 313	Amoco	Geosystems GSI	205 1853	15.01.86	15.03.86	534
Anketell Hills SS	EP 164	SOC	Western	785	01.03.86	20.03.86	150
Jarlemai SS	EP 175	BHP	Geosystems	204	21.03.86	18.05.86	459

Survey	Tenement	Company	Contractor	Vessel/crew	Dates		Kilometres recorded
					Start	Finish	
CARNARVON BASIN							
Giralia Aeromagnetic Survey	EP 166	Golden West	Aerodata	-	05.07.85	11.07.85	4 000
Scientific Investigation No 2SL/85	Vacant Area	GSI	GSI	Blue Nabilla	24.07.85	30.07.85	1 081
Erica MSS	WA-58-P	Lasmo	GSI	Eugene McDermott II	01.08.85	12.08.85	1 246
C85A MSS	WA-155-P	BHP	GSI	Eugene McDermott II	16.08.85	22.08.85	583
Pompano MSS	WA-198-P	Minora	GSI	Eugene McDermott II	10.09.85	13.09.85	328
B85A SS	WA-64-P	BHP	GSI	Eugene McDermott II	20.09.85	24.09.85	546
Goodwyn-Tidepole Dockrell MSS	WA-28-P WA-1,5,6-L	Woodside	GSI	Eugene McDermott II	28.09.85	19.12.85	7 262
Scientific Investigation No 3SL/85	WA-25-P	GSI	GSI	Eugene McDermott II	24.09.85	24.09.85	40
Tanpool SS	EP 137	Avon	Norpac	NV02	20.09.85	10.10.85	179
Lake MacLeod West SS	EP 274	WMC	Norpac	NV02	12.10.85	18.10.85	50
J85A SS	EP 110	Esso	SSL	421	12.10.85	05.11.85	298
EP 166 Bullara SS	EP 166	Golden West	Norpac	NV02	22.10.85	16.11.85	238
1985 NW Cape-Lefroy Detail SS	EP 41	Ampol	SSL	421	11.11.85	05.12.85	152
Koolinda (2) 447 MSS	WA-24-P	Wapet	GSI	Blue Nabilla	14.11.85	07.12.85	526
B 85T WA-192-P MSS	WA-192-P	Bond	GSI	1826	18.11.85	17.02.86	209
C85B MSS	WA-155-P	BHP	GSI	Blue Nabilla	08.12.85	15.12.85	334
Barrow (8) 449 MSS	PL - 2H	Wapet	GSI	Blue Nabilla	16.12.85	18.12.85	44
Thevenard (448) Telseis SS	WA-24-P EP 65	Wapet	GSI	1826	02.03.86	04.04.86	78

Survey	Tenement	Company	Contractor	Vessel/crew	Dates		Kilometres recorded
					Start	Finish	
PERTH BASIN							
Diamond Shamrock 1985 MSS	WA-162-P	Diamond Shamrock	Western	Western Odyssey	06.07.85	22.07.85	1 666
HV85A MSS	WA-170-P	BHP	GSI	Eugene McDermott II	11.07.85	19.07.85	545
Goonderoo Extension SS	EP 278	Agnew Clough	WAIT Seismology	-	24.08.85	27.08.85	10
S85 SS	EP 111	Pancont	Norpac	NV02	22.01.86	09.02.86	75
EP 23 Experimental SS	EP 23	WMC	Norpac	NV02	11.02.86	22.02.86	15
Mount Hill SS	EP 201	Lassoc	Geosystems	204	25.02.86	10.03.86	52
Goonderoo Gravity Survey	EP 278	Agnew Clough	WAIT Seismology	-	09.05.86 15.06.86	12.05.86 20.06.86	95

MSS = MARINE SEISMIC SURVEY SS = SEISMIC SURVEY

SUMMARY COMPARISON OF EXPLORATION PERMIT DEALINGS

	1984/85		1985/86	
	No.	Area (km^2)	No.	Area (km^2)
AREA ADVERTISED				
Onshore	1	15 964	2	6 685
Offshore	14	159 678	6	15 577
Totals	15	175 642	8	22 262
PERMITS GRANTED				
Onshore	10	81 731	6	37 202
Offshore	1	2 578	3	33 153
Totals	11	84 309	9	70 355
PERMIT APPLICATIONS (pending at year end)				
Onshore	3	-	-	-
Offshore	7	-	6	-
Totals	10	-	6	-
PERMITS HELD				
Onshore	63	519 331	56	471 218
Offshore	30	248 932	32	284 893
Totals	93	768 263	88	756 111
PERMITS SURRENDERED				
Onshore	8	106 541	5	16 931
Offshore	5	34 040	1	7 192
Totals	13	140 581	6	24 123
PERMIT RENEWALS				
Onshore	4	30 893	6	44 838
Offshore	-	-	5	9 057
Totals	4	30 893	11	53 895
PERMITS CANCELLED				
Onshore	2	25 735	2	8 176
Offshore	3	59 315	-	-
Totals	5	85 050	2	8 176
PERMITS EXPIRED				
Onshore	2	16 595	6	60 208
Offshore	-	-	-	-
Totals	2	16 595	6	60 208

