Australian Government

Geoscience Australia

AUSTRALIA'S IDENTIFIED

MINERAL RESOURCES

2018

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2018

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MINISTER'S FOREWORD

Australia is a leader in the global rankings of mineral resources for another year running. Our large inventory of mineral resources is driving industries around the country, ensuring our future economic prosperity, especially in regional Australia. These resources include the minerals used for infrastructure development around the world. Australia is also well-placed to meet the growing need for critical minerals, which are essential to high-tech digital technologies and the advanced energy systems of the future.

Australia's Identified Mineral Resources (AIMR), produced by Geoscience Australia since 1975, presents estimates of Australia's mineral reserves and resources. Compiled from the mining industry, these figures reveal trends in reserve estimates, resource estimates and mine production over more than 40 years.

Figures in the 2018 report show that Australia remains one of the best locations for investing in mineral resources. We hold the largest identified resources of nine valuable commodities, including gold, iron ore, zircon and zinc. We are also a world leader in the production of bauxite, iron ore, lithium and rutile, which are all important for manufacturing. The long-term potential for platinum group elements, which are critical for industrial applications across the globe, was revised upward by a factor of four in the last year.

The Australian Government is committed to ongoing development of our high quality deposits. Australia's mineral exports made up 46 per cent of all exported goods and services in 2017. Major commodities—iron ore, black coal, gold, aluminium and copper—also contributed $157 billion to Australia's export income.

We cannot just rely on our currently known resources though. That is why the Australian Government has invested $100.5 million in Exploring for the Future to boost investment in resource exploration. In addition, the Commonwealth and state and territory governments have committed a new collaborative critical minerals work program to boost exploration and open up new minerals provinces and downstream value adding activities.

To support future investment, the Australian Government is also developing Australia's first National Statement on Resources, highlighting the priorities and directions to make Australia's resources sector the best in the world. These are definitive actions to ensure Australia maintains its reliable workforce and strong economy for generations to come.

AIMR 2018 provides a strong evidence base to inform policy decisions and international investment, as well as managing the sustainable development of our mineral resources. The mining industry workforce in 2018 was around 243 000 and this industry significantly contributes to ongoing and new jobs across Australia.

I look forward to seeing support for our world-class and vital minerals sector continue, so our economy can thrive for many years to come. I am extremely pleased to launch this latest version of AIMR for another year.

Senator the Hon Matt Canavan
Minister for Resources and Northern Australia

CONTENTS

AUSTRALIA'S IDENTIFIED MINERAL RESOURCES **2018 OVERVIEW**

1

WORLD NUMBER ONE

RESOURCES

Gold • Iron Ore • Lead
Nickel • Rutile • Tantalum
Uranium • Zinc • Zircon

PRODUCTION

Bauxite • Iron Ore
Lithium • Rutile

5

WORLD TOP FIVE

RESOURCES

Antimony • Bauxite • Black Coal • Brown Coal • Cobalt • Copper
Diamond • Gold • Ilmenite • Iron Ore • Lead • Lithium • Magnesite
Manganese • Nickel • Niobium • Rutile • Silver • Tantalum • Thorium
Tin • Tungsten • Uranium • Vanadium • Zinc • Zircon

PRODUCTION

Antimony • Bauxite • Black Coal • Cobalt • Copper • Diamond
Gold • Ilmenite • Iron Ore • Lead • Lithium • Manganese • Rare Earths
Rutile • Uranium • Zinc • Zircon

ECONOMIC DEMONSTRATED RESOURCES

TOP MOVERS

Graphite ▲ **636%**
Platinum Group Elements ▲ **370%**
Vanadium ▲ **88%**
Phosphate ▲ **9%**
Zinc ▲ **6%**
Cobalt ▲ **5%**
Manganese Ore ▲ **5%**
Rare Earths ▼ **5%**
Tin ▼ **15%**
Niobium ▼ **24%**
Molybdenum ▼ **24%**
Tantalum ▼ **27%**
Diamond ▼ **66%**

RESOURCE LIFE

>100 YEARS
Black Coal • Brown Coal
Cobalt • Copper • Lithium
Mineral Sands • Nickel
Phosphate • Rare Earths
Uranium

50–100 YEARS
Bauxite • Iron Ore • Lead
Silver • Tin • Zinc

<50 YEARS
Antimony • Diamond • Gold
Manganese Ore

EXPLORATION EXPENDITURE 2017 $1754 million ▲ 23%

MINERAL EXPORT EARNINGS 2017

$179 billion ▲ 19%

TOP FIVE EXPORT EARNERS

Iron Ore
35%—$63 billion

Black Coal
32%—$57 billion

Gold
9%—$17 billion

Bauxite-Alumina-Aluminium
7%—$12 billion

Copper
4%—$8 billion

MINING 8.1% GDP 2017

Notes
Economic Demonstrated Resources and production rankings as at 31 December 2017.
Changes are from 31 December 2016 to 31 December 2017.
Resource life for each mineral commodity is calculated by dividing the inventory (EDR) by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. INTRODUCTION

Australia has a robust and world-leading mining industry evidenced by a top five position as a producer for some 17 commodities including gold, bauxite, iron ore, rare earths, mineral sands, zinc, lead and coal. In 2017, Australia's mineral exports (excluding petroleum products) amounted to $179 billion which was 59% of all export merchandise and 46% of all exported goods and services[1]. In 2017, mining accounted for 8.1% of gross domestic product[2]. In addition, the mining industry employed some 220 000 people in 2017, with many more employed by related industries[3].

The major commodities of iron ore, black coal, gold, aluminium and copper contributed some $157 billion to Australia's export income in 2017[4]. Australia is also richly endowed with many other minerals, particularly those that are regarded as critical or strategic by many trading partners. Growing markets for these commodities, particularly for those associated with emerging technologies such as battery storage, renewable energy and electric vehicles have stimulated exploration and resource delineation in Australia in recent years.

Geoscience Australia and its predecessors have prepared the annual assessment of Australia's mineral resources since 1975. Thus, this publication—Australia's Identified Mineral Resources (AIMR)—is able to draw on more than 40 years of data to reveal trends in reserve estimates, resource estimates and mine production over both short and long time periods. This assessment also provides useful long-term indicators of potential resource life and future supply capability. AIMR is designed to assist government policy decision making, enable mineral sector program planning, and contribute to the sustainable development of Australia's mineral resources.

AIMR presents Australia's mineral reserves at operating mines (Table 1) and all deposits (Table 2), longer-term estimates of the nation's resources (Table 3) and changes in resource estimates from the previous year (Table 4).

AIMR also provides useful comparisons of the mine inventory as a proportion of the national inventory (Table 5), national reserves as a proportion of national resources (Table 6) and insights into the distribution of Australia's mineral wealth within the largest deposits (Table 7). It is also of interest to note Australia's ranking as a global source of minerals as many countries are dependent on reliable supply from Australia for their own economies (Table 8).

The estimates in AIMR 2018 of Australia's mineral reserves and resources are as at 31 December 2017. The data in the national minerals inventory is sourced primarily from published company reports but includes some confidential and historical data. The category of highest geological and economic confidence in the national inventory is Economic Demonstrated Resources (EDR) which, in essence, combines the Joint Ore Reserves Committee (JORC) Code categories of Proved and Probable Ore Reserves and most of Measured and Indicated Mineral Resources.

Mine production figures are sourced from the *Office of the Chief Economist* at the Department of Industry, Innovation and Science and company reports. World rankings of Australia's mineral resources have been calculated mainly using information published by the *United States Geological Survey (USGS)*.

1 Office of the Chief Economist, Resources and Energy Quarterly, June 2018, Table 17. Department of Industry, Innovation and Science.

2 Australian Bureau of Statistics (ABS), Australian National Accounts, National Income, Expenditure and Product, cat. no. 5206.0, Table 45.
Note: In the 2016–17 financial year, mining accounted for 7.6% of gross domestic product and in the 2017–18 financial year, this figure grew to 8.2%. ABS, Australian System of National Accounts, cat. no. 5204.0, Table 5.

3 Australian Bureau of Statistics. Labour Force, Australia, Detailed, Quarterly, cat. no. 6291.055.003, Table 4.

4 Office of the Chief Economist. Footnote 1.

JORC CODE

The following terminology and definitions are used by the Joint Ore Reserves Committee (JORC) Code for reporting of Mineral Resources and Ore Reserves (2012 Edition). A full copy of the JORC Code can be found at *www.jorc.org*.

Mineral Resource: A 'Mineral Resource' is a concentration or occurrence of solid material of economic interest in or on the Earth's crust in such form, grade (or quality), and quantity that there are reasonable prospects for eventual economic extraction. The location, quantity, grade (or quality), continuity and other geological characteristics of a Mineral Resource are known, estimated or interpreted from specific geological evidence and knowledge, including sampling. Mineral Resources are sub-divided, in order of increasing geological confidence, into Inferred, Indicated and Measured categories.

Inferred Mineral Resource: An 'Inferred Mineral Resource' is that part of a Mineral Resource for which quantity and grade (or quality) are estimated on the basis of limited geological evidence and sampling. Geological evidence is sufficient to imply but not verify geological and grade (or quality) continuity. It is based on exploration, sampling and testing information gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes. An Inferred Mineral Resource has a lower level of confidence than that applying to an Indicated Mineral Resource and must not be converted to an Ore Reserve. It is reasonably expected that the majority of Inferred Mineral Resources could be upgraded to Indicated Mineral Resources with continued exploration.

Indicated Mineral Resource: An 'Indicated Mineral Resource' is that part of a Mineral Resource for which quantity, grade (or quality), densities, shape and physical characteristics are estimated with sufficient confidence to allow the application of Modifying Factors in sufficient detail to support mine planning and evaluation of the economic viability of the deposit. Geological evidence is derived from adequately detailed and reliable exploration, sampling and testing gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes, and is sufficient to assume geological and grade (or quality) continuity between points of observation where data and samples are gathered. An Indicated Mineral Resource has a lower level of confidence than that applying to a Measured Mineral Resource and may only be converted to a Probable Ore Reserve.

Measured Resource: A 'Measured Mineral Resource' is that part of a Mineral Resource for which quantity, grade (or quality), densities, shape, and physical characteristics are estimated with confidence sufficient to allow the application of Modifying Factors to support detailed mine planning and final evaluation of the economic viability of the deposit. Geological evidence is derived from detailed and reliable exploration, sampling and testing gathered through appropriate techniques from locations such as outcrops, trenches, pits, workings and drill holes, and is sufficient to confirm geological and grade (or quality) continuity between points of observation where data and samples are gathered. A Measured Mineral Resource has a higher level of confidence than that applying to either an Indicated Mineral Resource or an Inferred Mineral Resource. It may be converted to a Proved Ore Reserve or under certain circumstances to a Probable Ore Reserve.

Modifying Factors: 'Modifying Factors' are considerations used to convert Mineral Resources to Ore Reserves. These include, but are not restricted to, mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social and governmental factors.

Ore Reserve: An 'Ore Reserve' is the economically mineable part of a Measured and/or Indicated Mineral Resource. It includes diluting materials and allowances for losses, which may occur when the material is mined or extracted and is defined by studies at Pre-Feasibility or Feasibility level as appropriate that include application of Modifying Factors. Such studies demonstrate that, at the time of reporting, extraction could reasonably be justified.

Probable Ore Reserve: A 'Probable Ore Reserve' is the economically mineable part of an Indicated, and in some circumstances, a Measured Mineral Resource. The confidence in the Modifying Factors applying to a Probable Ore Reserve is lower than that applying to a Proved Ore Reserve.

Proved Ore Reserve: A 'Proved Ore Reserve' is the economically mineable part of a Measured Mineral Resource. A Proved Ore Reserve implies a high degree of confidence in the Modifying Factors.

2. AUSTRALIA'S ESTIMATED ORE RESERVES

Over 2250 companies and securities are listed on the Australian Securities Exchange (ASX) of which nearly 900 (40%) are categorised as belonging to the materials and energy sectors, which includes mining and exploration companies. Recognising that confidence in such a large part of the Australian economy is paramount, the Joint Ore Reserves Committee of The Australasian Institute of Mining and Metallurgy, the Australian Institute of Geoscientists and the Minerals Council of Australia has developed the *JORC Code* for reporting Exploration Results and estimates of Mineral Resources and Ore Reserves to the public. The JORC Code has been adopted by the ASX as part of its listing rules and its use is mandatory for all mining companies listed on the ASX and New Zealand Stock Exchange. Variations of the JORC Code have been adopted in many other parts of the world and the code is compatible with the international templates of *CRIRSCO*[5] and the *United Nations Framework Classification for Resources*.

As part of the Australian Government's annual assessment of the national minerals inventory, Geoscience Australia compiles all known estimates of Ore Reserves and Mineral Resources reported publicly by mining companies in compliance with the JORC Code, or JORC-equivalent codes. In addition, reserve and resource estimates from private companies and foreign companies operating in Australia are also included in the annual compilation wherever possible.

Determining how much of a particular mineral commodity is in the ground and how much is extractable is not an exact science, hence Ore Reserves and Mineral Resources are always referred to as estimates, never calculations. Mineral Resources and Ore Reserves are categorised by confidence in both the geology of the deposit and the economic viability of production. Of all the different categories (see description of JORC Code on page 2), an Ore Reserve is the category of highest confidence. From a commercial point of view, this category is the most applicable to understanding the state of Australia's minerals industry now and in the near future (say, the next five years).

Geoscience Australia began publishing amalgamated national totals for Ore Reserves in 2002. Prior to this, these estimates were only included within the national inventory of EDR and were not specifically noted.

OPERATING MINES

In 2017, Australia had over 300 operating mines producing 35 major and minor mineral commodities. In addition, there were a large number of excavations for a range of industrial materials and gemstones (not covered in this publication). Mining contributed 8.1% to Australia's gross domestic product in 2017[6] and 46% of Australia's export income. In determining the outlook for the industry in Australia, it is useful to look at the Ore Reserves and Mineral Resources associated with operating mines (Table 1) as it is usually easier and cheaper to expand current mines than to start new ones. While some of the mines that operated in 2017 have since closed or been placed on care and maintenance, subject to favourable economic, environmental and regulatory conditions, most will continue mining for the foreseeable future.

One way of gaining an impression of future viability of a mine or resource is to calculate the ratio of reserves or resources to production, thus establishing a reserve or resource 'life' (Table 1). The resulting reserve and resource life must be treated with caution as it is an average and it assumes three things: (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced. In reality, production rates vary from year to year, mining companies continually reassess the economic viability of their deposits and companies typically do upgrade resources or discover new resources to replace ore depletion. Nonetheless, this ratio provides a potentially useful 'snapshot in time' that can help reveal trends in Australia's ability to supply a range of mineral resources.

Gold was extracted at 128 mines in 2017 (Table 1). Many companies have multi-mine operations so a single company failing could potentially affect the exploitation of a greater number of individual deposits. In addition, gold reserves and resources are dominated by large multi-element deposits such as Olympic Dam (Cu-Au-U) in South Australia and Cadia (Cu-Au) in New South Wales, whereas production is dominated by lode-gold deposits such as those of the Kalgoorlie goldfields of Western Australia (see Section 5). In 2017, nearly 70% (203 t) of the 292 t of gold produced nationally came from lode-gold deposits. Gold at operating lode-gold deposits accounted for 987 t (34%) of the Ore Reserves

5 CRIRSCO is the Committee for Mineral Reserves International Reporting Standards.

6 Australian Bureau of Statistics (ABS), Australian National Accounts, National Income, Expenditure and Product, cat. no. 5206.0, Figure of 8.1% calculated by dividing Mining (B) Table 45 by Gross Domestic Product Current Table 1.

and 1977 t (29%) of the Measured and Indicated Resources. At this continued rate of production, operating lode-gold deposits have an average reserve life of five years and a resource life of ten years, based on Measured and Indicated Resources. In comparison, all gold-producing deposits have a resource life of 23 years (Table 1).

