



Australian Government
Geoscience Australia

AUSTRALIA'S IDENTIFIED MINERAL RESOURCES 2008



Australian Government
Geoscience Australia

Resources, Energy and Tourism Portfolio

Minister for Resources, Energy and Tourism: The Hon. Martin Ferguson AM, MP

Geoscience Australia

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ISSN 1327-1466

Bibliographic reference: Geoscience Australia 2008. Australia's Identified Mineral Resources 2008. Geoscience Australia, Canberra.

FRONT COVER: Hope Downs iron ore mining operations, Western Australia (Rio Tinto Iron Ore Pty Ltd).

DESIGN AND LAYOUT: Henry Pippan, Geospatial Applications and Visualisation (GAV)
Geoscience Australia

Foreword

Geoscience Australia provides important information on Australia's future capacity to produce mineral resources. *Australia's Identified Mineral Resources* is an annual nation-wide assessment which takes a long term view of what is potentially economic. Data on mining company estimates of ore reserves (JORC Code), which are generally based on short to medium-term commercial considerations, are included for comparison. The assessment also includes evaluations of long-term trends in mineral resources, international rankings, summaries of significant exploration results, brief reviews of mining industry developments and an analysis of mineral exploration expenditure across Australia. Comparable information on petroleum resources is published in another Geoscience Australia publication, *Oil and Gas Resources of Australia*.

Australia's Identified Mineral Resources provides technical information on mineral and energy resources, which is used in the formulating of Australian Government policies and is reproduced by the Australian Bureau of Statistics. It also provides government, industry, the investment sector and general community with an informed understanding of Australia's known mineral endowment and the level of exploration activity.

Australia's resource stocks remain healthy overall, although there has been a levelling off of resource trends for several major commodities. Reflecting strong world demand for mineral resources, expansions in mine production of bauxite, coking coal, iron ore and other commodities continued in 2007. The 'minerals boom' in the Australian economy continued during 2007 and the mining industry contributed substantively to Australia's prosperity – economically, environmentally and socially. The Australian Bureau of Agricultural and Resource Economics reported that in calendar year 2007, the value of Australia's exports of mineral and energy commodities (excluding petroleum and gas) was \$90.5 billion, which represented about 42% of the value of total exports of goods and services from Australia.

The ability of Australia's minerals sector to sustain its strong recent growth remains dependent on effective exploration leading to the discovery and development of new ore deposits. Successful exploration outcomes rely heavily on continuing updates of pre-competitive geoscience data by government agencies. State-of-the-art geoscientific syntheses and integrated research are needed to reduce exploration risks in prospective frontier regions.

Australia's Identified Mineral Resources and other fundamental data on the minerals sector can be accessed through the online *Atlas of Australia's Mineral Resources, Mines and Processing Centres* (www.australianminesatlas.gov.au). The atlas has a web-based geographic information system format and shows the location of mineral and energy resources, mines and production/processing centres.

As with other major sectors of the Australian economy, it is imperative that governments retain access to a comprehensive set of data that is fundamental to evidence-based mineral policy and to sustaining a strong minerals industry. In recent years, the ability of the Australian, State and Northern Territory governments to access mineral resource data and analyse trends has been inhibited by the rapid increase in the number of foreign-listed, private and private equity companies involved in mining and mineral exploration in Australia. Only companies listed on the Australian Securities Exchange (ASX) are required to publicly report on the ore reserves and mineral resources they control. As public reporting provides the basic information for the national minerals inventory, the Ministerial Council on Mineral and Petroleum Resources has established a Resource Reporting Committee to prepare recommendations in relation to reporting on mineral resources and mine production controlled by companies not listed on the ASX. Geoscience Australia is participating in the work of the committee.



Neil Williams
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Summary

Australia's economic demonstrated resources (EDR) for the following 18 mineral commodities increased during 2007 — antimony, bauxite, cobalt, copper, gold, iron ore, manganese ore, ilmenite, rutile, zircon, molybdenum, nickel, rare earths, silver, tungsten, uranium, vanadium and zinc. In the same period, EDR of eight commodities — black coal, cadmium, diamonds (gem and industrial), lead, niobium, phosphate rock, platinum group metals and tantalum decreased. EDR for brown coal, lithium, magnesite, shale oil and tin remained at levels similar to those reported in 2006.

Increases in EDR were due to on-going drilling and evaluation of known deposits resulting in the transfer (re-assessment) of resources from inferred or sub-economic categories into EDR and the discovery of new deposits or extensions of known deposits. Sustained increases in prices for most metal and mineral commodities over recent years has allowed companies to re-assess the economic viability of lower grade resources and deposits which previously were considered to be uneconomic. Overall this has contributed to an increase in EDR for many metal and mineral commodities.

World ranking: Australia's EDR of brown coal, mineral sands (rutile and zircon), nickel, uranium, zinc and lead remain the world's largest, while antimony, bauxite, black coal, copper, gold, iron ore, industrial diamond, ilmenite, lithium, manganese ore, niobium, silver and tantalum rank in the top six worldwide.

Accessible economic demonstrated resources (AEDR): A relatively small number of mineral deposits are inaccessible for mining because of government policies or environmental and land access restrictions which prevent mining. This is the case in particular for some mineral sands and uranium deposits.

Resources and current rates of mine production: Ratios of AEDR to current mine production provide indicative estimates of the resource life. AEDR of most major commodities can sustain current rates of mine production for many decades. While this is the longer term assessment, resource life based on ore reserves is shorter in duration, reflecting a shorter term commercial outlook. Further, rapid increases in production forecast for some major commodities will have marked impacts on resource life unless major new resources are discovered, or there are technological breakthroughs.

Based on AEDR, the resource lives for gold (an average of 24 years at current rates of production), diamonds (about 10 years), platinum group metals (20 years), zinc (28 years), and manganese (31 years) are the lowest. These assessments continue to highlight the need for ongoing successful exploration in the short and medium-term to sustain production of these commodities at current levels.

Mineral exploration: Australian mineral exploration spending in 2007 rose by 41% to \$2061.1 million. This increase reflected strong growth in prices for many commodities on the back of anticipated strong and growing demand, particularly from China. It also reflected major increases in the cost of exploration.

Gold remained the predominant single element target in calendar year 2007 with its share of total exploration spending being 24.4% or \$502.9 million in the year, an increase of \$73 million on 2006. The base metal group attracted the largest spending in 2007 with \$702.4 million, an increase of 64.9% or \$276.3 million. The growth in base metals was driven by substantial increases in zinc-lead-silver exploration, which rose by \$86.7 million to \$187.4 million, copper which rose by \$86.2 million to \$263.7 million and nickel exploration which increased by \$103.3 million to \$251.2 million. Uranium exploration spending more than doubled in 2007 rising from \$80.7 million to \$181.4 million. Iron ore exploration rose by \$129.4 million to \$354.1 million and its share of total spending increased to 17% from 15% in 2006. The growth in iron ore exploration was in response to continuing strong international demand, particularly from China. The only two commodities for which exploration fell in 2007 were coal — down \$6.1 million in 2007 to \$192.6 million — and diamond — down by \$9.4 million to \$18.4 million.

The ongoing strong exploration activity saw a very large number of reported intersections of economic grade mineralisation and several new discoveries. Some of the discoveries in 2007 include Spotted Quoll sulphide nickel deposit in Western Australia, and the mineral sands discoveries of Cyclone, Hurricane

and Lefroy in the Western Australian portion of Eucla Basin and Dromedary in the South Australian part of Eucla Basin as well as the Atlas deposit in the Murray Basin in New South Wales. In response to world demand there was substantial activity in the iron ore sector with new resources and drilling results released for many smaller deposits and prospects. Similarly uranium exploration surged and the number of new companies with a focus on uranium is likely to ensure spending will continue to grow.

A major review of the highlights of mineral exploration in Australia in 2007 is available in the report “Australian Mineral Exploration: A Review of Exploration for the Year 2007 - Extended Edition” which can be downloaded free from the Geoscience Australia web site at www.ga.gov.au. Overall, the rate of discovery of significant new mineral deposits continued to fall despite a marked increase in exploration expenditures over recent years.

Introduction

Geoscience Australia and its predecessors have prepared annual assessments of Australia's mineral resources since 1975. The resource data and related information from *Australia's Identified Mineral Resources* are used by the Australian Bureau of Statistics and provide input into Australian Government policy decisions associated with the minerals sector, sustainable development of resources and financial allocations. Other Australian Government departments and agencies to utilise the data included the Department of Resources, Energy and Tourism (formerly Department of Industry, Tourism and Resources), the Department of Prime Minister and Cabinet, the Department of Environment, Water, Heritage and the Arts, the Department of Defence, the Office of National Assessments, and the Department of Foreign Affairs and Trade.

Australia's Identified Mineral Resources 2008 presents estimates of Australia's mineral resources for all major and several minor mineral commodities (Table 1) based on published and unpublished data available to Geoscience Australia to the end of December 2007. These resource estimates provide a long term view of what is likely to be mined. They are compared with national totals of ore reserves for each commodity, which provide the industry view of what is likely to be mined in the short to medium term. Mine production data are based on the Australian Bureau of Agricultural and Resource Economics figures. World ranking of Australia's mineral resources have been calculated mainly from information in publications of the United States Geological Survey. A summary of significant industry developments also is presented.

Australia's Identified Mineral Resources 2008 provides information on and analysis of mineral exploration expenditures in Australia for 2006–07 and the calendar year 2007. Trends in expenditure are presented and discussed.

National Resource Classification Scheme

The mineral resource classification scheme used for Australia's national inventory is based on two general criteria: i) the geological certainty of existence of the mineral resource, and ii) the economic feasibility of its extraction over the long term (see Appendix 2 ‘National classification system for identified mineral resources’). The classification category ‘Economic Demonstrated Resources’ is used instead of ‘reserves’ for national totals of economic resources. This is because the term ‘reserves’ has a specific meaning for individual mineral deposits under the criteria of the *Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves*, which is known as the JORC Code and is used by industry for reporting ore reserves and mineral resources.

Economic Demonstrated Resources, or EDR, are defined as the total of measured and indicated resources as shown in Appendix 2 for which profitable extraction or production had been established, analytically demonstrated or assumed with reasonable certainty using defined investment assumptions (refer Guideline (iii) in Appendix 2). EDR provided a basis for meaningful comparisons of Australia's economic resources with those of other nations. Ore is generally mined from resources in the EDR category. Long-term trends in EDR for bauxite, black coal, iron ore, gold, copper, nickel, lead, zinc, mineral sands and uranium are presented and the reasons for significant changes in resource trends are noted.

Accessible Resources

Geoscience Australia also assesses the amount of resources within EDR which are accessible for development and mining. Some mineral deposits are inaccessible for mining currently because of government policies or various environmental and land-access restrictions such as location within National/State parks and conservation zones, military training areas or environmental protection areas or areas over which mining approval has not been granted by traditional owners. Accessible economic demonstrated resources (AEDR) as shown in Table 1 represent the resources within the EDR category that are accessible for mining. It should be noted that the factors which restrict access for mining could be changed or abolished in future.

Resource Life

The national total ore reserves (OR) figures shown in Table 1 are from estimates prepared by companies for mine planning and marketing purposes and generally have a shorter term outlook than EDR. The ratios of EDR/production, AEDR/production and OR/production provide information on the resource life of Australia's mineral commodities based on production rates at the time of assessment. Each of these have deficiencies as an indicator of resource life. OR/production is a more conservative indicator of resource life, and for some commodities very much more conservative, than EDR/production. The ratios can change quite rapidly through various influences such as major changes in production rates and changes in metal prices.

Notes for Table 1

Abbreviations: t = tonne; m³ = cubic metre; L = litre; kt = 10³t; Mc = 10⁶ carat; Mt = 10⁶t; Gt = 10⁹t; GL = 10⁹L.

- | | |
|---|--|
| <ul style="list-style-type: none"> a) Total inferred resources in economic, sub-economic and undifferentiated categories. b) Accessible EDR (AEDR) is the portion of total EDR that is accessible for mining. AEDR does not include resources which are inaccessible for mining because of environmental restrictions, government policies or military lands. c) Joint Ore Reserves Committee (JORC) Proven and Probable Ore Reserves as stated in company annual reports and reports to Australian Stock Exchange. d) Sources: Australian Bureau of Agricultural and Resource Economics (ABARE). e) Sources: Geoscience Australia for Australian figures, USGS Mineral Commodities Summaries for other countries. f) World mine production for 2007, mostly USGS estimates. g) Black and brown coal reserves include both JORC reserves and Geoscience Australia estimated reserves for operating mines that do not publish JORC reserves. h) Raw coal. i) Geoscience Australia estimate. j) Saleable coal. k) Excludes Morocco and USA. l) 192 277 t of spodumene concentrate containing 4.8% to 7.5% Li₂O (Talison Minerals Ltd). | <ul style="list-style-type: none"> m) Excludes USA. n) Not reported by mining companies. o) Production of phosphate rock at Duchess mine (Qld) for 2006-07. Production data for Christmas Island not available for commercial-in-confidence reasons. p) Latest production figure is 358 t for 2003 from <i>USGS Mineral Commodities Summaries 2004</i>. q) This total inferred resource includes a 'total potential' shale oil resource of the Toolebuc Formation, Queensland of 245 00 GL that was estimated by the Bureau of Mineral Resources and CSIRO in 1983 (Refer to Shale oil section). r) Source: World Energy Council (WEC) Survey of Energy Resources 2007. s) Latest production figures for end 2005 from WEC Survey of Energy Resources 2007. t) Tantalum production from Western Australian Department of Industry and Resources data. u) Paramarginal resources 29.2 kt from Nolan's Bore and 17.1 kt from Toongi, inferred resources include 24.1 kt from Nolan's Bore and 17.9 kt from Toongi. v) Source: OECD/NEA & IAEA (2007). Compiled from the most recent data for resources recoverable at costs of less than US\$80/kg U. w) Source: Cameco Corporation Annual Report 2007. |
|---|--|

Table 1. Australia's resources of major minerals and world figures as at 31 December 2007.

Commodity	Units	Australia							World	
		Demonstrated Resources			Inferred Resources (a)	Accessible EDR (AEDR)(b)	JORC Reserves(c) (% of AEDR)	Mine Production(d) 2007	Economic Demonstrated Resources(e)	Mine Production(f) 2007
		Economic (EDR)	Subeconomic							
			Para-marginal	Sub-marginal						
Antimony	kt Sb	136	43	36	60	136	96 (70%)	–	2100	135
Bauxite	Gt	6.2	0.2	1.4	0.69	5.4	1.9 (35 %)	0.062	25	0.190 ^(e)
Black coal in situ recoverable	Gt Gt	56.4 38.9	4.1 2.2	9.8 6.7	97.7 61.6	38.8	12.5 ^(g) (30%)	0.421 ^(h)	687 ⁽ⁱ⁾	5.5 ^{(i)(j)}
Brown coal in situ recoverable	Gt Gt	41.4 37.3	43.4 39	18.1 16.3	112 100.8	32.3	4.9 ^(g) (15%)	0.066 ⁽ⁱ⁾	148 ⁽ⁱ⁾	0.86 ⁽ⁱ⁾
Cadmium	kt Cd	60.8	10.0	10.2	0.3	60.8	51.3 (84%)	0.46	490	19.9(m)
Cobalt	kt Co	1521	183	106	1519	1521	462 (30%)	4.74	7075	60
Copper	Mt Cu	59.4	6.9	1.6	38.5	59.4	18.3 (31%)	0.87	525	15.7
Diamond gem & near gem industrial	Mc	97.3	98.2	0.2	13.1	97.3	95.7 (98%)	9.4	–	106
	Mc	101.3	102.3	0.3	13.7	101.3	99.6 (98%)	9.8	590	69
Fluorine	Mt F	–	0.2	23.7	21.3	–	–	–	117 ^(k)	2.6
Gold	t Au	5839	1272	138	4336	5780	3284 (56%)	245	42 000	2476
Iron ore	Gt	20.3	0.3	1.7	24.4	20.2	8.1 (40 %)	0.299	154	1.9
Lead	Mt Pb	23.3	8.5	1.6	19.3	23.3	10.6 (45%)	0.641	78	3.6
Lithium	kt Li	169	54	25	7	170	145 (85%)	^(l)	4269	25.0 ^(m)
Magnesite	Mt MgCO ₃	344	22	35	931	344	37.5 (11%)	0.447	7630	15.96 ^(m)
Manganese ore	Mt	164	23	167	137	164	148 (90%)	5.29	1300	35
Mineral sands										
Ilmenite	Mt	221.4	35.3	0.1	128.0	185.0	45.7 (25%)	2.326	1276	10.4
Rutile	Mt	23.1	9.6	0.14	31.0	17.4	5.2 (30%)	0.312	46	0.6 ^(m)
Zircon	Mt	39.0	14.6	0.15	35.7	30.8	8.9 (29%)	0.601	83	1.29
Molybdenum	kt Mo	198	93	262	489	198	196.5 (99%)	–	8800	187
Nickel	Mt Ni	25.8	1.6	1.1	21.9	25.8	6.58 (25%)	0.185	68.7	1.7
Niobium	kt Nb	40	144	0	811	40	21 (52%)	⁽ⁿ⁾	2700	45
Phosphate rock	Mt	81.6	911.6	–	1150.1	81.6	81.6 (100%)	2.129 ^(o)	18 000	147
PGM (Pt, Pd, Os, Ir, Ru, Rh)	t metal	19.1	119	35.3	135	14.8	0.12 (8%)	0.742	71 000	462 ^(p)
Rare earths (REO & Y ₂ O ₃)	Mt	1.13	0.7	26.1	24.4	1.13	0 (–)	0 (–)	84	0.13
Shale oil	GL	4.5	208.5	3719	246 115 ^(q)	4.5	4.5 (100%)	0	449 226 ^(r)	0.859 ^(s)
Silver	kt Ag	50.1	20.4	8.0	31.0	50.1	26.2 (52%)	1.879	289	20.4
Tantalum	kt Ta	41	32	0.2	87	41	40.3 (98%)	0.435 ^(t)	130	0.985
Thorium	kt Th	–	46.3 ^(u)	–	440	–	–	–	–	–
Tin	kt Sn	247	59	195	306	247	216 (87%)	2.071	6100	300
Tungsten	kt W	86.6	10.0	18.9	52.9	86.6	10.8 (12.5%)	0	2900	89.6
Uranium	kt U	983	10	0	621	824	228 (28%)	8.603	2867 ^(v)	41.926 ^(w)
Vanadium	kt V	898	121	4124	2757	898	5.3 (0.6%)	0	13 000	58.6
Zinc	Mt Zn	42.5	18.3	2.3	23.3	42.5	22.2 (52%)	1.514	179	10.6

Trends in Australia's Economic Demonstrated Resources of Major Mineral Commodities

The trends in EDR for Australia's major mineral commodities have undergone significant and sometimes dramatic changes over the period 1975–2007 (Fig. 1). These changes for each commodity can be attributed to one, or a combination of the following factors:

- increases in resources resulting from discoveries of new deposits and delineation of extensions of known deposits,
- depletion of resources due to mine production,
- fluctuations in commodity prices and currency exchange rates which can move previously subeconomic resources into EDR,
- advances in mining and metallurgical technologies, eg. carbon-based processing technologies for gold have enabled economic extraction of gold from low-grade deposits which previously were uneconomic,
- adoption of the resource classification scheme (JORC Code) ¹ by the Australian minerals industry and the subsequent impacts on re-estimation of ore reserves and mineral resources to comply with the requirements of the Code. Many companies re-estimated their mineral resources to comply with the Code and some re-assessment was made of resource data for other deposits identified by Geoscience Australia's predecessor, the Bureau of Mineral Resources. The impacts of the Code on EDR occurred at differing times for each of the major commodities.

Past trends and changes in EDR for a number of Australia's major mineral commodities are discussed below.

Black Coal

A major re-assessment of New South Wales coal resources during 1986 by the NSW Department of Mineral Resources and the Joint Coal Board resulted in a large increase in black coal EDR as reported in 1987 (refer 'a' on Fig. 1).

EDR for black coal has declined since 1998 due to the combined impacts of mining companies re-estimating ore reserves and mineral resources more conservatively so as to comply with requirements of the JORC Code, and increased rates of mine production.

Bauxite

Increases in bauxite EDR in 1989 resulted from delineation of additional resources in deposits on Cape York Peninsula ('b' on Fig. 1). Decreases in bauxite EDR in 1992 were due to re-classification of some resources within deposits on Cape York Peninsula so as to comply with requirements for the JORC Code ('c').

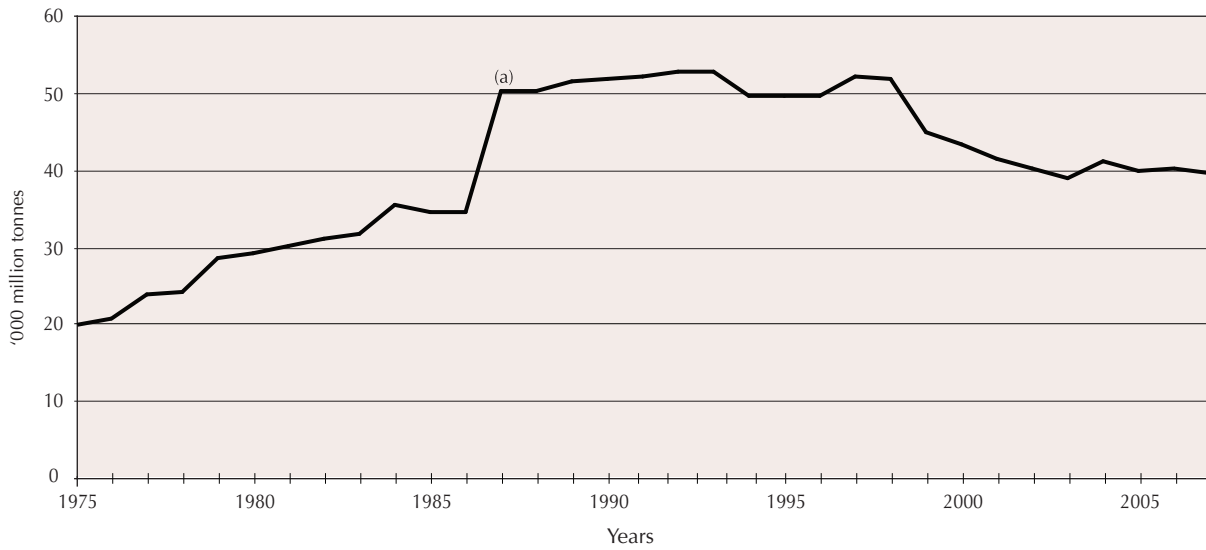
Iron Ore

EDR for iron ore declined from 1996 to 2001 due to the combined impacts of mining companies re-estimating ore reserves and mineral resources more conservatively so as to comply with requirements of the JORC Code, and increased rates of mine production. However since 2003 EDR has increased due to reclassification of magnetite resources to economic, newly reported resources and increases in resources at some major mines.

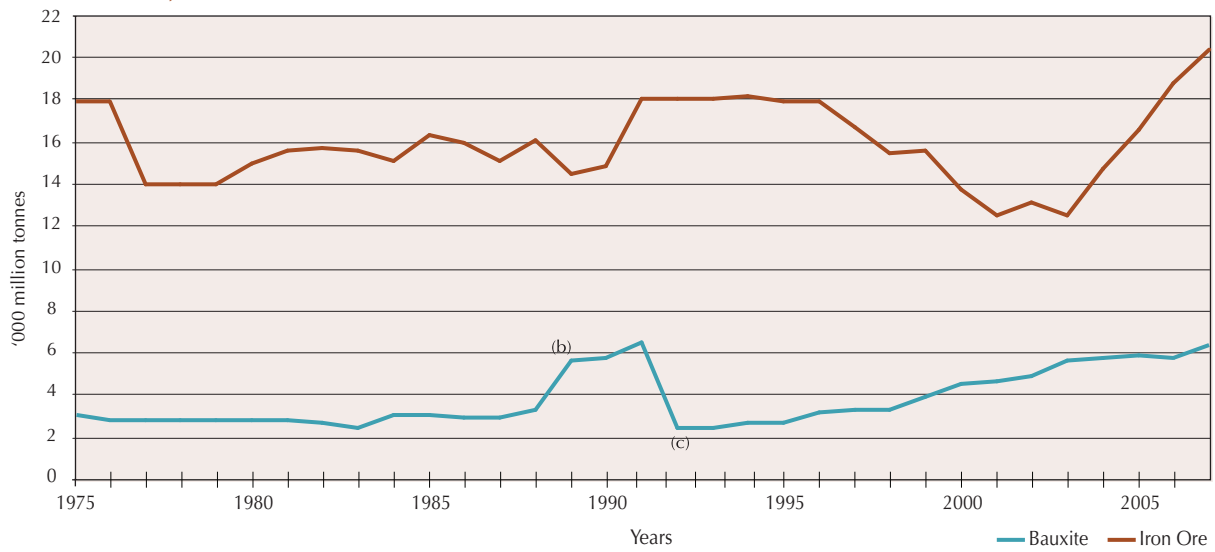
¹ In 1988, the Australian mineral industry adopted the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves (JORC Code). Many companies first used this code for reporting their mineral resources in 1989. The requirements of the Code differed significantly from the resource classification schemes used by companies prior to 1989.

Figure 1: Trends in Economic Demonstrated Resources (EDR) for major commodities since 1975.

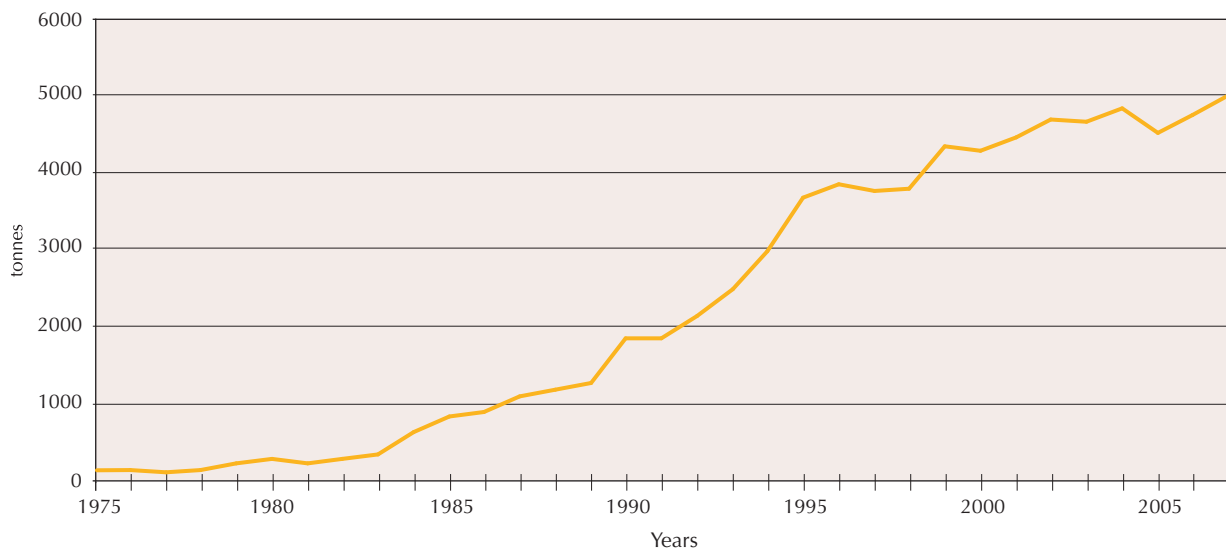
Black Coal (recoverable)



Bauxite, Iron Ore



Gold



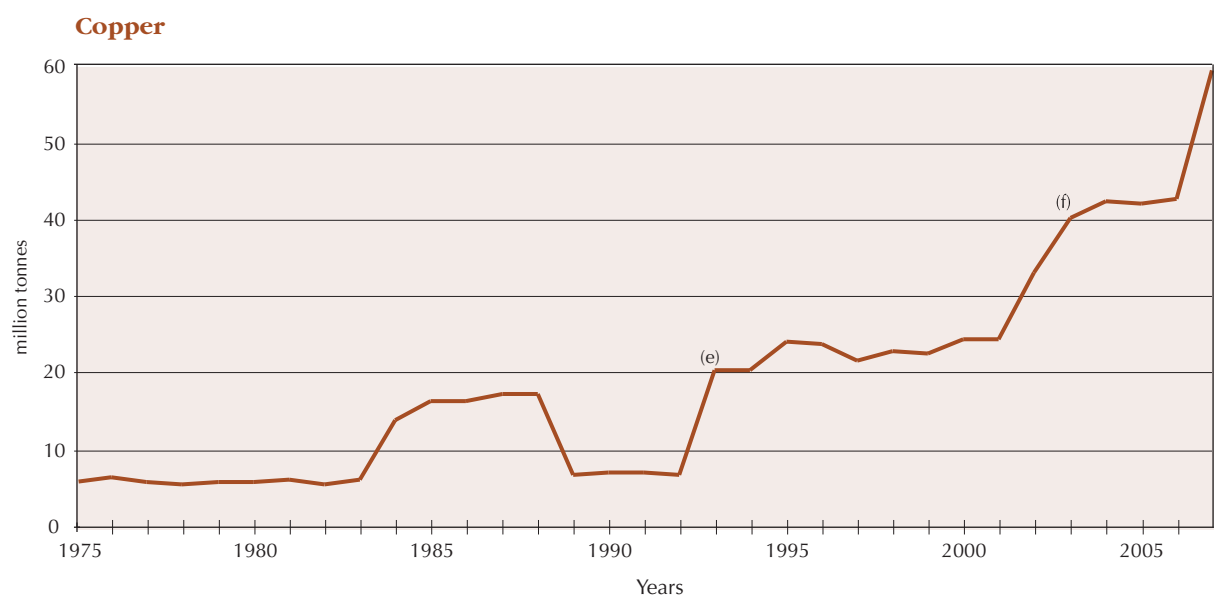
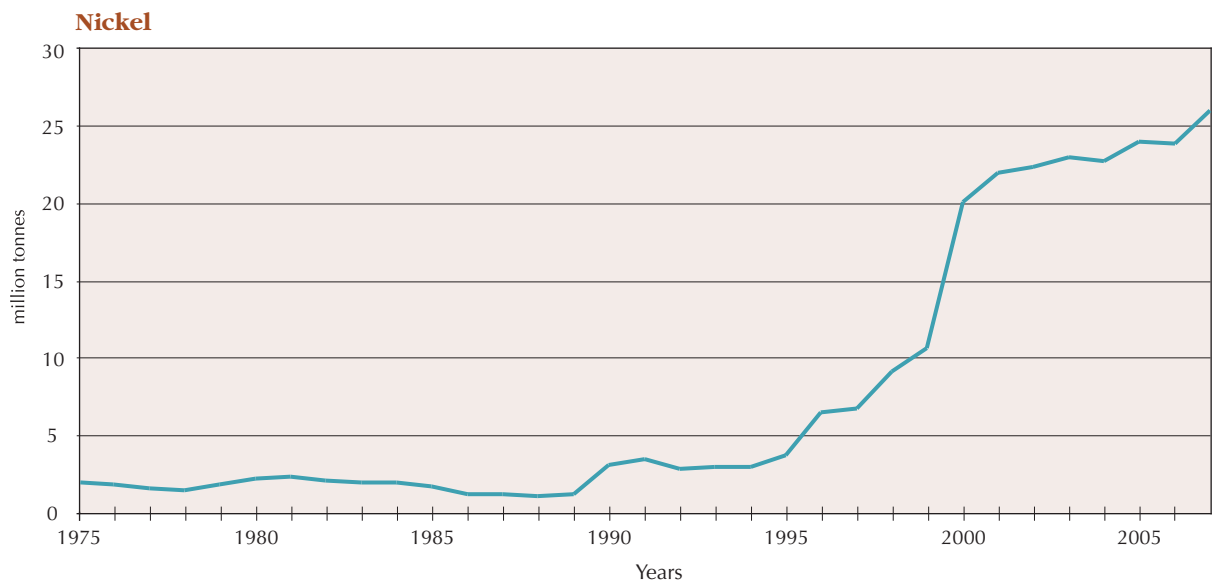
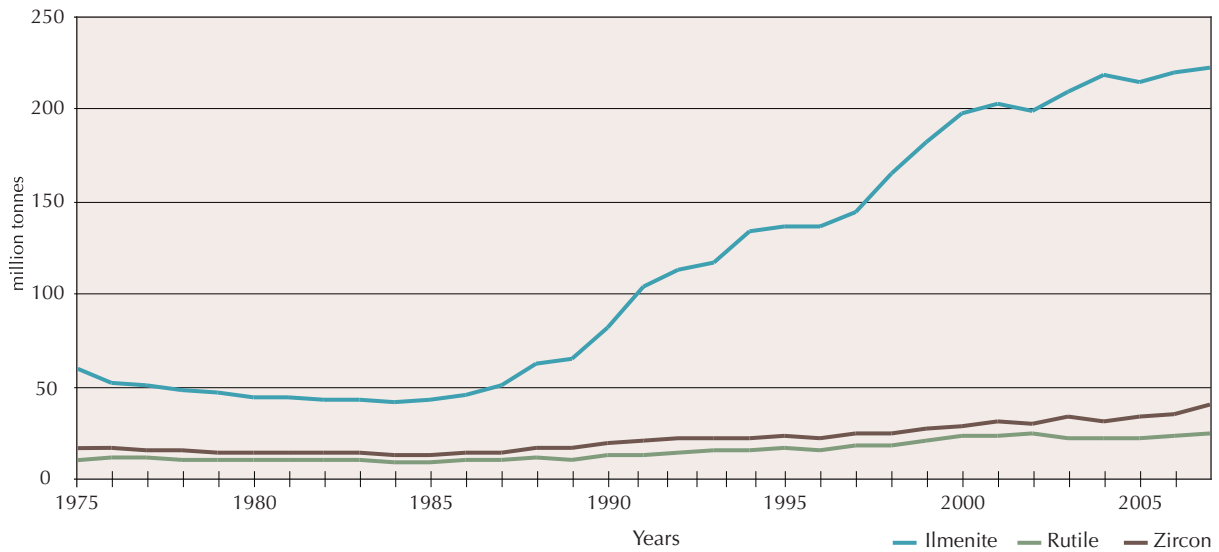
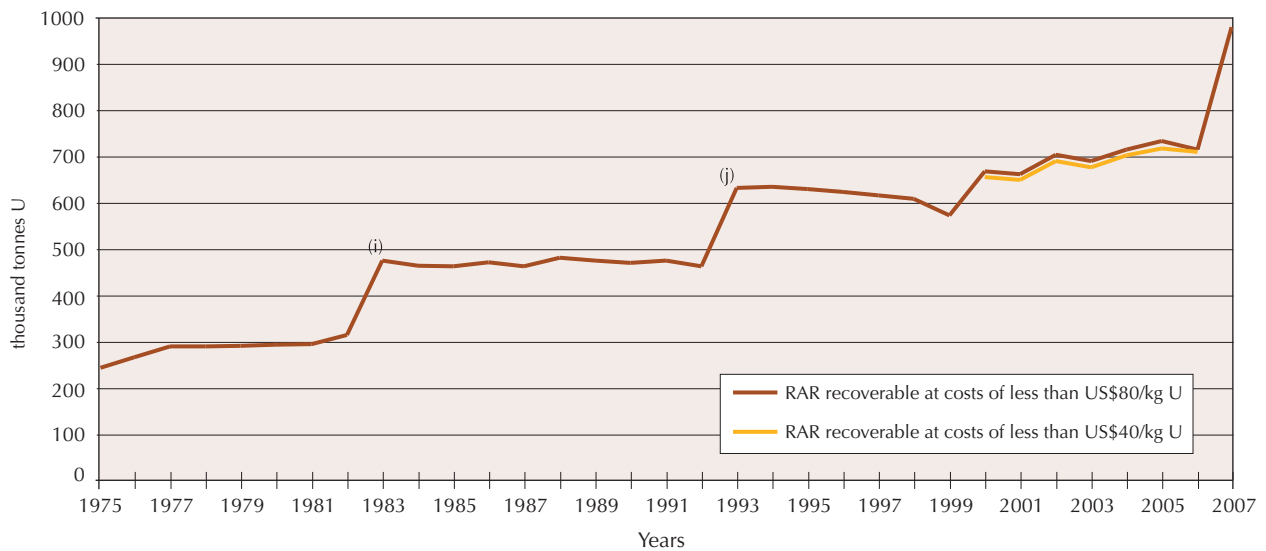


FIGURE 1: Trends in Economic Demonstrated Resources (EDR) for major commodities since 1975 (continued).

Mineral Sands



Uranium (recoverable)



Gold

Gold EDR has increased steadily since 1975 with a clear increase in the rate of growth since 1983. Much of the increase can be attributed to the successful introduction of the carbon-based processing technology which allowed the profitable processing of relatively low grade ore deposits. In addition, the higher than previous prevailing gold prices (denominated in US\$) supported high levels of exploration for gold to the extent where gold accounted for over half of the total mineral exploration expenditure in Australia for many years. Increased exploration contributed to the increases in EDR.

Nickel

The EDR for nickel increased during the period 1995 to 2001 by 18.2 Mt. This was mainly due to progressive increases in resources of **lateritic deposits** at Bulong, Cawse, Murrin Murrin, Mt Margaret, Ravensthorpe (all in WA), Marlborough (Qld), Syerston and Young (NSW). Australia's EDR of nickel doubled in 2000 (compared to the level at the end of 1999) – this dramatic increase was due to further large increases in resources at the Mt Margaret and Ravensthorpe deposits, and other lateritic deposits in the Kalgoorlie region (WA). In addition, during the period 1995 to 2001 there were increases in resources of **sulphide deposits** at Yakabindie, and discoveries of the Silver Swan and Cosmos high-grade sulphide deposits (all in WA).

From 2001 onwards, the sharp rises in market prices for nickel led to increased expenditures on exploration and on evaluation drilling at many known deposits. This contributed to further increases in total EDR for sulphide deposits at Perseverance, Sally Malay, Maggie Hays, Anomaly 1, Honeymoon Well, deposits in the Forrestania area as well as new deposits at Prospero and Tapinos (all in WA), Avebury (Tas), and remnant resources at several sulphide deposits in the Kambalda region including Otter-Juan and Lanfranchi groups of deposits.

From 2001 onwards EDR there has been only minor increases in nickel EDR because increases in resources for some deposits have been offset by companies reclassifying their lateritic nickel resources to lower resource categories pending more detailed drilling and resource assessments.

Copper

Following the adoption of the JORC Code by the Australian mineral industry, many companies first used this code for reporting their copper resources in 1989. These companies re-estimated mineral resources in order to comply with the Code. This resulted in a sharp fall in Australia's copper EDR in 1989 ('d').

The sharp increase in copper EDR in 1993 was due mainly to an increase in company announced resources for Olympic Dam deposit (SA). Additional resources were also reported for Ernest Henry (Qld), North Parkes (NSW) and other smaller deposits ('e').

Re-assessments of copper resources by Geoscience Australia in 2002 and 2003 resulted in further transfers (reclassification) of Olympic Dam resources into EDR ('f'). In 2007, copper resources increased by 40% mainly due to a large increase in resources for Olympic Dam. Drilling over recent years has outlined large resources in the south eastern part of the deposit.

Lead, Zinc

The adoption of the JORC Code in 1988 by the Australian mineral industry led to a re-estimation of mineral resources by many companies to align with the Code, and some re-assessments of resource data for other deposits by the former Bureau of Mineral Resources. This resulted in a sharp fall in Australia's lead and zinc EDR in 1989 ('g').

