Report to client

Medium term prospects for basic processing of Australia’s nonenergy mineral exports

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ABARE Submission to the House of Representatives Standing Committee on Industry, Science and Resources' Inquiry into increasing value adding to Australian raw materials

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Australian Bureau of Agricultural and Resource Economics
GPO Box 1563 Canberra 2601

Telephone +61 2 6272 2000 Facsimile +61 2 6272 2001
Internet www.abare.gov.au

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Foreword

On 20 April 1999 the Minister for Industry, Science and Resources, Senator Nick Minchin, asked the House of Representatives Standing Committee on Industry, Science and Resources to inquire into and report on the prospects of increasing value adding to Australian raw materials. The Committee is required to start with an evaluation of the current state of value adding and how that compares internationally. This will provide a base from which the Committee will evaluate several specific issues identified in the terms of reference.

The main objective in this submission is to provide an assessment of recent trends and medium term prospects for Australia's major nonenergy mineral exports. The submission covers early stage processing of nonenergy minerals including unprocessed, semi processed and basic processed minerals. The submission therefore includes such activities as smelting, refining and chemical processes which result in the production of refined metal cathode, ingot or equivalent basic forms.

BRIAN S. FISHER
Executive Director

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Acknowledgments

This submission was prepared in the Industries Branch. The project was developed and managed by Ian Haine and Tom Waring. The submission was prepared by Ian Haine, Jane Anderson, Peter Berry, Antony Clarke, Michael Evans, Marat Fainstein, Lindsay Hogan, Andrew Maurer, Adam Roberts and Tom Waring.

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1. Introduction

The primary focus in this submission is on the extent of early stage processing (broadly, up to the basic metal or equivalent stage) of Australia's nonenergy mineral exports. In 1998-99, the nonenergy minerals exports sector, including basic metals, contributed around 60 per cent of total resource sector export earnings, 29 per cent of merchandise export earnings and 22 per cent of the total value of Australian exports of goods and services.

Terms of reference

On 20 April 1999, the Minister for Industry, Science and Resources, Senator Nick Minchin, asked the House of Representatives Standing Committee on Industry, Science and Resources to undertake an inquiry into increasing value adding to Australian raw materials. The terms of reference are:

> 'That the House of Representatives Standing Committee on Industry, Science and Resources inquire into and report on the prospects of increasing value adding to Australian raw materials. The Committee will start with an evaluation of the current state of value adding in Australia, and how that compares internationally. This will provide a base from which to evaluate the following topics:
>
> - incentives and impediments to investment;
> - intellectual property rights;
> - national/international marketing factors which may encourage or hinder Australian value adding;
> - government intervention, both nationally and internationally;
> - the location of value adding industries and projects in regional Australia;
> - resource licensing/permit arrangements;
> - the impact of vertical integration within particular industries; and
> - the Australian skills base and any associated impediments.'

In a media release dated 19 May 1999, the Committee invited submissions on the first phase of the inquiry on the evaluation of the current state of value adding in Australia, and how that compares internationally. The Committee requested the first round of submissions by Friday 25 June 1999, although submissions will be accepted throughout the course of the inquiry. Public hearings on the first phase of the inquiry are scheduled to finish in December 1999. The Committee will call for further submissions on specific case studies as the inquiry progresses.

Information about the Inquiry, including the terms of reference, are provided on the website www.aph.gov.au/house/committee/isr.

Objectives and scope of the submission

This submission complements and, in some respects extends, the submission made by the Department of Industry, Science and Resources (ISR) on 25 June 1999. While the ISR submission addressed a wide range of issues pertaining to value adding across the industry spectrum, the ABARE submission assesses trends and provides some basic analysis on one major component — Australia's non energy mineral exports sector.

The scope of the submission is confined to early stage processing of nonenergy minerals (up to and including refined metal, or equivalent, but excluding semi fabricated and fabricated products). The focus in this submission on non energy minerals reflects the view that in this sector there is significantly greater potential for additional basic processing of ores and concentrates before export than there is for further processing energy minerals (petroleum, coal and uranium). The focus on exports, rather than production, reflects the principal focus of the Australian minerals industry and the important contribution that exports of minerals makes to Australia's net economic welfare. Australia has a prominent position in these markets as a large and competitive supplier of a wide range of minerals.

The key objective in the submission is to evaluate recent trends and medium term prospects for basic value adding in the Australian nonenergy minerals exports sector. Relatively detailed assessments of eight major nonenergy minerals are provided in the submission — aluminium, copper, gold, iron ore and iron and steel, lead, mineral sands, nickel and zinc. Historical data and analysis generally covers the period 1984-85 (or 1985) to 1998-99 (1998). Discussion of future developments extends to 2003-04.

This evaluation will take into account recently completed, currently planned, and possible, minerals processing development projects over the medium term. In the past five years, substantial investment in new mines as well as processing capacity in Australia has significantly enhanced the sector's ability to meet growing regional and world demand for minerals and metals, and substantially expanded export earnings.

However, the full effect of that investment in terms of production and, importantly, export revenue has yet to be realised. This is because much of that investment is relatively recent, with full production capacity for some major completed developments not yet attained. A number of other major investment projects, while nearing completion or fully committed to, have yet to come into production. In addition, there are several projects at less advanced planning stages which may be developed over the next five years, subject to market and other conditions. It is important to understand these recent trends well, particularly their implications for the value adding profile of Australian mining, in assessing Australia's future resources value adding potential.

Important tools for undertaking this assessment include ABARE's database on major development projects and its standing commodity analysis and forecasting capacity. Project data, derived from a variety of published information as well as information provided directly by companies, are updated and published six monthly in ABARE's quarterly *Australian Commodities*. They contain details (such as capital expenditure and additional output capacity) of all major mineral resource projects that are planned to be developed over the medium term. The focus is on projects at relatively advanced stages of planning — that is, stage of planning categories range from 'feasibility study underway' through to 'under construction', placing considerably less emphasis on a range of 'possible' projects at earlier stages of consideration. Experience has shown that this conservative approach to listing projects provides a more realistic view of the dynamics of capacity changes and export levels.

These lists provide an important platform for the analysis and assessment of Australia's current and future (medium term) value adding capability and potential. The most recent project listing published in the June 1999 issue of ABARE's *Australian Commodities* is provided in Appendix A (see also Haine 1999).

Section 2 contains a brief discussion of the role and importance of the resources sector in the Australian economy through time and an aggregated view of value adding in the non energy minerals export sector in Australia. Levels and nature of investment in processing capacity in recent years and planned and possible investment over the medium term are discussed in section 3.

Individual commodity reviews are given in sections 4 to 11 for aluminium, copper, gold, iron ore and iron and steel, lead, mineral sands, nickel and zinc, respectively. For each commodity, an assessment is given of the current and future extent of basic processing, with reference to the major economic and technological factors driving those changes. Some concluding comments are provided in section 12, including an aggregated view of the outlook for increased basic processing of Australia's mineral exports and issues arising from relevant comparisons with other countries.

2. Background

Early stage processing and transformation coefficients

For the purposes of this submission, 'early stage processing' includes such activities as smelting, refining, and chemical processes which result in the production of refined metal cathode, ingot or equivalent basic forms. In ABARE analysis these activities are considered to be closely linked to mining activity and part of broadly defined 'mineral resources' sector activity. In most instances they produce homogeneous, traded commodities which are basic industrial inputs to manufacturing processes around the world. Consideration of the diverse activities further downstream, such as the manufacture of semi wrought or wrought products is beyond the scope of this submission.

The submission aggregates minerals processing into three principal stages, namely:

- **Unprocessed minerals**: where mine production is exported in the form of ores and concentrates, having undergone preliminary processing, such as crushing, blending and concentrating.
- **Semi processed minerals**: where a fundamental change in chemical composition and/or structure of the mine product is induced, to produce intermediate products such as nickel matte, lead bullion and alumina.
- **Basic processed minerals**: where unprocessed and semi processed minerals are transformed by fire refining, electrolytic or hydrometallurgical means to their refined metal cathode, ingot or equivalent stage.

In the estimation of transformation cost and transformation coefficients relating to individual minerals in Sections 4 to 11, the concept employed is the gross value per unit of output which is added by transforming the unprocessed mineral (for example, bauxite) to a higher value stage (alumina). This methodology includes in the transformation cost a range of other inputs necessary for the production of the processed product. The transformation cost concept has been employed primarily to focus attention on the changes in export value associated with progressive transformation of Australia's primary mineral resources.

Location choices in mining and mineral processing

The location of mining and mineral processing activities is influenced by decision making in both the private and public sectors. Mining and mineral processing companies locate activities to maximise profit over time, taking into account the various costs and risks associated with different sites. Government policies may influence location decisions by altering the industry assessments of the economic viability of particular projects (policy issues are discussed further below).

Regions across Australia vary according to identified mineral deposits, mineral prospectivity, availability and skills of the labor force and infrastructure (for example, energy and transport services). The location of mining activities is restricted to a choice of sites providing access to mineral deposits. However, the availability of other inputs to production such as transport and energy infrastructure services and labor have significant implications for the viability of any mining operation and the cut off grades required to make the mining of resources economic. This, in turn, affects the location decisions for minerals exploration. Other things equal, more exploration will take place in relatively well developed regions.

The location of mineral processing activities reflects various influences such as the particular input requirements of the industry, technologies, transportation costs of both inputs and outputs, and regional policies. Both mining and mineral processing industries tend to be relatively capital intensive activities.

Australia has extensive identified mineral resources and has considerable potential for the discovery of a range of new mineral deposits, particularly in remote locations (Lambert and Perkin 1998; AGSO 1999). (A location map for Australia's major mineral deposits is available on www.isr.gov.au.) Traditionally, mining projects in remote areas have required the construction of new mining towns. With advances in transport services and greater flexibility in labor arrangements, long distance commuting or fly in-fly out (FIFO) has become a relatively profitable option for remote resource developments. Increased flexibility in project development options has important implications for the relative profitability of resource developments and hence for the location of mining and mineral processing activities. Worker settlement options for mining projects are discussed in, for example, Robinson and Newton (1988), Houghton (1993) and briefly in Hogan, Berry and Thorpe (1999).

Based on ABS census employment data, excluding some regions mainly in south east Australia, all regions have a revealed comparative advantage in mining (Hogan, Berry and Thorpe 1999). Three regions that have a very strong revealed comparative advantage in mining are the Pilbara (which includes onshore activities associated with the North West Shelf gas project), the South Eastern region in Western Australia (Kalgoorlie) and the North West region in Queensland (Mt Isa). Several regions that are relatively close to capital cities also have a revealed comparative advantage in mining. These include, for example, the Hunter, Illawarra and Central West regions in New South Wales, East Gippsland in Victoria, and the Perth and South West regions in Western Australia. [Regions are based on Australia's Statistical Divisions which are defined in ABS (1993) with data based on ABS (1998).]

There are several regions that have a revealed comparative advantage in manufacturing which is likely to be at least partly due to mineral processing activities. These include, for example, the Northern region of South Australia (production of copper and other metals at Olympic Dam), the South West region of Western Australia (alumina refineries and gold metal production), and areas in northern Tasmania and south west Victoria (aluminium smelters).

Policy issues

A key role of the public sector is to ensure the provision, directly or through private supply, of efficient economic and social infrastructure (subject to budgetary and other constraints) to complement private sector economic activities and to ensure people have access to some reasonable level of infrastructure services. To facilitate private investment, governments also have an important role in maintaining a stable low inflation macroeconomic environment and providing a simple, stable and transparent institutional framework (to reduce the costs and risks of investment).

More generally, industry assistance provided by government may also influence the location of industry. The fundamental objective of industry assistance is to promote economic growth and employment. As discussed in some detail in Industry Commission (1996), several arguments are often put forward to provide selective assistance to industry.

- *The presence of market failure whereby certain goods and services are not provided optimally through the normal workings of markets*. Market failure may indicate a role for government action provided such action is cost effective and well targeted. Examples include public goods (such as defence), industries where the price does fully reflect net economic benefits and hence output is below the optimal level (such as research and development expenditure), and industries where there are substantial costs or difficulties in obtaining relevant market information.

- *The presence of significant benefits through multiplier effects to the local and regional economies*. However, the industry assistance should still be required to result in a net gain to social welfare taking into account economywide effects and the distortionary impacts of raising tax revenue.
- *The presence of external benefits from agglomeration*. Agglomeration is the observed tendency of firms in the same and closely related industries to cluster within a particular location to take advantage of, for example, increased supply of specialised labor and technological spillovers. Industry assistance has been argued in the context of targeting selected 'seed' firms to commence the process of agglomeration.
- *The presence of 'lighthouse' effects from a high profile investment project, particularly in depressed locations*. A large high profile investment may assist in informing potential market participants and changing market sentiment about the costs and risks of investments in specific locations.
- *Facilitate regional development, particularly in depressed regions, to reduce regional inequities and structural adjustment costs*.
- *The presence of intangible benefits from the staging of major events such as the Olympic and Commonwealth games*.

In practice, there are several issues in governments realising net gains from industry assistance (Industry Commission 1996).

- The extent to which inter-state rivalry increases costs to taxpayers.
- Difficulties in acquiring information to assess the cost effectiveness of various policy options.
- The extent to which governments are risk averse and hence tend to select activities that have a significant probability of occurring in the absence of assistance.
- The risks of governments responding to short term political pressures.
- The risks of governments providing additional assistance to the project, even if the assistance was initially provided as a short term measure. This may be a particular risk for footloose industries.
- The extent to which assistance tends to favor well organised groups of firms or large firms.
- The extent to which firms incur costs to lobby governments for assistance, particularly if there are multiple assistance schemes.
- The risks of unfair competition to established firms in a region. (The concept of competitive neutrality was embodied in the national competition

reform process to ensure individual firms are not specifically favored or penalised by government policies.)

Resource access and environmental policies also have the potential to influence the location of mining and mineral processing activities. Influences on the location choices of these industries are discussed further in chapter 12. Regional policies are described in Anderson and MacDonald (1999).

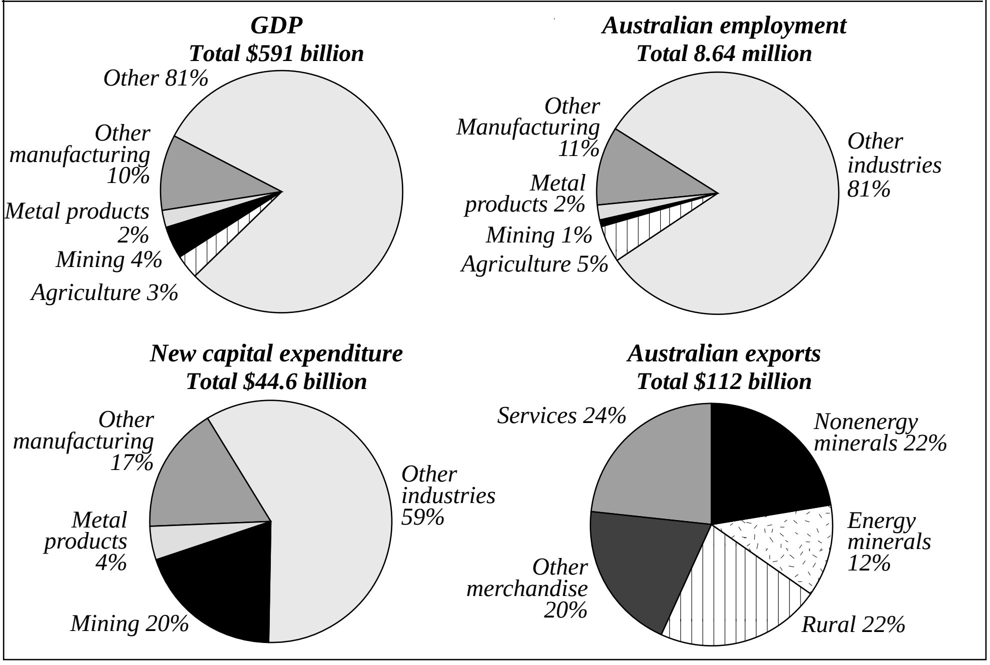
The provision and pricing of infrastructure, industry assistance and regional development are discussed in, for example, EPAC (1988, 1991), Industry Commission (1993, 1996), Mintz and Preston (1993), OECD (1993), BIE (1992, 1994, 1995) and Productivity Commission (1999). Regional policies are also discussed in Armstrong and Taylor (1993).

Recent trends in nonenergy mineral exports

Nonenergy minerals and the mineral resources sector

Figure 2.1 shows the contribution of the mineral resources sector to the Australian economy in 1998-99 in terms of GDP, exports, investment and employment. It is evident that the sector makes a substantial contribution to

2.1 ***Resources sector in the Australian economy, 1998-99***

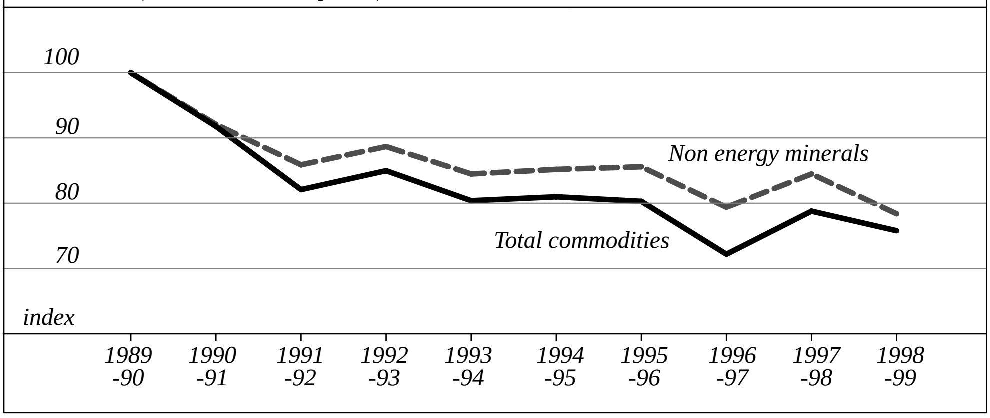


both exports and investment and a smaller contribution to GDP and employment. With the sector accounting for over one third of total Australian export earnings and around 45 per cent of the value of merchandise exports in 1998-99, its contribution to Australian economic performance via export receipts commands attention. Non energy minerals comprised almost two thirds of the mineral resource sector's export earnings in 1998-99 (figure 2.1).

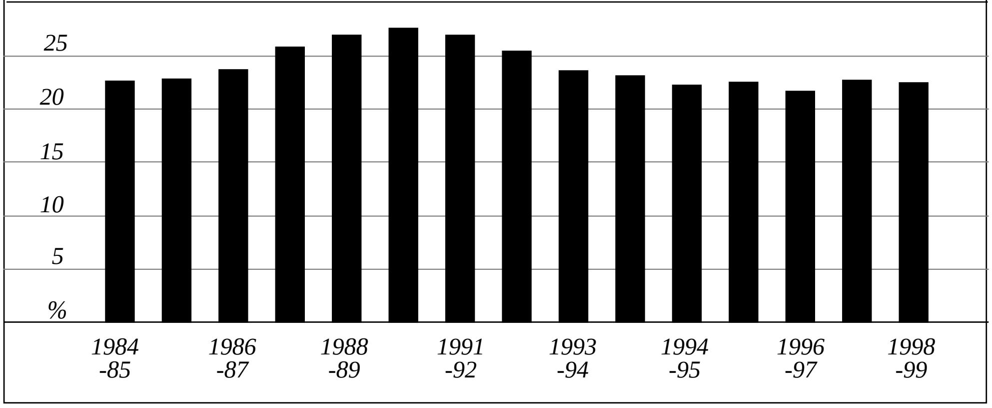
To compare export performance between different commodities and across sectors it is necessary to use a common measure, such as export earnings, as physical volume measures vary from commodity to commodity. Attention has been focussed on the trends in real export earnings. However, it needs to be recognised that growth in real export earnings over time usually understates growth in export volumes because of the long term trend of declining real commodity prices associated with ongoing strong productivity gains in the world's mining industries. Figure 2.2 shows the decline in real unit export returns from 1989-90 (the first available data) to 1998-99 for both non energy minerals and all exported commodities (including rural products). It is apparent from figure 2.2 that, in the 1990's, real unit export returns for non energy minerals have declined more than returns for the commodities sector as a whole. That is, over this period, real metal prices in world markets have fallen to a greater extent than prices in most other commodity groups.

Figure 2.3 shows the changing contribution of non energy mineral export earnings to total, merchandise and resource sector export earnings since 1984-85. Non energy minerals exports share of both total and merchandise exports rose in the late 1980s, peaking in 1989-90, as world metal prices rose and energy prices, particularly petroleum prices, fell. Significantly, the non energy minerals share of resource sector export earnings increased sharply, from 54 per

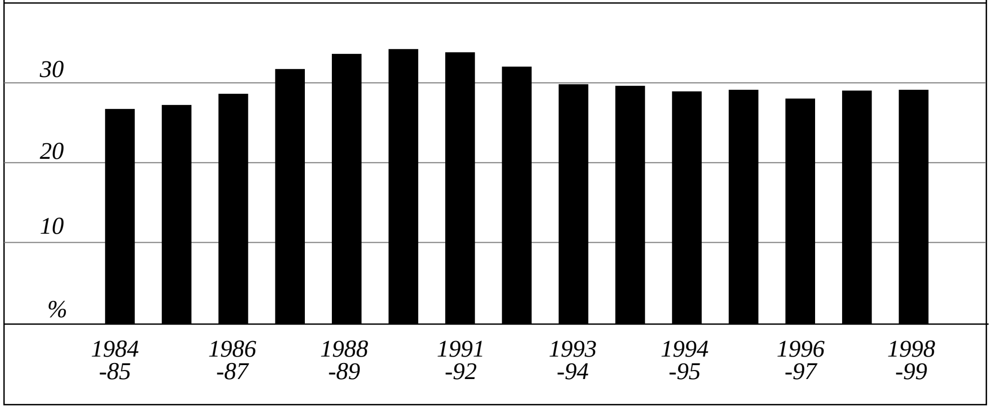
2.2 Unit export returns, 1989-90 = 100
(constant 1998-99 prices)



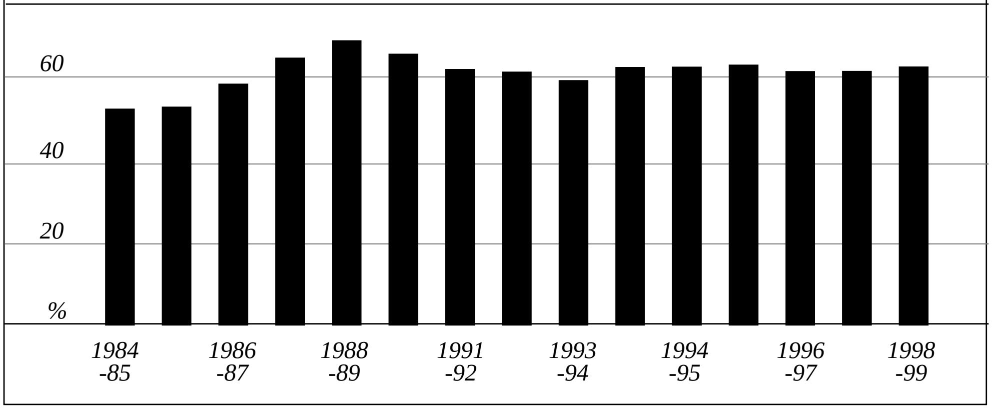
2.3a Nonenergy mineral exports share of total exports of goods and services



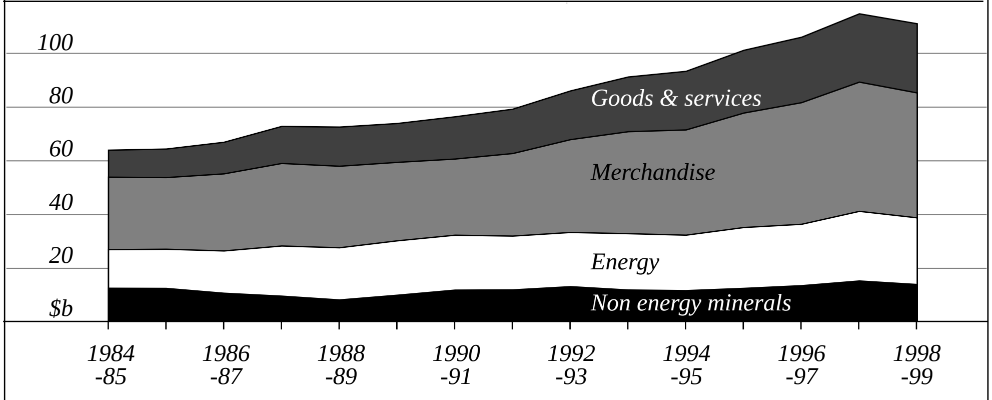
2.3b Nonenergy mineral exports share of total merchandise goods



2.3c Nonenergy mineral exports share of resource sector exports



2.4 ***Total exports*** ***(Constant 1998-99 dollars)***



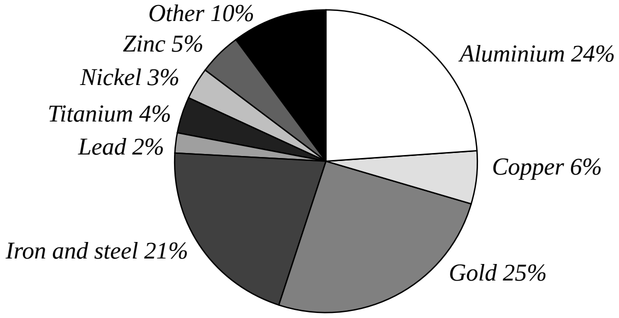
cent in 1984-85 to 65 per cent in 1998-99. This has reflected, among other things, the substantial and sustained increases in new export income from the gold and aluminium industries and relatively slower growth in earnings from the energy minerals. Over that period total resource sector export earnings, in constant 1998-99 dollar terms, grew by 44 per cent, while non energy minerals surged by 73 per cent (and energy minerals increased by 11 per cent) (figure 2.4).

Extent of processing of nonenergy mineral exports

Figure 2.5 shows the shares of each of Australia's major non energy minerals exports in 1998-99. Three industries — gold, alumina/aluminium and iron ore/steel — dominate; together, they comprised 70 per cent of non energy

2.5 ***Value of nonenergy mineral exports, 1998-99***

Total $24.8 billion



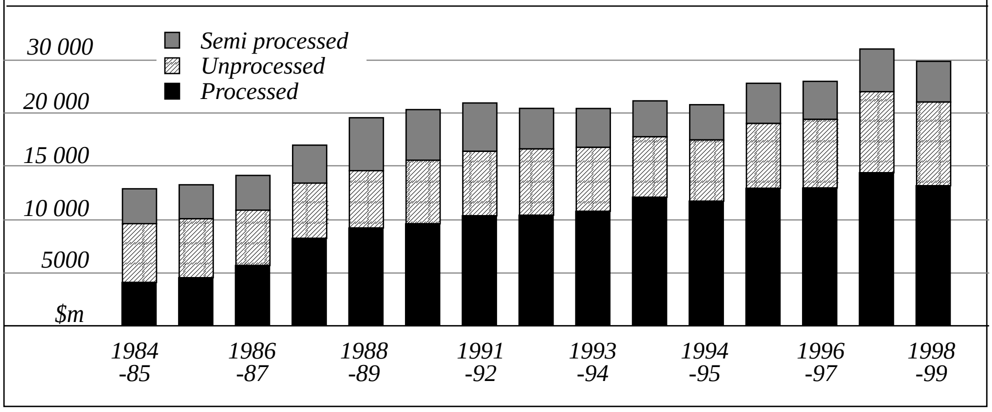
minerals export earnings in 1998-99. Export earnings of all three have increased substantially in real terms since 1984-85: alumina/aluminium by 43 per cent, iron ore and steel by 46 per cent and gold by a dramatic 591 per cent. Both gold and alumina/aluminium are relatively highly processed before export.

Figure 2.6 shows a breakdown by processing stages of non energy mineral export earnings in constant dollar terms over the period 1984-85 to 1998-99. This breakdown demonstrates the contribution to non energy export earnings of the individual processing stages. It does not provide insight into the proportion of the mine output of ores and concentrates (in volume terms) which is processed to each stage before export. The extent to which mine output is processed before export can only be analysed on an individual mineral basis. This is provided in the individual commodity reviews which follow in sectiosn 4 to 11.

Figure 2.6 shows that real export earnings in each processing stage rose over the period 1984-85 to 1998-99. Note that the rise in processed export earnings was dramatic — an increase of 225 per cent, with refined gold being the main contributor. Export earnings from unprocessed ores and concentrates rose by 42 per cent and from semi processed intermediate products, by 17 per cent.

Figure 2.7 gives a further perspective on these trends by showing, for each processing stage, the changing share of aggregate real export earnings which was attributable to non energy minerals over that period. The processed minerals' share of aggregate export earnings rose from 31 per cent in 1984-85 to 53 per cent in 1998-99. This gain was at the expense of both unprocessed and semi processed minerals.

2.6 ***Value of nonenergy mineral exports by stage of processing***
(constant 1998-99 prices)



2.7 Share of nonenergy mineral export earnings by processing stage

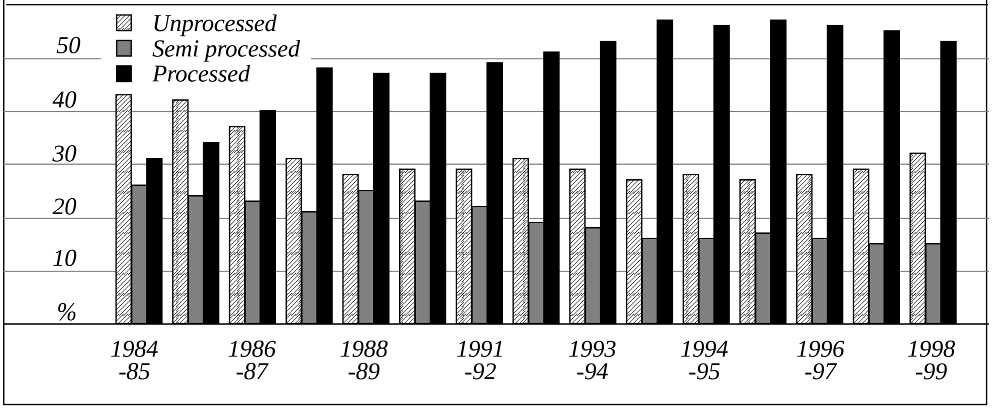


Table 2.1 compares the shares of export earnings contributed by each processing stage in 1984-85 and 1998-99. This shows that most major non energy minerals increased the processing share of earnings over that period. The notable exceptions were the base metals (copper, lead and zinc), for which the share of export earnings contributed by unprocessed ores and concentrates increased substantially. The share of copper earnings attributable to ores and concentrates rose from 48 per cent in 1984-85 to 72 per cent in 1998-99, lead's from 19 per cent to 40 per cent and zinc's from 45 per cent to 61 per cent.