Australia also has a large number of operating black coal mines (91; Table 1), nearly all of which are located in New South Wales or Queensland. Black coal Ore Reserves at operating mines could last 23 years at 2017 rates of production (Table 1) and, when all Reserves are considered (Table 2), this figure extends to 33 years.

There were 33 operating iron ore mines in 2017 (Table 1) producing 37% of the global supply (Table 8). At 2017 rates of production, these mines have enough Ore Reserves for another 11 years, but 20 years when the Measured and Indicated Mineral Resources of these mines are included (Table 1). When non-operating mines are included, the 2017 ratio of Ore Reserves to production is 27 years (Table 2).

Of the other bulk commodities at operating mines—bauxite, manganese ore and mineral sands—manganese ore has the longest reserve life (18 years) and a resource life (Measured and Indicated categories only) of some 35 years at 2017 production rates (Table 1). This outlook is reduced from that of 2016 because Australian mine production increased from 3.2 Mt to 5.6 Mt when Woodie Woodie (Western Australia) and Bootu Creek (Northern Territory) came out of care and maintenance to join Groote Eylandt (Northern Territory) in operation. Only Nicholas Downs (Western Australia) remains non-operational. This positions Australia as the third largest producer of manganese in the world (Table 8).

Bauxite mining remains strong in Australia with Australia ranked number one for bauxite production globally (Table 8). Of the seven mines that operated in 2017 (Table 1), the four largest—Gove (Northern Territory), Weipa (Queensland), Worsley and Huntly (both Western Australia)—accounted for almost all production. At 2017 rates of production, Ore Reserves at these mines could last an average of nine years and when developing mines (e.g. the large Amrun project south of Weipa) are considered, reserve life could potentially be 25 years (Table 2).

Ten mines produced ilmenite, eight produced rutile and nine produced zircon in 2017 (Table 1). Globally, this placed Australia first for rutile production and second for ilmenite and zircon production (Table 8). At 2017 rates of production, Ore Reserves at these operating mines could last 11 years for ilmenite, 7 years for rutile and 9 years for zircon (Table 1). The reserve life of all deposits using 2017 rates of production is much greater at 38 years for ilmenite, 22 years for rutile and 40 years for zircon (Table 2).

The nonferrous metals of copper, lead, zinc and nickel all have potential reserve lives greater than 20 years at 2017 rates of production (Table 2). Copper is dominated by the huge Olympic Dam deposit in South Australia, which produced nearly 20% of Australia's copper output in 2017 and comprises half the national Ore Reserve. If Olympic Dam were removed from the calculations, the reserve life for copper would drop from 27 years to just 14 years (Table 2). Longer term, the resource life of operating copper mines, based on Measured and Indicated Resources, is 82 years, again skewed strongly by Olympic Dam (Table 1).

The Measured and Indicated Resources of lead and zinc at operating mines could potentially last around 60 years at 2017 rates of production (Table 1). Lead-zinc (-silver) deposits are widely dispersed in Australia with lead and zinc produced in Queensland (Cannington, Mount Garnet, George Fisher, Mount Isa), New South Wales (Broken Hill, Rasp, Endeavour, Hera), the Northern Territory (McArthur River), Tasmania (Rosebery) and Western Australia (Gossan Hill). In addition, the Bentley mine (Western Australia) produced zinc and the Peak mine (New South Wales) produced lead.

Nickel is mined at 10 deposits (Table 1), all in Western Australia, from either sulphide or lateritic ores. The reserve life of operating mines at 2017 rates of production is potentially 10 years (Table 1) but reserve life is triple that when all deposits are included in the calculation (Table 2). This is because low nickel prices in recent years have led to some nickel mines being placed on care and maintenance and delayed the development of others. Consequently there is a relatively large Ore Reserve of nickel that is not currently being exploited but is still published as current by the owners.

Australia is richly endowed in silver, ranking second globally (Table 8). Much of it is associated with lead-zinc deposits, but silver is also commonly found with gold and in other deposit types. It is widely dispersed in Australia, with all states having Ore Reserves, dominated by Queensland (49%), the Northern Territory (21%), South Australia (12%) and New South Wales (10%). Despite this dispersion, more than two thirds of Australia's silver resources are held by the giant silver-lead-zinc deposits of McArthur River in the Northern Territory, George Fisher, Mount Isa and Cannington, all in Queensland, as well as the Olympic Dam iron oxide-copper-gold (IOCG) deposit in South Australia. Silver was produced as a major product at 21 mines in 2017 as well as at most gold mines as a by-product. These major silver mines have a potential reserve life of 17 years and a possible resource life (Measured and Indicated) of 59 years, at 2017 rates of production (Table 1).

Australia has large uranium Ore Reserves (285 kt; Table 2) of which more than 95% is associated with three mines: Olympic Dam and Four Mile, both in South Australia, and Ranger in the Northern Territory (Table 1). In 2017, mining took place at the South Australian properties with Ranger producing from stockpiles. At 2017 rates of production, these mines have an average reserve life of 51 years and a potential resource life (Measured and Indicated) of 284 years (Table 1), strongly skewed by Olympic Dam which is the world's largest uranium deposit. In 2017, Olympic Dam alone produced more than 60% of Australia's uranium with reserves that could last about 75 years.

Australia has very few diamond deposits with only Argyle in the Kimberley region of Western Australia and Merlin in the Northern Territory having current Ore Reserves. In 2017, only Argyle was fully operational (Table 1). After pilot production in 2013, test mining at Merlin restarted at the end of 2016 and was ongoing in 2017, but without significant production. The Argyle diamond mine (Rio Tinto Ltd) is a leading global supplier and the largest supplier of naturally coloured diamonds. It is particularly famous for its pink stones, producing more than 90% of all pink diamonds in the world. Argyle is expected to close in 2021 and while production in 2017 was higher than that of 2016, the Ore Reserves at this mine have almost halved in the same period.

Table 1 Australia's Ore Reserves and Mineral Resources of selected commodities at operating mines in 2017.

Commodity	Unit	No. of Operating Mines[1]	Ore Reserves[2]	Measured and Indicated Mineral Resources[3]	Inferred Mineral Resources[4]	Mine Production[5]	Reserve Life (years)	Resource Life 1 (years)	Resource Life 2 (years)
Antimony	kt Sb	1	17.1	36.5	4.2	4.61[6]	4	8	9
Bauxite	Mt	7	813	2184	2533	87.9	9	25	54
Black Coal	Mt	91	12 713	28 242[7]	11 842[7]	559[8]	23	51	72
Copper	Mt Cu	35	20.08	70.65	30.01	0.860	23	82	117
Diamond	Mc	2	39.01	39.14	3.82	17.14	2	2	3
Gold	t Au	128	2903	6702	1949	292	10	23	30
Iron Ore	Mt	33	9424	17 470	31 739	883	11	20	56
Lead	Mt Pb	12	9.95	30.47	6.25	0.459	22	66	80
Lithium	kt Li	4	1003	1437	1161	21.3[9]	47	67	122
Manganese Ore	Mt	3	102	195	34	5.6[10]	18	35	41
Mineral Sands									
Ilmenite	Mt	10	16.1	57.8	13.5	1.5[11]	11	39	48
Rutile	Mt	8	2.2	8.0	2.1	0.3[11]	7	27	34
Zircon	Mt	9	4.7	14.1	3.0	0.5[11]	9	28	34
Nickel	Mt Ni	10	1.81	5.11	1.13	0.179	10	29	35
Rare Earths[12]	Mt oxide	1	1.02	1.51	0.59	0.017[13]	60	89	124
Silver	kt Ag	21[14]	19.25	66.20	17.30	1.120	17	59	75
Tin	kt Sn	1	171	215	90	7.4[15]	24	30	43
Uranium	kt U	3	271	1518	822	5.344	51	284	438
Zinc	Mt Zn	12	18.54	47.15	11.75	0.841	22	56	70

Abbreviations

t = tonne; kt = kilotonnes (1000 t); Mt = million tonnes (1 000 000 t); Mc = million carats (1 000 000 carats).
Where an element symbol follows the unit it refers to contained metal content.

Notes

Reserve Life = Ore Reserves÷production.
Resource Life 1 = Measured and Indicated Resources÷production.
Resource Life 2 = Measured, Indicated and Inferred Resources÷production.

1. The number of operating mines counts individual mines that operated during 2017 and thus contributed to production. Some of these mines may belong to larger, multi-mine operations and some may have closed during or since 2017.
2. The majority of Australian Ore Reserves and Mineral Resources are reported in compliance with the JORC Code, however there are a number of companies that report to foreign stock exchanges using other reporting codes, which are largely equivalent. In addition, Geoscience Australia may hold confidential information for some commodities. NB: Not all operating mines report Ore Reserves. Ore Reserves are as at 31 December 2017.
3. Measured and Indicated Mineral Resources are inclusive of the Ore Reserves. NB: Not all operating mines report Mineral Resources. Mineral Resources are as at 31 December 2017.
4. Inferred Mineral Resources are as at 31 December 2017. NB: Not all operating mines report Mineral Resources.
5. Source: Resources and Energy Quarterly, June 2018, published by the Office of the Chief Economist, Department of Industry, Innovation and Science unless otherwise stated. Production data often have a higher level of certainty than reserve and resource estimates and, thus, may be presented with more significant figures.
6. Antimony production from company reports.
7. Measured, Indicated and Inferred Mineral Resources for black coal are presented on a recoverable basis (these are Geoscience Australia estimates unless provided by the company).
8. Mine production refers to raw coal.
9. Lithium production is a Geoscience Australia estimate based on Mineral and Petroleum Statistics Digest 2016–17, published by the Department of Mines, Industry Regulation and Safety, Western Australian Government.
10. Manganese production from company reports. Minimum estimate as Woodie Woodie production unknown.
11. Mineral sands production from company reports.
12. Rare earths comprise rare earth oxides (REO) and yttrium oxide (Y_2O_3).
13. Rare earths production from company reports.
14. Major silver producing mines only; many gold and copper mines also produce silver as a by-product but these are not counted here.
15. The Office of the Chief Economist reports tin production of 7.4 kt in 2017, however the sole operating mine (Renison Bell) reports 7.1 kt. The remainder is by-product from other operations such as Greenbushes.

Table 2 Australia's Ore Reserves[1] as at December 2017.

Commodity	Unit	Proved Ore Reserves	Probable Ore Reserves	Proved & Probable Ore Reserves[2]	Total Ore Reserves	Mine Production 2017[3]	Reserve Life
Antimony	kt Sb	14.6	49.7	0	**64.3**	4.61[4]	14
Bauxite	Mt	1032	1138	0	**2170**	87.9	25
Black Coal	Mt	8433	8341	1762	**18 536**	559[5]	33
Brown Coal	Mt	n.a.	n.a.	n.a.	**n.a.**	53[6]	n.a.
Chromium	kt Cr	0	0	0	**0**	0	0
Cobalt	kt Co	107	199	<1	**307**	5.8[7]	65
Copper	Mt Cu	6.06	16.20	0.77	**23.03**	0.860	27
Diamond	Mc	0	39.01	0	**39.01**	17.14	2
Fluorine	kt F	0	0	0	**0**	0	0
Gold	t Au	883	2961	25	**3869**	292	13
Graphite	Mt	0.06	0.99	0	**1.05**	0	0
Iron							
Iron ore	Mt	8447	15 698	2	**24 146**	883	27
Contained iron	Mt Fe	4096	6705	1	**10 801**	547	20
Lead	Mt Pb	6.67	4.93	0	**11.60**	0.459	25
Lithium	kt Li	165	1497	0	**1662**	21.3[8]	78
Magnesite	Mt $MgCO_3$	10	3	24	**37**	<1[9]	187
Manganese Ore	Mt	48	31	22	**102**	5.6[10]	18
Mineral Sands							
Ilmenite	Mt	25.7	31.5	0	**57.1**	1.5[11]	38
Rutile	Mt	3.2	3.5	0	**6.7**	0.3[11]	22
Zircon	Mt	9.6	10.4	0	**20.0**	0.5[11]	40
Molybdenum	kt Mo	0	4.2	0	**4.2**	0	0
Nickel	Mt Ni	2.0	3.4	<1	**5.4**	0.179	30
Niobium	kt Nb	58	0	0	**58**	0[12]	0
Oil Shale	GL	0	0	0	**0**	0	0
PGE	t metal	0	0	0	**0**	<1[13]	n.a.
Phosphate							
Phosphate rock[14]	Mt	W	W	W	**81**	1.5[15]	54
Contained P_2O_5	Mt P_2O_5	7.1	15.5	0	**22.7**	n.a.	n.a.
Potash	Mt K_2O	0	1.4	0	**1.4**	0	0
Rare Earths[16]	Mt oxide	0.81	1.11	0	**1.92**	0.017[17]	113
Silver	kt Ag	12.91	11.92	0	**24.82**	1.120	22
Tantalum	kt Ta	6.5	7.0	0	**13.5**	n.a.	n.a.
Thorium	kt Th	0	0	0	**0**	0	0
Tin	kt Sn	37	118	98	**253**	7.4	36
Tungsten	kt W	21	195	0	**216.4**	<1[18]	>100 000
Uranium	kt U	89	196	0	**285**	5.344	53
Vanadium	kt V	681	394	0	**1075**	0	0
Zinc	Mt Zn	12.55	12.75	0	**25.30**	0.841	30

Abbreviations

t = tonne; kt = kilotonnes (1000 t); Mt = million tonnes (1 000 000 t); Mc = million carats (1 000 000 carats); GL = gigalitre (1 000 000 000 L); n.a. = not available; W = withheld for confidentiality reasons; PGE = platinum group elements (Pt, Pd, Os, Ir, Ru, Rh).

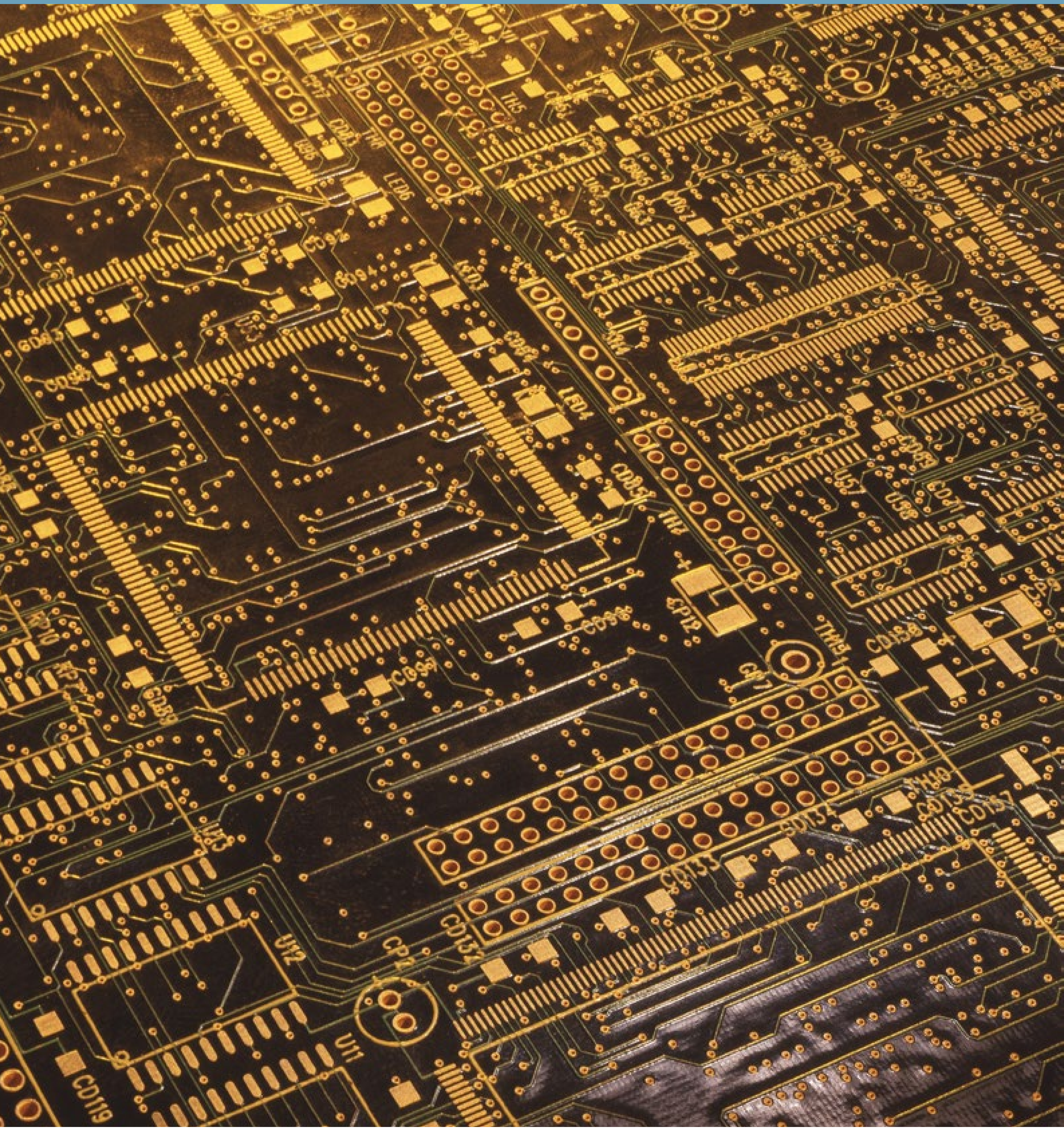
Where an element symbol follows the unit it refers to contained metal content.