Increases in EDR for lead and zinc in 1993 were due to re-classification of paramarginal demonstrated resources into EDR for McArthur River (NT) and Hilton deposits (Qld). Additional resources were also reported for Century and Cannington deposits (Qld) ('h').

Mineral Sands

Increases in EDR of ilmenite from 1996 to 2003 resulted from discovery and subsequent evaluation drilling of heavy mineral sands deposits in the Murray Basin – these deposits are in Victoria (Wemen and Woornack), New South Wales (Gingko and Snapper) and South Australia (Mindarie project). In addition, from 1998 onwards there were progressive increases in resources at mineral sands deposits in the North Swan Coastal Plain area north of Perth, and the Blackwood Plateau region (includes the Beenup deposit) in Western Australia.

Uranium

The majority of Australia's uranium deposits were discovered between 1969 and 1975 – approximately 50 deposits (15 with significant resource estimates) were discovered during this short period. Since 1975, only another six deposits have been discovered – of these, only two deposits (Kintyre in the Paterson Province, WA and Junnagunna, north west Qld) have Reasonably Assured Resources recoverable at less than US\$80/kg U (equates with EDR). Hence, the progressive increases in Australia's EDR for uranium from 1975 to the present (as shown in Fig. 1) were largely due to on-going delineation of resources at known deposits.

From 1983 onwards, the Olympic Dam deposit has been the major contributor to increases in Australia's EDR. The large increases shown on Fig. 1 were due to the following:

- in 1983, initial resource estimates for Olympic Dam and Ranger No. 3 Orebody (NT) made by the former Australian Atomic Energy Commission ('i').
- in 1993, further increases in EDR for Olympic Dam (based on estimates reported by WMC Resources Ltd), and first assessment of resources for the Kintyre deposit by the former Bureau of Mineral Resources ('j').
- in 2000, increases were due to continuing additions to the Olympic Dam resources.
- in 2007, major increase in EDR for Olympic Dam. Drilling in recent years has outlined major extensions to the south eastern part of the deposit.

COMMODITY REVIEWS



Dragline at the Blair Athol coal mine, Queensland (Rio Tinto Coal Australia).

Bauxite

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Bauxite is a heterogeneous, naturally occurring material from which alumina (Al_2O_3) and aluminium metal are produced. The principal minerals in bauxite are gibbsite ($\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$), boehmite ($\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$) and diasporite, which has the same composition as boehmite, but is denser and harder.

Australia is the world's largest producer of bauxite, with 33 per cent of global production in 2007. The bauxite resources at Weipa (Qld) and Gove (NT) have nearly 50 per cent available alumina and are amongst the world's highest grade deposits. In Western Australia, deposits in the Darling Range and the undeveloped Mitchell Plateau are relatively low grade with around 30 per cent available alumina.

More than 85 per cent of the bauxite mined globally is converted to alumina for the production of aluminium metal. An additional 10 per cent goes to non-metal uses in various forms of specialty alumina and the remainder is for non-metallurgical bauxite applications. In most commercial operations, alumina is extracted (refined) from bauxite by a wet chemical caustic leach process known as the Bayer process. Alumina is smelted using the Hall-Heroult process to produce aluminium metal by electrolytic reduction in a molten bath of natural or synthetic cryolite (NaAlF_6).

Australia's aluminium industry is a highly integrated sector comprising mining, refining, smelting and semi-fabrication centres and is of major economic importance nationally and globally. The industry consists of five bauxite mines, seven alumina refineries, six primary aluminium smelters, 12 extrusion mills and two rolled product (sheet, plate and foil) mills. The industry is geared to serve world demand for alumina and aluminium with more than 80 per cent of production exported. Figures on the value of industry exports are collated half-yearly by the ABS. The Australian Aluminium Council also compiles data on bauxite, alumina and aluminium exports, which it updates on a monthly basis.

Resources

The long-term future of Australia's aluminium industry is underpinned by vast resources of bauxite located in the Weipa (Qld) and Gove (NT) regions adjacent to the Gulf of Carpentaria, and in the Darling Range south of Perth (WA). Deposits in these regions rank among the world's largest

Mining face at Gove bauxite mine, Northern Territory (Geoscience Australia, Paul Kay).





Bauxite ore at Gove mine, Northern Territory (Geoscience Australia, Paul Kay).

identified resources in terms of extractable alumina content. The undeveloped bauxite deposits at Mitchell Plateau and Cape Bougainville in the north of WA currently are uneconomic to develop, but are a significant potential future resource.

In 2007 there was a slight increase in EDR to 6.2 Gt on the previous year, with some para-marginal resources being assessed as economic due largely to continued high prices. The nett change in overall Demonstrated Resources was minor because exploration drilling added to mineral resources and offset the depletion through mine production.

Accessible Economic Demonstrated Resources

About 95 per cent of bauxite EDR is accessible for mining. Some areas within mining leases in the Darling Range of Western Australia in particular are not available for extraction for environmental reasons. The ratio of AEDR to current mine production shows the resource life for existing bauxite operations is around 70 years. Significant potential exists for further mineral exploration and reserve delineation to extend the current resource life estimate.

JORC Reserves

Approximately 30 per cent of AEDR is JORC Code ore reserves as reported by industry. The remaining AEDR represents resources assessed by Geoscience Australia as being economically recoverable from measured and indicated categories of mineral resources, as defined under the Code and other classification systems used by companies not listed on the Australian Securities Exchange. In certain terrains, the surface expression of bauxite and confidence in lateral continuity of thickness and grade make it possible to classify some inferred resources as EDR.

Exploration

Data relating to exploration for bauxite specifically are not available nationally.

Production

Australia was the leading producer of bauxite and alumina globally in 2007, and the fifth largest aluminium producer, behind China, Russia, Canada and the United States. Production totalled 62.7 Mt of bauxite (33 per cent of world production), 18.5 Mt of alumina (23 per cent of world production) and 1.954 Mt of aluminium (5 per cent of world production). Production of bauxite at Weipa in Qld during 2007 was a record 17 Mt, 5 per cent higher than in 2006, mainly due to increased production from the Andoom mine north of Weipa. Further expansion of Weipa operations south of the Embley River are under consideration, including the potential construction of a new deepwater port. Bauxite production in WA also increased 5 per cent, from 39.3 Mt in 2006 to 41.4 Mt in 2007. Production of alumina in Australia also rose by 4 per cent during 2007. The increase from 17.8 Mt to 18.5 Mt reflected capacity expansion at Rio Tinto Alcan's Gove refinery in the NT, as well as increases at the Worsley refinery in WA.

World Resources

Based on USGS data for other countries, Australia's demonstrated bauxite resources of 7.9 Gt rank second in the world after Guinea and ahead of Brazil, Jamaica and China.

Industry Developments

The 2007 Sustainability Report on Australia's bauxite, alumina and aluminium industries was released by Australian Aluminium Council in mid-2008. The report, which was the fourth in a series, documents how the industry is using physical resources, the impacts of that use, how industry is managing outputs and how it is working to reduce the impact of production processes.

Companies engaged in Australia's bauxite-alumina-aluminium industry continued to respond to the needs of increased trade during 2007, with further expansion proposals under consideration. The trend of aluminium industry consolidation continued in 2007 with Rio Tinto finalising its merger with Canadian aluminium producer Alcan in October. This part of the organisation is now known as "Rio Tinto Alcan". Efforts by BHP Billiton since early 2007 to takeover Rio Tinto continued.

Looking to the future, alumina production levels in 2008 are not clear due to issues with WA's gas supply. A fire at the Varanus Island gas plant and consequent supply disruption led Alcoa to declare force majeure on its alumina contracts on 11 June 2008. An announcement is yet to be made on the impact to production.

Black Coal

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Black coal is a sedimentary organic rock consisting of anthracite, bituminous and sub-bituminous rank coals. In Australia, black coal deposits occur in all States and the Northern Territory and range in age from 140 to 225 million years old. Black coal is primarily used as a solid fuel to raise steam to generate electricity and to produce coke for the steel making process. By-products of coke-making include coal tar, ammonia, light oils and coal gas. Black coal is used also in cement manufacturing, food processing, paper manufacturing and alumina refineries.

In December 2007 there were 118 operating black coal mines in Australia which included 74 open-cut mines and 44 underground mines. The bulk of the mines were in New South Wales (62) and Queensland (49). Most of the coal was produced in New South Wales (41.3%) and Queensland (56.2%) with locally significant operations at Collie (WA), Leigh Creek (SA) and in the Fingal Valley (Tas).

Resources

Recoverable EDR in 2007 decreased 1.8% to 38.9 Gt due mainly to a significant decrease of Peabody Pacific's resources and reductions at Mt Arthur, Minerva and New Acland. However, these decreases were not offset by new resources at Carborough Downs, Ellensfield, Exevale, Eagle Downs, Rocklands, Nebo South, Narrabri and Sunnyside. The largest share of recoverable EDR in Australia



Haul trucks at the Hail Creek coal mine, Queensland (Rio Tinto Coal Australia).

was in Queensland (53%) and New South Wales (42%). The recoverable EDR of 38.9 Gt consists of 8.8 Gt of hard coking coal, 3.6 Gt of soft coking coal, 0.95 Gt of PCI/Thermal coal and 25.55 Gt of thermal coal.

In 2007 the recoverable PDR increased 6.7% to 2.2 Gt mainly due to Dartbrook. The recoverable SDR reduced 6.5% to 6.7 Gt mainly due to decreases at Dawson, Myuna and Bulga. The recoverable inferred resources increased 3.6% to 61.1 Gt. Large increases in inferred resources occurred at Curragh North, Minerva, Minyango, Eagle Downs and Rolleston. Inferred resources were included for the first time at North and South Alpha, Yamala, Rocklands and Narrabri. The recoverable inferred resources of 61.1 Gt consists of 12.2 Gt of hard coking coal, 1.0 Gt of soft coking coal, 0.15 Gt of PCI/Thermal coal and 47.75 Gt of thermal coal.

Accessible EDR

Almost all black coal EDR is accessible with only a relatively small tonnage at Hill River (WA) being quarantined within State Reserves. At current rates of production the resource life of the Accessible EDR of 38.8 Gt was about 95 years.

JORC Reserves

JORC reserves are 12.5 Gt or 30% of Accessible EDR and include estimates by Geoscience Australia of reserves at some operating mines which had no reported JORC reserves. This estimate constituted 2.3 Gt or about 18% of JORC reserves. BHP Billiton, Rio Tinto, Xstrata Coal, Peabody Pacific and Anglo Coal manage about 68% of JORC reserves in Australia. The resource life of the JORC reserves of 12.5 Gt is 30 years.

Exploration

Data published by ABS indicated that coal exploration expenditure for 2007 totalled \$192.6 million, a decrease from \$198.7 million in 2006. Expenditure in Queensland was \$118.8 million or 62% of the total while \$49.8 million was spent in New South Wales, representing 26% of the total. Exploration also occurred in South Australia, Western Australia, Tasmania and Victoria. In 2007 coal exploration expenditure accounted for 9.3% of the total mineral exploration expenditure in Australia.

Production

In 2007 Australia produced 416 Mt of raw coal (398 Mt in 2006) which yielded 322 Mt of saleable coal (302 Mt in 2006). ABARE has projected that Australia's saleable production will grow to 405 Mt by 2013. Exports of black coal during 2007 comprised 138 Mt of coking coal valued at \$13.9 billion and 112 Mt of steaming coal valued at \$6.8 billion. Exports of coking and thermal coals are projected to increase to 173 Mt and 168 Mt respectively by 2013.

World ranking

Australia has 6% of the world's recoverable black coal EDR and ranks sixth behind USA (31%), Russia (21%), China (13%), India (8%) and South Africa (7%).

Australia produced about 6% of the world's black coal in 2007 and ranked fourth after China (45%), the USA (18%) and India (8%).

Industry Developments

QUEENSLAND

Rio Tinto Coal Australia (RTCA): In December 2007 RTCA announced that US\$991 million would be spent on the Kestrel mine to extend its life to 2031 and increase production from 4 Mtpa to an average of 5.7 Mtpa. Subject to approvals, construction is due to begin in 2008 and the first coal is expected from the 375 m wide longwall in 2012. A 7 km overland conveyor will be constructed to the existing coal handling and preparation plant. Reserves from the current mine area are expected to be exhausted in 2014. Construction of the US\$750 million Clermont project commenced in March 2007 with production expected in 2010. The open-cut mine will produce 12.2 Mtpa of thermal coal over a planned 17 year mine life. A 15 km conveyor will connect the mine to the current infrastructure at Blair Athol where production is expected to wind down by 2011.

BHP Billiton Mitsubishi Alliance (BMA Coal): In April 2007 the new 14 Mtpa coal handling and preparation plant was commissioned at the Blackwater mine. Mining at the Crinum longwall mine was completed in late 2007. The roof supports were refurbished then installed at Crinum East for mining to begin in early 2008. At the Norwich Park mine the average waiting time for dozers at the draglines has been reduced by 20%. At the Broadmeadow mine, new 5 m cutting height equipment was installed into Longwall Block 3 in July 2007. The \$40 million project to extend longwall blocks from 200 m wide to 320 m is expected to commence in early 2008 in Longwall Block 4. Under the Energy Excellence Program, BMA Coal has reduced electricity consumption at the South Walker Creek mine by 630 MWh through more efficient working of dragline buckets.

Xstrata Coal: The two Oaky Creek open-cut mines closed in 2007. At Oaky No 1 only one longwall face will operate from 2008 with overall production decreasing to around 5.3 Mtpa. The Oaky North longwall should continue to produce around 5.1 Mtpa of run-of-mine (ROM) coal until at least 2027. The \$70 million Wollombi open-cut project was approved in October 2007. The mine will produce up to 2.5 Mtpa of ROM coal over 15 years. Xstrata is investigating the feasibility of a \$1 billion 20 Mtpa open-cut thermal coal mine at Wandoan. A decision on mine development is not expected until late 2009 and, if developed, the project is expected to have a 30 year mine life. A new rail connection will need to be constructed between Wandoan and the existing Moura-Gladstone rail line.

Anglo Coal: In July 2007 Anglo Coal announced a \$210 million longwall upgrade for the Moranbah North mine to ensure a 4 Mtpa production rate beyond 2009. A 40 MW mine methane power station is expected to be commissioned at Moranbah North in late 2008. The Dawson expansion project was completed in mid-2007 with a capacity of 12.5 Mtpa of saleable coal and including a 27 km southern overland conveyor. At the Lake Lindsay project a \$347 million 4 Mtpa coal handling and preparation plant was due for completion in early 2008. A 21 km long conveyor connects the mine to the infrastructure at German Creek. Anglo Coal began a detailed feasibility study of the Grosvenor project with the view of developing a 6 Mtpa longwall mine in late 2009. An overland conveyor would connect the mine to the Moranbah North infrastructure.

Macarthur Coal: At the Coppabella mine a new P&H4100 electric shovel and six Cat 240 t trucks were commissioned in January 2008. The equipment is expected to save Macarthur Coal about \$5 per product tonne from 2009. At Moorvale an expansion was completed in late 2007 with an additional 1 Mtpa of ROM capacity from Pit F and Pits C and D. The Olive Downs open-cut deposit will be developed later as a satellite mine of the Moorvale operation. At the Middlemount project a bulk sample open-cut began in 2007 with plans to produce 1.8 Mtpa of saleable coal by late 2009.

Wesfarmers: The \$360 million Curragh North project was completed in 2007 with the commissioning of a new coal handling plant and a 20 km conveyor to the Curragh washplant. Wesfarmers is undertaking a feasibility study on expanding the Curragh mine to between 8 and 8.5 Mtpa of metallurgical coal. The study is due to be completed in mid-2008 and if viable ramp-up could start in late 2009.

Felix Resources: A new excavator started operating at the Yarrabee mine in July 2007. Exploration at Yarrabee is continuing in order to increase the mine life beyond the current six years.

Peabody Australia: In 2007 the Millenium open-cut mine began ramping up production to a planned 3 Mtpa in 2010. At Wilkie Creek, a feasibility study is underway to increase production which would require upgrading the preparation plant and transport infrastructure.

Ensham Resources: The \$600 million Ensham Central Project is planned to increase production from 9 to 20 Mtpa. The project includes an extension to the life of the current open-cut by six years and an underground bord and pillar operation prior to the introduction of a longwall system capable of producing up to 8 Mtpa over an 11 year mine life. Ensham also is investigating the feasibility of dragline pull back and highwall mining.

Vale: At the Isaac Plains project development of the South deposit is planned for late 2008 subject to approvals. Production is expected to increase from 1.2 to 2.8 Mtpa. A BE1370 dragline is due to be relocated from the USA to Isaac Plains during 2008. At the Ellensfield project a 5.5 Mtpa ROM longwall is planned to commence in late 2009 with a mine life of at least 20 years. A pre-feasibility study is underway into the Belvedere project which is planned to produce up to 9 Mtpa of hard coking coal from two longwalls. The \$620 million Eagle Downs project is planned to produce 4 Mtpa of hard coking coal. A pre-feasibility study of this longwall project is due in mid-2008.

New Hope Corporation: The Jeebropilly operations closed in February 2007. The \$60 million New Acland Stage 2 expansion to 3.65 Mtpa was completed in March 2007. New Acland is to be supplied with recycled water via a 47 km pipeline from the Toowoomba City Councils Wetalla water reclamation facility. The New Saraji longwall project is planned to be a 5 Mtpa coking coal mine commencing in 2012. New Hope is investigating opportunities for coal-to-liquids technologies to be applied to New Acland coal. Detailed design engineering and processing testing started in 2007.

QCoal: The Sonoma project commenced production in late 2007 at an initial rate of 2 Mtpa with plans to expand to up to 7 Mtpa once the Abbott Point coal terminal expansion has been completed.

CSEnergy: The \$1.2 billion Kogan Creek power station and open-cut mine opened during 2007. The 2.8 Mtpa open-cut mine is connected to the 750 MW power station by a 4 km conveyor.

Tarong Energy: The Meandu mine will be operated from January 2008 by Tarong Energy until the new Kunioon mine is operational in 2011. The proposed 7 Mtpa Kunioon open-cut mine will be connected to Tarong's two power stations by a 16 km conveyor.

Caledon Resources plc: At the Cook Colliery a coal production rate of 1.5 Mtpa is expected for 2008 by the introduction of continuous bolter-miner equipment with a continuous haulage system. Caledon has a detailed mine plan for the next 10 years.

Lake Vermont Resources Pty Ltd: Construction of the \$176 million Lake Vermont project commenced in 2007. The open-cut mine is due to start production at a rate of 4 Mtpa of coking coal in 2008.

NEW SOUTH WALES

BHP Billiton: Development of a \$20 million adit commenced in 2007 in the Woodlands Hill seam at the Mt Arthur mine. About 5 km of roadway will be developed from an open-cut highwall to investigate underground geological conditions. The adit is expected to be completed in late 2008 and, if viable, longwall production is expected to commence in 2011 at a rate of 6 to 8 Mtpa. BHP Billiton also is planning to extend the southern pit at Mt Arthur by 2 km to expand production by 3 Mtpa. At the Appin Colliery, extraction of longwall block 409 has been approved while development of longwall panels continues in Area 7 at the Douglas mine.

Coal and Allied (CA) (75% Rio Tinto): At the Hunter Valley Operations South, which includes the Cheshunt, Riverview and Lemington pits, CA is seeking approval for a 21 year project life. At HVO South, CA plans to increase mining and processing capacity to 16 Mtpa and construct a new load out facility on the Wambo rail spur. At Bengalla, CA is planning to spend \$21 million to extend mining operations into the Wantana pit. CA is continuing feasibility studies to increase ROM production from 8.7 to 10.7 Mtpa. At the US\$600 million Mount Pleasant project a mine plan was completed during 2007 which consists of mining two pits at a rate of 10.5 Mtpa.

Xstrata Coal: The \$350 million South Blakefield project is planned to replace the Beltana operation at the Bulga complex. A new 400 m wide longwall will extract semi-soft coking coal from 2009. Approval has been granted for a \$91 million expansion at the Liddell open-cut mine from 4.5 to 8 Mtpa. The Cumnock open-cut mine is due to cease production in 2008. A third processing plant module currently under construction is expected to increase capacity from 10 to 15 Mtpa at Mt Owen to handle coal from the Glendell open-cut mine. The Glendell Environmental Assessment document was on display from August to October 2007. In late 2007 Xstrata purchased the Anvil Hill project and the Tahmoor Colliery from Centennial Coal for a total of \$1.1 billion. The Anvil Hill open-cut project was granted approval during 2007. The \$240 million project is expected to produce up to 10.5 Mtpa ROM from 2009 over a 20 year mine life.

Anglo Coal: Anglo plan to extend the mine life at the Drayton open-cut mine to 2017 and increase production from 5.5 to 8 Mtpa ROM. At Dartbrook a project team is assessing future options for the mine which currently is on care and maintenance. At the proposed Saddlers Creek project studies have been completed on a combined open-cut and underground mine.

Centennial Coal: At the Charbon mine, Centennial is investigating options to extend the mine's operating life. The new Angus Place longwall supports on a widened 280 m face are expected to commence operation in June 2008 at a rate of 3 Mtpa. At Springvale, a mine lease extension approval has increased reserves to 75 Mt. In late 2007 the Springvale longwall was successfully commissioned following a major overhaul. A Springvale optimisation plan is being undertaken to increase exports. At the Myuna mine production is expected to increase from 1.5 to 2 Mtpa with a new mining unit installed in the Wallarah seam. The Myuna mine currently operates within three seams to maximise production and product quality. The Mandalong mine is planned to expand to 4.4 Mtpa in 2008 and to 5 Mtpa in 2009. The Stage 1 Mandalong Export project feasibility study is due in late 2008 with construction expected to be completed in late 2009. The Stage 2 Mandalong export project involving a rail loop and washery is proposed to be completed in 2010. The Newstan and Mannering mines are both planned to be placed on care and maintenance in mid-2008. Feasibility studies have commenced into a reconfigured mine plan for Newstan. The Awaba mine is planned to close in early 2009 when reserves are exhausted. The new Awaba East longwall mine feasibility study is due to be completed in mid-2009 with operations commencing in 2012.

Peabody Pacific Pty Ltd: The \$101 million North Wambo longwall started production in September 2007 at a rate of 3 Mtpa. The \$123 million Wilpinjong open-cut mine commenced production in late 2006 and is expected to ramp up to 8 Mtpa by 2011.

Gloucester Coal: In February 2007 Gloucester Coal was granted approval to mine the Roseville West pit. A \$2 million secondary flotation plant was completed in October 2007 which is expected to increase yield by 2%. A \$30 million washery upgrade from 3.2 to 4 Mtpa is expected to be completed in late 2009.

Felix Resources: The 2 Mtpa Ashton underground longwall mine was commissioned in March 2007. The Ashton coal preparation plant was expanded with the addition of a second module in March 2007. In September 2007 Felix gained approval for Stage 1 of the \$220 million Moolarben project. Construction is expected to start in mid-2008 with commissioning due in late 2010. Felix is planning a 4 Mtpa underground longwall mine at Moolarben after the open-cut has reached full capacity. Felix expects to be producing about 10 Mtpa over a 25 year mine life.

Resource Pacific Holdings: The 4 Mtpa Newpac No 1 longwall commenced operation in January 2007. New development equipment was delivered in mid-2007 to reduce delays between longwall blocks.

Gujarat NRE Resources: Gujarat purchased the Elouera mine from BHP Billiton in late 2007 for \$49 million which will allow access to the Avondale NRE Colliery utilising the Elouera infrastructure. A mine plan is being prepared for a 1.5 Mtpa longwall to start operations in 2011. At the NRE No 1 Colliery, a \$1.5 million feasibility study is being undertaken into a 4 Mtpa multi-seam longwall operation to commence production in 2012.

Yancoal Australia Pty Ltd: The planned \$80 million Stage 3 Austar Longwall Top Coal Caving (LTCC) mine extension project proposes to start extracting coal in 2010 from an area east of the current operation.

Integra Coal Operations Pty Ltd: In 2007 a subsistence management plan was submitted for the Glennies Creek longwall to extract 12.5 Mt of coal from underneath Xstrata's Mount Owen and Ravensworth East mines.

Donaldson Coal Pty Ltd: The \$84 million Abel bord and pillar mine is planned to extract 4.5 Mtpa over a 21 year mine life starting in 2009. Coal will be transferred to the existing Bloomfield coal processing plant.

Whitehaven Coal Mining Ltd: Construction of the Narrabri North project began in early 2008. The \$140 million Stage 1 project consists of a 2.5 Mtpa continuous miner operation that is due to commence in mid-2009. The \$90 million Stage 2 project consists of a 7 Mtpa longwall that is planned to begin production in 2011. The \$15 million Sunnyside open-cut mine is expected to commence during 2008 at a production rate of 1 Mtpa. The proposed \$35 million Belmont open-cut is expected to start operations in late 2009 at a rate of 1.5 Mtpa.

Wyong Areas Coal Joint Venture (Kores Australia 82.25%): The \$550 million Wallarah 2 Coal Project is planned to produce 4 to 5 Mtpa of export quality thermal coal over a 40 year period. The initial development coal is expected to be produced in 2009 with longwall coal production in 2010.

WESTERN AUSTRALIA AND SOUTH AUSTRALIA

Hydrogen Energy International Ltd: In 2007 BP and Rio Tinto began a feasibility study into establishing a \$2 billion 500 MW clean coal power station at Kwinana in Western Australia. The plan is to gasify Collie coal to produce hydrogen and carbon dioxide. A development decision is due in 2011 with operations starting in 2014.

Aviva Corporation Ltd: Aviva plans to develop the \$1 billion 400 MW Coolimba base load power station 20 km south of Eneabba in Western Australia. The nearby Central West coal deposit is expected to provide 2 Mtpa over 30 to 40 years. The feasibility is due for completion in 2008 with start-up in 2012.

The Griffin Group: In Western Australia, The Griffin Group plans to spend \$240 million over the next three years on the development of the Ewington 1 and 2 coal mines and refurbishment and expansion of the charring plant and coal drying facilities.

Altona Resources plc: Altona is conducting a feasibility study into the development of an integrated 10 million barrels a year coal-to-liquids plant with a 560 MW cogeneration power station located near the Wintinna coal deposit in South Australia.

Flinders Power: At the Leigh Creek mine in South Australia, Flinders Power is investigating the feasibility of extending the life of the open-cut from 2017 to 2025.

INFRASTRUCTURE IN QUEENSLAND

Abbott Point Coal Terminal: The \$116 million Stage 2 expansion from 15 to 21 Mtpa was opened in November 2007. The \$770 million Stage 3 expansion to 50 Mtpa is dependent on the construction of the Northern Missing Link Rail Line.

Dalrymple Bay Coal Terminal: The \$590 million Phase 1 expansion from 60 to 68 Mtpa is due to be completed in March 2008. The \$640 million Phase 2 and Phase 3 expansions to 85 Mtpa are expected to be completed in 2009.

Hay Point Coal Terminal: The Phase 2 expansion from 40 to 44 Mtpa was completed in 2007. A \$500 million Phase 3 expansion to 55 Mtpa is planned.

Port of Gladstone: The \$700 million R.G. Tanna Coal Terminal expansion from 40 to 68 Mtpa was completed in 2007. Construction of the \$3 billion Wiggins Island Coal Terminal is expected to commence in 2009 with an initial capacity of 25 Mtpa and is due to come on line in 2012. The ultimate capacity is planned to be 84 Mtpa.

Port Alma: Xstrata and the Central Queensland Ports Authority are conducting a conceptual study into a \$1 billion 30 Mtpa coal terminal to facilitate the development of the Wandoan coal project.

Queensland Rail: Capacity is being increased from 175 to 255 Mtpa by 2011 through the expenditure of \$3.5 billion. The projects include:

- Northern Missing Link Rail Project: Construction of the \$769 million 69 km rail line between the Goonyella and Newlands rail systems is expected to commence in mid-2008 with completion due in 2010.
- Southern Missing Link Rail Project: The \$1 billion 207 km rail line between Wandoan and Theodore is planned to be completed in 2011.
- Jilalan Rail Yard Project: The \$250 million upgrade of the Goonyella rail system is expected to add a further 37 Mtpa in capacity from late 2009.

SunWater: The \$300 million 220 km pipeline delivering 17,000 Mega litres of water per annum from the Burdekin Falls Dam to Moranbah opened in August 2007.

INFRASTRUCTURE IN NEW SOUTH WALES

Port of Newcastle: The \$170 million expansion of the Koorangang Island Coal Terminal from 89 to 102 Mtpa was completed in 2007. A further \$78 million is being spent on increasing capacity to 120 Mtpa in 2009. In January 2008, construction began on the \$1 billion Newcastle Coal Infrastructure Group's (NCIG) Coal Terminal. An initial capacity of 30 Mtpa is due for completion in 2010.

Australian Rail and Track Corporation: The Hunter Valley rail network is planned to be expanded to 120 Mtpa by mid-2009 and 150 Mtpa by 2011 at a cost of \$207 million.

RESEARCH AND DEVELOPMENT IN QUEENSLAND

CSEnergy: The 120 MW Callide A power station is planned to be retrofitted with oxyfuel combustion technology. Construction of the \$200 million retrofit project is expected to begin in 2008 and be operational in mid-2009.

ZeroGen Pty Ltd: A 100 MW Integrated Gasification Combined Cycle demonstration plant is planned to be built at Stanwell, with a decision expected in mid-2009.

Western Australian State Government: \$300,000 is planned to be spent on a series of coal gasification trials on Collie coal.

Linc Energy: In 2007 construction began on a demonstration gas-to-liquids plant at the Chinchilla Underground Coal gasification project. The plant is expected to commence production in early 2008.

Carbon Energy: Approximately \$19 million is planned to be spent on an Underground Coal Gasification trial at Bloodwood Creek. The trial is expected to start in mid-2008.

Cougar Energy: In 2008 Cougar plans to trial Underground Coal Gasification near Kingaroy.

Anglo Coal: During 2007 Anglo Coal carried out trials using DRYSCAN technology at the Callide mine. The technology uses lasers to identify and reject the undesirable material from the coal feed and to minimise the need for water in the processing plant.

RESEARCH AND DEVELOPMENT IN NEW SOUTH WALES

Delta Electricity and CSIRO: A \$5 million post carbon capture pilot facility will be built at the Munmorah power station. The facility will use ammonia absorption technology and is expected to be in operation in mid-2008. The pilot facility will determine whether a larger \$150 million demonstration plant should proceed.

University of New South Wales and Coal Services Pty Ltd: Realistic virtual reality technology of underground and surface mining environments has been developed by the School of Mining Engineering. It is planned to use the technology to provide enhanced safety training.

Brown Coal

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Brown coal or lignite is a low rank, brownish-black coal which has a high moisture content of around 60%. In Australia brown coal deposits occur in all States and are Tertiary in age (15 to 50 million years old). Victoria has substantial deposits of brown coal, including the La Trobe Valley coalfield which contains some of the thickest seams in the world (up to 330 m thick). Brown coal is mined only in Victoria where it is used mainly in mine mouth power stations. Briquettes are produced by Energy Brix Australia for industrial and domestic heating and Australian Char Pty Ltd produces brown coal char. At Maddingley a brown coal fertiliser is produced for the domestic market.

Resources

Recoverable EDR for 2007 was 37.3 Gt, the same as 2006. Recoverable PDR and SDR remained unchanged at 39 Gt and 16.3 Gt respectively. Recoverable inferred resources also remained unchanged at 100.8 Gt. Victoria accounts for more than 96% of Australia's identified resources of brown coal. All EDR are located in Victoria and about 93% of the total EDR is in the La Trobe Valley.

Accessible EDR

Approximately 86% of brown coal EDR is accessible. Quarantined resources include the Holey Plains State Park and the APM Mill site which was subjected to a 50 year ban on mining in 1980. The resource life of the accessible EDR of 32.3 Gt is about 490 years.

JORC Reserves

No brown coal resources are JORC Code compliant. However, Geoscience Australia has estimated reserves at the operating mines from published information. Reserves are about 4.9 Gt with almost 38% being at Loy Yang. The resource life of published reserves is more than 70 years.

Exploration

Data relating to exploration for brown coal specifically are not available nationally.

Production

Australian brown coal production for 2006-07, all of which was from Victoria, was 65.6 Mt with a value of around \$820 million. The La Trobe Valley mines of Yallourn, Hazelwood and Loy Yang produce about 98% of Australia's brown coal. Locally significant brown coal operations also occur at Anglesea and Maddingley.

World Ranking

Australia has about 25% of world recoverable brown coal EDR and is ranked first. However, it produces only about 8% of the world's brown coal and is ranked the fifth largest producer after Germany (21%), USA (9%), Russia (9%), USA and Greece (8%).

Industry Developments

Asia Pacific Coal and Steel Pty Ltd (100% owned by Environmental Solutions International Ltd): In September 2007 a 60 day production trial was completed on the Coldry process at the Maddingley brown coal mine near Bacchus Marsh. The Coldry process is a low pressure technology which expels 95% of the water from brown coal to produce a dense high energy pellet. The pellet improves the thermal efficiency of brown coal and can reduce CO₂ emissions from current power stations by about 10%. The Coldry project has been supported with \$238,000 from the Victorian Government's Sustainability Fund.

The \$6.3 million Mechanical Thermal Expression (MTE) pilot plant at Long Yang commenced operation in November 2007 with testing expected to conclude in early 2008. The MTE process allows more than 70% of the water in brown coal to be removed with the potential to significantly reduce carbon dioxide (CO₂) emissions when the dry coal is burnt to generate electricity. The MTE project has been jointly funded by the Australian and Victorian Governments and five power generation companies. The MTE pilot plant project is the culmination of eight years of research undertaken by the Co-operative Research Centre for Clean Power from Lignite.

LaTrobe Lignite Developments Pty Ltd (LLD): LLD has Brown Coal Densification technology which removes water from brown coal to produce a low moisture coal, char and char-based products. LLD plans to develop a \$400 million 100 MW power plant in the LaTrobe Valley in 2010 and a 1000 MW plant by 2015.

HRL Ltd and Harbin Power Equipment Group Corporation: The two companies plan to develop a \$750 million 400 MW demonstration power plant based on HRL's Integrated Drying Gasification Combined Cycle technology (IDGCC). The project is expected to be operational in 2009. It is anticipated that it will result in CO₂ emissions being reduced by 30% and water consumption by 50% compared to current power generation technology. The Australian and Victorian Governments have committed \$100 million and \$50 million respectively to this demonstration project.

Monash Energy: Anglo America and the Shell Group have formed an alliance to develop a \$300 to \$400 million demonstration coal-to-liquids plant near the Loy Yang power station. Construction is expected to begin in 2008 with commissioning to occur in 2010. If viable, a \$5 billion, 25 Mtpa coal mine, drying and gasification plant, CO₂ capture and storage system and a Fischer-Tropsch gas to liquids plant producing 60,000 barrels per day will be constructed by 2016.

International Power plc: Under the Hazelwood 2030 project, International Power plans to spend \$370 million to develop low emission technology. In 2007 a 1500 t sample of brown coal was sent to Germany for coal drying tests. In late 2007 construction started on a demonstration plant using complex technology which can reduce water content from 60% to 12% that was developed by RWE in Germany. The coal drying demonstration phase includes a boiler efficiency upgrade to one of Hazelwood's 200 MW generating units to reduce CO₂ emissions by more than 20%. The Hazelwood 2030 project also involves the construction of a pilot carbon capture plant, which is scheduled for completion in late 2008. The project was awarded \$50 million by the Australian Government and \$30 million by the Victorian Government.

Spitfire Oil Ltd: At Salmon Gums about 100 km north of Esperance in Western Australia, Spitfire plans to develop an open-cut mine and brown coal-to-liquids processing plant to extract oil and distillate products, mainly for the Kalgoorlie district. The 3.5 Mtpa operation is planned to produce about 270 million litres of oil products per annum over an initial 10 year mine life.

Hybrid Energy Australia: Hybrid is conducting a two year feasibility study into a 150 to 300 MW power station fuelled by coal from the Kingston deposit located about 250 km south east of Adelaide in South Australia. The FuturGas Project plans to use coal gasification and carbon capture and storage technology to produce baseload electricity by 2015.

Coal Bed Methane

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Coal Bed Methane (CBM) is a naturally occurring methane gas that is formed during the coalification process in which organic matter is converted into coal. Usually the methane is mixed with carbon dioxide, other hydrocarbons and nitrogen. CBM also is referred to as Coal Seam Methane (CSM) and Coal Seam Gas (CSG). Methane which is produced or released as part of coal mining operations is called Coal Mine Methane (CMM)

CBM is similar to conventional natural gas and is used to power water heaters, stoves and space heaters, both domestically and commercially. CBM is used also as a fuel at industrial facilities and to generate electricity. Water is produced as a by-product of CBM production but its reuse is dependent on a number of factors including its quality, the cost of treatment required and pipeline infrastructure. Water of suitable quality can be used for domestic purposes, aquaculture, recharging aquifers, wetlands, recreational lakes or at mining operations and power stations. Poor quality water may be required to be contained in storage ponds.

Resources

As at December 2007 the proven and probable (2P) reserves of CBM in Australia were 7,500 Petajoules (PJ), a 61% increase on the 2006 2P reserves of 4,640 PJ. The life of the resource is more than 65 years at the current extraction rate of 110 PJ. Queensland has 7,050 PJ (or 94%) of the 2P reserves with the remaining 450 PJ in New South Wales. Note that there are no CMM reserves.

Exploration expenditure

Data relating to exploration expenditure are not published by the ABS on either a State or National basis. During 2006-07 CBM exploration in Queensland continued at record levels with 392 CBM wells drilled compared to 171 conventional oil and gas wells. Exploration in Queensland continues to concentrate on the Bowen and Surat Basins while in New South Wales exploration continues in the Sydney, Gunnedah and Clarence-Moreton Basins and all have 2P reserves. Other prospective basins include the Gloucester, Galilee, Murray, Perth, Ipswich, Maryborough and Otway Basins.

Production

Production of CBM in Australia has increased rapidly over the last decade. In 2003, production was only 20 PJ, however by 2006 CBM production had risen to 75 PJ and increased by a further 46% in 2007 to 110 PJ. During 2007, Queensland produced 105 PJ or 95% with the remaining 5% being produced in New South Wales. CBM production was 48% of the total Queensland gas production during 2007. According to the independent industry commentator, Wood Mackenzie, CBM could provide up to 50% of the Australian east coast gas supply by 2020. Note that CMM is not counted in CBM production statistics.

Industry developments

QUEENSLAND

Queensland CBM and CMM developments include:

Energy Developments Ltd: A \$60 million 40 MW CMM power plant is currently under construction at the Moranbah North Colliery. Commissioning is expected in 2008.

Arrow Energy: In February 2007 the Tipton West CBM operation started supplying about 6 Petajoules per annum (PJ/a) to the Braemar Power Station. In April 2007 Arrow signed an agreement with Liquegas Energy to supply 2 PJ/a over 15 years from the Daadine field for use in a proposed mini-LNG plant at the field commencing in 2009. The LNG is to be used by long haul trucks. In May 2007, Arrow announced plans to supply 55 PJ/a of CBM to an LNG plant at Gladstone with an initial capacity of 1 Mtpa in late 2010. Arrow and ERM plan to jointly develop the \$545 million 450 MW Braemar 2 power station 40 km south west of Dalby.

Origin Energy: In April 2007 Origin announced plans to invest \$53 million to expand CBM production at Spring Gully by another 20 TerraJoules/day as well as construct a reverse osmosis water plant. Origin is committed to a \$780 million 630 MW gas fired power station on the Darling Downs using CBM from Spring Gully. Commissioning is expected in late 2009.