However, this trend will be at least partly reversed in the near future. There has been substantial investment in base metals processing capacity over the past few years, particularly for copper, and this will increase export earnings,

2.1 Nonenergy mineral exports: Degree of processing of selected minerals
Percentage by value

	Unprocessed		Semi processed		Processed	
	1984-85	**1998-99**	**1984-85**	**1998-99**	**1984-85**	**1998-99**
	%	%	%	%	%	%
Aluminium	5	3	60	49	35	48
Copper	48	72	0	0	52	28
Gold	0	0	0	0	100	100
Iron and steel	95	75	0	0	5	25
Lead	19	40	60	34	21	26
Nickel	16	17	30	16	54	67
Mineral sands	100	42	0	24	0	34
Zinc	45	61	0	0	55	39
Total nonenergy minerals	43	32	26	15	31	53

and lead to an increase in the share of export earnings attributable to processed base metals, in the near term.

Analysis of the outlook for further processing of exports for each of the major minerals is presented in the commodity reviews which follow.

International comparisons

Data presented in the ISR submission (of 25 June) to the Inquiry show that in 1998 Australia's ranking, when compared with other major minerals producing nations, in terms of the proportion of mine production processed domestically, was relatively low for several of our major commodities. These include copper, lead, zinc, iron and steel and aluminium. Australia's ranking as a processor of alumina, gold and nickel was relatively high. A summary of Australia's relative ranking, for the major non energy mineral commodities, is shown in table 2.2.

Among the many factors determining the extent of minerals processing in a country, it is expected that aggregate domestic consumption (that is, the size of the local market) would play a key role. Large local markets, which tend to be naturally protected by transport costs and other business advantages, represent relatively secure operating platforms through the business cycle. Compared with major diversified mining countries such as Canada, the United States and China, Australia's domestic consumption of metals is relatively low, reflecting the relative size and diversity of domestic economies. However, the degree of non energy minerals processing undertaken in Australia more than satisfies domestic requirements, even for those commodities where the extent

2.2 ***Extent of nonenergy mineral processing: Australia's world ranking*** [a]

	Mine/ intermediate production	Mine production world rank	Processed production	Percentage processed	Processed world rank
	kt		kt	%	
Commodity processing					
Iron ore to steel	165 700	2	8 900	9	8
Bauxite to alumina	44 700	1	13 500	82	1
Alumina to aluminium	13 500	1	1 600	23	7
Mined copper to refined	600	5	290	47	8
Mined lead to refined	617	2	206	45	6
Mined nickel to refined	136	3	79	58	4
Mined zinc to refined	1 005	3	300	30	11

a Based on 1997 or 1998 data.
Source: ISR submission, attachment C, pp. 38–42.

2.3 Major mine producers of selected non energy minerals: ratio of refined production to domestic consumption 1998

	Aluminium	Copper	Lead	Nickel	Steel	Zinc
Australia	4.4	1.8	3.7	50	1.3	2.4
Canada	3.2	2.3	4.3	14	1	4.4
United States	0.6	0.9	0.9	na	0.8	0.3
China	1	0.9	1.4	1.1	1	1.3

of processing in Australia is low by international standards. Table 2.3 provides an indication of the extent to which domestic consumption requirements are satisfied by domestic production of processed metals in Australia compared with other countries producing a similar range of mine commodities. The commodities shown are those for which Australia's ranking is relatively low in relation to share of domestic production processed.

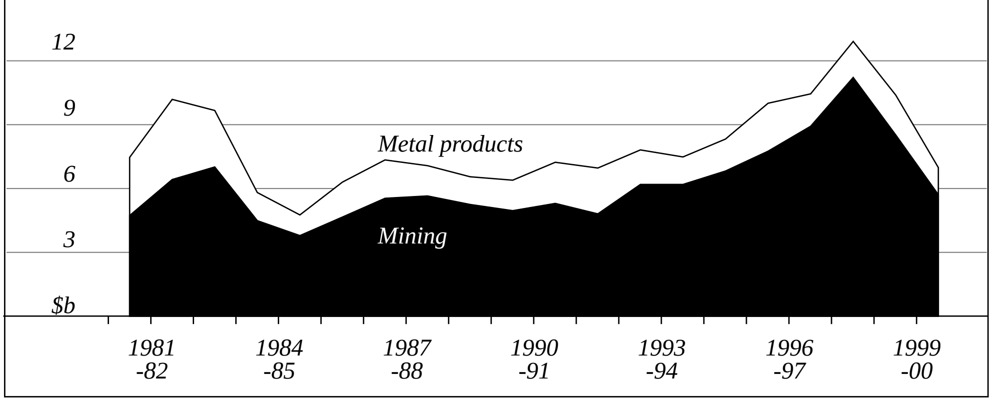
3. Investment in nonenergy minerals processing facilities

Figure 3.1 shows new capital expenditure, in real terms, in Australia's mineral resources sector (including metals etc production) over the past twenty years. These data are based on ABS statistics. In 1998-99, the sector's new capital expenditure was $10 .7 billion, around one quarter of the Australian total.

From 1991-92 to 1997-98, capital expenditure on the mining component of the sector (including energy minerals — separate data for the non energy minerals component are not available) showed substantial and sustained rises. Mining investment increased by an average of 12 per cent a year in real terms. However, it fell sharply in 1998-99; by 21 per cent to $8.7 billion. A further substantial fall is expected in 1999-2000. Nevertheless, the increased investment in new and expanded mine capacity through most of the 1990s underpinned the substantial increase in export earnings of unprocessed ores and concentrates evident from 1996-97 (figure 2.6).

ABS data on annual capital expenditure in the metal products component (figure 3.1) show periodic rises in the early, mid and late1990s, followed by falls in subsequent years. However, these data may understate actual investment in non energy minerals processing facilities. This is because some integrated mining/processing developments such as the recently completed Olympic Dam expansion in SA and the new lateric nickel operations in WA, which involved considerable capital expenditure, may have been classified as mining

3.1 ***New capital expenditure*** ***(Constant 1998-99 dollars)***



operations in the ABS statistics. (If this is the case, statistics on mining investment would be overstated to the same extent).

Table 3.1 is a list of the major non energy minerals processing facilities brought into production in Australia over the past six years. The number, and capital cost, of these new and expanded operations underlines the scale of investment in new processing capacity in Australia in recent years. This investment in new capacity is reflected in the steady rise in export earnings attributable to processed mineral exports from 1993-94 (figure 2.6). However, several of these operations have only recently been commissioned, and several are currently in commissioning phase. Their full contribution to export earnings will not be fully reflected in annual export statistics until around 2000-01.

Table 3.2 lists major processing projects currently either under construction, committed or under consideration, and proposed to be constructed in Australia, over the next five years. These projects, and others which will progressively emerge, will provide the platform for further expansion of exports of value added mineral products from Australia over the medium term.

However, the list now contains relatively few planned projects at an advanced stage (those under construction or committed) compared with the number in this category over the past couple of years. Factors which may explain this include: a cyclical downturn in new resource discovery; a relatively uncertain outlook for demand and prices for many commodities against a background of weaker Asian demand and strong global supply in recent years; difficulty in securing project financing in such a climate; and the fact that many companies have recently invested substantial sums in new capacity and are seeking to consolidate their operations.

However, there remain a significant number of less advanced processing projects (those not committed or under construction) on the list. In most cases these are either still undergoing feasibility study, or no definite decision has been taken on development following the completion of a feasibility study. Some of these projects may confront changed economic or competitive conditions (as illustrated by the recent economic downturn in Asia and in metal markets generally), or may be targeting the same emerging market opportunity, necessitating rescheduling. Also, securing finance for project development — even for world class, low cost projects — can present problems, particularly in periods when there is perceived to be overproduction and/or an uncertain economic outlook.

Encouragingly, several new planned projects relate to commodities (and in some cases, processes) new to the Australian resources sector. These projects

3.1 *Australian nonenergy minerals processing facilities commissioned, 1993 to 1999*

Project	Company	Location	Startup	New Capacity	Capital expend.
Alumina					
Wagerup expansion	Alcoa World Alumina	Darling Ranges, WA	1993	900 kt	na
Gladstone expansion	Comalco	Gladstone, Qld	1997	300 kt	na
Worsley expansion	Worsley Alumina	Darling Ranges, WA	1997	150 kt	$80m
Wagerup expansion	Alcoa World Alumina	Darling Ranges, WA	1999	440 kt	$258m
Aluminium					
Tomago expansion	Tomago Smelters	Hunter Valley, NSW	1993	140 kt	$600m
Bell Bay expansion	Comalco	Bell Bay, Tas	1994	18 kt	na
Boyne Island expansion	Comalco	Gladstone, Qld	1998	230 kt	$1billion
Tomago expansion	Tomago Smelters	Hunter Valley, NSW	1999	40 kt	$160m
Copper					
Mount Isa copper smelter expansion	MIM	Mount Isa, Qld	late 1998	75 kt Cu anode	$285m
Townsville refinery expansion	MIM	Townsville, Qld	late 1998	45 kt Cu cathode	$50m
Olympic Dam expansion	WMC	Roxby Downs, SA	late 1998	115 kt Cu 3 kt U_3O_8 45 000 oz Au 450 000 oz Ag	$1.9b
Mt Gordon expansion	Western Metals	Mt Isa, Qld	mid 1998	37 kt Cu	$125m
Nifty SX–EW	Straits Resources	Nullagine, WA	late 1993	17 kt Cu	na
Cloncurry SX–EW	Cloncurry Mining	Cloncurry, Qld	early 1996	6 kt Cu	$11m
Girilambone SX–EW	Straits Resources	Nyngan, NSW	mid 1993	17 kt Cu	na
Mt Cuthbert SX–EW	Murchison/ Brancote	Cloncurry, Qld	late 1996	5.5 kt Cu	na

Continued ➪

3.1 *Australian nonenergy minerals processing facilities commissioned, 1993 to 1999* Continued

Project	Company	Location	Startup	New Capacity	Capital expend.
Iron and steel					
Blast furnace upgrade	BHP	Port Kembla, NSW	1996	2.6 Mt	$400m
HBI plant	BHP	Port Hedland, WA	1999	2.5 Mt	$2.5b
Tinplate expansion	BHP	Port Kembla, NSW	1999	150 kt steel	$304m
Billet caster	BHP	Whyalla, SA	1999	300 kt	$70m
Hot Stip mill expansion rolling mill upgrade	BHP	Western Port, Vic	1999	n/a	$100m
Wire mill upgrade	BHP	Newcastle, NSW	1999	n/a	$44m
Lead					
Port Pirie refinery upgrade	Pasminco	Port Pirie, SA	1998	35 kt Pb	$30m
Mineral sands					
TiO_2 pigment plant expansion	Tiwest JV	Kwinnana, WA	1996	83 kt TiO_2	na
TiO_2 pigment plant	Millenium Inorganic Chemicals	Kemerton, WA	1996	79 kt TiO_2	na
Synthetic rutile plant expansion	Tiwest JV	Chandala, WA	1996	183 kt SR	na
Synthetic rutile plant expansion	Iluka	Capel, WA	1996	250 kt SR	na
Nickel					
Acid plant	WMC	Kalgoorlie, WA	1996	500kt sulphuric acid	$146m
Bulong	Preston Resources	Kalgoorlie, WA	1999	9kt Ni	$242m
Cawse	Centaur Mining	Kalgoorlie, WA	1999	9kt Ni	$274m
Murrin Murrin	Anaconda Nickel	Leonora, WA	1999	45kt Ni	$1b
Zinc					
Townsville zinc refinery	Sun Metals (Korea Zinc)	Townsville, Qld	late 1999	170 kt Zn 325 kt sulphuric acid	US$425m

3.2 *Major Australian nonenergy minerals processing projects (November 1999)*

Project	Company	Location	Status	Startup	New capacity	Capital expend.
Alumina						
Projects under construction or committed						
Pinjarra alumina refinery	Alcoa World Alumina	Darling Ranges, WA	Efficiency improve-ments under construction	2001	165 kt alumina	na
Worsley alumina refinery	Reynolds Australia Alumina	Darling Ranges, WA	Expansion, under construction	late 2000	1250 kt alumina	$800m
Less advanced projects						
Comalco alumina refinery project	Comalco Aluminium	Gladstone, Qld or Malaysia	New project, location study underway	after 2000	1400 kt alumina	$1.4 b
Wagerup refinery expansion (stage 2)	Alcoa World Alumina	Darling Ranges, WA	Expansion, feasibility study completed	na	1100 kt alumina	$700m
Aluminium						
Less advanced projects						
Lithgow aluminium smelter	Aust-Pac Aluminium	Lithgow, NSW	New project, feasibility study underway	na	450 kt aluminium	$2.75 b
Kurri Kurri aluminium smelter	Capral Aluminium	Kurri Kurri, NSW	Expansion, feasibility study completed	na	50 kt aluminium	$250m
Copper						
Projects under construction or committed						
Port Kembla copper smelter/ refinery	Furukawa/ Nittetsu/ Nissho/ Iwai/ITOCHU consortium	Port Kembla, NSW	Reconstruction, under construction	early 2000	120 kt Cu cathode	$271m
Less advanced projects						
Qsmelt copper smelter	Queensland Minex (Mineral Commodities)	Phosphate Hill, Qld	New project, feasibility study underway	2002	105 kt Cu matte 175 kt sulphuric acid	$120m

Continued ➩

3.2 Major Australian nonenergy minerals processing projects (November 1999) *Continued*

Project	Company	Location	Status	Startup	New capacity	Capital expend.
Crude iron and steel						
Projects under construction or committed						
Blast furnace expansion	BHP	Port Kembla, NSW	Expansion, under construction	2001	0.4 Mt	$93 m
Less advanced projects						
DRI plant	Australian United Steel Industries	Pilbara, WA	New project, feasibility study completed	na	3.6 Mt DRI	$1.8 b
DRI and steel plant	An Feng Kingstream	Geraldton, WA	New project, feasibility study completed	na	2.4 Mt steel	$1.4 b
HBI plant	Mt Gibson Iron	Geraldton, WA	New project, feasibility study completed	na	2.6 Mt HBI	$1.1 b
Pellet and HBI plant	Mineralogy	Pilbara, WA	New project, feasibility study completed	na	6.0 Mt pellets 4.0 Mt HBI	$1.8 b
Pig iron plant	Australian Bulk Minerals	Port Latta, Tas	New project, feasibility study completed	na	0.5 - 1 Mt pig iron	$120m
Pig iron plant	SA Steel and Energy	Coober Pedy, SA	New project, feasibility study underway	na	2.5 Mt pig iron	$830m
Steel mini mill	Boulder Group, Australian Overseas Resources, Danieli	Newcastle, NSW	New project, feasibility study underway	na	110 kt steel	$215m
Steel plant	Compact Steel	Rockingham, WA	New project, feasibility study underway	na	1.4 Mt steel	$1.5 b
Gold						
Projects under construction or committed						
Fosterville	Perserver-ance	Fosterville, Vic	Expansion, committed	late 2000	50 000 oz	$29m
Mt Rawdon	Equigold	Bundaberg, Qld	New project, under construction	2000	80 000 oz	$32m
Vera Nancy	Normandy	Charters Towers, Qld	Expansion, under construction	early 2000	100 000 oz	$48m

Continued ➪

3.2 Major Australian nonenergy minerals processing projects (November 1999) *Continued*

Project	Company	Location	Status	Startup	New capacity	Capital expend.
Less advanced projects						
Ashburton	Taipan	Ashburton, WA	New project, feasibility study completed	2000	na	$43m
Ballarat	Ballarat Goldfields	Ballarat, Vic	New project, pre-feasibility study completed, on hold	na	100 000 oz	$65m
Bendigo	Bendigo Mining	Bendigo, Vic	New project, pre-feasibility study completed	early 2002	150 000 oz	$70 - $100m
Boddington/ Wandoo	Normandy	Perth, WA	Expansion, feasibility study underway	2003	> 300 000 oz	$350m
Cowal	North	West Wyalong, NSW	New project, feasibility study underway	na	250 000 oz	$220m
Gwalia Deeps	Sons of Gwalia	Gwalia, WA	Expansion underground feasibility study underway	2003	150 000 - 200 000 oz	$60m
Maud Creek	Kilkenny Gold	Katherine, NT	New project, feasibility study underway	2000	55 000 oz	$24m
Ridgeway	Newcrest	Orange, NSW	New project, feasibility study underway	early 2001	150 000 oz 12 kt Cu	$175m
Sarsfield	MIM/ Haoma Mining	Ravens-wood, Qld	New project, feasibility study completed	2000	60 000 oz	$45m
St Ives	WMC	Kambalda, WA	Expansion, on hold	na	150 000 - 300 000 oz	$157m
White Foil	Cogema SA	Kalgoorlie, WA	New project feasibility study underway	mid 2000	na	na

Continued ➪

3.2 *Major Australian nonenergy minerals processing projects (November 1999)* *Continued*

Project	Company	Location	Status	Startup	New capacity	Capital expend.
Magnesium						
Less advanced projects						
Arthur/ Lyons River magnesium metal project	Crest Magnesium	Bell Bay, Tas	New project feasibility study underway	2003	95 kt magnesium metal/alloy	$1.08b
Batchelor magnesium project	Mount Grace Resources	Darwin, NT	New project, pre-feasibility study nearing completion	2002	50 kt magnesium metal	$625m
Magmetal project	Australian Magnesium Corp (QMC/Normandy/ Fluor Daniel)	Rock-hampton, Qld	New project, feasibility study nearing completion	2002	90 kt magnesium metal	$800m
PMMA project	Pilbara Magnesium Metal Associates	Pilbara, WA	New project, feasibility study underway	na	50 kt magnesium metal	na
South Australia magnesium project	SAMAG (Pima Mining/ RFC)	Port Augusta, SA	New project, feasibility study underway	2003	52.5 kt magnesium metal/alloy	$640m
Woodsreef magnesium project	Golden Triangle Resources	Woodsreef, NSW	New project, pre-feasibility study underway	2003	80 kt magnesium metal/alloy	$630m
Nickel						
Less advanced projects						
Marlborough	Preston Resources	Rock-hampton, Qld	New project, feasibility study completed	2001	25 kt Ni 2 kt Co	$738m
Murrin Murrin 2	Anaconda Nickel	Leonora, WA	Expansion, feasibility study underway	2001	55 kt Ni 4.5 kt Co	$1 b
Syerston	Black Range Minerals	Parkes, NSW	New project, feasibility study underway	na	13 kt Ni 3 kt Co	$493m
Yabulu refinery expansion	Billiton	Townsville, Qld	Expansion, feasibility study underway	2002	35 kt Ni 1.3 kt Co	$200m

Continued ➪

3.2 *Major Australian nonenergy minerals processing projects (November 1999)* *Continued*

Project	Company	Location	Status	Startup	New capacity	Capital expend.
Silicon						
Less advanced projects						
Lithgow silicon project	Doral Mineral Industries/ Portman Mining JV	Lithgow, NSW	New project, feasibility study nearing completion	early 2001	30 kt silicon metal 17 kt silica fume	$100m
Titanium						
Less advanced projects						
Kemerton TiO_2 pigment plant	Millenium Inorganic Chemicals	Kemerton, WA	Expansion, on hold	na	190 kt Ti O_2 pigment	$470m
Kwinana TiO_2 pigment plant	Tiwest JV	Kwinana, WA	Three stage expansion, on hold	na	180 kt TiO_2 pigment	$200m
Pinjarra rare earth plant	Rhodia Pinjarra	Pinjarra, WA	New project, feasibility study underway	late 1999	15 kt rare earth nitrates	$60m

cover proposals to produce magnesium metal, vanadium and zirconia. Their planning provides examples of the expanding breadth of Australia's resource base. The diversity of these projects also illustrates the responsiveness of the sector in recognising the potential for new market opportunities away from the more traditional commodities, some of which appear well supplied in world markets over the medium term.

However, it should be borne in mind that there are several project proposals which are targeting the same market opportunity (for example, six magnesium metal projects and several proposals for DRI/HBI/pig iron plants) and not all will necessarily proceed to development.

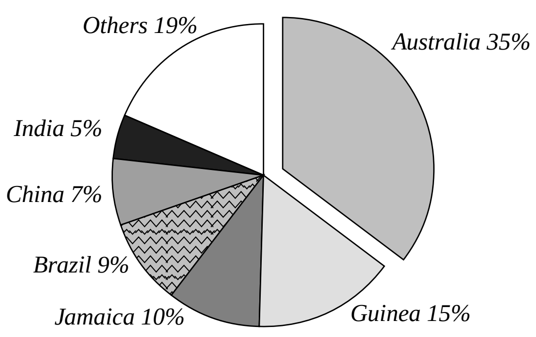
Nevertheless, despite their uncertainty, the processing project plans listed at the less advanced stages of commitment provide a useful indication of the nature and extent of the emerging platform for future growth in non energy minerals processing.

4. Aluminium

The bauxite, alumina and aluminium industry in Australia has grown rapidly since the 1960s, and Australia is now a major player in the world aluminium industry. In 1998, Australia was the world's largest producer of bauxite, accounting for 35 per cent of total world bauxite production (figure 4.1) and the largest alumina producer, accounting for almost one third of total world alumina production (figure 4.2). Australia was also the fifth largest producer of aluminium, behind the United States, Russia, China and Canada. Australia accounted for around 7 per cent of total world aluminium production in 1998 (figure 4.3).

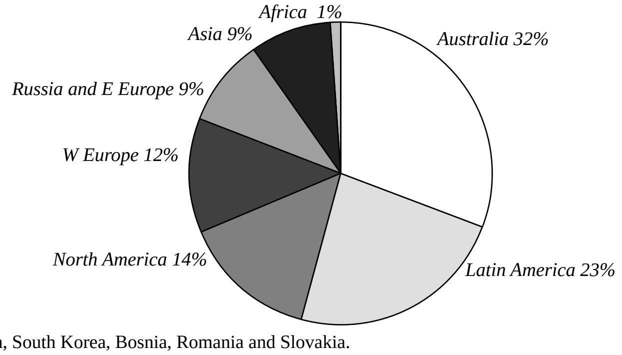
4.1 *World bauxite production, 1998*

Total 127 million tonnes



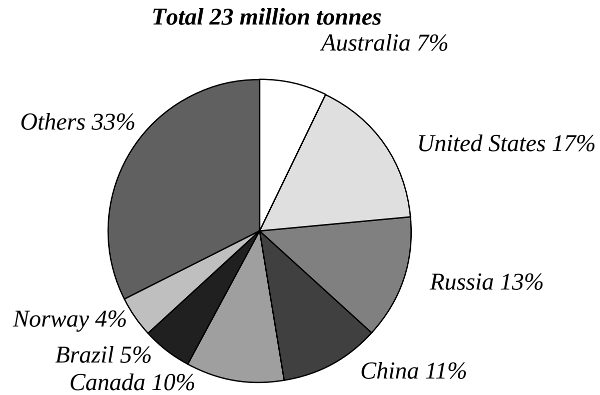
4.2 *World alumina production, 1998a*

Total 45 million tonnes



a Excludes China, South Korea, Bosnia, Romania and Slovakia.

4.3 World aluminium production, 1998



Australia consumes most of its substantial output of bauxite in alumina production and, as a result, exports relatively small volumes of bauxite. In contrast, Australia consumes a relatively small proportion of both its alumina and particularly its aluminium production because of the small size of the domestic market (7 per cent and 2 per cent of world consumption respectively). As a result, Australia's export/production ratios are very high (78 per cent and 81 per cent respectively). Australia is the world's largest exporter of alumina and the third largest exporter of aluminium, after Russia and Canada.

In 1998, Australia was estimated to have 13 per cent of the world's economic demonstrated resources (EDR) of bauxite. At current rates of production, Australia's EDR of bauxite represent almost 70 years supply. Australia's currently producing bauxite mines, alumina refineries and aluminium smelters are shown in table 4.1.

Value adding

There are three stages to primary aluminium production - bauxite mining, alumina refining and aluminium smelting. Bauxite is mined using heavy earth-moving equipment, once the covering layer of earth and vegetation are removed. The bauxite is crushed and then transported to the refinery where alumina is extracted using the Bayer process. This process consists of four stages: digestion, clarification, precipitation and calcination. Aluminium metal is then extracted from the alumina at a smelter by electrolytic reduction using the Hall-Heroult process. Aluminium smelting is energy intensive.

The processing of bauxite to alumina and then to aluminium increases the value of the raw material (bauxite) significantly. The transformation cost concept

4.1 Australia's bauxite mines, alumina refineries and aluminium smelters, 1998-99

Operation	Company	Location	1998-99 capacity
			kt
Bauxite mines			
Gove	Gove Aluminium	Northern Territory	7 000
Huntly	Alcoa World Alumina	Western Australia	14 000
Weipa	Comalco	Queensland	10 000
Willowdale	Alcoa World Alumina	Western Australia	7 000
Worsley	Worsley Alumina	Western Australia	7 000
Total			45 000
Alumina refineries			
Gladstone	Comalco	Queensland	3 600
Gove	Gove Aluminium	Northern Territory	1 780
Kwinana	Alcoa World Alumina	Western Australia	1 900
Pinjarra	Alcoa World Alumina	Western Australia	3 100
Wagerup	Alcoa World Alumina	Western Australia	1 700
Worsley	Worsley Alumina	Western Australia	2 190
Total			14 270
Aluminium smelters			
Bell Bay	Comalco	Tasmania	138
Boyne Island	Comalco	Queensland	490
Kurri Kurri	Capral Aluminium	New South Wales	150
Point Henry	Alcoa of Australia	Victoria	162
Portland	Alcoa of Australia	Victoria	345
Tomago	Tomago Aluminium	New South Wales	440
Total			1 725

referred to in table 4.2 is the gross value per unit of output which is added by transforming the unprocessed mineral (bauxite) to higher value stages (alumina and aluminium). Transformation coefficients indicate the extent to which a tonne of bauxite increases in value as it passes through the alumina refining and aluminium smelting stages. The transformation coefficient for processing bauxite into alumina is around 3 and the coefficient for processing bauxite into aluminium is around 15.

In Australia, the extent of processing/production is high at the bauxite to alumina refining stage, with 82 per cent of bauxite produced in Australia processed into alumina. However, only 23 per cent of alumina refined in Australia is smelted to aluminium domestically.

4.2 Transformation costs in the Australian aluminium industry [a]

	1998-99 average EUV [b]	Input coefficient [c]	Transformation coefficient [d]
	A$/t		
Bauxite	25	…	…
Alumina	263	2.68	2.9
Aluminium	2 081	5.226	14.9

a The transformation cost concept employed refers to the gross value which is added to the unprocessed mineral input (bauxite) by processing to the stage indicated. (Transformation cost = Value of processed output minus value of unprocessed mineral input consumed). **b** EUV (export unit value) is the average realised price per tonne of Australian exports in 1998-99 (EUV = Total export returns/Total exported quantity). **c** Tonnes of unprocessed mineral input required to produce a tonne of processed output. **d** The proportion by which the value of unprocessed mineral consumed is increased by processing to the stage indicated. (Transformation coefficient = Transformation cost / Value of unprocessed mineral input consumed).

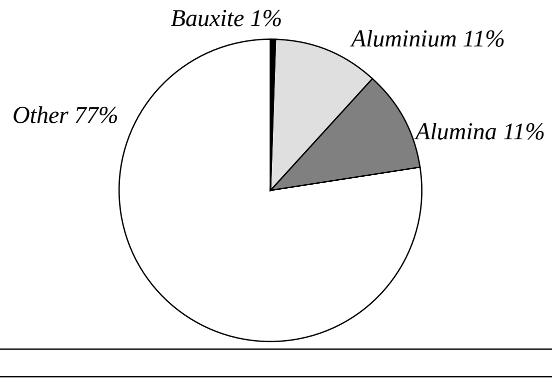
Australian aluminium industry exports

The aluminium industry is a major contributor to Australia's nonenergy mineral export earnings — with bauxite, alumina and aluminium combined accounting for 23 per cent of the total in 1998 (figure 4.4). However, this is down from 32 per cent in 1985. The fall in share largely reflects the rapid expansion of the gold industry over that period, rather than any decline in the aluminium industry.

In fact, the total value of aluminium exports increased by almost two thirds (in constant 1998-99 dollar terms) between 1984-85 and 1998-99 (figure 4.5), largely reflecting a 60 per cent increase in export volumes (in bauxite equivalent terms) (figure 4.6) and a higher proportion of alumina and aluminium

4.4 Aluminium: contribution to Australia's nonenergy mineral exports, 1998

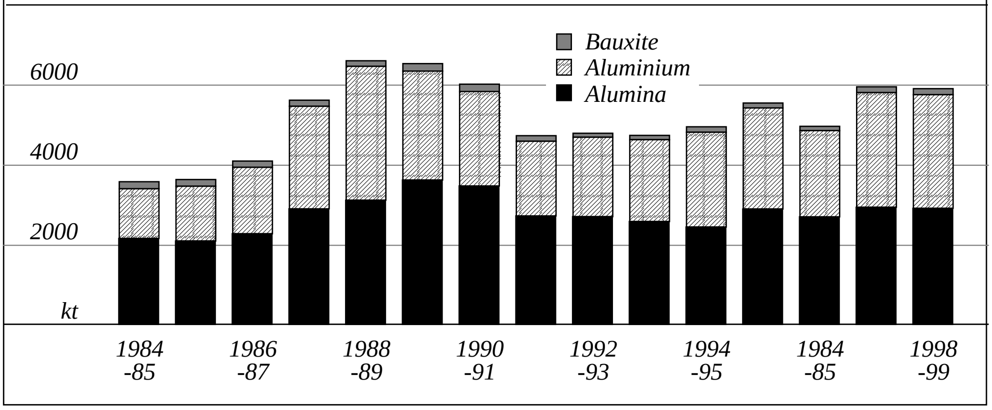
Total $27.2 billion



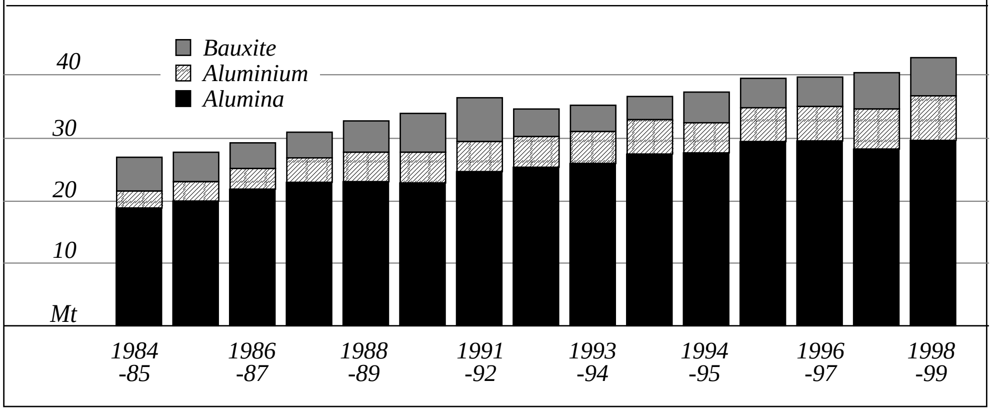
processing. During that time, however, the average export unit values (in constant 1998-99 dollar terms) for aluminium and alumina have trended lower, reflecting the productivity driven long term decline in real aluminium and most other commodity prices (figure 4.7).