Notes

Reserve Life = Ore Reserves÷production.

Figures are rounded so Proved, Probable and Proved & Probable Ore Reserves may not add up to Total Ore Reserves exactly.

1. The majority of Australian Ore Reserves are reported in compliance with the JORC Code, however there are a number of companies that report to foreign stock exchanges using other reporting codes, which are largely equivalent. In addition, Geoscience Australia may hold confidential information for some commodities.
2. 'Proved & Probable Ore Reserves' is a distinct reporting category that is no longer supported by the JORC Code. Some overseas reporting codes still use this category and some historical resources fall into this category.
3. Source: Resources and Energy Quarterly, June 2018 published by the Office of the Chief Economist, Department of Industry, Innovation and Science unless otherwise stated. Production data often have a higher level of certainty than reserve and resource estimates and, thus, may be presented with more significant figures.
4. Antimony production from company reports.
5. Black coal production refers to raw coal.
6. Brown coal production is a Geoscience Australia estimation.
7. Australian cobalt production from company reports and Geoscience Australia estimates.
8. Lithium production is a Geoscience Australia estimate based on Mineral and Petroleum Statistics Digest 2016–17, published by the Department of Mines, Industry Regulation and Safety, Western Australian Government.
9. The Department of State Development, South Australia (Report Book 2017/00014) reported magnesite production of 3241 t in 2017. The Queensland Department of Natural Resources and Mines (Annual mineral and metal statistics) reported magnesite production of 207 603 t in 2016–17.
10. Manganese production from company reports. Minimum estimate as Woodie Woodie production unknown.
11. Minerals sands production from company reports.
12. There are no mines producing niobium as a primary product in Australia. It is possible that niobium is produced as a by-product at some lithium/tantalum operations, but these data have not been reported.
13. The Western Australia Department of Mines, Industry Regulation and Safety (Mineral and Petroleum Statistics Digest 2016–17) reported 783 kg of platinum and palladium produced as by-product in 2016–17.
14. Phosphate rock is reported as being economic at grades ranging from 8.7% to 30.2% P_2O_5.
15. Christmas Island mined 550 140 t in 2017. The Queensland Department of Natural Resources and Mines (Queensland Annual Mineral Summary) reported phosphate production of 940 827 t in 2016–17. Minor production (1213 t) was recorded in South Australia (Report Book 2018/00017).
16. Rare earths comprise rare earth oxides (REO) and yttrium oxide (Y_2O_3).
17. Mount Weld in Western Australia supplies rare earth mineral concentrates to the Lynas Advanced Materials Plant (LAMP) in Malaysia. Lynas Corporation Ltd (Quarterly Reports to the ASX) reported that LAMP produced 17 264 t of ready-for-sale rare earth oxides in 2017.
18. Tungsten production from company reports.



Australia is one of the world's leading producers of gold which has a wide variety of uses including jewellery, finance, dentistry, medicine, printing, aerospace and modern computing technologies. The billions of mobile phones, computers and tablets in the world today each require small amounts of gold, as well as a host of other minerals such as copper, lead, silver, magnesium, cobalt, nickel, iron, platinum group elements and rare earths. They also require plastics which are usually derived from petroleum.

TRENDS IN RESERVE LIFE

The reserves/production ratios of the bulk commodities bauxite (Figure 1) and black coal (Figure 2) have been generally decreasing since the turn of this century. This is because production has increased at a faster rate than depleted Ore Reserves have been replaced. The iron ore industry, however, has managed to increase Ore Reserves at a similar rate to their production increases and, since 2008, reserve life has been steady at around 25 to 30 years (Figure 3).

Some commodities, such as copper and gold, experience long periods with little variation in reserve life from year to year. Gold is a particularly good example with a reserve life that has varied little (from 12 to 16 years) since 2002 (Figure 4) whereas copper has a slightly larger range of 21 to 29 years (Figure 5). This narrow range reflects ongoing industry practice of steadily replenishing depleted Ore Reserves by upgrading a similar quantity from Measured and Indicated Resources. In turn, Inferred Resources are upgraded to Measured and Indicated and new resources are added to the inventory through exploration.

Notable yearly swings in reserve life do occur for some commodities such as lead (Figure 6), zinc (Figure 7) and silver (Figure 8), and can be mostly explained by: mine closures (sometimes temporary) with accompanying loss of production; companies upgrading or downgrading Ore Reserves as individual projects succeed or fail; or companies reducing or ramping up production in response to price fluctuations. Lead and zinc both saw strong upticks in reserve life in 2016 (Figure 6 and Figure 7) reflecting reduced production at Mount Isa and McArthur River but are expected to return to trend as Dugald River comes online.

Larger trend changes are seen for nickel (Figure 9) and uranium (Figure 10). Nickel reserve life decreased from 2002 to 2009 as production was not matched by new reserve delineation (Figure 9). Production subsequently fell as some mines became uneconomic at lower nickel prices post the global financial crisis of 2007–08 which, along with lagging reserve increases, resulted in greater reserve life (Figure 9). Uranium reserve life, while consistently large, has been volatile over the last 15 years (Figure 10). With so few existing mines and the challenges associated with developing new uranium mines, any reassessment of reserves or changes in production can result in a large variation in reserve life from year to year.

The reserve life of mineral sands has also been volatile over time (Figure 11, Figure 12 and Figure 13). For approximately ten years from 2002, the reserve life of mineral sands ranged from 13 to 22 years for ilmenite (Figure 11) and 15 to 24 years for rutile (Figure 12) with zircon generally trending up, particularly since 2007, to reach 40 years in 2017 (Figure 13). From 2011 to 2013, reserve life increased strongly for each commodity. For ilmenite and rutile this was mainly a result of falling production outpacing new Ore Reserve estimates. Production fell in response to lower prices for these commodities after the global financial crisis. Zircon production did not fall, rather it has generally increased since 2011, but reserve estimates have risen faster resulting in an increased reserve life overall.

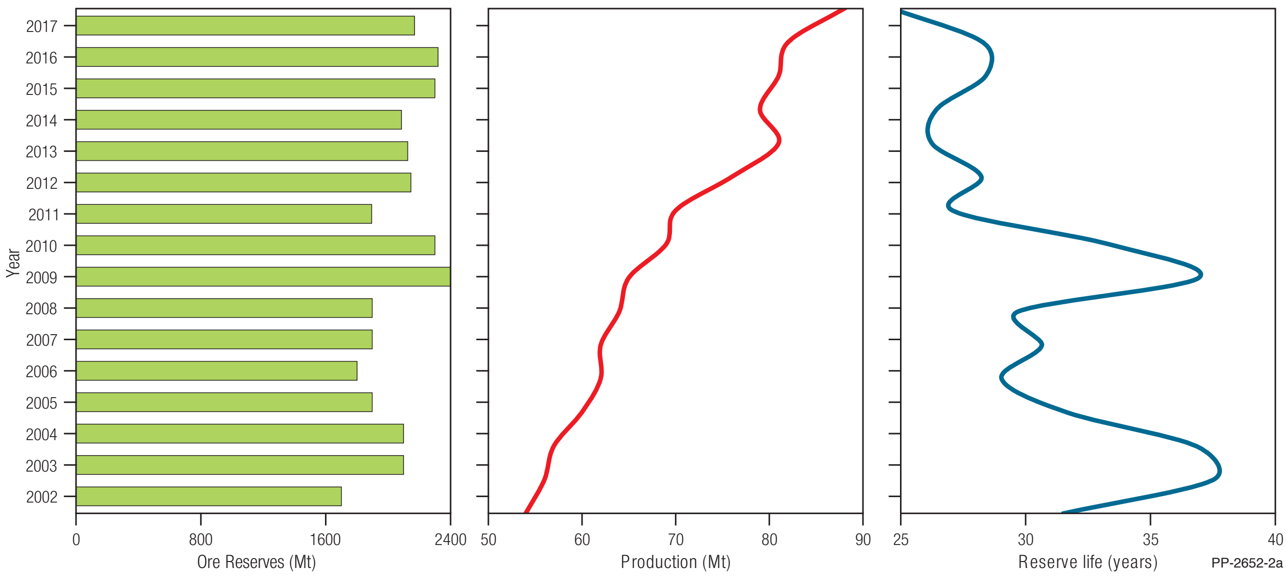


Figure 1 **Trends in Ore Reserves, annual production and reserve life for BAUXITE from 2002 to 2017.**
Mt = million tonnes.

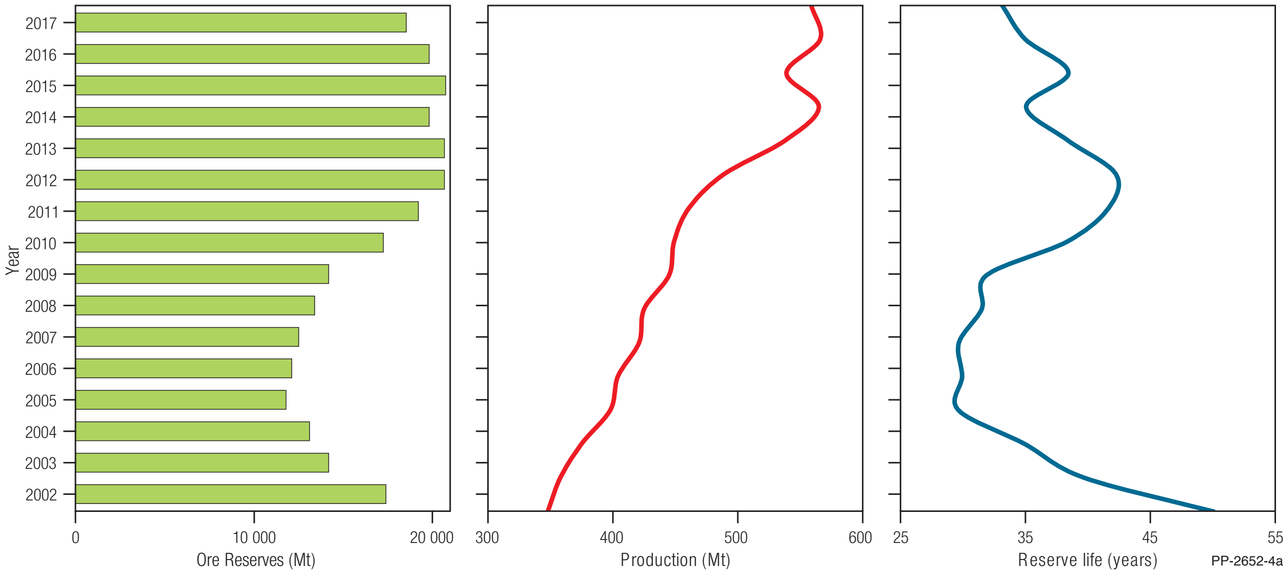


Figure 2 Trends in Ore Reserves, annual production and reserve life for BLACK COAL (recoverable) from 2002 to 2017.

Mt = million tonnes.

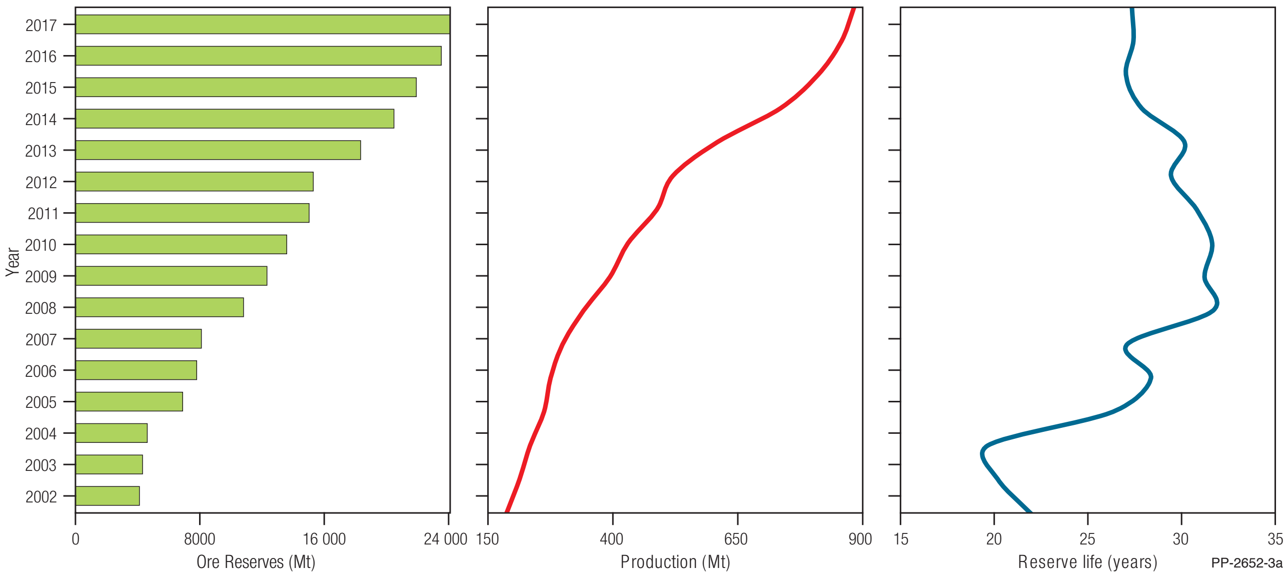


Figure 3 Trends in Ore Reserves, annual production and reserve life for IRON ORE from 2002 to 2017.

Mt = million tonnes.

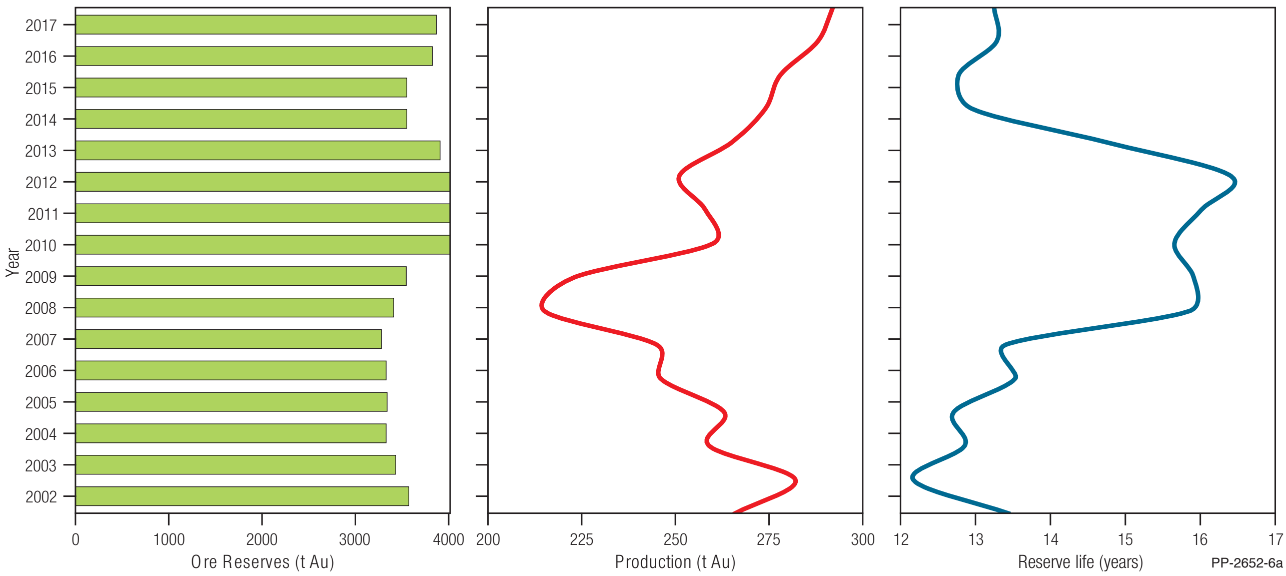


Figure 4 Trends in Ore Reserves, annual production and reserve life for GOLD from 2002 to 2017.

t Au = tonnes of contained gold.

