Overview of the mineral sector in Western Australia in 2001–02

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Abstract

Consistent with worldwide trends and Australia as a whole, mineral-exploration expenditure figures (excluding petroleum) for Western Australia fell for the fifth successive year, dropping to $376 million in 2001–02, down by 46% since the peak activity in 1996–97. Trends and issues affecting exploration include merger and acquisition activity, a swing away from greenfields exploration, difficulties in obtaining seed and venture capital for junior explorers, declining mining-company market capitalization, taxation, land access, Aboriginal heritage issues, and perceived investment risk.

Drilling activity (RAB, RC, and diamond) in Western Australia is down by about 65% since the peak of 1996–97 and such a decline, together with access difficulties to land, greatly diminishes the number of opportunities for significant discoveries. These are necessary to boost mineral resource inventories, sustain the current level of mining development, and provide opportunities for growth in the industry. Both the Federal and State Governments have initiated parliamentary inquiries to identify impediments to exploration and ways to boost exploration, particularly greenfields exploration.

However, despite the downturn in exploration activities since 1996–97, important discoveries are still being made. These include the emergence of the Ashburton Basin and northeastern part of the Kimberley Basin as gold provinces, the huge resource upgrade at Telfer, further base metal discoveries at and around Golden Grove and Teutonic Bore (Jaguar), and discovery of high-grade nickel sulfides at Waterloo.

Mine development highlights include opening of the Thunderbox and Waugh gold mines, Ellendale diamond mine, West Angelas iron ore mine, and Dardanup heavy-mineral sands mine. The West Angelas operation represents a new phase in Western Australian iron ore mining as the first to market Marra Mamba iron ore as a stand-alone product. Advanced projects are numerous and include the direct smelting of iron ore (HIsmelt), the go-ahead for an iron ore mine at Eastern Ranges (near Paraburdoo), and the State's most advanced platinum–palladium project (Panton Sill) at the feasibility stage.

Mineral exploration trends

The State of Western Australia continues to attract the major proportion of mineral exploration expenditure in Australia (59%), a reflection of the State's real and perceived prospectivity (Fig. 1). However, mineral exploration expenditure figures (excluding petroleum) for Western Australia fell for the fifth successive year, from $424 million* in 2000–01 to $376 million in 2001–02, down by about 11%. This trend is also clearly illustrated by the quarterly data, which shows that the downturn is continuing (Fig. 2).

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* All $ figures in Australian dollars unless otherwise specified.

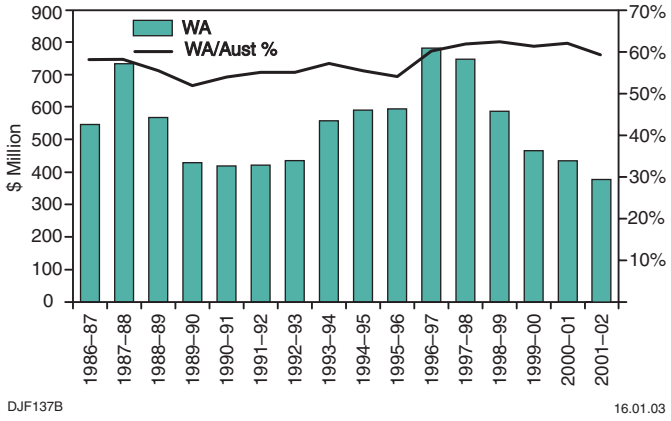

Figure 1. Mineral exploration expenditure in Western Australia, by year (June 2002 dollars)

The Western Australian figures are consistent with worldwide trends and Australia as a whole. The current level of mineral exploration expenditure within Australia is $636 million, which is 45% ($513 million) lower than the peak year of 1996–97 when expenditure reached $1149 million. The worldwide decline in exploration expenditure can be attributed to a number of factors, including continued low commodity prices, the ongoing perception of mining as a low-profit activity, lack of venture capital, slowing world growth, and the events of 11 September 2001. However, Australia and Western Australia continue to maintain their share of global exploration expenditure at about 17.5 and 10% respectively. This may be regarded as a positive reflection of the State's prospectivity as perceived by companies when they decide where to expend their reduced global exploration funds.

Exploration expenditure in Western Australia for gold and base metals (including nickel–cobalt) is now close to the lowest levels for a decade, with exploration expenditure activity similar to the recession years of the early 1990s. Despite this, Western Australia still accounts for the major proportion of the exploration dollars expended in Australia on exploration for iron ore (100%), gold (72%), diamond (82%), base metals including nickel–cobalt (47%), and heavy mineral sands (28%).

A number of trends and issues affecting exploration are now clear. They include merger and acquisition activity, a swing away from greenfields exploration, difficulties in obtaining seed and venture capital for

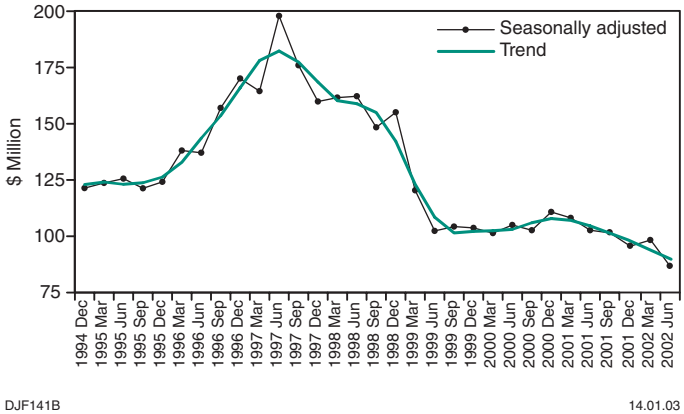

Figure 2. Mineral exploration expenditure in Western Australia, by quarter, on seasonally adjusted and trend terms (dollars of the day)

junior explorers, declining mining-company market capitalization, taxation, land access, Aboriginal heritage issues, and perceived investment risk.

Corporate rationalization, acquisitions, and mergers continued to dominate the mining industry, both nationally and internationally, but were down on the record levels of 2000–01 when more than $US60 billion of merger and acquisition activity occurred. Examples in 2001–02 include the acquisition of Normandy Ltd by Newmont Mining Corporation of America, Hill 50 Gold Mines by Harmony Gold Ltd of South Africa, AurionGold Ltd by Placer Dome Inc of Canada, and the in-progress acquisition of Lionore (Australia) Pty Ltd by Lionore International. WMC Ltd went against the current trend and plans to demerge its aluminium assets from the remainder of its core businesses.

Rather than targeting one sector of the minerals market, larger global companies are spreading asset acquisition across a number of metals, allowing diversification in the spread and depth of the mineral portfolio held by the individual companies. This spreading of risk has also been marketed as an attractive feature for investors. For example, in early 2002 Barrick advertized 'the lowest political risk profile of any major', whereas Newmont is understood to have 31% of its revenue obtained from 'politically sensitive areas' following the Normandy takeover; this is down from 42% pre-merger (Resource Stocks, 2002).

The result for the gold industry is a radical change in ownership — overseas control of Australia's gold production was 20% in 1995–96, 30% in 1999–2000, but rose to 60% in 2000–01 (Close, 2002). In contrast, the degree of ownership concentration within the copper and alumina sectors in 2002 is less than in the 1960s and 1970s.

A second trend in exploration expenditure is the steady fall in greenfields exploration. This is an important issue and is discussed in detail elsewhere in this volume in 'Declining greenfields exploration in Western Australia, 1996–2001'.