Santos Ltd: Santos announced in July 2007 a proposal to build a \$5 to \$7 billion LNG project at Gladstone with a capacity of 3 to 4 Mtpa. First shipments are expected in 2014.

Queensland Gas Company: In October 2007 construction started on a 135 MW power station at Condamine. In July 2007 the Argyle-Kenya CBM field in the Surat Basin commenced supplying Incitec Pivot at a rate of 7.4 PJ/a. In February 2008 Queensland Gas and the BG Group announced a commitment to a long term alliance for the development of an \$8 billion LNG plant at Gladstone with a capacity of 3 to 4 Mtpa over 20 years from 2013.

Sunshine Gas: In August 2007 the Lacerta CBM field in the Bowen Basin was declared commercial. In December 2007 Sunshine Gas signed a Heads of Agreement with Sojitz Corporation to build a 500,000 tpa LNG plant at Gladstone using Lacerta CBM as a feedstock. First production is expected in 2012.

NEW SOUTH WALES

New South Wales CBM and CMM developments include:

Metgasco Ltd: Metgasco plans to build a 30 MW power station at Casino fuelled by 2.5 PJ/a of CBM over 15 years. Metgasco also plans to provide CS Energy's Swanbank Power Station in Ipswich with 18 PJ/a of CBM. In December 2007 Metgasco signed a memorandum of understanding with BP to supply over 15 PJ/a of CBM to the Bulwer Island oil refinery.

Sydney Gas: In 2006-07 two new compressors were installed at the Rosalind Park Gas Plant increasing the capacity to 26 TerraJoules/day.

Eastern Star Gas: In March 2007 Eastern Star announced an investigation into supplying up to 500 PJ of CBM to the Bayswater Power Station from the Gunnedah Basin project. In November 2007 Eastern Star signed a memorandum of understanding to supply 40 PJ/a of CBM to Babcock and Brown's proposed power station in northern New South Wales.

Envirogen Pty Ltd: In 2007 the Glennies Creek CMM operation commenced, supplying gas to a 10 MW power station.

BHP Billiton: In 2007 the 5 MW \$30 million West Cliff Ventilation Air Methane Project was commissioned. The plant burns waste coal mine gas using VOCSIDIZER technology.

Coal to Liquids

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The production of liquids from coal requires the breakdown of the chemical structures present in coal through the simultaneous elimination of oxygen, nitrogen and sulphur and the introduction of hydrogen. This action produces a stable liquid product. Coal can be converted into a variety of products including petrol, diesel, jet fuel, plastics, gas, ammonia, synthetic rubber, naphtha, tars, alcohols and methanol. There has been extensive research into converting coal to a liquid, but there are basically three approaches, pyrolysis (direct method), hydrogenation (direct method) and gasification and synthesis (indirect method).

Coal to liquids (CTL) technology was developed in the early 20th century and was used in Germany in the 1930's and 1940's. Since 1955 in South Africa, the SASOL company has operated the only CTL plant in the world to date. However, the Senhua Group expect a CTL plant to start in late 2008 at Ordos in China. In Australia from 1955 to 1969, a Lurgi gasification plant produced gas for the Melbourne market from briquetted Yallourn brown coal. From 1985 to 1990 a Japanese consortium operated a CTL pilot plant at Morwell which demonstrated that hydrogenation of La Trobe Valley brown coal was technically feasible.

Underground Coal Gasification: Syngas can also be produced by underground or in-situ coal gasification. In this method fuel gases are produced underground when a coal seam gets enough air to burn but insufficient for all consumable products to be consumed. Carbon dioxide, carbon monoxide, hydrogen and methane are produced to yield a gas of low but variable heat content. Air is pumped into the burning coal bed through a well, and the gas is drawn off from a point behind the fire-front through another well. A problem is the collapse of the coal bed and subsidence on the surface. The gasified coal can then be used to produce liquids or electricity. The power station at Angren in Uzbekistan has the only operating underground coal gasification project in the world.

Resources

In 2007 no CTL projects in Australia were considered economic given that there is only one operating project in the world and all those in Australia are in the demonstration phase of development. Since CTL technology is well established, the CTL resource of 16,300 million barrels is considered paramarginal or PDR. Resources from operating coal mines were not included in CTL resources because the coal resources already have uses in other markets. If CTL projects ever become viable in Australia the resource life at current rates of oil consumption is about 50 years. At present the location of coal that has been considered suitable and available for CTL conversion includes coals from the Surat, Clarence-Moreton, Oaklands and Gippsland Basins.

Industry Developments

Monash Energy: In the La Trobe Valley (Vic.) construction of a \$300 to \$400 million brown coal to liquids demonstration plant is expected to commence in 2008 with commissioning in 2010. If viable a \$5 billion 60,000 barrels per day CTL operation is planned to be built by 2016.

New Hope Corporation: New Hope is considering constructing a CTL pilot plant near the New Acland mine (Qld) which would process some 185,000 tpa of coal into 75 million litres of fuel.

Altona Resources plc: A feasibility study is being conducted into a 10 million barrels a year CTL plant located near the Wintinna coal deposit in South Australia.

Spitfire Oil Ltd: A 270 million litres per annum brown coal to liquids plant is proposed to be located at Salmon Gums in Western Australia.

Linc Energy: In 2007 construction commenced on a demonstration gas to liquids plant at the Chinchilla underground coal gasification project in Queensland. It is expected to start production in 2008.

Copper

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Australia is a major copper producer with mining and smelting operations at Olympic Dam (SA) and Mt Isa (Qld). Other significant copper producing operations are at Northparkes, Cadia Ridgeway and Tritton in New South Wales, Ernest Henry, Osborne, and Mt Gordon in Queensland, Nifty and Golden Grove in Western Australia and Mt Lyell in Tasmania. Copper and copper alloys are used in building construction and electrical equipment such as electrical cables as well as in industrial machinery and equipment.

Resources

Australia's total Demonstrated resources of copper rose by 18.0 Mt in 2007. The increase occurred almost wholly in South Australia.

Australia's economic demonstrated resources (EDR) of copper rose by 17.0 Mt to 59.4 Mt, an increase of 40% for the year. South Australia has the largest EDR at 43 Mt, which increased by 63% in 2007 to be around 72% of the national total. Almost all of these resources are associated with the Olympic Dam deposit where, with the release of new data in 2007, EDR rose by 16.6 Mt to 41.8 Mt. Queensland has the second largest EDR with 12% of the national total, followed by New South Wales (7%) and Western Australia (6%).

Subeconomic demonstrated resources increased by 13% to 8.5 Mt, made up of 6.9 Mt in the paramarginal category and 1.6 Mt in the submarginal category. Most of the paramarginal demonstrated resources are in Queensland, Western Australia and New South Wales with 45%, 18% and 12% respectively. A range of deposits are being evaluated in all three States, including the Blackard and Little Eva deposits (Roseby project), and Mt Dore deposit in the Mt Isa region of Queensland, the Maroochydore deposit in Western Australia, and the Copper Hill and Woodlawn deposits in New South Wales.

Inferred Resources rose by 11% to 38.5 Mt in 2007. South Australia holds 70% of Australia's Inferred Resources (mostly at Olympic Dam) followed by Queensland 13%, Western Australia 8% and New South Wales 6%.

Accessible EDR

All copper EDR is accessible.

JORC Reserves

JORC Code reserves account for around 31% of AEDR. The remaining AEDR comprise those measured and indicated resources reported by mining companies which Geoscience Australia considers will be economic over the long term.

Exploration

Spending on exploration for copper rose by 49% in 2007 to \$263.7 million. Expenditure in South Australia of \$118 million was 45% of all copper exploration and the main areas of expenditure were the south eastern part of the Olympic Dam deposit and the search for further Olympic Dam style mineralisation in the Gawler Craton. Queensland had 29% of spending on copper exploration across a range of projects and Western Australia had 13%, with the remainder largely in New South Wales with 11% and to a lesser extent in the Northern Territory with 2%. Expenditure on exploration for copper made up 13% of all mineral exploration.

Production

In 2007, Australia's mine production of copper totalled 871 kt of contained copper, similar to that in 2006 (875 kt). Queensland continued to dominate production with 376 kt, largely from Mt Isa, which was 7% more than in 2006 and represented 43% of Australian production, up from 40% in 2006. South Australia regained the second largest producer position over New South Wales despite a decrease of 3% to 179 kt. Olympic Dam produced all of South Australia's output, contributing 21% of national production. New South Wales produced 168 kt in 2007, 19% less than in 2006 and mostly from Cadia Ridgeway and Northparkes. Western Australia produced 118 kt, up 14%, and Tasmania produced 30 kt, down 3%.

The value of Australia's exports of copper concentrates and refined copper in 2007 totalled just under \$6.4 billion which was only slightly down on the \$6.6 billion in 2006 and steady at 4% of the value of total merchandise exports. Copper prices levelled off in 2007 after three years of substantial rises, with the average down 5% to \$8,512/t compared to the average of \$9,003/t in 2006. Exports in 2007 decreased 2% to 707 kt in line with the slightly decreased copper production.

World Ranking

Based on USGS data for other countries, Australia has the second largest EDR of copper (12%) after Chile (30%) and ahead of the USA and Indonesia (both 7%) and Peru, Poland and Mexico (all 6%). As a producer, Australia ranks fifth in the world with 6% after Chile (37%), Peru and the USA (both 8%) and China (6%).

Industry Developments

Olympic Dam (SA): Production for 2007 totalled 179 kt of copper cathode. This was 3% less than in 2006 and 17% below the plant capacity of 215 ktpa. Lower production was due to a scheduled smelter shut down, lower head grades and fewer tonnes milled. BHP Billiton continued with a pre-feasibility study to examine capacity expansion options with open-pit being the preferred mining method. The project would more than double copper production with Olympic Dam becoming one of the world's largest mines. This will require major infrastructure for water, energy, transport and a township expansion. The scheduled timeframe for the project is conclusion of the feasibility study by early 2009 and construction from 2009 to 2013, resulting in operation of the expanded facilities from 2013 onwards. Additional drilling (542 surface and underground drill holes for 240,000 m) has provided significantly more information to assist in geological interpretation. BHP Billiton reported a 77% tonnage increase and 38% copper metal increase in the Olympic Dam resource base over the year ended 30 June 2007. Major factors contributing to the increase in resource tonnage were a lower cut-off grade to reflect open-cut mining, higher long-term metal price forecasts and modelling changes. A non-sulphide gold only ore type mineral resource was reported separately for the first time.

Mt Isa and Ernest Henry (Qld): Copper-in-concentrate production in 2007 from Xstrata Plc's Mt Isa and Ernest Henry operations totalled 268 kt, a decrease of 3% on 2006. Lower head grades at Mount Isa reduced production by 9% compared to 2006, but was largely offset by higher tonnages mined and improved head grades at Ernest Henry where production increased by 14% year-on-year. Smelter production of 218 kt copper was 2% higher than in 2006 and the Townsville refinery saw production increase by 11% to 232 kt compared to 2006. A series of projects to increase capacity at the refinery to 300 ktpa were completed in October 2007. The expanded refinery capacity enabled anode from Xstrata Copper's Altonorte metallurgical facility in Chile to be refined at Townsville during the fourth quarter. A concurrent expansion of the Mt Isa smelter to 300 ktpa was largely completed in 2007. This is designed to match the total copper-in-concentrate production from the Mt Isa and Ernest Henry copper mines.

In 2007, pre-feasibility studies progressed on underground bulk mining options for both Mount Isa and Ernest Henry mines with the aim to progressively increase the Mount Isa hoisting and milling rates to 7 Mtpa and to extend the mine life at both sites. The study included drilling that confirmed extensions to the Ernest Henry ore body for at least another 400 m below the final stages of the open pit. Xstrata will now spend \$26 million on the first stage of an underground decline at Ernest Henry which is expected to be completed in 2009. The 3.2 km decline will be part of conversion of the mine to an underground operation and facilitate further evaluation as the decline is being developed. At Mount Isa, pre-feasibility drilling on the 500 ore body enabled a significant upgrade of 25 Mt of resource to an indicated status from an inferred category. The study into underground bulk mining options is expected to be completed by the end of 2008 with a full scale feasibility study planned for 2009.

Prominent Hill (SA): This new copper-gold mine is on schedule to be producing in the third quarter of 2008. Construction was almost 50% complete by the end of 2007. Pre-stripping of the 100 m of sedimentary cover had exposed the ore body and mining and stockpiling of ore was underway. In the first full year of operation, 2009, Prominent Hill is expected to produce almost 120 kt of copper and 80,000 oz of gold in concentrates. The capital cost of the project increased by around 30% to \$1,080 million due to a combination of scope changes to improve the process plant and infrastructure, tight construction market conditions and cost increases in materials and equipment. Oxiana reported the discovery of further copper and gold resources both deeper and laterally to the present ore body. Consequently Oxiana is considering expanding throughput and extending the mine's life beyond the current 10-year pit. Work has commenced on studies of underground mining and expansion which could see mine life extended to 2030.

Nifty (WA): Ramp up of the underground Nifty sulphide project was completed in mid 2007 following commissioning in March 2006. Aditya Birla Minerals reported 53 kt of copper-in-concentrate was produced in 2007. The current expected mine life is 12 years at an average production rate of 60 ktpa from a reserve of 22 Mt at 2.5% Cu contained within a total resource of 43.5 Mt at 2.4% Cu.

The Nifty oxide open pit ceased operations in mid 2006. The oxide operations from flushing existing heaps produced 5 kt of copper cathode during 2007, down from 15 kt in 2006. Consolidation and impermeable layers are reducing percolation, so a project for retreatment of the heaps by re-mining, desliming and restacking was approved. Costing \$25 million for material handling equipment and a desliming plant, it is expected to be commissioned by mid 2009. The total material to be retreated is 15 Mt at 0.5% Cu over 7 years for 40 kt of available contained copper.

Northparkes (NSW): Production for 2007 was 43 kt of contained copper, down from 83 kt in 2006. Rio Tinto Ltd reported production was constrained by premature shutdown of the E26 Lift 2 due to the ingress of clay at the underground drawpoints. Ore was and will continue to be sourced from stockpiles, the E22 open pit and the Lift 2 North block cave, until production commences from the E48 block cave in 2009. The E48 block cave project will cost around \$200 million and extend mine life until 2016. Current reserves for Northparkes are just under 48 Mt at 1% Cu and 0.4g/t Au.

Roseby (Qld): The Roseby copper project consists of more than 10 deposits in a 25 km north-south corridor that includes the Blackard, Scanlan, Little Eva, Lady Clayre and Bedford deposits. Universal Resources Ltd announced a new feasibility study had resolved previous issues associated with the Roseby project. Phasing in of the development is expected to substantially reduce the upfront capital cost on the basis of an initial 4 Mtpa throughput producing around 20 ktpa of copper-in-concentrates. A decision to expand the operation to around 8 Mtpa, producing around 40 ktpa of copper-in-concentrates is likely to be taken about 12 months after commissioning the first phase with completion in a further 2 years. If no expansion occurs, the Phase 1 operation is expected to have a mine life of 13 years from reserves of 51 Mt at 0.69% Cu and 0.05g/t Au.

Mt Gordon (Qld): Production for 2007 was 24 kt of contained copper, which was similar to 2006. Aditya Birla Minerals Ltd announced its intention to embark on Phase 1 mining in mid-2008 at the Esperanza South deposit. The Esperanza South resource is estimated at a total of 3.3 Mt grading 2.6% Cu. The development of the Esperanza South Project increases the production rate at the Mt Gordon operation, extends the life of the mine to mid-2011 and provides the foundation for further extension of mine life.

Lady Annie (Qld): CopperCo Ltd officially opened operations at the Lady Annie copper project in October 2007. Production started at a rate of 19 ktpa and is expected to be ramped up to 25 ktpa by mid 2008 with 30 ktpa targeted thereafter. Copper cathode will be sold to Glencore International AG under an off-take agreement for the life of mine production, which is estimated at nine years. The project consists of open pit mining from several deposits including Mt Clarke, Lady Annie, Flying Horse, Mt Kelly Workings, Swagman and Lady Brenda. CopperCo has invested more than \$100 million in the Lady Annie Project which has a resource inventory of 40 Mt at 0.9% Cu for 359 kt of contained copper.

Browns (NT): Compass Resources reported significant cost increases in the development of Browns base metals oxide project. Recent estimates for the project were over \$100 million. The operation is undergoing commissioning in 2008 and is expected to produce about 10 kt copper cathode, 1 kt cobalt and 750 t nickel annually from the 10-year, 1 Mtpa project. Compass said the cost-estimate increase resulted largely from additional works and extended construction time, but greater competition for equipment and construction personnel also had affected costs.

Leichhardt (Qld): In April 2007, Matrix Metals Ltd commenced mining copper oxide ore from the Mt Watson open pit for processing 30 km south at its refurbished Mt Cuthbert plant using heap leach and solvent extraction electrowinning to produce copper cathode. Glencore International AG has an agreement to buy 100% of the cathode over the life of mine. The ramp up for Stage 1 of the project to 5.5 ktpa of copper cathode was completed on schedule in October 2007. In December 2007, Matrix Metals committed to a further scale-up of production to 9 ktpa copper cathode at an estimated cost of \$5.5m by increasing plant throughput from 700 ktpa to 1 Mtpa from an oxide resource of around 8 Mt at 1% Cu.

Kanmantoo (SA): In December 2007, Hillgrove Resources Ltd released a definitive feasibility study for the Kanmantoo copper gold project and announced its decision to proceed with development.

The deposit has an 11 Mt probable ore reserve within a mineral resource of 31.8 Mt at 0.9% Cu and 0.2 g/t Au. From a pre-production capital expenditure of \$130 million the open pit mine is expected to process 2 Mtpa to produce up to 19 kt of copper-in-concentrate and 6,000 oz gold annually for an initial minimum mine life of 6.5 years.

Eloise (Qld): Breakaway Resources Ltd reported a new resource named Eloise Deeps of 2.1 Mt at 2.9% Cu and 0.7 g/t Au. Mine improvements in 2007 included the development of a decline to the upper portion of the Eloise Deeps block and a new \$13 million ventilation rise and associated infrastructure to allow mining to continue to at least 400 m vertically below the current stoping levels.

Redbank (NT): Redbank Mines Ltd reported a 20% increase in resource to a new project total of 5 Mt at 1.4% Cu. Redbank currently is vat-leaching high grade oxide stockpiles to produce 1 ktpa Cu. A definitive feasibility study into expanding to a 6 ktpa operation is underway.

Diamond

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Diamond is composed of carbon and is the hardest known natural substance although it can be shattered with a sharp blow. It also has the highest thermal conductivity of any known material at room temperature. Diamonds form 150–200 km below the Earth's surface at high temperatures (1,050°C–1,200°C) and pressures (45–55 kilobars). They are carried to the surface within kimberlite and lamproites which intrude through the earth's crust. These intrusions form narrow cylindrical bodies called pipes and only a very small proportion has significant diamond content. When pipes are eroded liberated diamonds can accumulate in alluvial deposits and may be found far from their source as their hardness allows them to survive multiple episodes of erosion and deposition. The quality of diamonds is subdivided into gem, near gem and industrial categories. In rare cases up to 90% of diamonds in a deposit are of gem quality, but most economic deposits contain 20% to 40% gem quality diamonds. Current uses for diamond include jewellery, mining and exploration, stone cutting and polishing, computer chip manufacture, machinery manufacture, construction and transportation services. A large proportion of industrial diamond is manufactured and it is possible to produce synthetic diamonds of gem quality.

Resources

EDR for gem/near gem was 97.3 Mc and industrial 101.3 Mc, both down 11% compared with 2006 due to production at the Argyle mine in WA.

Accessible EDR

All diamond EDR is accessible for mining.

JORC Reserves

JORC Code reserves account for almost all AEDR. The remaining AEDR comprise those measured and indicated resources reported by mining companies, which Geoscience Australia has assessed as being economic in the long term.

Exploration

ABS data indicate that expenditure on exploration for diamond in Australia in 2007 was \$18 million, down 34% on 2006. Exploration continues to be concentrated in WA, notably the Kimberley region, and in the NT.

Production

Australia produced 19.2 Mc of diamond in 2007, 10.1 Mc less than in 2006. Australia ranks as the world's fourth largest producer of diamond by weight after Russia, Botswana and Congo. As a producer of gem/near gem diamond, Australia is the fourth largest after Russia, Botswana and Canada, and is the third largest producer of industrial grade diamond after Congo and Russia.

Production was almost entirely from Rio Tinto Ltd's Argyle mine, which produced 18.7 Mc making it the leading global producer. Argyle production is mostly industrial and cheap diamonds with an average price of US\$15-16 per c. Due to lower grades; production was 36% less than in 2006 despite a 2% increase in the volume of ore treated. Production is expected to remain at about 60% of Argyle's historical annual average of 34 Mc as the open pit winds down and underground production ramps up.

Production from the Ellendale mine in the West Kimberley region increased to 475,735 c in 2007, up from 213,000 c in the previous year. The average grade was around 8c per hundred tonnes. The average sale price for 2007 was over US\$135 per c ranging up to US\$216 per c for parcels tendered late in the year. Ellendale is noted for high-value fancy yellow gem diamonds.

World Ranking

Australia's EDR of industrial diamond ranks third with 17% of current world total EDR after the Democratic Republic of the Congo (Kinshasa) with 25% and Botswana with 22%. Detailed data are not available on world resources of gem/near gem diamond, but Australian stocks are among the largest for this category.

Industry Developments

Argyle (WA): Rio Tinto Ltd approved the development of an underground block cave mine under the AK1 open pit in late 2005. It also approved an open pit cutback on the Northern Bowl to facilitate the transition from open pit to underground mining. The underground operations are expected to extend the life of the mine to about 2018. The cost estimate for the project has been revised to US\$1.5 billion, up from US\$910 million, due to cost increases in the Australian mining and construction industry and challenging ground conditions. The underground development consisting of 34 km of tunnels and excavations was 40% complete by the end of 2007. Construction of the major underground infrastructure commenced in February 2008. Production from Argyle's AK1 open pit mine is to continue through 2008 with initial underground production expected in 2009 when the mine will transition to an underground operation. Full production from the underground operation is on schedule to be achieved by December 2010.

Ellendale (WA): In November 2007, London-based resource firm Gem Diamonds Ltd acquired a controlling interest in Kimberley Diamond Company, the Australian company which developed and owned the Ellendale Mine. The total cost of the takeover was US\$249 million cash. Gem Diamonds reported that what had been a marginal operation and a loss-making business is being turned to profit through access to capital to progress modifications to the processing plants and to optimise sales processes. The company expects the mine will process 8.5 Mt to produce almost 600,000 c in 2008 with improved sales techniques to capture downstream margins. Further increases to the design capacity are underway and in 2009, Ellendale is expected to process 10.5 Mt.

Merlin (NT): North Australian Diamonds Ltd is evaluating a potential mining project which could produce 400,000 c per year based on the higher grade central and southern pipe clusters. To confirm resources to underpin this 10 year plus operation, the company is undertaking a drilling program to increase the known resource by around 30% to 15 Mt containing approximately 5 Mc.

Gold

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Very strong gold prices throughout 2007 supported substantial growth in exploration spending. Production remained virtually unchanged in 2007 but is expected to increase slightly in 2008.

Exploration continued to generate a large number of intersections of economic significance justifying further work. The announcement of an initial resource estimate of 4 million ounces (Mozs) for the Tropicana project in Western Australia was a highlight for the year.

Gold has a range of uses but the two principal applications are as an investment instrument and in the manufacture of jewellery. Secondary uses in terms of the amount of gold consumed are in electronic and dental applications.

Resources

Australia's gold resources occur and are mined in all States and the Northern Territory. At the end of 2007, total Australian gold resources were 212 t higher than at the end of 2006. After allowing for the replacement of those resources lost to production (245 t) newly delineated resources added to the national inventory totalled 458 t (14.7 Mozs) in 2007.

Australia's EDR rose by 358 t (11.5 Mozs) in 2007 to 5839 t and accounted for 81% of total demonstrated resources, a similar proportion to 2006. In 2007, EDR increased in New South Wales, Tasmania and South Australia. Western Australia, with 2850 t, continued to dominate EDR with 49% of the national total compared to 54% in 2006. Western Australia's reduced share was caused by the combined impact of lower total EDR in the State and increased EDR in South Australia.

Subeconomic demonstrated resources rose by 17 t in 2007 with increases in both paramarginal demonstrated resources and submarginal demonstrated resources. Resources in the paramarginal category rose by 7 t to 1272 t with 72% of total paramarginal resources occurring in Western Australia. The submarginal demonstrated resources rose by 10 t to 138 t, just under half of which was in Western Australia.

Inferred resources fell by 163 t to 4336 t. Western Australia (43%) and South Australia (26%) dominate inferred resources.

Accessible EDR

EDR for gold are essentially unencumbered (less than 1% is in any form of restricted area). At Australia's 2007 rate of production, EDR is sufficient for about 24 years. If, however, resources classified only as reserves under the JORC Code are considered, they will support only 13 years at the 2007 production rate. This is slightly lower than the 2006 reserve:production ratio. These are average figures and there are some operations which may continue after these periods and there are others that will close before the end of those periods. These figures continue to highlight the need for ongoing successful exploration in both the short and medium terms.

JORC Reserves

EDR is the sum of the JORC Code reserves categories plus those resources from the measured and indicated resource categories assessed by Geoscience Australia as likely to be economic. In 2007, just under 56% of EDR fell into the JORC reserves.

Exploration

On the basis of calendar year exploration spending reported by ABS, gold remained the dominant single commodity target in 2007 but its share of total spending fell sharply again from 29% in 2006 to 24% in 2007 as spending on base metals, iron ore and uranium grew strongly. This fall occurred despite a 17% increase in exploration expenditure to \$502.9 million. Western Australia continued to dominate gold exploration by attracting \$296.3 million (\$36.6 million more than in 2006). However, its share of total gold exploration fell slightly to 59%. All other regions, except the Australian Capital Territory, had gold exploration during the year and encouraging results were reported from them.

It should be noted that ABS data reported above will not include exploration for copper-gold mineralisation where the explorer nominates copper as the principal commodity. Such expenditure will be reported as exploration for copper.

On a financial year basis, the ABS reported gold exploration spending for 2006-07 was \$455.8 million, an increase of \$56.1 million over 2005-06.

Data published by the Canadian company Metals Economics Group (MEG) on company exploration budgets for non-ferrous minerals indicates that intended budgets for gold exploration in Australia for 2007 totalled US\$460.5 million (A\$569 million based on the exchange rate used by MEG). This budget was about 12% higher than actual spending reported by the ABS. The differences between reported budgets and actual spending on gold exploration may in part have been caused by the rapid increase in base metals exploration resulting in gold budgets being reduced as additional funds were directed to base metals.

The MEG data show that 47% of gold exploration budgets were expected to be directed at grassroots exploration compared to 33% in 2006 which suggests there may be a trend toward earlier stage gold exploration. The shares of both minesite and late stage gold exploration budgets reported by MEG fell in 2007 to 23% for minesite exploration (33% in 2006) and 30% for late stage exploration (34% in 2006).

New gold resources were reported for many deposits across the country. The more substantial included:

- The announcement of an initial resource at the Tropicana project (AngloGold Ashanti 70% and manager, and Independence Group 30%). An open-cut resource of 62.8 Mt @ 2.0g/t Au for 4.05 Mozs of gold was reported for the Tropicana-Havana mineralisation. This resource occurs at the junction of the Yilgarn Craton and the Fraser Range Mobile Belt in Western Australia and may represent the first deposit in a new gold province.
- BHP Billiton Pty Ltd reported a 77% increase in resource tonnage at its Olympic Dam deposit in the Gawler Craton, South Australia. Ongoing drilling and geological interpretation allowed a resource estimate to be prepared which put total resources in the deposit at 7738 Mt @ 0.87% Cu, 0.29kg/t U₃O₈, 0.30g/t Au and 1.61g/t Ag and a separate gold only resource of 117 Mt @ 1.19g/t Au. Included in the resource is a combined proved and probable reserve estimated by the company at 399 Mt @ 1.87% Cu, 0.58kg/t U₃O₈, 0.68g/t Au and 4.0g/t Ag.

New gold mineralisation was found across the continent and at depth below known deposits in a variety of mineralisation styles. The Archaean greenstones of Western Australia's Yilgarn Craton remain a very favourable target but substantial opportunities exist in other provinces. A major review of the highlights of gold exploration in Australia in 2007 is available in the document "*Australian Mineral Exploration: A Review of Exploration for the Year 2007 - Extended Edition*" available for download from the Geoscience Australia web site. Drill intersections reported from across the country in 2007 and the first half of 2008 indicate potential, with further exploration, to yield resources to underpin the Australian gold sector into the medium to longer term. Indicative of these are:

- Alkane Exploration Ltd's Caloma prospect (New South Wales) where intersections included 4 m @ 14.00g/t Au, 3 m @ 5.54g/t Au and 7 m @ 9.12g/t Au.
- Avoca Resources Ltd's exploration near Higginsville (Western Australia) yielded a shallow gold resource under about 20 m of clay cover on the Wills Prospect in an area of no previous drilling or evidence of historical workings.
- At Tunkillia (SA), drilling by Minotaur Exploration Ltd in parts of the Area 223 deposit continued to yield good intersections including 10 m @ 8.3g/t Au, 3 m @ 16.2g/t Au and 9 m @ 4.1g/t Au, all from the oxide zone.
- GBS Gold International Inc. continued to report encouraging intersections from drilling in the Chinese Big Pit zone (NT) including 11 m @ 35.7g/t Au, 13 m @ 4.8g/t Au and 4 m @ 4.6g/t Au.

Production

Australian gold production reported by ABARE for 2007 was 245 t, a similar level to 2006. Australia's largest producer in 2007 was the Telfer operation in Western Australia where 0.62 Mozs (19 t) was produced. Telfer was followed by the Super Pit at Kalgoorlie where production was almost 0.61 Mozs (18.9 t) and Sunrise Dam which produced 0.60 Mozs (18.7 t). In 2007, Western Australia dominated Australian production with 155 t, just under two-thirds of total Australian output (Table 2).

Table 2. Australian gold production 2003 to 2007.

	2003 (t)	2004 (t)	2005 (t)	2006 (t)	2007 (t)
New South Wales	27.49	29.14	29	28	35
Victoria	3.11	3.46	6	6	6
Queensland	26.24	23.16	23	21	21
South Australia	5.33	5.12	6	7	8
Western Australia	189.07	164.32	173	165	155
Tasmania	9.31	10.60	8	5	4
Northern Territory	22.85	22.27	18	13	17
Australia	283.39	258.07	263	245	245

Source: ABARE Australian Commodity Statistics 2006 and ABARE Australian Mineral Statistic March Quarter 2008

World Ranking

The USGS estimate of world gold reserves of 42,000 t was similar to 2006. According to the USGS, South Africa still has the world's largest reserve of gold at 6000 t (14.3%), similar to 2006. According to the USGS Australia has the second largest reserve with approximately 12% of the world's holdings.

World mine production in 2007 fell slightly to 2,476 t. A major change in world rankings occurred in 2007 as China replaced South Africa as the world's leading gold producer. China produced about 281 t in 2007, followed by South Africa with 270 t and Australia with 246 t.

Industry Developments

A Ltd review of developments is available in the document "*Australian Mineral Exploration: A Review of Exploration for the Year 2007 - Extended Edition*" available for download from the Geoscience Australia web site. For a more comprehensive discussion of project development the ABARE report "*Minerals and Energy - major development projects – October 2007 listing*" is available for download from the ABARE website.

Some of the major developments are:

- Boddington (Newmont 66.67%; AngloGold Ashanti 33.33%) in Western Australia where milling is expected to start in late 2008 or early 2009 and production over the first five years is expected to average around 1 Mozs/yr. Average annual production over the current 15 year life of mine will be around 850,000 ozs of gold and 30,000 t of copper. Development at Boddington is over 70% completed.
- Ballarat East (Victoria) where Lihir Gold's current plan is to produce, on average, 200,000 ozs/yr over a 20 year mine life with initial production expected from late in 2008.
- Development of Oxiana Ltd's Prominent Hill (SA) project is progressing with the first ore expected to be processed late in 2008 to yield 10,000 t copper and 6000 oz gold for the year. Production for 2009 is expected to 110,000 - 120,000 t of copper and 75,000 - 85,000 oz of gold.
- At Higginsville (WA) Avoca Resources' treatment plant was on schedule for completion and commissioning by the end of June 2008. The plant is expected to start processing high grade feed from Trident in July with an output of 170,000 ozs in 2009-10.
- Newcrest Mining Ltd expects to achieve full production from its Ridgeway Deeps gold-copper development at its Cadia project in New South Wales in 2010-11. In the next two years mining will be in transition from the current Ridgeway underground mine to Ridgeway Deeps from which the company expects to produce some 1.6 Moz gold and 0.21 Mt copper over a mine life of 12 years.

Iron Ore

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Iron (Fe) makes up about 5% of the Earth's crust and is the fourth most abundant element and the second most abundant metal in the crust after aluminium. Most of the iron is found combined with oxygen as iron oxide minerals such as hematite (Fe_2O_3) and magnetite (Fe_3O_4). Almost all iron ore (98%) is used in iron and steel making with the remainder used in applications such as coal washeries and cement manufacturing. Iron is the most used metal and makes up 95% of all the metal tonnages produced worldwide. Iron is alloyed with a number of elements such as carbon, manganese and nickel to produce stronger and harder steels which are indispensable in construction, motor vehicles, ships, trains and railway tracks.

Western Australia dominates the Australian iron ore industry, accounting for 97% of total production. The Pilbara region of Western Australia is particularly significant with 85% of Australia's total identified resources and 92% of its production. Locally significant iron ore mines also operate in the Northern Territory, South Australia, Tasmania and New South Wales.

Resources

In 2007 EDR increased by 8.9% to 20.3 Gt mainly due to the inclusion of Marillana, Mungada, Phils Creek and Red Hill-West Pilbara for the first time and large increases at the Cape Lambert deposit and the undeveloped Rio Tinto deposits. Western Australia has about 99% of Australia's EDR with about 89% occurring in the Pilbara region. Magnetite ore currently constitutes 24% or 4.8 Gt of Australia's EDR.

PDR increased by 74% to 0.3 Gt due a reclassification of resources and SDR decreased to 1.7 Gt following a reclassification of resources. Inferred resources increased by 36.4% to 24.4 Gt due to the inclusion of Abydos, Beebyn, Lake Giles, Wiluna West, Caliwingina North and Yalgoo for the first time and increases at Pardoo, Weld Range, undeveloped Rio Tinto deposits and Mining Area C. Western Australia has about 92% of Australia's total identified resources of iron ore with about 85% of the total identified occurring in the Pilbara Region.

Accessible EDR

Almost all EDR is accessible except for the remaining resource at Orebody 23 (18 Mt) in the Newman District and 30% of the Windarling resource which have both been quarantined for environmental reasons. The resource life of the accessible EDR of 20.2 Gt is more than 65 years.

JORC Reserves

JORC reserves of 8.1 Gt makes up about 40% of accessible EDR. The resource life of JORC reserves is more than 25 years. Rio Tinto and BHP Billiton manage 61% of the JORC reserves and magnetite ore constitutes 23% of the JORC reserves.

Exploration expenditure

ABS data indicates that exploration expenditure for iron ore in 2007 totalled \$354.1 million an increase from \$224.7 million in 2006. About \$333.3 million, or 94.1% was spent in Western Australia.

Production

ABARE reported that Australia's iron ore production in 2007 was 299.1 Mt compared to 275.1 Mt in 2006 with 97% produced in Western Australia. Exports in 2007 totalled 267.2 Mt compared to 248.4 Mt in 2006 and had a value of \$16 billion. ABARE has projected that Australia's iron ore production will increase from 287.7 Mt in 2006-07 to 522.8 Mt by 2012-13. Exports are projected to rise from 257.4 Mt to 488.7 Mt over the same period.

World ranking

In 2007 Australia had about 13% of world EDR of iron ore and was ranked fourth after Ukraine (19%), Russia (16%) and China (14%). In terms of contained iron, Australia has about 15% of the world's EDR and is ranked second behind Russia (19%). Australia produces around 16% of the world's iron ore and is ranked third behind China (32%) and Brazil (19%).

Industry Developments

WESTERN AUSTRALIA

Rio Tinto Iron Ore: At Yandicoogina, mining at the US\$530 million Junction South East (JSE) project began in May 2007. This expanded the capacity of Yandicoogina from 26 to 52 Mtpa and included an additional rail loop and train load out. Site works commenced in December 2007 on the US\$1,521 million Brockman Syncline 4 (BS4) project located about 60 km north west of Tom Price. Commissioning of the 22 Mtpa project is expected begin in early 2010 with an allowance for an increase in output to 36 Mtpa to be included in Phase 1. The mine will be connected to the Pilbara Iron rail network by a 35 km rail spur to the Brockman 2 operation. In February 2008 Rio Tinto announced a significant resource had been identified at Caliwingina which is located about 100 km north north west of Tom Price.

The Mesa A and Warrambo deposits located about 50 km from Pannawonica are being developed to replace the Mesa J operation which will cease in 2010. In January 2008 site works started on the US\$901 million project which will have an initial capacity of 20 Mtpa in 2010 rising to 25 Mtpa in 2011. A 49 km rail extension will connect the new mine to the Rio Tinto rail network. Current production from Mesa J will reduce to 7 Mtpa of sub-grade material to be processed in scrubber plants until 2015.

BHP Billiton: Commissioning activities for the US\$1.5 billion Rapid Growth Project 3 (RGP3) began at the end of 2007. RGP3 included the development of Deposit E and an overland conveyor as well as new crushing and screening facilities at Mining Area C to increase capacity from 22 to 42 Mtpa. RGP3 also increased rail and port capacity by 20 Mtpa to 129 Mtpa. In March 2007 the US\$2.1 billion RGP4 project was approved and is expected to deliver a mine, rail and port capacity of 155 Mtpa in the first half of 2010. The RGP4 project includes increasing production at Yandi to 45 Mtpa, developing a new crushing and screening plant and additional stockyards, car dumping and train loading facilities. Since 2002 BHP Billiton has spent US\$4.9 billion on increasing capacity by 77 Mtpa to 155 Mtpa on the Pilbara operations.

In February 2008 BHP Billiton announced the approval of US\$1.094 billion for Rapid Growth Project 5 (RGP5) which is expected to increase installed capacity from 155 Mtpa to more than 200 Mtpa in 2011. RGP5 will include the duplication of the rail line between the Yandi mine and Port Hedland, the expansion of the inner harbour at Port Hedland and the expansion of capacity at the Yandi and Area C mines.

Fortescue Mining Group Ltd (FMG): Mining activities at the 45 Mtpa Cloud Break project commenced in September 2007. The first loaded train was expected to arrive at Port Hedland in April 2008 and the first shipment was scheduled to leave port in May 2008. The capital cost is forecast to be \$2.6 billion (excluding financing costs). The 255 km rail line will have a capacity of 70 Mtpa of which 45 Mt will be for FMG leaving the rest for junior miners. Planning is being undertaken to bring forward the construction of a lump circuit at the mine, the construction of a third de-sand plant, the commissioning of a second ship berth and the improvement of rail capacity by a super lift (placing more ballast under track). These optimisation initiatives could deliver 55 Mtpa in 2009 and up to 100 Mtpa in 2010. In November 2007 FMG announced that a significant resource had been identified at the Solomon deposit located about 60 km north of Tom Price.