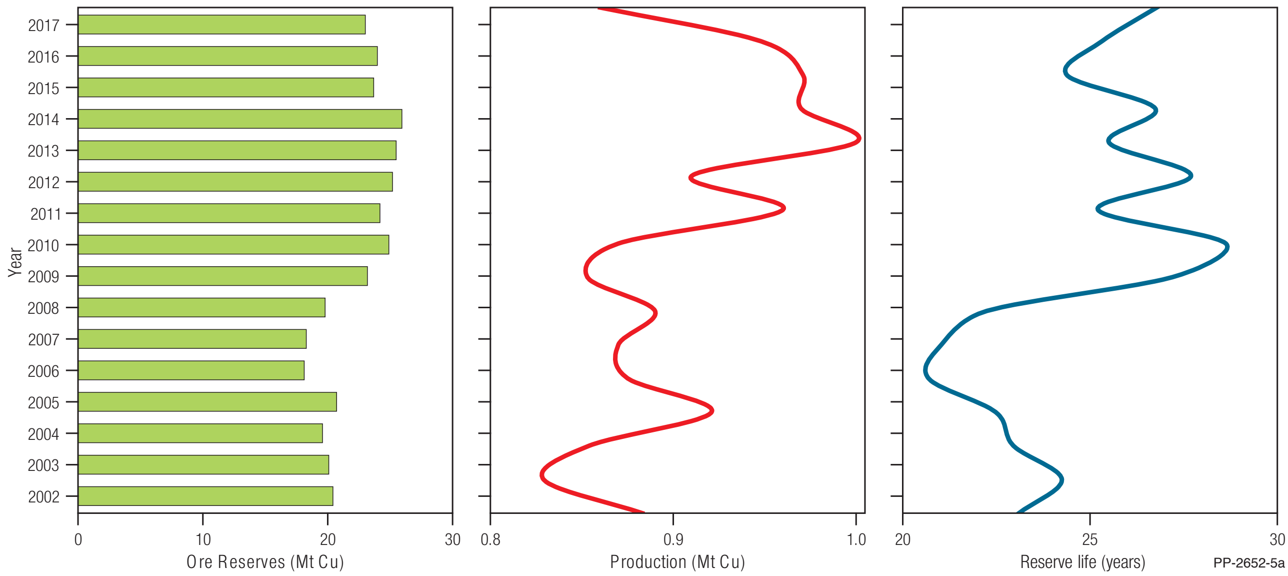


Figure 5 Trends in Ore Reserves, annual production and reserve life for COPPER from 2002 to 2017.

Mt Cu = million tonnes of contained copper.

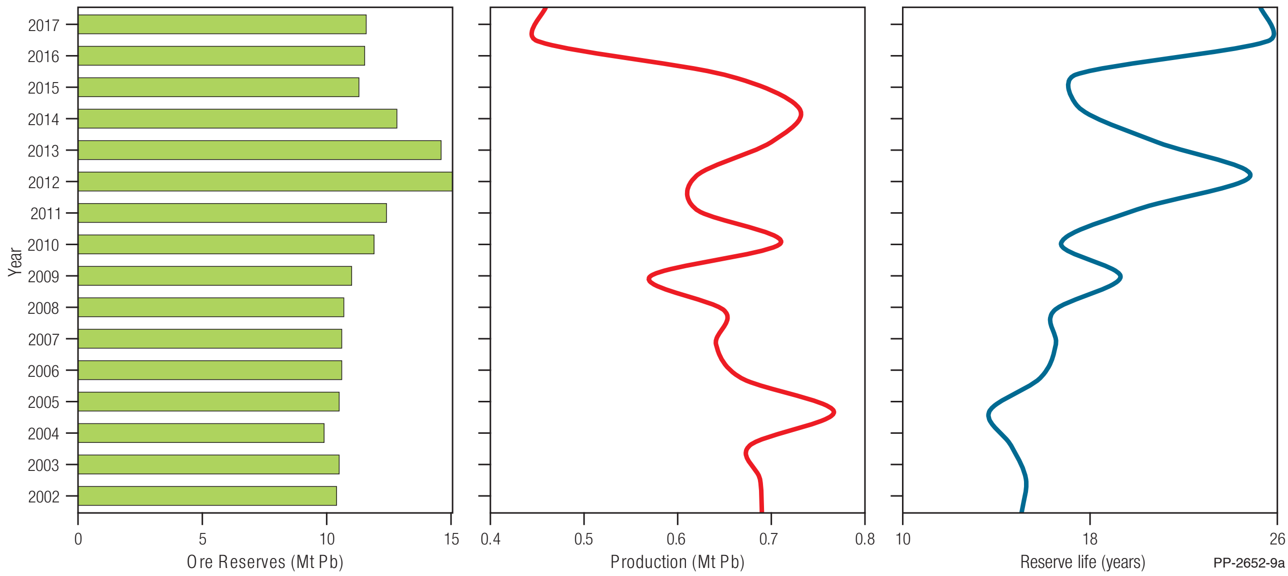


Figure 6 Trends in Ore Reserves, annual production and reserve life for LEAD from 2002 to 2017.

Mt Pb= million tonnes of contained lead.

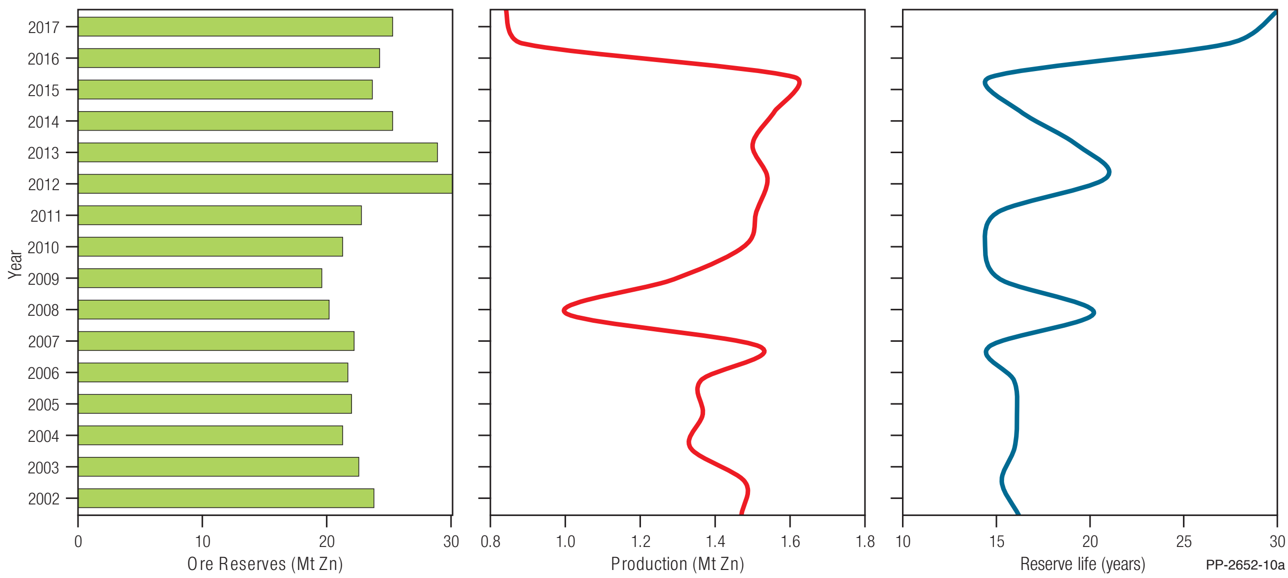


Figure 7 Trends in Ore Reserves, annual production and reserve life for ZINC from 2002 to 2017.

Mt Zn= million tonnes of contained zinc.

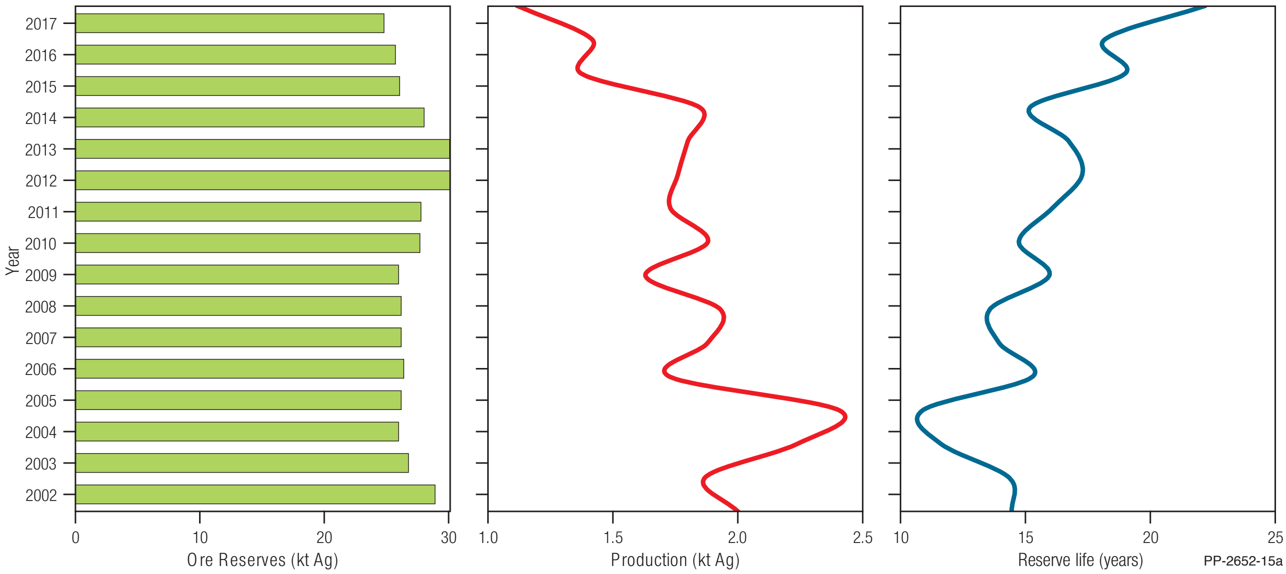


Figure 8 Trends in Ore Reserves, annual production and reserve life for SILVER from 2002 to 2017.

kt Ag = thousand tonnes of contained silver.

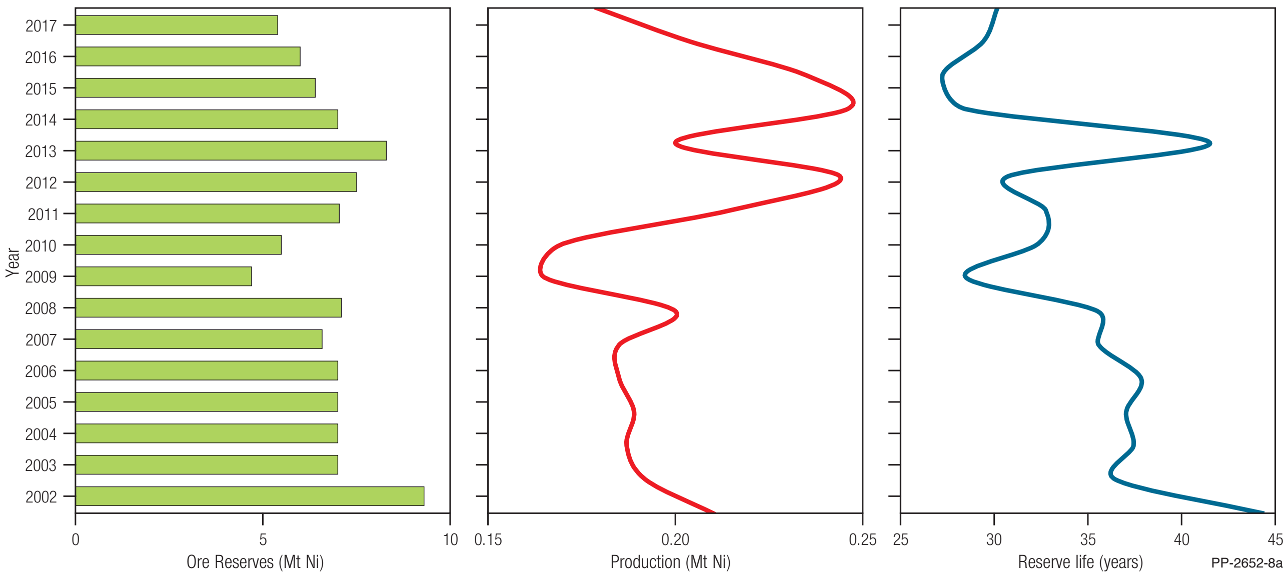


Figure 9 Trends in Ore Reserves, annual production and reserve life for NICKEL from 2002 to 2017.

Mt Ni= million tonnes of contained nickel.

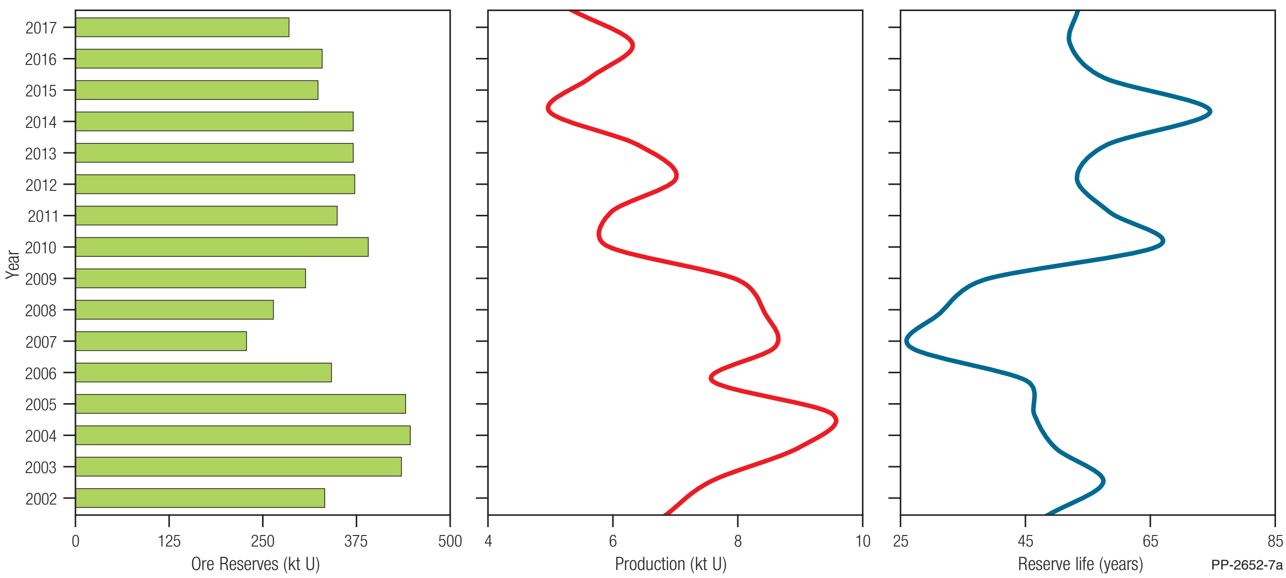


Figure 10 Trends in Ore Reserves, annual production and reserve life for URANIUM from 2002 to 2017.

kt U = thousand tonnes of contained uranium.