The volume of aluminium exports, as a proportion of total bauxite equivalent exports increased from 10 per cent in 1984-85 to 16 per cent in 1998-99. The corresponding proportion for alumina has remained at 70 per cent. This reflects significant expansions to capacity for both commodities over that period, particularly of aluminium in the mid to late 1980s. Recent additions to alumina refining and aluminium smelting capacity are shown in figure 4.8.

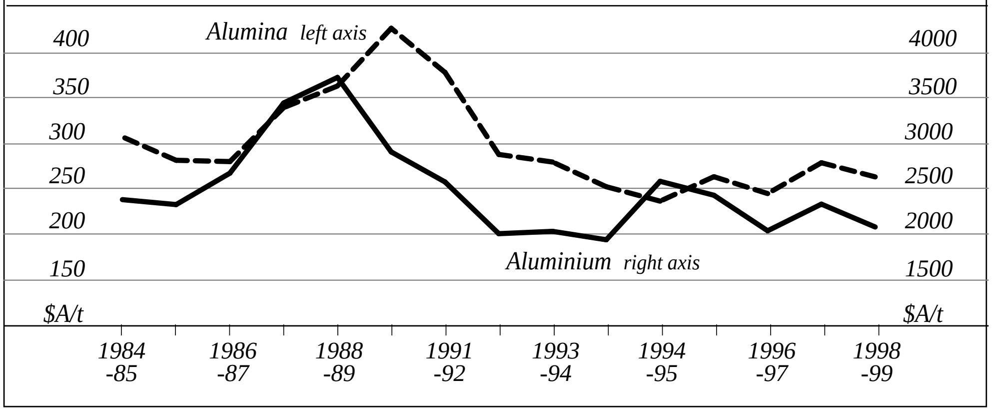
4.5 *Real value of Australian aluminium industry exports*
(Constant 1998-99 dollars)



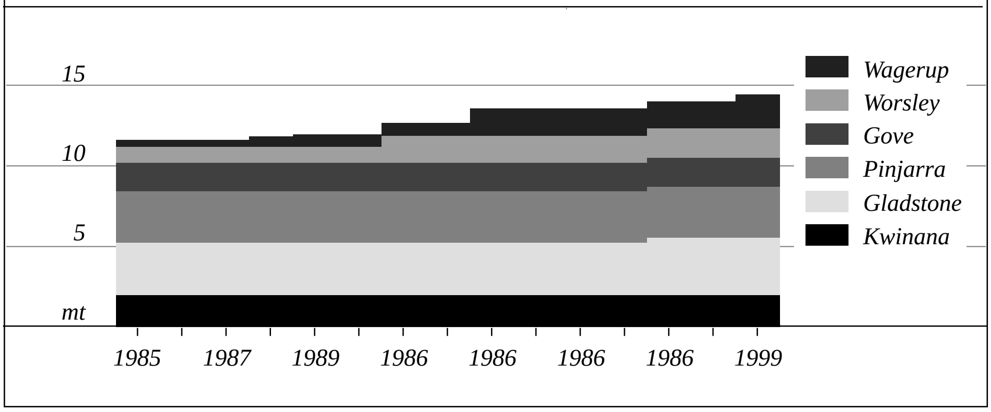
4.6 *Australian aluminium industry exports*



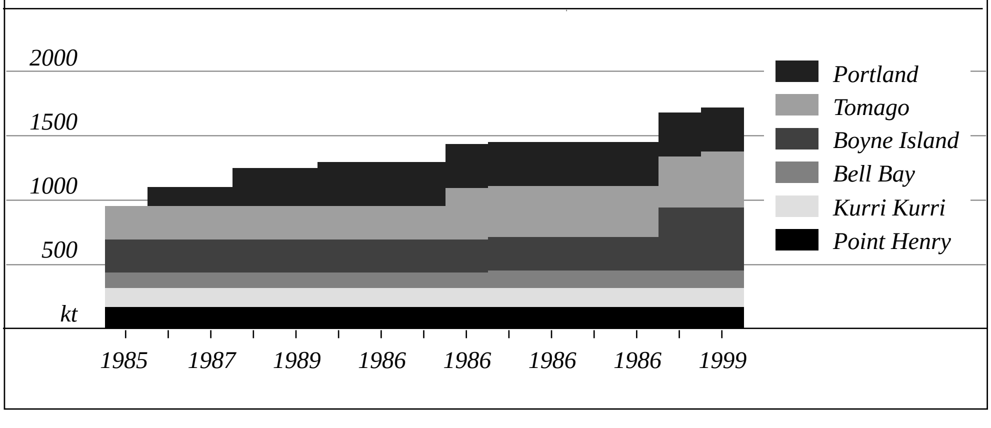
4.7 **Unit prices of Australian alumina and aluminium exports**
(constant 1998-99 dollars)



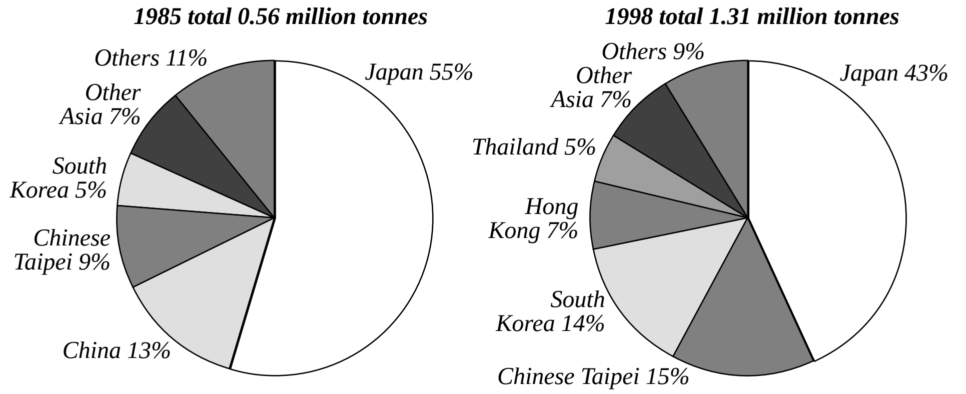
4.8a **Australian alumina capacity**



4.8b **Australian aluminium capacity**



4.9 **_Australian aluminium exports, by destination_**



Most of Australia's exports of aluminium are directed toward Asia (91 per cent in 1998), and, in particular Japan (figure 4.9). Chinese Taipei and South Korea also import large quantities of Australian aluminium. Dependence on Asian markets has generally been increasing over the past decade. In recent years, the proportion of exports to Asia has averaged around 98 per cent. The lower proportion in 1998 reflects the dampening effect of the recent Asian economic and financial upheavals on aluminium consumption in the region.

In 1985, 89 per cent of aluminium exports were directed towards Asia, with Japan being by far the largest market. The second largest market was China, which now imports only very small quantities of aluminium from Australia due to the expansion of its domestic aluminium industry.

Data for Australian exports of bauxite and alumina by destination are unavailable.

Outlook for further value adding of exports

Between 1985 and 1999, there was substantial investment in new alumina and aluminium capacity (figure 4.8). In that period, alumina refining capacity increased by almost 50 per cent, mainly through expansions at the Wagerup and Worsley refineries in Western Australia, with the most recent expansion to Wagerup completed this year. Aluminium smelting capacity doubled in that period, with the main additions being the development of the Portland smelter in Victoria and expansions at the Tomago (NSW) and Boyne Island (Queensland) smelters.

Plans for further investment in new capacity in the Australian alumina and aluminium industries over the next five years are shown in table 4.3.

4.3 Major Australian alumina refining and aluminium smelting projects

Project	Company	Location	Status	Capacity	Expected startup	Capital exp.
Processing projects committed / under construction						
Alumina						
Worsley	Reynolds Aust.	Darling Ranges, WA	Expansion, construction	1.25 Mt	mid 2000	$800m
Pinjarra	Alcoa World Alumina	Darling Ranges, WA	Efficiency improvements, under construction	165 kt	2001	na
Less advanced processing projects						
Alumina						
Wagerup	Alcoa World Alumina	Darling Ranges, WA	Expansion, feasibility study completed	1.1 Mt	2002	$700m
Comalco Alumina Project	Comalco Ltd.	Gladstone, Qld	New project, location study underway	1.4 Mt	na	$1.4b
Aluminium						
Lithgow	Aust-Pac Al.	Lithgow, NSW	New project, feasibility study underway	450 kt	na	$2.75b
Kurri Kurri	Capral Al.	Kurri Kurri, NSW	Expansion, feasibility study completed	50 kt	na	$250m

Committed additions to alumina capacity in the medium term total around 1.4 million tonnes, with further expansions at Worsley and Wagerup, expected to be completed in 2000 and 2002 respectively, providing the bulk of the increase. However, importantly, the 165 000 tonnes a year expansion at Alcoa's Pinjarra refinery reflects productivity improvements generated by a new process which reduces the use of some raw materials — lime and caustic soda. Alcoa plans to extend the application of the new process to other Australian refineries, but no details were available at the time of writing.

As a result of these developments, alumina production is projected to rise from 14.1 million tonnes in 1998-99 to 16.7 million tonnes in 2002-03, before stabilising.

A further substantial addition to alumina capacity of 1.4 million tonnes could occur if a decision is made to locate Comalco's proposed alumina project in Gladstone. In that event, Australian alumina production will be higher than projected above.

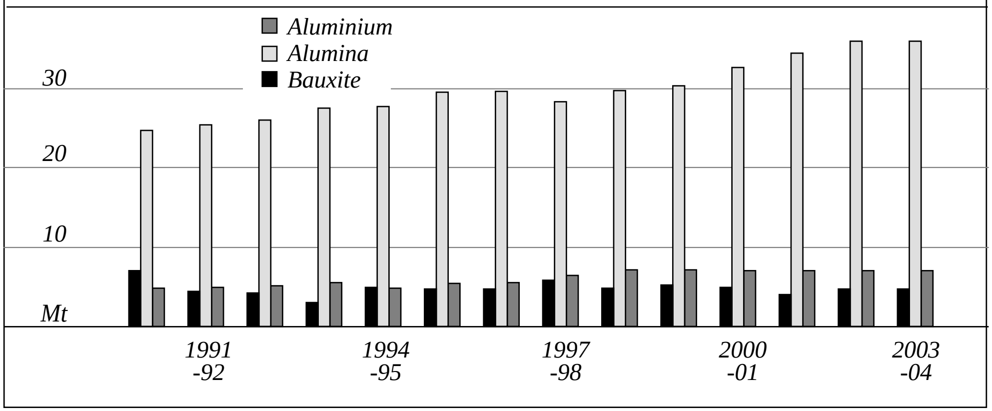
Currently, there are no advanced plans to increase aluminium smelting capacity in Australia. Aluminium production is projected to increase from 1.6 million tonnes in 1998 to 1.71 million tonnes in 2000 and stabilise at that level over the medium term. The increase to 1.71 million tonnes reflects additional output from the recently commissioned expansion at Tomago (by 40 000 tonnes a year) and the progressive commissioning and resolution of technical problems at the 490 000 tonnes a year facility at Boyne Island.

However, there are two projects at feasibility stage which could add a total of 500 000 tonnes a year to aluminium smelting capacity if they proceed (table 4.3). The larger of these is the proposed 450 000 tonnes a year smelter in Lithgow. The smaller proposed expansion at the Kurri Kurri smelter (50 000 tonnes a year) is possible if power negotiations result in the smelter attracting competitive electricity prices.

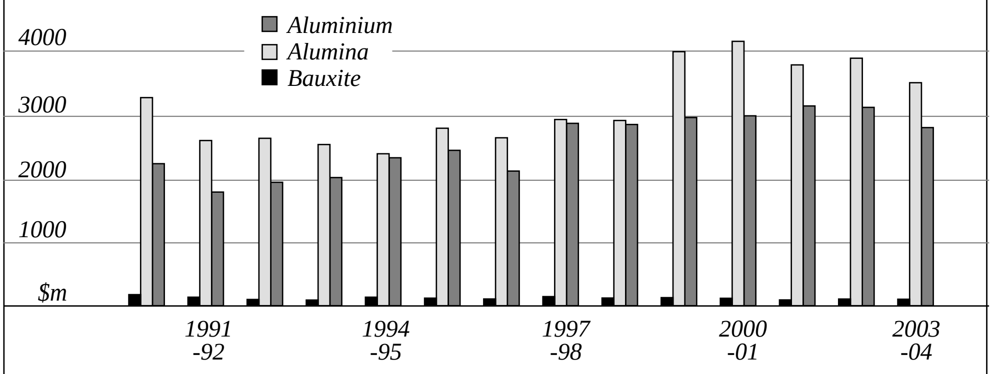
The proportion of alumina processed into aluminium is projected to rise slightly from 23 per cent in 1998 to 23.5 per cent in 1999, before declining to 20 per cent by 2004, as more alumina capacity comes on stream. Meanwhile, the proportion of bauxite processed into alumina is expected to remain fairly stable.

Projected export volumes in bauxite equivalents (figure 4.10) include only committed additions to capacity and follow trends very similar to those for production of the two commodities. Alumina exports are projected to increase

4.10 **Projections of aluminium industry exports** **(Bauxite equivalent)**



4.11 Projections of aluminium industry export earnings
(Constant 1998-99 dollars)



from 11 million tonnes (29.6 Mt bauxite equivalent) in 1998-99 to almost 13.4 million tonnes (35.6 Mt bauxite equivalent) in 2002-03, as production from new alumina capacity currently under construction comes on stream. Australian aluminium exports are projected to decline gradually from 1.37 million tonnes (7.1 Mt bauxite equivalent) in 1998-99 to 1.33 million tonnes (7.0 Mt bauxite equivalent) in 2003-04 as domestic aluminium consumption increases.

Projected real export earnings from the aluminium industry are shown in figure 4.11. Alumina export earnings are forecast to climb sharply in 1999-2000, and again in 2000-01, to over A$4 billion, as alumina prices increase. Export earnings from alumina will then generally decline over the medium term as projected falls in price more than offset rises in export volumes. In contrast, export earnings from aluminium are projected to rise to above $3 billion by 2002-03, in line with projected price rises, before declining in 2003-04, as export volumes decline slowly and prices fall.

5. Copper

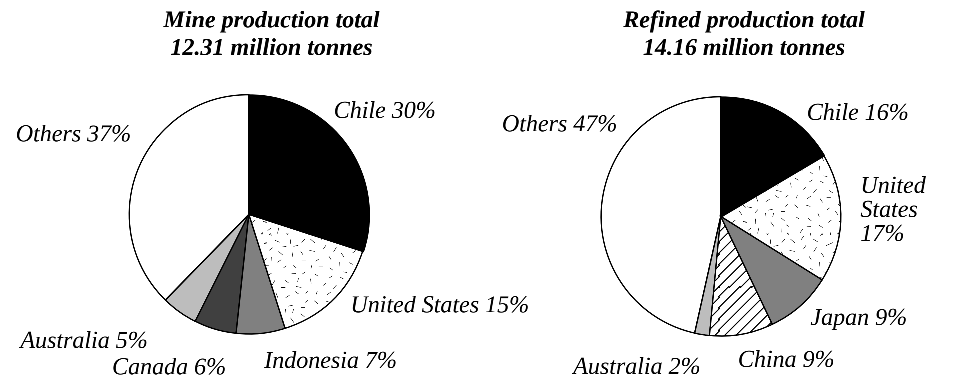
In 1998, Australia was the world's fifth largest mine producer of copper behind Chile, the United States, Indonesia and Canada, accounting for around 5 per cent of total world production. In terms of copper metal, Australia accounted for only 2 per cent of world production in 1998 (figure 5.1). These shares have changed little since 1985 when Australia accounted for 4 per cent of world mine output and 2.7 per cent of world metal production.

However, with recent substantial investment in new and expanded production capacity, particularly of refined metal, Australia's share of world mine and metal output is expected to increase significantly in the near term.

Australia has the world's third largest economic demonstrated resources (EDR) of copper (6.3 per cent of total known world resources, or 23 million tonnes) behind Chile (26 per cent) and the United States (14 per cent). Australia's EDR of copper represents about 35 years supply at current rates of mine production.

Australia's domestic consumption of copper is small relative to its production, with Australia accounting for approximately 1 per cent of world consumption in 1998, compared with 22 per cent for the United States and over 10 per cent for China. With domestic consumption low, Australia exports around 80 per cent of its mine output, a relatively high proportion. Australia accounted for more than 10 per cent of world exports of copper ores and concentrates in 1998, and was the fourth largest exporter of concentrates after Chile, Indonesia

5.1 *World copper production, 1998*



and Canada. Australia was also the eleventh largest exporter of refined copper, accounting for more than 2 per cent of world exports in 1998.

Value adding

Copper is typically mined in association with gold (in many cases gold is a significant byproduct of copper mining). Mine production is usually from sulphide ores and leaves the mine in the form of copper concentrate averaging around 30 per cent copper, but also containing other metals, principally gold and silver. Traditional copper processing involves the smelting and refining of concentrates to produce an intermediate product and, subsequently, refined copper. Intermediate smelter products are copper matte and blister copper (or copper anode) containing around 70 per cent and 99 per cent of copper respectively, together with varying quantities of gold and sometimes silver. The final refining stage produces primary refined copper metal and precious metals as byproducts.

There are difficulties in estimating the added value associated with the processing of copper concentrates. The gold content of copper concentrate adds to the market price of the unprocessed or semi processed product, making it inappropriate to consider the apparent value added to the production of refined copper in isolation. Furthermore, the metallic composition of copper concentrate tends to vary from mine to mine, and over time, resulting in variations in the percentages of gold content. This results in considerable variation in the export values of concentrates.

At some operations refined copper is produced directly at the mine site using Solvent Extraction–Electro-Winning (SX–EW) technology. This method bypasses the conventional smelting and refining processes and involves the extraction of copper metal from solution by electrolytic means. As such, the copper produced is usually low cost. Some 14 per cent of global copper output is currently produced using SX–EW processes. In Australia the proportion of total refined copper produced by SX–EW was 19 per cent in 1998. However, at this stage, SX–EW technology is usually only appropriate for oxidised ore bodies — as distinct from sulphide ore bodies which comprise the bulk of copper deposits — and therefore has some limits on its application. Nevertheless, ongoing development work is expected to expand the application of SX–EW technology and an increasing proportion of global copper, including from Australia, is expected to be produced by this method over the medium and longer terms.

Table 5.1 shows Australia's principal copper mines and refineries and their production in 1998-99.

5.1 *Australia's principal copper mines and refineries, 1998-99*

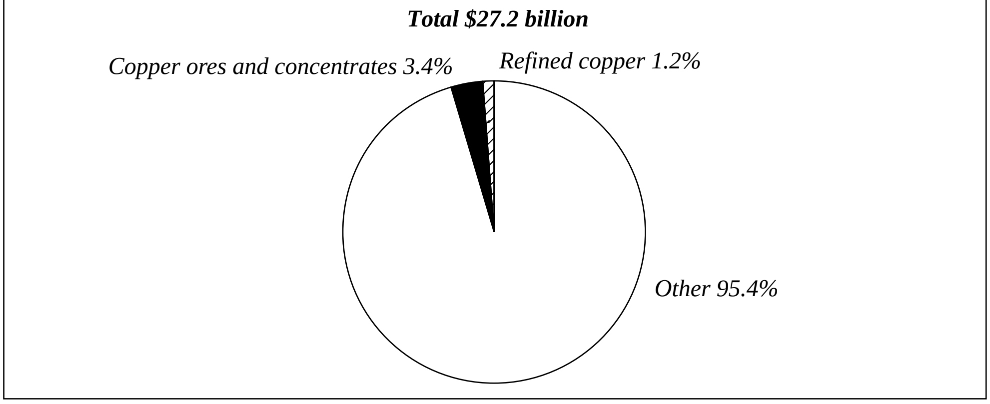
Operation	Company	Location	1998-99 production
			kt
Mines			
Nifty (SX–EW)	Straits Resources	Western Australia	15
Girilambone (SX–EW)	Straits Resources	New South Wales	16
Mt Gordon (SX–EW)	Western Metals	Queensland	19
Cadia	Newcrest	New South Wales	22
Eloise	Amalg	Queensland	21
Mt Lyell	Sterlite	Tasmania	25
Osborne	Placer Dome	Queensland	37
Highway Reward	Iluka	Queensland	46
Northparkes	North	New South Wales	57
Ernest Henry	MIM	Queensland	94
Olympic Dam	WMC	South Australia	84
Mt Isa	MIM	Queensland	168
Others	Various	Various	42
Total			645
Refineries			
Nifty (SX–EW)	Straits Resources	Western Australia	15
Girilambone (SX–EW)	Straits Resources	New South Wales	16
Mt Gordon (SX–EW)	Western Metals	Queensland	19
Olympic Dam	WMC	South Australia	84
Townsville	MIM	Queensland	168
Others	Various	Various	8
Total			310

The majority of world trade in copper is in the form of refined metal. However, there is also substantial trade in copper concentrates, amounting to around half that traded in refined form. There is also trade in semi processed copper (matte, blister and anode) although the volume of this trade is considerably smaller than that in refined or concentrate form. The significant trade in concentrates reflects the fact that smelting and refining capacity is not necessarily located in countries that produce copper concentrate.

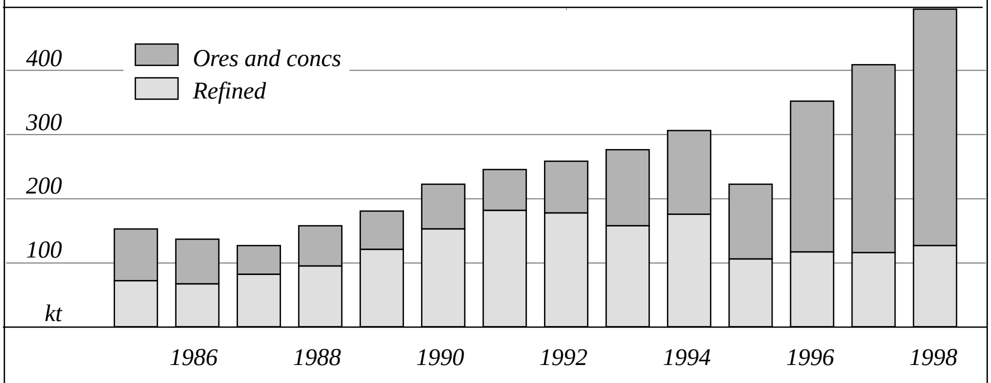
Australian copper exports

The copper industry's contribution to Australia's non energy mineral export earnings (in constant dollar terms) has risen since the mid 1980s — from 3.6 per cent of total nonenergy mineral export income in 1985 to 4.8 per cent in 1998 (figure 5.2). However, this is a relatively small increase in view of the

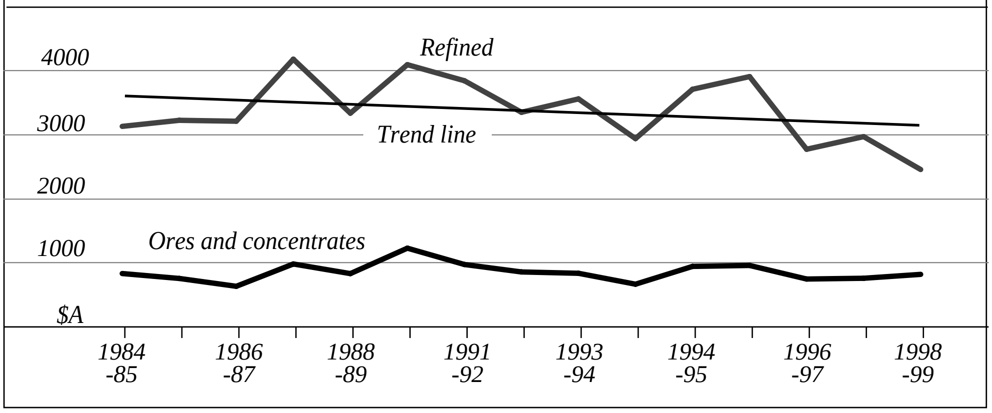
5.2 Copper: contribution to nonenergy mineral exports, 1998



5.3 Australian copper industry exports (copper content)



5.4 Unit prices of Australian copper exports
(constant 1998-99 dollars)



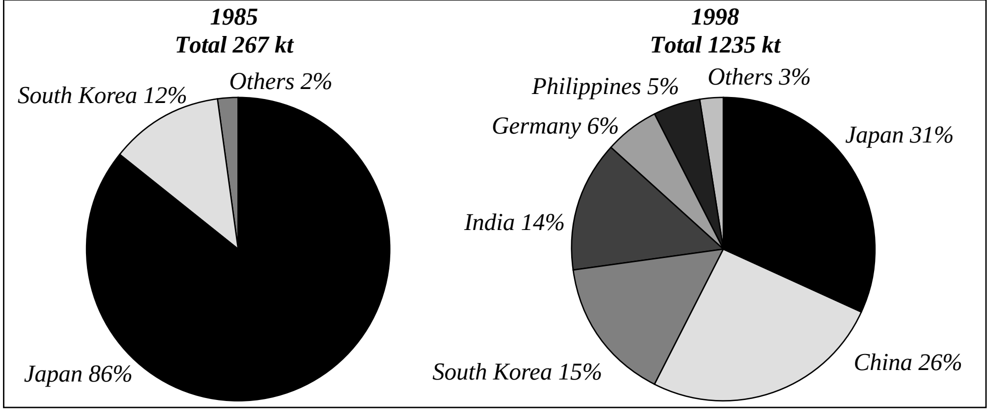
large increases in export volumes over the period (figure 5.3). To some extent this reflects a declining trend in the price of copper (in real terms) since the mid 1980s (figure 5.4), and proportionately greater increases in export volumes and values of other commodities in the minerals sector, particularly gold and aluminium/alumina.

Over the period 1985 to 1998, Asia remained the major destination for Australian exports of copper ores and concentrates (figure 5.5). However, exports rose almost fivefold over that period and Australia now exports to a wider range of Asian countries than in 1985. In 1985, total exports of copper ores and concentrates were 267 000 tonnes, with around 98 per cent going to Asian countries. In 1998, total ores and concentrates exports had risen dramatically, by 350 per cent, to 1.24 million tonnes, with 93 per cent going to Asia and Japan taking around one third of the total. The large increase in exports to Asia reflects strong growth in metals consumption and refining capacity in some Asian countries and Australia's proximity to these markets.

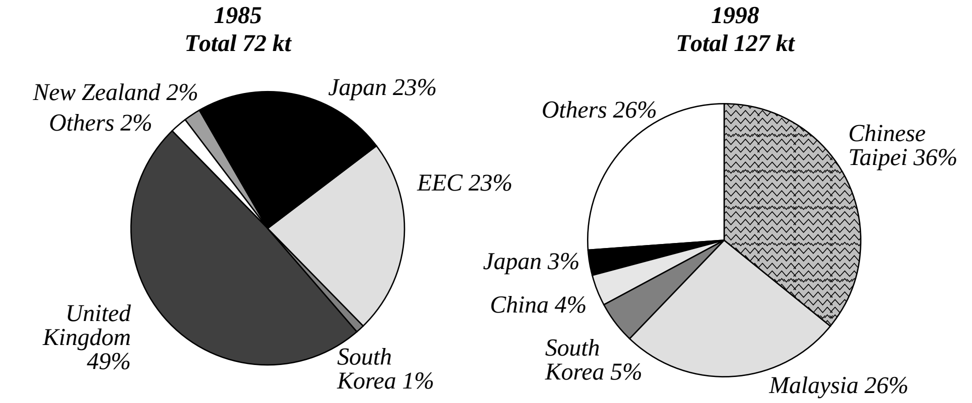
For refined copper, figure 5.6 shows that, in 1985, Australia's exports of refined copper to Asia accounted for only one quarter of the total, with the balance going to the United Kingdom and the European Union. By 1998, however, Asia's share had risen strongly, to almost 89 per cent. Chinese Taipei was the largest consumer in 1998, accounting for 36 per cent of the total in 1998 (nil in 1985).

For most of the period from the mid 1980s to 1994, exports of copper in processed form (mainly refined copper) accounted for over 60 per cent of total Australian copper exports by volume (figure 5.3). In 1998, however, refined copper accounted for only about one quarter of the total. The fall in the share

5.5 ***Australian copper ores and concentrates exports, by destination***

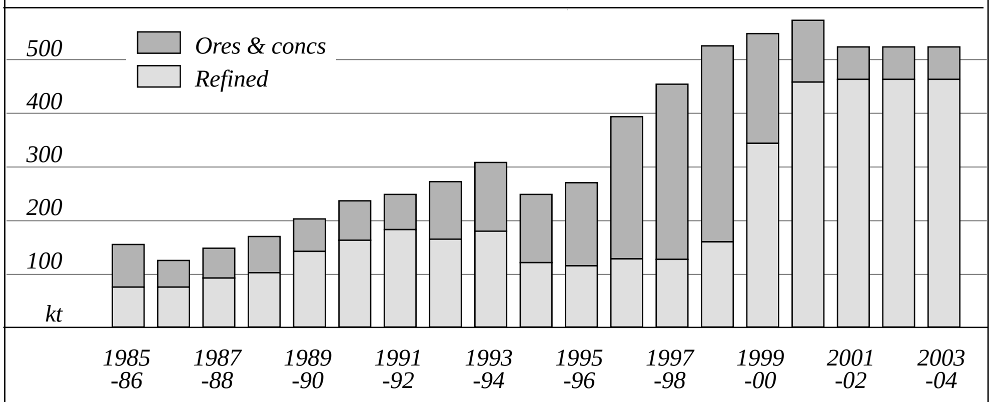


5.6 **Australian refined copper exports, by destination**



of processed copper exports was due, in large part, to the closure in late 1994 of the Southern Copper refinery at Port Kembla. This resulted in a higher proportion of copper being exported as concentrate. This proportion increased further over the period from 1995 to 1998 as a number of new and expanded copper mines (such as Ernest Henry) greatly boosted Australian concentrate production. At the same time, refined output at other facilities suffered from disruptions due to major expansion work. As a result, Australian exports of refined copper fell significantly, and copper concentrate increased even further as a proportion of exports. Thus 1998 was an unusual year — with refined metal accounting for little more than a quarter of total copper exports by volume.

5.7 **Projections of Australian copper industry exports**
(Copper content)



However, with the recent substantial investment in new Australian smelting and refining capacity now largely completed, the proportion of copper exported in refined form is expected to increase significantly in the near term and to remain high at around 88 per cent, in coming years (figure 5.7).