SUMMARY OF IDENTIFIED RECOVERABLE RESERVES AT 30 JUNE 1986

	OIL (10^6kL)		GAS $C_1 + C_2$ (10^9m^3)		L.P.G. $C_3 + C_4$ (10^6m^3)		CONDENSATE $C_5 + C_6$ (10^6kL)	
	P1	P2	P1	P2	P1	P2	P1	P2
PRODUCING FIELDS								
Barrow Island	6.63	11.04	–	11.08	0.02	0.02	–	0.39
Blina	0.23	0.56	–	–	–	–	–	–
Dongara	0.03	0.03	0.56	1.67	–	–	–	–
Mt Horner	0.50	0.50	–	–	–	–	–	–
North Rankin	–	–	224.63	271.93	15.80	18.20	24.55	29.74
Sundown	0.04	0.08	–	–	–	–	–	–
Woodada	–	–	1.39	2.75	–	–	–	–
West Terrace	0.03	0.06	–	–	–	–	–	–
Harriet	3.24	3.70	–	–	–	–	–	–
TOTAL	10.70	15.97	226.58	287.43	15.82	18.22	24.55	30.13
UNDEVELOPED FIELDS								
Angel	–	–	25.80	62.20	–	–	7.16	18.00
Brecknock	–	–	112.00	176.00	–	–	6.33	9.65
Brewster	–	–	–	55.00	–	–	–	–
Goodwyn	3.30	6.13	82.64	98.04	8.70	11.10	27.30	27.20
Gorgon	–	–	–	57.19	–	–	–	0.16
Central Gorgon	–	–	–	45.57	–	–	–	0.40
North Gorgon	–	–	–	130.34	–	–	–	1.66
Rankin	–	–	5.66	5.66	–	–	0.69	0.69
* North Herald	–	0.40	–	–	–	–	–	–
Saladin	–	2.59	–	0.18	–	–	–	–
Scarborough	–	–	170.00	555.00	–	–	–	–
Scott Reef	–	–	387.00	701.00	–	–	27.20	46.90
* South Pepper	–	0.80	–	–	–	–	–	–
Spar	–	–	–	7.04	–	–	–	0.79
* Tern	–	–	15.08	17.81	–	–	–	–
Tidepole	0.97	1.18	13.00	17.20	–	–	1.61	2.13
Tubridgi	–	–	2.14	2.16	–	–	–	–
West Tryal Rocks	–	–	–	80.73	–	–	–	3.93
Wilcox	–	–	12.40	19.50	–	–	3.62	5.47
TOTAL	4.27	11.10	825.72	2030.62	8.70	11.10	73.81	116.98
TOTAL RESERVES	14.97	27.07	1052.30	2318.05	24.52	29.32	98.36	147.11

P1 probability 75 per cent; P2 probability 25 per cent

* These figures have been prepared by the Mines Department

PETROLEUM PRODUCTION

Field or reservoir	No. of producing wells at 30.06.86	Production for year 1985/86			Cumulative production		
		Gas ($10^6 m^3$)	Condensate (10^3kL)	Oil (10^3kL)	Gas ($10^6 m^3$)	Condensate (10^3kL)	Oil (10^3kL)
CARNARVON BASIN							
North Rankin	3	2 370.91	382.17	-	3 582.08	563.89	-
Barrow Island	399	104.21	-	1 147.68	3 078.81	-	34 107.29
Harriet	5	81.02	-	202.73	81.02	-	202.73
NORTHERN PERTH BASIN							
Dongara	12	485.34	1.96	8.64	10 702.78	40.99	134.75
Mondarra	2	21.88	0.24	-	600.03	8.38	-
Yardarino	1	4.41	0.05	-	125.79	0.77	1.86
Woodada	3	61.01	0.44	-	525.57	3.92	-
Mt Horner	-	-	-	0.26	-	-	1.16
CANNING BASIN							
Blina	6	-	-	41.13	-	-	120.63
Sundown	2	-	-	7.96	-	-	18.26
West Terrace	1	-	-	8.07	-	-	8.50
Totals	434	3 128.78	384.86	1 416.47	18 696.08	617.95	34 595.18

Production LPG and Natural Gasoline to 30.06.86

	Annual	**Cumulative**
LPG	3 788 kL	53 775 kL
Nat Gasoline	7 783 kL	73 110 kL

BARROW ISLAND - WELL COMPLETION STATUS BY RESERVOIR AT 30 JUNE 1986

Horizons/pool	On production	On injection	SHUT IN			Abandoned(3)	Total
			Producers(1)	Injectors	Misc(2)		
Tertiary Carbonates(4)	-	8	1	-	-	-	9
Early Cretaceous - Gearle	1	-	11	-	1	-	13
- Windalia Radiolarite	-	-	1	-	-	-	1
- Windalia Sandstone	346	192	62	5	5	5	615
- Muderong	44	-	19	-	1	1	65
- Flacourt (Water Source)	5	-	5	-	-	1	11
- 5500' to 6200' sands	1	-	2	-	-	-	3
Late Jurassic	2	-	3	-	-	-	5
"Other Jurassic"	-	-	-	-	1	1	2
Middle Jurassic	-	-	3	-	-	-	3
Totals	399	200	107	5	8	8	727

(1) Shut-in producers includes well where attempts to obtain production have been unsuccessful.

(2) Miscellaneous includes wells cased but currently perforated plus wells completed in the water leg for observation.

(3) Abandoned wells are fully plugged and abandoned.

(4) Includes salt water disposal.

NOTE: Recompleted wells are included in horizon/pool of current completion.