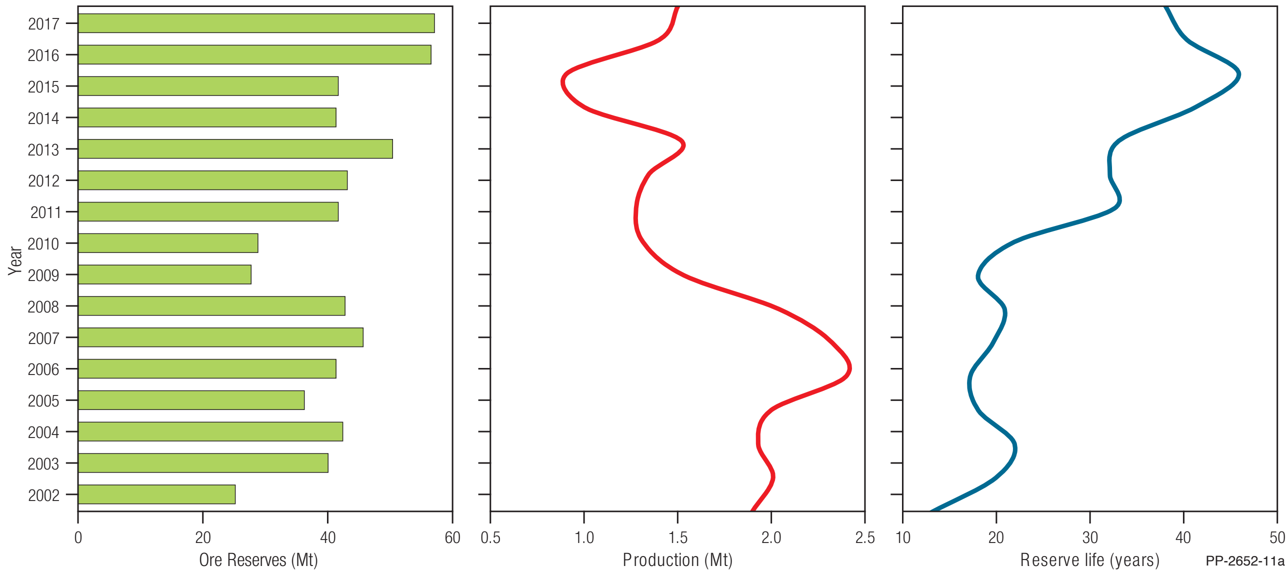


Figure 11 Trends in Ore Reserves, annual production and reserve life for ILMENITE from 2002 to 2017.

Mt = million tonnes.

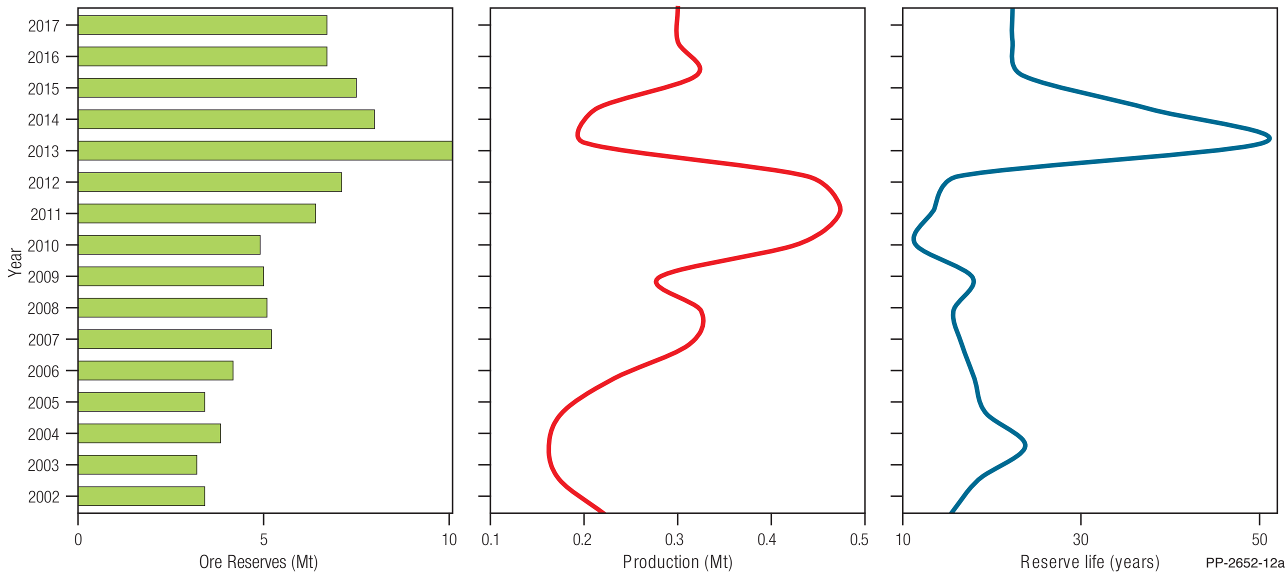


Figure 12 Trends in Ore Reserves, annual production and reserve life for RUTILE from 2002 to 2017.

Mt = million tonnes.

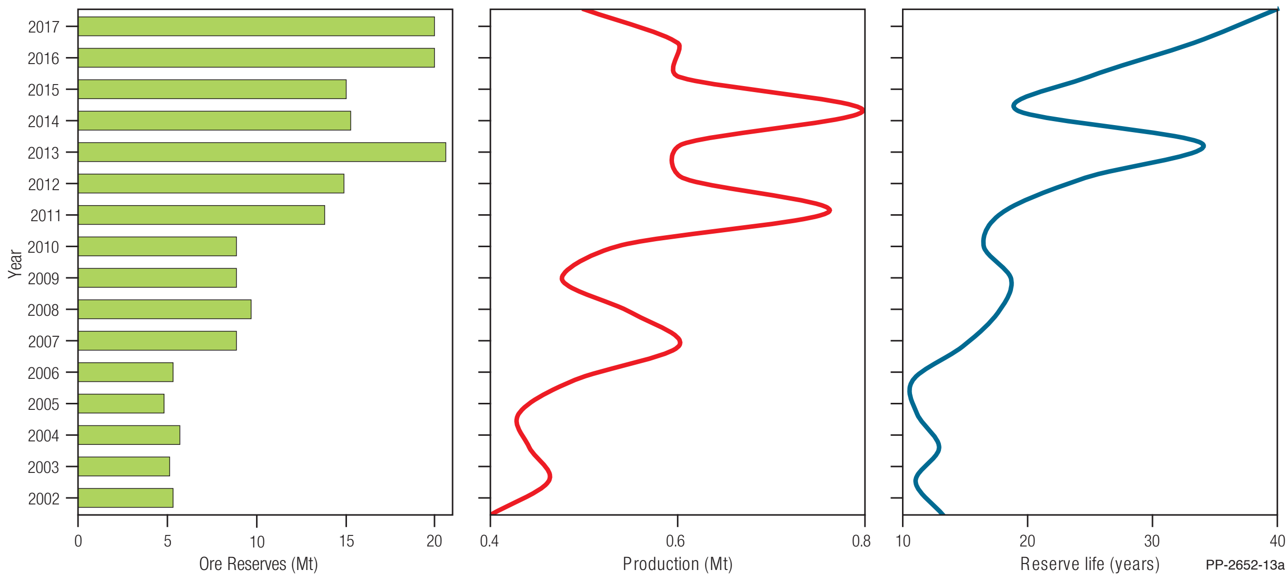


Figure 13 Trends in Ore Reserves, annual production and reserve life for ZIRCON from 2002 to 2017.

Mt = million tonnes.

NATIONAL CLASSIFICATION SYSTEM

The following terminology and definitions are used in Australia's National Classification System for Identified Mineral Resources.

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.

Identified Resource: A specific body of mineral-bearing material whose location, quantity and quality are known from specific measurements or estimates from geological evidence for which economic extraction is presently or potentially (within a 20–25 year timeframe) feasible.

To reflect degrees of geological assurance, Identified Resources can be divided into Measured Resources, Indicated Resources and Inferred Resources where Measured Resources have the most geological confidence and Inferred Resources the least. The National Classification System's definitions for Measured, Indicated and Inferred Resources are consistent with those of the JORC Code.

Under the JORC Code, with the application of Modifying Factors and mine planning, Measured Resources can be converted into Proved Ore Reserves or Probable Ore Reserves and Identified Resources can be converted into Probable Ore Reserves.

Demonstrated Resource: A collective term for the sum of Measured and Indicated Resources, including Proved and Probable Ore Reserves.

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.

Economic Demonstrated Resource (EDR):
A Demonstrated Resource that is regarded as economic under the definition above. The EDR category provides a long-term view of what is likely to be available for mining (potential supply). It does not include Inferred Resources which do not have enough geological confidence to support mine planning. For shorter term, commercial viewpoints of the economic category see Table 1 (Ore Reserves and Mineral Resources at Operating Mines) and Table 2 (Australia's Ore Reserves).

Subeconomic: This term refers to those resources that are geologically demonstrated but which do not meet the criteria of economic at the time of determination. Subeconomic Resources include paramarginal and submarginal categories:

- **Paramarginal:** That part of Subeconomic Resources which, at the time of determination, could be produced given postulated limited increases in commodity prices or cost-reducing advances in technology. The main characteristics of this category are economic uncertainty and/or failure (albeit just) to meet the criteria of economic.
- **Submarginal:** That part of Subeconomic Resources that would require a substantially higher commodity price or major cost-reducing advance in technology to render them economic.

Accessible Economic Demonstrated Resource (AEDR):
Some resources have enough geological confidence to be considered a demonstrated resource and, in normal circumstances, would also be regarded as economic but they are not currently available for development because of legal and/or land-use restrictions. They are included in EDR but not in AEDR.

3. AUSTRALIA'S IDENTIFIED MINERAL RESOURCES

The National Classification System for Identified Mineral Resources has been used by the Australian Government since 1975 for classifying mineral resources for regional and national assessments. It provides a long-term view on what is likely to be available for mining.

The National Classification System uses two general criteria for classifying Australia's national inventory of mineral resources:

1. the geological certainty of the existence of the mineral resource, and
2. the economic feasibility of its extraction over the long term.

The National Classification System uses reports on mineral resources published by companies using the JORC Code (or equivalent foreign codes) and, to a lesser extent, confidential information, to compile national total resources for the classification categories set out in Table 3 (see page 14 for terminology and definitions). Both the National Classification System and the JORC Code are based on the McKelvey resource classification system used by the USGS. Thus Australia's national system is compatible with the JORC Code and remains comparable to the USGS system as published in the annual *USGS Mineral Commodity Summaries*.

Economic Demonstrated Resources (EDR) is the category used for the national totals of economic resources and provides a basis for meaningful comparisons of Australia's economic resources with those of other nations. For major commodities, Section 5 presents long-term trends in EDR as well as trends in Ore Reserves, total resources and production, and also comparisons to cumulative production, with accompanying notes on significant changes.

Estimating the total amount of each mineral commodity likely to be available for mining over the long term (EDR) is not a precise science. The long-term perspectives presented herein take account of the following:

- Ore Reserves reported in compliance with the JORC Code (or equivalent foreign codes) will all be mined, but they only provide a short-term view on what is likely to be available for mining.
- Most current Measured and Indicated Resources reported in compliance with the JORC Code are also likely to be mined.
- Some current Inferred Resources will be transferred to Measured and Indicated Resources and Ore Reserves.
- New discoveries will add to the resource inventory.

In addition, some resources that, all being equal, would normally be considered EDR are not accessible because of environmental, legal or military land-use restrictions. Thus Table 3 also lists Accessible Economic Demonstrated Resources (AEDR). Of the 35 mineral commodities assessed in this publication, only black coal, brown coal, gold, mineral sands, platinum group elements and uranium have EDR that is considered inaccessible.

Over time, all of Australia's current EDR of gold, silver, tin, zinc, lead, iron and any number of other commodities will be mined. At first glance, this statement might seem somewhat astonishing because, obviously, not every deposit that contributes to EDR will have all of that EDR brought into production. Indeed, some deposits currently contributing to EDR will never produce any metal. However, the National Classification System is not designed to be used for individual mine assessments but instead is a way of estimating regional and national totals. So, from an aggregated point of view, it is a reasonable proposition that, eventually, people will mine all of the current EDR (and more). This is seen in the data presented in the figures for each of the major commodities in Section 5 (e.g. Figure 26).

Australia is yet to run out of EDR because, to use JORC Code terminology, as individual Ore Reserves are depleted, Measured and Indicated Resources are reassessed into Proved and Probable Categories, Inferred Resources are worked on to bring them to Measured and Indicated status and new drilling at existing mines as well as new greenfield discoveries add to the resource inventory. In addition, extractive technologies improve over time and if a commodity becomes rare then the laws of supply and demand result in previously subeconomic deposits becoming profitable. Thus EDR fundamentally differs from Ore Reserves under the JORC Code because it is not meant to provide a picture of what is currently commercial to mine but rather an outlook on what is likely to be available for mining over the long term, i.e. of opportunity for supply.

Table 3 Australia's Identified Mineral Resources as at December 2017.

Australia								World	
Commodity	Unit	Demonstrated Resources			Inferred Resources[2]	Accessible EDR[3]	Mine Production 2017[4]	Economic Resources 2017[5]	Mine Production 2017[6]
		Economic (EDR)[1]	Subeconomic						
			Paramarginal	Submarginal					
Antimony	kt Sb	138.2	8.8	0	186.0	138.2	4.61[7]	1550	150
Bauxite	Mt	6015	144	1429	2079	6015	87.9	30 000	305
Black Coal									
In situ	Mt	87 490	1422	4287	109 263				
Recoverable	Mt	72 571	1056	3820	86 073	66 385	559[8]	715 800[9]	7600[10]
Brown Coal									
In situ	Mt	92 887	44 069	234 987	124 326				
Recoverable	Mt	76 508	41 112	215 449	103 579	66 439	53[11]	316 500[12]	830[13]
Chromium	kt Cr	0	302	0	6584	0	0	510 000[14]	31 000[14]
Cobalt	kt Co	1222	307	22	1282	1222	5.8[15]	7100	110
Copper	Mt Cu	87.47	1.76	0.36	46.59	87.47	0.860	790	19.7
Diamond	Mc	39.68	0	0	20.30	39.68	17.14	1090[16]	138
Fluorine	kt F	343	505	6	2301	343	0	135 000	2900[17]
Gold	t Au	10 070	185	62	4627	10 040	292	54 500	3140
Graphite	Mt	7.14	0.06	0	6.05	7.14	0	270	1.2
Iron									
Iron ore	Mt	47 987	11 450	1383	92 570	47 987	883	168 400	2400
Contained iron	Mt Fe	23 251	3656	476	42 006	23 251	547	81 900	1470
Lead	Mt Pb	36.42	2.70	0.14	23.28	36.42	0.459	89	4.71
Lithium	kt Li	2803	0	<1	1907	2803	21.3[18]	15 700	45.5
Magnesite	Mt $MgCO_3$	316	73	35	943	316	<1[19]	7750	27[20]
Manganese Ore	Mt	231	3	190	360	231	5.6[21]	682[22]	16[22]
Mineral Sands									
Ilmenite	Mt	276.5	26.2	<1	236.5	245.2	1.5[23]	1450	11.1
Rutile	Mt	32.9	0.3	0.1	34.8	29.0	0.3[23]	67	0.7
Zircon	Mt	78.3	1.1	0.1	62.3	71.8	0.5[23]	118	2.0
Molybdenum	kt Mo	160	1272	<1	610	160	0	17000	290
Nickel	Mt Ni	19.7	3.1	<1	20.0	19.7	0.179	74	2.1
Niobium	kt Nb	216	15	0	397	216	0[24]	>4500	64
Oil Shale (recoverable)	GL	0	213	2074	1472	0	0	961 873[25]	n.a.
PGE	t metal	24.9	136.7	0	125.5	22.3	<1[26]	69 300	410[27]
Phosphate									
Phosphate rock[28]	Mt	1170	312	0	2369	1170	1.5[29]	70 300	261
Contained P_2O_5	Mt P_2O_5	198	57	0	389	198	n.a.	n.a.	n.a.
Potash	Mt K_2O	58	8	0	105	58	0	3900	42
Rare Earths[30]	Mt oxide	3.27	0.35	30.21	24.81	3.27	0.017[31]	121	0.131
Silver	kt Ag	90.31	2.31	0.49	40.53	90.31	1.120	535	24.9
Tantalum	kt Ta	55.4	1.3	0.2	25.7	55.4	n.a.	>89	1.3
Thorium	kt Th	0	113	0	626	0	0	n.a.	n.a.
Tin	kt Sn	415	63	32	372	415	7.4	4740	290
Tungsten	kt W	386	0	5	232	386	<1[32]	3200	95
Uranium	kt U	1290	13	21	840	1232	5.344	3458[33]	59[34]
Vanadium	kt V	3965	10 854	1376	12 412	3965	0	21 500	80
Zinc	Mt Zn	67.52	0.45	0.75	36.68	67.52	0.841	237	13

Abbreviations: t = tonne; kt = kilotonnes (1000 t); Mt = million tonnes (1 000 000 t); Mc = million carats (1 000 000 carats); GL = gigalitre (1 000 000 000 L); n.a.= not available; PGE = platinum group elements (Pt, Pd, Os, Ir, Ru, Rh).