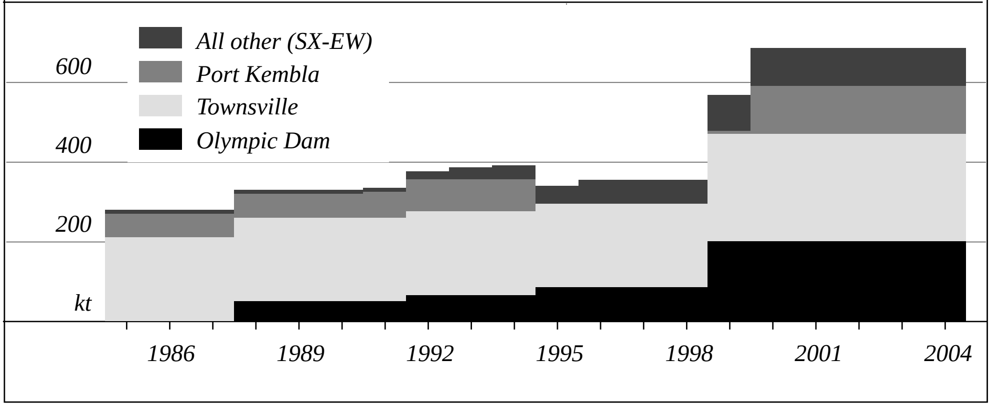
Outlook for further value adding of exports

Table 5.2 lists the major copper development projects either recently commissioned, under construction or proposed over the next 5 years. Amongst these, the most significant projects in terms of both output and capital expenditure, are those recently completed operations which involved substantial additions to refined output. These are WMC's Olympic Dam expansion from 85 000 to 200 000 tonnes a year of refined copper completed in early 1999; MIM's smelter and refinery expansions (in Mt Isa and Townsville, respectively) by 50 000 tonnes of refined copper a year; the reconstruction of the Port Kembla smelter/refinery complex (on the same site as the previous Southern Copper operation) adding 120 000 tonnes a year of refining capacity; and Western Metals Mt Gordon (in north west Queensland) expansion from 7000 to 50 000 tonnes a year of SX–EW cathode.

Of the other projects listed in table 5.2 the only value adding proposal is Queensland Minex's QSmelt copper smelter at Phosphate Hill. This is currently at feasibility stage and would produce copper matte, an intermediate smelter product, if it were to proceed.

Figure 5.8 shows actual and projected refined copper capacity for the period 1985 to 2004. This illustrates the dramatic increase in capacity from the end of 1998. All of the capacity increases are as a result of recently completed

5.8 ***Australian copper refining capacity***



5.2 *Major Australian copper projects*

Project	Company	Location	Status	New capacity	Startup	Capital expend.
Recently commissioned:						
Mine						
Cadia Hill mine	Newcrest Mining	21k SW of Orange, NSW	New project	23kt Cu	3rd qtr 1998	$441m
Ernest Henry mine	MIM/ Savage Resources	40km NE of Cloncurry, Qld	New project	95kt Cu	late 1997	$350m
Mount Gordon mine	Western Metals	120km N of Mount Isa, Qld	Expansion	37kt Cu	3rd qtr 1998	$125m
Northparkes mine	North	27km NW of Parkes, NSW	New project	70kt Cu	late 1997	$255m
Olympic Dam	WMC	Roxby Downs, SA	Expansion	115kt Cu cathode	from late 1998	$1.9b
Processing						
Mount Gordon Mine (SX–EW)	Western Metals	120km N of Mount Isa, Qld	Expansion	37kt Cu	3rd qtr 1998	$125m
Mount Isa copper smelter	MIM	Mount Isa, Qld	Expansion	75kt Cu anode	late 1998	$285m
Townsville copper refinery	MIM	Townsville, Qld	Expansion	45kt Cu cathode	late 1998	$50m
Olympic Dam	WMC	Roxby Downs, SA	Expansion	115kt Cu cathode	from late 1998	$1.9b
Pt Kembla copper smelter/ refinery	Furukawa/ Nittetsu/ Nissho Iwai ITOCHU consortium	Port Kembla, NSW	Recon– struction	120kt Cu cathode	early 2000	$250m

Continued Ó

5.2 Major Australian copper projects *Continued*

Project	Company	Location	Status	New capacity	Startup	Capital expend.
Under construction:						
Mine						
Enterprise mine	MIM	Mount Isa Qld	New project	progress-ively replacing 1100 orebody output	early 2000	$293m
Under consideration:						
Mine						
Ridgeway mine underway	Newcrest	near Orange NSW	New project feasibility study	12kt Cu 150000 oz Au	early 2001	$175m
Tritton (Bonnie Dundee)	Nord Pacific/ Straits Resources	22km SW of Girilambone NSW	New project feasibility study completed	20–24kt Cu	na	$50–70m
Processing						
Qsmelt copper smelter	Queensland Minex (Mineral Commodities)	Phosphate Hill, Qld	New project, feasibility study underway	105kt Cu matte 175kt sulphuric acid	2002	$120m

developments as there are no firm proposals for new refining capacity to come on stream over the next five years.

Based on these capacity increases, refined copper production is projected to rise sharply in the near term, reaching 685 000 tonnes in 2000-01, when full production capacity for these new and expanded developments is expected to be achieved. Projected production of refined copper in 2000-01 is more than double the level of refined copper production in 1998-99.

With almost all of the additional refining output expected to be exported, refined metal exports are also set to increase dramatically over the medium term (figure 5.7). Exports of refined copper are projected to be 460 000 tonnes in 2000-01, almost three times as much as in 1998-99. In addition, copper exported in refined form is projected to account for 88 per cent of total copper exports in 2001-02 — a significant increase on the proportion in 1998-99 (30 per cent). The higher proportion of total mine output being processed into metal will leave less material available for export in concentrate form. Consequently the volume of copper concentrate exports is expected to fall significantly.

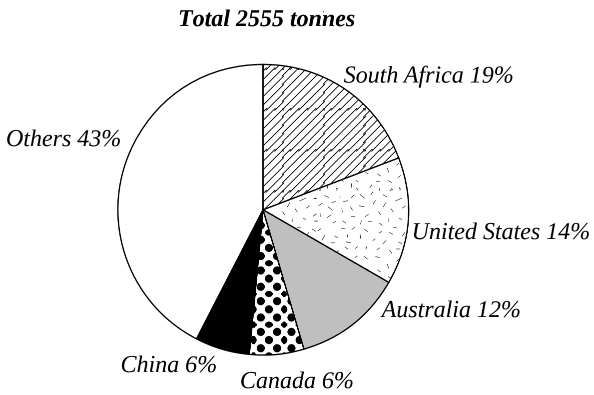
In nominal terms, Australia's export earnings from copper are projected to rise by 21 per cent, from $1.4 billion in 1998-99, to $1.7 billion in 2003-04. In real terms, exports are projected to rise by 7 per cent to $1.5 billion, given an assumed higher exchange rate.

6. Gold

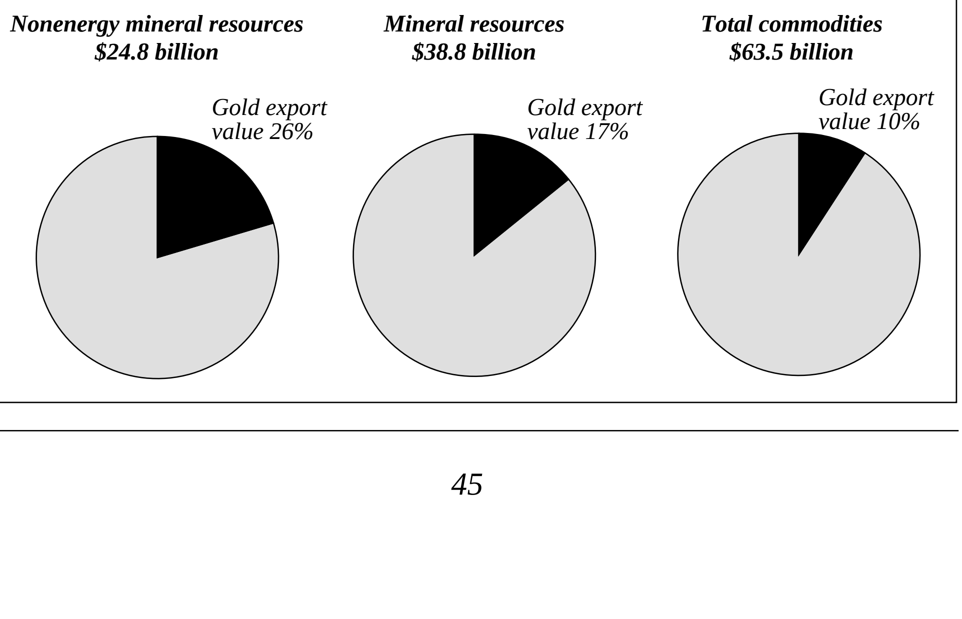
In 1998, Australia was the world's third largest gold producer, behind South Africa and the United States (figure 6.1). Australia's share of world mine production in 1998 was 12 per cent.

Gold is Australia's most valuable nonenergy commodity export. In 1998, the value of Australia's gold exports was $7.6 billion, or 28 per cent of Australia's total nonenergy mineral exports (figure 6.2), up significantly on its 9 per cent share in 1985. The increase in gold's share has been underpinned by a sub-

6.1 *World gold production, 1998*



6.2 *Gold: share of Australian exports, 1998-99*

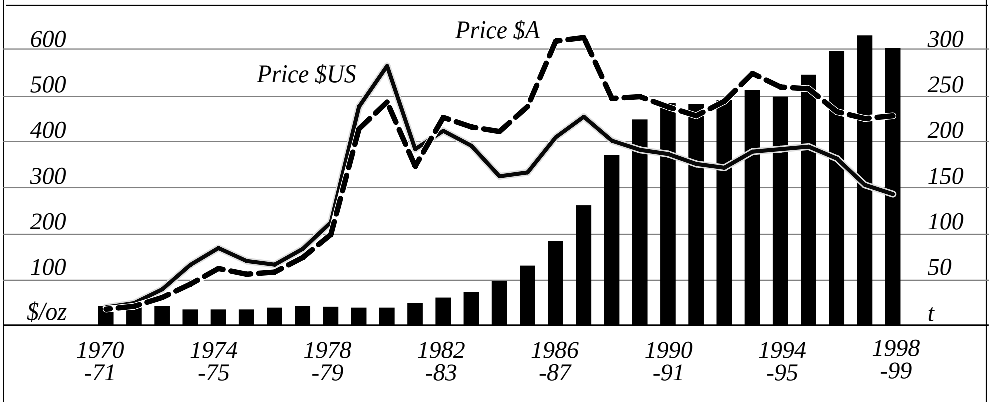


stantial rise in gold mine production over this period — from 59 tonnes in 1985 to 310 tonnes in 1998 (figure 6.3).

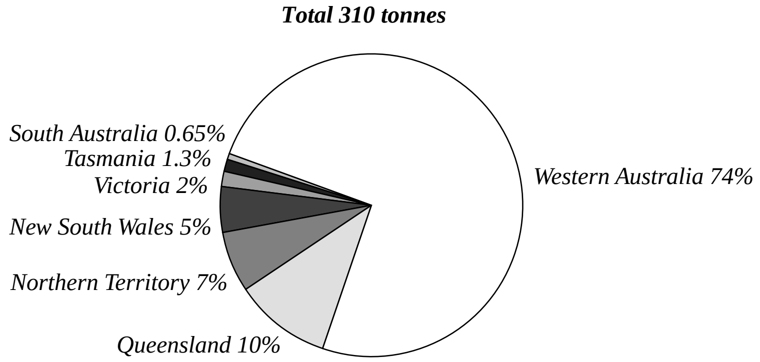
In 1998, three quarters of Australia's mine output of gold came from Western Australia (figure 6.4). There were approximately 100 operational gold mines in Australia in 1998, the 20 largest of these accounting for more than half of Australia's gold production (table 6.1).

Australia's economically demonstrated resources (EDR) of gold in 1998 totalled 4404 tonnes, or almost 10 per cent of world EDR. This represents around 15 years supply at current rates of mine production.

6.3 Australian gold production and price



6.4 Australian gold production by state, 1998



6.1 *Australian gold mines and refineries, 1998-99*

Operation	Company	Location	Production
			'000 oz
Largest 20 producers			
Super Pit	KCGM	WA	587
Granny Smith	Placer Dome	WA	518
St Ives	WMC	WA	408
Jundee/Nimary	Great Central Mines	WA	371
Telfer	Newcrest	WA	351
Mt Leyshon	Normandy	QLD	315
Kanowna Belle	North	WA	301
Bronzewing	Great Central Mines	WA	273
Cadia Hill	Newcrest	NSW	254
Plutonic	Homestake	WA	249
Boddington/Wandoo	Normandy	WA	242
Tanami Operations	Normandy	NT	225
Kidston	Kidston	QLD	215
Agnew/Leinster	WMC	WA	195
Tarmoola JV	Pacmin	WA	194
Mt Pleasant	Centaur	WA	179
Big Bell Consolidated	Normandy	WA	177
Paddington	Goldfields	WA	162
Sunrise Dam	Acacia	WA	162
Hill 50/Mt Magnet	Hill 50	WA	148
Others			4 196
Total Australian gold production			9 722
			302 tonnes
Refineries			
Western Australian mint		WA	na
Golden West		WA	na
Johnson Matthey		VIC	na
Olympic Dam		SA	na
Total refined gold			13 463

Value adding

Around 95 per cent of mined gold production in Australia is from specialist gold mines. The remainder is principally byproduct gold contained in concentrates produced at copper and other base metals mines. The mining processes and treatment generally employed at specialist gold mines mean that most gold leaves the mine site as gold dore — a semi-processed product which is usually at least 90 per cent gold, and therefore already a significantly value-added product.

6.2 *Major gold projects commissioned, 1993–99*

Project	Company	Location	Year commissioned	New capacity	Capital expend.
Cadia	Newcrest	NSW	1998	300 000 oz	$440m
Bronzewing	GCM	WA	1995	250 000 oz	$120m
Jundee	GCM	WA	1996	200 000 oz	na
Sunrise Dam	Acacia	WA	1997	180 000 oz	$66m
Kanowna Belle	NBH Peko	WA	1993	150 000 oz	$80m
Mt Todd	Pegasus	NT	1994	150 000 oz	$100m
St Ives	WMC	WA	1996	130 000 oz	na
Beaconsfield	Allstate Explorations	Tas	1999	100 000 oz	$50m
Henty	Goldfields	Tas	1996	100 000 oz	$70m
Paddington	Goldfields	WA	1996	100 000 oz	$36m
Union Reefs	Acacia	NT	1996	100 000 oz	$15m
Ravenswood	MIM	Qld	1995	100 000 oz	na
Sons of Gwalia	Sons of Gwalia	WA	1999	80 000 oz	$25m
Butcher Well/ Red October	Sons of Gwalia/ Mt Burgess	WA	1999	60 000 oz	na
Total new capacity added by major projects				2 000 000 oz (62 tonnes)	

Gold dore is produced at mine site gold processing plants of which there were an estimated 84 operating in Australia in 1998, processing ore from approximately 100 mines. The smaller number of processing plants (compared to mines) is due to a number of small mines sharing processing facilities. Gold processing plants often form the largest component of the start up capital of a new project and costs vary considerably depending on the size of the operation. Table 6.2 shows the major gold mine developments completed since 1993 and table 6.3 lists current gold projects under construction and in prospect over the medium term.

Almost all gold dore produced in Australia in 1998-99 was further processed into refined gold (greater than 99.5 per cent gold by weight) in Australia before being exported (domestic consumption is negligible). This means that gold is easily Australia's most processed mineral export with very little scope to further increase the degree of value adding. Australian refineries also treat imported gold dore from a number of mine sites in the Asia Pacific region.

6.3 *Major planned gold projects*

Project	Company	Location	Status	Expected startup	New capacity	Capital expend.
Projects under construction or committed						
Fosterville	Perserverance	Vic	Expansion, committed	late 2000	50 000 oz	$29
Vera Nancy	Normandy	Qld	Expansion, under construction	early 2000	100 000 oz	$48m
Mt Rawdon	Equigold	Qld	New project, under construction	2000	80 000 oz	$32m
Less advanced projects						
Ballarat	Ballarat Goldfields	Vic	New project, pre-feasibility study completed, on hold	na	100 000 oz	$65m
Bendigo	Bendigo Mining	Vic	New project, pre-feasibility study completed	early 2002	150 000 oz	$70–$100m
Boddington/ Wandoo	Normandy	WA	Expansion, feasibility study underway	2003	> 300 000 oz	$350m
Cowal	North	NSW	New project, feasibility study underway	na	250 000 oz	$220m

Continued ➪

The three most common methods of gold refining are chlorine refining, electrolytic refining and acid digestion refining. The refining process is relatively inexpensive and this is reflected in treatment charges that are estimated to be less than $1 an ounce.

Olympic Dam is the only mine in Australia where refined gold is produced on site. Apart from Olympic Dam, there are three major gold refineries in Australia — the Western Australian Mint and Golden West (Australasia), both in Perth, and Johnson Matthey in Melbourne (table 6.1). These three refineries, together with Olympic Dam, refined a record 419 tonnes of gold in 1998-99. This figure is significantly larger than Australian mined gold production in that year (302.4 tonnes) because of the large amount of scrap gold imported during the year for refining and re-export, reflecting significant dishoarding by Asian countries

6.3 *Major planned gold projects* *Continued*

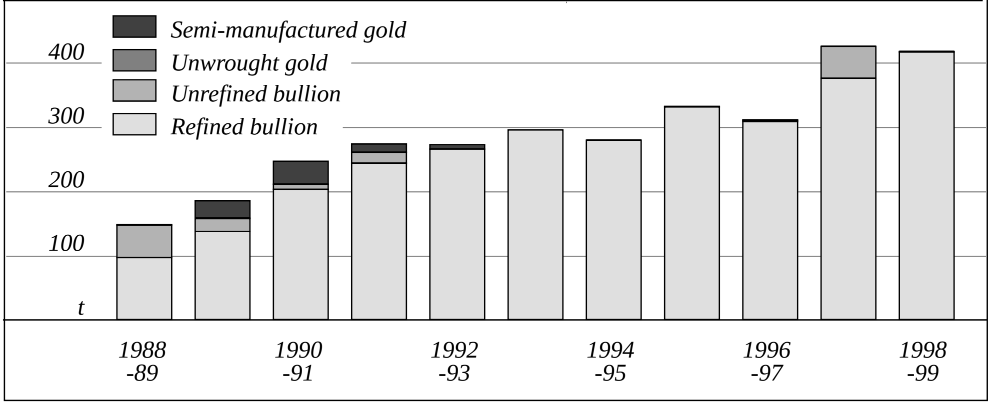
Project	Company	Location	Status	Expected startup	New capacity	Capital expend.
Gwalia Deeps	Sons of Gwalia	WA	Expansion underground feasibility study underway	2003	150 000–200 000 oz	$60
Maud Creek	Kilkenny Gold	NT	New project, feasibility study underway	2000	55 000 oz	$24m
Nullagine	Mt Grace Resources	WA	New project, feasibility study underway	na	na	$25m
Paulsens	Taipan	WA	New project, feasibility study underway	late 1999	na	$35m
Ridgeway	Newcrest	NSW	New project, feasibility study underway	early 2001	150 000 oz 12 kt Cu	$175m
Sarsfield	MIM/ Haoma Mining	Qld	New project, feasibility study completed	2000	60 000 oz	$45m
St Ives	WMC	WA	Expansion, on hold	na	150 000–300 000 oz	$157m
White Foil	Mineral Commodities NL	WA	New project feasibility study underway	mid 2000	na	na

(particularly South Korea) as a result of the economic downturn in the region. Of the 419 tonnes refined in Australia in 1998-99, 297 tonnes was of Australian origin with the remainder being of overseas origin.

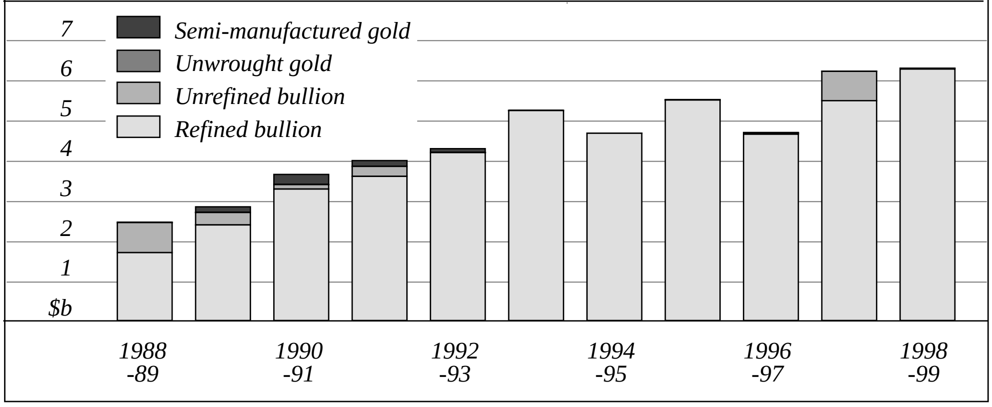
Gold exports and imports

Australian gold exports totalled 421 tonnes in 1998-99 (figure 6.5), valued at $6.3 billion (figure 6.6). Of the total gold exported in 1998-99, 299 tonnes were estimated to be of Australian origin. The value of Australian origin gold exports came to $4.5 billion in 1998-99, while the value of exports of overseas origin gold was $1.8 billion.

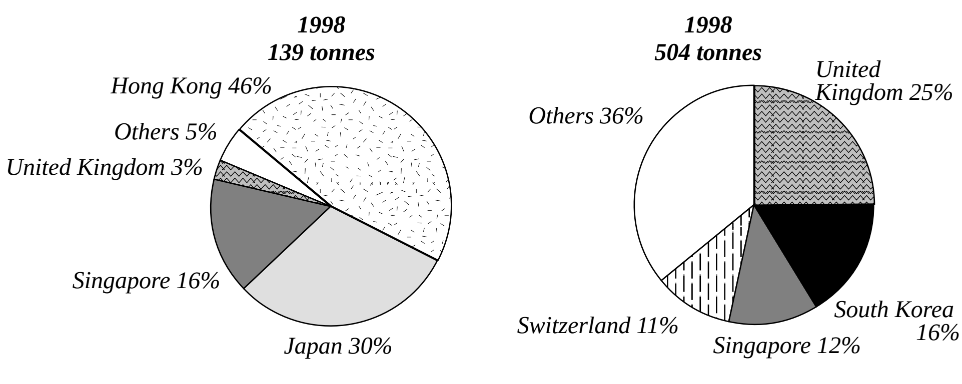
6.5 Australian gold exports



6.6 Australian gold exports earnings



6.7 Australian gold exports, by destination



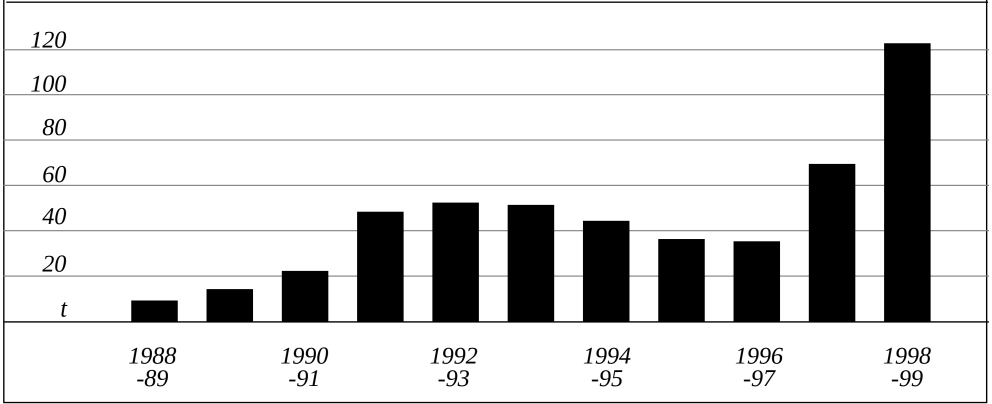
One-quarter of Australia's gold exports were directed to the United Kingdom in 1998 (figure 6.7), with the remainder going to at least a dozen different countries. South Korea was Australia's second largest gold export market in 1998, accounting for 82 tonnes (or 16 per cent of total exports) valued at $1.3 billion. However, the value of gold imports from South Korea — mainly in scrap form for re-refining — totalled $1.1 billion in 1998, resulting in little difference in the net value of Australia's gold trade with that country.

The extremely high unit value of gold makes transport costs as a proportion of total value almost negligible. Therefore, immediate destinations of Australia's gold exports may not be the countries of final consumption or even further processing. For example, it is estimated that a large proportion of Australia's gold exported to the United Kingdom in 1998 was further traded throughout Europe before being processed into jewellery, used in other industrial applications, or kept as bullion.

In 1988, only 3 per cent of Australia's gold exports went to the United Kingdom, while 46 per cent went to Hong Kong (figure 6.7). As with exports in 1998, it is assumed that a large proportion of Australia's gold exports to Hong Kong in 1988 was exported from Hong Kong to various international markets.

The amount of gold imported into Australia (predominantly for refining or re-refining) and subsequent exported, was unusually large in 1998 (figure 6.8). This was due to the large amount of gold dishoarding from Asian countries as a result of the economic downturn in the region. Severe currency devaluations led to local gold prices increasing significantly. This gold, predominantly in the form of jewellery, was mobilised and exported from Asian countries for

6.8 ***Australia's exports of gold of overseas origin***



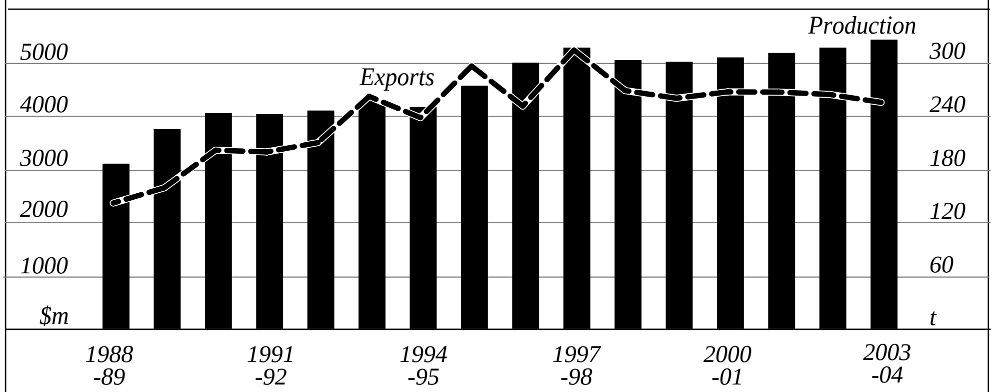
refining into gold bullion. In 1998, Australia imported an estimated 215 tonnes of gold — an almost threefold increase on 1997 gold imports. This level of gold imports is not expected to be repeated in 1999, with gold imports expected to return to more historical levels.

Outlook for further value adding of exports

Gold is Australia's most processed mineral output. The production methods employed in gold mining mean that all production at specialist gold mines (including gold-copper mines) leaves the minesite in at least semi processed form (gold dore). Around 95 per cent of Australia's mine output is in the form of dore, with the remainder principally contained in base metals concentrates exported. Because gold is generally traded in refined form, and because transport and refining costs are relatively low, a high proportion of dore output — over 99 per cent in 1998-99, although it has been slightly lower in earlier years — is further processed into refined gold in Australia before export. Apart from the possibility of domestically refining the very small volumes of dore exported in that form, there would appear to be very little potential for further value adding of gold in Australia over the medium term.

Table 6.3 shows the major gold projects under construction and in prospect over the medium term. The two projects currently under construction are both expected to begin production in the near term and will add around 180 000 ounces annually to Australia's gold production capacity. The prospects for the less advanced projects proceeding, or new projects being added, over the medium term are expected to be boosted by the recent rise in the price of gold, if prices are sustained at around current levels.

6.9 *Projections of Australian gold production and exports*



The value of Australian origin gold exports is forecast to fall by 3 per cent in 1999-2000 to $4.3 billion despite steady production over the same time period. This fall in export value reflects a slightly lower average gold price in Australian dollars in 1999-2000, despite firmer US dollar gold prices.

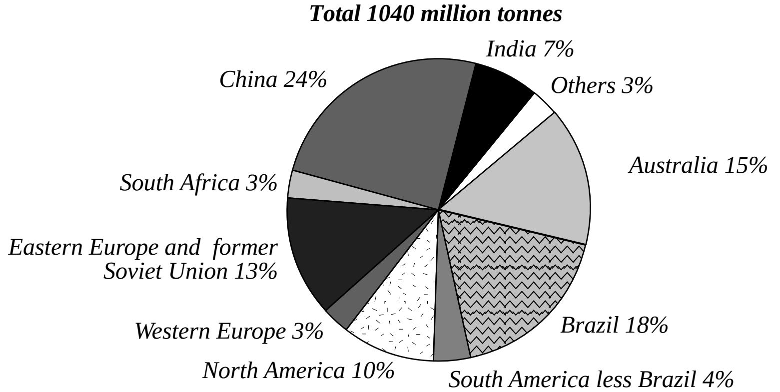
Over the medium term, forecast lower prices combined with slightly increased production and export volumes are expected to result in the value of Australian origin gold exports remaining steady, at around $4.2 billion, in 2003-04 (figure 6.9). Gold is expected to remain Australia's most processed non energy mineral export over the medium term and beyond.

7. Iron ore and iron and steel

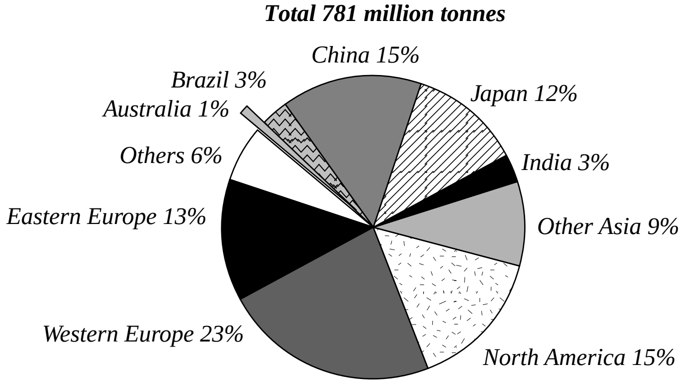
Iron ore production in Australia totalled 160.7 million tonnes in 1998, representing 15 per cent of world production, and ranking Australia as the third largest producer after China and Brazil (figure 7.1). Around 90 per cent of Australia's iron ore production is exported, with the rest consumed by the domestic iron and steel industry.

Substantial mineral resources underpin Australia's position as an iron ore producer. Australia's Economically Demonstrated Resources (EDR) of iron ore stood at 15.3 Gt in 1998, with most of the reserves located in the Pilbara region

7.1 **World iron ore production, 1998**



7.2 **World steel production, 1998**



7.1 *Australia's principal iron ore mines, and iron and steel processing facilities, 1998-99*

Company	Mine/processing facility	Location/type	1998-99 production
			kt
Iron ore mines			
BHP	Goldsworthy	WA	na
	Jimblebar	WA	na
	Middleback Ranges	SA	na
	Mt Whaleback	WA	na
	Orebody 23	WA	na
	Orebody 25	WA	na
	Yandi	WA	na
Total BHP			54 857
Hamersley	Brockman	WA	na
	Channar	WA	na
	Marandoo	WA	na
	Mt Tom Price	WA	na
	Paraburdoo	WA	na
Total Hamersley			52 849
Robe River	Mesa J	WA	28 495
Portman	Cockatoo Is.	WA	259
	Koolyanobbing	WA	1 010
Total Portman			1 269
Australian Bulk Minerals (ABM)	Savage River	TAS	4 235
Total Australian iron ore production			141 705
Iron ore and steel processing facilities			
BHP	Newcastle Rod and Bar	Blast furnace	1 642
	Port Kembla (Slab and Plate)	Blast furnace	4 901
	Sydney Minimill	Electric arc furnace	267
	Whyalla (Long Products)	Blast furnace	1 052
Smorgon **s**	Laverton Minimill	Electric arc furnace	593
	Newcastle Minimill [1]	Electric arc furnace	248
Total Australian steel production			8 703

s Estimate. 1 Aquired from ANI in early 1999.

of Western Australia. Australia is estimated to have about 11 per cent of the world's EDR of iron ore. There are also significant sub-economic deposits of iron ore (in excess of 15 Gt) the bulk of which are also located in the Pilbara. Elsewhere, deposits are located in the Savage River area of Tasmania and in the Middleback Ranges in South Australia.