DISPOSAL OF PETROLEUM 1985/86

Field	Gas sold ($10^6 m^3$)	Oil sold ($10^3 kL$)	Condensate sold ($10^3 kL$)	Royalty paid $
Barrow Island	-	1 205.20	-	26 759 100
Dongara, Mondarra, Yardarino	493.41	8.61	2.09	1 564 191
Woodada	60.84	-	0.42	431 063
Mt Horner	-	0.23	-	4 529
Blina, Sundown	-	52.51	-	761 690
North Rankin	2 201.81	-	379.33	2 568 916
Harriet	-	159.76	-	1 934 015
Totals	2 756.06	1 426.31	381.84	34 023 504

ACCIDENT STATISTICS RELATING TO THE PETROLEUM, EXPLORATION, PRODUCTION, AND PIPELINE INDUSTRY

	Year Ending 30 June 1985			Year Ending 30 June 1986		
	Onshore	Offshore	Total	Onshore	Offshore	Total
PART OF BODY						
Eye	1	8	9	2	3	5
Ear	-	2	2	-	-	-
Face	-	-	-	1	-	1
Head, neck	3	5	8	4	5	9
Trunk	10	11	21	14	9	23
Spine	2	1	3	-	-	-
Internal organs	1	1	2	1	-	1
Shoulder, upper arm	2	3	5	1	3	4
Elbow, lower arm	1	-	1	2	-	2
Wrist, hand, finger	9	17	26	10	13	23
Hip, thigh, groin	2	1	3	1	1	2
Leg, foot, toes	10	19	29	12	11	23
Skin	1	-	1	-	1	1
Multiple	-	-	-	-	-	-
Other	1	-	1	-	-	-
NATURE OF INJURY						
Fractures	7	4	11	9	1	10
Dislocations	1	-	1	1	1	2
Strains/sprains	14	16	30	17	19	36
Concussion	-	-	-	1	-	1
Internal	-	2	2	-	-	-
Amputation	-	-	-	1	-	1
Lacerations, cuts	7	10	17	6	9	15
Superficial (bruising)	8	6	14	9	5	14
Contusions, crushing	3	17	20	2	6	8
Burns	1	2	3	1	-	1
Multiple	-	1	1	-	-	-
Unconciousness	-	-	-	-	-	-
Fumed	-	-	-	-	-	-
Other	3	7	10	2	3	5
AGENCY OF INJURY						
Harmful contact	1	3	4	3	1	4
Chemicals	1	1	2	-	2	2
Slipping, falling	8	20	28	11	9	20
Falling objects	2	4	6	6	4	10
Machinery in operation	4	7	11	3	2	5
Stationary machinery	3	-	3	2	-	2
Hoisting	-	-	-	1	-	1

	Year Ending 30 June 1985			Year Ending 30 June 1986		
	Onshore	Offshore	Total	Onshore	Offshore	Total
AGENCY OF INJURY (CONT)						
Manual Labour	8	12	20	15	7	22
Vehicles	1	-	1	-	-	-
Explosions	-	-	-	-	-	-
Fires	-	-	-	-	-	-
Entrapment	9	6	15	3	8	11
Electricity	-	-	-	-	-	-
Noxious gases	-	-	-	-	-	-
Other	4	12	16	4	11	15
JOB DESCRIPTION						
Rig labour	32	56	88	36	36	72
Supervisor	4	2	6	3	2	5
Tradesman	3	4	7	7	3	10
Auxillary services	2	3	5	2	3	5
MAGNITUDE OF INJURY						
Minor	28	46	74	26	27	53
Serious	13	19	32	22	17	39
Fatal	-	-	-	-	-	-
TIME FACTOR						
Man-hours exposure	944 930	1 586 664	2 531 594	711 813	2 314 714	3 026 527
Man hours lost	8 288	15 876	24 164	11 424	18 998	30 422
FREQUENCY RATE	43.39	40.97	41.87	67.43	58.32	60.47

MINING TENEMENTS IN FORCE AS AT 30 JUNE 1986

Mineral Field/ District	1978 Mining Act			1904 Mining Act
	Prospecting Licences	Exploration Licences	Mining Leases & Others	Mineral Claims & Others
01 Greenbushes	-	-	12	-
04 West Kimberley	28	47	132	231
08 Ashburton	62	36	39	-
09 Gascoyne	29	25	31	-
12 Collie	-	-	155	-
15 Coolgardie	643	27	822	24
16 Kunanalling	356	14	63	2
20 Murchison	433	26	70	17
21 Day Dawn	102	3	18	17
24 Broad Arrow	672	13	216	5
25 Bulong	174	10	81	2
26 East Coolgardie	507	16	280	104
27 Kanowna	259	12	78	3
28 Kurnalpi	119	42	34	-
29 Menzies	346	20	49	12
30 Ularring	249	5	60	1
31 Yerilla	386	16	73	2
36 Lawlers	203	20	54	33
37 Mt Malcolm	819	23	157	14
38 Mt Margaret	350	34	78	11
39 Mt Morgans	396	38	98	1
40 Niagara	306	7	34	1
45 Pilbara	590	179	194	42
46 Nullagine	256	28	71	4
47 West Pilbara	230	82	153	28
51 Meekatharra	522	32	166	10
52 Peak Hill	114	59	105	3
53 Wiluna	137	39	99	127
57 Black Range	160	43	69	16
58 Mt Magnet	261	14	110	16
59 Yalgoo	263	52	89	1
63 Dundas	139	26	128	10
66 Northampton	5	-	2	-
69 Warburton	2	2	9	-
70 South West	134	67	241	507
74 Phillips River	52	7	36	15
77 Yilgarn	688	59	202	27
80 Kimberley	299	136	175	78
Special Agreement Act areas			28	
TOTAL	10 286	1 259	4 503	1 364