The number of junior exploration companies listed on the Australian Stock Exchange (ASX) has declined by 70% between 1997 and 2000 (from 270 companies to 80). This is a direct result of the lack of working capital, which remains a significant hurdle for juniors; the average cash reserve among explorers at the end of March 2002 was $2.1 million. A total of 95 listed mining-board companies held less than $1 million. Of these, 57 held less than $0.441 million, which was equivalent to the average cash requirements of a mining company to operate for a quarter. Amongst the 82 capital raisings in the March 2002 quarter, 39 brought in less than $0.5 million (Gonnella, 2002).

Market perceptions relating to mineral stocks also changed, and were well documented during 2001–02. For example, where the gold sector had comprised 7% of the ASX All Ordinaries Index in 1994, it was only 1% in 2001. Large investment-fund managers have used market index criteria (e.g. Dow Jones Index or TSE 300) as guides to investment in the mineral sector, and this has led to a decrease in the proportion of the metals, minerals, and gold sectors being represented in fund portfolios; from 20% in 1996 to only 5.5% in 2000 (Bogden, 2001; Brook and Alexander, 2001).

Another factor that leads to the exclusion of mining stocks from investment portfolios is the fact that the aggregate capitalization of all of the world's non-ferrous mining industry is still less than that of individual stocks such as General Electric or Microsoft. Therefore, most investment funds now require very little, if any, in the way of new mining equity to maintain their benchmark positions in mining stocks, leading to a dwindling of new capital that is available for mineral exploration.

Another issue contributing to the declining exploration expenditure in Australia is the continued perception of non-competitive taxation policies, compounded by the effect of Native Title issues on access to land.

Government inquiries into reduced mineral exploration

Both the Western Australian and Federal Governments recognize that the declining level of mineral expenditure is a major issue, and two parliamentary inquiries were commissioned during 2001–02.

In Western Australia, the State Government instigated a Ministerial Inquiry into greenfields exploration in Western Australia, chaired by Mr John Bowler MLA, Member for Eyre. The Bowler Inquiry is investigating numerous avenues that could be used to promote and increase levels of private investment in mineral exploration in Western Australia, particularly in greenfield or frontier areas. It will recommend actions that could be taken, particularly by the State and Federal Governments, to achieve a level of exploration that will sustain the resource sector's pre-eminent role in the Western Australian economy.

The Federal Government instigated a House of Representatives Inquiry, chaired by the Hon. Geoffrey Prosser MP, Federal Member for Forrest (WA). The Prosser Inquiry aims to identify impediments to increasing investment in mineral and petroleum exploration in Australia, including:

- An assessment of Australia's endowments of mineral and petroleum resources and the rates at which these are being drawn down;
- The structure of the resources industry and the role of small companies in resource exploration in Australia;
- Impediments to accessing capital, particularly by small companies;
- Access to land, including Native Title and cultural heritage issues;
- Environmental and other approval processes, including across jurisdictions;
- Public provision of geoscientific data by government agencies;
- Relationships with indigenous communities; and
- Contributions to regional development.

Mineral exploration expenditure by commodity and industry highlights

Within Western Australia, gold remains the main focus of mineral exploration (Fig. 3), accounting for about 63% of all exploration expenditure. Other commodities, in their order of importance as exploration targets in Western Australia, are base metals and nickel–cobalt (17%), diamond (8%), iron ore (5%), heavy mineral sands (2.5%), and others (4.5%).

Gold

Gold continues to be the main focus of mineral exploration expenditure in Western Australia, with $238 million expended during 2001–02. The slight recovery seen previously in 2000–01 was not sustained (Fig. 4), with expenditure declining in 2001–02 by 17% ($46 million). The level is now down 55% ($294 million) from the 1996–97 peak, and at a level equivalent to the base of the 1991–93 slump in exploration. Western Australia attracts 72% of the

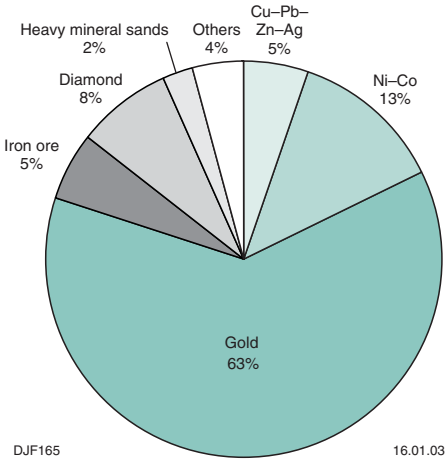

Figure 3. Mineral exploration expenditure in Western Australia, by commodity (2001–02 dollars).

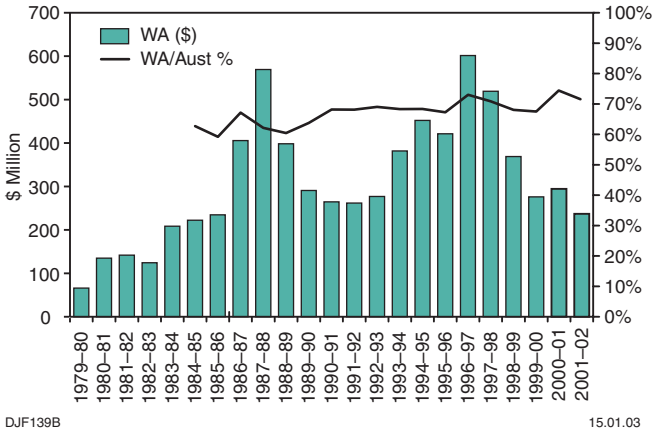

Figure 4. Gold exploration expenditure in Western Australia, by year (2001–02 dollars)

total Australian gold exploration budget (down slightly from 74% in 2000–01), with these proportions (72–74%) being the highest since 1984–85, indicating a positive perception of the State's prospectivity.

Exploration highlights for the gold sector in 2001–02 show that despite the downturn in exploration activities since 1996–97, important discoveries are still being made. Selected highlights include:

- Recovery of alluvial gold at Striker Resource's 88 Creek prospect in the north Kimberley, within a larger area containing evidence of epithermal activity. This Oombulgurri area represents a new district of gold mineralization and has caused a major re-evaluation of the gold potential of the Kimberley Basin.
- Encouraging exploration results returned from the Ashburton joint venture, near Paraburdoo, of Newcrest Ltd and Sipa Resources International NL. Results include 14 m at 5.5 g/t Au from the Ibex prospect near Cairn Hill, 17 m at 3.5 g/t Au from 16 m at the Electric Dingo prospect, and 36 m at 2.2 g/t Au from 84 m at Cheela West. These promising discoveries have led to a minirenaissance of exploration within the underexplored Proterozoic Ashburton Basin.
- Multiple high-grade mineralized zones intersected at Newmont's Jundee mine during drilling of the Westside Lode structure. Reported intercepts included 4.4 m at 148 g/t Au and 5 m at 3288 g/t Au. The Jundee Westside discovery may be similar in tonnage and tenor to the major Barton Deeps orebody.
- An electromagnetic anomaly was identified at the Winston Churchill prospect (23 km west of Kalgoorlie), which is part of the Mungari East joint venture between Dioro Exploration NL and Mines and Resources Australia. A first-pass diamond drilling program intersected thick laminated quartz veins containing visible gold. Exploration is continuing to determine whether the mineralization represents a strike extension of the Raleigh trend being mined by AurionGold Ltd to the north.
- Reporting of previously unknown mineralization from the Westonia deposit in rock types not previously thought to be gold mineralized. Westonia Mines Ltd, part of the Lion Selection Group, is currently completing a feasibility study on Westonia.
- Depth extensions to the known Sandpiper resource in the Tanami area, owned by Tanami Gold NL and Barrick Gold. Drilling encountered mineralization that is interpreted to be a down-plunge extension of the known Sandpiper lenses, showing increases in both grade and width over the shallow Sandpiper intercepts.
- Continued reports from AngloGold Ltd of anomalous gold intercepts in the vicinity of the Coyote prospect (250 km southeast of Halls Creek).