In contrast to iron ore, Australia is a small player in the world steel market, accounting for a mere 1 per cent of total world production (figure 7.2). This reflects a small domestic market, high levels of international competition and trade barriers preventing the utilisation of scale economies.

Table 7.1 lists Australia's existing major iron ore mines and iron ore and steel processing facilities.

Value adding

The value-added chain for iron ore involves the conversion of iron ore into intermediate iron products such as pig iron and directly reduced iron (DRI) or hot briquetted iron (HBI — a form of DRI). These are in turn used as feed for processing to form steel and alloyed steel products through two basic processes, the electric arc furnace (EAF) or the oxygen converter. Table 7.2 shows the substantial value added to be gained by processing iron ore to intermediate iron and final steel products.

In a decision, which in part demonstrates the difficulties associated with export of high value added products from locations remote from markets through economic cycles, steelmaking at BHP's 1.7 Mt capacity Newcastle operation

7.2 *Transformation costs in the Australian iron and steel industry* [a]

	1998 average EUV [b]	Input coefficient [c]	Transformation coefficient [d]
	A$/t		
Iron ore	29.2	…	…
DRI [e]	159.4	1.2	2.64
Steel	466.4	1.6	8.98

a The transformation cost concept employed refers to the gross value which is added to the unprocessed mineral input (iron ore) by processing to the stage indicated. (Transformation cost = Value of processed output minus value of unprocessed mineral input consumed). **b** EUV (export unit value) is the average realised price per tonne of Australian exports in 1998-99. (EUV = Total export returns/Total exported quantity). **c** Tonnes of unprocessed mineral input required to produce a tonne of processed output. **d** The proportion by which the value of unprocessed mineral consumed is increased by processing to the stage indicated. (Transformation coefficient = Transformation cost / Value of unprocessed mineral input consumed). **e** EUV estimated.

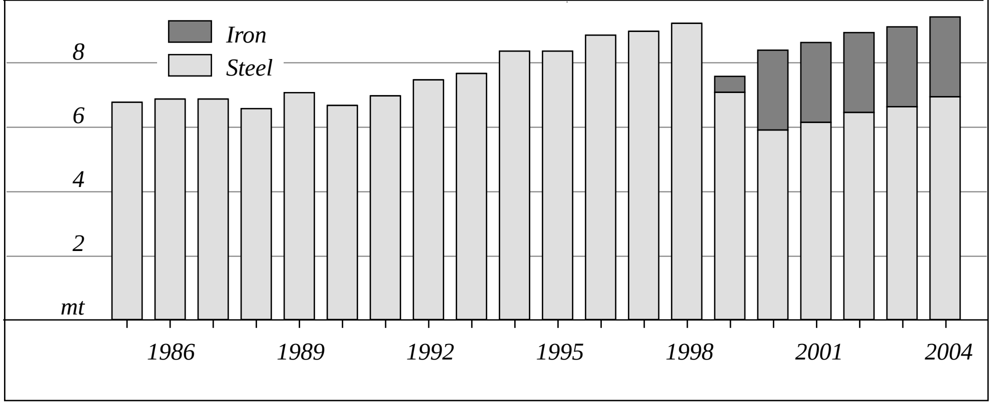
ceased at the end of September 1999. The decision — announced in April 1997 — reflected a decline in the competitiveness of steel produced at the facility and the generally difficult international operating environment faced by steelmakers in the latter part of the 1990s, with low average steel prices and significant world oversupply. As a result of the Newcastle closure, Australia's steelmaking capacity fell to around 7.6 Mt in late 1999 — a return to the capacity level of 1993 (figure 7.3).

However, an increase in iron and steel capacity through an expansion of BHP's Port Kembla blast furnace, and the recently completed construction of the 2.5 million tonne HBI plant, is expected to mitigate the impact of the loss of the Newcastle facility on industry export earnings over the medium term. By 2004, Australia's combined HBI and steelmaking capacity is expected to recover to around 1998 levels (figure 7.3).

Advances in steel and steelmaking raw materials technology — particularly the continuing market penetration of EAF — will influence the future direction of raw materials supply and demand and decisions on the nature and location of value added facilities. With lower capital costs, greater production flexibility, lower environmental impact and consequent superior efficiency of smaller scale operation, EAF facilities have increased their share of the world steel market from 14 per cent in 1970 to around 33 per cent in 1998. This trend is expected to continue, based on increasing demand for small-scale, flexible steel production close to markets that EAF offers.

The increase in total production from EAF facilities — particularly more recent increases in output of high quality flat products — has led to increased demand for high grade iron units as the key input, such as DRI/HBI. The expected

7.3 ***Australian iron and steel capacity***



7.3 *Major iron ore, and iron and steel projects*

Project	Company	Location	Status	Expected start up	New capacity	Capital expend.
Mining						
Mining projects committed						
Orebody 18	BHP	Pilbara, WA	New project, further construction deferred.	1999	5 Mt initially, 10 Mt eventually	$50m (initial capacity only)
Less developed mining projects						
Hope Downs	Hancock Prospecting	Pilbara, WA	New project, feasibility study underway	na	15–25 Mt	$0.8–1.6b
Mining Area C	BHP	Pilbara, WA	New project, feasibility study underway	2000	12 Mt	$200m
West Angelas	Robe River	Pilbara, WA	New project, feasibility study completed.	2001	5 Mt initially, 20 Mt eventually	$1b
Processing						
Projects under construction or committed						
Blast furnace expansion	BHP	Port Kembla, NSW	Expansion, under construction	2001	0.4 Mt	$93 m
Intermediate processing projects (all uncommitted)						
DRI plant	Australian United Steel Industries	Pilbara, WA	New project, feasibility study completed	na	3.6 Mt DRI	$1.8b
HBI plant	Mt Gibson Iron	Geraldton, WA	New project, feasibility study completed	na	2.6 Mt HBI	$1.1b
Pellet, HBI and possibly steel plant	Mineralogy	Pilbara, WA	New project, feasibility study completed	na	6.0 Mt pellets 4.0 Mt HBI	$1.8b
Pig iron plant	Australian Bulk Minerals	Port Latta, Tas	New project, feasibility study completed	na	0.5–1 Mt pig iron	$120m
Pig iron plant	SA Steel and Energy	60 km SE of Coober Pedy, SA	New project. Final feasibility study underway	na	2.5 Mt pig iron	$830m

Continued ➪

7.3 *Major iron ore, and iron and steel projects* Continued

Project	Company	Location	Status	Expected start up	New capacity	Capital expend.
Less advanced steel projects						
Steel plant	Compact Steel	Rockingham, WA	New project, feasibility study completed	na	1.4 Mt steel	$1.5b
Steel Mini mill	Boulder Group, Australian Overseas Resources, Danieli	Newcastle, NSW	New project, feasibility study completed	na	110 kt steel	$224 m
DRI and steel plant	An Feng Kingstream	Geraldton, WA	New project, feasibility study completed	na	2.4 Mt steel	$1.4b

expansion of EAF facilities in Asia represents a potential market for DRI/HBI produced in Australia. The export of higher value DRI/HBI to Asian EAF facilities is a significant step in the value added chain for Australia, where historically the bulk of exports has been in the form of unprocessed iron ore.

Australian raw material producers and other companies have been investigating the potential for further processing of iron ore in Australia for a long time. Direct reduction processes make prima facie economic sense in Australia because of the relative abundance of low cost iron ore reserves in Western Australia that are in close proximity to the large reserves of low cost natural gas of the North West shelf.

BHP’s 2.5 million tonne a year capacity HBI plant was commissioned at Port Hedland in Western Australia in early 1999 at a capital cost of $2.3 billion. This is Australia’s only commercial direct reduction facility.

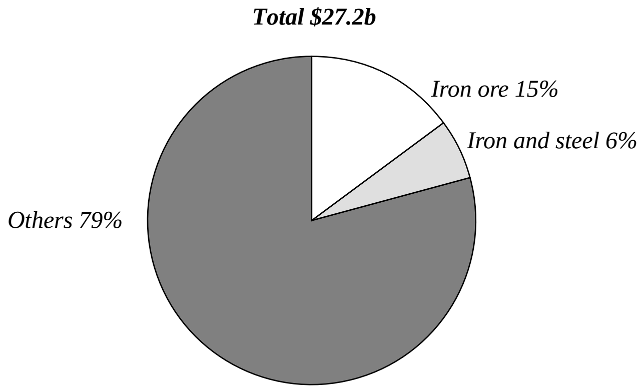
There are a number of other projects that involve various levels of processing value added which have been proposed for development in Australia (table 7.3). However, none of these has advanced beyond the feasibility stage and it is expected that few of them are likely to proceed in the medium term. This is mainly because these projects are aimed at markets in which there is very strong competition between suppliers worldwide, many of which are firmly based in large domestic markets.

The processing of iron ore into steel usually occurs near consumption centres, which usually reflects marketing, transport and labor cost advantages and often some subsidies and other protection. Reflecting the small size of the domestic Australian steel market, proposed Australian steelmaking projects face the vagaries of demand and supply in international markets for relatively homogeneous products.

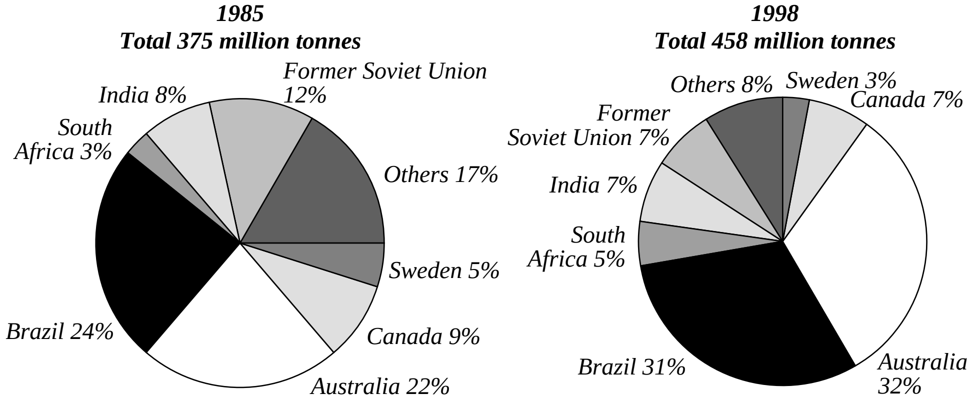
Iron ore and steel exports

Iron ore exports are Australia's second largest nonenergy mineral export after gold, accounting for 15 per cent ($4 billion) of nonenergy mineral exports in 1998. Steel exports also generate substantial export earnings, contributing 6 per cent ($1.6 billion) of Australia's nonenergy mineral exports (figure 7.4). In 1998, Australia accounted for 32 per cent of world iron ore exports and was

7.4 ***Iron and steel: contribution to Australia's nonenergy mineral exports, 1998***



7.5 ***World iron ore exports***



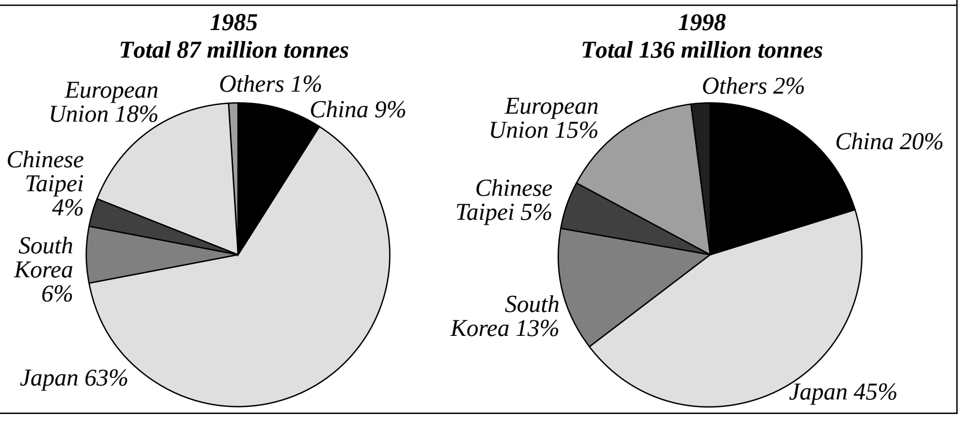
the world's largest iron ore exporter, followed closely by Brazil (figure 7.5). Australia and Brazil increased their share of the export market at the expense of smaller producers and a decline in exports from the Former Soviet Union.

Iron ore exports from Australia continue to be directed mainly toward Asia. Japan, China, South Korea and Chinese Taipei accounted for just over 80 per cent of Australia's total exports of 136 million tonnes in 1998 (figure 7.6). In 1985, the proportion of Australia's exports to these four countries was also around 80 per cent, but since 1985, the dependence on Japan has decreased while exports to South Korea and China have increased significantly. Higher demand for iron ore in China and the South Korea in that period is primarily the result of problems with domestic supply (absence in the case of South Korea), strong economic growth and the associated growth in domestic steel consumption and production.

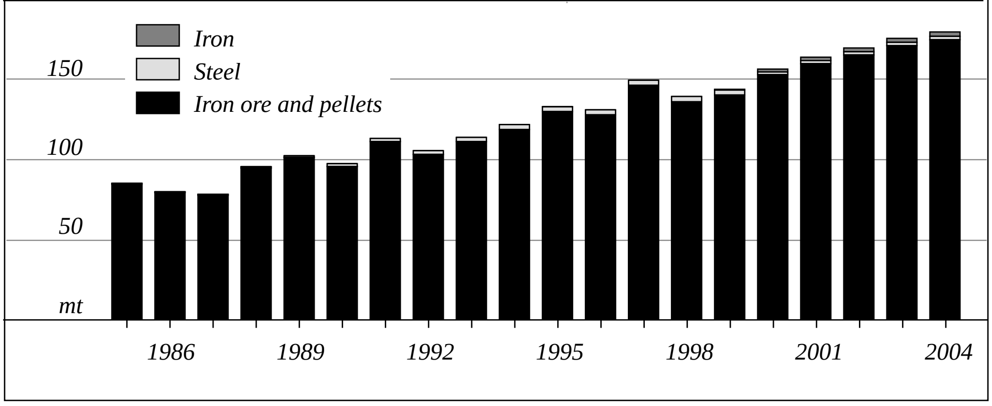
The volume of Australian steel exports is very low when compared with iron ore (figure 7.7), but the value of steel exports is significant (figures 7.4 and 7.8). This reflects the substantial value adding associated with converting iron ore into iron and steel (table 7.2). Most of Australia's crude steel exports are in the form of slabs, billets and flat coated products. Australia produced 8.8 million tonnes of steel in 1998 of which almost 40 per cent was exported. The destinations for the 3.4 million tonnes of iron and steel exported from Australia were diverse in 1998, with around 40 per cent being exported to Asian countries and 26 per cent exported to the United States (figure 7.9).

The total value of Australia's iron ore and steel exports was over $5.6 billion in 1998, 55 per cent higher in real terms than the $3.3 billion generated in 1985 (figure 7.8). In 1998, steel accounted for over 28 per cent of the total export

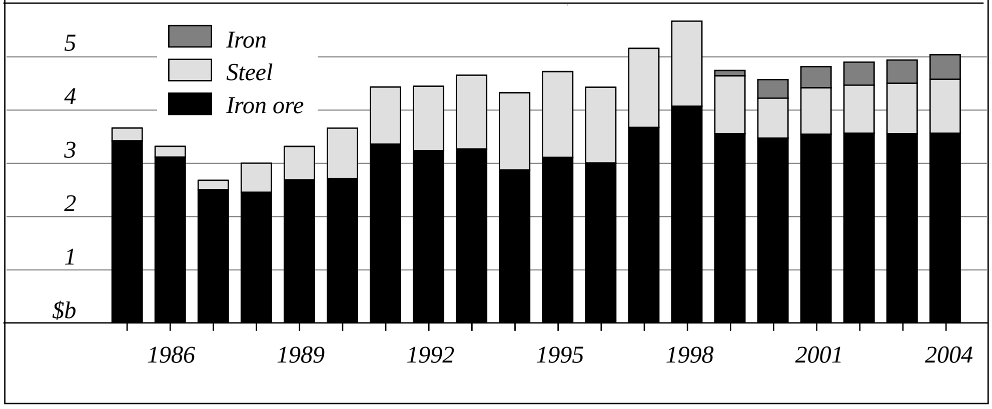
7.6 ***Australian iron ore exports, by destination***



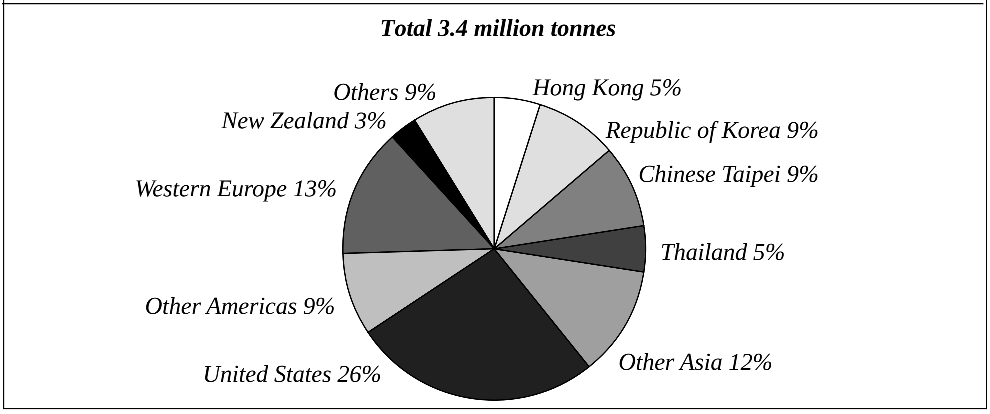
7.7 Projections of Australian iron ore, iron and steel exports (Iron content)



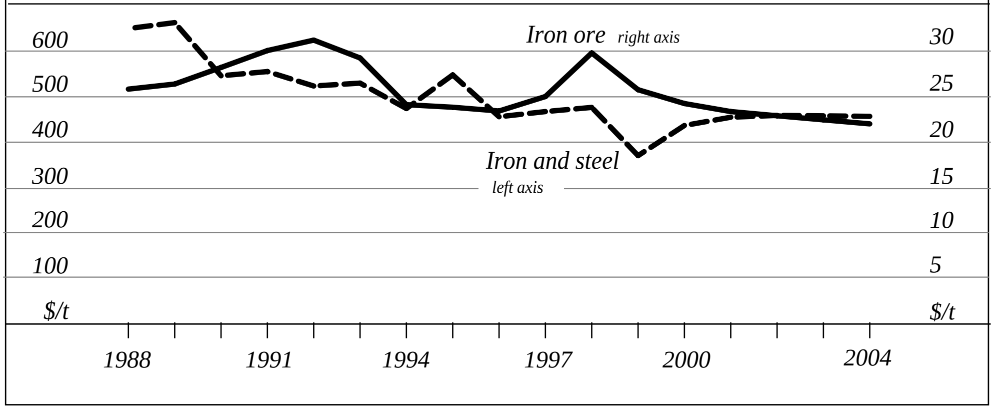
7.8 Projections of Australian iron ore, iron and steel export earnings
(Constant 1999 dollars)



7.9 Australian steel exports, by destinations, 1998



7.10 Projections of Australian iron ore and steel export unit returns
Constant 1999 dollars



earnings by the combined industries, but was less than 3 per cent of total exports on a volume basis in 1998 (figures 7.7 and 7.8). The average unit export value of Australian steel exports was $464 per tonne in 1998, 16 times higher than the $29 per tonne for iron ore exports (figure 7.10).

Outlook for further value adding of exports

Table 7.3 shows the list of the iron ore and iron and steel projects currently proposed in Australia over the medium term.

There are currently no steel projects at an advanced stage of development. However, several steel projects were completed in 1999. Of these, only one — BHP's 400 kt blast furnace expansion at Port Kembla — added to Australia's steelmaking capacity. Several other completed projects, such as the Tinplate expansion at Port Kembla, increased the proportion of higher value products exported.

All other value adding projects, including two steel projects — the 110 000 tonne per year steel minimill at Newcastle and the 1.4 million tonne steel plant at Rockingham Western Australia — have completed their feasibility studies and depending on market conditions, may or may not proceed to development. Several large scale proposals for producing intermediate value added products (DRI, HBI and pig iron) face highly competitive market conditions, high capital costs and long lead times.

Table 7.3 also lists four iron ore projects in the Pilbara region of Western Australia. Only one — BHP's Orebody 18 — is advanced, but further development work on this project has been deferred. However, with the demand for steelmaking raw materials in Asia likely to increase over the medium term, the iron ore development proposals generally face more favorable market conditions than those facing the valued added proposals.

Australia's proximity to Asian steel producers, and the large proportion of the total cost of landing iron ore in these markets accounted for by seaborne transport, gives Australian producers a significant competitive advantage over Atlantic basin iron ore exporters such as Brazil. This advantage has been eroded in the last few years, with dramatic falls in haulage rates due mainly to a fall in demand for ocean transport associated with Asian destinations. However, Australia's competitiveness is expected to benefit in the years ahead, with freight rates expected to increase in line with recovery in world, and particularly Asian, economic activity.

To meet iron ore demand in Asia over the next five years, Australian iron ore exports are projected to increase by 17 per cent to 162 million tonnes in 2004. Iron ore export earnings are projected to remain relatively constant in real terms at around $3.6 billion in the four years to 2004, after falling in 1999 with the significant reduction in negotiated prices for Japanese fiscal year 1999 (figure 7.8).

Exports of HBI from BHP's Port Hedland facilities commenced in early 1999 and will contribute significantly to iron and steel exports over the medium term. However, with the closure of the Newcastle facility, expected increased iron ore exports and uncertain prospects for iron and steel value adding proposals, Australia is expected to remain primarily a supplier of iron ore to the world steel industry over the next five years.

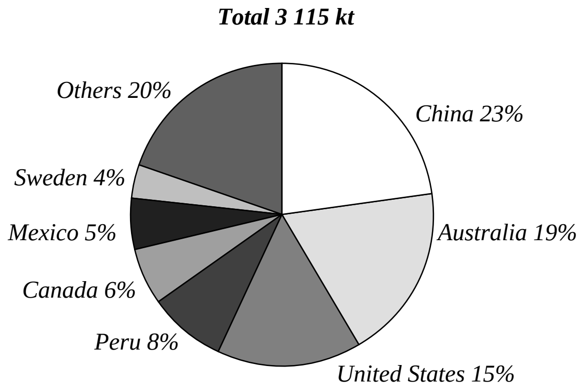
Australian iron and steel export volumes are projected to rise by 1.7 million tonnes to just under 5 million tonnes in 2004. Earnings from iron and steel exports are projected to fall by 25.7 per cent to $1.19 billion in 1999, before increasing to $1.48 billion (in 1999 dollar terms) in 2004 (figure 7.8).

8. Lead

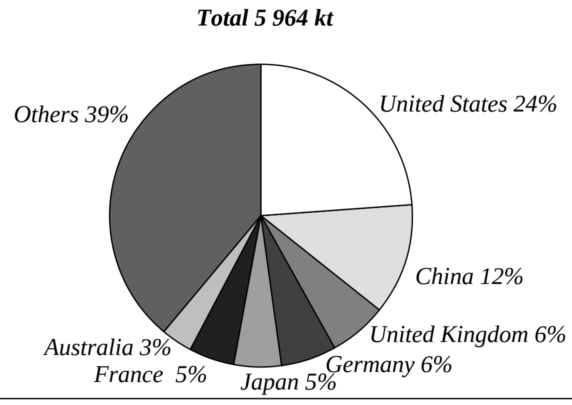
By virtue of its substantial production and export capacity, Australia plays a significant role in the world lead industry. In 1998, Australia was the world's second largest mine producer of lead (after China), accounting for 19 per cent of world production (figure 8.1), and the tenth largest producer of lead metal, accounting for 3 per cent of global production (figure 8.2).

Australia's domestic consumption of lead is small in comparison to most other significant lead producing countries — Australia accounts for only 1 per cent of world consumption compared with almost 30 per cent for the United States

8.1 *World lead mine production, 1998*



8.2 *World refined lead production, 1998*



8.1 Australia's principal lead mines, smelters and refineries, 1998-99

Operation	Company	Location	1998-99 production
			kt
Mines			
Cannington	BHP	Qld	153
Mount Isa	MIM	Qld	138
Broken Hill	Pasminco	NSW	109
Lennard Shelf	Western Metals	WA	61
Elura	Pasminco	NSW	45
Rosebery	Pasminco	Tas	18
McArthur River	MIM	NT	45
Hellyer	Western Metals	Tas	44
Woodcutters	Normandy	NT	14
Other	na	na	35
Total (lead in concentrates)			662
Smelters			
Cockle Creek	Pasminco	NSW	29
Mount Isa	MIM	Qld	128
Total (lead bullion)			157
Refineries			
Port Pirie	Pasminco	SA	196
Total (refined lead)			196

and 8 per cent for China. As a result, Australia is also a significant exporter of lead. Australia was the dominant exporter of lead ores and concentrates and the third largest exporter of refined lead (after China and Canada) in 1998. Australia also exports significant quantities of lead bullion, an intermediate smelter product.

The bulk of Australia's resources of lead are contained in zinc–lead–silver sulphide deposits. Australia is estimated to possess about 27 per cent of the world's demonstrated economic resources of lead. Australia's main currently producing lead mines, smelters and refineries are shown in table 8.1.

Value adding

Globally, lead is almost always mined in association with zinc and silver from zinc rich ore deposits. Mine products are usually in the form of lead concentrates with lead contents ranging from around 55 per cent to 70 per cent lead.

Value adding processes involve the smelting and refining of concentrates. The intermediate smelter product is lead bullion containing, typically, around 99 per cent lead and significant quantities of silver. The final refining stage produces primary refined lead metal and byproduct silver.

In addition, substantial quantities of lead are recycled, mainly from spent batteries, to produce refined lead. Globally, recycled, or 'secondary,' lead now accounts for around 58 per cent of total refined lead production, having risen from 51 per cent at the start of the decade. The proportion of secondary lead in total lead production is expected to gradually increase over the long term in line with policies to enforce stricter environmental guidelines on lead production, use and disposal. If sustained as expected, this trend means that the growth in world lead mine production, and hence the output of primary refined lead, will be slower than the growth in total world lead consumption over the medium to long term.

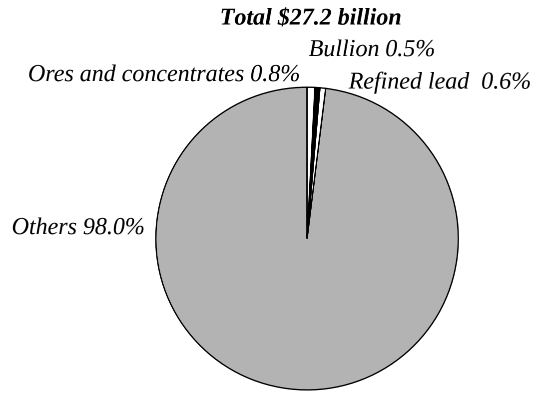
For lead, as for copper, it is difficult to estimate the added value associated with processing lead concentrates to a more refined form. The substantial and variable silver content of concentrates pushes up the price of the semi processed product (lead bullion) making it inappropriate to attribute apparent value added to the production of refined lead alone. Exports of lead bullion typically have a higher export unit value than refined lead because bullion contains lead as well as substantial amounts of silver (around 3 kg a tonne). In addition, the physical characteristics of concentrates vary from mine to mine, resulting in considerable variation in export value as shares of mines of origin change in the composition of exports. For example, the unit value of Australian lead concentrates exports rose significantly in 1998 because of the increasing proportion of high lead/high silver, concentrates originating from the large new Cannington mine in Queensland.

Although a majority of the global trade in lead is in the form of processed lead (bullion and refined), there is also substantial trade in lead concentrates — around half that traded in refined form. The significant trade in concentrates partly reflects the relatively small transport cost advantage to be gained by further processing, in part because of the relatively high lead content of the mine product.

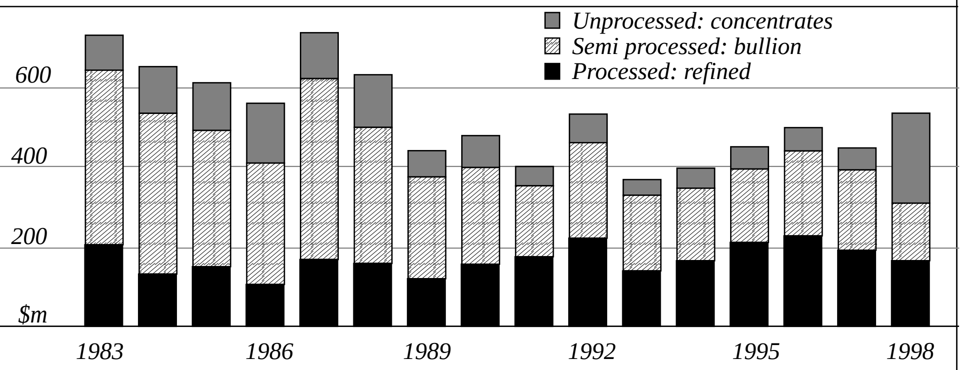
Australian lead exports

The lead industry's contribution to non energy mineral export earnings (in constant dollar terms) has fallen since the mid 1980s. In 1998, lead's contribution was 1.9 per cent (figure 8.3), compared with 4.6 per cent in 1985. Over that period the total value of lead exports fell by 12 per cent (in constant 1998

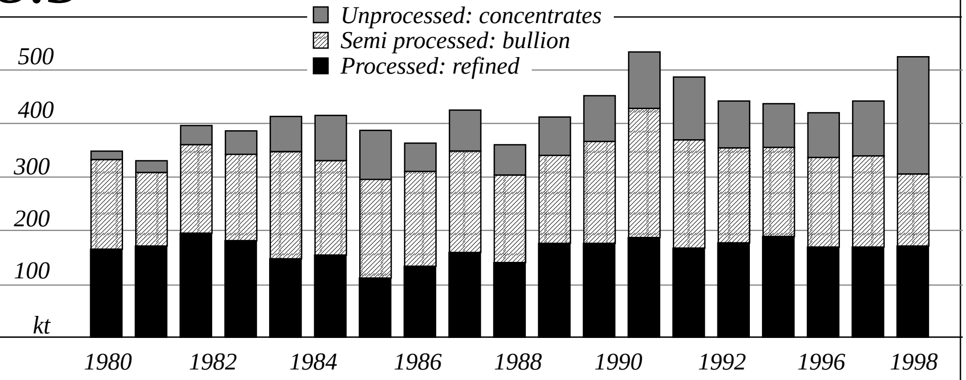
8.3 *Lead: contribution to nonenergy mineral exports, 1998*



8.4 *Value of Australian lead industry exports* (constant 1998-99 dollars)



8.5 *Australian lead industry exports (lead content)*



dollars) (figure 8.4), despite a 26 per cent rise in total export volumes (in terms of lead content) (figure 8.5). The decline in export value is mainly attributable to a fall in both the volume and the real unit export price of the intermediate product, lead bullion, over this period. To a large extent, this reflects the decline in real silver prices since the mid 1980s. The decline in lead's contribution to non energy mineral export earnings also reflects the proportionately greater increases in this period in the export volumes and values of other commodities in the sector, particularly gold and aluminium/alumina.