TOTAL AREA OF MINING TENEMENTS IN-FORCE

As at	Area (hectares)
31-12-82	12 756 046
31-12-83	10 505 270
31-12-84	17 308 525
30-06-85	18 414 443
30-06-86	17 496 124

AVERAGE NUMBER OF PERSONS EMPLOYED IN MINING OPERATIONS IN WESTERN AUSTRALIA DURING 1985/86

MINERAL Company	Location	Above Ground	Below Ground	Total
ALUMINA				
Alcoa of Australia Ltd	Jarrahdale/Kwinana	1 388	-	1 388
	Del Park/Huntley/Pinjarra	1 905	-	1 905
	Wagerup	467	-	467
	Administration	257	-	257
Worsley Alumina Pty Ltd	Worsley	914	-	914
				4 931
COAL				
Griffin Coal Mining Co Ltd	Collie	468	-	468
Western Collieries Ltd	Collie	430	339	769
				1 237
COPPER/SILVER/ZINC				
Seltrust Mining Corp. Ltd	Teutonic Bore	59	-	**59**
DIAMOND				
Argyle Diamond Mines Joint Venture	Lake Argyle	728	-	728
Bow River Joint Venture	Lissadell	24	-	24
				752
GOLD				
Australian Consolidated Minerals Ltd	Day Dawn	33	34	67
	Westonia	71	-	71
Australis Mining NL	Dundas/Norseman	34	-	34
Austwhim Resources NL	Cork Tree Well	26	-	26
Bamboo Creek Joint Venture	Bamboo Creek	36	8	44
BHP Minerals Ltd	Grants Patch/Ora Banda	35	-	35
Broad Arrow Joint Venture	Broad Arrow	16	-	16
Brunswick NL	Lennonville	53	-	53
Central Kalgoorlie Gold Mines NL	Kalgoorlie	33	-	33
Central Murchison Gold Ltd	Mt Magnet	20	-	20
Central Norseman Gold Corp. NL	Norseman	90	286	376
Edjudina Gold Mines Pty Ltd	Edjudina	76	-	76
Electrum NL	Brilliant	16	-	16
Endeavour Resources Ltd	Yaloginda	68	-	68
Forsayth NL	Lawlers	38	-	38
Great Victoria Gold Ltd	Marvel Loch	42	-	42
Harbour Lights Mining Ltd	Leonora	93	-	93
Hill 50 Gold Mine NL	Mt Magnet	97	91	188
Horseshoe Lights Gold Pty Ltd	Horseshoe	35	-	35
Kia Ora Gold Corp. Ltd	Marvel Loch	72	30	102
KLV - Mt Charlotte	Kalgoorlie	159	202	361
KLV - Perseverance	Boulder	209	315	524
Metana Minerals NL	Reedy	26	-	26
Mt Percy Project	Kalgoorlie	43	-	43
New Broken Hill Cons. Ltd	Leonora	32	-	32
North Kalgurli Mines Ltd	Boulder	242	146	388
Otter Exploration NL	Lake Grace	23	-	23
Paddy's Flat Project	Ingliston	11	10	21
Pancontinental Goldmining Areas Pty Ltd	Paddington	109	-	109
Paringa Project	Boulder	30	55	85
Pennant Mining Pty Ltd	Trafalgar	12	-	12
Sons of Gwalia Ltd	Leonora/King of the Hills	29	-	29
Southern Goldfields Ltd	Marvel Loch	31	-	31
Spargos Exploration Pty Ltd	Lawlers	33	-	33
Telfer Project	Telfer	237	-	237
West Coast Holdings Ltd	Black Flag/Carbine	25	-	25
Western Alluvials Pty Ltd	Wiluna	20	-	20
Whim Creek Cons. NL	Meekatharra	76	-	76
WMC - Gt Boulder Holdings	Agnew	4	-	4
	Kambalda	59	40	99
	Lancefield	47	57	104
WMC - Gt Boulder Mines	Boulder	12	-	12
WMC - Sand King	Ora Banda	10	-	10
All Other Operators		674	102	776
		✓ 3137	1376	~~4 498~~ 4513
IRON ORE				
Broken Hill Pty Ltd	Yampi	487	-	487
Goldsworthy Mining Ltd	Pilbara/Port Hedland	963	-	963
Hammersley Iron Pty Ltd	Tom Price-Paraburdoo/Dampier	4 396	-	4 396
Mt Newman Mining Co Ltd	Newman/Port Hedland	3 858	-	3 858
Robe River Mining Co Pty Ltd	Pannawonica/Cape Lambert	1 762	-	1 762
				11 466
MINERAL BEACH SAND				
Allied Eneabba Pty Ltd	Eneabba	347	-	347
Associated Minerals Cons. Ltd	Capel	140	-	140
	Eneabba	129	-	129
Cable Sands Pty Ltd	Capel	130	-	130
Westralian Sands Ltd	Capel	213	-	213
				959
NICKEL				
Agnew Mining Co Pty Ltd	Leinster	288	103	391
Metals Exploration Ltd	Nepean	30	40	70
Western Mining Corporation	Kalgoorlie	378	-	378
	Kambalda	652	641	1 293
	Kwinana Refinery	402	-	402
	Mt Windarra	338	85	423
				2 957
PETROLEUM PRODUCTS				
Bond Corporation Pty Ltd	Harriet	55	-	55
Home Energy Pty Ltd	Blina/Sundown	6	-	6
Pacific Basin Exploration	Mt Horner	2	-	2
Strata Oil NL	Woodada	4	-	4
West Australian Petroleum Pty Ltd	Barrow Island	174	-	174
	Dongara	18	-	18
Woodside Offshore Petroleum Pty Ltd	North Rankin A/Burrup Peninsula	1 324	-	1 324
				1 583
SALT				
Dampier Salt Ltd	Dampier	207	-	207
	Lake McLeod	129	-	129
Leslie Salt Co	Port Hedland	99	-	99
Shark Bay Joint Venture	Shark Bay	84	-	84
				519
ALL OTHER MATERIALS (Including Rock Quarries)		730	-	730
	TOTALS:	27 107	2 584	29 691