Where an element symbol follows the unit it refers to contained metal content.

Notes

1. Economic Demonstrated Resources (EDR) predominantly comprise Ore Reserves and most Measured and Indicated Mineral Resources that have been reported in compliance with the Joint Ore Reserves Committee (JORC) Code to the Australian Securities Exchange (ASX). In addition, some reserves and resources have been reported using other reporting codes to foreign stock exchanges and Geoscience Australia may hold confidential data for some commodities.
2. Total Inferred Resources in economic, subeconomic and undifferentiated categories.
3. Accessible Economic Demonstrated Resources (AEDR) is the portion of total EDR that is accessible for mining. AEDR does not include resources that are inaccessible for mining because of environmental restrictions, government policies or military lands.
4. Australian mine production from Resources and Energy Quarterly, June 2018 published by the Office of the Chief Economist, Department of Industry, Innovation and Science unless otherwise stated. Production data often have a higher level of certainty than reserve and resource estimates and, thus, may be presented with more significant figures.
5. World economic resources from Mineral Commodity Summaries 2018 published by the USGS and adjusted with Geoscience Australia data, unless otherwise stated.
6. World production from Mineral Commodity Summaries 2018 published by the USGS and adjusted with Geoscience Australia data, unless otherwise stated.
7. Australian antimony production from company reports.
8. Australian black coal production refers to raw coal.
9. World economic resources of black coal (2016) from the Federal Institute for Geosciences and Natural Resources, Germany (Energy Study 2017) and adjusted with Australian data.
10. World mine production of black coal from International Energy Agency (Coal Information 2018 Overview) and adjusted with Australian data.
11. Australian brown coal production is a Geoscience Australia estimate and refers to raw coal.
12. World economic resources of brown coal (2016) from the Federal Institute for Geosciences and Natural Resources, Germany (Energy Study 2017) and adjusted with Australian data.
13. World mine production of brown coal from International Energy Agency (Coal Information 2018 Overview) and adjusted with Australian data.
14. World economic resources and mine production are presented as chromite ore.
15. Australian cobalt production from company reports and Geoscience Australia estimates.
16. World resource figures are for industrial diamonds only, no data provided for resources of gem diamonds.
17. World mine production of fluorine excludes the USA.
18. Lithium production is a Geoscience Australia estimate based on Mineral and Petroleum Statistics Digest 2016–17, published by the Department of Mines, Industry Regulation and Safety, Western Australian Government.
19. The Department of State Development, South Australia (Report Book 2017/00014) reported magnesite production of 3241 t in 2017. The Queensland Department of Natural Resources and Mines (Annual mineral and metal statistics) reported magnesite production of 207 603 t in 2016–17.
20. World mine production of magnesite excludes the USA.
21. Australian manganese production from company reports. Minimum estimate as Woodie Woodie production unknown.
22. World economic resources and mine production are presented as manganese content, not manganese ore.
23. Australian mineral sands production from company reports.
24. There are no mines producing niobium as a primary product in Australia. It is possible that niobium is produced as a by-product at some lithium/tantalum operations, but these data have not been reported.
25. World resources of oil shale from World Energy Council (World Energy Resources 2016).
26. The Western Australia Department of Mines, Industry Regulation and Safety (Mineral and Petroleum Statistics Digest 2016–17) reported 783 kg of platinum and palladium produced as by-product in 2016–17.
27. World mine production is platinum and palladium only.
28. Phosphate rock is reported as being economic at grades ranging from 8.7% to 30.2% P_2O_5.
29. Geoscience Australia estimate based on reported mining production of 550 140 t from Christmas Island in 2017; 1213 t from South Australia in 2017 (Report Book 2018/00017); and 940 827 t from Queensland in 2016–17 (Queensland Annual Mineral Summary).
30. Rare earths comprise rare earth oxides (REO) and yttrium oxide (Y_2O_3).
31. Mount Weld in Western Australia supplies rare earth mineral concentrates to the Lynas Advanced Materials Plant (LAMP) in Malaysia. Lynas Corporation Ltd (Quarterly Reports to the ASX) reported that LAMP produced 17 264 t of ready-for-sale rare earth oxides in 2017.
32. Australian tungsten production from company reports.
33. World economic resources from the International Atomic Energy Agency estimate for Reasonably Assured Resources recoverable at costs of less than US$130/kg U published in Uranium 2016: Resources, Production and Demand (the Red Book).
34. World production of uranium from World Nuclear Organisation.

TRENDS IN EDR

Australia's EDR of the following seven mineral commodities increased significantly during 2017: cobalt, graphite, manganese ore, platinum group elements (PGE), phosphate, vanadium and zinc (Table 4). The EDR of six commodities decreased significantly in 2017: diamond, molybdenum, niobium, rare earths, tantalum and tin (Table 4). All other mineral EDR stayed within 5% of the previous year's estimates (Table 4).

Trends in EDR for Australia's major mineral commodities have undergone significant and sometimes dramatic changes over the period 1975 to 2017 (see Section 5). These changes 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 at known deposits.
- Depletion of resources as a result of mine production.
- Advances in mining and metallurgical technologies, e.g. carbon-based processing technologies for gold have enabled economic extraction from low-grade deposits that were previously uneconomic.
- Adoption of the JORC Code for resource classification and reporting 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 JORC Code. The impacts of the JORC Code on EDR occurred at differing times for each of the major commodities.
- Significant changes in the prices of mineral commodities driven largely by both escalating and cooling demand from China over the past two decades.

MINE INVENTORIES AS A PROPORTION OF EDR

While the national inventory is an aggregation of individual resources, it is a useful exercise to compare the EDR attributable to currently operating mines with all mines (operating + care and maintenance + developing) and the national total (Table 5) as, in many cases, operating mines dominate the minerals inventory. With the exception of mineral sands, black coal, iron ore and nickel, operating mines of all other major commodities contain more than 50% of Australia's EDR (Table 5). More than 50% of Australia's EDR of major commodities, without exception, are contained in all mines. In the case of bauxite, copper, diamond and uranium, Australian mines account for more than 80% of EDR (Table 5).

The high proportion of the national EDR attributed to operating mines is not unexpected as most resource delineation occurs at, and in the vicinity of, existing operations. However, this concentration of EDR at operating mines results in a number of potential supply vulnerabilities in the minerals sector. Many commodities have large EDR

Table 4 Changes in EDR of Australia's Identified Mineral Resources from 2016 to 2017.

Commodity (unit)	EDR 2016	EDR 2017	Change (%)	Commodity (unit)	EDR 2016	EDR 2017	Change (%)
Antimony (kt Sb)	138.9	138.2	↓-1%	Manganese Ore (Mt)	219	231	↑5%
Bauxite (Mt)	6005	6015	↑<1%	Molybdenum (kt Mo)	210	160	↓-24%
Black Coal, in situ (Mt)	85 753	87 490	↑2%	Nickel (Mt Ni)	18.5	19.3	↑4%
Black Coal, recoverable (Mt)	70 927	72 571	↑2%	Niobium (kt Nb)	286	216	↓-24%
Brown Coal, in situ (Mt)	92 887	92 887	0%	PGE (t metal)	5.3	24.9	↑370%
Brown Coal, recoverable (Mt)	76 508	76 508	0%	Phosphate rock (Mt)	1072	1170	↑9%
Cobalt (kt Co)	1164	1221	↑5%	Phosphate, contained (Mt P_2O_5)	180	198	↑10%
Copper (Mt Cu)	87.78	87.47	↓<1%	Potash (kt K_2O)	56	58	↑3%
Diamond (Mc)	115.84	39.68	↓-66%	Rare Earths (Mt oxide)[2]	3.43	3.27	↓-5%
Fluorine (kt F)	343	343	0%	Rutile (Mt)	33.0	32.9	↓<1%
Gold (t Au)	9830	10 070	↑2%	Silver (kt Ag)	89.29	90.31	↑1%
Graphite (Mt)	0.97[1]	7.14	↑636	Tantalum (kt Ta)	75.7	55.4	↓-27%
Ilmenite (Mt)	276.9	276.5	↓<1%	Tin (kt Sn)	486	415	↓-15%
Iron Ore (Mt)	49 588	47 987	↓-3%	Tungsten (kt W)	391	386	↓-1%
Iron, contained (Mt Fe)	23 771	23 251	↓-2%	Uranium (kt U)	1270	1290	↑2%
Lead (Mt Pb)	35.09	36.42	↑4%	Vanadium (kt V)	2111	3965	↑88%
Lithium (kt Li)	2730	2803	↑3%	Zinc (Mt Zn)	63.50	67.52	↑6%
Magnesite (Mt $MgCO_3$)	320.48	316	↓-1%	Zircon (Mt)	78.6	78.3	↓<1%

Abbreviations: t = tonne; kt = kilotonnes (1000 t); Mt = million tonnes (1 000 000 t); Mc = million carats (1 000 000 carats); GL = gigalitre (1 000 000 000 L); n.a. = not available; PGE = platinum group elements (Pt, Pd, Os, Ir, Ru, Rh). Where an element symbol follows the unit it refers to contained metal content.
EDR = Economic Demonstrated Resources.

Notes

1. Graphite EDR last assessed in 2013.
2. Rare earths comprise rare earth oxides (REO) and yttrium oxide (Y_2O_3).

(e.g. manganese ore, bauxite, uranium and mineral sands; Table 3) but relatively few operating mines (Table 1). Price shocks or other circumstances leading to the permanent closure of one or more of these mines would dramatically impact Australia's potential to supply these minerals. If there is no foreseeable possibility of a mine reopening, then the deposit is removed from EDR. New deposits will only replace EDR if mining and exploration companies can attract the capital necessary for exploration, drilling and development.

Other commodities with large EDR, such as gold, black coal and iron ore, have many mines (Table 1). Thus, Australia's EDR of these commodities and ability to supply appear unlikely to be significantly impacted by the fortunes of individual mines. Black coal, for example, has 290 deposits contributing the national EDR, but the 91 operating mines comprise only 49% of that EDR (Table 5). If even a sizeable proportion of coal mines were inaccessible in the future, a large resource could potentially still be exploited.

However, this is not necessarily the case for gold. Australia has the largest EDR of gold in the world (Table 8) but most of it is associated with large, low-grade, multi-commodity deposits such as Olympic Dam (South Australia) and Cadia (New South Wales). The majority of production, however, comes from lode-gold deposits which produced 70% of Australia's gold in 2017. At 2017 rates of production, all lode-gold deposits have a potential resource life of 20 years based on EDR, but the operations mining lode gold only have a comparable resource life of 10 years. With depletion of these high-grade mines, it is unlikely that production at the other deposit types could make up the shortfall in the same period, thus Australia's gold production, and export income, would inevitably decline.

This circumstance is, of course, based on the very unlikely scenario that three things will happen: (1) future rates of production are unchanged from those of 2017, (2) deposits currently assessed as economic/subeconomic remain so in the future and (3) companies do not replace depleted gold resources. The gold EDR from these lode-gold deposits will most likely be replaced by successful mineral exploration. Advances in extractive technologies or substantial price rises could also contribute to future EDR. Some of this exploration will occur in and around existing mines (brownfield exploration) but the most important contributions to Australia's future EDR of gold, and other commodities, is more likely to come from successful exploration in new and under-explored areas of the continent (greenfield exploration). It is through the discovery of large, globally significant mineral deposits such as Broken Hill, Mount Isa, Olympic Dam and the Kalgoorlie goldfields, that Australia has become a world leader in the mining sector. If Australia wishes to remain globally competitive then new discoveries are essential as only the very best deposits will attract the funds necessary for development in an internationally competitive investment environment.

Table 5 Comparisons of EDR of major commodities at Australian mines to total EDR as at December 2017.

Commodity	Total EDR	Number			Percentage of EDR		
		Deposits with EDR[1]	Operating Mines	All Mines	Operating Mines	All Mines[2]	Other Deposits
Bauxite	6015 Mt	20	7	12	56%	89%	11%
Black Coal (recoverable)	72 571 Mt	284	91	128	49%	63%	37%
Copper	87.47 Mt Cu	170	35	58	81%	84%	16%
Diamond	39.68 Mc	3	2	3	99%	100%	0%
Gold	10 070 t Au	690	128	160	67%	69%	31%
Iron Ore	47 987 Mt	91	33	46	46%	63%	37%
Lead	36.42 Mt Pb	66	12	17	63%	74%	26%
Manganese Ore	231 Mt	6	3	4	84%	98%	2%
Mineral Sands							
Ilmenite	276.5 Mt	80	10	21	21%	67%	33%
Rutile	32.9 Mt	58	8	17	24%	60%	40%
Zircon	78.3 Mt	81	9	19	18%	55%	45%
Nickel	19.3 Mt Ni	74	10	19	26%	53%	47%
Silver	90.31 kt Ag	122	22	30	56%	62%	38%
Uranium	1290 kt U	37	3	6	81%	82%	18%
Zinc	67.52 Mt Zn	79	13	17	56%	66%	34%

Abbreviations: t = tonne; kt = kilotonnes (1000 t); Mt = million tonnes (1 000 000 t); Mc = million carats (1 000 000 carats).
Where an element symbol follows the unit it refers to contained metal content.

Notes

1. Deposits with EDR is inclusive of the mines.
2. All Mines = mines that are currently operating, placed on care and maintenance or under development.

ORE RESERVES AS A PROPORTION OF EDR AND AEDR

The National Classification System's category of EDR captures those Demonstrated Resources that are considered to be economic under current conditions or those of the foreseeable future. EDR indicates potential supply. However, just because a deposit could be exploited profitably does not mean that it will be. EDR does not capture modifying factors (such as metallurgical, engineering, processing, infrastructure, environmental, social and regulatory considerations) and commercial considerations (e.g. costs and internal rates of return) that mining companies must consider for individual deposits to determine an Ore Reserve and mine plan. Table 6 compares the short-term outlook provided by Ore Reserves to the long-term outlook of EDR.

In addition, some resources that would normally meet the criteria to be considered EDR are not accessible because of environmental, legal or military land-use restrictions. Only six mineral commodities are currently affected by land-use restrictions: 9% of black coal EDR, 13% of brown coal, <1% of gold EDR, around 10% of mineral sands EDR, 10% of platinum group elements EDR and 5% of uranium EDR. Thus it is better to compare Ore Reserves to AEDR for these commodities (Table 6).