Figure 8.5 shows that for the period from 1985 to 1997, the proportion of Australian lead exported in semi processed and processed form remained relatively stable, varying between 76 per cent and 85 per cent. However, in 1998 the proportion exported in these forms fell to 58 per cent, reflecting the substantial increase in the production and exports of concentrates from the new Cannington mine, as well as a decrease in exports of lead bullion due to lower production at Mount Isa. Lead bullion exports are expected to increase moderately when MIM's George Fisher mine comes into production in 2000.

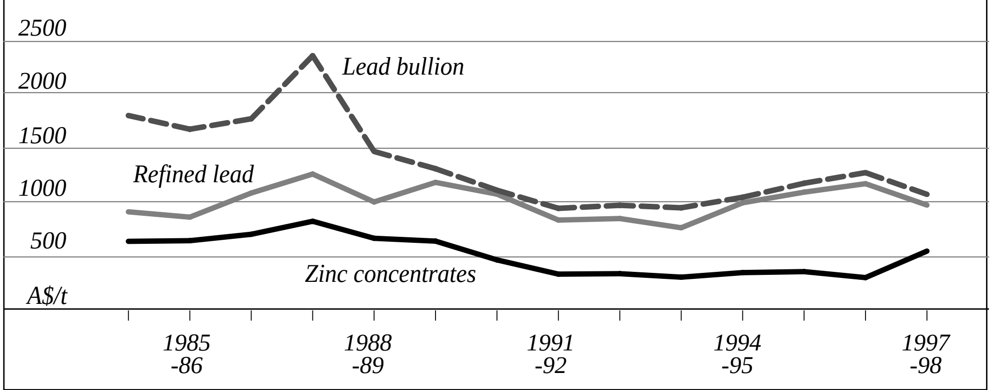
Trends in constant dollar export prices of lead products are shown in figure 8.6. Figure 8.7 shows world prices of lead and silver in constant US$ terms.

Figure 8.8 shows the relative size, and changing pattern, of lead concentrate exports between 1985 and 1998. The increase in the volume of lead concentrates exports in 1998, compared with 1985, largely reflects output from the Cannington mine which came into production toward the end of 1997. Cannington contributes over one quarter of total Australian lead mine production and a significantly higher proportion of lead concentrate exports. Since 1985, South Korea and China have emerged as important new destinations for Australian lead concentrate exports as their domestic smelting and refining capacities and consumption requirements have increased. South Korea now accounts for almost a third of total Australian exports of lead concentrates.

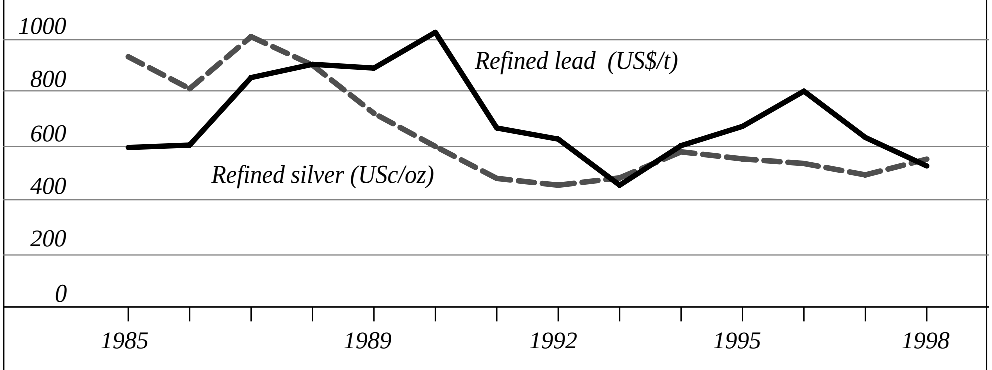
Figure 8.9 compares the size and pattern of refined lead exports in 1985 with those in 1998. While the increase in the volume of refined lead is not substantial over that period, Asian markets, particularly South Korea, Chinese Taipei and Malaysia, have significantly increased their share of total Australian exports.

All exports of lead bullion currently originate from MIM's lead smelting operations at Mount Isa and are refined at MIM's Northfleet refinery in the United Kingdom, so while that value is not added in Australia, it is added by an Australian company.

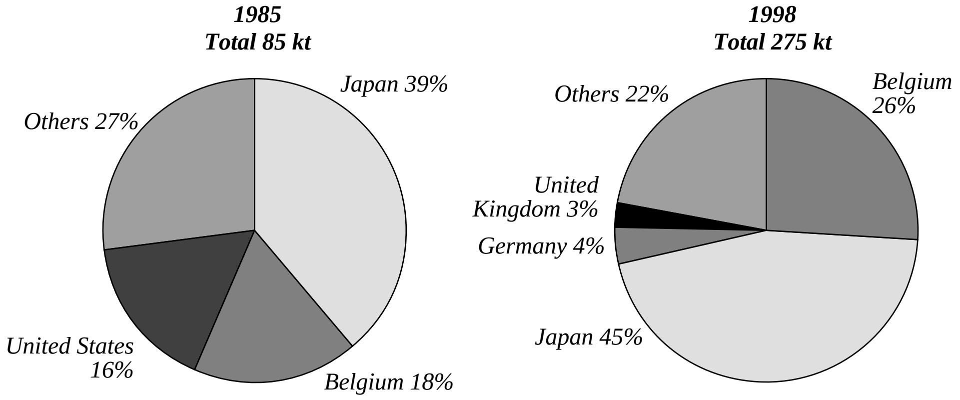
8.6 Unit prices of Australian lead exports *(constant 1998-99 dollars)*



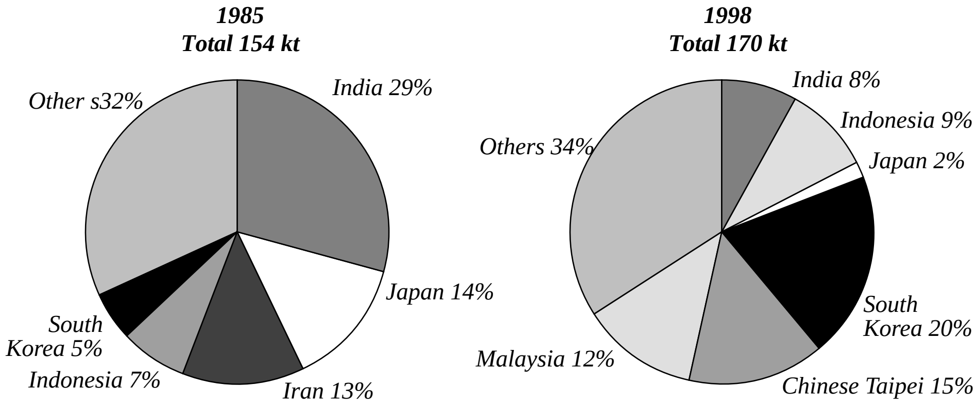
8.7 World lead and silver prices *(constant 1998 dollars)*



8.8 Australian lead ores and concentrates exports, by destination
(Lead content)



8.9 ***Australian refined lead exports, by destination***

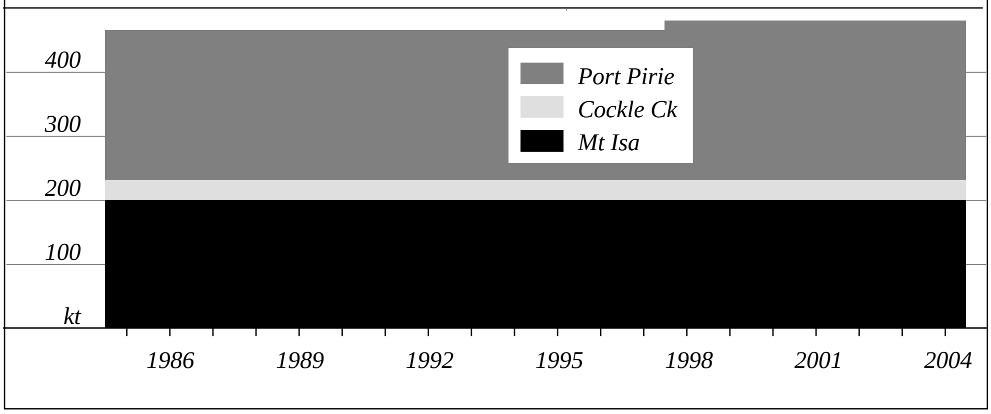


Outlook for further value adding of exports

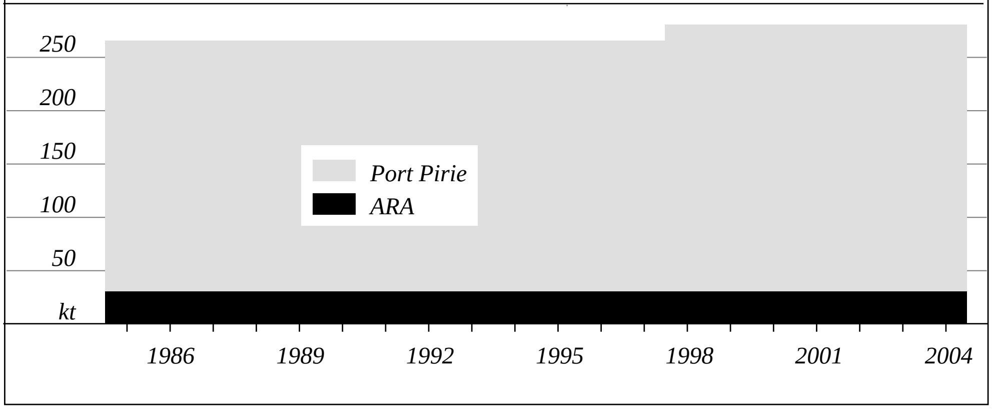
The only change in lead processing capacity in Australia since the mid 1980s has been a capacity increase resulting from the modernisation and upgrade of Pasminco's Port Pirie smelter/refinery – the largest in the world – completed toward the end of 1998 (figures 8.10 and 8.11). Capacity at Port Pirie has been raised from around 215 000 tonnes a year to 250 000. Refined lead exports in 1999-2000 are expected to fully reflect this expansion.

With much of the growth in world lead demand expected to be met by secondary lead, existing and currently planned global primary refined lead capacity is expected to be adequate to accommodate projected increases in mine output and demand for primary lead over the medium term. Coupled with the relatively

8.10 ***Australian lead smelter capacity***



8.11 Australian lead refining capacity



small additional value which comes from processing to refined metal, there is little incentive for Australian investment in new greenfields primary lead refining capacity at this time.

Table 8.2 shows that two major lead projects are currently under development in Australia, with several other projects at feasibility study stage. Most of these are mine development proposals with only one, Browns polymetallic project, aimed at producing a value added product (lead bullion). The Browns project remains at feasibility stage.

Pasminco's Century mine, currently commissioning, is predominantly a zinc mine with lead concentrates produced as a byproduct. It is possible that some of this output will be processed at Pasminco's Port Pirie refinery and exported as refined lead. MIM's George Fisher mine is essentially a replacement for its Mount Isa lead/zinc mining operations where ore reserves are almost depleted. Output is expected to be processed to lead bullion at MIM's lead smelter in Mount Isa and subsequently exported (as now happens with the output from the Mount Isa operations).

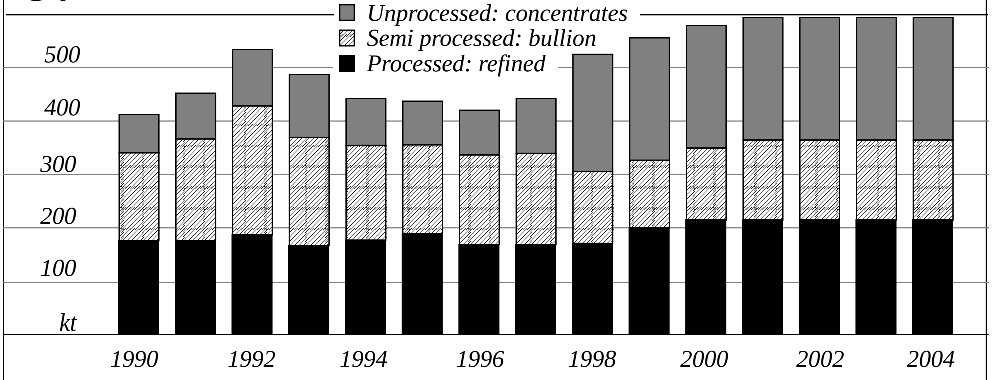
If only the committed lead developments (Century and George Fisher) are factored into projections over the medium term, the proportion of lead exported in processed or semi processed form over that period is expected to show little change from the levels of recent years (figure 8.12).

However, if a decision is made to proceed with development, the Browns project could add 70 000 tonnes a year of processing capacity (lead bullion). It is expected that this output would be exported, given that the Port Pirie refinery is likely to be fully committed. In addition, while not included in table 8.2,

8.2 Major Australian lead projects

Project	Company	Location	Status	Expected startup	New capacity	Capital expend.
Advanced mining projects						
Century	Pasminco	250 km NW of Mt Isa, Qld	New project, commissioning	late 1999	450 kt Zn 41 kt Pb	$810m
George Fisher	MIM	22 km N of Mt Isa, Qld	New project, under construction	mid 2000	170 kt Zn 100 kt Pb 155 t Ag	$270m
Less advanced mining projects						
Balcooma	Lachlan Resources	200 km WNW of Townsville, Qld	New project, feasibility study completed	na	40 kt Zn 8 kt Pb 5 kt Cu	$60m
Bowden's silver project	Silver Standard Australia	25 km ESE of Mudgee, NSW	New project, feasibility study underway	na	124 t Ag in concentrate	$60–65m
Dugald River	Pasminco	85 km NE of Mt Isa, Qld	New project, feasibility study ongoing	after 2003	na	$250m
Lady Loretta	Buka Minerals/ Noranda	115 km NW of Mt Isa, Qld	New project, development subject to proving up additional reserves	na	na	na
Processing projects						
Browns polymetallic project	Compass Resources/ Guardian Resources	Near Batchelor, NT	New project, feasibility study underway	2001	71 kt Pb bullion (plus Co, Cu, Ni)	$298m

8.12 Projections of Australian lead industry exports (lead content)



there have been two other, more speculative, processing proposals mooted for possible development over the longer term. These are an expansion of Pasminco's Cockle Creek zinc–lead smelter and the addition of a lead smelter/refinery complex to the new Sun Metals zinc refinery.

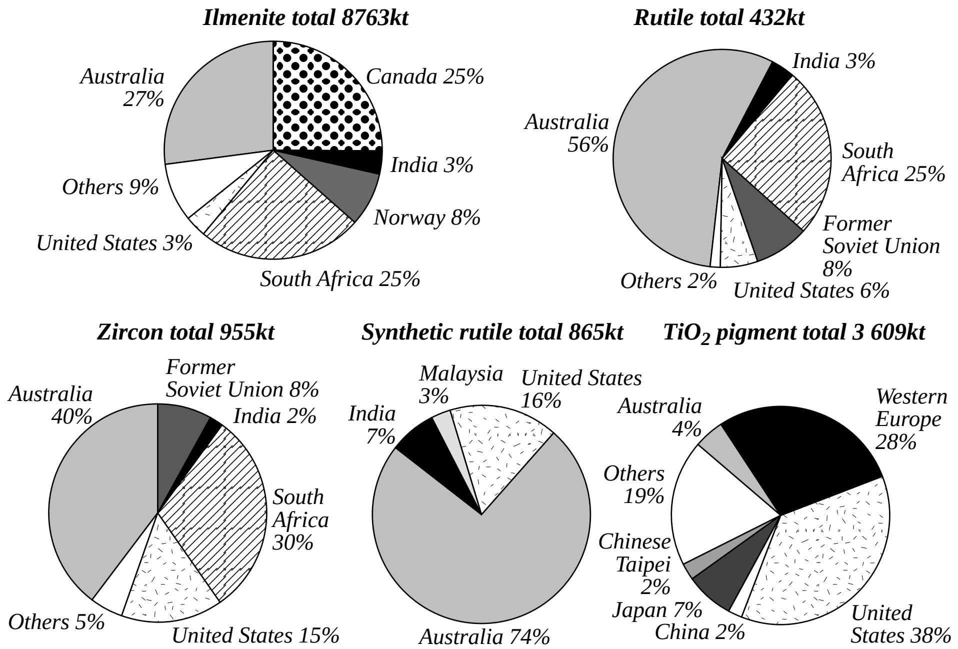
9. Mineral sands

Australia plays a substantial role in the world mineral sands industry. In 1998, Australia was the world's largest producer of ilmenite, rutile and zircon, and the largest producer of the semi-processed titanium feedstock, synthetic rutile (figure 9.1). Australia was also a significant producer of titanium dioxide pigment, accounting for around 4 per cent of world production.

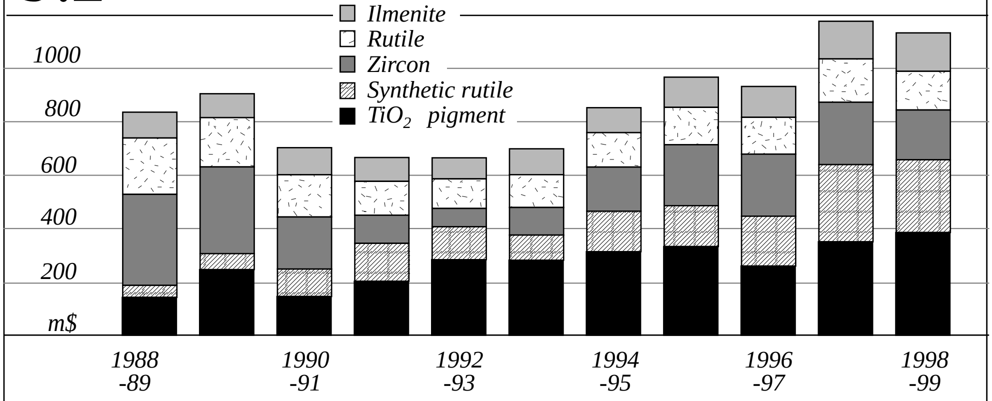
Australia is a large exporter of mineral sands products, with major markets in Europe the United States, and Asia (for zircon). The total value of Australian mineral sands exports in 1998-99 was $1.1 billion, with exports of the value added products, titanium dioxide pigment and synthetic rutile, together accounting for over half of the total (figure 9.2).

Australia has a large share of the world's economic demonstrated resources (EDR) of mineral sands. Of total world mineral sands EDR, Australia accounts for 26 per cent of ilmenite, 39 per cent of rutile and 36 per cent of zircon resources. Australia's currently producing mineral sands operations are listed

9.1 World titanium minerals and zircon production, 1998



9.2 Value of Australian mineral sands exports *(constant 1998-99 dollars)*



in table 9.1. At current rates of production, Australia's EDR of these minerals represents around 70 years supply of ilmenite and rutile and almost 60 years supply of zircon.

Value adding

Mineral sands are mined from orebodies containing varying quantities of heavy minerals, such as ilmenite, rutile, zircon, leucoxene and monazite. Value adding processes involve beneficiation and chemical processing which are used to produce synthetic rutile (a semi-processed product derived from ilmenite) and titanium dioxide pigment (a processed product derived from high quality ilmenite, synthetic rutile or rutile).

Ilmenite contains between 45 and 65 per cent titanium dioxide and is mainly used in the production of titanium dioxide pigment, either directly or after upgrading into synthetic rutile. Titanium dioxide pigment's main end use is in the paint industry.

Rutile is the most valuable of the unprocessed heavy mineral sands produced, containing over 94 per cent titanium dioxide. Rutile is used predominantly in the manufacture of titanium dioxide pigment, but is also used in the production of titanium metal, although not in Australia.

Zircon is used mainly in the ceramics industry and in refractories. In both of these applications, zircon is used without further major processing. Zircon is also used to produce zirconium metal, although this is not currently produced in Australia.

9.1 Australian mineral sands operations

Operation	Company	Location	1998-99 production Ilmenite	Zircon	Rutile
			kt	kt	kt
Mineral sands mining operations					
Beenup	BHP	WA	229	2	–
Jangardup	Cable Sands	WA	250	28	10
Southwest	Cable Sands	WA	251	15	–
Eneabba West	Iluka	WA	215	95	65
Eneabba	Iluka	WA	301	48	26
Capel	Iluka	WA	150	14	–
Cataby	Tiwest	WA	319	–	21
North Stradbroke Island	CRL	QLD	123	–	–
Yoganup	Iluka	WA	474	–	–
Total			2312	202	122
Synthetic rutile plants			Synthetic rutile		
Narngulu	Iluka	WA	na		
Capel	Iluka	WA	na		
Eneabba	Iluka	WA	na		
Yoganup	Iluka	WA	na		
Total			408		
Titanium pigment plants			Titanium dioxide pigment		
Chandala	Tiwest	WA	na		
Cataby	Tiwest	WA	na		
Total			82		
Pigment					
Kwinanana	Tiwest	WA	42		
Kemerton	MIC	WA	122		
Total			126		

Table 9.2 provides a measure of the transformation cost associated with processing ilmenite to synthetic rutile and titanium pigment. The transformation coefficient indicates the extent to which the value of the unprocessed mineral commodity (ilmenite) is increased by processing to the stages indicated (synthetic rutile and titanium pigment). The processing of ilmenite adds significant value, especially when processed to titanium dioxide pigment where the transformation coefficient is 10. This compares with transformation coefficients for bauxite to aluminium of 15; iron ore to steel (9); and zinc concentrate to zinc metal (around 1).

9.2 *Transformation costs in the Australian mineral sands industry* [a]

	1998-99 average EUV [b]	Input coefficient [c]	Transformation coefficient [d]
	A$/t		
Ilmenite	117	…	…
Synthetic rutile	581	1.25	2.97
Titanium pigment	2 912	2.19	10.36

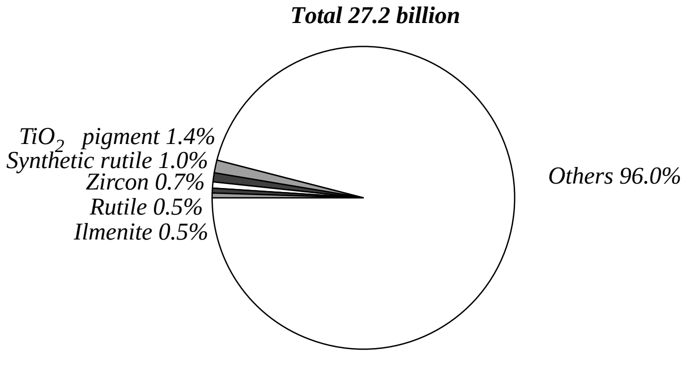
a The transformation cost concept employed refers to the gross value which is added to the unprocessed mineral input (e.g. ilmenite) by processing to the stage indicated. (Transformation cost = Value of processed output minus value of unprocessed mineral input consumed). **b** EUV (export unit value) is the average realised price per tonne of Australian exports in 1998-99. (EUV = Total export returns/Total exported quantity). **c** Tonnes of unprocessed mineral input required to produce a tonne of processed output. **d** The proportion by which the value of unprocessed mineral consumed is increased by processing to the stage indicated. (Transformation coefficient = Transformation cost / Value of unprocessed mineral input consumed).

Australian mineral sands exports

In 1998, mineral sands contributed 4 per cent to total nonenergy mineral export earnings (figure 9.3). Over the period 1988 to 1998, the value of mineral sands exports grew by an average of 6 per cent a year, reflecting an increasing proportion of value added products in total mineral sands exports over this period.

Exports of the value added products, titanium dioxide pigment and synthetic rutile, increased markedly in volume terms over the period 1988 to 1998 (figure 9.4), underpinned by strong increases in mine production of ilmenite. Pigment exports increased almost fivefold from 28 000 to 133 000 tonnes, while synthetic rutile exports rose almost sixfold from 79 000 to 466 000 tonnes in this

9.3 *Mineral sands: contribution to Australia's nonenergy mineral exports, 1998*



period. The strong growth in synthetic rutile and titanium dioxide pigment exports was made possible by substantial investment in new capacity over this period and was driven by strong growth in world demand for these products.

The volume of unprocessed mineral sands exported also grew over this period (see figure 9.5), though more modestly.

The significantly faster growth in synthetic rutile and titanium dioxide pigment exports resulted in a significant increase in the proportion of the semi processed and processed products in total mineral sands exports. In constant dollar terms, the combined share of processed mineral sands products rose from 21 per cent of total mineral sands exports in 1988-89 to 58 per cent in 1998-99 (figure 9.2).

The value of titanium pigment exports was around $384 million in 1998, contributing almost a third of the value of all mineral sands exports. This contrasts with 1988, when it accounted for less than 14 per cent of the total value of exports. The proportion of synthetic rutile exports in total mineral sands earnings also grew significantly over the period, increasing from 6 per cent in 1988, to almost 23 per cent in 1998, in response to rising world demand.

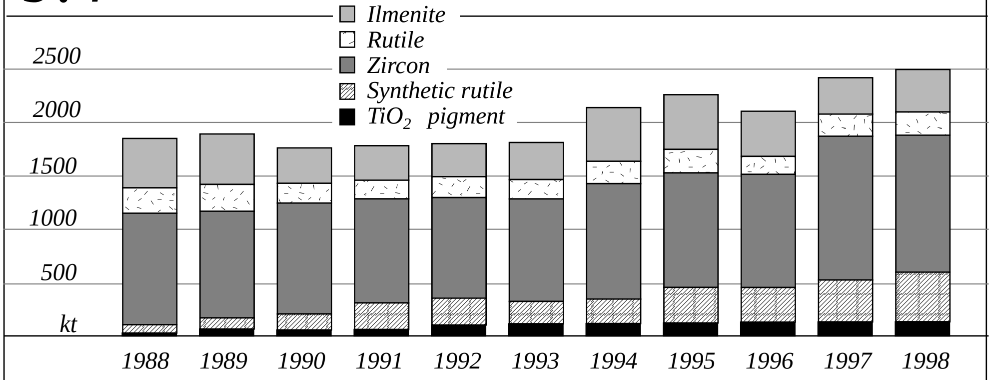
Trends in real export prices (constant 1998-99 dollars) of mineral sands products are shown in figure 9.6. This shows that the prices of rutile and zircon, and to a lesser extent titanium dioxide pigment, fell over the early part of the period, but recovered in later years.

The size and pattern of mineral sands exports in 1985 and 1998 are compared in figures 9.6 to 9.9. The United States has been Australia's major trading partner for ilmenite over this period, making up around one third of Australian exports (figure 9.6). The main change to the pattern of ilmenite exports over the period 1985 to 1998 was an increase in the share of exports to Norway, which reached 12 per cent in 1998. The closure of the Beenup mine in Western Australia in 1999, due to persistent technical and operational problems, is likely to limit Australia's future exports of ilmenite to Norway. Norway imported around half of the output from Beenup.

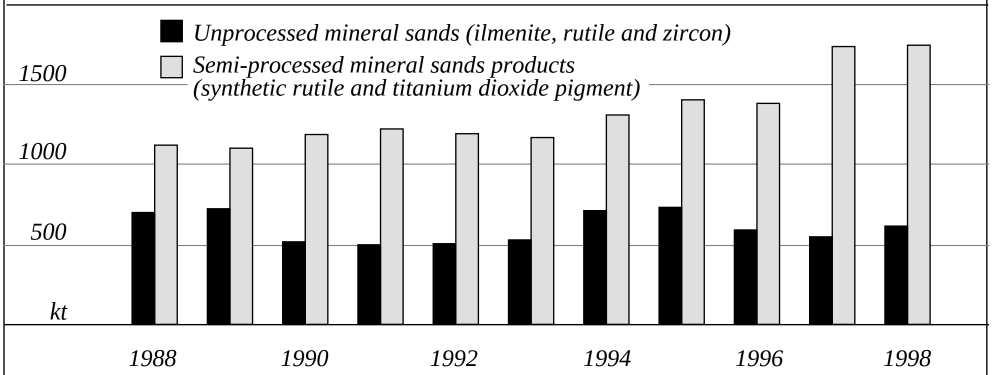
Over this period, the proportion of Australian rutile exports to the United States fell slightly, while exports to the United Kingdom and Japan fell more significantly (figure 9.7). The Netherlands significantly increased its share of exports from 6 per cent to 26 per cent in 1998.