AngloGold has defined 11 prospects within 20 km of Coyote and has a further 20 exploration targets within 20–50 km of the project.

- A similar geological setting to the 750 000 oz Goldrush deposit in the Northern Territory has been found by Barrick at the Finch prospect (270 km southeast of Halls Creek) in the Tanami area.
- Placer Dome Inc., the Binduli joint venture operator, reported discovery of a new mineralized corridor at Nefertiti, 400 m west of the existing Binduli line of openpits.
- Exploration drilling by AurionGold at the White Feather Reward prospect east of Kanowna Belle (20 km northeast of Kalgoorlie) returned 3 m at 70 g/t Au in the initial drillhole.

Development highlights for the gold sector during 2001–02 include increases in the resource inventories of a number of projects, rapid development from exploration target to operating mine, and the continued re-evaluation of previously subeconomic mineralization using alternative mining or extraction methods. Selected highlights include:

- A massive upgrade in resources at the Newcrest-owned Telfer mine to 26 Moz (808 t) of gold. The Telfer project now contains one of the largest gold endowments in Western Australia. Newcrest is continuing with a feasibility study into an expanded Telfer project whereby the company plans a 25-year mine life commencing operations in 2004, with a planned production rate of about 750 000 oz of gold per annum.
- Successful mining by Placer/Aurion of Wallaby (first ore production was in late 2001). Wallaby is now the cornerstone of the Granny Smith project, and production of around 400 000 oz is expected for 2002. A further expansion is planned for 2003.
- Commencement of mining operations in mid-2002 at the Thunderbox deposit (54 km southeast of Leinster), a joint venture between Dalrymple Resources NL (40%) and Lionore Mining International Ltd (60%). Total reserves are 10.89 Mt at 2.4 g/t Au.
- Mining commenced at Raleigh, part of the Kundana East joint venture, and a feasibility study continued on the possibility of underground mining as well.
- Mining of the White Foil deposit, 23 km southwest of Kalgoorlie, commenced in mid-2002.
- Mining of the Waugh deposit (36 km southeast of Paraburdoo) started in mid-2002, marking one of the most rapid transitions from exploration discovery to mine — the deposit was discovered in November 2001.
- Commencement of mining at Minjar (50 km southeast of Yalgoo) in December 2001. Gindalbie Gold NL has produced over 1 t of gold from the project by late 2002, and further pits are under development.
- The private company Whinnen Gold Pty Ltd commenced mining of the Whinnen Shoot, part of the Hamill Resources-owned Mount Ida project (80 km northwest of Menzies) in mid-2002.
- In November 2001, Barra Resources Ltd commissioned the First Hit mine (145 km northwest of Kalgoorlie). However, the high-grade Kylies lode performed under expectations, and total production was 0.11 Mt at 7.47 g/t Au.
- The Boddington gold mine (12 km north of Boddington) was placed on indefinite care-and-maintenance in December 2001, but the joint venture partners (Newcrest Mining Ltd 22%, AngloGold Ltd 33%, and Newmont Mining Corporation 44%) obtained regulatory approvals for the $500 million Boddington Expansion (Wandoo) project.
- Plans by the Coolgardie joint venture (Mining Project Investors, Pittson Mineral Ventures of Australia Pty Ltd, and Herald Resources Ltd) to recommence underground mining of the Empress deposit and opencut mining of Lindsays pit.
- Completion of a feasibility study by Equigold NL into the development of the Kirkalocka deposits (100 km southeast of Mount Magnet). First production is expected in late 2002.

- Detailed project design and tendering activities by St Barbara Mines Ltd are in progress for the Paulsen project (180 km west of Paraburdoo). The total resources at Paulsen are 3.97 Mt at 4.5 g/t Au, and would support a five-year mine life.
- A feasibility study has been commissioned into openpit and underground mining of the Frogs Legs deposit, 22 km east of Kalgoorlie. Resources total about 3.2 Mt averaging 5.8 g/t Au.
- Pit optimization studies leading to a bankable feasibility study are underway at Mount Gibson (280 km north of Perth); Oroya Mining Ltd expects to recommence production in mid-2003.

During 2001–02, Western Australia produced 184.9 t of gold, valued at $3.279 billion. This represented a decrease in quantity of production of 16.3 t from 201.2 t in 2000–01, but a slight increase in value (by $34 million) from $3.245 billion in 2000–01. A list of the top-ten gold producers (by production) in Western Australia is presented in Table 1. The largest producers include KCGM Ltd at Golden Mile – Kalgoorlie; Gold Fields Ltd at St Ives – Kambalda; Placer Dome Inc/AurionGold Ltd at Granny Smith, Kanowna Belle, and Paddington; Newmont Mining Corporation at Jundee–Nimary; AngloGold Ltd at Sunrise Dam; and Sons of Gwalia Ltd at Marvel Loch – Southern Cross. Collectively, these produced 108.98 t of gold during 2001–02, representing 59% of the State's gold output.

Base metals and nickel–cobalt

Exploration expenditure for base metals (including nickel and cobalt) fell by 25% ($20.4 million), from $82.5 million in 2000–01 to $62 million in 2001–02. This is the fourth consecutive year of decline in base metal exploration, with expenditure down by about 52% ($55 million) since the 1996–97 peak. Nickel–cobalt exploration expenditure fell by 26% ($19.1 million) from $72.8 million in 2000–01 to $53.7 million in 2001–02. Exploration for the base metals copper, lead, and zinc fell by 19.6% ($32.5 million), from $165.4 million in 2000–01 to $132.9 million in 2001–02.

During 2001–02, Western Australia received 47% of the Australian base metal exploration budget, up slightly from 44% in 2000–01. This increase can be attributed to higher expenditures on the new discoveries of nickel sulfide and volcanic-hosted massive sulfide mineralization reported during the year.

These exploration successes include:

- The brownfields success of Pilbara Mines Ltd and Inmet Mining Corporation at the Jaguar deposit, 4 km south of the historic Teutonic Bore base metal mine (operational during 1980–85). Jaguar is a previously unknown volcanogenic massive-sulfide (VMS) system, and the discovery drillhole intersected a thickness of 7.7 m of massive sulfide mineralization assaying 4.3% Cu, 16.1% Zn, and 173 g/t Ag at 450 m drilled depth.