Hancock Prospecting: The first production blast at the US\$980 million 22 Mtpa Hope Downs project (50:50 owned by Rio Tinto and Hancock Prospecting) occurred in July 2007 and the first ore reached the Port of Dampier in December 2007. A Stage 2 US\$350 million expansion at the Hope Downs 1 South deposit is expected to increase production from the Hope Downs project by 8 Mtpa to 30 Mtpa

in early 2009. In December 2007 Rio Tinto (the operator) announced a US\$71 million feasibility study to investigate the expansion of production from the Hope Downs 4 deposit located 45 km east of the Hope Downs 1 mine. During 2008 Hancock Prospecting plan to prepare a Bankable Feasibility Study on the Roy Hill 1 deposit located 300 km south east of Port Hedland. Construction is planned to commence in 2009 with a 2011 mine start-up date.

Portman Ltd: At the Koolyanobbing project, Portman is studying a number of expansion options in consultation with rail and port service providers. Portman also is studying the beneficiation of lower grade ores to increase the ore reserve base. In September 2007 a new contractor started mining, crushing and screening services at the project. The product is transported 578 km by rail to the Port of Esperance for export. On Cockatoo Island Phase 2, mining is due to end in June 2008 but a Phase 3 mining plan has been approved in principle subject to a number of conditions being resolved. Phase 3 includes building a double seawall to enable mining to go to a depth of 60 m below sea level and adding four years to the life of the mine. Environmental remediation commenced in the September Quarter of 2007.

Mount Gibson Iron Ltd: At Talling Peak during 2007, development of the T3C and T6A pits exposed high grade hematite. The mine produces about 3 Mtpa and has a current mine life of about 6 years. There is a possibility of extending the mine's life with the development of the area called T1 as well as extending the resource below the existing Main Range T2 pit. At Koolan Island, the first shipment from new berth and load out facilities occurred in June 2007. Currently, mining is occurring in satellite deposits including Eastern and Mullet-Acacia pits until access to the Main Pit orebody is available. The cutback of the Main Pit commenced in December 2007 along with the construction of the seawall across Arbitration Cove. Dewatering and footwall rehabilitation could take up to 18 months to complete. The planned pit floor will be 160 m below sea level. At the Extension Hill project a Definitive Feasibility Study was completed in early 2007 with a plan to mine 3 Mtpa over an initial four year mine life. Ore would be trucked 85 km to Perenjori then railed 239 km to Geraldton. Construction of the \$84 million project is expected to commence in the March Quarter of 2008 subject to permitting approvals with production due to start in early 2009.

Asia Iron Pty Ltd: Plans to produce 5 Mtpa of concentrate from the Extension Hill magnetite deposit commencing in 2010. The project will cost \$715 million and includes a 280 km slurry pipeline to Geraldton.

Murchison Metals Ltd: The \$44 million Stage 1 Jack Hills project shipped the first ore from the Port of Geraldton in February 2007. Stage 1 involves producing 2 Mtpa over a 5 year mine plan using contract mining, crushing and screening and contract road haulage 540 km to the Port of Geraldton. In 2007 the Stage 1 pits were optimised using geological knowledge gained from the first six months of mining to reduce the strip ratio to 4:1. Murchison expects that a fines product produced from beneficiation of low grade ore will add another high grade product from Jack Hills. A \$2.6 billion Stage 2 Jack Hills project is planned to produce 25 Mtpa commencing in 2011. Stage 2 will require a 560 km multi-user rail line and a new port at Oakajee near Geraldton. A \$20 million bankable feasibility study is expected to be completed in 2008.

Midwest Corporation Ltd: Midwest is planning to transfer ore haulage from road to rail between the Koolanooka operation and Geraldton by June 2008. Midwest has sufficient ore in stockpiles until June 2008 at which time it expects the Stage 2 hard rock mines to commence at Koolanooka and Blue Hills. Annual production will be restricted to 1.5 Mt with operations planned to start once approvals have been granted. At the \$579 million Weld Range project a 15 Mtpa direct shipping ore operation is planned to commence in 2011 with an initial 15 year mine life. Rail and port infrastructure is to be provided by Yilgarn Infrastructure Ltd. A pre-feasibility study is expected to be completed in September 2008 and a Bankable Feasibility Study in mid-2009. Midwest also is planning a 10 Mtpa mine at Jack Hills to start in 2013. The \$1 billion Koolanooka magnetite project, 160 km south east of Geraldton, is planned to produce 6 Mtpa of concentrate or pellets for an initial 20 years.

Grange Resources Ltd: Grange is planning to mine the US\$625 million Southdown magnetite project at a rate of 17.8 Mtpa to produce 6.6 Mtpa of concentrate over an initial 22 year mine life. The concentrate will be pumped 105 km via a slurry pipeline to the Port of Albany and exported to a pellet plant located in Kemaman, Malaysia. Construction of the US\$1.175 billion Southdown-Kemaman Project is expected to commence in early 2009 with pellet production to begin in 2011.

Gindalbie Gold Ltd: At the \$94 million Mungada direct shipping ore project Gindalbie plans to mine 3 Mtpa over an initial six year mine life. A Bankable Feasibility Study completed in September 2007 included an initial 85 km road haul to Morawa and 200 km by rail to Geraldton for export. Production is planned to commence in 2009 subject to approvals. At the \$1.6 billion Karara magnetite project located 225 km south east of Geraldton, Gindalbie plans to mine 20 Mtpa of ore to produce 8 Mtpa of concentrate. The Bankable Feasibility Study was completed in September 2007 and concluded that rail transport to Geraldton was the preferred method of transport. The first concentrates are expected to be produced in 2010 and the project has an initial mine life of 25 years.

Atlas Iron Ltd: A Definitive Feasibility Study was completed in July 2007 on the \$9.9 million Pardoo Project located 75 km east of Port Hedland. Atlas is planning to commence a 1 Mtpa direct shipping ore operation in October 2008 by trucking ore to the public access port facilities at Port Hedland. Atlas proposes spending another \$14.5 million to expand the operation to 3 Mtpa by 2010. A Scoping Study was completed in late 2007 on the Abydos Project located 100 km south of Port Hedland. Plans exist for a \$38.5 million operation producing 3 Mtpa of direct shipping ore which would be trucked to Port Hedland for export. A pre-feasibility study on the Pardoo magnetite deposit is expected to be completed in October 2008.

Cape Lambert Iron Ore Ltd: The \$600 million Cape Lambert magnetite project is only 5 km from the coast near Karratha. The company plans to produce 7 Mtpa of concentrate from 2010 over an initial 20 year mine life. A Bankable Feasibility Study is expected to be completed in mid-2008.

CITIC Pacific Mining: The \$5.2 billion Sino Iron Ore Project is based on the Balmoral Central magnetite deposit located about 100 km south west of Karratha. CITIC plans to export 27.6 Mtpa of concentrate and pellets over 25 years commencing in 2009. The development includes magnetic concentrator, pellets plant, port facilities at Cape Preston, a 450 MW gas fired power station and a desalination plant.

Australasian Resources Ltd (ARL): The \$2.6 billion Balmoral South magnetite project is planned to mine 42 Mtpa of ore to produce 5.2 Mtpa of concentrate, 4.9 Mtpa of pellets and 1.45 Mtpa of hot briquetted iron (HBI). The Bankable Feasibility Study is due to be completed in March 2008 with concentrate being produced from 2010 and pellets in 2011 followed by HBI. ARL plans to share port facilities at Cape Preston with CITIC on a pro-rata cost basis.

Golden West Resources Ltd: At the Wiluna West project located 40 km west of Wiluna, a 10 Mtpa direct shipping ore operation is proposed to commence in 2011. Ore would be transported by rail to either Esperance or Oakajee depending of the outcomes of a pre-feasibility study due to be completed in mid-2008.

Ferrowest Ltd: Ferrowest plans to develop a \$437 million 0.5 Mtpa pig iron plant at Eradu, 98 km east of Geraldton. A 2.4 Mtpa mine would be required at the Yogi magnetite deposit located 120 km to the east.

Aurox Resources Ltd: At Balla Balla, located about 90 km east of Karratha, Aurox plans to construct a \$603 million concentration plant to produce 6 Mtpa of a vanadium rich titanomagnetite concentrate. A Bankable Feasibility Study was completed in October 2007 and commissioning is expected in mid-2010. Aurox plans to transport the product to Port Hedland via a 110 km slurry pipeline.

Australian Premium Iron Joint Venture: The joint venture plans to commence the \$2 billion 25 Mtpa West Pilbara Iron Ore Project in 2011 based on three deposits located about 50 km south west of Pannawonica.

Iron Ore Holdings Ltd: A 1.5 Mtpa direct shipping ore operation is planned to commence in 2010 at the Phil's Creek Project located about 10 km east of the Yandi mine.

FerrAus Ltd: A 2 Mtpa direct shipping ore operation is planned to commence in 2009 at the Robertson Range Project. Ore would be trucked 50 km to the Jimblebar mine then taken by rail to Port Hedland for export.

Brockman Resources Ltd: The \$300 million Marillana Iron Ore Project is planned to produce up to 10 Mtpa from 2012. A pre-feasibility study for the project, which is located 100 km north west of Newman, is expected at the end of 2008.

SOUTH AUSTRALIA, TASMANIA, NORTHERN TERRITORY AND NEW SOUTH WALES

OneSteel Ltd: In early 2007 exports of hematite began from the port at Whyalla in South Australia. OneSteel plans to export 4 Mtpa of hematite over 10 years from the Iron Magnet project. Ore is transhipped by barge 8 km offshore to Cape size vessels (160,000 t). Construction of the magnetite infrastructure for the \$395 million Project Magnet Expansion program was completed in the first half of 2007 and changeover to a pellet feed to the blast furnace occurred at the end of 2007. Project Magnet has extended the life of the Whyalla steelworks from 2020 to 2027 and has lowered the cost of steel production.

Western Plains Resources Ltd (WPG): A Bankable Feasibility Study on the \$109 million Peculiar Knob direct shipping ore project located 100 km south east of Coober Pedy in South Australia was completed in September 2007. The study envisages a 2.7 Mtpa operation over six years with an 85 km haul road to the Wirrida siding for delivery by rail to a port such as Darwin, Port Pirie or Port Bonython. Mining is expected to begin in mid-2008 with exports starting in early 2009. Planning is underway to extend the life of the project by developing the Buzzard hematite deposit at the nearby Hawks Nest project. WPG also is proposing to develop a magnetite mine at the Hawks Nest project by 2011 with a capacity of 8 Mtpa of concentrate over a 50 year mine life.

IMX Resources NL: Trial mining is expected to commence in early 2008 at the \$41.6 million Cairn Hill project located 55 km south east of Coober Pedy in South Australia. Run-of-mine magnetite ore will be taken 58 km by truck to the Wirrida rail siding and then by rail to Darwin for export to China. Full production of 1.4 Mtpa is expected in mid-2008 with the first shipment at the end of 2008. Approximately 7.3 Mt of ore averaging 50.9% Fe, 0.43% Cu and 0.13g/t Au will be produced over an initial 5.5 year mine life.

Centrex Metals Ltd: Mining at the \$10 million Wilgerup hematite project located 30 km south east of Lock in South Australia is expected to begin in August 2008 with first shipments in early 2009. The 2 Mtpa five year project will take direct shipping ore 17 km by truck to a rail siding near Tooligee for transport to a port such as Port Lincoln.

Ironclad Mining Ltd: A \$296 million 2 Mtpa magnetite concentrate project is proposed for the Wilcherry Hill deposit located 90 km west north west of Whyalla in South Australia. A feasibility study is due to be completed by the end of 2008 with production commencing in 2010.

Jiangsu Shagang: In 2007, work started on a major pre-strip operation designed to extend the life of the Savage River mine through to 2022. The removal of about 56 Mtpa of overburden by truck and shovel will provide 6 Mtpa of magnetite ore to produce 2.5 Mtpa of concentrate for pellet production. Savage River is located 110 km south west of Burnie in Tasmania.

Gujarat NRE Resources NL: At the Nelson Bay River deposit located 70 km south west of Smithton in Tasmania, bulk sampling indicated favourable results for the production of a marketable magnetite concentrate for the heavy media market. Gujarat intends to update the previous conceptual mine study.

Territory Iron Ltd: In April 2007 mining started at the \$15 million Frances Creek project located 180 km south of Darwin in the Northern Territory. The first ore from the 1.5 Mtpa project was transported by rail in July 2007 and the first shipment of 67,500 t of iron ore left Darwin in September. Territory Resources plans to increase production to 3 Mtpa by 2009. A \$32.5 million development of and improvement to the Darwin port facilities was completed in the first half of 2007.

Peko Rehabilitation Project Pty Ltd: In May 2007 a 50 ktpa magnetite tailings re-treatment plant was commissioned at the historic Peko mine near Tennant Creek in the Northern Territory. Approximately 3.9 Mt of tailings is planned to be re-treated over 6 to 7 years to produce a premium grade magnetite suitable for coal washeries. The tailings re-treatment will allow the rehabilitation of the old Peko mine.

FerroMin Pty Ltd: Council approval has been granted for the \$2 million Broula open-cut mine located 19 km west south west of Cowra in New South Wales. The mine is expected to yield 1.3 Mt of magnetite, 0.15 Mt of hematite and 0.9 Mt of limestone over 15 years. The magnetite would be for use in coal washeries, the hematite in cement or steel production and the limestone in agriculture or as mineral filler.

IRON AND STEEL

Operating and proposed Direct Reduced Iron (DRI) and steelworks in Australia include:

- Steel production at Port Kembla, Whyalla, Rooty Hill, Mayfield and Laverton North.
- **Hismelt:** The world's first commercial Hismelt facility at Kwinana in Western Australia is now two years into a three year ramp-up to full capacity of 800 ktpa in 2008.
- **Ferrowest Ltd:** A \$437 million 0.5 Mtpa pig iron plant is planned to be located at Eradu in Western Australia. A \$303 million Stage 2 project is planned to increase production to 1 Mtpa. A Definitive Engineering Study is due for completion at the end of 2008 with commencement proposed for mid-2011. Ferrowest has sent a sample of concentrate from the projects Yogi magnetite deposit to Japan to determine the suitability for use in two Midrex pig iron processes.
- **Boulder Steel Ltd:** The company plans to produce 400 ktpa of seamless tubes per year in Ipswich, Queensland. The \$572 million project requires the construction of an electric arc steel mill, a seamless tube mill and a finishing mill. The project is expected to be operating at full capacity in 2011. The Australian Government has granted the proposed steel mill Major Project Facilitation Status.
- **Australasian Resources Ltd:** The company plans to develop a HBI plant with a capacity of 1.45 Mtpa at Cape Preston, Western Australia.

INFRASTRUCTURE AND RESEARCH AND DEVELOPMENT

BHP Billiton: Under Project Quantum BHP Billiton is assessing options for further infrastructure expansions with targets of 300 Mtpa within the next 10 to 20 years. This includes investigating duplication of the 426 km railway from Port Hedland to Newman and studies of the outer harbour development at Port Hedland.

Rio Tinto Iron Ore: At the end of 2007 the US\$690 million Dampier Port upgrade from 116 to 140 Mtpa was completed. In February 2007 Rio Tinto announced the US\$860 billion expansion of the Cape Lambert port from 55 to 80 Mtpa. When construction is completed in the Fourth Quarter of 2008 Rio Tinto's mine, rail and port capacity in the Pilbara will be capable of exporting 220 Mtpa. Rio Tinto is considering expanding capacity by a further 100 Mtpa to 320 Mtpa.

Port of Geraldton: Construction of the \$35 million Berth 5 Iron Ore Expansion Project was completed in late 2007 and the first shipment occurred in January 2008. The Berth 5 project will enable the port to load up to 12 Mtpa of iron ore. Yilgarn Infrastructure Ltd is proposing to construct a \$3 billion 60 Mtpa multi-user open-access port at Oakajee 25 km north of Geraldton and a 470 km railway to projects in the Mid-West Region, including the proposed Weld Range and Jack Hills projects. Definitive planning and design studies began in early 2007 with construction expected to start in late 2008 and operations to commence in 2011. Murchison Metals Ltd also has proposed a \$2.6 billion port and rail development at Oakajee to service the 25 Mtpa Jack Hills Stage 2 Project.



Mining operations at the Cloud break iron ore mine, Western Australia (Fortescue Metals Group).

Port Hedland Port Authority: A new \$225 million multi-user public berth with an annual capacity of 18 Mt will be built at Utah Point on Finucane Island and is expected to be operational in the first half of 2009. In October 2007 the Western Australian Government committed almost \$1.3 million to assess the feasibility and capacity of a new outer harbour off Finucane Island. Ronsard Island located 80 km west of Port Hedland has been recommended as the site of the Pilbara's next major iron ore port. The port would be a multi-user facility commencing after 2015.



Surface miner loading haul trucks at Cloud Break iron ore mine, Western Australia (Fortescue Metals Group Ltd).

Rio Tinto is investigating the introduction of driverless trains for the Pilbara rail operations. The current trial could lead to significant savings, including an estimated 4% in rail operational efficiency. A decision on automation could be made as early as 2008 and, if implemented it is likely the technology will take up to five years to be fully integrated across the network.

The Fortescue Metals Group introduced the first surface miners into iron ore mining at the Cloud Break mine during 2007. Three \$3.2 million Wirtgen 2500SMs are in operation at Cloud Break and 11 more have been ordered. Surface miners theoretically lower mining costs by removing much of the drilling, blasting and crushing which is required in conventional open-pit mines (potentially saving up to \$1 per tonne). Surface miners also may prolong tyre life on dump trucks because of smoother pit floors. Both Rio Tinto and BHP Billiton started surface miner trials during 2007. Surface miners need long, straight benches in relatively soft ore.

The CSIRO and Rio Tinto have begun to operate the Fe HyLogger technology which provides a rapid and automated spectroscopic determination of the mineralogy of drill cores and chips along with core logging and grade estimations. The instrument is mounted in a custom built air conditioned container made in Australia by a team at the CSIRO.

Lithium

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Lithium (Li) is recovered from the mineral spodumene ($\text{Li}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$) and lithium-rich brines. It is used in a range of products such as ceramics, glass, batteries and pharmaceuticals. Lithium use has expanded significantly in recent years due to increasing use in rechargeable batteries in portable electronic devices and in batteries and electric motors for hybrid and electric cars.

Lithium produced from the Greenbushes mine in south west WA has been used in the production of specialty glasses, glass bottles, ceramics and ceramic glazes. Its ore also is a feedstock for the production of lithium carbonate in the chemical industry.

Resources

EDR in 2007 was reduced by 1 kt to 169 kt of lithium. All of Australia's lithium resources are in the Greenbushes spodumene deposit in WA. It is the world's largest and highest grade spodumene deposit. All of lithium EDR is accessible for mining. Approximately 85% of EDR comprises JORC Code reserves as reported by industry.

In 2007, subeconomic resources total 79 kt, which account for 31% of total demonstrated resources. Paramarginal and submarginal resources were 54 kt and 25 kt respectively. Inferred resources amounted to 7 kt. Western Australia accounts for all the subeconomic and inferred resources.

Exploration

There are no statistics available on exploration expenditure for lithium. There are only a few companies exploring for lithium in WA and Qld.

Production

In 2007, the Talison Minerals' Greenbushes operation produced 192,277 t of spodumene concentrate, which contains between 4.8% and 7.5% Li_2O .

World Resources

Based on USGS estimates for 2007, which have been modified by Geoscience Australia for Australia's resources, world resources totalled 4269 kt, although the resource data does not include some important producing countries such as Argentina and Russia. According to the USGS, of the total world lithium resources Chile holds approximately 3000 kt, followed by China with 540 kt, Brazil with 190 kt and Canada with 180 kt.

Lithium resources occur in two distinct categories, lithium minerals and lithium-rich brines. Canada, China and Australia have the most significant resources of lithium minerals while lithium brine resources, which is the dominant feedstock for lithium carbonate production, is produced predominantly by Chile, followed by Argentina, China, Russia and the USA.

World production in 2007 was estimated by the USGS to be 25 kt of contained lithium, excluding the USA production for commercial reasons. Based on the USGS data, Chile produced 9.4 kt to remain the world's largest producer in 2007 followed by Australia, China and Canada.

Industry Developments

The demand for lithium is growing as a result of the increased use of rechargeable batteries in electronic devices and the development of lithium-ion batteries and electric motors for hybrid and electric cars.

In August 2007, the assets of Sons of Gwalia were sold to a consortium of five private equity funds which led to the formation of Talison Minerals Pty Ltd comprising the Sons of Gwalia Ltd assets, including the Greenbushes and Wodgina mines and exploration leases near Wodgina mine in WA.

Wodgina is an open pit mine with a primary processing plant. The Greenbushes operation includes a lithium plant along with an open pit and underground mines, primary and secondary tantalum processing plants and a tin smelter.

Magnesite

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Magnesite (magnesium carbonate MgCO_3) is marketed in three main forms:

- crude magnesite, primarily for use in chemicals and agriculture;
- dead-burned magnesia, a durable refractory for use in cement, glass, steel and in metallurgical industries; and
- caustic calcined magnesia, for use in making oxychloride and oxysulphate cements for flooring and wallboards, mouldings and acoustic tiles, and various environmental and chemical applications.

Resources

EDR of magnesite remained unchanged at 344 Mt in 2007. South Australia has the largest holding of EDR with 235 Mt of magnesite, which is unchanged from 2006.

Qld has Australia's second largest inventory of magnesite EDR. The bulk of this occurs at Kunwarara 70 km north west of Rockhampton, where Queensland Magnesite Pty Ltd has global resources of 1200 Mt of magnesite-bearing material. Within this global resource, which has an inferred resource of 500 Mt of magnesite, the company has identified several high-grade magnesite zones which are classified as EDR. The Kunwarara deposit contains substantial accumulations of very high-density "bone-type" magnesite characterised by nodular and cryptocrystalline structure and low iron-content.

The third largest inventory of EDR is in Tasmania where the Arthur River deposit has an indicated resource of 26 Mt. Magnesite in the deposit typically grades at 42.8% MgO and is part of a much larger global resource of 195 Mt in the Arthur-Lyons River area, about 53 km south of Burnie.

Minor EDR occurs in the Winchester deposit near Batchelor, NT, at Thuddungra 80 km north west of Young, NSW, and at Bandalup 20 km east of Ravensthorpe, WA.

Subeconomic demonstrated resources of 57 Mt of magnesite remained unchanged from 2006. All of these resources occur in Qld and Tas.

Inferred resources remained steady at 931 Mt with Qld accounting for 50% followed by SA with 31% and Tas. with 16% and the remainder in NSW and NT.

Accessible EDR

All magnesite EDR is accessible for mining.

JORC Reserves

About 11% of AEDR comprise JORC Code reserves. The remainder represents resources assessed by Geoscience Australia from the measured and indicated categories of industry reported mineral resources as defined under the Code and other classification systems used by companies not listed on the Australian Stock Exchange. At Australia's 2007 rate of production, magnesite resources in the JORC Code reserves categories are adequate for 84 years.

Exploration

Data relating to exploration expenditure for magnesite are not published by ABS on either a State or national basis.

Production

According to ABARE, magnesite production in 2007 totalled 447,000 t. The bulk of production was by Queensland Magnesite Pty Ltd which supplies high-grade electrofused and deadburned magnesia to the global refractory market and is expanding calcined magnesia production for a wide range of applications. About 2500 t of magnesite was produced from the Myrtle Springs region in SA.

USGS data indicate that China (41%), Turkey (20%), North Korea and Russia (8% each) were the largest producers of magnesite in 2007.

World Ranking

According to Geoscience Australia and USGS data, Australia has about 5% of the world's EDR of magnesite. Russia, North Korea and China, together, account for almost 70% of the world's EDR. The Kunwarara deposit in Qld is the world's largest known resource of cryptocrystalline nodular magnesite, a high quality ore.

Industry Developments

Queensland Magnesite Pty Ltd announced plans to expand its total magnesia capacity from 220,000 t/year to 320,000 t/year, add a third multiple hearth furnace (MHF), and to diversify its markets into hydrometallurgical and agricultural applications. Construction of the third MHF is scheduled to commence in July 2008 with commissioning to begin in September 2009.

Manganese Ore

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Manganese is the twelfth most abundant element in the Earth's crust. Among about 300 minerals containing manganese only around a dozen are of economic significance. The two main manganese minerals are pyrolusite (MnO_2) and rhodochrosite (MnCO_3). Manganese is the fourth most used metal in terms of tonnage after iron, aluminium and copper and 90% of all manganese consumed annually goes into steel as an alloying agent. No satisfactory substitute has been identified for manganese which combines a relatively low price with outstanding technical benefits such as the ability to combine with sulphur and a powerful de-oxidation capacity. After steel, the second most important market for manganese is in the form of electrolytic manganese dioxide which is used in dry cell batteries. Manganese also is an important alloying element with aluminium and copper, is used in plant fertilisers and animal feeds and is a colorant.

In Australia there are three operating mines and one tailings re-treatment plant. The Woodie Woodie mine is located about 400 km south east of Port Hedland in Western Australia. A manganese tailings processing plant also operates near the Woodie Woodie mine. The Northern Territory has two manganese mines, one on Groote Eylandt in the Gulf of Carpentaria and the other at Bootu Creek 110 km north of Tennant Creek. Manganese ore processing plants are operated by TEMCO at Bell Bay in Tasmania and by Delta plc at Newcastle in New South Wales.

Resources

In 2007 Australia's EDR of manganese ore increased by 18.2% to 164 Mt with increases in EDR at Groote Eylandt and Bootu Creek being offset by a decrease in EDR at Woodie Woodie. PDR remained unchanged at 23 Mt and SDR remained unchanged at 167 Mt. Inferred resources decreased 14.3% to 137 Mt mainly due a decrease at Groote Eylandt.

Accessible EDR

All 164 Mt of EDR manganese ore is accessible and at the current rate of production of beneficiated manganese ore this EDR has a resource life of about 30 years.



Mining operations at Bootu Creek manganese mine, Northern Territory (OM Holdings Ltd).

JORC Reserves

Manganese ore JORC reserves are 148 Mt, which represents 90% of accessible EDR. The resource life based on the JORC reserves and the current rate of production of beneficiated manganese ore is about 28 years.

Exploration expenditure

Data relating to exploration expenditure for manganese are not published by the ABS on either a State or National basis. Consolidated Minerals Ltd plans to spend \$12.2 million on exploration in 2007-08. OM Holdings Ltd plans to spend \$3.6 million on exploration, including a reverse circulation drilling program within a 10 km radius of the Bootu Creek mine. Companies actively exploring for manganese include, Trafford Resources Ltd, Spitfire Resources Ltd, Sandfire Resources NL, Ausquest Ltd, FerrAus Ltd, Churchill Mining plc, Brumby Resources Ltd, Montezuma Mining Company and De Grey Mining Ltd.

Production

ABARE reported that Australia produced 5.3 Mt of beneficiated manganese ore in 2007 compared to 4.6 Mt 2006. Exports for 2007 totalled 4.9 Mt compared to 4.2 Mt 2006 and was valued at \$717 million, an increase of \$252 million on the \$465 million in 2006.

World ranking

Australia has 12% of the world's EDR of manganese ore and is ranked fourth behind Ukraine (31%), South Africa (17%) and China (15%). Australia produces 15% of the world's manganese ore and is ranked third behind China (23%) and South Africa (21%).

Industry Developments

GEMCO: At the Groote Eylandt mine a US\$150 million construction program is underway to overcome a bottleneck in the processing plant and increase capacity from 3.1 Mtpa to 4.1 Mtpa. The project also will reduce operating costs from 2008. GEMCO employ about 250 people of whom about

15% are indigenous and the company plans to increase the indigenous workforce to about 24% by 2012. Progressive rehabilitation of disturbed areas is undertaken by a group of the local Anindilyakwa indigenous population. GEMCO plans by 2012 to reduce energy use by 13% per tonne of product produced at 2006 levels.

OM Holdings Ltd: At the Bootu Creek mine, product is trucked 60 km to the Muckety rail siding then railed 800 km to the Port of Darwin where it is stockpiled and loaded into vessels destined for Asia. A fleet of five scrapers was introduced in 2007 to increase total production. A \$5.3 million materials rectification program was completed in the second half of 2007. Opportunities to increase production from 550 to 700 ktpa in 2008 are being examined. A revised life of mine plan is planned for completion in early 2008.

Consolidated Minerals Ltd: The Woodie Woodie mine has a capacity of 1.1 Mtpa and more than \$20 million is budgeted to be spent on new capital to enhance and improve the operation by up to 5%. A resource of 1.4 Mt at 44% manganese defined at the Rhodes pit is the second largest discovery in the history of the Woodie Woodie manganese field. Lump and fine products are trucked about 400 km to Port Hedland where blending occurs prior to export to overseas markets.

Mineral Resources Ltd: The re-treatment plant at Woodie Woodie has been expanded to a capacity 400 ktpa of high grade fines. Concentrates are trucked to Port Hedland then blended and held in a storage facility at Port Hedland ready for export. The project has a life exceeding 10 years at current production rates.

Mineral Sands

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The principal components of mineral sands are rutile (TiO_2), ilmenite (FeTiO_3), zircon (ZrSiO_4) and monazite ($[\text{Ce}, \text{La}, \text{Th}]\text{PO}_4$). Rutile and ilmenite are used principally in the production of titanium dioxide pigment. Less than 4% of total titanium mineral production, typically rutile, is used in making titanium sponge metal. Zircon is used as an opacifier for glazes on ceramic tiles, in refractories and for foundry industry. Recently there has been some interest in monazite as a source of thorium for possible use in thorium nuclear reactors for electricity generation.

Resources

EDR of ilmenite increased by 1.3% to 221.4 Mt in 2007, up from 218.5 Mt in 2006. About 56% of Australia's EDR of ilmenite is in WA and 22% is in Qld with the remainder in Vic (11.3%), NSW (7.4%) and SA (2.8%).

EDR of rutile, which includes some leucoxene in WA, increased by 6.5% from 21.7 Mt in 2006 to 23.1 Mt in 2007. Victoria has the largest share of Australia's rutile EDR with 33.2% followed by Qld (25.3%), NSW (20%), WA (18.2%) and SA (3%).

EDR of zircon increased by 15% from 33.9 Mt in 2006 to 39.0 Mt in 2007 with WA (31.1%), Vic (23.2%) and Qld (21.5%) accounting for most of Australia's zircon EDR. The balance was in SA (14.4%) and NSW (9.6%).

Australia's subeconomic demonstrated resources of ilmenite, rutile and zircon in 2007 amounted to 35.4 Mt of ilmenite, which was a reduction of 27.7% on 2006, 9.7 Mt of rutile, a decrease of 29.7% on the previous year, and 14.8 Mt of zircon, a decrease of 29.5% on 2006.

Inferred resources of ilmenite increased by 2 Mt in 2007 to 128 Mt. Victoria has the largest proportion of inferred ilmenite resources with 42.4% of the Australian total followed by NSW (23.9%), WA (14.3%) and Qld (13.6%).

Inferred resources of rutile increased to 31 Mt from 28 Mt in 2006. Victoria has the largest share of Australia's inferred rutile resources with 47.7% of the Australian total followed by NSW (36.1%) SA (7.3%), Qld (5.2%) and WA (3.7%).

Inferred resources of zircon increased to 35.7 Mt from 30.0 Mt in 2006. Victoria is the main holder of zircon inferred resources with 48.1% of the Australian total, followed by NSW (20.3%), Qld (16.2%) and WA (9.1%).

Accessible EDR

A significant portion of mineral sands EDR is in areas quarantined from mining because they are largely incorporated in national parks. Geoscience Australia estimates that some 16% of ilmenite, 25% of rutile and 21% of zircon EDR is unavailable for mining. Deposits in this category include Moreton Island, Bribie Island and Fraser Island, the Cooloola sand mass, the Byfield sand mass and the Shoalwater Bay area, in Qld and the Yuraygir, Bundjalung, Hat Head and Myall Lakes National Parks in NSW.

JORC Reserves

Approximately 25% of ilmenite, 30% rutile and 29% zircon of accessible EDR (AEDR) comprise JORC Code reserves. The remaining AEDR represents resources assessed by Geoscience Australia from the measured and indicated categories of industry reported mineral resources as defined under the Code and other classification systems used by companies not listed on the Australian Stock Exchange.

Duration of Resources

At Australia's 2007 rate of production, AEDR of ilmenite, rutile and zircon is sufficient for an average of 80, 56 and 51 years respectively. However, resources in the JORC Code reserves categories are adequate for only 20 years for ilmenite, 17 years for rutile, and 15 years for zircon.

Exploration

According to quarterly ABS figures, expenditure on exploration for mineral sands in 2007 was estimated at \$36.5 million compared with \$31.3 million in 2006.

Production

In 2007, Australia produced 2.326 Mt of ilmenite, 312,000 t of rutile, 170,000 t of leucoxene and 601,000 t of zircon compared with 2.4 Mt of ilmenite, 232,000 t of rutile, 133,000 t of leucoxene and 492,000 t of zircon in 2006. About 875,000 t of ilmenite was exported during 2007 while rutile (345,000 t) and zircon (610,000 t) exceeded the level of production for the two commodities. The ilmenite not exported was upgraded to synthetic rutile containing about 92-94% TiO₂. In 2007, Australia produced 726,000 t of synthetic rutile compared with 703,000 t in 2006.

World Ranking

According to Geoscience Australia and USGS data, Australia has the world's largest EDR of rutile and zircon with 50%, and 47%, respectively and has the second largest share of the world's ilmenite with 17%, behind China, which has 30%. Other major country rankings include India (13%), South Africa (9%) and Brazil (6%) for ilmenite; South Africa (18%) and India (16%) for rutile; and South Africa (26%) and Ukraine (7%) for zircon.

In 2007, world production of ilmenite increased by 10% to 10.4 Mt, rutile increased by 18% to 600,000 t, and zircon increased by 39% to 1,290,000 t. Australia is the largest producer of rutile with about 53% of the world production followed by South Africa with 20% and Sierra Leone with 14%. Australia is the largest producer of ilmenite also with 22% followed by South Africa with 19% and is the largest producer of zircon with 47% followed by South Africa at 31%.

Industry Developments

Companies which produced heavy mineral sands during 2007 were Iluka Resources Ltd, Bemax Resources Ltd, TiWest joint venture and Doral Mineral Sands Pty Ltd, all in WA and Consolidated Rutile Ltd in Qld. Iluka and Bemax also produced heavy minerals in the Murray Basin in Vic and NSW respectively while production continued at Matilda Mineral's Andranangoo deposit on the Tiwi

Islands off the NT. Production also commenced from the Mindarie heavy minerals project, held by Australian Zircon NL, in SA and production of ilmenite was started at the Goondicum alluvial/eluvial deposit near Monto in Qld.

Iluka Resources Ltd heavy mineral sand operations in WA are located in two regions. The mid-west region north of Perth comprises the main mines of Eneabba (two wet concentrators, five mining units) and Gingin (wet concentrator, one mining unit). The Narngulu facility at Geraldton includes mineral separation, zircon finishing and synthetic rutile plants as well as port operations and storage facilities at Geraldton. Iluka is planning to process the heavy mineral concentrates from the development of its Jacinth-Ambrosia deposits in the Eucla Basin at the Narngulu plant.

Iluka's south west region, south of Perth, is based on mines at Waroona and Wagerup (wet concentrator and mining unit at each site). The commencement of the Cloverdale and Waroona mines has continued the transition of Iluka's south west mining region to more prominent ilmenite and synthetic rutile production region.

The production of heavy mineral sand commodities from Iluka's mining and processing activities in WA amounted to 77,100 t rutile, 526,600 t synthetic rutile, 1,234,300 t ilmenite and 244,500 t zircon.

Iluka Resources Ltd's Douglas project in Vic is based on the resources of three main deposits, Bondi Main, Bondi West and Bondi East. The infrastructure includes a single mining unit plant, a wet concentrator plant and a mineral separation plant located at Hamilton to produce the final specification rutile and zircon. Iluka successfully completed the commissioning and ramp up of its Hamilton mineral separation plant during 2007. Combined rutile and zircon production of 187,000 t in 2007 was above the company's initial forecast. In addition to rutile and zircon, an initial shipment of tin pre-concentrate (a by-product of the heavy minerals processing) took place in the final quarter of 2007. The ilmenite production is currently being returned to the mine. Production from the Douglas mine in 2007 totalled 59,300 t rutile, 2,300 t leucoxene and 128,300 t zircon.

In addition to the Douglas project, the company has a group of deposits at Ouyen in north west Vic with two thirds of the company's heavy mineral resources in Murray Basin at Kulwin, Woornack, Rownack, Rainlover, and Pirro with another group at Euston in NSW named Castaway, Kerribee, Earl, Dispersion and Koolaman. Iluka has announced plans to commence mining at Kulwin during the first Quarter of 2009. The company is then planning to move to Woornack, Rownack and Pirro in late 2009/2010 with mining and processing operations coming on stream during 2009 to 2014.

In the Eucla Basin, Iluka holds the Jacinth-Ambrosia and Gulliver's deposits and has a joint venture agreement with Adelaide Resources Ltd over the Tripitaka deposit in SA. The company completed a definitive feasibility study for the Jacinth-Ambrosia project in the first half of 2008 that envisages utilisation of spare processing capacity at Narngulu, near Geraldton in WA. A wet concentrator is to be relocated from Georgia in the US to the mine site at Jacinth-Ambrosia. The first product is expected to be available for sale in the second half of 2010.

Continuing exploration by the company in 2007 also led to the discoveries of heavy mineral deposits, including the Nepean and Minsk deposits in the NSW portion of Murray Basin and the Dromedary and Typhoon deposits in the Eucla Basin.

To the end of 2007, Consolidated Rutile Ltd's operations at the Yarraman and Enterprise mines on North Stradbroke Island produced 79,545 t rutile, 60,561 t zircon and 174,413 t ilmenite. The company reported an increased ore throughput of 13% compared to 2006 achieving 55.4 Mt from both mine sites.

The TiWest Joint Venture (Exxaro Australia Pty Ltd 50%, Tronox Incorporated 50%) operates an integrated titanium dioxide project in WA incorporating a dredging and dry-mining heavy mineral sands operation at Cooljarloo, dry separation and synthetic rutile plants at Chandala and a titanium dioxide pigment plant at Kwinana. Production in 2007 was approximately 432,000 t of ilmenite, 72,000 t of zircon, 34,000 t of rutile, 32,000 t of leucoxene, 200,000 t of synthetic rutile and 108,000 t of TiO₂ pigment.

The heavy mineral resources/reserves controlled by Bemax are located in old shorelines in two geological/geographic provinces – the Murray Basin of Vic and NSW, and the south west region of WA.

Bemax Resources NL reported that it has upgraded its resource base in the Murray Basin from 85.2 Mt of contained heavy minerals at 31 October 2006 to 86.5 Mt at 31 October 2007. This increase was achieved despite resource depletion associated with mining at Ginkgo in part due to the discovery of the new Atlas deposit in NSW and extensions to the North Kulwin deposit in Vic, both of which increased the resource base by 2.3 Mt heavy minerals.

Bemax reported that both the Ginkgo mine and the Broken Hill mineral separation plant achieved production at design capacity during 2007. Environmental and development approvals were granted by the NSW Government in the second half of 2007 to enable Bemax to expand its operations in the northern Murray Basin and process up to 650,000 t of heavy mineral concentrate per year.

The company is advancing its final process design also for the Snapper Mine wet concentrator, about 10 km south west of Ginkgo and expects to commission the mine in mid 2009. Bemax's Ginkgo operation production for the first full year in 2007 totalled 207,264 t ilmenite, 27,379 t secondary ilmenite, 55,423 t leucoxene, 57,751 t rutile and 45,068 t zircon.