Compared to other mineral sands products, the United States is a relatively minor importer of Australian zircon, accounting for between 5 and 10 per cent

9.4 Australian mineral sands exports

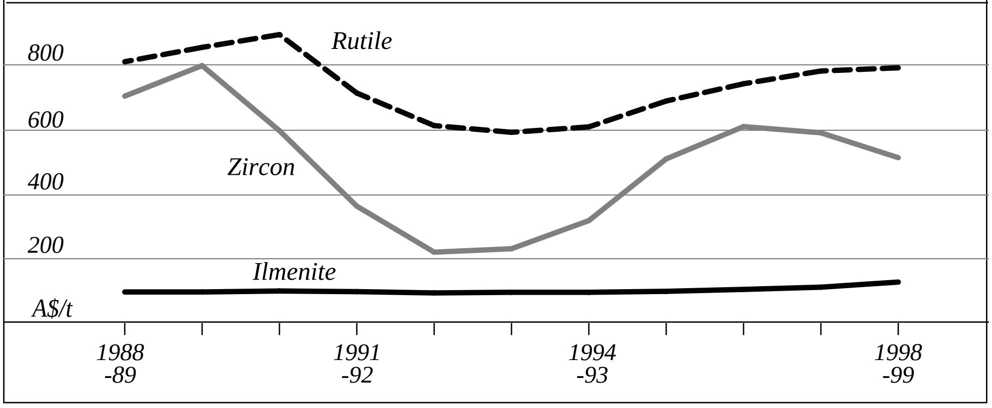


9.5 Australian unprocessed and semiprocessed mineral sands exports

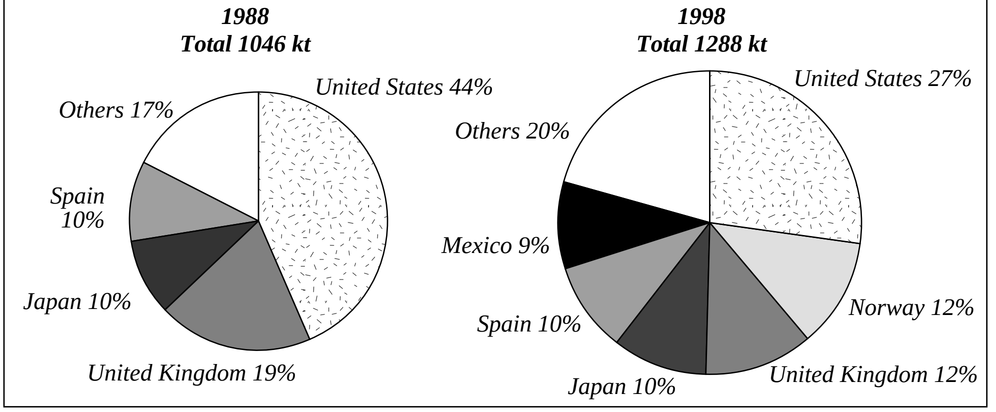


9.6 Unit export prices of Australian ilmenite, zircon and rutile

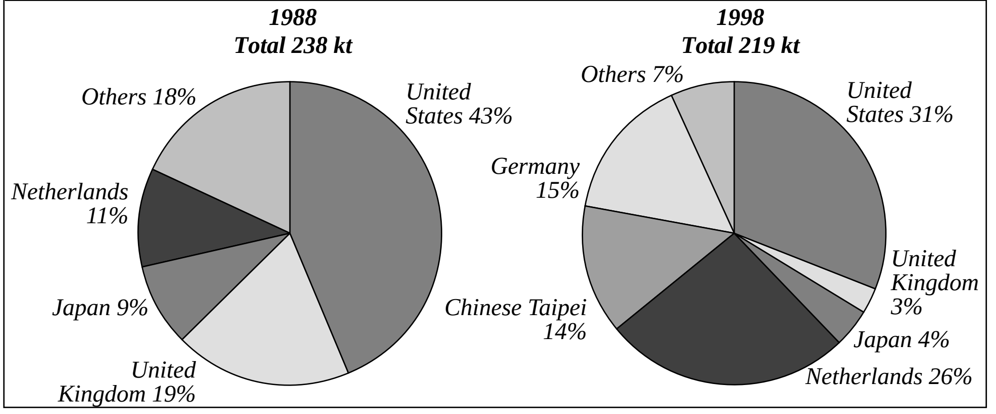
(constant 1998-99 dollars)



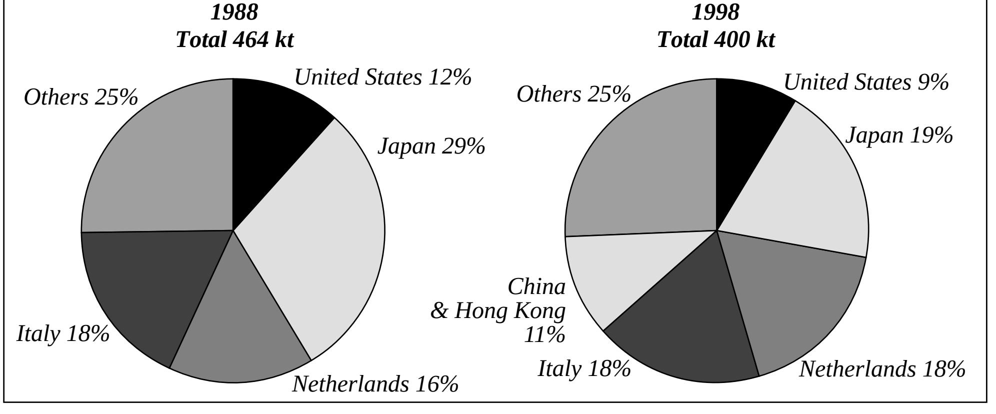
9.7 Australian ilmenite exports, by destination



9.8 Australian rutile exports, by destination



9.9 Australian zircon exports, by destination



of exports (figure 9.8). Since 1983, the United Kingdom increased its share of Australian zircon exports, and in 1998 was Australia's main export destination.

There is limited information available regarding Australia's trading patterns in synthetic rutile. However, available information indicates that over the past five years, the United States has remained Australia's largest export customer for synthetic rutile, with Saudi Arabia, the United Kingdom and Japan remaining important trading partners (figure 9.9). Recently, there has been rapid growth in demand for Australian synthetic rutile from Chinese Taipei, due to its continued strong economic growth.

There are no data available on the destination of Australian titanium pigment exports.

While there have been a number of substantial changes in the patterns of Australia's trade in mineral sands, the Asian economic downturn in the late 1990s does not appear to have had a significant impact on trading patterns. Of the countries affected, China (including Hong Kong), Japan, Chinese Taipei, Malaysia and Thailand remain major export destinations for Australian mineral sands products.

Outlook for further value adding of exports

Table 9.3 lists the major Australian mineral sands projects which are currently under consideration.

Of the six projects listed, only one — Monto Minerals' Goondicum mining project in Queensland — is committed. Two of the three processing projects listed are proposed expansions of existing titanium dioxide pigment plants, but both are currently on hold. There are currently no plans for new or expanded synthetic rutile capacity.

During the 1990s, there were a number of changes to titanium dioxide pigment production capacity (figure 9.10), with two plants closing and two (effectively replacement) facilities coming into production. The combined capacity of the new plants — Tiwest Joint Venture's Kwinana operations and MIC's Kemerton facility — is 160 000 tonnes a year, significantly more than the 70 000 tonnes a year combined capacity of the plants shut down. The closure of both the Bunbury and Burnie facilities was due to environmental concerns associated with the use of sulfate processing technology. (Both of the existing operations at Kwinana and Kemerton use chloride processing technology which has environmental and other advantages over the sulfate process). Between

9.3 *Major Australian mineral sands projects*

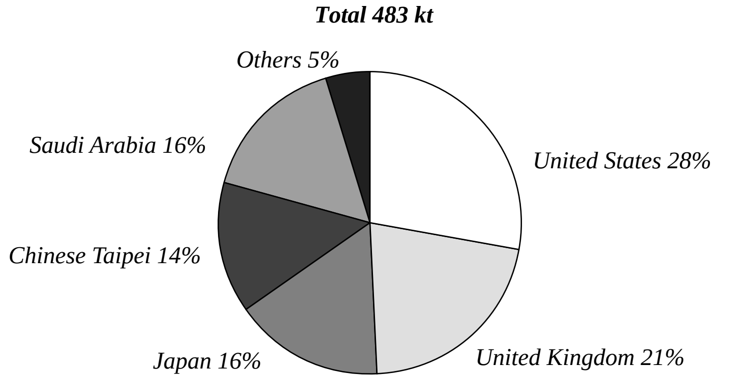
Project	Company	Location	Status	Expected startup	New capacity
Mining projects committed					
Goondicum	Monto Minerals	Burnett River, QLD	New project, committed, development studies ongoing	Stage 1: 2000 Stage 2: 2003	Stage 1: 275 kt ilmenite Stage 2: 410 kt ilmenite
Less advanced mining projects					
Jangardup South	Cable Sands	Jangardup South, WA	New project, EIS and feasibility tudy under way	2002	na
Mt Weld	Ashton Rare Earths	Meenaar, WA	New project, feasibility and plant process studies ongoing	na	5 kt rare earth oxides
Mineral sands processing projects – all uncommitted					
Kemerton TiO_2 pigment plant	Millenium Inorganic Chemicals	Kemerton, WA	Expansion, on hold	na	110 kt TiO_2 pigment
Kwinana TiO_2 pigment plant	Tiwest JV	Kwinana, WA	Three stage expansion, on hold	na	100 kt TiO_2 pigment
Pinjarra rare earth plant	Rhodia Pinjarra	Pinjarra, WA	New project, feasibility study underway	na	15 kt rare earth nitrates

1988 and 1998-99, exports of pigment rose fivefold, from 28 000 to 133 000 tonnes.

The proposals to expand both the Kemerton and Kwinana facilities by 100 000 and 110 000 tonnes a year respectively are currently in abeyance because of poor market conditions. Recent pigment prices and associated market expectations remain below the levels needed to make investment in new capacity viable, and this is evident from the lack of commitment to new projects worldwide. Combined with long lead times in the construction of new facilities, it becomes unlikely that these proposed expansions will proceed over the medium term and, in this event, Australian pigment capacity and exports would remain at current levels.

In response to increased export and domestic demand (from an expanding domestic pigment industry), Australian synthetic rutile capacity grew rapidly in the late 1980s and early 1990s with the establishment of new facilities and

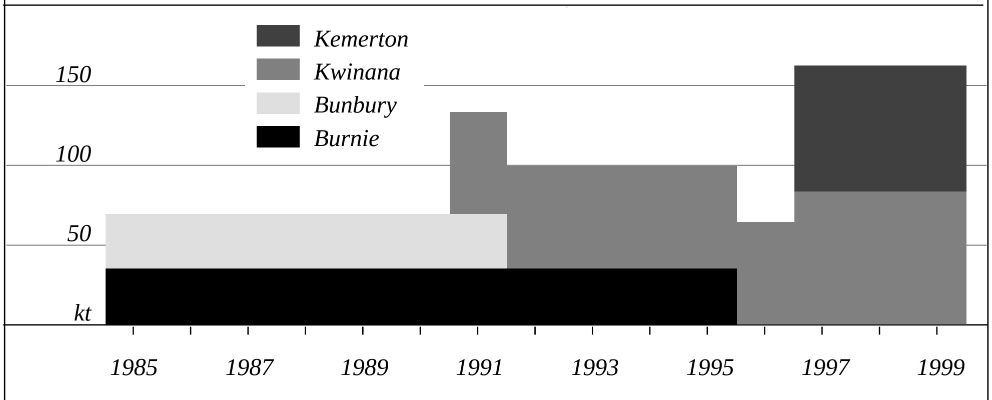
9.10 Australian synthetic rutile exports, by destination, 1998



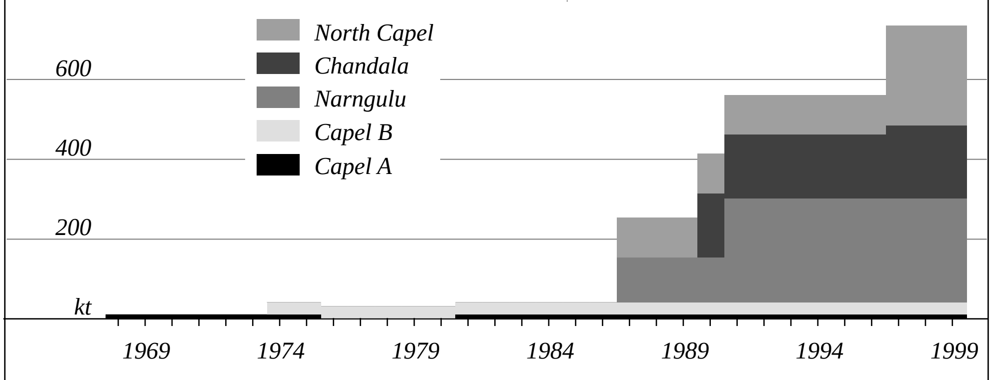
their subsequent expansions (figure 9.11). The most recent expansion was in 1996 when Tiwest Joint Venture's Chandala operation increased its capacity from 160 000 to 183 000 tonnes a year. Total synthetic rutile capacity now stands at 730 0000 tonnes a year. As a result of capacity increases over the part decade, Australian exports of synthetic rutile rose from 79 000 tonnes in 1988-89 to 466 000 tonnes in 1998-99, a sixfold increase

There has been speculation that the Chandala facility may eventually be expanded to 200 000 tonnes capacity. However, with no firm proposals in prospect for new synthetic rutile capacity over the medium term, exports are likely to remain at around current levels for the next five years.

9.11 Australian titanium dioxide pigment capacity



9.12 **Australian synthetic rutile capacity**



Given that there are no large scale, advanced developments in prospect over the medium term for either mineral sands concentrates or value added products, the proportion of processed products in mineral sands exports is expected to remain at around 1998-99 levels (58 per cent) — figure 9.12.

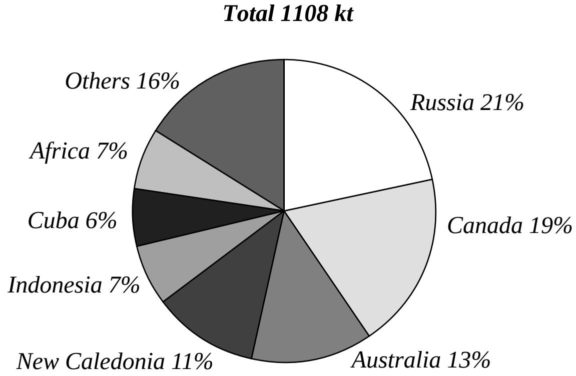
Australia's export earnings from mineral sands exports are projected to be $1.6 billion in 2003-04, 25 per cent more than earnings in 1998-99. This increase is expected to come through higher export values for Australian mineral sands exports over this period, as world demand for titanium dioxide pigment and mineral sands feedstocks increases.

10. Nickel

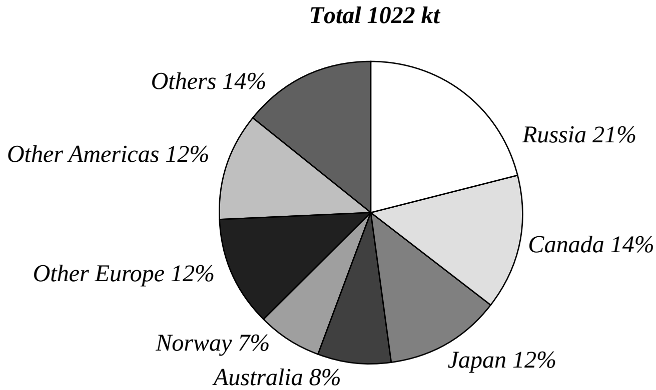
Since the mid 1980s Australia has emerged as a major force in the world nickel industry. Australia is now the third largest producer of nickel behind Russia and Canada (figure 10.1). In 1998, Australia mined an estimated 141 000 tonnes of nickel, or 13 per cent of total world output.

Australia was also the fourth largest producer of refined nickel behind Russia, Canada and Japan in 1998 with output of 80 000 tonnes, or 8 per cent of total world production (figure 10.2).

10.1 World nickel mine production, 1998



10.2 World refined nickel production, 1998



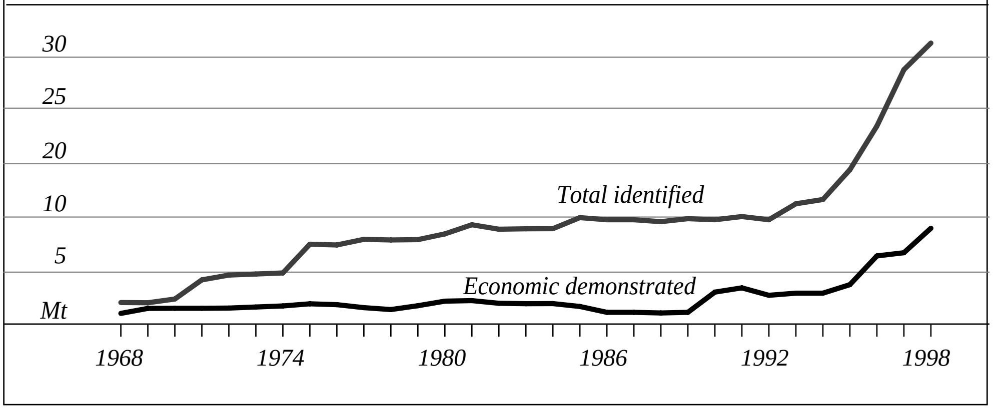
As negligible quantities of nickel metal are consumed domestically, Australia is a significant exporter of nickel to world markets. Comprehensive world trade figures for nickel are not available. However, available data show Australia to be the third largest exporter of refined nickel products. Russia is by far the largest player in nickel metal trade, with exports of around 200 000 tonnes in 1998, followed by Canada with around 125 000 tonnes, Australia with an estimated 80 000 tonnes and Norway with exports of around 60 000 tonnes.

Australia is the second largest exporter of nickel ores and concentrates, with just under 40 000 tonnes of nickel in concentrate exported in 1998. New Caledonia supplies the largest quantity of ores and concentrates to the world market, with annual exports of around 60 000 tonnes of contained nickel. Norway is the third largest supplier in 1998, with exports of around 34 000 tonnes.

Australia also exports significant quantities of intermediate nickel products, such as nickel matte and oxide sinter, but comparative data are unavailable.

Australia's economic demonstrated resources (EDR) of nickel have increased significantly over the past three decades, rising from less than half a million tonnes in 1967 to 9 million tonnes in 1998 (figure 10.3). Australia's EDR of nickel increased sharply from around 1993 as a result of exploration successes, particularly in Western Australia. Total identified nickel resources have also increased dramatically, rising from 2 million tonnes in 1968 to 26.4 million tonnes in 1998. The bulk of Australia's nickel resources occur in Western Australia, but identified nickel resources have also been boosted by recent exploration activity in Queensland and New South Wales. Australia has the largest EDR of nickel — 20 per cent of the 1998 world total — ahead of Russia

10.3 Australian nickel resources



(15 per cent) and Cuba and Canada (both around 12 per cent). At current rates of mine production, Australia's EDR of nickel represents around 65 years of supply.

Australia's EDR of nickel can be expected to increase substantially in the period to 2004 as mining companies explore for new deposits, and as project developers continue to prove up additional reserves in order to establish the feasibility of their operations and as all operators attempt to increase the economic life of their mines. This exploration activity will underpin the future expansion of the nickel industry and provides the opportunity to increase Australia's exports of value added mineral products. Table 10.1 shows Australia's currently producing nickel facilities.

Value adding

Commercial mining of nickel around the world is primarily based on the exploitation of both sulphide and lateritic ore bodies. Broadly speaking, laterite

10.1 *Australian nickel facilities, 1998-99*

Operation	Owner	Output
		kt Ni content
Mines		
Bulong	Preston Resources	2.3
Carnilya Hill	BHP/WMC	0.1
Cawse	Centaur	3.7
Forrestania	Outokumpu	11.0
Kambalda	WMC	22.0
Leinster	WMC	38.7
Mt Keith	WMC	37.7
Murrin Murrin	Anaconda	7.0
Radio Hill	Titan Resources	4.4
Silver Swan	Mining Project Investments	12.0
Total		138.9
Processing facilities		
Kalgoorlie smelter	WMC	100.1
Refineries		
Bulong refinery	Preston Resources	0.5
Cawse refinery	Centaur	0.5
Kwinana refinery	WMC	53.7
Murrin Murrin refinery	Anaconda	25.9
Townsville refinery	QNI	1.2
Total refined		81.8

ore deposits of possible commercial importance comprise some 60 per cent of known nickel reserves but currently account for around 35 per cent of nickel production. In contrast, sulphide deposits account for 40 per cent of reserves and contribute 65 per cent of production. This apparent paradox reflects the different relative complexity (and therefore cost) of processing these types of ores in the past.

Laterite ores, and concentrates produced from sulphide ores, can be processed by either pyrometallurgical (smelting) or hydrometallurgical (leaching) methods. QNI's nickel refinery in Queensland processes laterite ore through an ammoniacal solvent extraction facility to produce nickel metal. In contrast, WMC uses a smelting process to convert sulphide nickel ore into nickel matte, which is then refined into metal through a ammoniacal leach process.

Environmental concerns, the depletion of high grade sulphide deposits and cost pressures on mining (particularly underground mining) and processing, have resulted in a renewed interest in the pressure acid leach process for the extraction of nickel from both lateritic ore bodies and large, lower grade, sulphide ore bodies suitable for open-cut mining.

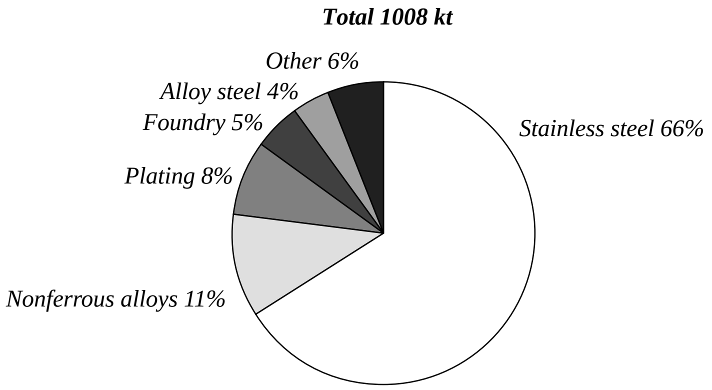
Australian companies have led the way toward the commercial application of leaching processes for laterite ores. Anaconda Nickel (Murrin Murrin), Preston Resources (Bulong) and Centaur Mining and Exploration (Cawse) are the only operations to attempt commercial application of leaching technology since the original development of the process at the Moa Bay facility in Cuba during the 1950s. All three of these new producers commenced operations in Western Australia in early 1999 and are using pressure acid leach technology for the processing of lateritic ores directly into LME grade nickel metal for the export market. While these operations are yet to demonstrate the success of the pressure acid leaching technology at the scale required to produce at design capacity, their success to date has encouraged many other proposals for similar projects both in Australia (table 10.2) and overseas.

While the end use applications for nickel are numerous, most nickel is consumed in the manufacture of nickel alloys which are valued particularly for their heat and corrosion resistance. Dominating these nickel alloys is stainless steel, which accounts for around two thirds of Western world nickel consumption (figure 10.4). The automotive, machinery, tooling and transport equipment industries are also significant consumers of stainless steel.

10.2 Potential new Australian nickel projects

Project	Company	Location	Status	Expected startup	Capacity
Cosmos	Jubilee Gold Mines	WA	Feasibility study completed	2000	10 kt Ni concentrate
Marlborough	Preston Resources	QLD	Feasibility study completed	2001	25 kt Ni metal
Ravensthorpe	Comet Resources	WA	Feasibility study completed	2000	35 kt Ni metal
Murrin Murrin II	Anaconda Nickel	WA	Feasibility study underway	2000	70 kt Ni metal
Syerston	Black Range Minerals	NSW	Feasibility study underway	2002	25 kt Ni metal

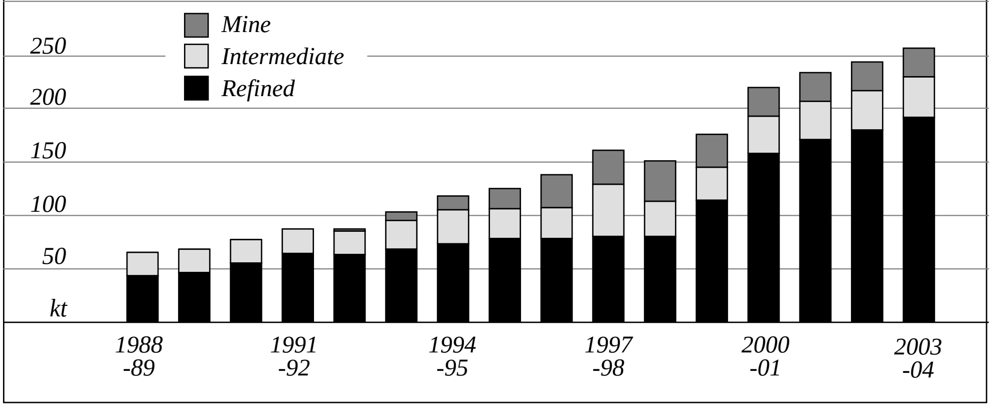
10.4 Composition of world nickel consumption, 1998



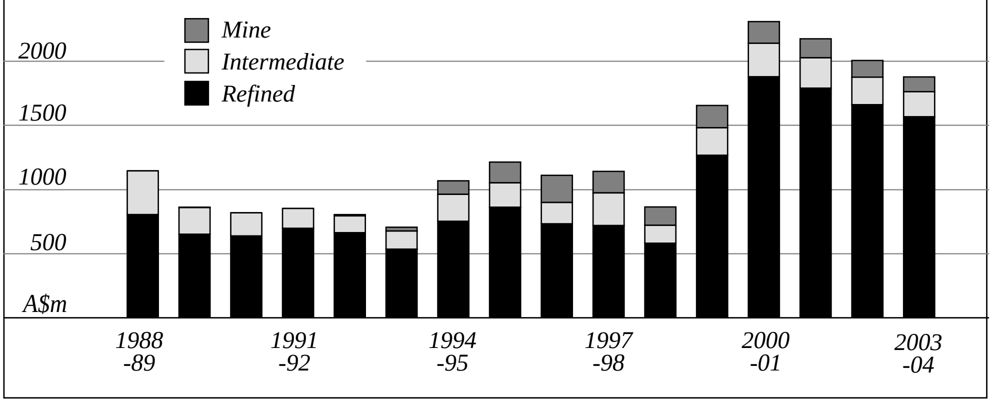
Nickel exports

Australia produces and exports nickel in a number of forms (figures 10.5 and 10.6). These include refined metal, intermediate products (such as nickel matte) and ores and concentrates. A substantial proportion — around 70 per cent — of mined nickel in Australia is processed into higher value products, predominantly for export. Australia is also an importer of nickel ores and concentrates. QNI's nickel refinery in Townsville imports nickel concentrate (mainly from New Caledonia) for processing into higher value nickel metal and chemicals — again, predominantly for export.

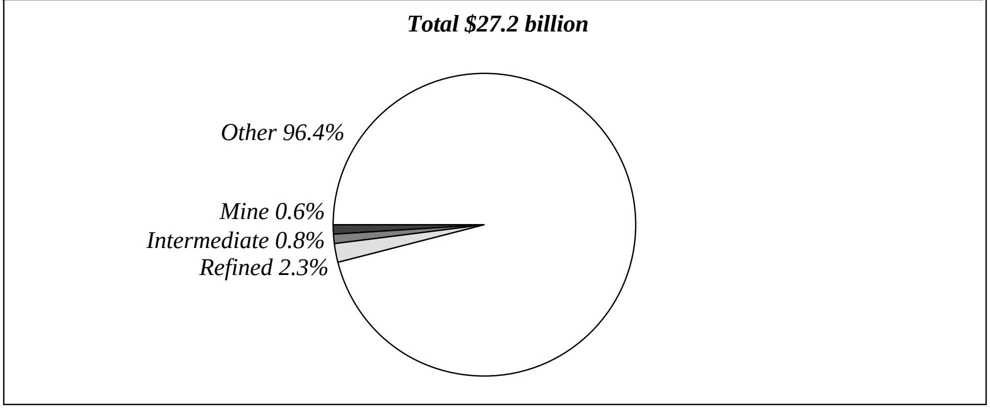
10.5 Projections of Australian nickel exports (nickel content)



10.6 Projections of Australian nickel export earnings
Constant 1999-2000 dollars



10.7 Nickel: contribution to Australian nonenergy minerals exports, 1998



In terms of nickel content, 53 per cent of Australia's total nickel exports in 1998-99 was in the form of nickel metal, 22 per cent was in the form of intermediate nickel products and 25 per cent was exported as ores and concentrates (figure 10.5). Australia's largest export markets for nickel have been Europe, Japan and the United States of America. Australia's nickel industry exports were valued at $843 million in 1998-99, with intermediate and refined products contributing 83 per cent of this amount.

The value of nickel exports represented 3.6 per cent of the total value of Australia's nonenergy mineral exports in 1998 (figure 10.7), down from 6.6 per cent in 1985. The fall in nickel's share over this period is mainly attributable to the proportionally greater increases in the export volumes and values of some other commodities, particularly gold and alumina/aluminium.

Outlook for further value adding of exports

In the period 1989 to 1998, Australian nickel capacity more than doubled from 42 ktpa to 85 ktpa, with expansions at QNI's Townsville refinery and WMC's Kwinana refinery (figure 10.8). Substantial investment in recent years saw nominal refinery capacity rise in 1999 by a further 63 ktpa with the commencement of the new 'mine to metal' laterite operations — Murrin Murrin, Cawse and Bulong — in Western Australia. While these operations are gradually increasing their output, they have yet to reach full production capacity.

As a result, the proportion of Australia's nickel exported in refined form (including nickel refined from imported ores and concentrate) is forecast to increase significantly from 1999 onwards. The share of nickel exported in processed form (refined and intermediate products) is projected to rise from 76 per cent in 1998 to around 90 per cent in 2004 (figure 10.5).

10.8 ***Australian refined nickel production capacity (current operations only)***

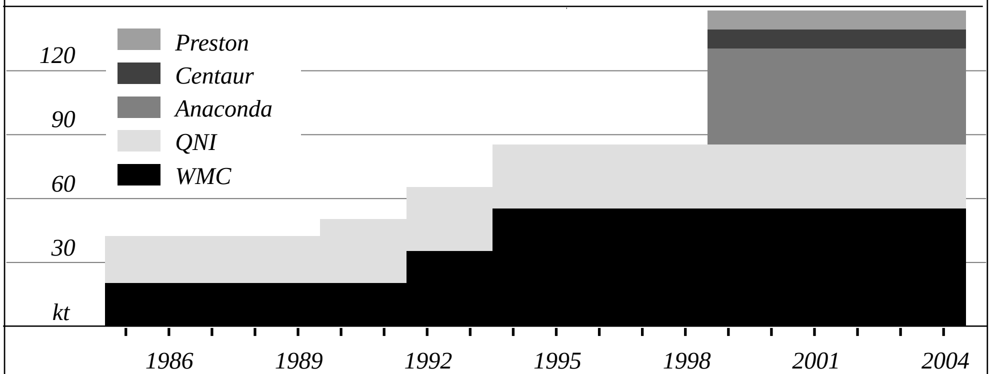


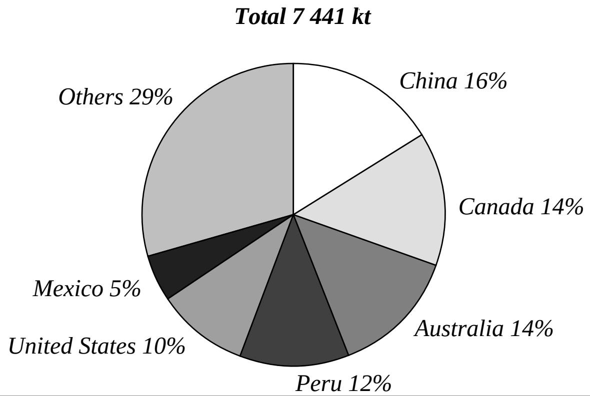
Table 10.2 lists a number of nickel projects (including an expansion of Murrin Murrin) which potentially could add significantly to Australia's processing and export capacity over the medium term. In general, these proposals are also aimed at producing metal for the export market using similar technology to the three pioneering laterite developments. However, none of these has yet advanced beyond the feasibility stage and it is possible that some may not proceed in the foreseeable future. They may not proceed because of changing economic conditions, or because they are aimed at market opportunities for which there is strong competition between suppliers, including other Australian projects. The majority of the proposed projects plan to process nickel ore into metal for the export market. Nevertheless, these projects indicate the possibility of substantial growth in the Australian nickel industry and in the proportion of Australian nickel that is processed domestically into higher value nickel metal.