Table 1. Top-ten gold mining operations in Western Australia by production (2001–02)

Ranking	*Mine*	*Owner*	*Production 2001–02 (t Au)*	*Ranking 2000–01*	*Production 2000–01 (t Au)*	*% Change in production*
1	Golden Mile – Kalgoorlie	KCGM Ltd	21.79	1	25.77	-15
2	Kambalda – St Ives	Gold Fields Ltd	16.01	2	13.60	+18
3	Granny Smith	Placer Dome Inc/AurionGold Ltd	13.01	4	9.81	+33
4	Jundee–Nimary	Newmont Mining Corp	11.07	3	12.79	-13
5	Sunrise Dam	AngloGold Ltd	10.11	6	8.45	+20
6	Plutonic	Barrick Gold Corp	8.74	5	8.84	-1
7	Bronzewing – Mount McClure	Newmont Mining Corp	8.50	8	8.10	+5
8	Kanowna Belle	AurionGold Ltd	7.10	7	8.40	-15
9	Paddington	AurionGold Ltd	6.57	16	4.45	+48
10	Marvel Loch – Southern Cross	Sons of Gwalia Ltd	6.08	17	4.41	+38

- Further exploration successes reported by Newmont Mining Corporation at Golden Grove (230 km east of Geraldton), with the discovery of base metal, gold, and silver sulfides in a number of stacked, high-grade lenses at the Ethel, Zeewijk, and Hougoumont zones.
- Discovery of disseminated and fault-hosted massive nickel-sulfide mineralization by Dalrymple Resources NL at the Waterloo prospect, 48 km southeast of Leinster. The discovery drillhole returned an intercept of 10.68 m at 4.83% Ni.
- An upward revision of resources at the Fossil Downs Zn–Pb deposits following recent diamond drilling. The Fossil Downs project, about 20 km north of the Pillara minesite and within the Lennard Shelf, is owned by Western Metals Ltd.
- Outokumpu Zinc Australia Pty Ltd completed a feasibility study on the Sulphur Springs (Panorama project) VMS zinc–copper deposit (52 km west of Marble Bar).
- Significantly enhanced tonnages of nickel and cobalt resources reported from Acclaim Exploration NL's large lateritic deposit at Wingellina in the Musgrave Complex (240 km east of Warburton).
- Identification by Jubilee Mines NL of nickel sulfide mineralization at the Babylon prospect (65 km northwest of Leonora). The discovery drillhole intersected 0.9 m at 2.6% Ni from 118.8 – 119.7 m located within an identified komatiite lava channel.
- At the Bow River prospect (140 km southwest of Kununurra) in the Kimberley, Valdera Resources Ltd reported low-grade Ni–Cu intercepts, up to 20 m thick, of disseminated, stringer, and massive nickel sulfides.
- WMC Ltd reported further disseminated nickel-sulfide mineralization within the Babel–Nebo zone at the Gerar prospect (760 km northeast of Kalgoorlie) in the Musgrave Complex.
- Western Areas NL identified a new zone of nickel sulfide mineralization in the footwall zone at New Morning, in the Forrestania greenstone belt (114 km southeast of Marvel Loch). Assay results from the discovery intersection included 1.7 m at 4.1% Ni from 299.6 m.

The development highlights of the year 2001–02 included:

- Production of nickel ore recommenced at the Long–Victor complex, near Kambalda. Independence Gold NL purchased the operations from WMC Ltd in 2002.
- Lionore Australia NL decided to develop the Maggie Hays nickel deposit (110 km west of Norseman) within the Forrestania greenstone belt. The existing plant at the Emily Ann mine will be expanded to 500 000 tpa capacity.
- Underground development commenced at Western Metal Ltd's Zn–Pb deposit at Kapok West on the Lennard Shelf (76 km southeast of Fitzroy Crossing).
- The solvent extraction plant at the Nifty copper mine (located 350 km east of Port Hedland, and operated by Straits Resources) was upgraded to a nameplate capacity of 25 000 tpa. Other metallurgical modifications to the Nifty process resulted in increased recoveries and additional ore sources identified.
- A feasibility study on mining sulfide ore from the Nifty deposit was commissioned. The study is also to include an evaluation of mining of the Maroochydore copper deposit, 60 km southeast of Nifty.
- An updated feasibility study was completed by Straits Resources on the Whim Creek and Mons Cupri copper deposits (90 km east of Roebourne), with plans to utilize plant and equipment from the company's Nifty and Girilambone operations.
- Completion of a feasibility study into mining the Panorama – Sulphur Springs polymetallic VMS deposits (59 km west of Marble Bar). The Panorama project is a joint venture between Outokumpu Zinc Australia Pty Ltd and Sipa Resources International NL.

- The Magellan lead mine (30 km west of Wiluna) is under construction. The project is a joint venture between Ivernia West Inc of Ireland and the unlisted Australian company Magellan Metals Pty Ltd. Capital costs of development are estimated at $44 million.
- Tectonic Resources NL plans to mine the Trilogy shale-hosted, copper–gold–silver–lead–zinc deposit (18 km southeast of Ravensthorpe).
- BHP Billiton completed a feasibility study on the Ravensthorpe nickel laterite project (16 km east of Ravensthorpe). The company was awaiting confirmation that new low-pressure leach technology could work effectively in economically extracting nickel and cobalt.
- The feasibility study on the Sally Malay nickel sulfide deposit (105 km northeast of Halls Creek) was completed by Sally Malay Mining. The project will commence as an opencut operation, and proceed later to underground mining. Ore is to be treated using conventional technology to produce a bulk Ni–Cu–Co concentrate to be exported from Wyndham and be treated at Jinchuan Group Ltd smelter–refinery complex in China.
- Titan Resources NL purchased nickel sulfide deposits in the North Widgiemooltha block (47 km south of Kambalda) from WMC. The company also acquired nickel sulfide deposits at the Carr Boyd Rocks property (71 km southeast of Menzies) from Defiance Mining NL.
- A consortium of Mining Project Investors Pty Ltd (80%) and the OM Group (20%) acquired the Black Swan (45 km northeast of Kalgoorlie) and Honeymoon Well (37 km southeast of Wiluna) nickel sulfide projects in mid-2002;
- Fox Resources Ltd acquired nickel sulfides at the Radio Hill mine (closed) and the nearby Mount Sholl deposit (30 km southeast of Karratha) from Titan Resources.
- Mincor Resources NL purchased the closed Wannaway nickel mine (47 km southeast of Kambalda) from WMC.
- Anaconda Nickel NL completed metallurgical testwork on nickel laterite and preliminary designs for a 30 000 t trial pit at Heron Resources Ltd's Goongarrie South project.
- WMC Ltd announced long-term development of the Yakabindie nickel sulfide deposit to supplement ore from the Mount Keith operations.

During 2001–02, Western Australian mines produced about 195 000 t of nickel (as refined nickel, or as contained nickel in nickel matte and concentrate), with sales valued at $2.0 billion. About 20% of the nickel was obtained from lateritic nickel deposits, and WMC accounted for about 103 500 t (53%) of mine production. The State's top-ten nickel operations and their operators are shown in Table 2. Sales of byproduct cobalt during 2001–02 were 4 500 t valued at $133 million.

Table 2. Top-ten nickel operations in Western Australia by mine production (2001–02)

Ranking	*Mine*	*Owner*	*Production (t)*
1	Mount Keith	WMC Ltd	45 850
2	Leinster	WMC Ltd	38 405
3	Murrin Murrin	Anaconda Nickel Ltd	28 651
4	Silver Swan	Outokumpu Oyj	[(a)]21 828
5	Kambalda	WMC Ltd	19 337
6	Cosmos	Jubilee Mines NL	10 809
7	Miitel	Mincor Operations Ltd	7 759
8	Bulong	Preston Resources NL	6 409
9	Radio Hill	Titan Resources NL	5 168
10	RAV8	Tectonic Resources NL	3 260

NOTE: Production data sourced from company quarterly reports to Australian Stock Exchange
(a) Silver Swan figures reported on a calendar year, not financial year. Figures are production for 2001

Table 3. Top-three base metal operations in Western Australia by mine production (2001–02)

Ranking	*Mine*	*Owner*	*Production*		
			Cu (t)	*Pb (t)*	*Zn (t)*
1	Lennard Shelf	Western Metals Ltd	–	69 833	182 237
2	Golden Grove	Newmont Mining Corporation	26 069	[a]2 455	57 329
3	Nifty	Straits Resources Ltd	22 338	–	–

NOTE: Production data sourced from company quarterly reports to the Australian Stock Exchange
(a) Lead production reported for first half of 2001–02 only

The total value of copper, lead, and zinc production for Western Australia during 2001–02 was $337 million. Zinc dominated production, representing 51% of the total value. Zinc production dropped in quantity from 236 089 t (2000–01) to 223 669 t (2001–02), with a commensurate fall in the value of production from $280 million to $173 million respectively. Table 3 summarizes the mine production details for the top-three base metal producers in Western Australia — Western Metals (Lennard Shelf), Newmont Mining Corporation (Golden Grove), and Straits Resources (Nifty).