Bemax's heavy mineral sand mining in south west region of WA was completed at the Tutunup and Ludlow deposits and the new dry mining operation commenced at Gwindinup, reaching full production rates in March 2008. The company's Gwindinup project includes the Gwindinup North and South deposits and the extensions of Happy Valley North and South deposits. The environmental studies for the Happy Valley deposits were completed during the quarter ending December 2007. Heavy mineral production from Bemax's operations in the region amounted to 153,352 t ilmenite, 11,725 t secondary ilmenite, 7,541 t leucoxene and 20,910 t zircon.

On 16 June 2008 the Bemax directors issued a statement unanimously recommending the acceptance of a takeover offer of Bemax Resources Ltd by Cristal Australia Pty Ltd, a wholly owned subsidiary of The National Titanium Dioxide Company Ltd.

Matilda Minerals Ltd continued mining operations at Andranango Creek in the Tiwi Islands off the NT with the first full year of production for 2007 amounting to 24,730 t heavy mineral concentrate containing zircon, rutile, leucoxene and ilmenite. Apart from the Tiwi Islands, the company's heavy mineral sand exploration activities include Broome and Carnarvon in WA and Cape York Peninsula and Surat Basin in Qld. The company also has signed a farm-in and joint venture agreement with Oresome Australia Pty Ltd (a wholly owned subsidiary of Metallica Minerals Ltd) which will allow Matilda Minerals Ltd to earn 70% interest in the exploration permit at Urquhart Point, Cape York Peninsula. In May 2008 Matilda Minerals Ltd announced an indicated resource of 2.78 Mt at 7% heavy minerals. The company also has applied for an exploration permit to explore for heavy mineral sands along the eastern margin of the inland region of Surat Basin.

Australian Zircon NL reported that it completed the construction of its Mindarie zircon mine in the western Murray Basin, 148 km east-north-east of Adelaide, SA. The first shipments of products took place in early November 2007.

Australian Zircon NL also is earning an 80% participating interest in its WIM 150 joint venture with Austpac Resources NL. The preliminary results of a prefeasibility study on the WIM 150 zircon and titanium mineral deposit recommended that the first stage of a bankable feasibility study be started. Testwork has shown that conventional feed preparation techniques will successfully recover 85% to 90% of raw feed zircon to an acceptable grade heavy mineral concentrate. Austpac has previously demonstrated that a +95% TiO₂ synthetic rutile can be produced from the fine WIM 150 ilmenite, and that the synthetic rutile product can be agglomerated.

Austpac Resources NL started construction of a 3,000 tpa ERMS SR (Enhanced Roasting and Magnetic Separation Synthetic Rutile) synrutile demonstration plant on its site on Koogarang Island near Newcastle in NSW. The purpose of the plant is to produce samples of high grade synrutile and iron pellets for market assessment. Construction of stage 1 of the demonstration plant was completed in

early February 2008. Austpac secured 150 t of ilmenite from Consolidated Rutile Ltd North Stradbroke mine in Qld, 500 t from Bemax's Ginkgo mine in NSW and 70 t from BHP Billiton's Corridor Sands deposit in Mozambique. The roasting of these samples is planned for completion by the end of June 2008. Commissioning of stage 2 of the plant will begin in July 2008 and synrutile/iron pellet production will commence in August 2008 and finish in September 2008. Subject to successful results from the demonstration plant, Austpac and BHP Billiton will consider a 60,000 tpa commercial plant.

Monto Minerals reported that production at its Goondicum mine commenced in October 2007 and stockpiles of ilmenite, feldspar, apatite and titanomagnetite were established by the end of 2007. Deliveries to customers began with apatite in October 2007 and ilmenite in January 2008, with feldspar and titanomagnetite (for coal washing for Australian and international markets) to follow later in 2008. Once full production for the initial project is achieved, the company will proceed with planned expansion in 2008/09.

Gunson Resources Ltd signed a second memorandum of understanding with China Triumph International Engineering Co. Ltd (CTIEC which provides for CTIEC's parent, China National Building Material Company (CNBM), and an electric power supply company in the Chinese city of Bengbu to take a combined 40% participating interest in the Coburn zircon project. Gunson is discussing with CTIEC its fixed price turnkey construction proposal for the Coburn project, operating costs and product quality. The company noted in its September 2007 quarterly report that it would be substantially cheaper to build and operate a heavy mineral separation plant in China. In April 2008, Gunson reported that the total JORC compliant indicated and measured resources at Coburn increased to 728 Mt averaging 1.2% heavy minerals.

Image Resources Ltd continued extensive exploration activities in their tenement areas in the north Perth Basin. In May 2008, Image Resources reported indicated and inferred resources for seven deposits totalling 206 Mt averaging 2.4% heavy minerals containing 6.4 Mt of heavy minerals.

Astron Ltd's Donald project in the Murray Basin in Vic comprises the Donald (WIM 250) and Jackson (WIM 200) heavy mineral sand deposits. In January 2006 the company reported a total indicated and inferred resource of 693 Mt with a heavy mineral content of 5.1%. Contained within this resource is an indicated and inferred resource of 477 Mt at 1.1% zircon, 1.8% ilmenite, 0.3% rutile and 1.1% leucoxene. The project is planned to be a 7.5 Mtpa mining operation, producing 500,000 tpa of heavy mineral concentrate for export to China. The DMS Pty Ltd (a wholly owned subsidiary of Astron Ltd) released an Environmental Effects Statement for the Donald project on 5 February 2008 for review and public comment lasting six weeks.

Olympia Resources NL reported that it had signed an agreement with Bemax Resources NL to treat Olympia's heavy mineral concentrate from the Keysbrook deposit through Bemax's Bunbury dry separation plant. In October 2007 the Western Australian Environmental Protection Authority recommended that the Keysbrook project proceed subject to a number of conditions. With the environmental approvals process continuing in the first half of 2008, development of the Keysbrook deposit is not expected before the second half of 2008.

On 11 March 2008, Territory Mineral Sands Pty Ltd, a wholly owned subsidiary of Territory Resources Ltd, announced an on market bid for all ordinary shares in Olympia Resources Ltd.

During 2006, Territory Mineral Sands Ltd issued a prospectus outlining extensive mining tenements covering heavy mineral deposits and prospective areas for heavy minerals in the Murray Basin in Vic, the Eucla Basin in SA, the Yaringa area in the coastal Gascoyne district of WA and the Inkerman Project made up of mining tenements along the western coast of Cape York Peninsula in Qld. The Murray Basin projects include three deposits, the Wedderburn with indicated and inferred resources of 173.2 Mt at 4.4% heavy minerals containing 14.4% zircon and Graybridge with 47.6 Mt of inferred resources at 3.42% heavy minerals containing 15.19% zircon. During 2007 the company increased the resources at its third deposit, Avonbank/Kalkee to 360.3 Mt of indicated and inferred resources at 5.8% heavy minerals with 31% ilmenite, 17.6% rutile, 15.8% zircon and 12.9% leucoxene. The company also reported the discovery of the Lefroy heavy mineral prospect located in the Pioneer project tenements in the western Eucla Basin.

In mid 2007, Diatrema Resources Ltd reported the Cyclone and Hurricane heavy mineral sand discoveries in northern Eucla Basin in WA near the SA border. A resource was announced in February 2008 for the Cyclone deposit amounting to 60 Mt at 3.8% heavy minerals with 41% zircon, 3% rutile, 42% leucoxene and 10% ilmenite.

Molybdenum

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Molybdenum (Mo) is used in steels and superalloys to enhance strength, toughness and corrosion resistance. The main commercial source of molybdenum is molybdenite (MoS_2) but it is found also in minerals such as wulfenite (PbMoO_4) and powellite (CaMoO_4). Molybdenum is mined as a principal ore and is recovered as a by-product or co-product of copper and tungsten mining.

Resources

Australia's EDR of molybdenum rose from 0.4 kt in 2006 to 198 kt in 2007. This was due to large increases in economic resource at Spinifex Ridge (WA) and Molyhil deposits (NT). WA is the largest holder of molybdenum resources with about 98% of EDR followed by the NT with 1.6% EDR. All EDR is accessible for mining. JORC code reserves account for 99% of EDR.

Subeconomic demonstrated resources account for about 64% of total demonstrated resources. Qld accounts for 76% of subeconomic resources followed by WA with 22% and SA with 2%. In 2007, the paramarginal resources decreased by 67% to 93 kt, as a result of resources upgrades to EDR while the submarginal resources increased by 258.3 kt to 262 kt due to resource assessment. Inferred resources increased by 48 kt (11%) to 489 kt in 2007. WA and Qld account for 51% and 48% of inferred resources respectively.

Exploration

The rise in molybdenum price has led to increased molybdenum exploration, which has resulted in resource upgrades for several deposits. Data relating to exploration for molybdenum are not available nationally.

Production

There was no molybdenum production in Australia in 2007.

World Ranking

The distribution of molybdenum resources and production is concentrated in a few countries in the world, with China, USA, Chile and Canada holding about 88% of the resources. In 2007, world economic resources are estimated to be about 8800 kt based on USGS data.

USGS estimates that world production in 2007 amounted to 187 kt of molybdenum. The USA, China and Chile accounted for almost 80% of global outputs in 2007 with USA producing 59.4 kt followed by China with 46 kt and Canada with 41.1 kt.

Industry Developments

The world molybdenum price soared in 2007, reaching a high of US\$38/lb from a low of about US\$5/lb in 2001 and it is forecast to continue rising in 2008. For almost 20 years the market has been stagnant, but has been transformed as a result of Ltd supplies and continued strong demand. China's high level of steel production and consumption has led to strong internal demand for molybdenum, reducing China's molybdenum exports and supporting the high prices. In Australia, feasibility studies for several projects were initiated because of higher prices.

In June 2008, Queensland Ores Ltd announced that the first tonne of molybdenum concentrate was processed at its Wolfram Camp tungsten-molybdenum project 90 km west of Cairns, in Qld. Commissioning of the treatment plant is underway and the company has indicated the first molybdenum concentrate shipment will be in 2008. Average annual production is estimated to be 120 t of molybdenum.

In 2007, Moly Mines Ltd completed a definitive feasibility study of a 20 Mtpa molybdenum-copper open pit mine and concentrator facility for the Spinifex Ridge project in the Pilbara region of WA. The initial 10 year mining operation will produce approximately 10.89 ktpa molybdenum concentrate and 12.25 ktpa copper concentrate. The company have indicated construction will commence in 2008 with production in 2009.

Thor Mining Plc has proposed an open cut mine and processing facility for the Molyhil tungsten-molybdenum project 250 km north east of Alice Spring in the NT. A definitive feasibility study completed in 2006 included a preliminary design for a 400 Mtpa operation with a mine life of more than 5 years. The company anticipate construction would start in 2008 with production commencing in 2009.

Glengarry Resources Ltd is undertaking a scoping study to determine the economic viability of the Maitland copper-molybdenum deposit west of Townsville in Qld.

Nickel

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More than 80% of the nickel (Ni) production is used in alloys. When alloyed with other elements, nickel imparts toughness, strength, resistance to corrosion and various electrical, magnetic and heat resistant properties. About 65% of world nickel output is consumed in the manufacture of stainless steel which is used widely in the chemical industry, motor vehicles, the construction industry and in consumer products such as sinks, cooking utensils, cutlery and white-goods.

Resources

Australia's EDR of nickel increased by 8.9% from 23.7 Mt to 25.8 Mt in 2007.

Western Australia remains the largest holder of nickel resources with more than 90% of total Australian EDR. NSW is the second largest with 6.1%, followed by Qld (2.9%) and Tas (0.3%). The EDR in WA comprises both sulphide and lateritic deposits while EDR in NSW and Qld are associated with laterite deposits.

Subeconomic demonstrated resources, which accounted for about 5.3% of total identified resources, decreased from 7.1% during 2007. The paramarginal resources decreased from 2.3 Mt to 1.6 Mt while the submarginal resources decreased from 1.2 to 1.1 Mt in 2007. WA has 74.3% of the subeconomic nickel resources.

Inferred resources decreased by 0.3 Mt to 21.9 Mt in 2007. WA maintained its dominant share of Australia's inferred resources with 90.8% followed by Qld with 5.9%.

The ratio of inferred resources to EDR in 2007 was 0.85 to 1.

Accessible EDR

Currently, all nickel EDR is accessible for mining. At the rate of production in 2007, AEDR of nickel are sufficient for 139 years.

JORC Reserves

About 25% of AEDR comprise JORC Code reserve. The remaining 75% of EDR represents resources assessed by Geoscience Australia from the measured and indicated categories of industry reported mineral resources, as defined under the Code and other classification systems used by companies not listed on the Australian Stock Exchange.

Total JORC Code reserves of nickel are adequate for 36 years at current rates of production.

Exploration

Expenditure on nickel-cobalt exploration for the 2007 calendar year, as reported by the ABS, was \$251.2 million, an increase of 70% compared with 2006. WA attracted most of this expenditure with \$230.6 million. Other States with significant nickel-cobalt exploration included NSW, SA and Tas.

Production

All of Australia's nickel production in 2007 was from WA and amounted to 185 kt, as reported by ABARE. The value of all nickel products exported was \$7.5 billion. Australia was the world's third-largest producer, accounting for 11.1% of estimated international nickel output.

World Ranking

Based on figures published by the USGS and the latest Australian resource figures, world EDR of nickel increased by 7.7% to 68.7 Mt in 2007 from 63.8 Mt in 2006. Australia's share of world EDR was 37.6% in 2007, which was down 0.5% from 2006. It remained the largest holder of EDR followed by New Caledonia (10.3%), Russia (9.6%) and Cuba (8.2%).

Russia was the largest producer again with 322 kt (19.7%), followed by Canada with 258 kt (15.5%) and Australia with 185 kt (11.1%). The fourth largest producer was Indonesia with 145 kt (8.9%) followed by New Caledonia with an output of 119 kt (7.3%).

Industry Developments

Australia has several nickel sulphide mines currently in operation. With the exception of the Avebury mine operated by Allegiance Mining NL in Tas, all are in WA. They include BHP Billiton's Leinster and Mount Keith; OJSC MMC Norilsk Nickel's Black Swan, Emily Ann and Maggie Hays; Jubilee Mines NL's (now Xstrata Nickel Australia Pty Ltd) Cosmos; Mincor Resources NL's Miitel, Redross, Mariners, Wannaway; Independence Gold NL's Long-Victor and Consolidated Minerals Ltd's (now Palmary Enterprises Pty Ltd) Beta Hunt operation. Nickel sulphides are mined also by Sally Malay Mining Ltd (now Panoramic Resources Ltd) at the Savannah mine (formerly Sally Malay) and the company continued mining at the Lanfrachi mine in a joint venture with Brilliant Mining Corp. Mining continued also at Australian Mining NL's Blair mine and at the Radio Hill deposit operated by Fox Resources Ltd. New nickel sulphide mines include Western Areas NL's Flying Fox deposit and Mincor's Otter Juan and North Dordie. Three laterite nickel mines were in operation: Norilsk's Cawse, Minara Resources NL's Murrin Murrin and mining operations commenced at BHP Billiton's Ravensthorpe mine. WA also has a nickel smelter at Kalgoorlie and a refinery at Kwinana as well as BHP Billiton's concentrators at Leinster, Mt Keith and Kambalda (which processes ores from third party operators). Another refinery is located at Yabulu in Qld. In June 2008 BHP Billiton commenced a rebuild of the furnace at its Kalgoorlie smelter.

NICKEL SULPHIDE DEPOSITS

According to BHP Billiton's March 2008 quarterly report, its West Australian operations produced 95,500 t of nickel for the 2007 calendar year with most sourced from the Mt Keith and Leinster mines.

Most of the nickel ore treated at the Kambalda, Leinster and Mt Keith concentrators, all in WA, is smelted into nickel matte containing about 68% nickel at the Kalgoorlie nickel smelter. The mill and concentrator at Kambalda are supplied with third party ore and produce concentrate containing about 13% nickel. Some of the nickel matte was sold to overseas customers but most of it was refined at BHP Billiton's Kwinana nickel refinery to produce LME accredited nickel briquettes, nickel powder and other intermediate products such as cobalt-nickel-sulphide. The Kwinana nickel refinery has a capacity of 70,000 tpa of nickel metal.

BHP Billiton also reported in its March quarter 2008 report that its 360,000 tpa nickel ore project at Cliffs in WA is 58% complete.

On 1 March 2007, as a result of the acquisition of OM Group's nickel business, OJSC MMC Norilsk Nickel (Open Joint Stock Company Mining and Metallurgical Company Norilsk Nickel) acquired the

initial 20% in MPI Nickel (Proprietary) Ltd which held 100% in Black Swan and the Honeymoon Well project. Norilsk Nickel then acquired the entire Black Swan operation in WA as a result of its acquisition on 28 June 2007 by LionOre Mining International Ltd, which held 80% in MPI Nickel (Proprietary) Ltd.

Norilsk Nickel reported production figures for 2007 of 12,006 t Ni from the Black Swan open pit and the Silver Swan underground mine. Norilsk Nickel's Lake Johnston operations of Emily Ann and Maggie Hays mines produced 6065 t Ni, and the Waterloo mine, also in WA, produced 57,818 t of ore at 3150 t of Ni.

Production from Jubilee Mines NL Cosmos deeps orebody was depleted in early 2007 and amounted to 6845 t Ni. Nickel production continued at the Alec Mairs 1 deposit and mining commenced at the Alec Mairs 2 and Tapinos deposits in early 2007. First production from the Prospero deposit was scheduled for late March 2008. A feasibility study on the Sinclair deposit was completed in December 2008 and a comprehensive review of the metallurgical work on the Anomaly 1 deposit was commenced. All of Jubilee's operations are in WA.

Xstrata Nickel Australia Pty Ltd completed compulsory acquisition of Jubilee on 31 March 2008.

Western Areas NL has seven separate mining and development projects underway plus a major expansion of the Cosmic Boy accommodation village, all of which are in WA. The company reported that mining at its Flying Fox deposit commenced in November 2007 and by end of the year nickel production amounted to 677 t Ni. Production is expected to reach 8000 t Ni in concentrate in 2008. A feasibility study was commenced on the Diggers South deposit which has indicated resources at the deposit amounting to about 80,300 t of nickel metal (44,700 t 'core' + 35,600 t 'halo'). The company is building a concentrator at Cosmic Boy also which is due to be commissioned in early 2009. In October 2007 the company announced the discovery of the Spotted Quill nickel deposit and by early 2008 it had delineated an indicated and inferred resource of 34,510 t Ni. By mid 2008 the company had a feasibility study in progress for a four year open pit operation.

During 2007, Panoramic Resources Ltd's (previously Sally Malay Mining Ltd) underground mine operation at Savannah (previously Sally Malay in the Kimberley region of WA) produced 7541 t Ni, 3812 t Cu, and 413 t Co. In early 2008 the company announced initial indicated and inferred resources for its northern ore zone and reported that drilling confirmed the continuation of the Main Ore Zone (MOZ) below the 500 Fault. Best drill results in the MOZ include 11.2 m at 1.62% Ni, 40.9 m at 1.63% Ni and 12.1 m at 2.08% Ni. The company also is proceeding with approval processes for the nearby Copernicus deposit (852,000 t at 1.24% Ni) which is being developed in a joint venture between Panoramic Resources Ltd (60%) and Thundelarra Exploration Ltd (40%). Panoramic Resources also holds 75% and is operator of the Lanfranchi joint venture nickel project. In 2007 Lanfranchi (in WA) produced 5083 t of Ni and 447 t of Cu. Mining of the high grade Winner ore deposit started during 2007 and the company commenced the development of the Deacon orebody which has an indicated and inferred resource of 58,089 t Ni and 5183 t Cu.

Mincor Resources NL operated six nickel mines in WA in 2007, comprising the Mittel, Redross, Mariners, Wannaway, plus two new mines, the Otter Juan and North Dordie mines. The combined metal in concentrate production for these mines in 2007 was 14,235 t Ni, 1227 t Cu and 253 t Co. Small scale remnant mining continued at the Wannaway mine. The company started developing its Carnilya Hill nickel mine and a decision was made to proceed with a \$23 million development of the McMahon Project. The company also concluded the acquisition from BHP Billiton of Bluebush Line of tenements which contain numerous nickel occurrences, including those at Cameron, Lawry, Grimsby and Stockwell. Early in 2008 the company reported an estimated inferred and indicated resource of 20,800 t Ni at the Stockwell and Grimsby prospects.

Fox Resources Ltd production from its Radio Hill mine in 2007 in north west WA, amounted to 1466 t Ni and 2344 t Cu. Near mine diamond drilling resulted in intersection of significant new mineralisation (the F-Zone) including 10.58 m at estimated grade of 1.4% Ni and 3.6% Cu from 106.5 m down hole depth. Significant mineralisation was encountered also at the Bertram prospect, 12 km south of the

Radio Hill mine. Fox Resources announced it had executed an agreement with Jinchuan Group Ltd, for all nickel and copper concentrates produced from the company's Sholl B2 Nickel Project.

Production from Australian Mines Ltd's Blair nickel mine (WA) in 2007 amounted to 904 t Ni. During the year the company deepened the main decline and resumed the development of Blair Deeps ore shoots. It is anticipated that nickel resources in Area 57 will be mined out in 2008. The company also reported that exploration at the Marriott nickel deposit increased the nickel resource in this deposit by 25% to 9400 t. The company continued exploration of its Golden Ridge joint venture areas around the Blair mine and announced an inferred resource of 16,000 t for its Goodyear deposit south of the Golden Ridge area.

Independence Group NL reported total production for 2007 of 11,019 t Ni and 802 t Cu from its Long, Victor South and McLeay mines. The company is continuing to explore for extensions of ore south of the Long and Victor-McLeay orebodies.

Consolidated Minerals Ltd reported a production of 2913 t Ni up to 30 September 2007. The production was sourced mainly from the East Alpha and Beta Hunt operations at Kambalda with additional contribution from selective mining from the Armstrong pit. Mining operations also commenced at the 132N deposit at Widgiemooltha. The company announced plans to expand the Kambalda operation towards the end of 2007. Drilling at the Gillet Prospect continued to intersect significant nickel mineralisation including 14 m at 3.34% Ni. Consolidated Minerals Ltd was taken over by Palmary Enterprises Pty Ltd in January 2008. All of these operations are in WA.

Australasian Resources Ltd continued with planning of a proposal for a 5000 t nickel heap leach trial at its Sherlock Bay nickel project in WA.

Tectonic Resources NL closed the small mining operation at RAV 8 (WA) in September 2005, but with appreciating nickel prices the company continued delivery of small parcels of ore from low grade dumps in 2007. By September 2008 the mine had produced about 53 t Ni and the company announced that all mining activities at RAV 8 have ceased. Tectonic Resources has a farm in agreement with Mincor Resources NL which allows Mincor Resources to explore the RAV 8 tenement area.

Allegiance Mining NL reported that by the end of 2007 the company had commenced mining from all three main orebodies in Tasmania at Avebury; Viking, North Avebury and Central Avebury. The ore stockpile at the end of 2007 totalled 45,200 t. Exploration in the immediate mine area intersected 17 m at 1.4% Ni about 100 m below the base of the current calculated Viking resource. The company also reported high grade intersection, 2.3 m at 2.27% Ni and 1.77% Cu, at Melba Flats on the Nickel Reward prospect. Elsewhere during 2007 the company discovered its first ore-grade intercept outside the main Avebury mineralised zone. The discovery which was at the company's Foundation Stone prospect, was an intercept of 8 m averaging 1% Ni. Wet commissioning of the Avebury processing plant is expected to take place in 2008.

Zinifex Australia Ltd made a takeover offer for all of the ordinary shares in Allegiance Mining and by 21 April 2008 it had acquired a controlling interest of 85.6% in Allegiance Mining.

Compass Resources NL reported in May 2008 that early commissioning activities have commenced at the Browns oxide project in NT, and will continue through June 2008. It is anticipated production for export will be 10,000 tpa of copper cathode, 1000 tpa of cobalt chemicals and 750 tpa of nickel chemicals.

LATERITIC NICKEL DEPOSITS

The annual production for 2007 from the Murrin Murrin lateritic nickel plant (WA), operated by Minara Resources Ltd, amounted to 27,585 t Ni and 1884 t Co. The mine production was impacted by a planned seven week \$100 million plant shut down for statutory maintenance and major refurbishment to upgrade plant performance. The company commissioned a heap leach demonstration plant early in 2007 and the plant is operating to capacity to deliver at the rate of more than 2000 tpa Ni metal and 150 tpa Co metal by the end of 2008. In March 2008 Minara's Board gave approval for a \$300 million heap leach expansion which it is anticipated will deliver 8000 to 10,000 tpa of Ni.

OJSC MMC Norilsk Nickel reported an annual production of 4554 t Ni from its lateritic Cawse deposit in WA.

BHP Billiton's Ravensthorpe project (WA) is based on three laterite nickel deposits with combined proved and probable reserves of 238 Mt at 0.68% Ni. The operation includes development of an open cut mine, hydrometallurgical treatment plant and associated infrastructure. The hydrometallurgical process plant is designed to treat both limonite and saprolite ores and produce up to 220,000 t of mixed nickel-cobalt hydroxide intermediate product containing up to 50,000 t of nickel and 1400 t of cobalt which will be shipped from Esperance to the Yabulu refinery in Qld. The refining section of Yabulu has been expanded to increase production to 76,000 t of nickel and 3500 t of cobalt. BHP Billiton commenced production of mixed nickel-cobalt hydroxide product in October and achieved its first production milestone of 5000 t in the December quarter of 2007. The Yabulu expansion project in Qld was completed in the March quarter in 2008.

On 30 July 2005, Heron Resources Ltd signed a definitive farm-in and joint venture agreement with Inco Ltd (now Vale Inco Ltd) providing for the potential development of the Kalgoorlie Nickel Project (KNP, in WA). One of the main objectives for Vale Inco in its feasibility studies will be to evaluate whether a plant-scale screen upgrade to 1.5% Ni is achievable. Heron reported that on 5 November 2007, Vale Inco advised that it would proceed with the KNP Step 3 of the prefeasibility study which involves the completion of the study by end of January 2009. Vale Inco will investigate the application of high pressure acid leach, heap leach and atmospheric leach to the extraction of nickel from laterite ores of the KNP. Under the terms of the agreement a feasibility study must be finished by July 2011. The agreement also requires that subject to a positive bankable feasibility study result, a decision to mine must be made before 2013. In January 2008 the company announced that its prefeasibility study indicated that escalating costs did not justify investment in a heap leach process for the Jump-up Dam deposit (outside Heron's KNP project area). Instead, the company decided to evaluate atmospheric leach as a processing option for Jump-up Dam and the surrounding deposits collectively referred to as the Yerilla nickel project.

In April 2008, Metallica Minerals Ltd updated the lateritic nickel resources of the NORNICO group of lateritic deposits, including Minnamoolka and Bell Creek deposits, to 35.51 Mt at 0.73% Ni and 0.04% Co with a 0.45% Ni cut-off. A feasibility study on the NORNICO project is progressing on a 1 Mt per annum heap leach nickel operation producing 7500 tpa Ni. Metallica is in a joint venture with Metals Finance Corporation to develop the Lucky Break deposit which has 1.022 Mt at 0.8% Ni and 0.05% Co. Experience from the proposed development of Lucky Break is intended to provide information for the much larger NORNICO project. Apart from the NORNICO and Lucky Break projects, Metallica is exploring the cobalt-rich nickel laterite deposit of Kokomo which has indicative grades of 0.6% to 0.9% Ni, 0.12% to 0.25% Co and contains areas of high scandium grades.

Metals X Ltd is undertaking a detailed feasibility study for the development of its Wingellina nickel-cobalt oxide deposit in WA, with an updated financial feasibility study to be completed in July 2008 and a detailed feasibility stage to be completed in mid 2009. The feasibility study is focusing on development of a mine and associated infrastructure to produce 40,000 t of Ni and 3500 t of cobalt metal per annum.

In January 2008, Gladstone Pacific Nickel Ltd announced the results of an integrated definitive feasibility study for its proposed mining operation of lateritic nickel at Marlborough, Qld, and for its proposed nickel processing plant at Yarwun, near Gladstone. The plant is anticipated to process a blend of Marlborough ore (around 30%) with east coast New Caledonian ore (around 70%) to produce about 64,700 t of Ni and 6160 t of cobalt in its first year of production. The first year of full production is expected to be 2015.

Niobium

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Niobium (Nb) and tantalum often are found together in the same ores due to their very similar chemical properties. Niobium is used in alloys by steel and aerospace industries and niobium-titanium alloy wire is utilised in the medical sector for magnetic resonance imaging. In Australia, niobium is recovered as a by-product of tantalum mining.

Resources

Total niobium EDR was 40 kt in 2007. Most of Australia's EDR of niobium is in the Greenbushes deposit in WA. All of Australia's EDR of niobium is accessible. In 2007, JORC code reserves of niobium accounted for just over 50% of EDR.

Paramarginal resources totalling 144 kt accounts for all the subeconomic demonstrated resources. Almost 80% of the paramarginal resources are in the Toongi deposit (Dubbo Zirconia Project) near Dubbo in NSW. Inferred resources are estimated to be 811 kt. WA is the largest holder of inferred resources with 85% and NSW holding the remaining inferred resources.

Exploration

Exploration for niobium is occurring in WA and NSW but data relating to exploration are not available.

Production

Production of niobium is not reported, but the USGS estimated a total of 0.2 kt of niobium in export tantalum products was produced in Australia during 2007.

World Ranking

Based on world estimates published by the USGS for 2007, the world's largest niobium resources are located in Brazil, which accounts for 2600 kt of the estimated world EDR of 2700 kt. Canada has the second largest EDR with 62 kt, followed by Australia, although data are incomplete for 2007.

Based on USGS, world production of niobium in 2007 amounted to 45 kt. The USGS estimates that production was dominated by Brazil with 40 kt in 2007 followed by Canada with 4.2 kt and Australia with 0.2 kt.

Industry Developments

In August 2007, the assets of Sons of Gwalia were sold to a consortium of five private equity funds which led to the formation of Talison Minerals Pty Ltd comprising the Sons of Gwalia Ltd assets, including the Greenbushes and Wodgina mines and exploration leases near Wodgina mine in WA. Wodgina is an open pit mine with a primary processing plant. The Greenbushes operation consist of an open pit and underground mines, primary and secondary tantalum processing plants, tin smelter and a lithium plant. Greenbushes open pit is operating and the secondary processing plant is processing primary tantalum concentrates from the Wodgina mine. The primary tantalum plant remains under care and maintenance.

Alkane Resources Ltd is undertaking process optimisation and development work for its Dubbo Zirconia Project in NSW. In April 2008, a demonstration pilot plant was commissioned at ANSTO Minerals in Sydney. The pilot plant is testing the mechanical and process integrity of the flow sheet to recover a suite of zirconium chemicals, zirconia, niobium-tantalum concentrate and yttrium-rare earth concentrate.

Phosphate

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Phosphate rock is a general term which refers to rock with high concentrations of phosphate minerals, most commonly of the apatite group. It is the major resource mined to produce phosphate fertilisers for the agriculture sector. Phosphorous also is used in animal feed supplements, food preservatives, anti-corrosion agents, cosmetics, fungicides, ceramics, water treatment and metallurgy. There is no substitute for phosphate.

Australia's commercial resources of phosphate are in north west Qld at Phosphate Hill, 140 km south east of Mount Isa and on the Territory of Christmas Island in the Indian Ocean. Phosphate Hill is a world-class rock phosphate resource which is close to the surface, easy to access and mine. The rock

is ideal for the manufacture of high analysis mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP) fertilisers for domestic and international use.

Christmas Island is a source of quality rock phosphate of which approximately 0.7 Mtpa is exported to the Asia-Pacific region with products used widely in the palm oil sector of the region. Sales of higher-grade rock phosphate are made to Australian manufacturers of MAP fertiliser.

DAP and MAP have different ratios of phosphorous (P) and nitrogen (N), and have slightly different applications. Both products are generally produced as granules with a diameter of between 2-4 mm. DAP (20% P and 18% N) is used on broad-acre crops such as cereal, legume, fodder, horticultural and row crops as well as for dairy and newly-established pastures. MAP (22% P and 10% N) assists with early crop growth and enhances phosphorous uptake in broad-acre crops.

Resources

Excluding Christmas Island resources, EDR of phosphate rock is 81.6 Mt. There is no publicly available information on phosphate rock resources for Christmas Island. All EDR is sedimentary phosphate rock (phosphorites) from Phosphate Hill, Qld, which has an average grade of about 24% P₂O₅. All EDR is accessible for mining and account for 100% JORC Code reserves.

About 93% of Australia's demonstrated resources occur in the Georgina Basin in Qld and are classified as paramarginal totalling 911.6 Mt. Two deposits, Swan and Emu, occur within carbonatite at Mount Weld 26 km south east of Laverton, WA and make up the remaining 7% of demonstrated resources.

The bulk of Australia's inferred phosphate resources are in phosphorites in the Georgina Basin, and are estimated to be 1150.1 Mt. These resources are distributed between Qld and the NT.

Exploration

There is renewed interest in phosphate rock exploration in Qld, the NT and WA although specific data relating to phosphate rock exploration are not available.

Production

There are two main locations for the production of phosphate rock; Phosphate Hill (Qld) and Christmas Island. Several small operations near Bendleby, SA are mainly used in domestic industrial applications.

The Queensland Department of Mines and Energy estimates that Incitec Pivot's production from Phosphate Hill in 2006-07 amounted to 2.129 Mt of phosphate rock. Phosphate Resources Ltd's production figures for Christmas Island operations in 2007 are not available because of commercial-in-confidence reasons. In 2005-06 the company exported 0.959 Mt of phosphate rock and 0.069 Mt of phosphate dust.

World Ranking

USGS estimated that total world resources are 18,000 Mt. Australia's EDR of phosphate rock comprises less than 1% of the world's resources. China and Morocco hold about 36% and 32% respectively followed by South Africa with 8% and the USA with 6%.

World production totalled 147 Mt in 2007, with China producing 35 Mt, the USA 29.7 Mt and Morocco 28 Mt. USGS estimates that in 2007 Australia produced 2.2 Mt, excluding Christmas Island.

Industry Developments

Phosphate rock prices rose strongly during 2007 from around US\$50 per tonne to US\$200 per tonne. The rise in price is due to the increasing global demand for fertiliser for food production and for biofuel crops as well as to tighter phosphate rock supplies from Middle East and North Africa.

In Queensland, Legend International Holdings Inc. (Legend) has phosphate projects in the Georgina Basin where its main focus is the development of the Lady Annie and Lady Jane deposits north west of Mount Isa, Qld. A feasibility study in 1974 indicated mining, beneficiation and pipeline transport

of concentrated slurry to the Gulf of Carpentaria was feasible. The company plans to transport 4-5 Mt of phosphate rock slurry via a 300 km pipeline to a port facility in Gulf of Carpentaria and export to the Asian market. A pre-feasibility study is planned to start in early 2008, with mining scheduled to commence in the forth quarter of 2009.

In the Northern Territory, Minemakers Ltd owns the Wonarah phosphate project in the Georgina Basin. The company is undertaking further resources assessment, a pre-feasibility study and metallurgical test work. Minemakers Ltd is aiming to produce and export 3 Mtpa of beneficiated phosphate rock from 2010.

On Christmas Island, Phosphate Resources Ltd is seeking an additional 200 hectares of land for mining, which would extend phosphate operations from 5 years up to 12 years. However, in May 2007 the environmental approval for the proposed extension was not granted but the company is appealing the decision in the Federal Court. The case is expected to be heard in 2008.

Rare Earths

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Rare earths are a group of 15 elements with atomic numbers ranging from 57 to 71. In order of their respective atomic numbers the elements are: lanthanum (La), cerium (Ce), praseodymium (Pr), neodymium (Nd), promethium (Pm), samarium (Sm), europium (Eu), gadolinium (Gd), terbium (Tb), dysprosium (Dy), holmium (Ho), erbium (Er), thulium (Tm), ytterbium (Yb), and lutetium (Lu). Two other elements, scandium (Sc) and yttrium (Y), are commonly classed as rare earths because of their natural association with rare earths.

The market for rare earth elements has experienced a dramatic growth over the past decade with total rare earth oxides (REO) demand of 85,000 t in 2003 rising to 117,000 t in 2007. Consumption is predicted to increase also by 2012 to between 180,000 t and 190,000 t with a total value of US\$2,000 million. The biggest increases in demand are due to predicted expansion in hybrid cars with lanthanum used in rechargeable batteries and neodymium in high power magnets for 3 million vehicles by 2012 as well as disk drives and speakers. Other sectors include petroleum catalyst lanthanum and autocatalyst cerium, which has application also in glass manufacturing and polishing and multi-level electronic components, yttrium stabilised zirconia also is used in high wear resistance ceramics. The smallest sector by volume but largest by value are europium and terbium which are used in the production of phosphors for televisions and energy efficient lamps.

The main consumers of rare earths are China, the US, Japan, Korea and Thailand with China reportedly consuming about 50% of its rare earth production. The Chinese government has imposed production and export restrictions, adding upward pressure on prices for rare earths and contributing to incentives for development of rare earth resources outside China.

Resources

Geoscience Australia's latest estimate of Australia's demonstrated resources of rare earths reported as REO amounted to about 27.9 Mt (1.13 Mt EDR and 26.8 Mt sub-economic) with a further 24.4 Mt in the inferred resources category. About 45 Mt of these resources are in the Olympic Dam iron oxide copper gold deposit (dominantly 0.2% La and 0.3% Ce) and are not currently economic. Small quantities of yttrium (3,300 t Y₂O₃) and scandium (770 t Sc), commonly included with rare earths, were reported as inferred resources. In addition, about 4,000 t of demonstrated resources and 52,000 t of inferred resources were reported as rare earth elements (REE).

Very significant resources of rare earths are contained in the monazite component of heavy mineral sand deposits, which are mined for their ilmenite, rutile, leucoxene and zircon content. Monazite is a rare earth-thorium phosphate mineral, found within heavy mineral sand deposits in Australia. Using available information, Geoscience Australia estimates Australia's monazite resources to be of the order of 6.2 Mt. Assuming a REO content of Australian monazite to be about 60%, the heavy mineral deposits could

hold an REO resource in the order of 3.72 Mt. Currently, extraction of rare earth from monazite is not viable because of the cost involved with the disposal of thorium and uranium present in the monazite.

Production

Mining operations have commenced at the Mt Weld deposit in WA and by the end of 2007 some 98,000 cubic metres of ore had been stockpiled pending the completion of a concentration plant at the mine site. There was no recorded production of REO in Australia during 2007.

Globally, the production and resources of rare earths is dominated by China which accounts for 97.8% of the production followed by India with 2.2%. The REO production figures for the Commonwealth of Independent States are not available.

World Ranking

China holds 27 Mt (32.4%) of the EDR for REO, followed by the Commonwealth of Independent States 19 Mt (22.8%) REO and the US with 13 Mt (15.6%). Australia accounts for 1.4% of world EDR with 1.13 Mt REO.

The main types of REE deposits make up the largest REO resources in the world, the Bayan Obo deposit in China, which is predominantly REE-iron ores with bastnasite and monazite as the main REE bearing minerals, totalling at least 48 Mt REO at a grade of 6%. The only production of REOs from REE bearing carbonatite has been from the Mountain Pass deposit in California which has total resources of 1.8 Mt REO at an average grade of about 9% REO. Deposits associated with carbonatite laterites include Araxa in Brazil with 8.1 Mt REO at 1.8% and Mt Weld in WA with 1.18 Mt REO at 9.7%. Other deposit types include Nolans Bore, NT (vein type); Toongi, NSW (alkaline trachyte); and Lovozero, Russia (peralkaline syenite).