Substantial increases in production and higher world prices over the next two years are forecast to result in real export earnings rising by 170 per cent, to $2.3 billion, in 2000-01. Beyond that point, earnings (in real terms) are projected to ease to around $1.9 billion in 2003-04 as world prices decline (figure 10.6).

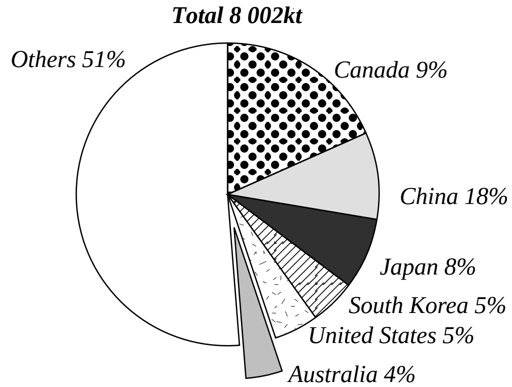
11. Zinc

Australia is a significant player in the world zinc industry. In 1998, Australia was the world's third largest mine producer of zinc (after China and Canada), accounting for 14 per cent of world production (figure 11.1), and the ninth largest producer of zinc metal, accounting for 4 per cent of global production (figure 11.2). With two major new zinc projects about to be commissioned — the Century zinc mine and the sun Metals' zinc refinery — Australia's importance in the industry, in terms of both mine and metal output, is set to increase.

11.1 World zinc mine production, 1998



11.2 World refined zinc production, 1998



Australia's domestic consumption of zinc is small in comparison to most other significant zinc producing countries — Australia accounts for only 2 per cent of world consumption compared with almost 16 per cent for the United States and 11 per cent for China. As a result, Australia exports, in either concentrate or refined form, over 90 per cent of its zinc mine output — a relatively high proportion. Australia was the dominant exporter of zinc ores and concentrates and the fourth largest exporter of refined zinc (after Canada, China and The Netherlands) in 1998.

The bulk of Australia's resources of zinc are contained in zinc-lead-silver sulphide deposits. Australia is estimated to possess about 18% of the world's demonstrated economic resources (EDR) of zinc. At current rates of production, Australia's EDR of zinc are equivalent to about 30 years supply. Australia's main, currently producing zinc mines and smelters are shown in table 11.1.

Value adding

Globally, zinc is usually mined in association with lead and silver from zinc rich ore deposits. Zinc is also sometimes mined in association with copper from copper-zinc deposits. Mine products are usually in the form of zinc

11.1 ***Australia's principal zinc mines and smelters, 1998-99***

Operation	**Company**	**Location**	**1998-99 production**
			kt
Mines			
Cannington	BHP	Qld	45
Mount Isa	MIM	Qld	150
Broken Hill	Pasminco	NSW	198
Lennard Shelf	Western Metals	WA	139
Elura	Pasminco	NSW	67
Rosebery	Pasminco	Tas	75
McArthur River	MIM	NT	159
Hellyer	Western Metals	Tas	129
Woodcutters	Normandy	NT	28
Scuddles	Normandy	WA	110
Other	na	na	42
Total			1142
Smelters			
Cockle Creek	Pasminco	NSW	77
Risdon	Pasminco	Tas	214
Port Pirie	Pasminco	SA	32
Total			323

11.2 Transformation cost in the Australian zinc industry [a]

	1998-99 average EUV [b]	Input coefficient [c]	Transformation coefficient [d]
	A$/t		
Zinc concentrates	397	…	…
Refined zinc	1 618	2.1	0.94

a The transformation cost concept employed refers to the gross value which is added to the unprocessed mineral input (zinc concentrates) by processing to the stage indicated. (Transformation cost = Value of processed output minus value of unprocessed mineral input consumed). **b** EUV (export unit value) is the average realised price per tonne of Australian exports in 1998-99. (EUV = Total export returns/Total exported quantity). **c** Tonnes of unprocessed mineral input required to produce a tonne of processed output. **d** The proportion by which the value of unprocessed mineral consumed is increased by processing to the stage indicated. (Transformation coefficient = Transformation cost / Value of unprocessed mineral input consumed).

concentrates with zinc contents ranging from around 40 per cent to 60 per cent zinc. The value adding process involves the smelting of concentrates followed by electrolytic or fire refining to produce primary refined zinc metal.

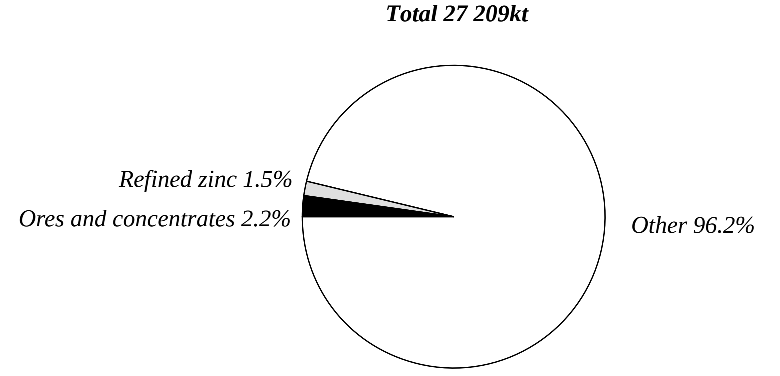
Table 11.2 provides a measure of the transformation cost associated with processing zinc concentrates to refined zinc. The transformation coefficient indicates the extent to which the value of the unprocessed mineral consumed (zinc concentrate) is increased by processing to the stage indicated (refined zinc). The coefficient in 1998-99 was 0.94. However, this should be regarded as indicative only, as the value of the coefficient varies from year to year because of factors such as differences in the average content of zinc, and the variable quantities (and prices) of other metals in the concentrates exported (such as silver and lead). In the nine years to 1998-99 the value of the coefficient has ranged from 0.7 to 1.6, with an average value of 1.2 over that period. Nevertheless, these coefficient values imply that processing to the refined zinc stage in the zinc industry, while important in value terms, does not add as much value as, for example, the processing stages in the aluminium or steel industries (with gross value added coefficients of 16 and 9 respectively).

More than half of the global trade in zinc is in the form of concentrates (in terms of contained zinc). The significant trade in concentrates reflects the relatively small value added to be gained by further processing, as well as the limited transport cost advantage as a result of the relatively high zinc content of the mine product.

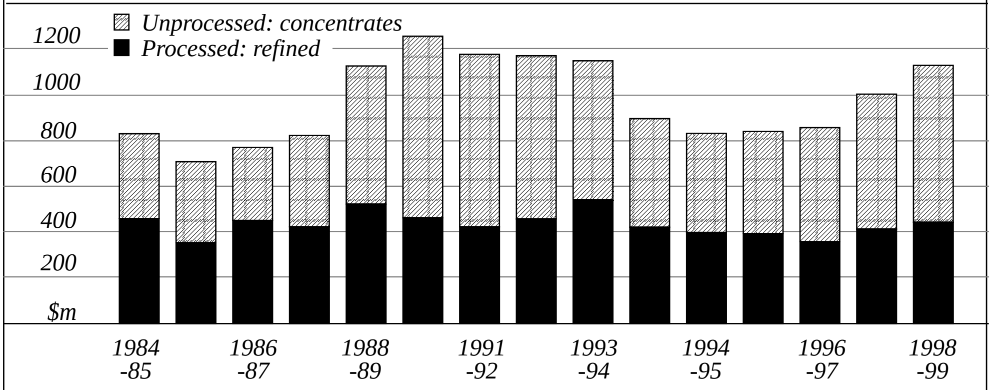
Australian zinc exports

The zinc industry's contribution to non energy mineral export earnings (in constant dollar terms) has fallen significantly since the mid 1980s. In 1998, zinc's

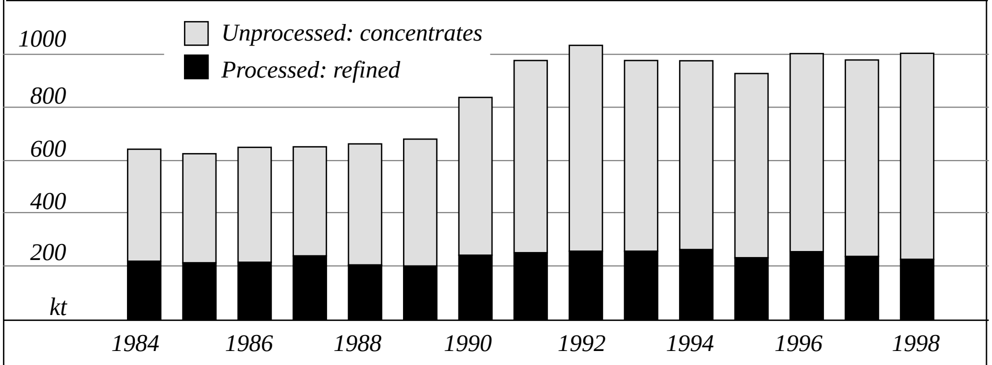
11.3 Zinc: contribution to nonenergy mineral exports, 1998



11.4 Value of Australian zinc industry exports (constant 1998-99 dollars)



11.5 Australian zinc industry exports (zinc content)



contribution was 3.7 per cent (figure 11.3), compared with 8.8 per cent in 1985. However, this is not due to any decline in zinc exports over that period — in fact, the total value of zinc exports grew by 36 per cent in real terms (figure 11.4), while export volumes (in terms of zinc content) rose by 60 per cent (figure 11.5). Instead, the decline in zinc's contribution to non energy mineral export earnings mainly reflects the proportionately greater increases in the export volumes and values of some other commodities in the sector in this period, particularly gold and aluminium/alumina.

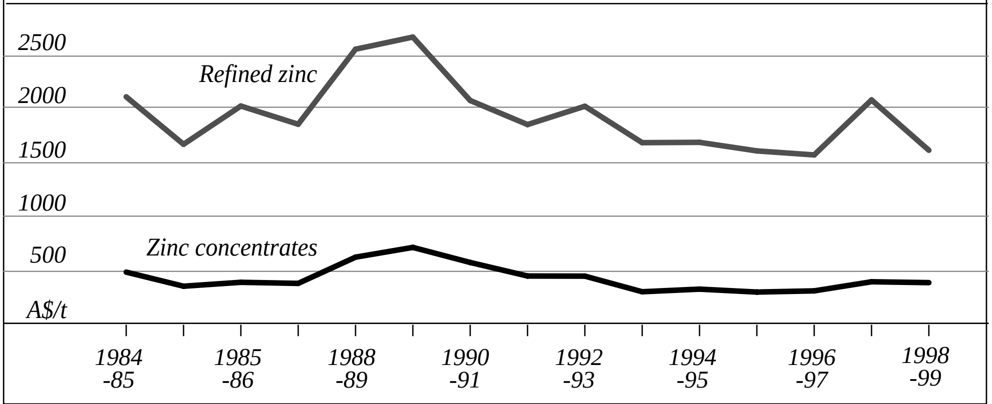
The proportionately greater rise in total zinc export volumes (60 per cent) compared with the increase in real export values (36 per cent) partly reflects the decline in real zinc prices over this period (figure 11.6).

Figure 11.5 shows that from 1985 to 1998, export volumes of refined zinc remained relatively constant, reflecting stable production capacity over this period, while export volumes of zinc in concentrate form almost doubled, with substantial rises occurring from around 1990 as several new mines commenced exporting. As a result of the substantial increase in concentrates exports, combined with stable refining capacity, the proportion of Australian zinc exported in processed form fell from 34 per cent in 1985 to 23 per cent in 1998.

Trends in constant dollar export prices of zinc products are shown in figure 11.6.

Figure 11.7 shows the relative size, and changing pattern, of zinc concentrate exports between 1985 and 1998. The sharp upturn in exports of zinc in unprocessed form from around 1990 reflects the commencement of new mines, such as Hellyer in Tasmania and Scuddles in Western Australia, in the late

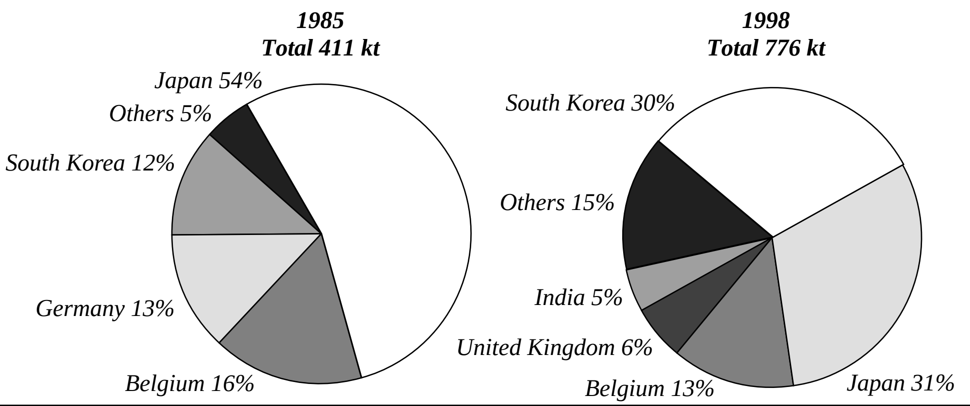
11.6 ***Unit prices of Australian zinc exports*** *(constant 1998-99 dollars)*



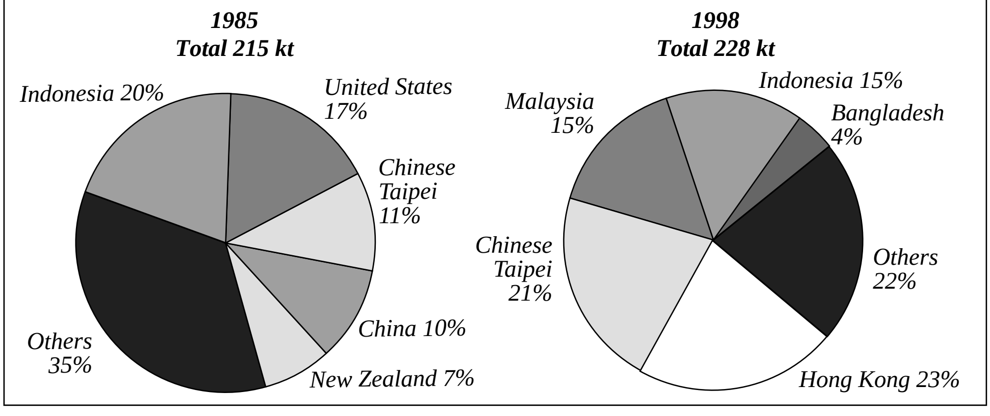
1980s. Since 1985, South Korea has emerged as an increasingly important destination for Australian zinc concentrate exports as its domestic smelting and refining capacities and consumption requirements have increased. In 1998, South Korea accounted for almost a third of total Australian exports of zinc concentrates, up from 12 per cent in 1985. While Japan's share of Australian zinc concentrate exports fell from 54 per cent in 1985 to 31 per cent in 1998, actual export volumes increased slightly over that period.

Figure 11.8 compares the volume and pattern of refined zinc exports in 1985 with those in 1998. While the increase in the volume of refined zinc is not substantial over that period, Asian markets, particularly Hong Kong, Chinese Taipei and Malaysia, have significantly increased their share of total Australian exports.

11.7 ***Australian zinc ores and concentrates exports, by destination (zinc content)***



11.8 ***Australian refined zinc exports, by destination***



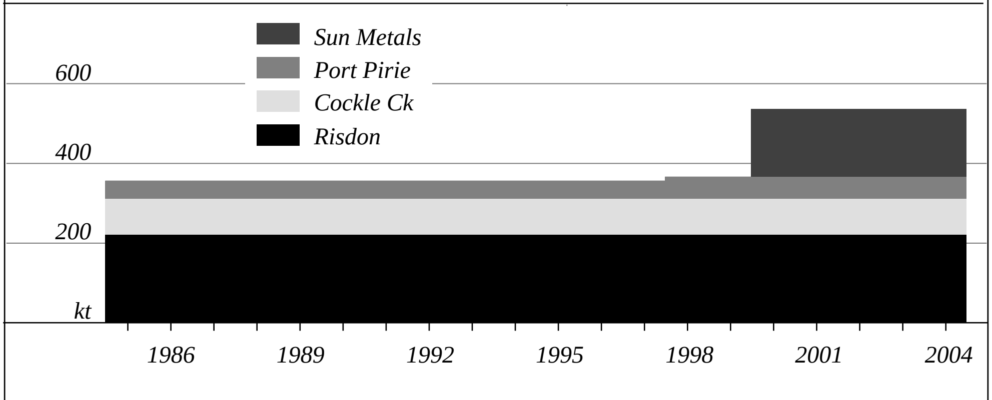
Outlook for further value adding of exports

From 1985 to 1998 the only increase in Australian refined zinc production capacity was a small rise at Pasminco's Port Pirie smelter/refinery in early 1998 (figure 11.9). This resulted from the commissioning of the co-treatment process at Port Pirie, enabling zinc to be extracted from residues generated at Pasminco's Risdon zinc smelter. However, over the same period, Australian zinc mine output capacity underwent significant expansion, with several large new mines brought into production from the late 1980s. These included Hellyer (Tasmania); Scuddles, Cadjebut and Pillara (Western Australia); McArthur River (Northern Territory); and Thalanga (Queensland).

Table 11.3 shows the major Australian zinc projects currently in commissioning phase, under development, or under active consideration over the medium term. Most of these are mine development proposals with only one, Sun Metals' (Korea Zinc) refinery in Townsville (now commissioning), aimed at producing a value added product (zinc metal). Apart from Pasminco's large new Century mine, also currently being commissioned, and MIM's George Fisher mine, under construction, the mine development proposals remain at feasibility stage.

With the commissioning of Sun Metals' new, 170 000 tonnes a year capacity, zinc refinery in Townsville now underway, Australian zinc metal production capacity is set to expand by around 50 per cent, to over 500 000 tonnes a year (figure 11.9). The Townsville refinery is the world's first greenfields zinc refinery built in over a decade. Full production capacity at Townsville is expected to be achieved early in 2000 and refined zinc exports in 2000-01 are expected to fully reflect this development. Sun Metals have indicated that the Townsville facility could eventually be expanded to double its initial capacity,

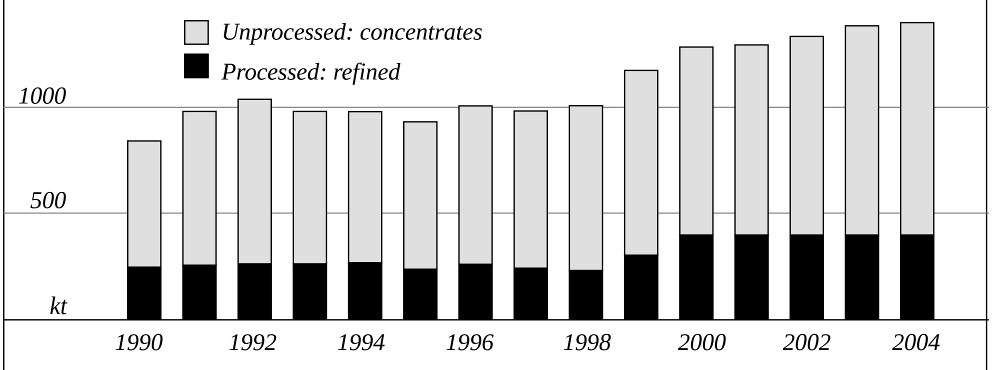
11.9 ***Australian zinc refinery capacity***



11.3 *Major Australian zinc projects*

Project	Company	Location	Status	Expected startup	New capacity	Capital expend.
Advanced mining projects						
Century	Pasminco	250 km NW of Mt Isa, Qld	New project, commissioning	late 1999	450 kt Zn 41 kt Pb	$810m
George Fisher	MIM	22 km N of Mt Isa, Qld	New project, under construction	mid 2000	170 kt Zn 100 kt Pb 155 t Ag	$270m
Less advanced mining projects						
Balcooma	Lachlan Resources	200 km WNW of Townsville, Qld	New project, feasibility study completed	na	40 kt Zn 8 kt Pb 5 kt Cu	$60m
Bowden's silver project	Silver Standard Australia	25 km ESE of Mudgee, NSW	New project, feasibility study underway	na	124 t Ag in concen-trate	$60–65m
Dugald River	Pasminco	85 km NE of Mt Isa, Qld	New project, feasibility study ongoing	after 2003	na	$250m
Lady Loretta	Buka Minerals/ Noranda	115 km NW of Mt Isa, Qld	New project, development subject to proving up additional reserves	na	na	na
Processing facilities						
Townsville zinc refinery	Sun Metals (Korea Zinc)	Townsville, Qld	New project, commissioning	late 1999	170 kt Zn 325 kt sulphuric acid	US$425m

11.10 *Projections of Australian zinc industry exports (Zinc content)*



subject to market and other conditions. However, only the initial development has been factored into the medium term refined metal export projections shown in figure 11.10.

Pasminco's Century mine, currently in commissioning phase, will provide a substantial boost to Australia's zinc mine production and export capacity from 2000. At full capacity, Century will produce around 520 000 tonnes of zinc in concentrate a year, over 6 per cent of world mine output, and will increase Australia's zinc mine production capacity by almost 50 per cent. While the bulk of Century's output is expected to be exported in concentrate form — over 200 000 tonnes a year is earmarked for processing at Pasminco's Budel smelter in Holland — it is possible that some will also be processed in Australia.

MIM's George Fisher mine is due for commissioning around mid 2000 and is essentially a replacement for its existing Mount Isa zinc/lead mining operations where ore reserves are nearing exhaustion. A significant proportion of the Mount Isa/George Fisher zinc concentrates is expected to be processed at the Sun Metals refinery in Townsville. This is in contrast to the current situation where Mount Isa's output is exported in concentrate form.

With most of the proposed mine projects listed in table 11.3 still at feasibility stage, only the committed zinc mine developments (Century and George Fisher) are factored into the medium term export projections in figure 11.10.

Given this, the proportion of zinc exported in processed form over that period is expected to rise from 23 per cent in 1998-99 to around 28 per cent in 2003-04. Australia's export earnings from zinc, in real terms, are projected to rise from $1.13 billion in 1998-99 to almost $1.5 billion in 2000-01, an increase of 28 per cent, before gradually declining to around $1.2 billion in 2003-04 as world zinc prices trend lower.

12. Summary and conclusion

Prospects for further value adding of Australian non energy minerals

Given the relatively small size of Australia's domestic market for non energy minerals, the focus in this submission has been on the extent of processing of Australia's exports rather than on production and consumption. This focus reflects the fact that the Australian minerals industry is highly export oriented. Table 12.1 shows, for each major non energy mineral produced in Australia, the proportion of total exports in 1998-99 accounted for by semi processed and processed forms (in both value and volume terms, where available). The differences in the processed export proportions based on volumes compared with values for commodities such as iron–steel and alumina–aluminium, reflect the relatively high transformation coefficients.

Four commodities stand out as having a relatively low proportion (below 50 per cent) of exports in processed form — copper, zinc, iron–steel and aluminium. For three of these — iron–steel, copper and zinc — there has been substantial investment in new processing capacity over the past few years. However, while these developments will lead to substantial increases in processed exports, for the most part they have yet to reach full capacity and the full effect of the new and expanded capacity will not be reflected in export statistics until around 2000-01.

12.1 *Australian nonenergy minerals: percentage exported in processed form, 1998-99*

Commodity	In volume terms	In value terms
	%	%
Alumina	72 **a**	49
Aluminium	17 **a**	48
Copper	30	28
Gold	100	100
Iron ore and steel	5	29
Lead	55	60
Mineral sands	na	58
Nickel	na	83
Zinc	24	39

a In bauxite equivalent terms.

Copper is the prime example. Three major processing developments were completed in the past 12 months — WMC's Olympic Dam expansion; MIM's smelter and refinery expansions at Mount Isa and Townsville, respectively; and Western Metals' expansion of its Mount Gordon mine (which produces SX–EW metal), in Queensland. In addition, the reconstructed Port Kembla copper smelter–refinery is expected to be commissioned early in 2000. Collectively, these developments will add over 300 000 tonnes of new copper capacity a year when they are fully operational. As a result, by 2003-04, the proportion of copper exported in processed form is expected to rise to around 85 per cent (in volume terms) compared with 30 per cent in 1998-99.

Despite the commencement of operations at the new Sun Metals' zinc refinery in Townsville, the situation for zinc is less clearcut. The Sun Metals refinery, with a capacity of 170 000 tonnes a year, will raise Australian zinc smelting capacity by over 50 per cent, with virtually all of the increased metal output being available for export. However, there is expected to be only a small increase in the proportion of zinc exported in processed form over the medium term. This is because the large new Century mine (annual capacity of 520 000 tonnes of zinc in concentrates, currently in commissioning phase) will export most of its output in unprocessed form, largely offsetting the expected rise in exports of refined metal. Based on these developments, the proportion of zinc exported in processed form is expected to rise marginally, from 24 per cent in 1998-99 to 28 per cent in 2003-04.

Nevertheless, with the additional capacity provided by the Sun Metals facility, Australia will be ranked fourth in the world in zinc smelting capacity, surpassed only by China, Canada and Japan. If stage two of the Sun Metals refinery proceeds as envisaged, capacity at that facility would be doubled and total Australian capacity would exceed that of Japan and the proportion of Australian zinc exported in refined form would approach 40 per cent. A commitment to expand the Sun Metals refinery could be made in the next few years but this will depend on market conditions.

In terms of the proportion of iron ore–steel exported in processed form, exports of HBI from BHP's new plant in the Pilbara are expected to largely offset the effect of the closure of the Newcastle steel plant. In value terms, the proportion of processed products in total iron ore and steel exports is expected to be around 28 per cent in 2003-04, about the same as in 1998-99. While there are a number of Australian proposals to produce and export DRI–HBI–steel under consideration, these face highly competitive market conditions. Over the medium term, further opportunities are expected to emerge, however Australia is expected to remain a major supplier of iron ore to the world steel industry, given the significant competitive advantage the Australian industry has in this activity.

The combined proportion of alumina–aluminium in total aluminium industry exports (in bauxite equivalent terms) is relatively high, at 89 per cent. However, the semi processed product (alumina) makes up the bulk of that share (72 per cent of total aluminium industry exports). Currently there are several proposals to expand both alumina and aluminium capacity over the medium term. However, only two of these are at an advanced planning stage and both are proposals to increase alumina refining capacity — Worsley and Pinjarra, both in WA. Considerable uncertainty surrounds industry expectations of the future cost of electricity for aluminium smelters in Australia, particularly in the context of evolving policies on environmental issues. Given that there are currently no advanced plans to increase aluminium smelting capacity, alumina's share of total aluminium industry exports is expected to become increasingly dominant over the longer term.

Influences on location decisions for mineral processing

Several of Australia's major non energy mineral exports exhibit relatively low degrees of processing compared with other major mining countries. These include zinc, aluminium, iron and steel and copper. Recent investment in new copper processing capacity is expected to result in a sharp turnaround in the extent of copper exported in processed form over the medium term. Prospects for increasing the extent of processing for the others are more modest, as outlined above.

However, the relatively low proportions of exports which are processed in some non energy mineral industries need to be carefully interpreted. The Australian minerals industry has demonstrated an ability to process a wide range of minerals, and to compete effectively on world markets, including markets for those commodities where the degree of processing in Australia is relatively low.

Decisions on where to undertake further processing of minerals, or indeed whether it is relatively efficient to export in unprocessed form, involve consideration of a wide range of economic, technological, environmental and political factors. All such considerations are subject to significant change over time. In terms of decisions on the location of new processing capacity, important dynamic influences include:

- Trends in transport costs for both bulk commodities and (typically lower volume) processed exports are an important influence on competitive advantage. While bulk transporting of ores and concentrates involves transport of wastes, important efficiencies associated with high volume, bulk transport to single buyers require transport cost issues to be closely examined, particularly when costs of transport of raw materials to domestic processing locations are taken into account.

- Processing close to final markets can raise problems of environmental impact. The changing impact of ***additional*** pollution that would be generated by locating new, or expanded processing operations at different sites — particularly mine location versus market location comparisons — is an important consideration. Regional industrial concentration and changing community valuation of incremental pollution, particularly in the industrial areas of developed countries, are playing an increasingly important role in influencing the location of processing operations.
- Changes in technologies can fundamentally change the economics of location. For example, the continuing growth in the application of electric arc furnace (EAF) steelmaking technology in the 1990s is, among other things, facilitating the location of small scale, flexible and relatively low polluting steelmaking operations close to markets. But this technology is also encouraging value adding to iron ore to produce the intermediate iron products which are increasingly required as high quality inputs to EAF facilities.
- Increased globalisation and improving communications technologies can be expected to enhance the flexibility of decision making with respect to the location of processing facilities, by broadening the range of possible locations. However, the logistical considerations of just-in-time inventory management potentially impose a different set of constraints on location decisions.
- Changes through time in the relative attractiveness (risks) of some countries as locations for processing operations can arise through changes in political or social stability. However, the perceived stability of domestic policy with respect to the minerals industry is also a major risk factor. Considerations could include prospects for changes in direct economic incentives–disincentives, and indirect effects via prospects for significant change in policies on investment, taxation, macroeconomic regimes, indigenous rights, environmental impacts and energy costs.

In addition to these dynamic influences there are other factors which may have a bearing on processing location decisions. These may include:

- The existence, or otherwise, of nearby markets, and conditions of access to those markets. For example, Canada's large resource base, coupled with its proximity to US manufacturing centres, membership of NAFTA and environmental regulations applying in US centres, are likely to be factors affecting the extent of basic processing undertaken in Canada before export to the US market. However, Australia's relative proximity to the rapidly developing countries in Asia, while very important in the development of the mining sector, has not had the same effect on processing. A high proportion of Australian base metals exports to East Asia, our major market, are in unprocessed form. This reflects development strategies in many of these countries in identifying minerals processing as a priority in their industrialisation, with associated development policies frequently including escalating trade barriers along the value adding chain and a range of incentives and input subsidies.

- The specific location of mines within countries can also influence processing decisions. With some mines located in remote regions of Australia, further processing of mine products before export may not be an economic option because of the costs of transporting outputs and inputs, the high capital cost of establishing processing facilities on site and the absence of other important inputs or infrastructure. This applies in particular to minerals for which the value added by further processing is relatively small (such as zinc) or to operations which are of limited scale or mine life. On the other hand, the processing of some minerals at remote locations, such as the copper processing facilities at the isolated Olympic Dam operations, partly reflects the economics of transport of final outputs and the large scale and expected longevity of operations based on an extensive resource. Also, using SX–EW technology to produce metal on site from orebodies amenable to this process facilitates remote location processing (for example, the Nifty mine in the Pilbara).

This submission has focused on the extent of processing of Australia's non energy mineral exports since the mid 1980s and the outlook for further processing of exports over the medium term to 2003-04. Resource and data constraints have meant that this analysis has necessarily been at a relatively broad level. However, it is clear that location decisions for mineral processing involve consideration of a wide range of complex issues, many of which are specific to individual operations.

A case study approach would appear to be a practicable way for the Inquiry to examine the range of factors which have been important to decisions to process in Australia or elsewhere. While such case studies would focus on individual decisions, they can also provide practical examples of the application of general principles guiding the nature and future direction of value adding in Australia.

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