Diamond

Diamond exploration in Western Australia increased by $4 million (15%) to $30 million in 2001–02. About 82% of Australia's diamond exploration budget was expended in the State, mainly in the Kimberley region. The increase is due in part to:

- Commissioning by Kimberley Diamond Company NL of the State's second diamond mine at Ellendale (90 km northwest of Fitzroy Crossing). An 11.47 carat yellow octahedral diamond was recovered in 2002, and represents the largest diamond ever recorded from the Ellendale field. Mining is forecast to continue at 657 000 tpa for 2–3 years from the near-surface zones of the Ellendale 4 and 9 pipes. The first 15 months of production was expected to return about $56 million;
- Increased exploration expenditure by companies utilizing BHP Billiton's patented Falcon airborne gravity system.

Mine production of diamond in Western Australia for 2001–02 was 30.5 million carats, with Rio Tinto Ltd the only producer (Table 4). Diamond sales were valued at $489 million. Kimberley Diamond Company NL commenced production at Ellendale in mid-2002, with mine production of 4320 carats in July–August 2002.

Iron ore

During 2001–02, iron ore exploration within the State fell by 11% ($3 million), from $23 million in 2000–01 to $20 million in 2001–02. A combination of factors was responsible, including the collapse of the Kingstream Steel consortium, apparent lack of significant progress by the Austeel consortium

Table 4. Western Australia diamond production (2001–02)

Ranking	*Mine*	*Owner*	*Production (carats)*
1	Argyle	Rio Tinto Ltd	[a]30 563 000
2	Ellendale	Kimberley Diamond Co NL	[b]4 320

NOTE: Production data sourced from company quarterly reports to the Australian Stock Exchange
(a) Production includes both AK1 and alluvial diamond sources
(b) Production for first 5.5 weeks of opearation in 2002, equates to August 2002 production

that is developing the Fortescue deposits, and the uncertainty over the development of the Hope Downs deposits, where access to railway infrastructure remains contentious. However, there were some very significant positive developments during 2001–02.

Development highlights of the year included:

- Opening of the West Angelas mine (110 km west of Newman) in mid-2002. The West Angelas operation, owned by Robe River Iron Associates, comprises an openpit mine, an ore processing plant producing lump and fine ores, stockpiles, reclaimers, and train-loading facilities. Ore production commenced in April 2002. The mine is producing at an initial 7 Mtpa, which is expected to rise to approximately 20 Mtpa by 2005. The West Angelas operation represents a new phase in Western Australian iron ore mining as the first to market Marra Mamba iron ore as a stand-alone product.
- Signing of a joint-venture agreement between Hamersley Iron (Rio Tinto) and China's largest steel maker, Shanghai Baosteel Group Corporation (Baosteel), to form an unincorporated iron ore joint-venture operation in which Hamersley Iron will supply Baosteel with a total of 200 Mt of iron ore products, averaging 10 Mtpa over the joint venture's 20-year life. The arrangement includes the development of a new mine (Eastern Ranges), 10 km east of Hamersley's established Paraburdoo mine, with an initial capital outlay of $124 million (US$64 million).
- Agreement by Rio Tinto to continue development of the HIsmelt direct smelting project at Kwinana.
- $100 million expansion plans announced by Portman Ltd. These included upgrading of the Esperance harbour facilities and commissioning of a feasibility study to develop the Windarling and Mount Jackson deposits about 130 km north of Southern Cross.
- Agreement by Portman Ltd to extract a further 4 Mt of ore from below sea level at Cockatoo Island in the west Kimberley.
- Aztec Resources is evaluating the feasibility of recommencing iron-ore mining operations at Koolan Island in the west Kimberley.
- A study by Mount Gibson Iron Ltd into the feasibility of mining Tallering Peak (following its purchase from Kingstream Steel Ltd) and exporting shipping-grade hematite from Geraldton.

During 2001–02, Western Australia produced 159.79 Mt of iron ore, valued at $5.098 billion, of which 94% was exported. This represented a slight decrease in quantity of production (1.98 Mt), but a slight increase in value of production ($0.19 billion), from 2000–01. The major producers and their approximate share of production are BHP Billiton (42%), Rio Tinto Ltd (37%), Rober River Iron Associates (17%), and Portman Ltd (3%).

Heavy mineral sands

Mineral sand exploration in Western Australia had declined in the period 1997–2001 in response to the change in focus by explorers to the Murray Basin in Australia's eastern states. During that time, Western Australia was regarded as a mature exploration area for heavy mineral sands, hence Western Australia's share of the Australian exploration expenditure for heavy minerals fell steadily — from 69% in 1994–95 to only 28% in 2001–02. However, exploration expenditure on mineral sands in Western Australia during 2001–02 increased by 17% ($1 million) from $8 million to $9 million.

Nissho Iwai Corporation of Japan advised during 2001–02 that it was considering divestment of its Australian subsidiary, RZM Cable Sands (WA) Pty Ltd, which has operations at Sandalwood, Jangardup, and Yarloop and a dry-separation plant at Bunbury.

Activity highlights for the year included:

- Opening of the $30 million Dardanup mine (17 km east of Bunbury) owned by Doral Mineral Industries. The mine is expected to produce about 110 000 tpa of ilmenite and 10 000 tpa each of leucoxene and zircon over a planned nine-year mine life.

- Completion of a prefeasibility study on the Dongara project (26 km southeast of Dongara) owned by Magnetic Minerals NL. Ticor were undertaking due diligence on the deposit in late 2002.
- Plans by Cable Sands to develop the Jangardup South mineral sands deposit (45 km east of Augusta) were given a boost when a Native Title agreement was signed, following two years of negotiation, with the Boojarah people.

During 2001–02, Western Australia produced 1.87 Mt of heavy mineral sands (ilmenite, upgraded ilmenite or synthetic rutile, rutile, staurolite, leucoxene, and zircon, but excluding garnet) valued at $848 million. Lower pigment prices, together with excess inventory, maintenance shutdowns, and commissioning problems, led producers to be below 2000–01 production figures, when a total of 2.24 Mt of heavy mineral sands valued at $904 million were produced.

Tantalum

The fall in the tantalum price during 2001–02, due to disputes between end-purchasers of tantalum product, has affected exploration expenditure and caused several planned mining operations to be shelved.

Sons of Gwalia Ltd, which had committed to a $70 million expansion of the Greenbushes project (15 km northwest of Bridgetown) in 2000, saw the mine expansion opened by the Minister for State Development, Clive Brown, in 2002. Production capacity is now a nameplate 1.25 million pounds of Ta_2O_5 per annum. A similar upgrade in plant capacity, from 0.8 to 1.1 million pounds per annum, at a cost of $35 million, was made for Sons of Gwalia's Wodgina operation (110 km south of Port Hedland). Haddington International Resources Ltd commenced production from its Bald Hill mine (60 km southeast of Kambalda) in 2001, with all of the concentrate from a 200 000 tpa throughput being sold to Sons of Gwalia.