Industry Developments

Mt Weld in WA (in laterite over alkaline carbonatite complex), owned by Lynas Corporation Ltd, started mining the deposit in 2007. In early 2008 the company announced an increase in resources to 12.2 Mt at 9.7% REO with an REO content of 1.18 Mt. The company has decided to build a concentration plant at the mine site and construction of a treatment plant has begun in Malaysia. The company anticipates beginning production in Malaysia in the third quarter of 2009 and attain full production of 21,000 t in 2011. In another part of the carbonatite complex there are indicated (1.5 Mt) and inferred (36.2 Mt) resources totalling 37.7 Mt which include total lanthanides at 1.16% and 0.09% Y_2O_3 .

Arafura Resources Ltd's Nolans Bore rare earth deposit is a phosphate uranium deposit located 135 km northwest of Alice Springs in the NT containing thorium (18.6 Mt at 3.1% REO). The deposit has the potential to be a large, high grade, low cost producer of rare earths. Production is expected to begin in 2010.

The Dubbo Zirconia project, owned by Alkane Resources Ltd, located 30km south of Dubbo in NSW is undergoing a feasibility study, the results of which should be known by late 2008, with expectations of a 200,000 tpa ore throughput producing 3,000 t as zirconium sulphate, zirconium hydroxide and zirconium carbonate, 600 t of niobium pentoxide as 80% concentrate; and 1,200 t of yttrium rare earth oxide as 70% concentrate.

The Cummins Range carbonatite deposit occurs in the south east part of the Kimberley region in WA. In March 2008 Navigator Resources Ltd reported inferred resources of 3.55 Mt at 2% REO, 11.2% P_2O_5 , 216ppm U_3O_8 and 36ppm Th.

The Yangibana ferrocarnatite-magnetite-rare earth-bearing dykes (ironstones) form part of the Gifford Creek Complex in WA. The dykes occur as lenses and pods, are typically the last stage of carbonatite fractionation and are enriched in REEs, fluorite and U-Th mineralisation. The Yangibana prospect has a recorded resource of 3.5 Mt at 1.7% REO. The rare earths are in coarse grained monazite containing up to 20% Nd_2O_5 and 1,600ppm Eu_2O_3 .

Other deposits of possible significance include Olympic Dam iron oxide copper gold deposit and the Mt Gee uranium rare-earth deposit in SA.

Shale Oil

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Oil shale is organic-rich shale, which yields substantial quantities of oil (normally referred to as shale oil) and combustible gas by heating (retorting) and distillation. The organic material in oil shale is called kerogen, which under appropriate conditions in the crust can be a precursor to conventional oil reservoirs. One tonne of commercial grade oil shale may yield from about 100 to 200 L of oil.

Resources

Oil shales of commercial interest are predominantly in a series of narrow and deep extensional-basins near Gladstone and Mackay in central Qld. These are thick Tertiary lacustrine (lake-formed) deposits, which are relatively easy to mine and process compared to carbonate-rich oil shales (marls) elsewhere in the world. The Permian Galilee and Bowen Basins in Qld contain oil shale associated with coal measures. Oil shales occur in the Cretaceous Toolebuc Formation of the Eromanga Basin in north west Qld. Minor deposits are located in northern Tas (Latrobe tasmanite deposit) and an oil shale – heavy mineral sand deposit in southern WA.

Australia has 4.5 GL (28 million barrels) of shale oil EDR. This could increase significantly if research and development into processing shale oil resulted in the development of a commercial plant. Paramarginal and submarginal demonstrated resources are 208.5 GL (1.3 billion barrels) and 3,719 GL (23.4 billion barrels) respectively. As at December 2007 all of shale oil EDR was accessible, however on 24 August 2008, the Queensland Premier announced a 20-year moratorium on activities over the McFarlane (Condor) oil shale deposit in the Whitsunday region, and two years of research into whether oil shale deposits can be environmentally developed. This will result in a portion of EDR being inaccessible for mining over the next 20 years. Inaccessible resources will be reported in the next edition of AIMR.

An inferred resource is estimated to amount to 246,115 GL. This figure includes the 'total potential' shale oil resources of the Toolebuc Formation of around 245,000 GL estimated by the Bureau of Mineral Resources (now Geoscience Australia) and the CSIRO in 1983². The research project undertook detailed geological, petrophysical and geochemical examination of the oil shales of the Toolebuc Formation. The objectives of the project included investigating and developing methods to assist government and industry to assess the potential of the sedimentary sequence as a possible future source of oil shale and developing an understanding of geological controls and the distribution of oil shale within the Toolebuc Formation. A resource assessment of around 245,000 GL was based on a productive oil shale covering an area of 484,000 km² that ranges in thickness from 6.5-7 m, a specific gravity of 1.9 and yields an average 37 L of oil per tonne.

Exploration

Exploration is predominantly focused near Gladstone and Mackay in central Qld and north west Qld. South east of Devonport in Tas, Boss Energy Ltd is continuing to undertake exploration work to define the resource extent of the Latrobe oil shale deposit. Data relating to shale oil exploration are not available.

Production

There is no oil being extracted from oil shale in Australia. From 2000 to 2004, the Stage 1 demonstration-scale processing plant at the Stuart deposit near Gladstone in central Qld produced more than 1.5 million barrels of oil using a horizontal rotating kiln process (Alberta Taciuk Process). No oil has been produced since 2004. The facility is currently being dismantled.

The demonstration plant achieved stable production capacity of 6,000 t of shale per day and oil yield totalling 4,500 barrels per stream day while maintaining product quality and adhering to Environment Protection Authority emissions limits. The oil products from the demonstration plant were Ultra Low

² Ozimic, S. and Saxby, J.D., 1983. Oil Shale Methodology: An examination of the Toolebuc Formation and the laterally contiguous time equivalent units, Eromanga and Carpentaria Basins. Bureau of Mineral Resources and CSIRO research project.

Sulphur Naphtha (ULSN) 55% to 60% and Light Fuel Oil (LFO) 40% to 45%. The ULSN, which can be used to make petrol, diesel and jet fuel has a sulphur content of less than 1ppm. To put this into perspective, from January 1, 2008, the regulated maximum content of sulphur in premium unleaded petrol will be reduced from 150ppm to 50ppm.

World Ranking

The 2007 Survey of Energy Resources by the World Energy Council (WEC) reported that total world resources of shale oil are estimated at 2.8 trillion barrels (around 550,000 GL). The largest known deposit is in western USA (2.6 trillion barrels), with other important deposits in the Russian Federation, the Democratic Republic of the Congo, Brazil, Italy, Morocco, Jordan, Australia and Estonia. Only Estonia, China and Brazil produce shale oil. The same WEC survey reported that total oil production for 2005 was 859 ML, with Estonia producing 433 ML, China 226 ML and Brazil at 200 ML.

Industry Developments

There is renewed interest in shale oil worldwide. In Australia during the past 12 months there has been increased exploration activity. Currently, four companies are reviewing and testing extraction technologies, these include:

- Blue Ensign Technologies Ltd (Julie Creek Project (south), NW Qld): Thermal solution technology (Rendall Process), involving thermal conversion and hydrogenation followed by supercritical solvent extraction.
- Xtract Energy Plc (Julie Creek Project (north), NW Qld): Xtract technology, using hydrogen and supercritical solvent extraction process.
- Greenvale Mining NL (Alpha project, Qld): Surface processing involving microwave technology, which uses specific frequencies of microwave radiation to extract hydrocarbons.
- Queensland Energy Resources Ltd (Stuart Project, Qld): Paraho vertical shaft kiln processing system.

On 24 August 2008, the Queensland Premier announced a 20-year moratorium on activities over the McFarlane (Condor) oil shale deposit in the Whitsunday region, and two years of research into whether oil shale deposits can be environmentally developed. There are uncertainties about details and strong concerns have been expressed by oil shale companies and the broader minerals sector.

Tantalum

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Tantalum minerals have more than 70 different chemical compositions, of which tantalite, microlite, and wodginite are of greatest economic importance. It is common practice to name any mineral concentrate containing tantalum as 'tantalite' primarily because it will be processed for the tantalum.

Australia, through the Greenbushes and Wodgina operations in south west WA, is the world's largest producer of tantalum in the form of tantalum concentrates, producing almost half of the world mine output.

Resources

In Western Australia, granitic rare-metal pegmatites are almost exclusively the dominant style of primary tantalum mineralisation. The only exceptions are the carbonatite style at the Mount Weld deposit in the eastern goldfields, WA and an unusual form of subalkaline granite-syenite mineralisation at the Brockman deposit, south east of Halls Creek, WA.

Australia's tantalum EDR are estimated to be 41 kt in 2007. All tantalum EDR are accessible for mining. Approximately 98% of EDR comprises JORC Code ore reserves as reported by industry. Subeconomic demonstrated resources accounts for about 44% of total demonstrated resources. The paramarginal and submarginal resources amount to 32 kt and 0.2 kt, respectively. Inferred resources are estimated to be 87 kt. WA is the largest holder of tantalum with 88% of total demonstrated resources at 88% while NSW accounts for the remaining 12%.

Exploration

Data relating to exploration for tantalum are not available. Talison Minerals Pty Ltd is undertaking exploration near the Wodgina mine in the Pilbara region of Western Australia.

Production

In 2007, production of tantalite was estimated to be 435 t. Production decreased by about 25% in 2007 due to lost production at Wodgina caused by the effects of a major cyclone. All production was from the Wodgina mine where the ore is crushed at a primary plant before being transported to Greenbushes mine for secondary processing and upgrading to a final product.

World Resources and Production

USGS revised the world total resources to 130 kt in 2007, an increase of 135% from 2006 due to revised resources estimates for Brazil. The world's largest tantalum resource holder is Brazil with an estimated 88 kt, followed by Australia with 41 kt and Canada with 3 kt.

World production of tantalum in 2007 was estimated by Geoscience Australia (using Western Australian Department of Industry and Resources and USGS data) to be 985 t, a decrease of about 14% compared with 2006. Production was dominated by Australia, with 435 t in 2007, which amounted to about 44% of world output, although this figure is not complete for 2007. According to the USGS, other main producers were Brazil with 250 t, Mozambique, Canada and Ethiopia each producing 70 t.

Industry Developments

Over the past few decades, the tantalum market has been characterised by long periods of stability because the world's two largest tantalum processors have entered into long-term, fixed price supply contracts. The market has been over supplied for the past five years but is starting to show signs of tightening.

In August 2007, the assets of Sons of Gwalia were sold to a consortium of five private equity funds. Talison Minerals Pty Ltd was formed and comprises the Sons of Gwalia Ltd assets, which includes the Greenbushes and Wodgina mines in WA and exploration leases near Wodgina mine. Wodgina is an open pit mine with a primary processing plant. The Greenbushes operation consist of an open pit, underground mine, primary and secondary tantalum processing plants, tin smelter and a lithium plant. Greenbushes open pit is operating and the secondary processing plant is processing primary tantalum concentrates from the Wodgina mine. The primary tantalum plant remains under care and maintenance.

Thorium

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Thorium oxide (ThO₂) has one of the highest melting points of all oxides (3,300°C) and has been used in light bulb elements, lantern mantles, arc-light lamps, welding electrodes and in heat resistant ceramics.

Thorium also can be used as a nuclear fuel through breeding to U²³³. Several reactor concepts based on thorium fuel cycles are under consideration, but much development work is required before it can be commercialised. Early in April 2008, India commissioned a critical facility designed to conduct experiments to validate reactor physics for a 300 megawatt electric (MWe) technology demonstrator thorium-fuelled Advanced Heavy Water Reactor (AHWR). The facility was fuelled with natural uranium and went critical in early April 2008. Natural uranium fuel will be used to simulate Pressurised Heavy Water Reactors and thorium-uranium 233 fuel will be used to simulate the AHWR. However, full commercialisation of the AHWR is not expected before 2030.

The critical facility can be used also for experiments to simulate an Accelerator Driven System which can be used to burn thorium.

A research program at Moscow's Kurchatov Institute involves the United States company, Thorium Power Ltd, and is supported by United States Government funding to develop thorium-uranium fuel for the existing Russian Vodo-Vodyanoi Energetichesky (VVER-1000) reactors. While normal fuel uses enriched uranium oxide (UO_2), the new design has a demountable centre portion and blanket arrangement, with plutonium fuel in the centre surrounded by a blanket of thorium uranium fuel. The Th^{232} becomes U^{233} , which is fissile, as is the core Pu^{239} . Blanket material remains in the reactor for nine years but the centre portion is burned for only three years (as in a normal VVER) (World Nuclear Association Information Paper – Thorium, March 2008).

One of the main objectives of this program is to eliminate weapons grade plutonium by using it as thorium-plutonium fuel in nuclear reactors. More recently, (Platts Nuclear Fuel 19 November 2007), Thorium Power Ltd stated that it was shifting the emphasis of its thorium fuel development to commercial deployment of thorium-based fuel in the United States.

Thorium Power Ltd has successfully completed a three year test of experimental thorium fuel rods and is planning further testing to qualify the fuel for widespread use, initially in VVERs, then in other current light water reactors (World Nuclear News, 22 March 2007).

The company stated that because parts of fuel assemblies can remain in a reactor for up to nine years, more of the highly-radioactive actinides produced by fission are burnt, resulting in a 50% reduction in waste volume and a 90% reduction in waste toxicity. As a result, waste storage time is reduced to between 100 and 800 years. There also is a 10-20% improvement in fuel savings versus a conventional uranium fuel cycle (personal communication Dr A. Mushakov, Thorium Power Ltd, October 2007).

Thorium Power Ltd is planning further testing to qualify the fuel for widespread use – first in VVERs, then in other current light water reactors. The research program is on track for deployment of lead test assemblies within three years.

Atomic Energy of Canada Ltd (AECL) claims that its Advanced CANDU Reactor (ACR) 1000 reactors of 1080 to 1150 MWe will have the flexibility to use a variety of fuels including natural uranium, low enriched uranium, thorium and DUPIC (Direct Use of Spent Pressurised Water Reactor (PWR) Fuel). AECL noted that it is moving towards certification of ACR 1000 in Canada and the earliest in-service date for an ACR 1000 (Generation III+ 1200 MWe) unit is 2016. However, it is anticipated that use of thorium fuel will be in a later stage. In the shorter term, some jurisdictions are assessing the use of thorium cycles in existing CANDU 6 (700 MWe class) reactors.

Resources

There are no comprehensive detailed records on Australia's thorium resources because of the lack of large-scale commercial demand for thorium and a paucity of the required data.

Most of the known thorium resources in Australia are in the rare earth-thorium phosphate mineral monazite within heavy mineral sand deposits, which are mined for their ilmenite, rutile, leucoxene and zircon content. Prior to 1996, monazite was being produced from heavy mineral sand operations and exported for extraction of rare earths. However, in current heavy mineral sand operations, the monazite is generally dispersed back through the original host sand (to avoid the concentration of radioactivity) when returning the mine site to an agreed land use. In doing so, the rare earths and thorium present in the monazite are negated as a resource because it would not be economic to recover the dispersed monazite for its rare earth and thorium content. The monazite content of heavy mineral resources is seldom recorded by mining companies in published reports.

Most of the known resources of monazite are in Victoria and Western Australia. Mining of heavy mineral sands has begun in the Murray basin deposits at Ginkgo in New South Wales and at Douglas in Victoria while construction of another inland heavy mineral mine is well under way at Mindarie in South Australia.

Using available data, Geoscience Australia estimates Australia's monazite resources in the heavy mineral deposits to be around 6.2 Mt. The data on monazite and the thorium content in the monazite in the mineral sand resources is very variable, but the available sources include:

- Analyses for monazite and thorium in published and unpublished reports;
- published and unpublished analyses of thorium content in exported monazite concentrates; and
- monazite and thorium analyses on heavy mineral sand deposits in company reports on open file available at some State Geological Surveys.

Information from these sources was applied to resource data on individual heavy mineral sand deposits to estimate the thorium resources in these deposits. Where local data on the monazite and thorium was not available, regional data were applied to individual deposits to estimate their monazite and thorium resources. Using this information, Australia's inferred thorium resources in the mineral sands were estimated to be around 376,000 t.

Apart from heavy mineral sand deposits, thorium can be present in other geological settings such as alkaline intrusions and complexes, including carbonatites, and in veins and dykes. A significant example is the Nolans Bore rare earth, phosphate uranium deposit in Northern Territory, which is in fluorapatite veins and dykes. This deposit contains about 60,600 t of ThO_2 (53,300 t of Th) in 18.6 Mt of indicated and inferred resources grading 3.1% rare earth oxides, 14% P_2O_5 , 0.021% U_3O_8 and 0.326% ThO_2 .

In New South Wales, the Toongi alkaline trachyte plug is located 30 km south of Dubbo and hosts a measured resource of 35.7 Mt and 37.5 Mt of inferred resources grading 1.96% ZrO_2 , 0.04% HfO_2 , 0.46% Nb_2O_5 , 0.03% Ta_2O_5 , 0.14% Y_2O_3 , 0.745% total REO, 0.014% U_3O_8 , and 0.0478% Th, giving a total of about 35,000 t contained Th.

Similarly the peralkaline granitic intrusions of the Narraburra Complex 177 km north west of Canberra contain anomalous amounts of zirconium, REO and low concentrations of thorium (55 Mt at 1000 g/t ZrO_2 , 60 g/t Y_2O_3 , 300 g/t REO, 40 g/t HfO_2 , 80 g/t NbO_2 , and 50 g/t ThO_2).

Other alkaline complexes with known rare earth and thorium mineralisation include Brockman in Western Australia. It is a large low-grade Zr-Nb-REE deposit hosted in altered trachytic tuff of Palaeoproterozoic age containing mineralised material of 50Mt at 4,400ppm Nb, 270ppm Ta, 1.04% Zr, 1,240ppm Y, 350ppm Hf, 110ppm Ga and 900ppm REE (Aztec Resources Ltd, 2004 Annual Report). Historic company reports on open file on the Geological Survey of Western Australia WAMEX database show analyses for thorium in six separate drill hole intersections (in tuffs) of 16m to 28m averaging from 259 to 371ppm Th (Western Australia Geological Survey WAMEX database report A 40991).

Data on the thorium content of carbonatite intrusions in Australia is sparse. Mount Weld and Cummins Range in Western Australia have the most significant rare earth resources reported for carbonatites in Australia to date with both having some thorium content.

The Mount Weld deposit in Western Australia occurs within the regolith profile developed over the carbonatite and has a resource of 273Mt at 0.9% Nb_2O_5 . Tantalum is usually, but not always, associated with niobium, and the estimated resource amounts to 145Mt at 0.034% Ta_2O_5 . The typical thorium content is reported to be about 600ppm Th ($\sim 0.069\%$ ThO_2 – Carr Boyd Minerals Ltd, Mt Weld project promotion brochure, April, 1991). More recently Lynas Corporation Ltd quoted an REO resource of 7.7Mt at 12% REO with a ThO_2 content of 44ppm per 1% REO which works out about 464ppm Th. (http://www.lynascorp.com/content/upload/files/Presentations/Investor_Presentation_January_2008_-_Revised_31.1.08.pdf).

In March 2008, Navigator Resources Ltd reported inferred resources for Cummins Range in Western Australia carbonatite deposit of 3.55Mt at 2% REO, 11.2% P₂O₅ 216ppm U₃O₈ and 36ppm Th. However in other parts of the deposit, sample analyses recorded in open file report A16613 in the Geological Survey of Western Australia WAMEX database averaged about 500ppm Th in the top 48m of weathered zone in one drill hole. Thorium-rich zones of 200 to 400ppm Th were intersected in two drill holes in fresh carbonatite and carbonated magnetite amphibolite to depths of 400m.

The Yangibana ferrocarnatite-magnetite-rare earth-bearing dykes in Western Australia (termed 'ironstones') crop out over an area of 500 square kilometres and form part of the Gifford Creek Complex. The dykes are part of a carbonatitic episode which intrudes the Proterozoic Bangemall Group. The ferrocarnatite-magnetite-rare earth-bearing dykes occur as lenses and pods and are typically the last stage of carbonatite fractionation and are enriched in REEs, fluorite and U-Th mineralisation. The Yangibana prospect has a recorded resource of 3.5Mt at 1.7% REO. The rare earths are contained in coarse grained monazite containing up to 20% Nd₂O₅ and 1,600ppm Eu₂O₃. Whole rock chemical analyses of 21 ironstone samples collected from five prospects in the Yangibana area recorded more than 1,000ppm Th for 10 of the samples (1,062ppm to 5,230ppm Th).

Australia's total indicated and inferred resources amount to about 485,000 t Th.

As there is no established large scale demand and associated costing information for thorium, there is insufficient information to determine how much of Australia's thorium resources are economically viable for electricity generation in thorium nuclear reactors.

Exploration

There has been no widespread exploration for thorium in Australia apart from two exploration licences which have been reported as being primarily for thorium exploration in Queensland.

However thorium is a significant component of some deposits being explored for other commodities. As mentioned above, thorium is present in the Nolans Bore deposit and in the Toongi intrusives complex. Heavy mineral concentrations within the King Leopold Sandstone and the Warton Sandstone, which constitute the Durack Range uranium project, also contain up to 2% thorium in the heavy mineral concentrate (Northern Mining Ltd – announcement to the Australian Securities Exchange, 21 March 2007).

Production

There is no production of thorium in Australia, but it is present in monazite currently being mined with other minerals in heavy mineral beach sand deposits. Prior to 1996, monazite was produced from heavy mineral sand operations and exported for extraction of rare earths but is no longer considered to be a commercially viable source of rare earths because of the disposal costs associated with the radioactive material containing thorium.

World Ranking

OECD/NEA & IAEA (2006)* has compiled estimates of thorium resources on a country-by-country basis. The OECD/NEA report notes that the estimates are subjective due to variability in the quality of the data, a lot of which is old and incomplete. Table 3 has been derived by Geoscience Australia from information presented in the OECD/NEA analysis. The total identified resources refer to RAR plus inferred resources recoverable at less than US\$80/kg Th. Table 3 includes quantitative estimates of undiscovered thorium resources for some countries.

Table 3. Estimated thorium resources by country.

Country	Total Identified Thorium Resources <USD 80/kg Th		Undiscovered Resources
	('000 t Th)	%	('000 t Th)
Australia	485	18.6	Not available
United States	400	15.3	274
Turkey	344	13.2	400 - 500
India	319	12.2	Not available
Brazil	302	11.6	329 - 700
Venezuela	300	11.5	Not available
Norway	132	5.1	132
Egypt	100	3.8	280
Russian Federation	75	2.9	Not available
Greenland	54	2.1	32
Canada	44	1.7	128
South Africa	18	0.7	130
Others	33	1.3	81
TOTAL	2606	100	1786 - 2257

Sources: Data for Australia compiled by Geoscience Australia; estimates for all other countries are from: *OECD/NEA & IAEA, 2006: Red Book Retrospective. A review of Uranium Resources, Production and Demand from 1965 to 2003.

OECD/NEA & IAEA (2006) have grouped thorium resources according to four main types of deposits as shown in Table 4. Thorium resources worldwide appear to be moderately concentrated in the carbonatite type deposits accounting for about 30% of the world total.

Table 4. World and Australia's thorium resources according to deposit type (modified after OECD/NEA & IAEA (2006)).

World deposits			Australian deposits	
Major deposit type	Resources	Percentage	Resources	Percentage
	(1000 t Th)		(1000 t Th)	
Carbonatite	1900	31.3	4	0.8
Placer deposits	1524	24.6	378	77.8
Vein-type deposits	1353	21.4	53	10.9
Alikaline rocks	1155	18.4	51	10.5
Other	258	4.2	No data	-
TOTAL	6190	100.1	485	100.0

The remaining thorium resources are more evenly spread across the other three deposit types in decreasing order of abundance in the placers, vein type deposits, and alkaline rocks. In Australia, a larger proportion of resources is located in placers where the heavy mineral sand deposits account for about 80% of the known thorium resources in Australia.

Tin

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Tin (Sn) is used in solders for joining metals and pipes, as a coating for steel cans and in metal alloys. The largest single application for tin is in solders, which accounts for about one third of total world consumption. Solders are used in light engineering applications such as plumbing and sheet metal work, in the motor vehicle industry and in cans for various uses. Another major application for tin is coating steel sheet in the manufacture of tinplate, which accounts for about 27% of world tin consumption. Tinplate is used for containers in the form of tin cans for food products, drinks, oils, paints, disinfectants and chemicals.

Resources

Australia's total EDR at December 2007 was 247 kt Sn, a small increase of 1 kt Sn on the resources in 2006. Australia's EDR of tin are in the following deposits: Collingwood (North Qld); Renison Bell and Mount Bischoff (western Tas.); Greenbushes and Mt Deans (WA).

Accessible EDR

All of Australia's EDR for tin are unencumbered, and there are no restrictions to mining deposits.

JORC Reserves

JORC reserves comprise total tin resources in proven and probable reserves as defined in the JORC Code. In 2007, JORC Code reserves of 216 kt Sn accounted for approximately 87% of AEDR.

Exploration

After a hiatus of almost two decades, tin exploration resumed during 2007 in the historical tin mining areas of far north Queensland, mainly at the Herberton-Mount Garnet and Tate tin fields. Companies proposed drilling programs to outline resource for a number of hard-rock and alluvial tin deposits.

In the Mount Garnet-Herberton tin field 110 km south west of Cairns, Consolidated Tin Mine Ltd (CTM) commenced initial exploration over the Gillian (5 km south west of Mount Garnet), Windermere and Deadman's Gully (both approximately 25 km north east of Mount Garnet) tin deposits. These deposits are in iron-rich skarns adjacent to granitic intrusions. Although the deposits were discovered in the early 1970s, complex tin mineralogy which makes it difficult to recover the tin has meant that they have not been exploited. However, the company is investigating new metallurgical techniques, including tin fuming for processing the ores.

CTM also started evaluation of alluvial tin deposits at Nettle Creek (15 km E of Mount Garnet), Return Creek (5 km S of Mount Garnet) and Tate River (80 km W of Mount Garnet).

YDC Resources Ltd continued drilling at the Doradilla project 55 km south east of Bourke, NSW. The Doradilla-Midway-3KEL tin deposits are within a linear skarn unit which can be traced for more than 17 km along strike. The top 40-60 m of the skarn are highly weathered. For Midway and 3KEL deposits, the company announced a combined inferred resource of 7.81 Mt averaging 0.28% Sn representing 22.3 kt Sn. The resource is Ltd to the weathered profile (laterite) where tin is hosted in stanniferous goethite, garnets, secondary cassiterite and minor primary cassiterite.

Malachite Resources continued bulk sampling of greisen veins at the Sheep Station Hill and Newstead tin-tungsten prospects 20 km east of Inverell in northern NSW. The company tested gravity concentration technologies for Newstead ores.

Production

Australia's mine production in 2007 was 2071 t Sn in concentrates, which was 40% higher than in 2006, and 118 t Sn of refined ingots, 79% less than in 2006. Mine production of concentrates occurred at Collingwood (Qld) and Greenbushes (WA). The increase in Australia's mine production was due to the commencement of production at Collingwood. Refined tin was produced at Greenbushes from smelting of concentrates. Total exports for 2007 were 2533 t Sn valued at \$33 million.

World Ranking

Australia's EDR for tin was ranked at eight in the world. The major resources of EDR are in China, Malaysia, Indonesia, Peru, Brazil, Bolivia and Russia.

Industry Developments

During 2007, tin prices (London Metal Exchange) rose from less than US\$11,000 per tonne in January to end the year around US\$16,100 per tonne. This steady rise followed a slump in prices in late 2005 as a result of sharp increases in small scale, illegal tin production from Indonesia. This production rapidly declined when these illegal operations were controlled (Metals X Ltd, Quarterly report Dec. 2007).

Metals X Ltd was Australia's main tin mining company in 2007. It operated the Collingwood mine 30 km south-west of Cooktown in North Qld and owns the historic Renison and Mount Bischoff mines, both of which remained on care-and-maintenance. Re-commissioning of both these mines and the Renison Concentrator began in early 2008 in response to increased tin prices.

Production of concentrates commenced at Collingwood in January 2006 and it was Australia's main tin producer through 2007. In February 2008, the company reported that mining had shown that the greisen tin zones were more erratic in shape and grade distribution than predicted by resource drilling. Because the mine had not achieved planned grades and metal production, the company decided to close it in mid-2008. Total measured + indicated + inferred resources for Collingwood at the time of the mine closure were estimated to be 642,000 t averaging 1.19% Sn, which represents 7680 t contained Sn.

The historic Renison Bell mine and concentrator 15 km north east of Zeehan in Tasmania were refurbished in 2005 and operated for about a year before being placed on care and maintenance in October 2005 due to low tin prices. However, by mid-2008 Metal X had re-commenced commissioning of the mine and concentrator in response to high tin prices.

Mining re-commenced at the historic Mount Bischoff open cut 80 km north of Renison in February 2008. Production from Mount Bischoff and future mine production from Renison underground mine will be processed at the Renison concentrator. In addition, a copper circuit will be added to enable production of a copper concentrate from the Renison ores.

Metals X is investigating the feasibility of reprocessing and recovering tin from tailings from historic processing of ores at Renison Bell mine. Resources in the tailings dam were estimated at 18.2 Mt averaging 0.42% Sn and 0.2% Cu containing 76,000 t Sn and more than 36,000 t Cu metal. The project (referred to as Rentails Project) has been through a pre-feasibility study from which the company reported that a combination of sulphide flotation and tin flotation separation techniques had produced a low grade concentrate which would be fumed to produce a saleable tin product. During 2007, Metals X completed pilot plant testing of all aspects of the project, including the tin fuming trials which were completed in early 2008.

Talison Minerals produced 118 t Sn as refined ingots in 2007 from Greenbushes (WA), the world's largest hard rock tantalum mine. Tin occurs in association with tantalum minerals and is recovered as a by-product during ore processing, with ingots produced from a smelter at the site.

Van Dieman Mines continued development of the Scotia and Endurance alluvial mines in north east Tas. Alluvial mining operation commenced at Scotia in December with ore being stockpiled.

Production of tin concentrates from the plant is scheduled to commence in 2008. Approximately 3 t of sapphire concentrates from the pilot plant were dried ready for processing and sorting. Evaluation drilling of the alluvials will continue in 2008.

Stonehenge Metals continued construction of a gravity separation mill at the Granville tin project, 20 km north of Zeehan in western Tasmania. Milling of stockpiled ore and production of tin concentrates are planned to commence in mid 2008. The project has tin resources in the Granville East and the Central Big 'H' deposit (both are strata-bound carbonate replacement type deposits), and the North Heemskirk deep lead alluvial deposit located 1 km north of the mill.

North Queensland Metals Ltd announced that the feasibility study for the Baal Gammon copper-tin-silver-indium project was completed and the mine would be developed in 2009. Copper will be the main output together with the co-products of tin, silver and indium. The deposit is in the Herberton mining region west of Cairns, north Qld.

Tungsten

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Tungsten (W) metal and its alloys are amongst the hardest of all metals. It occurs as wolframite, $(\text{Fe,Mn})\text{WO}_4$, and scheelite, CaWO_4 . Tungsten carbide has a hardness approaching that of diamond and is used for cutting and wear-resistant materials primarily in the metalworking, mining, oil drilling and construction industries. Tungsten alloys are used also in electrodes, filaments for light bulbs, wires and components for electrical, heating, lighting, and welding applications.

Resources

Australia's EDR at December 2007 was 86.6 kt W. China has the world's largest resources of tungsten with approximately 62%. Other nations with large resources include Canada and Russia.

Exploration

There was virtually no exploration for tungsten in Australia between 1980 and the end of 2004. Tungsten prices have risen substantially since 2004, with the price more than doubling in 2005. The average scheelite ore concentrate price for the past 12 months was US\$212 (A\$249) per metric tonne unit (1 mtu = 10 kg), with a high of US\$222 (A\$260). In response to these rises, a number of companies started exploring and evaluating old tungsten mines and deposits, mainly in north Queensland, NSW and Tasmania.

King Island Scheelite continued with its preparatory work on various aspects of construction, including provision of infrastructure, procurement of materials and installation of mining services on its **King Island** tungsten deposit. The company is forming a joint venture with the Chinese Hunan Nonferrous Metals Corporation. The global resources at a cut-off grade of 0.25% WO_3 down to 308 m below sea level have been reported as indicated resources of 13.2 Mt averaging 0.64% WO_3 and inferred resources of 0.2 Mt averaging 0.35% WO_3 .

Vital Metals Ltd continued exploration at the **Watershed** project 25 km north east of Mt Carbine mine in far north Queensland. At a cut-off grade of 0.15% WO_3 , total measured plus indicated resources were 9.5 Mt averaging 0.28% WO_3 and inferred resources of 5.7 Mt averaging 0.30% WO_3 as at July 2008.

With two mining leases granted, Queensland Ores Ltd has started construction of the mine site and a treatment facility at its **Wolfram Camp** tungsten-molybdenum project, 90 km west of Cairns, in north Queensland. Wolframite and molybdenite mineralisation occur in high grade quartz pipes and as disseminated lower grade mineralisation surrounding these pipes. Mineralisation is within granite and is adjacent to the margins of the granitic body where it intrudes into sediments. The resources were reported as measured resources of 598,200 t averaging 0.42% WO_3 and 0.17% MoS_2 , indicated resources of 111,500 t averaging 0.41% WO_3 and inferred resources of 238,300 t averaging 0.4% WO_3 and 0.2% MoS_2 . The first shipment of concentrates is scheduled for July 2008.

Stonehenge Metals Ltd commenced exploration at the **Interview River** deposit in northwest Tasmania. Several high-grade tungsten-tin bearing veins with a combined strike length of 2.5 km occur within the youngest intrusive phase of the Interview Granite.

Wolf Minerals Ltd acquired the total rights from Graynic Metals to tungsten mineralisation at **Yanco Glen**, located 35 km north of Broken Hill, western NSW. The previous tenement holder identified an inferred resource of 830,000 t grading 0.21% WO₃.

Peel Exploration Ltd began exploration on the **Attunga Prospect 1** scheelite deposit, near Tamworth, NSW. Mineralisation occurs in a northerly plunging pipe within skarn and crystalline marble developed at the contact of a lime-rich sequence with the Inlet Monzonite.

Thor Ming PLC reported a resource of 3.73 Mt grading 0.51% combined WO₃ and MoS₂ for its **Molyhil** project in the Northern Territory. The proven and probable reserves, which total 2.15 million t grading 0.49% WO₃ and 0.22% MoS₂, comprised 456,000 of proven ore grading 0.47% WO₃ and 0.30% MoS₂ and 1.69 Mt of probable ore grading 0.49% WO₃ and 0.20% MoS₂. The company has signed an off-take agreement with CITIC Australia Commodity Trading Pty Ltd which is part of CITIC Group, one of China's largest State-owned companies, to take 100% of the tungsten and molybdenum concentrates produced from the Molyhil Project. The proposed project will have a mine-life of 5.7 year and approval for development is expected in mid 2008.

Production

Australia's only producing tungsten mine in 2007 was Kara scheelite mine near Hampshire in northwest Tasmania. It produced 17 t of scheelite concentrates averaging approximately 55% WO₃, representing 9.35 t contained WO₃. Scheelite and magnetite were produced from magnetite-pyroxene skarn within folded Ordovician limestone that is in contact with Devonian granite.

Industry Developments

World production of tungsten totalled 89.6 t in 2007, and was dominated by China which in recent years accounted for more than 80% of primary tungsten output. Other large producers were Russia and Canada. In recent years the Chinese Government took steps to regulate production and control the release of Chinese tungsten on to the world market. The lack of supplies of tungsten concentrates from China, together with increased demand in China and elsewhere, has resulted in higher prices since 2005.

Uranium

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Major uses for uranium are as fuel in nuclear power reactors to generate electricity, in the manufacture of radioisotopes for medical applications and in nuclear science research using neutrons from reactors. Nuclear power currently supplies 16% of the world's electricity from 435 commercial nuclear power reactors providing 372 gigawatts (electrical) of generating capacity, which is more than seven times Australia's total from all sources. The United States has the largest number of reactors with 104, followed by France with 59, Japan with 55 and the United Kingdom with 19. Thirty countries were producing electricity from nuclear reactors in 2008 (source: World Nuclear Association). As at mid 2008, a further 36 reactors were under construction in 12 countries, notably in Russia, China, India, South Korea, Japan and Slovakia.

Spot market prices for uranium rose progressively from US\$20/lb U₃O₈ in January 2005 to a peak of US\$138 in July 2007 and then fell to US\$60 by mid-2008. Price rises up to mid-2007 were due mainly to forecasts of reduced supplies of uranium from secondary sources, particularly material supplied from the blending down of highly enriched uranium in military stockpiles. Increases in crude oil prices in recent years also have influenced uranium market prices. In addition, concerns about climate change arising from increased greenhouse gas emissions has led to a renewed interest in nuclear

power by governments in many countries because it is a fuel which produces minimal greenhouse gasses. Developing countries such as China and India are planning major expansions of nuclear power capacity and could become significant importers of uranium.

Resources

Geoscience Australia prepares estimates of Australia's uranium resources within categories defined by the OECD Nuclear Energy Agency (OECD/NEA) and the International Atomic Energy Agency (IAEA). The estimates in each category are for resources of **recoverable** uranium after losses due to mining and milling have been deducted. In Table 1, these estimates are reported under the corresponding resource categories of the national classification scheme. The resource categories of both schemes are correlated in Table 5. Prior to 2006, resources in the less than US\$40 category were considered to be economic, although resources in the less than US\$80 category are considered to be economic now because of higher market prices.

Table 5. Correlation of resource classification schemes for uranium.

National Scheme	NEA/IAEA Scheme	Tonnes U recoverable (December 2007)
Economic Demonstrated Resources (EDR)	Reasonably Assured Resources (RAR) recoverable at less than US\$80/ kg U	983,000
Paramarginal Demonstrated Resources	RAR recoverable at US\$80–130/ kg U	10,000
Submarginal Demonstrated Resources	RAR recoverable at greater than US\$130/ kg U	Not estimated
Economic Inferred Resources	Inferred Resources (IR) recoverable at less than US\$80/ kg U	600,000
Paramarginal Inferred Resources	IR recoverable at US\$80–130/ kg U	21,000

Australia's EDR at December 2007 were estimated to be 983,000 t U which represented an increase of 38% over the estimates for December 2006 (714,000 t U). This was due mainly to a large increase in resource estimates for the Olympic Dam deposit (SA). Resources also increased at Ranger 3 deposit (NT) and in addition, Quasar Resources/Alliance Resources released the first estimates of resources for the Four Mile deposit (SA). Australia's EDR at December 2007 represents 34% of world resources in this category.

BHP Billiton continued a major drilling program to explore for extensions of the Olympic Dam deposit to the south. Up to 18 diamond drilling rigs operated concurrently in the area and discovered major extensions and additional resources to the south east portion of the deposit but it remains open to the south and at depth.

A revised estimate of reserves and resources for the Olympic Dam deposit was released during the year (source: BHP Billiton Annual report 2007). For these estimates there has been a major change in resource modelling based on the geological controls of copper sulphide minerals, hematite and structure. The total mineral resources increased considerably over estimates for June 2006 – total tonnages of resources increased by 77%, copper metal increased by 38%, and U₃O₈ increased by 40%. Factors contributing to the increases in resource tonnages are:

- additional drilling (542 surface and underground drill holes),
- lower cut off grade to reflect open pit mining,
- higher long term metal price forecasts, and
- modelling changes.

In addition, following a comprehensive technical review by the company of long-term planning for Olympic Dam operations, the cut-off grade in the reserves/resources estimates is now based on a copper equivalent grade, rather than an in situ value as used in previous years. The copper equivalent formula was derived using a notional nett smelter return based on metallurgical recoveries and BHP Billiton forecast prices (source: BHP Billiton Annual report 2007).