corrected BK 13/10/87.

ROYALTY RECEIPTS 1985/86

Mineral	Value ($A)			% up (% down)
	1984/85	1985/86	variance	
Alumina	9 638 703	9 923 606	284 903	3
Building stone	896	792	(104)	(11)
Clay	128 566	88 672	(39 894)	(31)
Coal	1 090 174	1 400 429	310 255	28
Cobalt	93 540	131 844	38 304	41
Construction materials				
aggregate	58 712	28 996	(29 716)	(51)
gravel	14 684	6 907	(7 777)	(53)
rock	14 262	21 779	7 517	53
sand	52 398	134 051	81 653	156
Copper	586 568	276 349	(310 219)	(53)
Diamond	3 062 632	2 864 655	(197 977)	(6)
Diatomite	120	281	161	134
Dolomite	60	369	309	515
Emerald	-	126	126	Inf.
Feldspar	1 655	2 906	1 251	76
Garnet sand	7 177	11 327	4 150	58
Gold	100 622	103 663	3 041	3
Gypsum	159 134	118 963	(40 171)	(25)
Iron ore	88 531 269	101 950 692	13 419 423	15
Limestone	88 437	86 091	(2 346)	3
Magnesite	10 797	-	(10 797)	(100)
Mineral beach sands				
ilmenite	909 724	1 150 156	240 432	26
kyanite	-	1 285	1 285	Inf.
leucoxene	98 546	133 303	34 757	35
monazite	182 708	282 594	99 886	55
rutile	492 691	1 173 396	680 705	138
xenotime	985	2 742	1 757	178
zircon	987 802	1 486 272	498 470	51
Nickel	5 572 626	5 926 069	353 443	6
Ochre	-	1 460	1 460	Inf.
Palladium	23 018	15 247	(7 771)	34
Peat	-	11 719	11 719	Inf.
Petroleum Products				
condensate	179 770	641 546	461 776	257
crude oil	13 621 418	29 538 137	15 916 719	117
natural gas	3 754 615	3 843 821	89 206	2
Platinum	23 011	15 247	(7 764)	34
Salt	505 586	555 276	49 690	10
Semi-precious stones				
amethyst	5 697	10 581	4 884	86
moss opal	80	1	(79)	(99)
tiger eye	-	3 766	3 766	Inf.
Silica sand	160 217	180 720	20 503	13
Silver	76 573	163 756	87 183	114
Spodumene	82 179	48 803	(33 376)	(41)
Talc	74 073	80 442	6 369	9
Tantalite	67 425	86 284	18 859	28
Tin	144 785	125 563	(19 222)	(13)
Vermiculite	596	377	(219)	(37)
Zinc	389 744	350 598	(39 146)	(10)
Total value	130 994 275	162 981 659	31 987 384	24