Two producers, Sons of Gwalia (at Greenbushes and Wodgina) and Haddington International Resources Ltd (at Cattlin Creek and Bald Hill) were responsible for the State's 905 t of tantalite output.

Platinum–palladium

Western Australia produces small quantities of platinum and palladium as byproducts from nickel-sulfide mining operations in the Eastern Goldfields. During 2001–02, two independent platinum–palladium projects advanced to feasibility status.

- Platinum Australia Ltd finished its prefeasibility study on the Panton project (52 km north of Halls Creek), which indicated robust project economics. The company is undertaking pilot plant testing on, and metallurgical evaluation of, ore sourced from an exploration decline.
- Helix Resources Ltd completed a scoping study on its Munni Munni project (40 km south of Karratha) and is currently drilling to evaluate additional resource potential along strike of the Ferguson Reef within the Munni Munni layered mafic intrusion. A decision on proceeding to a full feasibility study will be made in late 2002 or early 2003.
- Surface assays up to 108 g/t platinum, 70.2 g/t palladium, 119 g/t gold, 2700 g/t silver, and 8% copper were reported by Western Areas NL and Wedgeside Pty Ltd at the Copper Hills project (350 km east of Newman).

In 2001–02, production of platinum and palladium as byproducts from nickel–cobalt mining operations was 828 kg and 144 kg respectively, valued at $24 million.

Mineral tenement activity

In general, the trends in mineral exploration expenditure were also reflected in the 2001–02 mineral tenement statistics. For all tenement types under the Mining Acts of 1904 and 1978, the area under tenure has increased slightly (1%) from 23.8 million hectares in 2000–01 to about 24 million hectares in 2001–02. However, the number of tenements in force decreased by 5% (839 tenements) to 16 487 tenements, reversing the moderate increase of 2000–01 (Fig. 5).

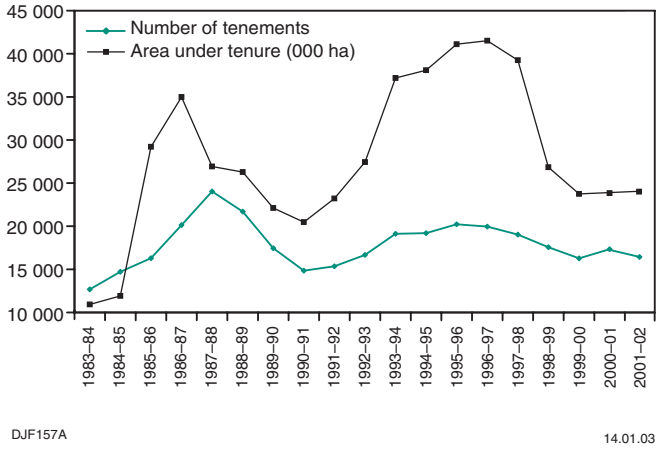

Figure 5. Tenements in force (1904 and 1978 Mining Acts)

The tenement data indicate declining numbers of large greenfields exploration licences. Although the decline partially stabilized in 2000–01, it appears to have restarted.

Figure 5 illustrates that the area held under tenure in Western Australia is currently at a level similar to the previous recession in mineral exploration of the early 1990s. This is interpreted to be largely the result of two factors. Firstly, there have been lengthy delays in progressing many tenement applications through the Native Title process, with a total of 11 802 tenement applications (including 5152 mining leases, 3703 exploration licences, and 2489 prospecting licences) outstanding and yet to be granted as at 30 June 2002. This is an increase of 80% over the last five years, corresponding to an average increase of 12.5% per year. Secondly, there have been large reductions in greenfields exploration; this aspect is discussed in detail elsewhere in this volume in 'Declining greenfields exploration in Western Australia, 1996–2001'.

Drilling activity

Drilling activity has declined markedly since the peak of exploration in 1996–97, demonstrating that cutbacks in exploration budgets have adversely impacted on all types of drilling (Fig. 6). Rotary air blast (RAB), reverse circulation (RC), and diamond drilling have now declined by about 80, 65, and 65% respectively since their peaks in 1996–97 or 1997–98. RAB drilling was the first to be affected when companies began cutbacks to expenditure

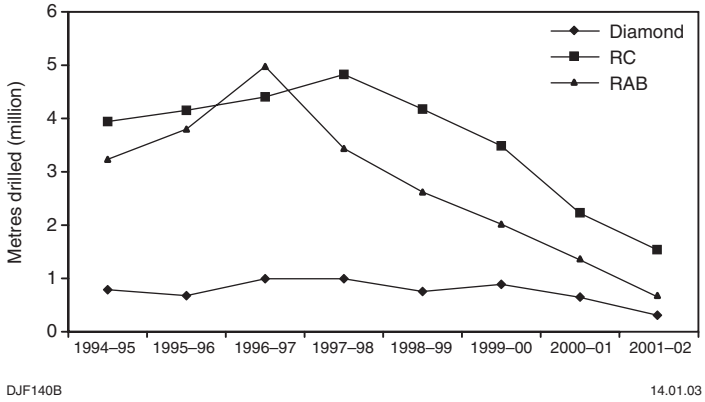

Figure 6. Mineral exploration drilling in Western Australia, by drilling type and year

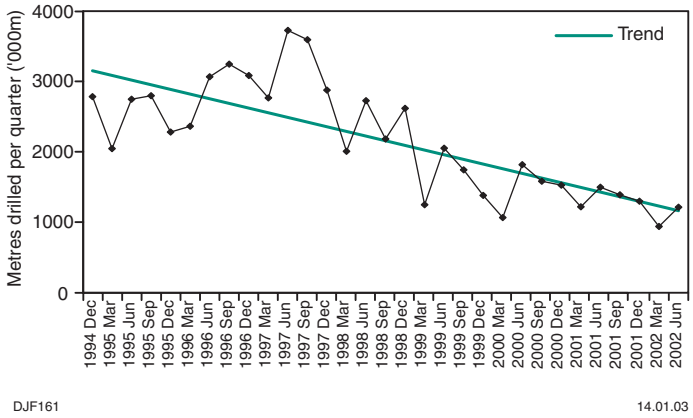

Figure 7. Australian mineral exploration drilling, by quarter

and moved away from grassroots greenfields exploration. This reduction in RAB drilling was followed one year later by declining RC drilling, as expenditure cuts deepened. RAB and RC drilling continued their decline during 2001–02, and have now been joined by a decrease in diamond drilling during 2001–02.

The falls in 'metres drilled' from earlier peak levels in 1996–97 show a more dramatic trend in reduced exploration activity than the more general fall shown in the overall trend for exploration expenditure. The decline of up to 80% in metres drilled since the peak of the boom should be compared with the corresponding drop of 'only' 45% in total exploration expenditure.

Recent quarterly data from the Australian Bureau of Statistics show that the downward trend in drilling activity is still firmly in place and does not show any sign of levelling off (Fig. 7). That data, which includes mineral exploration drilling of all types, both on production and non-production leases, shows that mineral exploration drilling in Australia has declined by 75% (2.79 million metres) since mid-1997.

Such declines in drilling activity greatly reduce the opportunities for significant discoveries that are necessary to boost mineral resource inventories, sustain the current level of mining development, and provide opportunities for growth in the industry.

Mineral resources

The substantial resources of major mineral commodities produced in Western Australia are listed in Table 5.