Australia had an additional 600,000 t U in inferred resources recoverable at costs of less than US\$80/kg U which is by far the world's largest resources in this category. These inferred resources are mainly in the south eastern part of the Olympic Dam deposit.

Approximately 95% of Australia's total uranium resources in EDR are within the following six deposits:

- Olympic Dam, which is the world's largest uranium deposit,
- Ranger, Jabiluka, Koongarra in the Alligator Rivers region (NT), and
- Kintyre and Yeelirrie (WA).

Table 6. Uranium resources in States and the Northern Territory at December 2007.

	Reasonably Assured Resources recoverable at <US\$80/kg U	Inferred Resources recoverable at <US\$80/kg U	Total Resources	Percentage of Australia's Total Resources
	Tonnes U	Tonnes U	Tonnes U	
South Australia	759,456	491,094	1,250,550	79%
Northern Territory	139,923	59,259	199,182	13%
Western Australia	59,595	26,933	86,528	5%
Queensland	21,269	19,730	40,999	3%
New South Wales	2968	3116	6084	<0.5%
Victoria	0	0	0	-
Tasmania	0	0	0	-
Australia Total (Rounded)	983,211 (983,000)	600,132 (600,000)	1,583,343 (1,583,000)	100%

Accessible EDR

Approximately 16% of uranium EDR is inaccessible for mining. All uranium deposits in Western Australia and Queensland are classified as inaccessible resources because the respective State Governments have policies banning uranium mining and development. In South Australia, all resources are considered to be accessible because state government policies permit the development of new uranium mines. Applications for new mine developments in the Northern Territory are subject to approval by the Commonwealth Government Minister for Resources, Energy and Tourism. In the Northern Territory, inaccessible resources are the Jabiluka deposit, because the traditional Aboriginal land owners have not granted approval to mine the deposit, and the Koongarra deposit where Aboriginal land owner approvals and environmental issues have yet to be resolved.

JORC Reserves

JORC reserves comprise total uranium resources in Proven and Probable Reserves as defined in the JORC Code. In 2007, JORC Code reserves of 228,000 t U account for approximately 28% of accessible AEDR.

World Ranking

Australia has the world's largest resources of uranium in RAR recoverable at <US\$80/kg U (equates to EDR), with 34% of world resources in this category at December 2007. Other countries with large resources include Kazakhstan with 12%, Canada 11%, South Africa 7% and the Russian Federation 6%.

Olympic Dam is the world's largest uranium deposit. Based on ore reserves and mineral resources reported by BHP Billiton as at June 2007, Geoscience Australia estimated that the deposit contains 26% of the world's total resources in RAR recoverable at <US\$80/kg U.

Exploration

Uranium exploration expenditure in Australia has increased progressively since 2003 mainly because of the significant increases in spot market uranium prices in recent years. In 2007, uranium exploration expenditure increased to a record level of \$181.4 million³, which is more than double the 2006 expenditure (\$80.7 million). The majority of expenditure was in South Australia (55%), followed by the Northern Territory (23%), Queensland and Western Australia (each 11%).

During 2007 significant uranium discoveries and major extensions to existing deposits were announced at Olympic Dam, Ranger 3, and Four Mile deposits (SA).

Main exploration areas (in terms of expenditure) during 2007 were:

- South Australia – the Gawler Craton-Stuart Shelf region, Palaeogene sediments of the Frome Embayment and palaeochannels overlying the Gawler Craton;
- Northern Territory – the Alligator Rivers region and Western Arnhem Land, Rum Jungle area and Ngalia Basin; and
- Queensland – the Mount Isa province.

Drilling at **Four Mile** outlined a broad area of mineralisation covering five square km in Eocene sands of the Eyre Formation along the flanks of Proterozoic basement rocks of the North Flinders Ranges. Four Mile deposit is 8 km north west of the Beverley uranium mine. There are two deposits within this broad area, Four Mile West and Four Mile East. Four Mile West has been defined by close-spaced drilling and has inferred resources of 3.9 Mt averaging 0.37% U₃O₈ which represents 15,000 t of contained U₃O₈. The average thickness of the mineralisation within the resource outline is 2.2 m and is hosted by fluvial sands at 140 to 170 m depth.

Exploration drilling continued at **Four Mile East** with up to eight drilling rigs in operation. The main mineralised zone is in a sequence of sediments ranging from coarse sand/gravel to silt, is between 200 and 210 m below the surface and ranges from 1 to 8 m thick. Average grades of mineralised intersections are typically greater than 0.1% pU₃O₈⁴ and are commonly around 0.3% pU₃O₈. Estimates of mineral resources are in progress. Hydrological and metallurgical studies are planned in order to determine whether permeabilities and uranium recoveries are sufficient to permit the use of in situ leach mining.

Quasar Resources/Alliance Resources joint venture is investigating two processing options for Four Mile leach solutions using the Beverley plant. They include: 1) a pipeline to transport solutions to and from Four Mile, or 2) establishing an ion exchange plant at Four Mile to capture uranium and truck the resin to the Beverley plant for elution. In 2008 Quasar Resources applied to the South Australian Government for a mining lease.

In the Mount Isa region, Paladin Resources continued drilling at **Valhalla, Skal, Andersons, Mirrioola, Watta, Warwai, Bikini and Mirrioola** uranium-vanadium deposits. Drilling intersected brannerite-rich mineralisation within hematite feldspar breccias at all these deposits. These deposits were drilled previously by Queensland Mines Ltd during the 1960s and Paladin Resources has discovered extensions of the mineralisation, particularly at Valhalla and Skal.

³ ABS Mineral and Petroleum Exploration, December quarter 2007

⁴ Uranium grades in drill holes measured with a prompt fission neutron tool.

Production

Production for 2007 from Australia's three uranium mines were Ranger 5412 t U₃O₈, Olympic Dam 3985 t U₃O₈, and Beverley in situ leach operations 748 t U₃O₈ for a total Australian production of 10,145 t U₃O₈ (8602 t U), 13.3% higher than for 2006. Australia, with approximately 21% of world uranium production in 2007, is the world's second largest producer after Canada.

Exports

Exports in 2007 were 10,232 t U₃O₈ (8,677 t U) valued at \$881 million. Exports of Australian uranium are controlled by stringent safeguards conditions which ensure that it is used only for peaceful purposes and does not enhance or contribute to any military applications. These conditions are given effect through bilateral safeguards agreements between Australia and the importing country. In the case of non-nuclear-weapon countries, it is a minimum requirement that IAEA safeguards apply to all existing and future nuclear activities in that country. In the case of countries with nuclear weapons, there must be a treaty-level assurance that Australian uranium will be used only for peaceful purposes and it must be subject to that country's safeguards agreement with the IAEA.

Australian mining companies supply uranium under long-term contracts to electricity utilities in United States, Japan, South Korea and Canada as well as members of the European Union including the United Kingdom, France, Germany, Spain, Sweden, Belgium, and Finland.

Industry Developments

Olympic Dam (SA): BHP Billiton is undertaking a two year pre-feasibility study into the expansion of Olympic Dam. The proposed expansion will increase uranium production from the current capacity of 4000 t U₃O₈ per annum to approximately 19,000 t U₃O₈ per annum. This expansion is based on a very large open pit to mine the south east portion of the deposit. At full production, it is proposed that the open cut and underground operations will mine a total of 80 Mt ore per year and annual production is estimated to reach 750,000 t refined copper, 19,000 t U₃O₈, 480,000 ounces gold and 1.5 million ounces silver. Mining of ore from the open pit is scheduled to commence in 2014.

An Environmental Impact Statement is being prepared for the Australian and South Australian Governments. Water requirements for the current mining and processing operations are drawn from groundwater aquifers of the Great Artesian Basin to the north of Olympic Dam. As part of the expansion, it is planned to develop a sea water desalination plant on Spencer Gulf (SA) to supply fresh water to the mine and the town.

BHP Billiton's estimates of ore reserves and mineral resources are shown in Table 7.

Table 7. Olympic Dam Mineral Resources and Ore Reserves.

	Million tonnes	Copper %	U ₃ O ₈ kg/t	Gold g/t	Silver g/t
Total resources *	7885	0.87	0.29	0.3	1.61
Total reserves	399	1.87	0.58	0.68	4.0

* Mineral Resources includes Ore Reserves

Source: BHP Billiton Annual report 2007

Ranger mine (NT): Production from Ranger mine in 2007 was 14% higher than for the previous year. This was achieved despite the plant shutdown as a result of extremely heavy rainfall associated with a tropical cyclone in February which flooded the pit, restricting access to higher grade ore.

During 2007, work commenced on extending the open pit, which, together with optimisation of the existing pit design, will yield an additional 4857 t U₃O₈ and increase the mine life by four years from 2008 to 2012.



Trunk lines and processing plant at Beverley in situ recovery uranium mine, South Australia (Heathgate Resources Ltd).

During 2007, ERA Ltd increased expenditure on exploration in the Ranger Project area. Drilling outlined extensions of the Ranger 3 orebody down-dip to the east of the open cut. This area is known as Ranger 3 Deeps. Further drilling is planned to search for additional resources to the north of Ranger 3 Deeps.

The company commenced feasibility studies into further extensions of the mine (both open pit and underground), expanding the processing plant and the potential application of heap leaching technologies to low grade ores, including existing stockpiles.

Construction commenced on a new radiometric sorter facility (\$17 million) and a laterite treatment plant (\$34 million). These projects will increase production by treating existing ore stockpiles. The laterite treatment plant will produce up to 400 t U_3O_8 per annum from 2008 to 2013. The radiometric sorter will produce a total of 1100 t U_3O_8 to 2013 through the selective upgrading of low grade ore stockpiles.

Beverley (SA): Heathgate Resources operates the Beverley in situ leach uranium mine which is located on the arid plains between the North Flinders Ranges and Lake Frome, approximately 300 km north east of Port Augusta, SA. During recent years, exploration has identified new zones of uranium mineralisation extending to the east of the Beverley Mining Lease and additional mineralisation in an area to the south known as Deep South. The company applied for a new larger mining lease which would subsume the existing Beverley lease. The environmental impacts for the extended operation are being assessed jointly by the Australian and South Australian Governments under the Environment Protection and Biodiversity Conservation Act.



Wellfield and injection well at Beverley uranium mine, South Australia (Heathgate Resources Ltd).

Honeymoon project (SA): Uranium One announced in May 2008 that it has decided to suspend development activities at Honeymoon while it looks for a joint venture partner. Annual production from Honeymoon was expected to be 400 tonnes U_3O_8 .

Oban project (SA): During 2007, drilling by Curnamona Energy outlined an area of more than two square km of potentially economic uranium mineralisation within sands of the Eyre Formation. The proposal for a field leach trial at Oban is awaiting South Australian Government approval.

Crocker Well deposit (SA): The deposit is being jointly developed by Sinosteel Corporation (60%) and PepinNini Minerals Ltd (40%), with a strategy to be in production by the end of 2010.

Angela-Pamela deposits (NT): The Northern Territory Government announced on 20 February 2008 that successful applicant for the Exploration Licence over the deposits was a joint application by Paladin Energy Minerals NL, and Cameco Australia Pty Ltd.

Kintyre deposit (WA): Rio Tinto has completed its sale of the Kintyre uranium deposit in WA during mid 2008. Cameco now has a 70% interest in the deposit, with Mitsubishi Development holding the remaining 30%.

Other Developments

The Australian Government has committed \$10.6 million over four years from 2008-09 for uranium initiatives. This includes a national radiation dose register for uranium workers, ensuring world's best practice in regulation, skills initiatives including radiation training for the uranium industry, improving outcomes for indigenous communities from uranium exploration and mining and addressing transport restrictions.

New nuclear safeguards agreement with Russia

In 2007 Australia and the Russian Federation signed a new nuclear cooperation agreement which would replace the existing (1990) Australia-Russia nuclear cooperation agreement.

The new agreement will allow Australian uranium producers to supply Russia's nuclear power industry while retaining and building on the strict safeguard conditions contained in the existing agreement and including Australia's other safeguards agreements.

Nuclear safeguards agreement with China

On 3 February 2007 the Australia-China Nuclear Transfer Agreement and Nuclear Cooperation Agreement came into force, creating the legal framework for Australian uranium producers to commence exports to China. The timing and quantities of exports will be a matter for commercial negotiation.

Government initiative in support of uranium exploration

Geoscience Australia completed the second year of the five years Onshore Energy Security Initiative. The program involves acquisition of new seismic, radiometric, airborne electromagnetic and geochemical data to provide pre-competitive information to attract investment in exploration for onshore petroleum, geothermal, uranium and thorium energy sources. The data acquisitions will provide information which will significantly lower the risk for evaluating the potential for energy resources and other mineralisation.

As part of the program, all available and new data is being considered in a uranium mineral systems framework to provide new concepts for uranium exploration, particularly in greenfields areas.

Vanadium

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Vanadium (V) is used in metal alloys with iron to produce high strength steel which have a wide range of uses, including structural applications such reinforcing bars in building and construction, gas and oil pipelines, tool steel, the manufacture of axles and crankshafts for the motor vehicle industry, and in jet engines for the aircraft industry.

Non-steel uses include welding and alloys in nuclear engineering and superconductors. Vanadium chemicals and catalysts are used in the manufacture of sulphuric acid and the desulphurisation of sour gas and oil.

Vanadium is sold as vanadium pentoxide (V_2O_5), or less commonly as vanadium trioxide (V_2O_3), or as an alloy of iron and vanadium, most commonly as FeV80 which has 80% contained vanadium, or as FeV50. V_2O_5 is typically quoted in US\$ per pound (lb), while FeV is quoted in US\$ per kilogram.

Primary production of vanadium from mining and processing of magnetite ores accounts for only 29% of annual world production of vanadium. The majority of world vanadium production (56%) is recovered from slag produced as a by-product of steel making, while the remaining 15% of world production is recovered from wastes including fly ash and oil residues.

Vanadium prices have fluctuated during the past decade with sharp price rises and declines over short periods. Historically, prices have ranged from US\$1.30 per lb V_2O_5 to more than US\$20 per lb. The average prices have been in the range of US\$3 to \$4 per lb.

Resources

Australia's EDR of vanadium increased by 8% in 2007 to 898 kt. Growth in EDR was recorded at Barambie near Mount Magnet, WA, Balla Balla mid-way between Karratha and Port Hedland, WA, at Windimurra 75 km south east of Mount Magnet, WA and at Bigrlyi 390 north west of Alice Springs, NT.

Historically, Australia's EDR have fluctuated because of the economic impacts of volatile prices and the nature of the vanadium market, which is supplied largely from secondary sources that rapidly increase or decrease output in response to price trends.

Exploration

Aurox Resources Ltd: As part of a bankable feasibility study of the **Balla Balla** WA, vanadium-titanium-iron ore project, Aurox Resources Ltd reported a JORC compliant ore reserve as proven reserves of 51.2 Mt grading 0.65% V_2O_5 and 46.07% Fe and probable reserves of 52.6 Mt grading 0.62% V_2O_5 and 45.36% Fe. Balla Balla is a titaniferous magnetite segregated zone within a large, basic ultramafic intrusion

Reed Resources Ltd: As part of a definitive feasibility study of its **Barrambie** Project, WA, Reed Resources Ltd reported resources at a cut-off grade of 0.5% V_2O_5 as indicated resources of 6.5 Mt grading 0.84% V_2O_5 , 17.3% TiO_2 and 46.7% Fe_2O_3 and inferred resources of 17.1 Mt grading 0.82% V_2O_5 , 18.2% TiO_2 and 49.3% Fe_2O_3 .

Energy Metals Ltd: As part of its scoping study of its **Bigirlyl** project, NT, Energy Metals Ltd released an updated resource estimate based on 0.05% U_3O_8 cut-off grade which showed indicated resources of 1.94 Mt grading 0.17% U_3O_8 and 0.19% V_2O_5 and inferred resources of 2.59 Mt grading 0.13% U_3O_8 and 0.14% V_2O_5 .

Windimurra Vanadium Ltd (formerly known as Precious Metals Australia) carried out further exploration drilling on its main **Windimurra** deposit, WA. It reported a total reserve at a cut-off grade of 0.275% V_2O_5 of 98.2 Mt grading 0.4% V_2O_5 within a total resource of 148 Mt grading 0.46% V_2O_5 . Vanadium mineralisation occurs within a shallow-dipping magnetite-rich horizon on the eastern side of a large gabbroic intrusion.

Interim Resources Ltd continued exploration at the **Julia Creek** project just north of the Mt Isa to Townsville railway in north west Queensland. JORC resources were reported as measured resources, 204.3 Mt averaging 0.4% V_2O_5 and 300g/t MoO_3 , indicated resources, 1,032 Mt averaging 0.4% V_2O_5 and 311g/t MoO_3 and inferred resources, 772 Mt averaging 0.39% V_2O_5 and 385g/t MoO_3 .

Production

There was no mining or production of vanadium in Australia during 2007. While there are a number of vanadium deposits in Australia, Windimurra, WA, has been the only deposit mined in recent years. Most of the world's mine production of vanadium during the year was from South Africa (39%), China (32%) and Russia (27%).

Industry Developments

Windimurra Vanadium Ltd is redeveloping the **Windimurra** mine, WA, with mining equipment and power generation equipment ordered. Construction at the mine site has commenced and first production is targeted for the 4th quarter of 2008. The mine is expected to produce 6,400 t per year of ferrovanadium and 1,000 t per year of vanadium pentoxide, which will represent about 8% of the world market.

In late 2007, Energy Metals announced that the initial scoping study demonstrated that the **Bigirlyl** project, NT, has the potential to produce 8.43 million lbs of U_3O_8 and 6.97 million lbs of V_2O_5 from 2.73 Mt of run-of-mine ore over a mine life of eight years based on the resource of 4.53 Mt at 0.14% U_3O_8 and 0.16% V_2O_5 at 0.5kg/t U_3O_8 cut off, assuming a treatment rate of 0.5 Mt per year and U_3O_8 and V_2O_5 metallurgical recoveries of 95% and 70% respectively.

Aurox Resources Ltd has arranged several pre-contract agreements for the installation of all major components required to commission the 6 Mt per year **Balla Balla** magnetite concentrate processing plant and related port infrastructure. The company is undertaking a pre-feasibility engineering study for the 110 km, 10 Mt per year slurry and return water pipelines between the mine processing plant at Balla Balla and the Port Hedland Port Authority planned multi-user facility at Utah Point. The mine is scheduled for commissioning in late 2010.

Reed Resources expects to complete its definitive feasibility study on its **Barrambie** vanadium project in June 2008, with first production scheduled for early 2011.

Zinc, Lead, Silver

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Zinc (Zn) is the 23rd most abundant element in the earth's crust the fourth most common metal in use after iron, aluminium and copper. The construction and appliance manufacturing industries use large amounts of zinc, mainly as anti-corrosion coatings (galvanizing) on sheet steel, steel beams and vehicle panels. World-wide, around 4 Mt of zinc is used annually to protect around 100 Mt of steel, representing almost half of the world's total consumption of zinc. The widespread use of zinc as a protective coating is due mainly to its resistance to normal weathering. This is an electrochemical reaction known as galvanic action. Zinc is used also in brass, alloy die cast precision components, pigments, salts, as oxide additives to rubber and for agricultural chemicals as well as for wrought or rolled products. Zinc metal is produced in Australia at Sun Metals' Townsville refinery in Qld and at Nyrstar NV's Hobart refinery in Tas.

The widespread occurrence of **lead** (Pb), its relatively simple extraction and combination of desirable properties have made it useful to humans since at least 5000 BC. In deposits mined today, lead (in the form of galena, PbS) is usually associated with zinc, silver (Ag) and commonly copper (Cu) and is extracted as a co-product of those metals. The largest use is in batteries for vehicles and communications. Less important uses include cable sheathing, solder, casting alloys, chemical compounds, ammunition, ceramics and glass in TV and computer screens for radiation protection. Uses for lead could increase in the future in large storage batteries used for load-levelling of electrical power and in electric vehicles. More than half of the lead currently used is from recycling, rather than mining. Lead recycling plants jointly owned by Nyrstar NV and the Sims Group are in Melbourne, Vic and in Sydney, NSW. Nyrstar NV's Port Pirie smelter in SA is the world's largest primary lead smelting facility and a leading global silver producer.

The relative scarcity, attractive appearance and malleability of **silver** (Ag) make it suitable for use in jewellery, ornaments and silverware. Its extensive use in coins throughout history has declined over the past 40 years. In Australia, the 1966 50 cent piece was the last coin in general use to contain silver (80% Ag, 20% Cu). Silver is mined and produced mainly as a co-product of copper, lead, zinc and, to a lesser extent, gold (Au). Currently, photographic paper and film followed by the electronics and jewellery/tableware industries are the most important users of silver. Other uses include mirrors, as an anti-bacterial agent, for example in water treatment (as an ioniser with copper in domestic swimming pools) and for biocide and bacteriostatic activity in plastic and textiles formulations.

Resources

Australia's total resources of zinc, lead and silver remained relatively stable in 2007. Total identified resources of zinc fell slightly from 87 Mt in 2006 to 86 Mt, lead from 54 Mt in 2006 to 53 Mt but silver increased slightly from 107 kt in 2006 to 110 kt.

ZINC

Australian EDR of zinc at 42.5 Mt is the world's largest holding, accounting for almost 24% of world EDR. The 2 Mt increase in national EDR compared to 2006 was mostly in Qld from the Mt Isa, George Fisher and Cannington mines. Queensland continued to hold the largest resource with 27.4 Mt or 64% of national EDR predominantly at the Mt Isa, Century and George Fisher deposits. The NT again had the second largest EDR with 10.2 Mt or 24% of national EDR all at the McArthur River deposit followed by NSW with 2.2 Mt EDR, mostly at Broken Hill and Endeavor deposits, and WA with 1.8 Mt.

Paramarginal demonstrated resources of zinc increased slightly to 18.3 Mt while submarginal demonstrated resources fell slightly to 2.3 Mt. Total inferred zinc resources decreased from 27 Mt in 2006 to 23.3 Mt in 2007.

LEAD

Australia's EDR of lead decreased slightly in 2007 to 23.3 Mt of contained lead and constituted 44% of Australia's total identified lead resources (52.8 Mt). Australia also contains the largest share of world

EDR for lead at 30%. Queensland retained the top ranking with its EDR increasing from 14.9 Mt in 2006 to 15.6 Mt in 2007, representing a 67% share of national EDR. In the NT, EDR decreased from 5 Mt to 4.9 Mt or 21% of the national total due to depletion of resources as a result of production at the McArthur River mine. New South Wales recorded an increase in EDR from 1.2 Mt in 2006 to 1.6 Mt because of increased resources at Broken Hill. A decrease in reported EDR for WA from 2.1 Mt in 2006 to 1.0 Mt is due largely to a reassessment of resources for the Magellan mine.

Australia's paramarginal demonstrated resources of lead increased slightly to 8.5 Mt, which is 16% of total identified resources. Submarginal demonstrated resources decreased from 2.6 Mt in 2006 to 1.6 Mt in 2007. Total inferred lead resources were largely unchanged in 2007 at 19.3 Mt.

SILVER

EDR for silver is 50.1 kt which is 17% of world EDR. Queensland has 32.4 kt or 65% of Australian EDR, mainly in the Cannington, George Fisher, Mt Isa, Century and Mungana deposits. Most other holdings occur in SA with 8.4 kt, the majority of which is at Olympic Dam with some at Prominent Hill, the NT with 4.6 kt, largely at McArthur River and partly Browns, NSW with 2.7 kt, largely Broken Hill and Endeavor, and WA with 1.4 kt, predominantly at Spinifex Ridge, Golden Grove and Jaguar. Victoria and Tasmania have combined EDR of 0.7 Mt silver.

Accessible EDR

All zinc, lead and silver EDR is accessible.

JORC Reserves

Of Australia's EDR of zinc, 52% occurs in the JORC Code ore reserves categories. The remaining EDR is made up of those measured and indicated resources as reported by mining companies which Geoscience Australia considers will be economic over the long term. The zinc resource life using national EDR divided by annual production is 28 years, but using the ore reserve and dividing by annual production gives a resource life of only 15 years.

Of Australia's EDR of lead, 45% occurs in the JORC Code ore reserves categories. For lead, the national EDR/production ratio is 36 years, but if the ore reserve/production ratio is used it is 17 years. For silver, JORC Code reserves account for around 52% of EDR and resource life is 27 years by EDR or 14 years by JORC reserves.

Exploration

In 2007, exploration spending on zinc-lead-silver was \$187 million, \$86 million or 86% higher than in 2006. The 2007 expenditure was 27% of total base metal expenditure of \$702 million compared to 24% in 2006. Expenditure on exploration for zinc-lead-silver made up 9% of all mineral exploration which, excluding petroleum, was \$2.06 billion, and compared to 7% in 2006. Western Australia, Qld, SA and NSW were the focus of most of this exploration expenditure with WA accounting for \$60 million or 32% of all zinc-lead-silver exploration. The WA expenditure was mainly exploration drilling at Golden Grove as well as the search for further volcanic hosted massive sulphide (VHMS) style mineralisation and for sediment or carbonate hosted sulphide style mineralisation. For example, Kagara Ltd commenced a \$15 million drilling program at the Admiral Bay zinc project in May 2007.

Production

The 2007 Australian mine production of zinc, lead and silver was 1.51 Mt, 0.64 Mt and 1.89 kt respectively. Compared to 2006, production in 2007 increased by 152 kt or 11% for zinc and by 153 t or 9% for silver but was down by 27 kt or 4% for lead. The increased production for zinc and silver largely reflects the completion of mine and processing capacity development projects which had caused concomitant outages in 2006. The majority of production was from Qld which contributed 879 kt, or 58% to national zinc production for 2007 (up 55 kt on 2006) along with 460 kt or 72% of lead (up 30 kt), and 1.5 kt or 81% of silver. Western Australia produced 182 kt of zinc and 47 kt lead while NSW produced 126 kt zinc and 72 kt lead, the NT 139 kt zinc and 33 kt lead and Tas 102 kt zinc and 30 kt lead.

The Century zinc mine which is located approximately 250 km north of Mt Isa, close to the Gulf of Carpentaria in north west Qld ranks second globally in zinc production. Century produced 502 kt of zinc and 38 kt of lead as metal-in-concentrate in 2006–07. The Cannington mine, also located in north west Qld, is the world's largest and lowest cost single mine producer of both silver and lead and a significant producer of zinc. Cannington produced 211 kt of lead, 0.9 kt of silver and 46 kt zinc in 2006–07. Also in Qld are Xstrata's Mt Isa mines which produced 227 kt of zinc, 126 kt of lead and 0.2 kt of silver in 2007.

The value of Australia's exports of zinc concentrates and refined zinc in 2007 totalled \$4.2 billion, 11% more than the \$3.8 billion in 2006 and 2% of the value of total merchandise exports. The increase reflects the higher zinc production in 2007 and consequent higher volume of exports which were up by 14% to 1.5 Mt compared to 1.3 Mt in 2006. The average price for zinc in 2007 was \$4382/t, 1% higher than the average of \$4343/t in 2006 although, the 2007 December quarter average price was 18% less than for the December quarter in 2006.

Exports of lead totalled 620 kt in 2007, down 7% on 2006. However, the value of the 2007 exports was 50% higher at \$2 billion compared to \$1.4 billion in 2006. The difference was due to the average price being 64% higher at \$3283/t compared to the average of \$1996/t in 2006. The value of Australia's mine production of silver was just under \$1 billion in 2007.

World Ranking

Based on USGS data for other countries, Australia has the world's largest EDR of both zinc (24%) and lead (30%). Australia has the world's second largest EDR of silver (17%) behind Poland (18%). In terms of production, Australia ranks second for lead and zinc after China and fourth for silver after Peru, Mexico and China.

Industry Developments

Mt Isa and George Fisher (Qld): Record zinc-lead mine production was achieved in 2007, with the Black Star open cut producing 2.3 Mt of ore, a 12% increase on 2006, and the George Fisher underground mine producing 2.8 Mt of ore, up by 8% on 2006. A fire in the zinc-lead concentrator feed system in September 2007 reduced production by 13 kt of zinc and 7 kt of lead.

Ore production at George Fisher is expected to increase further in 2008 as hoisting capacity is supplemented with ore trucked out through the George Fisher South decline and a new decline which will link George Fisher North with the surface. A new tailings filter plant and a paste-fill plant will allow for increased backfill to match increased ore production.

In June 2007, Xstrata Plc approved US\$61 million to develop the Handlebar Hill open cut zinc-lead mine 20 km north of Mt Isa. Recent drilling, metallurgical testing and design work confirmed an open pit reserve of 4.3 Mt at 7% Zn and 2% Pb. From mid 2008, ore will be mined at a rate of up to 1.75 Mtpa, crushed nearby at George Fisher and transported by truck to the Mount Isa zinc-lead concentrator.

The US\$150 million expansion of the zinc-lead concentrator to a capacity of 8 Mtpa continued during 2007 and full production rates are scheduled for the last quarter of 2008. The successful completion of this project will see production increase to 340 kt of zinc, effectively doubling output since Xstrata Plc acquired MIM in 2003.

McArthur River (NT): Production for 2007 was 138 kt zinc in concentrate and 33 kt lead in concentrate. The ongoing development of the open pit at McArthur River mine continued on schedule with various stages of mining and stripping to support increased production in 2008 and included the mining of lower grade transitional ore. Xstrata Plc reported the Barney Creek diversion was 99% complete while the McArthur River rechannelling was 95% complete and would be finished in the second quarter of 2008 following the wet season. The bund wall is due to be completed in the third quarter of 2008. In January 2007, Xstrata approved plans to increase the capacity of the concentrator at the mine from 1.8 Mtpa to 2.5 Mtpa of ore for a capital cost of US\$37 million. It is anticipated that the expanded capacity will be commissioned in the third quarter of 2008. A court decision on a

technical point of law about a mine application form lodged in 2002 saw mining and development cease for four days at the beginning of May 2007.

Century (Qld): Zinifex Ltd announced plans to spend \$50 million at Century on works aimed at increasing zinc recovery in the concentrator by 2 per cent. Zinc concentrate production in 2006-07 was 502 kt or 14 kt lower than the previous year because of planned maintenance and an unplanned rake failure in a thickener. Lead in concentrate was down substantially from 84 kt to 38 kt, due largely to lower lead grades in the ore mined. As part of the planned accelerated stripping program, stripping costs peaked in 2007 but will decline progressively as waste stripping reduces over the remaining expected life of the Century ore body to 2015.

Port Pirie smelter (SA) and Hobart refinery (Tas): During 2007 ownership of and operational responsibility for Zinifex Ltd's zinc, lead and silver smelting and alloying operations was merged with Belgian company Umicore to form a new company, Nyrstar NV, the world's largest producer of zinc metal.

Cannington (Qld): In January 2007, BHP Billiton completed a six-month US\$30 million accelerated program of decline and stope access rehabilitation to improve safety conditions at the southern zone of the Cannington silver-lead-zinc underground mine. Subsequently, production returned to expected levels from a 20% reduction in 2006-07.

Golden Grove (WA): Oxiana Ltd (now renamed OZ Minerals Ltd) reported that high grade extensions to mineralisation were delineated by drilling beneath the Gossan Hill orebody complex at Xantho and below the Scuddles mine to an area named Cervantes. As a result, studies are being conducted to investigate possible extensions of the underground mine to provide for zinc and copper production through to 2020. Xantho could be capable of producing high grade copper and zinc ore at a rate of 300-500 ktpa once developed. With the addition of Cervantes ore, Scuddles could continue to produce zinc and copper ore at 200 ktpa to 300 ktpa for at least the next 10 years. Milling circuit studies identified the potential to increase throughput by 50% with modest capital expenditure. Above the Gossan Hill mine, studies indicate open-pit mining is viable for 3 Mt of oxide ore at 2% Cu, 8 Mt of sulphide ore at 2% Cu and 0.9 Mt of gold oxide ore at 3.2 g/t Au and 91 g/t Ag.

Rasp – CML7 (NSW): CBH Resources Ltd reported the access decline to the Broken Hill Western Mineralisation, which is a previously unmined zinc lode, continued on budget and on schedule having reached 1.4 km of 2.1 km in length by the end of 2007. The decline, which starts in the old Kintore open pit in the centre of the Main Lode, provides access for bulk samples and infill drilling for a feasibility study into a 750 ktpa operation. The initial mine life would be five to seven years producing 65 ktpa zinc concentrate (50% Zn), 35 ktpa lead concentrate (70% Pb) and 0.8 Mozs Ag annually (in the lead concentrate). The resource estimate above 400 m is 5.6 Mt at 5.1% Zn, 3.8% Pb and 45g/t Ag. This increases to 10.1 Mt at 4.9% Zn, 3.5% Pb and 43g/t Ag, to a depth of 800 m. Underground drilling from the decline so far has confirmed adjacent high grade remnant Main Lode ore blocks partially mined prior to the 1930's by small inefficient mines. Intersections include 7m at 20.8% Zn, 15.6% Pb and 678 g/t Ag.

Potosi (NSW): During 2007, Perilya Ltd advanced the Potosi exploration decline 997 m from the bottom of the Potosi open pit at Broken Hill. 12 kt of ore was mined from development and trial stoping activities. Potosi ore tonnages are expected to increase to 200-300 ktpa over 30 months from a currently delineated inferred resource of 2.36 Mt with combined metal grades improving from 6.5% on Level 2 to more than 12.5% at depth.

North Mine (NSW): In December, Perilya Ltd announced the decision to proceed with a six month feasibility study at Broken Hill for the development of the North Mine Deeps project which has a mineral resource of 3.7 Mt at 11.3% Zn, 13.5% Pb and 219 g/t Ag and extends down to 1800 m. Also at Broken Hill, Perilya is seeking development approval for an open cut to develop the Flying Doctor section of the northern lease where a resource of 0.52 Mt at 5.4% Zn, 7.1% Pb, and 10.4g/t Ag has been identified.

Beltana (SA): During 2007 Perilya Ltd developed its Beltana high grade, direct shippable zinc oxide open pit as the first phase of its Flinders project. Mining to the final design depth of 100 m below surface and all crushing operations at Beltana were completed in January 2008. A total of 316 kt of zinc silicate ore was mined and stockpiled at an average grade of 32% zinc, for a total of 101 kt of contained zinc. Sales

of the ore stockpiled are expected to take place over 2 to 3 years. The first two shipments comprising 7 kt contained zinc were sold to a Chinese customer in late 2007. A two year sale agreement has been signed for a third of the ore to be processing at a smelter in Thailand. Perilya Ltd also plans to develop the Reliance, Moolooloo, Aristotle and Aroona2 deposits, located within 15 km of the Beltana operation. Resource development drilling was undertaken at the Reliance deposit during 2007.

Jaguar (WA): Jabiru Metals Ltd reported the Jaguar project had progressed on time and under budget, with the final cost being \$69 million for the 300 m deep underground mine development and the construction of the concentrator, including increased throughput capacity from 350 ktpa to 420 ktpa, and camp and infrastructure. The mine is expected to produce around 33.6 ktpa zinc and 9.6 ktpa copper plus 0.9 Mozs/annum of silver from reserves of 1.6 Mt at 3.1% Cu, 11.7% Zn, 0.72% Pb and 120 g/t Ag. The first two shipments of zinc concentrate (48% Zn) were dispatched to smelters in Asia during late 2007 and copper concentrate (20% Cu and 540 g/t Ag) was accumulated for shipment in February 2008.

Angas (SA): Terramin Australia Ltd commenced construction of its \$64 million Angas zinc mine located 46 km south east of Adelaide following approval in March of the mining and rehabilitation plan by the SA government. Angas is forecast to produce 320 kt of zinc concentrate (52% Zn) and 125 kt of lead concentrate (50% Pb, 4.5% Cu, 450 g/t Ag and 7 g/t Au) over its seven year life from a probable reserve of 2.34 Mt at 8.1% Zn, 3.1% Pb, 0.3% Cu, 33 g/t Ag and 0.5 g/t Au. First development ore is expected in January 2008, and first stope ore in June 2008.

Rosebery (Tas): Zinifex Ltd (now merged into OZ Minerals Ltd) announced a 65% increase in resource at Rosebery resulting from an accelerated exploration and delineation drilling program. Infill drilling is underway to confirm the extent of the potential discovery at Rosebery of new, stacked lenses. Ore has been mined at Rosebery for more than a century, including more than 70 years at the current site. Although Rosebery has had a mine life of between four and six years for many years, this new resource discovery now extends mine life to at least 2018.

Mungana (Qld): Kagara Ltd received environmental approvals and expects commissioning to take place in February 2009. The Mungana plant should produce 50 kt of zinc and 8 kt of copper annually, along with silver, gold and lead by-products from a probable reserve of 1.35 Mt at 11.8% Zn, 2% Cu, 1.1% Pb, 124 g/t Ag and 1 g/t Au. By the end of 2007 the decline had advanced 2417 m from the portal, long lead time items such as ball mills and filters had been purchased and delivered and an accommodation village had been built in Chillagoe. Total development costs are anticipated to be \$80 million.

Pillara (WA): Teck Cominco Ltd and Xstrata Plc in a 50/50 joint venture recommenced production at Lennard Shelf in early 2007. The operation had been on care and maintenance since October 2003. During 2007, 42 kt of zinc and 12 kt of lead were produced. The tonnage of ore mined and milled was broadly in line with expectations but lower zinc grades in the ore mined resulted in lower zinc concentrate production. A new zone, Pillara West was discovered about 400m west of existing underground workings with average grades of 6% to 7% Zn, which is typical of the Pillara area. With the subsequent fall in the price of zinc, the mine has returned to care and maintenance.

Woodlawn (NSW): Tri Origin Minerals Ltd commenced a bankable feasibility study for the Woodlawn underground project, targeting an initial mine life of eight years and an ore production rate of approximately 400 ktpa for 80 ktpa of zinc, copper and lead concentrates from 8.5 Mt of measured and indicated resources at 10.3% Zn, 4% Pb, 1.8% Cu, 0.53 g/t Au and 86 g/t Ag. The study also encompasses the Woodlawn retreatment project comprising approximately 10 Mt of tailings, which, at a processing rate of 1.5 Mtpa, are expected to yield approximately 60 ktpa of zinc and copper concentrates.

Magellan (WA): In 2007, exports of lead concentrate through the port of Esperance were suspended following emissions of lead carbonate concentrate dust during bulk loading of the product into ships. The mine went under temporary care and maintenance during the development and approval of a sealed shipping process to transport the lead concentrate for export from the Port of Fremantle using double lined sealed bags in locked shipping containers. Draft approval conditions require Magellan Metals Pty Ltd to lodge a \$5 million bond and fund an independent auditor.

PRODUCTION AND RESOURCE LIFE



Hydrometallurgical plant at Olympic Dam mine, South Australia (BHP Billiton Ltd).

Production and Resource Life

Australia's production and exports of major and other selected mineral resources, concentrates and metals for calendar years 2006 and 2007 are presented in Table 8. The data published by the Australian Bureau of Agricultural and Resource Economics (ABARE) on a quarterly basis.

ABARE reported that mineral production was higher in 2007 compared with 2006. There were significant production increases in rutile concentrates (up 35%), zircon concentrates (up 23%), manganese (up 16%), zinc ores and concentrates (up 16%), uranium (up 13%) and iron ore (up 9%). Diamond production declined significantly by 34% in 2007.

Table 8. Australian production and exports of selected mineral commodities for 2006 and 2007.