QUANTITY AND VALUE OF MINERALS 1984/85, 1985/86

Mineral	Unit Quantity	1984/85		1985/86	
		Quantity	Value ($)	Quantity	Value ($)
Alumina	tonne	5 326 982	1 056 839 641	5 430 255	1 029 283 528
Building Stone					
black granite	t	-	-	145	45 000
quartz	t	2 644	118 980	2 233	100 481
Clay					
attapulgite	t	-	-	41 885	n.a.
cement clay	t	28 155	70 389	23 131	57 828
fire clay	t	242 489	292 136	255 015	306 018
kaolin	t	1 710	31 505	4 600	188 422
white clay	t	-	-	126 899	372 318
Coal	t	3 672 619	109 120 090	3 765 045	126 840 815
Cobalt	t	449	5 937 452	515	9 230 525
Construction Material					
aggregate	t	160 544	1 007 069	117 255	744 055
gravel	t	58 944	67 107	6 379	16 098
rock	t	46 524	92 686	92 044	184 092
sand	t	594 017	1 007 661	886 091	1 660 770
Copper	t	3 424	3 141 119	3 484	4 162 432
Copper Concentrate	t	48 533	12 803 570	44 468	9 700 345
Cupreous Ore	t	42	6 748	-	-
Diamond	carat	5 569 285	45 056 768	17 472 460	147 567 905
Diatomite	t	257	1 029	1 638	8 450
Dolomite	t	300	2 100	330	2 310
Emerald	gram	-	-	225	1 685
Felspar	t	4 779	32 017	10 104	67 700
Garnet Sand	t	4 269	149 459	8 166	285 810
Gold	kilogram	37 425	508 891 876	46 072	707 113 630
Gypsum	t	545 151	6 169 189	348 639	3 908 872
Iron Ore	t	89 296 548	1 830 519 885	85 513 414	1 965 666 843
Limestone	t	209 618	1 187 327	206 289	1 088 735
Magnesite	t	16 729	215 936	-	-
Mineral Beach Sand					
ilmenite	t	1 187 577)		1 050 131)	
reduced ilmenite	t	140)	55 385 867	-)	59 817 919
upgraded ilmenite	t	69 516)		57 818)	
kyanite	t	39	3 618	249	29 817
leucoxene	t	19 571	4 583 699	19 002	6 219 583
monazite	t	16 590	7 512 887	17 962	10 384 934
rutile	t	73 484	25 457 848	71 794	30 751 960
xenotime	t	42	397 547	25	345 693
zircon	t	362 339	41 279 076	349 030	48 356 864
Nickel Concentrate	t	486 491	363 306 720	455 155	313 472 129
Nickel Ore	t	-	-	45 937	8 490 324
Palladium	kilogram	461	2 491 786	421	2 050 352
Peat	t	-	-	10 238	441 894
Petrol Products					
condensate	t	94 861	n.a.	293 088	n.a.
crude oil	kilolitre	1 216 456	284 790 518	1 430 180	311 924 009
natural gas	'000m^3	1 759 631	165 844 011	2 756 065	291 608 694
Platinum	kilogram	81	1 225 011	94	1 498 493
Salt	t	4 822 931	88 560 999	4 814 138	95 326 825
Semi-precious Stone					
amethyst	kilogram	59 586	90 368	8 988	50 716
moss opal	kilogram	-	-	21	14
tiger eye	t	-	-	54	50 214
Silica Sand	t	404 636	1 274 898	377 009	665 887
Silver	kilogram	44 670	12 761 245	41 135	10 705 718
Spodumene	t	8 505	1 852 772	12 690	2 967 402
Talc	t	182 613	n.a.	133 262	n.a.
Tantalite	t	69	4 219 279	143	4 853 625
Tin Concentrate	t	569	9 442 807	679	6 371 195
Vermiculite	t	471	7 740	552	9 034
Zinc Concentrate	t	42 438	10 451 891	75 946	20 044 441
Total Value			4 663 702 326		5 235 042 403

QUANTITY OF GOLD (KG) AND ORE TREATED 1985/86
SHOWING MINERAL FIELD DISTRICT

Mineral Field District	Alluvial kilograms	Dollied and specimens (kilograms)	Milled or smelted		Total gold kilograms	Silver (kilograms)
			Ore treated (tonnes)	Gold therefrom kilograms		
KIMBERLEY	7.588	0.352	-	-	7.940	0.584
WEST KIMBERLEY	-	-	-	-	-	-
Marble Bar	32.111	1.752	1 431 728.00	5 060.569	5 094.432	353.199
Nullagine	48.343	4.634	279.00	1.872	54.849	1.740
PILBARA	80.454	6.386	1 432 007.00	5 062.441	5 149.281	354.939
WEST PILBARA	6.177	0.119	-	-	6.296	0.531
ASHBURTON	3.618	0.248	-	-	3.866	0.085
GASCOYNE	0.111	0.175	120.00	0.367	0.653	0.079
PEAK HILL	40.490	0.032	398 466.00	1 685.679	1 726.201	108.948
Lawlers	4.452	0.127	87 531.00	956.966	961.545	16.252
Wiluna	3.332	0.296	-	527.930	531.558	72.754
Black Range	11.677	1.645	527.00	72.101	85.423	1.116
EAST MURCHISON	19.461	2.068	88 058.00	1 556.997	1 578.526	90.122
Cue	34.292	2.594	200 545.00	759.456	796.342	2.127
Meekatharra	80.011	3.716	649 574.00	1 702.367	1 786.094	10.442
Day Dawn	13.236	-	13 968.00	252.492	265.728	57.043
Mt Magnet	7.569	0.767	451 943.00	1 721.993	1 730.329	186.937
MURCHISON	135.108	7.077	1 316 030.00	4 436.308	4 578.493	256.549
YALGOO	2.306	0.738	1 211.00	53.501	56.545	8.253
Mt Morgans	18.281	0.281	1 077.00	11.140	29.702	1.970
Mt Malcolm	18.734	0.859	1 365 193.00	4 582.977	4 602.570	156.515
Mt Margaret	13.385	4.538	323 389.00	1 281.857	1 299.780	275.332
MT MARGARET	50.400	5.678	1 689 659.00	5 875.974	5 932.052	433.817
Menzies	1.355	0.774	231.00	153.116	155.245	21.068
Ularring	0.230	-	31 671.00	32.759	32.989	0.289
Niagara	0.230	0.012	152.00	4.458	4.700	0.553
Yerilla	0.106	6.664	281 170.00	932.172	938.942	211.393
NORTH COOLGARDIE	1.921	7.450	313 224.00	1 122.505	1 131.876	233.303
BROAD ARROW	0.541	0.527	1 079 936.00	3 045.710	3 046.778	84.589
Kanowna	5.017	0.267	6 662.00	33.669	38.953	2.137
Kurnalpi	-	-	79.00	0.433	0.433	0.022
NE COOLGARDIE	5.017	0.267	6 741.00	34.102	39.386	2.159
East Coolgardie	4.887	3.037	2 755 718.00	11 387.452	11 395.376	2 979.810
Bulong	0.089	0.075	3.00	1.629	1.793	0.567
EAST COOLGARDIE	4.976	3.112	2 755 721.00	11 389.081	11 397.169	2 980.377
Coolgardie	5.208	0.923	828 525.00	3 909.875	3 916.006	939.059
Kananalling	3.590	0.086	124 133.00	124.821	128.497	0.620
COOLGARDIE	8.798	1.009	952 658.00	4 034.696	4 044.503	939.679
YILGARN	1.525	0.621	1 022 324.00	3 387.043	3 389.189	291.207
DUNDAS	0.780	-	323 109.00	3 643.744	3 644.524	2 243.879
PHILLIPS RIVER	-	-	801.00	46.749	46.749	7.629
SOUTH WEST	-	-	89 855.00	289.722	289.722	-
STATE GENERALLY	1.643	0.735	-	-	2.378	0.175
TOTAL	370.914	36.594	11 469 920.00	45 664.619	46 072.127	8 036.904