CONTRIBUTION OF LARGEST DEPOSITS TO EDR

Most of Australia's EDR of major commodities are skewed heavily toward a small number of relatively large deposits. Table 7 shows that more than 80% of EDR lies in the top 20 deposits for most commodities. The two exceptions are gold and black coal, both of which have the greatest number of deposits of all mineral commodities in Australia, as well as the greatest number of deposits that contribute to EDR. Even so, the top 20 deposits of gold, which make up less than 3% of the 718 deposits with an EDR, account for 62% of all gold EDR (Table 7). For black coal, the top 20 deposits (7% of 290 deposits with an EDR) account for 38% of EDR.

GEOGRAPHICAL DISTRIBUTION OF EDR

Most bauxite EDR is attributable to Queensland and Western Australia (Figure 14) where the giant deposits in Cape York and the Darling Range respectively dominate. Similarly, Australia's enormous iron ore EDR is geographically concentrated in the Pilbara region of Western Australia. Western Australia also holds almost all of nickel and diamond EDR, though the latter has fallen dramatically in 2017 (Table 4) with the imminent closure of the Argyle mine. Manganese ore EDR is found in Western Australia and the Northern Territory. On the other side of the country, almost all black coal EDR is located in Queensland and New South Wales (Figure 14). Silver, lead, zinc, copper, uranium and mineral sands are more dispersed across the country (Figure 14), but the top ten deposits for each of these minerals dominate EDR (70–94%; Table 7).

Table 6 Comparisons of Ore Reserves of major commodities to total EDR and AEDR as at December 2017.

Commodity (unit)	Ore Reserves	EDR	AEDR	Ore Reserves/ EDR (%)	Ore Reserves/ AEDR (%)
Bauxite (Mt)	2170	6015	6015	36%	36%
Black Coal, recoverable (Mt)	18 536	72 571	66 385	26%	28%
Copper (Mt Cu)	23.03	87.47	87.47	26%	26%
Diamond (Mc)	39.01	39.68	39.68	98%	98%
Gold (t Au)	3869	10 070	10 040	38%	39%
Iron Ore (Mt)	24 146	47 987	47 987	50%	50%
Lead (Mt Pb)	11.60	36.42	36.42	32%	32%
Manganese Ore (Mt)	102	231	231	44%	44%
Mineral Sands (Mt)					
Ilmenite	57.1	276.5	245.2	21%	23%
Rutile	6.7	32.9	29.0	20%	23%
Zircon	20.0	78.3	71.8	26%	28%
Nickel (Mt Ni)	5.4	19.3	19.3	28%	28%
Silver (kt Ag)	24.82	90.31	90.31	27%	27%
Uranium (kt U)	285	1290	1232	22%	23%
Zinc (Mt Zn)	25.30	67.52	67.52	37%	37%

Abbreviations
t = tonne; kt = kilotonnes (1000 t); Mt = million tonnes (1 000 000 t); Mc = million carats (1 000 000 carats).
Where an element symbol follows the unit it refers to contained metal content.
EDR = Economic Demonstrated Resources.
AEDR = Accessible Economic Demonstrated Resources.

Table 7 Distribution of EDR of major commodities in Australia as at December 2017.

Commodity	Number of		EDR	Percentage of EDR in largest	
	Deposits	Deposits with EDR		10 Deposits	20 Deposits
Bauxite	38	20 (53%)	6015 Mt	99%	100%
Black Coal (recoverable)	409	284 (69%)	72 571 Mt	25%	38%
Copper	386	170 (44%)	87.47 Mt Cu	83%	90%
Diamond	12	3 (25%)	39.68 Mc	100%	100%
Gold	1804	718 (40%)	10 070 t Au	52%	62%
Iron Ore	342	85 (25%)	47 987 Mt	65%	85%
Lead	164	70 (43%)	36.42 Mt Pb	91%	97%
Manganese Ore	44	6 (14%)	231 Mt	100%	100%
Mineral Sands					
Ilmenite	224	80 (36%)	276.5 Mt	70%	83%
Rutile	201	58 (29%)	32.9 Mt	71%	86%
Zircon	224	81 (36%)	78.3 Mt	78%	89%
Nickel	217	74 (34%)	19.7 Mt Ni	71%	91%
Silver	260	122 (47%)	90.31 kt Ag	79%	88%
Uranium	111	37 (33%)	1290 kt U	94%	98%
Zinc	179	79 (44%)	67.52 Mt Zn	89%	94%

Abbreviations: t = tonne; kt = kilotonnes (1000 t); Mt = million tonnes (1 000 000 t); Mc = million carats (1 000 000 carats).
Where an element symbol follows the unit it refers to contained metal content.
EDR = Economic Demonstrated Resources.
AEDR = Accessible Economic Demonstrated Resources.

Note: For classification as a mineral deposit there must be, at a minimum, an Inferred Resource compliant with the JORC Code (or equivalent) or, in some cases, a historical (pre-JORC) resource estimate.

Figure 14 Distribution of EDR of major commodities by Australian jurisdiction as at December 2017. Where applicable, the number of mines in each jurisdiction is in brackets after the percentage of EDR in each jurisdiction.

Abbreviations: NSW = New South Wales; NT = Northern Territory; QLD = Queensland; SA = South Australia; TAS = Tasmania; VIC = Victoria; WA = Western Australia.

4. WORLD RANKINGS

Australia's EDR of gold, iron ore, lead, nickel, rutile, tantalum, uranium, zinc and zircon in 2017 were the world's largest (Table 8), unchanged from 2016. Another 17 commodities ranked in the top five for world economic resources: antimony, bauxite, black coal, brown coal, cobalt, copper, diamond, ilmenite, lithium, magnesite, manganese, niobium, silver, thorium, tin, tungsten and vanadium (Table 8). Australia's ranking for diamond resources fell from third place in 2016 to fifth in 2017 owing to the depletion of the Argyle diamond mine in Western Australia.

In 2017, Australia was also the top global producer for bauxite, iron ore and rutile (all bulk commodities), as well as lithium, which is becoming increasingly important for battery storage technologies. Australia was the second largest producer of gold, ilmenite, lead, rare earths and zircon, the third largest producer of cobalt, manganese and uranium, the fourth largest producer of antimony, diamond and black coal, and the fifth largest producer of copper and zinc (Table 8).

Table 8 Australia's mineral resources and production ranked against world economic resources and production, as at December 2017.

Commodity	World Ranking Resources	Share of World Resources	World Ranking Production	Share of World Production
Antimony	4	9%	4	3%
Bauxite	2	20%	1	29%
Black Coal (recoverable)	4	10%	4	7%
Brown Coal (recoverable)	2	24%	6	7%
Chromium	n.a.	n.a.	0	0%
Cobalt	2	17%	3	5%
Copper	2	11%	5	4%
Diamond	5	4%	4	12%
Fluorine	minor	minor	0	0%
Gold	1	18%	2	9%
Graphite	7	3%	0	0%
Ilmenite	2	21%	2	15%
Iron Ore	1	28%	1	37%
Lead	1	41%	2	10%
Lithium	3	18%	1	47%
Magnesite	5	4%	7	2%
Manganese	4	14%	3	15%
Molybdenum	6	1%	0	0%
Nickel	1	26%	6	9%
Niobium	2	5%	0	0%
Oil Shale	n.a.	n.a.	0	0%
Phosphate	10	2%	minor	minor
PGE	minor	minor	minor	minor
Potash	10	2%	0	0%
Rare Earths	6	3%	2	13%
Rutile	1	49%	1	37%
Silver	2	17%	6	4%
Tantalum	1	62%	unknown	unknown
Thorium	2	10%	0	0%
Tin	4	9%	7	3%
Tungsten	2	12%	minor	minor
Uranium	1	29%	3	9%
Vanadium	3	18%	0	0%
Zinc	1	29%	5	6%
Zircon	1	66%	2	24%

Abbreviations: n.a. = not applicable because Australia has no EDR of that particular commodity.

Notes: Minor = <1% of global economic resources and/or production, therefore Australia's ranking unable to be determined.
Unknown = production is known to have occurred during the year but quantities are not publically available.
World rankings determined by comparing Australia's EDR and production to economic resources and production reported for other countries, see sources below.

Sources: USGS (Mineral Commodity Summaries 2018), OECD Nuclear Energy Agency/International Atomic Energy Agency (The Red Book 2016), World Nuclear Association (World Uranium Mining Production, July 2018 update), Federal Institute for Geosciences and Natural Resources, Germany (Energy Study 2017), International Energy Agency (Coal Information 2018 Overview) and Geoscience Australia.

Electric vehicles are becoming an increasingly popular alternative to traditional cars. An electric vehicle does not use petroleum products for propulsion, but it does require a wide range of minerals. Its rechargeable batteries can be made from lithium, nickel, cobalt, manganese, vanadium, aluminium and graphite; its frame and wheels use aluminium, its seat frames and steering wheels use magnesium, its motor uses rare earth magnets and copper is used throughout the vehicle and recharging infrastructure.

5. IDENTIFIED RESOURCES OF MAJOR COMMODITIES SINCE 1975

BAUXITE

Australia's EDR of bauxite were estimated to be 6015 Mt in 2017 (Table 3), up from 6005 Mt in 2016 (Table 4) but down from a peak of 6464 Mt in 2013. This is the second largest economic resource in the world (Table 8) behind the Republic of Guinea and ahead of Vietnam, Brazil, Jamaica and Indonesia. Australia was the world's leading producer of bauxite in 2017 (Table 8), the second largest producer of alumina and the sixth largest producer of aluminium[7]. Australia's aluminium industry is underpinned by vast resources of bauxite at Gove in the Northern Territory (185 Mt, 3% of national EDR), the Darling Range southeast of Perth in Western Australia (2634 Mt, 44%) and Cape York in Queensland (3155 Mt, 52%).

Australia also has large Ore Reserves of bauxite amounting to 2170 Mt (Table 2) in 2017, of which 813 Mt (37%) is attributable to seven operating mines (Table 1). These mines produced 88 Mt of bauxite in 2017, up 7% from 2016 (82 Mt). World bauxite production was similarly up (9%) in 2017, with the USGS reporting that while the Malaysian ban on bauxite mining continues, the Indonesian Government allowed a number of companies that are constructing alumina refineries in Indonesia to export bauxite for the first time since 2014.

Since 2002, bauxite production has risen 76% from 50 Mt to 88 Mt, reaching a record high in 2017 (Figure 15). Annual production since government records began in 1975 has increased a massive 319% whereas EDR has only increased 101% in the same period (Table 9). Ore Reserve estimates have only increased 28% since records began in 2002 and have actually fallen over the last decade (Table 9). This outstripping of production over new resource delineation reflects the fact that much of Australia's bauxite was identified early on and the major companies now focus on proving up just enough new Ore Reserves to replace expected depletion going forward.

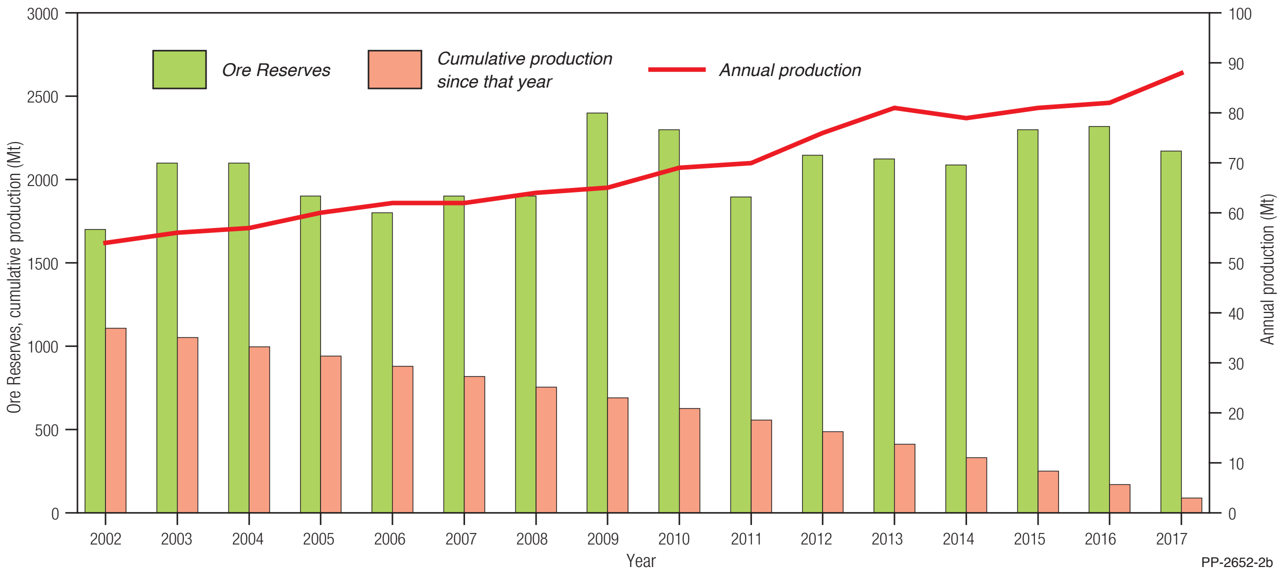


Figure 15 **Bauxite Ore Reserves, annual production and cumulative production 2002–2017.**

Notes: Cumulative production is read as the amount of bauxite that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of bauxite that has been produced since 2002 is 1106 Mt, the amount of bauxite that has been produced since 2010 is 626 Mt. Mt = million tonnes.

7 USGS, Mineral Commodity Summaries 2018.

Table 9 Changes in bauxite production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Bauxite	Change since 2016	Change since 2007	Change since start of records
Annual Production	7.3%	42%	319% (1975)
Ore Reserves	-6.4%	14%	28% (2002)
EDR	0.2%	-3%	101% (1975)
All Resources	1.6%	14%	45% (1976)

Abbreviations: EDR = Economic Demonstrated Resources.

Notes: All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

Australia's operating bauxite mines are known for their high quality ore which is determined not just by the aluminium content but also by other minerals present, such as iron oxides, titanium oxides and, in particular, the amount of reactive silica. The Darling Range bauxites and those at Weipa and Gove all have low reactive silica making them relatively cheap to process. In fact, the Darling Range mines have such low reactive silica (generally 1–2%) that they are still profitable even with the lowest grade bauxite of any commercial-scale operation in the world—approximately 30% Al_2O_3 compared to Weipa and Gove which average around 50% Al_2O_3.

Figure 16, again, demonstrates the vast Australian bauxite inventory by showing that even over the last 40 years, cumulative production (2069 Mt) has only mined out 69% of the 3000 Mt of resources assessed as economic back in 1975. Despite these vast resources, Figure 17 shows that over the last 40 years, bauxite production has increased more rapidly than the bauxite inventory. In 1975, bauxite production was 21 Mt which rose to 88 Mt in 2017, a 319% increase (Table 9). Bauxite EDR has doubled over the same time period (3000 Mt in 1975 to 6015 Mt in 2017) and total resources of bauxite (EDR + Subeconomic + Inferred) have increased from 6678 Mt in 1976 to 9668 Mt in 2017, an increase of 45% (Table 9).

Australia's aluminium industry continues to be a highly vertically integrated sector of mining, refining, smelting and semi-fabrication and is of major economic importance nationally and globally. However, over the last decade, increased processing costs have made some operations unviable, leading to the closure of the Kurri Kurri aluminium smelter (New South Wales) in 2012, the Point Henry aluminium smelter (Victoria) in 2014 and the Gove alumina refinery (Northern Territory) also in 2014. Conversely, there has been a move by industry to direct shipping ore with Rio Tinto supplying China from its Weipa and Gove operations and new, small-scale operations aimed at supplying Chinese alumina refineries have recently started in Tasmania and Cape York. In 2016, Alcoa shipped 47 kt of bauxite ore from its Western Australian operations to China for metallurgical testing and was subsequently authorised by the state government to export up to 2.5 Mt per annum for five years.

Alumina refineries continue to operate in Western Australia's Darling Range at Kwinana, Pinjarra, Wagerup and Worsley and near Gladstone in Queensland at QAL Alumina and Yarwun. Aluminium smelters continue to operate at Tomago in New South Wales, Bell Bay in Tasmania, Boyne Island in Queensland and Portland in Victoria.