Commodity	Production		Exports		Export value \$ million	
	2006	2007	2006	2007	2006	2007
Aluminium						
Bauxite (Mt)	61.8	62.4	5.5	7.2	133	197
Alumina (Mt)	18.3	18.8	15.0	15.3	6 083	5 975
Aluminium (Mt)	1.9	2.0	1.5	1.7	5 464	5 365
Coal						
Black raw (Mt)	398	420.6				
Black saleable (Mt)	302	324.6	236	250.4	23 195	20 760
Brown (Mt 2006–07)	71.0	65.6				
Copper						
Ores and concentrates (kt)	2 969	3 111.2	1 561	1 541.6	4 079	3 843
Refined primary (kt)	429	441.6	284	294.6	2 504	2 561
Diamond (Mc)	29.3	19.2	29.3	19.2	614	684
Gold						
Mine production (t)	245	245.2				
Refined (t) (a)	379	374.9	349	411.0	8 862	10 789
Iron and Steel						
Ore and Pellets (Mt)	275	299.0	247	266.9	14 366	16 258
Iron and steel (Mt)	7.9	8.0	2.6	2.5	1 728	1 669
Lead						
Ores and concentrates (kt)	936	905.5	451	369.0	737	951
Refined (kt)	206	201.7	218	221.8	365	666
Bullion (kt)	118	125.2	121	129.2	259	434
Manganese						
Ores and concentrates (kt)	4.6	5.3	4.2	4.9	465	717
Mineral sands						
Ilmenite concentrates (kt)	2 378	2 325.8	905	874.2	99	100
Rutile concentrates (kt)	232	312.0	231	346.1	192	276
Synthetic rutile (kt)	703	726.6	491	497.1	340	334
Titanium dioxide pigment (kt)	208	208.4	173	176.8	429	398
Zircon concentrates (kt)	492	601.0	487	609.9	446	453
Nickel						
Concentrate (kt Ni)	185	184.5		0.0		909
Refined (kt)	(b)165	(b)167.2	201	170.6	(c)5 514	(c)5 334
Uranium (kt U ₃ O ₈)	8.9	10.1	8.7	10.2	529	884
Zinc						
Ores and concentrates (kt)	2 554	2 961.8	1 831	2 213.8	2 386	2 513
Refined (kt)	464	502.3	356	404.0	1 411	1 678

Notes for Table 8

Source: Australian Mineral Statistics, ABARE, March quarter 2008 & March quarter 2007.

t = tonnes; kt = 10^3 t; Mt = 10^6 t; Mc = 10^6 carats

- (a) Includes primary and secondary gold of Australian and overseas origin
- (b) Sum of products in the Intermediate nickel, <99% Ni and >99% Ni categories
- (c) Sum of all nickel product export values

Commodity export volumes increased for the majority of commodities in 2007. Export volumes decreases were reported for diamonds, copper ore and concentrates, lead ore and concentrates, ilmenite concentrates and refined nickel in 2007. ABARE reported that Australia's export earnings from mineral resources (excluding petroleum and gas) rose to \$90.5 billion in 2007, an increase of 5% compared with 2006.

High export volumes and US dollar prices for most commodities offset the strong Australian dollar resulting in modest rise in export earnings in 2007. The main minerals contributing to the higher export earning in 2007 were diamond, gold, iron ore and pellets, lead, manganese, rutile, uranium and zircon, due to higher prices received and higher export volumes. The largest decline in export earnings in 2007 was metallurgical coal as a result of decline in the US dollar contract prices. Export earnings also declined for the minerals thermal coal, copper ore and concentrates and alumina, mainly due to the stronger Australian dollar.

ABARE forecasts that strong demand in China and other developing countries will continue to drive the growth in mineral markets. World production of mineral commodities has struggled to keep pace with consumption in the past few years. Production at existing mines and commissioning of new capacity has been affected by skills shortages, long lead times for equipment and rising costs.

To sustain such growth and contribution to national economic performance in the medium and longer terms depends on new resources being discovered and developed for production at rates sufficient to meet demand. To facilitate assessment of the future supply capability of identified resources, ratios of AEDR to current mine production are provided in the commodity reviews above, as an indicator of resource life. It is important to note that these 'duration indicators' can change rapidly with significant changes in rates of production and/or major changes to resources. Iron ore, for example, shows how resource life can change markedly over a relatively short period. Increased production in response to growing demand from Asia is a major factor contributing to a 50% reduction in the duration of iron ore resources from 125 years in 1995 to around 65 years in 2007. In addition, the 20% reduction in EDR over the period is due to implementation of the JORC Code by the iron ore industry.

Table 9 presents a comparison of the AEDR/production ratios as assessed over a 10 year period. The assessment provides an indication of the length of time that mining of AEDR could continue at rates of production for each year. There is a markedly lower AEDR/production ratio for coal and iron ore, which are the net result of major increases in production and reassessment of resources.

Resource life duration for gold (about 25 years at current rates of production), zinc and lead (around 30 and 35 years, respectively), and diamond (about 10 years) are relatively low. Increases in the price of gold have contributed to increased expenditure on exploration for this commodity since 1980. However, despite a progressive increase in EDR of gold since the mid-1980s, there is still a need for ongoing successful exploration in the short and medium terms to ensure sufficient available resources to maintain gold as one of Australia's main exports.

Table 9. Years of accessible economic demonstrated resources (AEDR) at the production level for the year (rounded to nearest 5 years).

Commodity	1997	2002	2007
Bauxite	70	85	85
Black coal	190	115	90
Brown coal	670	485	490
Copper	40	35	70
Diamond	5	5	10
Gold	15	20	25
Iron Ore	105	70	65
Lead	35	25	35
Manganese ore	55	55	30
Mineral sands			
ilmenite	65	85	80
rutile	75	80	55
zircon	55	50	50
Nickel	55	105	140
Silver	35	20	25
Uranium	95	90	95
Zinc	35	20	30

There is a need for significant new discoveries of lead and zinc just to maintain production at current levels beyond the next 25 years, when almost all existing base metal mines will have closed. In this regard the focus is on discovery and development of new high quality lead-zinc deposits that are amenable to processing by conventional metallurgical methods.

EXPLORATION



Exploration drilling (rotary mud drill rigs) at Four Mile uranium deposit, Frome Embayment, South Australia (Alliance Resources Ltd)

Exploration

Overview

Australian mineral exploration spending in 2006–07 rose by 38.2% to a record \$1714.6 million of which 35.6% was spent on the search for new deposits.

Western Australia dominated with 48.9% of Australian mineral exploration spending while South Australia, New South Wales, Victoria and Queensland had record expenditure.

Gold remained the main single element target with a share of 26.6% but the base metals, (copper, zinc, lead, nickel, cobalt) formed the largest single exploration target with 32.4% of total spending in 2006-07.

Figure 2. Australian mineral exploration expenditures by commodity in constant 2006–07 dollars (Based on ABS data deflated by Consumer Price Index series).

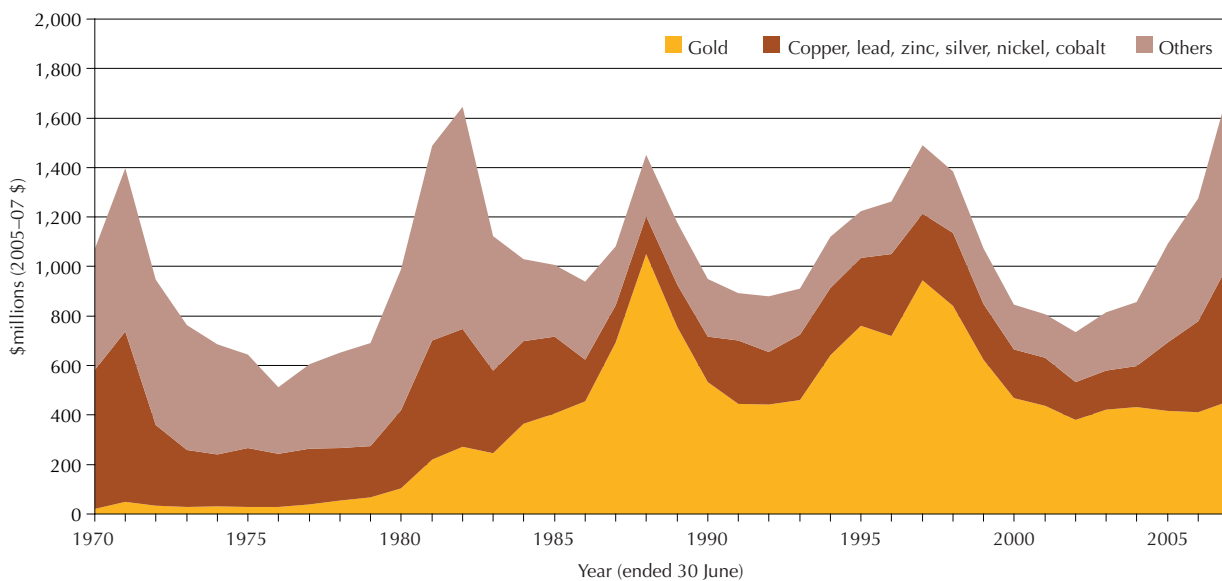
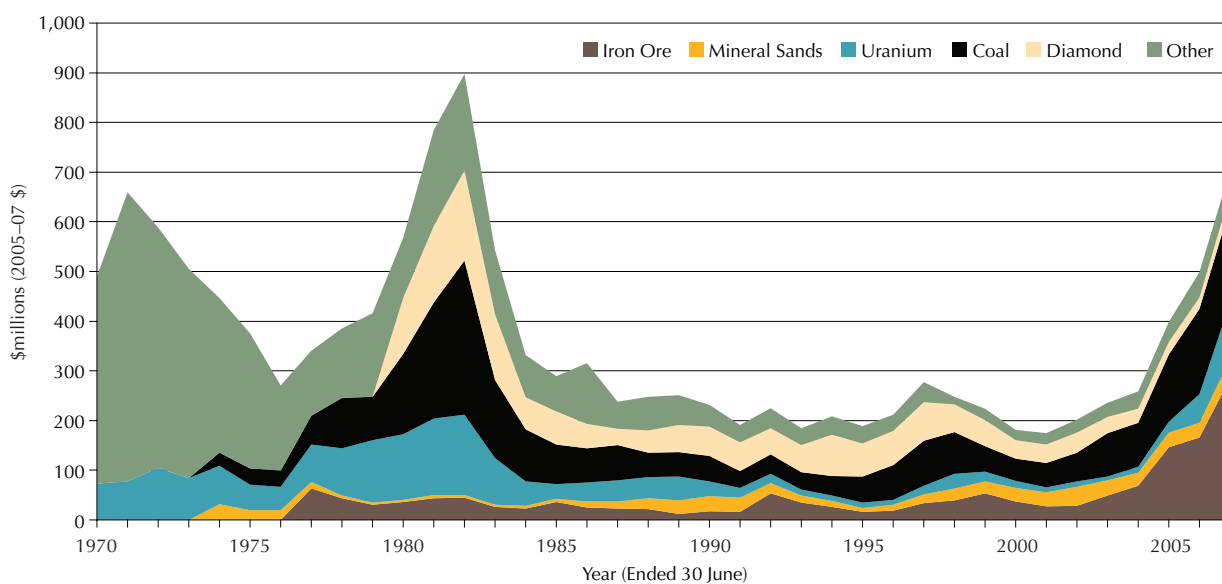


Figure 3. Australian mineral exploration expenditures, excluding gold and base metals, in constant 2006–07 dollars (Based on ABS data deflated by Consumer Price Index series).



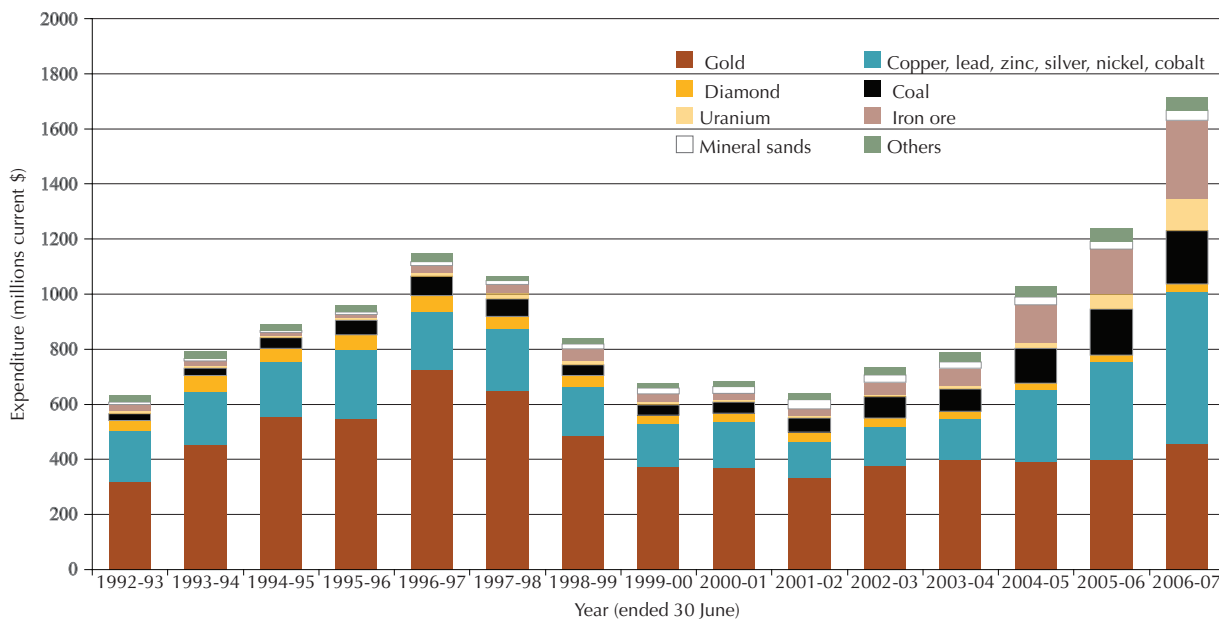
Review

Exploration resulted in significant increases in resources at known deposits and a substantial number of drill intersections of economic interest. The base metals group (nickel-cobalt, copper, zinc-lead-silver) overtook gold as the main target as gold's share fell to 26.6% of total spending. Strong growth was again recorded in spending for iron ore, coal and uranium exploration.

Australian mineral exploration expenditure rose by 38.2% to \$1714.6 million in 2006–07 according to the Australian Bureau of Statistics (ABS). This was a record for annual current dollar expenditure for Australia. In 2006–07 constant dollars, expenditure was also a record after rising by 34.3% (Figs. 2 and 3).

The base metals group (nickel-cobalt, copper, zinc-lead-silver) overtook gold as the main exploration target in 2006–07 (Fig. 4). Base metal exploration spending rose by 55.6% to \$555.0 million with expenditure on copper exploration being the principal driver. Copper exploration rose by 68.1% to \$234.5 million and zinc-lead-silver spending increased by 96.1% to \$139.4 million. Exploration for nickel recovered from a fall in 2005–06 to rise by a more modest 24.1% to \$181.1 million. Gold exploration rose by 14.0% to \$455.8 million which was 26.6% of total exploration compared to 32% in 2005–06. Continued strong international demand and high prices for coal, iron ore and uranium resulted in significant growth in exploration spending for those commodities. Coal exploration spending rose by 16.2% to \$193.3 million, iron ore rose by 77% to \$285.3 million and uranium by 103.4% to \$114.1 million.

Figure 4. Australian mineral exploration spending by commodity (Source: ABS).



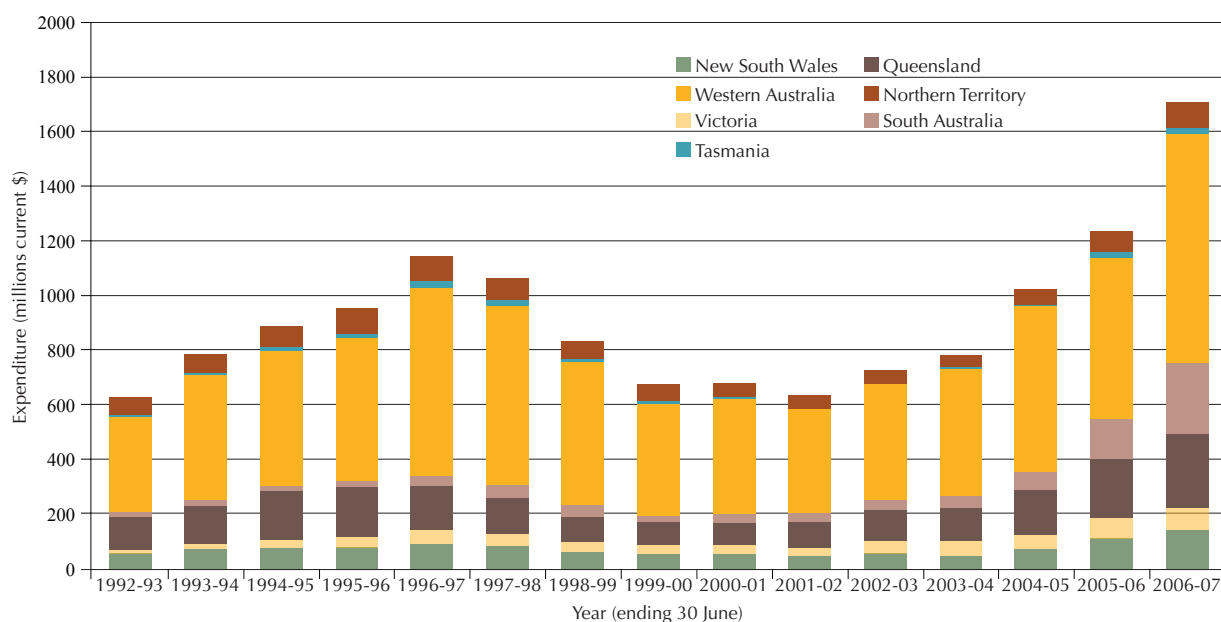
Spending increased in all jurisdictions in 2006–07 (Fig. 5). Western Australia was still dominant attracting \$839.1 million. Record spending was reported in: Queensland, up 24.5% to \$272.3 million; South Australia up 78.0% to \$260.7 million; New South Wales up 26.4% to \$144.1 million and Victoria up 11.3% to \$82.5 million. Spending increased by 23.4% in the Northern Territory to \$92.2 million and in Tasmania it rose by 4.9% to \$23.7 million.

Exploration Stage

ABS reports data on spending on exploration for new deposits and for the further delineation and/or extension of known mineralisation that has resources delineated. Spending is classified as being for the search for new deposits until there has been a JORC resource estimate of any classification prepared. Subsequent spending on exploring that mineralisation would be classified as further delineation or extension of a deposit.

ABS survey data of spending showed that, nationally, 35.6% of spending was on exploration for new deposits, compared to 37% in 2005–06. Victoria (46.3%) had the highest proportion of

Figure 5. Australian mineral exploration spending by State (Source: ABS).



its exploration directed to the search for new deposits while South Australia had the lowest at 24.4%. The national share of exploration for new deposits is lower than the Metals Economics Group (MEG) world survey of non-ferrous minerals exploration budgets for 2007 which found that 41% of exploration budgets in Australia was for grassroots exploration.

Exploration Drilling

In 2006–07, ABS reported that exploration drilling totalled 8.455 million metres, an increase of 1.618 million metres from 2005–06. Drilling in the search for new deposits and on existing deposits increased significantly in 2006–07. An increase of 0.622 million metres occurred in drilling in search of new mineralisation with 3.24 million metres drilled. Drilling on existing deposits rose by 0.996 million metres to a total of 5.215 million metres.

Over 100 initial public offerings on the Australian Stock Exchange in 2007 were fully or partially for mineral exploration in Australia. These companies aimed to raise over \$520 million for Australian exploration and many were heavily oversubscribed.

Calendar Year 2007

On a calendar year basis, exploration spending in 2007 rose by 41% to \$2061.1 million.

Strong growth in the calendar year resulted from substantial increases in spending in each quarter. This growth reflects strong growth in price for many commodities on the back of anticipated strong and growing demand, particularly from China.

Gold remained the predominant single element target in calendar year 2007 its share of total spending was 24.4%. Gold exploration spending totalled \$502.9 million in the year, an increase of \$73 million. The base metal group attracted the largest spending in 2007 with \$702.4 million, an increase of 64.9% with actual spending rising by \$276.3 million. The growth in base metals was driven by substantial increases in zinc-lead-silver exploration, which rose by \$86.7 million to \$187.4 million, copper which rose by \$86.2 million to \$263.7 million and a \$103.3 million increase in nickel exploration to \$251.2 million. Uranium exploration spending more than doubled in 2007 rising from \$80.7 million to \$181.4 million. Iron ore exploration rose by \$129.4 million to \$354.1 million and its share of total spending increased to 17% from 15% in 2006. The growth in iron ore exploration was in response to continuing

strong international demand, particularly from China. In contrast, coal exploration spending fell by \$6.1 million in 2007 to \$192.6 million and along with diamond exploration which fell by \$9.4 million to \$18.4 million were the two commodities for which exploration fell in 2007.

The Northern Territory and all States, except Tasmania, recorded increased exploration spending in calendar year 2007. Western Australia remained dominant with an increase of \$353.5 million in 2007 to \$1038.8 million. This growth allowed the State to recover some of the share of national spending that fell in 2006 to reach just over half national spending. South Australia also recorded a significant dollar increase in spending and increased its share of national spending to 16.2%.

Exploration Outcomes

The ongoing strong exploration activity saw a very large number of reported intersections of economic grade and several new discoveries. A major review of the highlights of mineral exploration in Australia in 2007 is available in the document "Australian Mineral Exploration: A Review of Exploration for the Year 2007 - Extended Edition" available for download from the Geoscience Australia web site.

Responding to world demand there was substantial activity in the iron ore sector with new resources and drilling results released for many smaller deposits and prospects. Similarly uranium exploration surged particularly as the large number of new companies with a focus on uranium started exploration.

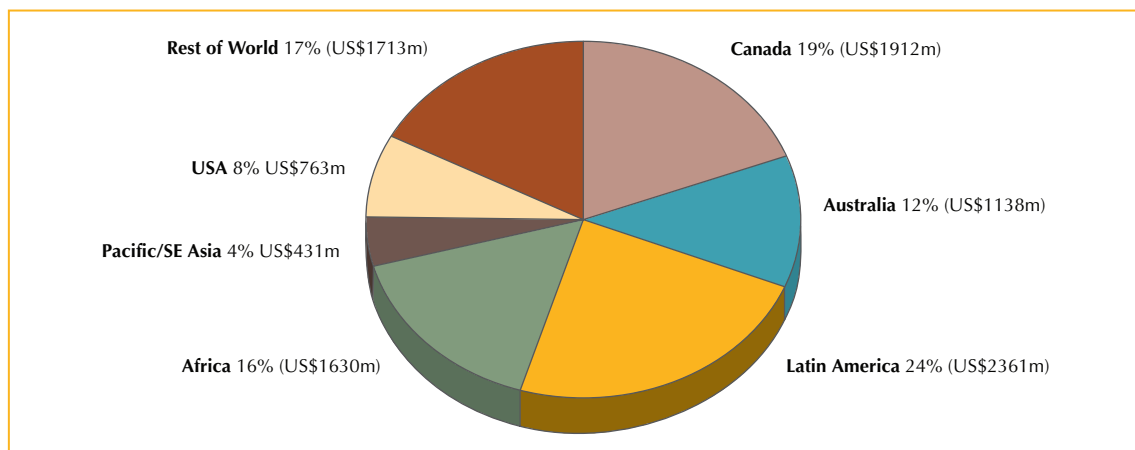
The increased exploration expenditure has been partly offset by major increases in the costs of exploration. Furthermore, the rate at which significant new discoveries are being made continues to decline despite the increasing exploration expenditure, largely reflecting the challenges faced in exploration in frontier regions and at greater depths in established mineral districts.

World Exploration

The MEG survey of world non-ferrous mineral exploration budgets for 2007 reported an increase of 40% to a record estimated total budget of US\$10.5 billion. MEG included uranium in the survey for the first time in 2007 and it estimated that, including uranium, world budgets for non-ferrous mineral exploration was US\$11.4 billion. Of this, US\$1183.2 million was directed to exploration in Australia. Australia's share of global non-ferrous mineral exploration budgets (excluding uranium) rose to 11.9% and Australia retained its position as the country with the second highest share of budgets after Canada (19%).

According to the MEG survey, 60% of the 2007 non-ferrous mineral exploration budgets for Australian-based companies was for exploration in Australia. The survey included 512 companies with non-ferrous exploration budgets of more than US\$100 000 that were exploring in Australia. Budgets for Australian non-ferrous mineral exploration included: gold (US\$387.5 million), base metals (US\$585.9 million) and uranium (US\$154.2 million).

Figure 6. Distribution of world non-ferrous mineral exploration budgets, 2007 (Source: Metals Economics Group).



Outlook for Exploration

Both world and domestic mineral exploration levels grew strongly in 2007. The continuing high metal prices, particularly for the base metals and iron ore, and the sustained higher gold price levels remain conducive to greater exploration activity in 2008. The strong growth in the Chinese economy continues to drive high levels of demand for many commodities and is expected to contribute to ongoing strong exploration spending.

Overall, the outlook for exploration is sound and further growth in exploration expenditure can be expected.

Offshore Mineral Exploration in Commonwealth Waters

The Commonwealth *Offshore Minerals Act 1994* regulates the exploration for, and the production of minerals other than petroleum over the continental shelf three nautical miles beyond the territorial baseline (generally the low water mark) of the States and Territories. The administration is shared between the Commonwealth, the States and the Northern Territory. A Joint Authority consisting of the relevant Australian Government minister and the State and Northern Territory ministerial counterparts is responsible for major decisions such as grants and refusals. The State and Northern Territory ministers make up the Designated Authority and are responsible for the day-to-day administration of the Act.

Applications for a mineral exploration licence (MEL) are made to the Designated Authority. The initial term of a licence is four years and may be renewed for three two year periods subject to satisfactory performance of the licence conditions. There is a mandatory reduction of 50% of the licence area on renewal of an MEL.

As at April 2008, a total of 78 offshore MEL applications had been received since February 1990. Currently there are two active licences, T-2-MRL (Mineral Retention Licence) and T-3-MEL, both of which are in Ringarooma Bay off north east Tasmania. The Mineral Retention Licence owner, Van Dieman Mines plc, is investigating the viability of mining an offshore tin and sapphire deposit. Currently, Van Dieman Mines is constructing an onshore alluvial mine at the Scotia tin and sapphire deposit. Mineral Holdings Australia is exploring for tin and sapphire deposits within T-3-MEL.

An **Australian Offshore Minerals Locations** map showing mineral occurrences and deposits within Australia's 200 nautical mile exclusive economic zone and extended continental shelf is available from the Geoscience Australia Sales Centre sales@ga.gov.au or as a free download ⁵ on the Geoscience Australia website. The Australian Offshore Mineral Locations data also can be viewed online by using Geoscience Australia's **Australian Marine Spatial Information System** (AMSIS).

⁵ <http://www.ga.gov.au/minerals/exploration/offshore/>

Appendix 1

Abbreviations and Acronyms

ABARE Australian Bureau of Agricultural and Resource Economics

ABS Australian Bureau of Statistics

A\$ Australian dollar (where not stated, assume Australian currency)

AEDR accessible economic demonstrated resources

AIMR Australia's Identified Mineral Resources

BRS Bureau of Resource Sciences

c carat

CBM coal bed methane

CMM coal mine methane

CSG coal seam gas

CSM coal seam methane

cpht carats per hundred tonne

CSIRO Commonwealth Scientific and Industrial Research Organisation

EDR economic demonstrated resources

GIS geographical information system

g grams

g/t grams per tonne

GL gigalitre

Gt gigatonne

IAEA International Atomic Energy Agency

JORC Joint Ore Reserve Committee – Australasian Code for Reporting of Exploration Results,

Mineral Resources and Ore Reserves

kg kilogram

km kilometre

kt kilotonne (thousand tonnes)

ktpa kilotonne per annum

L litre

lbs pounds

LNG liquefied natural gas

m metre

m³ cubic metre

Mc million carats

MEL mineral exploration licence

ML million litres

Mlbs million pounds

mm millimetre

Mozs million ounces

Mt million tonnes

Mtpa million tonnes per annum

MW megawatt

MWh megawatt hour

na not available

NSW New South Wales

NT Northern Territory

OECD/NEA Organisation for Economic Cooperation and Development/Nuclear Energy Agency

ozs ounces

PDR paramarginal demonstrated resources

PGM platinum-group metals

PJ petajoules

ppm parts per million

Qld Queensland

RAR reasonably assured resources

REO rare earth oxide

REE rare earth element

ROM run-of-mine

SA South Australia

SDR subeconomic demonstrated resources

t tonne

Tas Tasmania

tpa tonnes per annum

U uranium

U₃O₈ uranium oxide

USA United States of America

USGS United States Geological Survey

US\$ United States of America dollar

Vic Victoria

WA Western Australia

\$1 M million dollars

Appendix 2

National Classification System for Identified Mineral Resources

INTRODUCTION

Australia's mineral resources are an important component of its wealth, and knowledge of the location, quantity and quality of such resources – including estimates of resources yet to be discovered – is an essential prerequisite of formulating sound policies on resources, land-access, land-use and conservation. Results of resource assessment can also be used to set priorities for exploration and mineral potential which are important inputs to decisions where alternative land uses are being considered.

In 1975, the then Bureau of Mineral Resources, Geology and Geophysics (BMR) adopted, with minor changes (BMR 1976), the McKelvey resource classification system used by the US Bureau of Mines and USGS (USBM/USGS 1980). Subsequently informal guidelines for using the system's definitions were developed and used by BMR for several years, until the whole system and its application was reviewed in the light of accumulated experience. The results of that review were published (BMR 1984) as the refined BMR mineral resource classification system for national resource assessment.

The principles of the McKelvey system were retained, as were most of the definitions used by BMR in its original system, although minor changes were made to some. Guidelines on applying the system were established, and adopted. It was decided that the term 'reserves' would not be used for regional or national aggregates of resources, so as to avoid the confusion arising from its use with different meanings in other contexts, particularly for commercial reporting for individual deposits using the JORC Code.

Several editions of an industry code for reporting resources in individual deposits have been published, the most recent being the 2004 edition entitled 'Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves', commonly referred to as the JORC Code. This is a report by a Joint Committee of the Australasian Institute of Mining and Metallurgy, the Australian Institute of Geoscientists, and the Minerals Council of Australia.

The modified McKelvey system and JORC Code are compatible, and data reported for individual deposits by mining companies are used by Geoscience Australia in the preparation of its national assessments of Australia's mineral resources

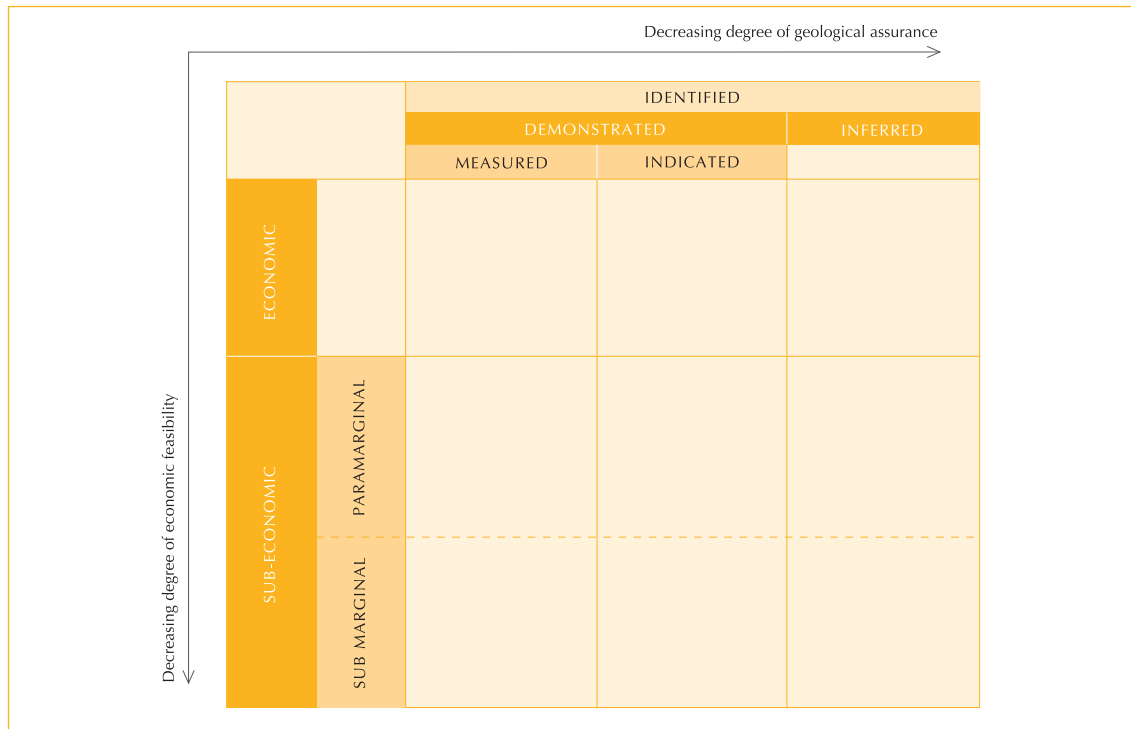
CLASSIFICATION PRINCIPLES

Geoscience Australia classifies known (identified) mineral resources according to two parameters: degree of assurance of occurrence (degree of geological assurance) and degree of economic feasibility of exploitation. The former takes account of information on quantity (tonnage) and grade; the latter takes account of changing economic factors such as commodity prices, operating costs, capital costs, and discount rates.

Resources are classified in accordance with circumstances at the time of classification. Resources which are not available for development at the time of classification because of legal and/or land-use factors are classified without regard to such factors; however, the amount of resource thus affected will, wherever possible, be stated.

The classification framework is designed to accommodate all naturally occurring metals, non-metals, and fossil fuels, and to provide a means of comparing data on different resources, which may have a similar end use (eg. petroleum, coal, and uranium as energy sources).

The modified McKelvey system used by Geoscience Australia for classifying identified mineral resources is illustrated below.



TERMINOLOGY AND DEFINITIONS

Resource: A concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust and in such form that its economic extraction is presently or potentially (within a 20–25 year timeframe) feasible (see guideline i).

CATEGORIES OF RESOURCES BASED ON DEGREE OF ASSURANCE OF OCCURRENCE

Identified (Mineral) Resource: Specific bodies of mineral-bearing material whose location, quantity, and quality are known from specific measurements or estimates from geological evidence. Identified resources include economic and subeconomic components. To reflect degrees of geological assurance, identified resources can be divided into the following categories:

Measured: Resources for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, and drill holes, and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are spaced so closely, and the geological character is so well defined, that size, shape, and mineral content are well established.

Indicated: Resources for which tonnage and grade are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than for resources in the measured category, is high enough to assume continuity between points of observation.

Demonstrated: A collective term for the sum of measured and indicated resources.

Inferred: Resources for which quantitative estimates are based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there is geological evidence. This evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geological evidence of their presence. Estimates of inferred resources should be stated separately and not combined in a single total with measured or indicated resources (see guideline ii).

CATEGORIES OF RESOURCES BASED ON ECONOMIC CONSIDERATIONS

Economic: This term implies that, at the time of determination, profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty (see guideline iii).

Subeconomic: This term refers to those resources which do not meet the criteria of economic; subeconomic resources include paramarginal and submarginal categories.

Paramarginal: That part of subeconomic resources which, at the time of determination, almost satisfies the criteria for economic. The main characteristics of this category are economic uncertainty and/or failure (albeit just) to meet the criteria which define economic. Included are resources which could be produced given postulated changes in economic or technologic factors.

Submarginal: That part of subeconomic resources that would require a substantially higher commodity price or some major cost-reducing advance in technology, to render them economic.

Geoscience Australia guidelines for classifying mineral resources

- (i) Use of the term 'resources' is restricted to material, the extraction of which is generally judged to be potentially economically viable in an arbitrary time frame of about 20 to 25 years. The term includes, where appropriate, material such as tailings and slags. The definition does not intend to imply that exploitation of any such material will take place in that time span, but only that its possibility might reasonably be considered. This guideline attempts to establish a lower limit to what is worth assessing. It should be applied on a commodity by commodity basis to take account of prevailing and prospective technologies. Material falling outside the category of resource should be referred to as 'occurrences'.
- (ii) By definition, inferred resources are classified as such for want of adequate knowledge and therefore it may not be feasible to differentiate between economic and subeconomic inferred resources. Where inferred resources are shown as 'undifferentiated', the amount known or judged to be economic may be indicated. Such judgements must take careful account of the commodity being assessed and its mode of occurrence as these factors will have a bearing on the reliability of estimates made. Specifically, grade estimates can be more reliably made for concordant sedimentary and biological deposits than for discordant epigenetic deposits (King et al. 1982, p. 8).
- (iii) The definition of 'economic' is based on the important assumption that markets exist for the commodity concerned. All deposits which are judged to be exploitable economically at the time of assessment, whether or not exploitation is commercially practical, are included in the economic resources category. It is also assumed that producers or potential producers will receive the 'going market price' for their production. The classification is therefore based on the concept of what is judged to be economic rather than what is considered to be commercial at any particular time.

The information required to make detailed assessments of economic viability of a particular deposit is commercially sensitive (eg. a company's costs and required internal rate of return), and these data may not be available to Geoscience Australia. Furthermore, as corporate strategies are likely to be different, individual companies will have different criteria for what is considered to be 'economic'. Thus to standardise the approach for national or regional resource assessments, the following mineral deposits/situations are accepted by Geoscience Australia, as a general guide, to be economic:

- (a) the resources (published or unpublished) of operating enterprises, whether or not such operations are sustained by long- or short-term, direct or indirect, government subsidies;
- (b) resources in a deposit which is being developed for production (ie. where there is a corporate commitment to production);

- (c) undeveloped resources which are judged to be economic on the basis of a financial analysis using actual, estimated, or assumed variables – viz., the tax rate, capital and operating costs, discount rate (which reflects the long-term bond rate), commodity prices, and depreciation schedules; the values for the economic variables used in an assessment must be realistic for the circumstances prevailing at the time of the assessment;
- (d) resources at mines on care-and-maintenance meeting the criteria outlined in (c) above.

(iv) *Allowances (deductions) for losses due to mining and milling*

For resource categories of the National Scheme, allowances for losses due to mining and milling are the same as those for corresponding categories in the JORC Code. The allowances for losses, which apply to all minerals except coal and uranium, are summarised as follows:

National scheme	JORC scheme	Mining losses	Milling losses
Measured Resources	Proved Ore Reserves	deducted	not deducted - but are considered in assessing economic viability
	Measured Mineral Resources	not deducted	not deducted
Indicated Resources	Probable Ore Reserves	deducted	not deducted - but are considered in assessing economic viability
	Indicated Mineral Resources	not deducted	not deducted
Inferred Resources	Inferred Resources	not deducted	not deducted

For coal, different terms are used – ‘Recoverable coal resources’ is used when allowance has been made for mining losses only. ‘Saleable coal’ is used when allowance has been made for mining as well as processing losses.

Uranium resources are reported in the categories of the OECD Nuclear Energy Agency & International Atomic Energy Agency classification scheme. Losses due to mining and milling are deducted from resources in all categories. These estimates are referred to as ‘Recoverable resources’ and reported under the corresponding categories in the National Scheme.

- (v) Some minerals derive their economic viability from their co-product or by-product relationships with other minerals. Such relationships and assumptions must be clearly explained in footnotes or in accompanying text.
- (vi) National aggregates of resource estimates should be rounded to the appropriate last significant digit, so as not to create false impressions of accuracy.

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Appendix 3

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