QUANTITY AND VALUE OF MINERALS:
SHOWING MINERAL FIELD AND METALLIC CONTENT

Mineral	Mineral Field	Quantity tonnes	Metallic Content	Value ($)	Ref.
Alumina	South West	5 430 255		1 029 283 528	(a)
Building stone:					
black granite	West Kimberley	145		45 000	
quartz	South West	2 233		100 481	
		2 378		145 481	(b)
Clay:					
attapulgite	South West	41 885		NA	
cement clay	South West	23 131		57 828	
fire clay	South West	255 015		306 018	
kaolin	Greenbushes	4 600		188 422	
white clay	South West	126 899		372 318	
		451 645		924 586	(b)
Coal	Collie	3 765 045		126 840 815	(h)
			Cobalt tonnes		
Cobalt (metallic by-product of nickel mining)	Coolgardie		381.482	7 308 394	
	East Murchison		133.909	1 922 131	
			515.391	9 230 525	(c)
Construction Materials:					
aggregate	East Coolgardie	93 400		666 812	
	Kimberley	7 428		29 712	
	Pilbara	3 956		15 033	
	West Pilbara	12 471		32 498	
		117 255		744 055	(b)
gravel	Pilbara	3 839		3 839	
	West Pilbara	2 540		12 259	
		6 379		16 098	(b)
rock	West Pilbara	92 044		184 092	(b)
sand	Coolgardie	11 594		45 921	
	East Murchison	2 573		12 350	
	Kimberley	10 266		41 064	
	Pilbara	19 735		101 969	
	South West	773 665		1 292 907	
	West Kimberley	19 000		38 000	
	West Pilbara	49 258		128 559	
		886 091		1 660 770	(b)
		1 101 769		2 605 015	

QUANTITY AND VALUE OF MINERALS:
SHOWING MINERAL FIELD AND METALLIC CONTENT - continued

Mineral	Mineral Field	Quantity tonnes	Metallic Content	Value ($)	Ref.
			Copper t		
Copper (metallic by-product of nickel mining)	Coolgardie		2 691.371	3 436 840	
	East Murchison		792.459	725 592	
			3 483.830	4 162 432	(c)
			Copper t		
Copper Concentrates	Mt Margaret	44 468	8 787.746	9 700 345	(c)
			Carats		
Diamond	Kimberley		17 472 460	147 567 905	(c)
Diatomite	South West	1 638		8 450	(d)
Dolomite	South West	330		2 310	(d)
			Grams		
Emerald	North Coolgardie		225	1 685	(d)
Felspar	South West	10 104		67 700	(d)
Garnet sand	South West	8 166		285 810	(d)
		Ore treated	Estimated kg*		
Gold	State generally	11 469 920	46 072.127	707 113 630	
	*Includes alluvial, dollied + specimens, gold obtained from tailings retreatment and gold contained in exported gold-bearing material.				
Gypsum	Dundas	35 848		322 632	(d)
	Gascoyne	157 578		2 681 468	(c)
	South West	71 913		648 287	(b), (d)
	Yilgarn	83 300		256 485	(d)
		348 639		3 908 872	
	Plaster of Paris reported as manufactured during the year - 54 520 tonnes from 79 511 tonnes of gypsum by two companies.				