The State's inventory of measured and indicated gold resources increased by 552 t (13.8%) to 4551 t during 2001 (Fig. 8). The increase is primarily due to one resource upgrade — that by Newcrest for Telfer. Other increases in the measured and indicated resources are from resource upgrades at some of the existing operating mines, and from the conversion of some inferred resources to the measured and/or indicated category for a number of companies. The latter is evident in some company floats during 2001 and early 2002, where older resource estimates have been 'reworked' as part of the company float. When the Telfer resource increase is excluded from the data, there is no net increase of gold contained within measured and indicated resources for Western Australia during 2001; contained gold would have declined by about 10 t.

Gold contained within the inferred resource category decreased by 96 t (5.0%) to 1834 t during 2001, primarily due to resource upgrades at some of the existing operating mines and deposits (especially Telfer), as discussed above. The decrease in inferred resources of contained gold would have been substantial (more than 400 t) without the large boost from the revised resource estimate for Telfer.

Table 5. Estimates of mineral resources for major commodities in Western Australia

Commodity	*Units*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
Measured and indicated resources							
Iron ore (high grade)	Mt	21 960	22 539	22 407	22 282	22 316	14 892
Gold	t	3 009	3 376	3 496	3 752	3 999	4 551
Bauxite ore	Mt	3 359	3 386	3 387	3 387	3 194	3 194
Mineral sands	Mt	128.9	163.4	208.7	208.7	215	216
Nickel	Mt	10.73	13.41	16.77	20.23	17.44	17.90
Diamond (industrial + gem)	Mct	140	177	534	534	646	614
Inferred resources							
Iron ore (high grade)	Mt	10 466	10 382	10 525	10 587	12 796	16 288
Gold	t	1 295	1 549	1 750	1 807	1 930	1 834
Bauxite ore	Mt	1 326	1 314	1 314	1 314	1 314	1 314
Mineral sands	Mt	52	53	73	73	68	70
Nickel	Mt	6.96	10.58	10.15	11.68	15.94	14.96
Diamond (industrial + gem)	Mct	86	59	59	59	34	33

NOTE: Data sourced from the MINEDEX database. Information nominally as at 31 December for year shown, but data extracted from the MINEDEX database on 30 June in following year
For iron ore and bauxite, it is the quantity of resources that is shown. Only high-grade iron ore resources are included. High-grade iron ore is based on iron content only, but cut-off grade (55% or 60% Fe) depends on mineralization type
For heavy minerals, the total of all heavy minerals is shown
For all other commodities, it is the contained element/mineral in the resources that is shown
t Tonnes
Mt Million tonnes
Mct Million carats

The net increase in gold contained within measured and indicated resources and reserves corresponds to an average discovery cost for 2001 of $A12 per ounce (Table 6). If inferred resources are also included, then the average discovery cost rises to about $A13 per ounce as there was a net decrease in gold contained within inferred resources.

During the last decade, gold production in Western Australia has ranged between 182 t and 238 t per year, with peak production in 1997. Since then, gold production has declined steadily, with only 191.7 t produced during 2001. Annual gold production in Western Australia has declined by 46 t (almost 20%) since 1997.

Re-estimation of mineral resources at some of the major nickel mines and deposits has led to an increase of nickel contained within measured and indicated resources of 459 kt, but with a decrease of 977 kt of nickel contained within inferred resources. Figure 9 clearly illustrates that nickel sulfide

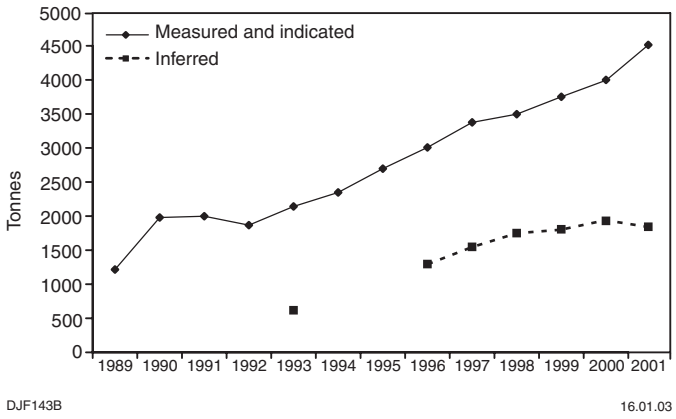

Figure 8. Estimates of gold resources in Western Australia, by year

Table 6. Gold discovery costs per ounce of measured and indicated resources, Western Australia [a]

Year	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
Cost ($A) per ounce discovered	21	28	22	26	26	30	17	20	12

NOTE: (a) This includes any resources converted to reserves, but does not include inferred resources. Discovery costs are in dollars of the day

resources in Western Australia have remained essentially static for the period 1996–2000, and that the increase has been for nickel contained in laterite deposits.

Much of the State's nickel resources are within projects that are not currently economic and many of these are nickel laterite deposits. Consequently, it is difficult to assess what the future production might be in the medium term. The unresolved issue is obviously the technical and financial viability of mining lateritic nickel deposits, which contain 58% of the State's nickel in measured–indicated resources and reserves and 71% of the nickel contained within inferred resources.

Current reserves for lateritic nickel projects total 446 kt of contained nickel, sufficient for an industry 'mine life' of about 12 years at current production rates for the laterite sector. However, the low average grades of the resources (measured, indicated, and inferred), at only 0.76 – 0.93% Ni, suggest that many deposits may not be economic without further technological advances or sustained higher prices for nickel, although small selected (high-grade) portions of the deposits may be economically extracted.

The situation for nickel sulfide resources in Western Australia is similar, with an average grade that is very low — in the range of 0.63 to 0.90% Ni, and where the total of measured and indicated resources is smaller than the total reserves. Although the total proven and probable reserves are high, the figures are dominated by the reserves at WMC's opencut mines at Mount Keith, which contain 70–75% of the proven and probable reserves. The reserves at Mount Keith have marginal grades of only 0.53 – 0.58% Ni, whereas remaining reserves at underground nickel mines elsewhere in Western Australia typically have grades of over 3% Ni.

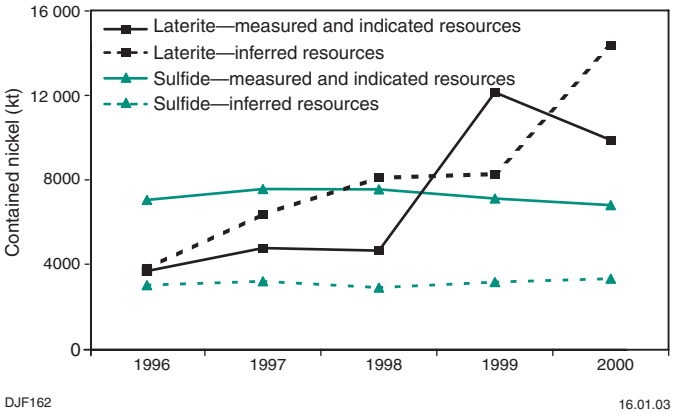

Figure 9. Total contained nickel in resources, Western Australia, by mineralization style and resource type

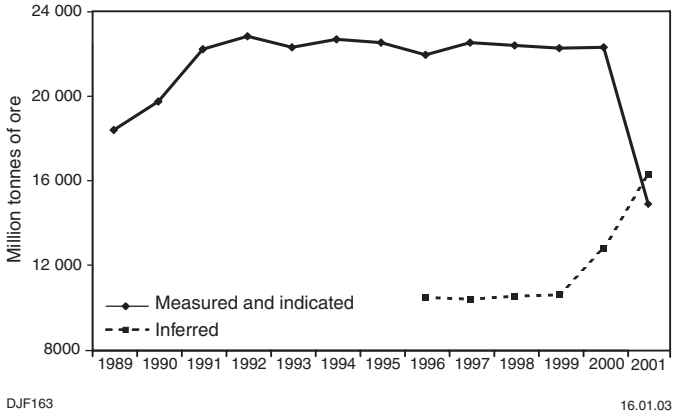

Figure 10. Total iron ore resources in Western Australia, by year

Western Australia's high-grade iron ore resources in the measured and indicated category plunged by 7424 Mt (33%) during 2001, falling to 14 892 Mt (Fig. 10). Conversely, inferred resources of iron ore increased, but by a smaller amount of 3492 Mt to 16 288 Mt, an increase of 27%. Several factors combined to produce this result. These include:

- Companies now use the current JORC code for reporting resources.
- Elimination of 20 to 30 year-old resources that companies no longer regard as part of the official resource base.
- MPR obtaining extensive new JORC-compliant estimates from the major producers Rio Tinto Ltd and BHP Billiton.
- MPR conducting a thorough update and audit of the resources in MINEDEX, including MPR eliminating double counting of some of the resource estimates in MINEDEX.

For other commodities (diamond, bauxite, and heavy mineral sands) resources have remained essentially unchanged during 2001–02 (Table 5).

Mineral production

Following the record values for mineral and petroleum production in Western Australia during 2000–01, production values contracted by 5% to $26 billion during 2001–02. Given the poor global commodity prices, slow world growth, and the extraordinarily high production values recorded in the period 1999–2001, the State's achievement is still remarkable. Between 1990–91 and 2001–02, there has been an average annual growth rate of 8.1% per annum in the value of mineral and petroleum production. This represents a doubling of the value of production every ten years, which far outstrips the general growth of the economy. The overall rise in production values since 1993–94 (assisted by the fall in the Australian dollar) is illustrated in Figure 11.

The gold sector experienced more buoyant prices that translated to a small sales-value increase, despite an 8% drop in sales volumes to 5.9 million ounces. Similarly, iron ore sales increased in value, thanks to higher prices from an earlier round of negotiations between producers and consumers. Lower international prices for nickel, diamond, alumina, and base metals translated to these commodities showing decreased, or at best static, sales values for 2001–02, despite increases for the quantity of sales.

Western Australia continues to be a very significant producer of the following minerals and mineral products (an estimate of the proportion of world production is shown in brackets) — diamond, including industrial diamond (38%), zircon (32%), tantalite (25%), rutile (24%), ilmenite (20%), alumina (20%), iron ore (14%; also has 34% of the world seaborne trade), nickel (14%), gold (8%), and vanadium (7%).

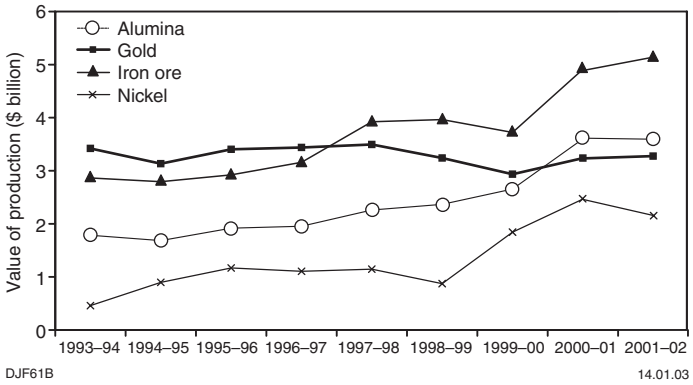

Figure 11. Comparative value of mineral production for major commodities in Western Australia, by year (dollars of the day)

Exploration expenditure versus the value of production

Each of the main commodities produced in Western Australia shows a characterisitic profile when the proportion of production value is compared to exploration expenditure. This relationship is sufficiently consistent in many cases to be a good predictive tool. Figure 12 illustrates the relationship for gold, base metals (including nickel–cobalt), heavy mineral sands, iron ore, and diamond. All of these commodities, except diamond, are exhibiting low points in the period 1999–2000 to 2001–02.

The gold sector stands out as being the most active in funding ongoing exploration, with about 7–8% of production value returned to exploration even in recessionary times, and up to 16% during boom times (Fig. 12). However, the level of exploration expenditure necessary to sustain the gold industry in Western Australia may be about 10% of the value of gold production (for further details see the Western Australian Government's submission to the 2002 Prosser Inquiry).

Expenditure on base metal (including nickel–cobalt) exploration, relative to the value of production, is now only 2.5% — by far the lowest level since 1991–92 (Fig. 12). Much of the fall in exploration over the last few years reflects lower expenditures that followed after the completion of feasibility studies and the commissioning of various nickel-laterite projects, some of which have experienced technical and financial problems.

Expenditure on diamond exploration, relative to the value of production, has fluctuated between 3.5 and 10% during the last decade (Fig. 12). The

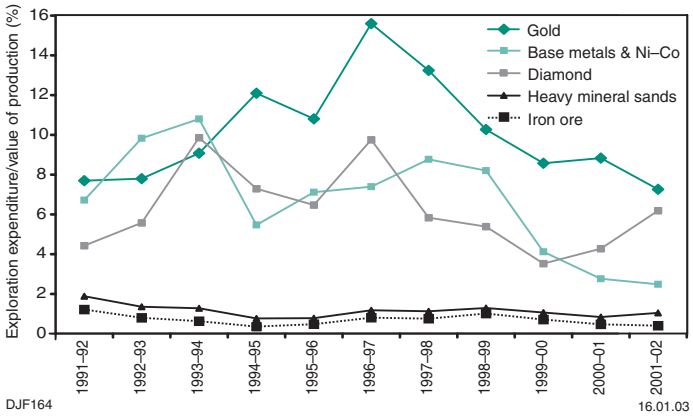

Figure 12. Exploration expenditure relative to the value of mineral production for major commodities in Western Australia, by year

expenditure has been primarily at Argyle where increased exploration was carried out to delineate further resources needed to extend the life of the mine. Following this phase of exploration at Argyle, which was successful, the proportion of exploration expenditure had eased back to around 4%, but over the last two years the proportion has risen to around 6%, due primarily to increased exploration as a prelude to mining at Ellendale.

Exploration expenditure for iron ore and heavy mineral sands, relative to the value of production, reflects the very mature stage of these industry sectors. Both have consistently returned less than 2% of the value of mineral production back in to exploration (Fig. 12). Although the proportion of expenditure did rise very slightly during the minerals boom of the late 1990s, exploration expenditure relative to the value of production has declined since then, and both are now at or near historic low points of 1% or less.

As a comparison with the mineral sector, exploration expenditure for petroleum (relative to the value of production) has typically ranged between 8 and 10% during the last decade.

Acknowledgments

Mineral exploration expenditure data were compiled by the Australian Bureau of Statistics.

Information on the State's inventory of mineral resources is contained within the Department's MINEDEX (mines and mineral deposits information) database, a compilation of resource estimates that have been reported by a large number of companies. Drilling statistics for mineral exploration were extracted from the Department's WAMEX (Western Australian mineral exploration) database, and were compiled from statutory mineral-exploration reports received by the Department during the period (hence there are some data in them that relate to the previous period). The Royalties Branch of the Department supplied information on the quantity and value of mineral production from Western Australia for 2001–02. Information on mining tenements in Western Australia was supplied by the Mineral Titles Division of the Department.

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