QUANTITY AND VALUE OF MINERALS:
SHOWING MINERAL FIELD AND METALLIC CONTENT - continued

Mineral	Mineral Field	Quantity tonnes	Metallic Content	Value ($)	Ref.
			Assay Fe %		
Iron Ore:					
Ore shipped interstate	Peak Hill	4 684 092	64.00	89 404 231	
	Pilbara	104 266	62.18	2 911 591	
	West Kimberley	1 493 223	67.53	16 425 453	
	West Pilbara	368 813	62.89	7 247 484	
		6 650 394		115 988 759	
Ore exported overseas	Peak Hill	22 404 461	63.00	589 145 056	
	Pilbara	5 059 328	63.43	120 900 346	
	West Kimberley	2 372 158	66.71	56 073 267	
	West Pilbara	49 027 073	61.40	1 083 559 415	
		78 863 020		1 849 678 084	
		85 513 414		1 965 666 843	(c)
Limestone	South West	200 289		1 082 735	
	West Pilbara	5 971		5 971	
		206 289		1 088 735	(b)
			Av. Assay TiO_2%		
Mineral beach sands:					
ilmenite	South West	1 050 131	56.53)		
upgraded ilmenite	South West	57 818	92.00)	59 817 919	(c)
kyanite	South West	249		29 817	(c)
			TiO_2 tonnes		
leucoxene	South West	19 002	17 113	6 219 583	(c)
			ThO_2 units		
monazite	South West	17 962	115 246	10 384 934	(c)
			TiO_2 tonnes		
rutile	South West	71 794	68 409	30 751 960	(c)
			Y_2O_3 kg		
xenotime	South West	25	2 400	345 693	(c)
			ZrO_2 tonnes		
zircon	South West	349 030	230 149	48 356 864	(c)

QUANTITY AND VALUE OF MINERALS:
SHOWING MINERAL FIELD AND METALLIC CONTENT - continued

Mineral	Mineral Field	Quantity tonnes	Metallic Content	Value ($)	Ref.
			Assay Ni%		
Nickel concentrates	Coolgardie	282 153	11.31	188 954 687	
	East Coolgardie	23 299	11.68	16 668 209	
	East Murchison	84 058	12.69	65 742 624	
	Mt Margaret	65 645	10.63	42 106 609	
		455 155		313 472 129	(e)
			Assay Ni%		
Nickel ore	Coolgardie	45 937	3.03	8 490 324	(b)
			kg		
Palladium (metallic by-product of nickel mining)	Coolgardie		420.585	2 050 352	(c)
Peat	South West	10 238		441 894	(b)
	Basin				
Petroleum: condensate	Carnarvon	291 150		NA	
	Perth	1 938		NA	
		293 088			
		Kilolitres			
crude oil	Canning	56 384		11 734 187	
	Carnarvon	1 364 960		298 375 541	
	Perth	8 836		1 814 281	
		1 430 180		311 924 009	(g)
		$m^3 10^3$			
natural gas	Carnarvon	2 201 812		257 661 700	
	Perth	554 253		33 946 994	
		2 756 065		291 608 694	(i)
		kg			
Platinum (metallic by-product of nickel mining)	Coolgardie	94.460		1 498 493	(c)
Salt	Gascoyne	1 421 420		95 326 825	
	Pilbara	1 605 412		31 572 864	
	West Pilbara	1 787 306		36 834 888	
		4 814 138		95 326 825	(c)

QUANTITY AND VALUE OF MINERALS:
SHOWING MINERAL FIELD AND METALLIC CONTENT - continued

Mineral	Mineral Field	Quantity tonnes	Metallic Content	Value ($)	Ref.
Semi-precious stones:			kg		
amethyst	Gascoyne		8 988	50 716	
moss opal	Dundas		21	14	
tiger eye	West Pilbara	53.98		50 214	
				100 944	(d)
Silica sand	Coolgardie	83 068		203 518	
	South West	293 941		462 359	
		377 009		665 887	(c)
			kg		
Silver	By-product of gold mining		7 160.662	1 333 945	
	By-product of nickel mining		715.685	143 724	(c)
	Mt Margaret		33 258.830	9 228 049	(c)
			41 135.177	10 705 718	
			LiO_2 t		
Spodumene	Greenbushes	12 690.174	888.31	2 967 402	(c)
Talc	South West	133 262		NA	
			Ta_2O_5 kg		
Tantalite	Greenbushes	140.560	64 504	4 752 625	
	Pilbara	2.824	1 519	101 000	
		143.384	66 023	4 853 625	(c)
			Sn tonnes		
Tin	Greenbushes	646.72	452.70	6 015 615	
	Pilbara	32.34	23.42	355 580	
		679.26	476.12	6 371 195	(c)
Vermiculite	Phillips River	552		9 034	(d)
			Zn tonnes		
Zinc	Mt Margaret	75 946	31 822.075	20 044 441	(c)
	Value of minerals			4 527 928 773	
	Value of gold			707 113 630	
				5 235 042 403	

ABBREVIATIONS

cons.	concentrates	f.o.t.	free on truck
f.o.b.	free on board	n.a.	not available
f.o.r.	free on rail		

REFERENCES

(a) Value based on the average Australian value of alumina as published by the Bureau of Mineral Resources in the Australian Mineral Industry Review.

(b) Value at works.

(c) Estimated f.o.b. value.

(d) Estimated f.o.r. value.

(e) Estimated f.o.b. value based on the current price of nickel-containing products.

(f) Nett wellhead value.

(g) Value based on the price per barrel as assessed by the Commonwealth for crude oil at Kwinana.

(h) Value at pithead.

(i) Nominal price at wellhead

UNITS AND CONVERSION FACTORS

	Metric unit	Symbol	Imperial unit	Conversion factors	
				Multiply imperial unit by	Multiply metric unit by
Mass	gram	g	troy (fine) ounce (oz)	31.1035	0.0321507
	kilogram	kg	pound (lb)	0.453592	2.20462
	tonne	t	long tonne (2240 lbs)	1.01605	0.984207
	tonne	t	short tonne (2000 lbs)	0.907185	1.10231
Volume	cubic metre	m^3	barrel (bbl)	0.158987	6.28981
	litre	L	gallon	4.54609	0.2199692
	kilolitre	kL			

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