The largest new bauxite development in Australia is Rio Tinto's Amrun project, previously known as 'South of Embley', located approximately 45 km southwest of Weipa. Government and environmental approvals were obtained in 2012 and 2013 and, in late 2015, the board of Rio Tinto approved the project including capital expenditure of US$1.9 billion which includes the construction of processing and port facilities as well as the mine.

Amrun is expected to start producing in the first half of 2019 and will extend the life of the Weipa operations by at least 40 years. It will replace some of the current production from the East Weipa mine (now more than 50 years old) as well as adding some 10 Mt per annum of extra capacity. Rio Tinto has described Amrun as a long-life, low-cost, expandable asset that is strategically placed to satisfy increasing demand for seaborne bauxite in China and the Middle East as well as the company's own refineries in Australia.

Recent, smaller scale, developmental activity has also taken place in Queensland at Hey Point (Green Coast Resources Pty Ltd) which commenced mining in 2016, Urquhart (Metallica Minerals Ltd), Bauxite Hills (Metro Mining Ltd) and Binjour (Australian Bauxite Ltd). The Bald Hill operation in Tasmania (Australian Bauxite Ltd), which commenced mining in late 2014, was closed and rehabilitated.

Resource life is a snapshot in time derived by taking a reserve or resource number and dividing it by a production number. Resource life fluctuates as mine production responds to market demand and increased prices often stimulate drilling that leads to new exploration discoveries. Many major bauxite discoveries were made in northern Australia during the 1950s and 1960s. As the Weipa and Gove deposits were developed, the resource life for bauxite from the mid-1970s to the late 1980s fell as production ramped up (Figure 17). Between 1989 and 1991, there was a temporary 'blip' in resource life (EDR) as large new discoveries in Cape York were added to the minerals inventory but then removed following the introduction of mandatory use of the JORC Code for reporting mineral resources (Figure 17). From 1991, resource life (EDR) again increased as new drilling added to the resource base faster than production increased but, since 2009, the opposite has occurred with rising extraction rates outpacing new resource delineation in recent years (Figure 17).

At 2017 levels of production, average reserve life at operating mines is nine years and demonstrated resource life (Measured and Indicated categories only) could be 25 years (Table 10). If Ore Reserves at developing mines and undeveloped deposits are also considered, the reserve life of bauxite is potentially 25 years. If AEDR is used as an indication of long-term potential supply, then at 2017 rates of production, Australia's bauxite resources could last approximately 70 years (Table 10).

At current rates of production, and even with increased rates of production, Australia has the potential to produce bauxite for many decades into the future (Table 10). However, Australia's alumina refineries and aluminium smelters are arguably vulnerable to the impacts of rising costs and, in the case of the smelters at Boyne Island, Portland, Bell Bay and Tomago, they are particularly vulnerable to both high energy costs and insecurity of energy supply.

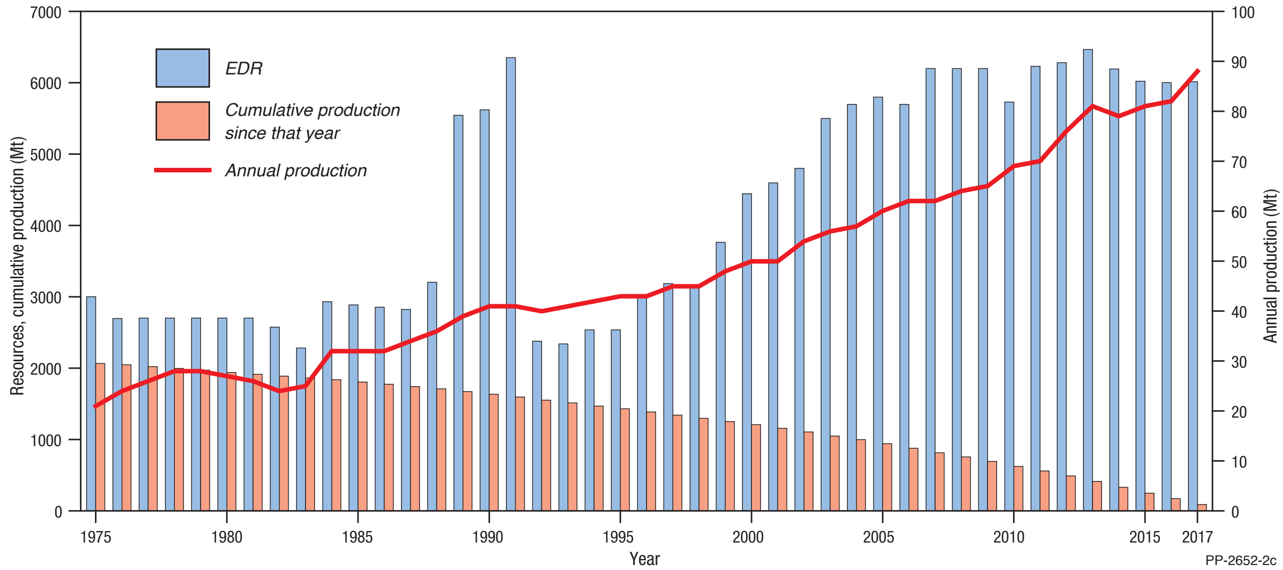


Figure 16 Economic Demonstrated Resources (EDR), annual production and cumulative production of bauxite, 2002–2017.

Notes: Cumulative production is read as the amount of bauxite that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of bauxite that has been produced since 1975 is 2069 Mt, the amount of bauxite that has been produced since 1995 is 1430 Mt. Mt = million tonnes.

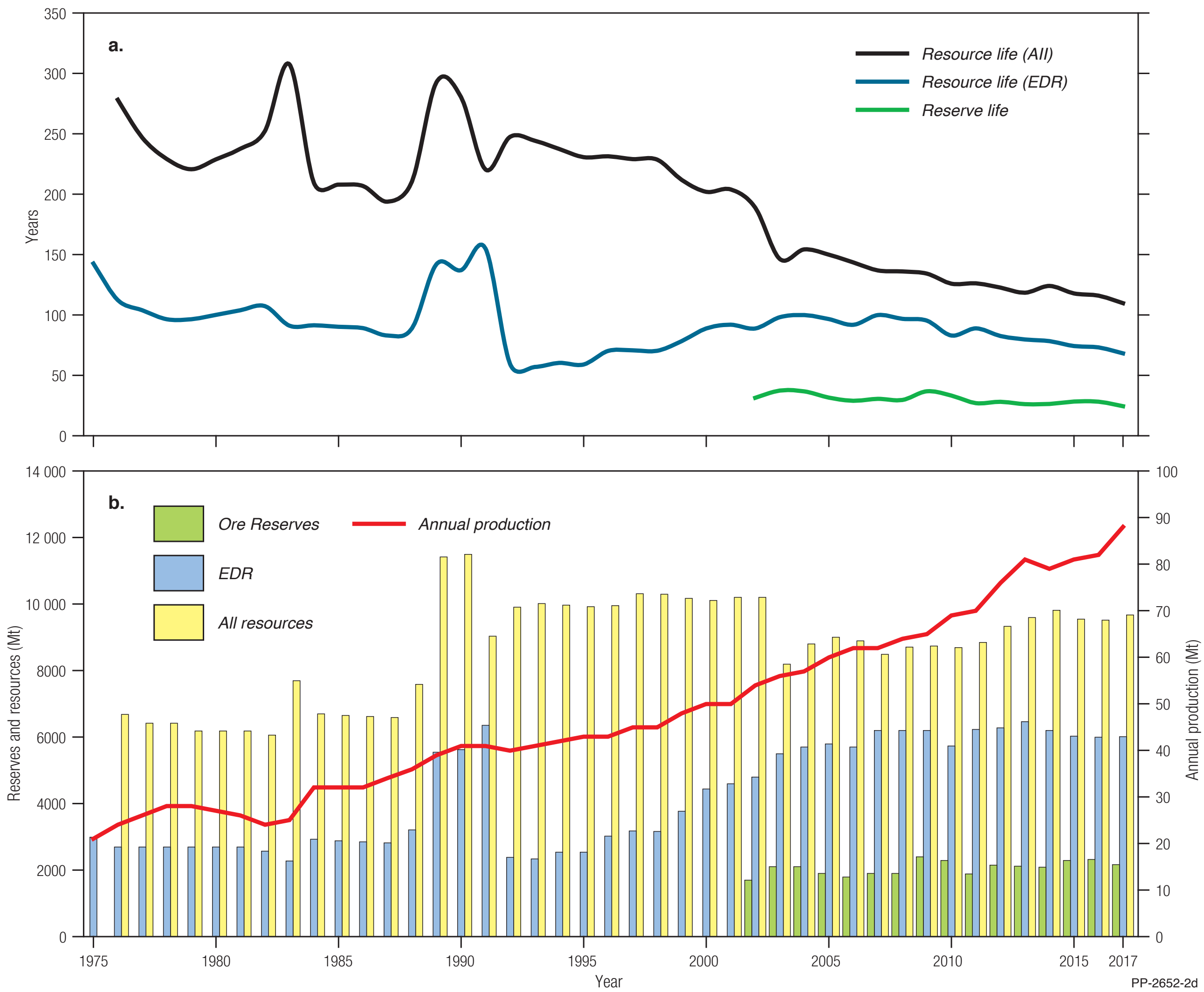


Figure 17 Trends in (a) bauxite reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. Mt = million tonnes. Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

Table 10 Average reserve life and resource life (years) for bauxite as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
9	25	54	25	70	110

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. All bauxite EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

BLACK COAL

Australia's black coal resources comprise both thermal and metallurgical coal. Thermal coal is mainly used for generating electricity at coal power stations, whereas metallurgical coal is mainly used to make steel. There is currently no commercial-scale substitute for metallurgical coal in steel making. In 2017, the estimate of Australia's in situ EDR of black coal was revised upward to 87 490 Mt (Table 3), an increase of 2% from the previous year (Table 4). Of this, 72 571 Mt is considered to be recoverable[8], which is also an increase of 2% from 2016 (Table 4). In addition, Australia has 109 263 Mt of Inferred Resources with 86 073 Mt estimated to be recoverable (Table 3). In 2017, Australia was globally ranked fourth (Table 8), behind the USA, China and India for recoverable economic coal resources and fourth as a producer (Table 8), behind China, India and the USA.

Most of Australia's black coal EDR is located in Queensland (61%) and New South Wales (36%; Figure 14) with 35% and 28% of recoverable EDR located in the Bowen (Queensland) and Sydney (New South Wales) basins, respectively. These basins also dominate black coal production. Significant black coal resources are also found in the Surat, Clarence-Moreton and Galilee basins in Queensland and in the Gunnedah Basin in New South Wales.

Australia has a very large Ore Reserve of black coal amounting to 18 536 Mt in 2017 (Table 2) of which 12 713 Mt (69%) is attributable to 91 operating mines (Table 1). These mines produced 559 Mt of black coal in 2017, a modest decrease of approximately 1% relative to 2016 levels (566 Mt) owing to industrial action, bad weather and operational issues at particular mines. Conversely, during 2017, world coal production increased (3.2%) as did consumption (1%) for the first time since 2013. China and the USA both made notable contributions to the annual increase in global production; although the USA actually decreased domestic consumption, it increased exports to the Asian region.

From 2002 to 2005, Ore Reserves of black coal declined and then rapidly increased until 2012, from which point they have been at similar levels each year (Figure 18). In 2017, Australia mined 559 Mt of black coal (Table 1), which is a small fraction of the Ore Reserves at currently operating mines (4%) and a smaller percentage of total Ore Reserves (3%). Indeed, Figure 18 shows that over the last 16 years of mining, cumulative production (7340 Mt) amounts to only 42% of the 2002 Ore Reserve (17 400 Mt), yet the Ore Reserve is greater today than it was then, indicating that the exploited coal has been replaced in the inventory and more added.

While Ore Reserves have risen this century, production has increased at a faster rate (Figure 18). Since 2002, Ore Reserves of black coal have risen 7% (Table 11) but production has increased by 33% over the same period (Figure 18). Over the last ten years, recoverable black coal EDR has risen 87% and all resources 49% (Table 11) as mining companies drilled out new reserves to meet rising demand. This reversed the decade-long decline in resources that began in 1997 (Figure 19) due to the impact of increased production rates and mining companies re-estimating Ore Reserves and Mineral Resources more conservatively to comply with requirements of the JORC Code.

Table 11 Changes in recoverable black coal production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Black Coal	Change since 2016	Change since 2007	Change since start of records
Annual Production	-1.2%	33%	816% (1975)
Ore Reserves	-6.4%	48%	7% (2002)
EDR	2.3%	87%	272% (1975)
All Resources	3.7%	49%	54% (2002)

Abbreviations
EDR = Economic Demonstrated Resources.

Notes: All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources.
Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

8 Recovery is the percentage of material of interest that is extracted during mining. Geoscience Australia has applied recovery factors to coal Mineral Resource estimates in order to improve understanding of Australia's resource potential. Unless otherwise stated by the company, deposits mined with open-cut methods are assumed to have a recovery factor of 90% and underground methods are assumed to have recovery factors of 50–75%. A coal Ore Reserve is reported at a higher level of confidence than a Mineral Resource and includes diluting materials, and allowances for losses that may occur during mining. Geoscience Australia does not apply recovery factors to Coal Reserves.

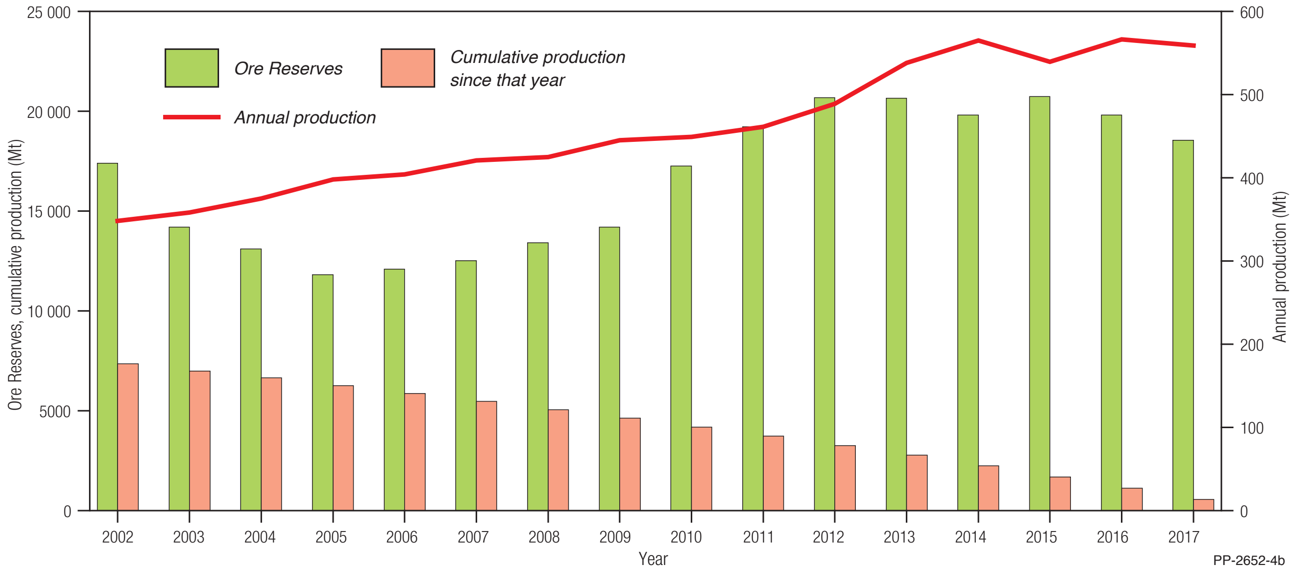


Figure 18 Black coal Ore Reserves, annual production and cumulative production 2002–2017.

Notes: Cumulative production is read as the amount of coal that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of coal that has been produced since 2002 is 7340 Mt, the amount of coal that has been produced since 2010 is 4166 Mt. Mt = million tonnes.

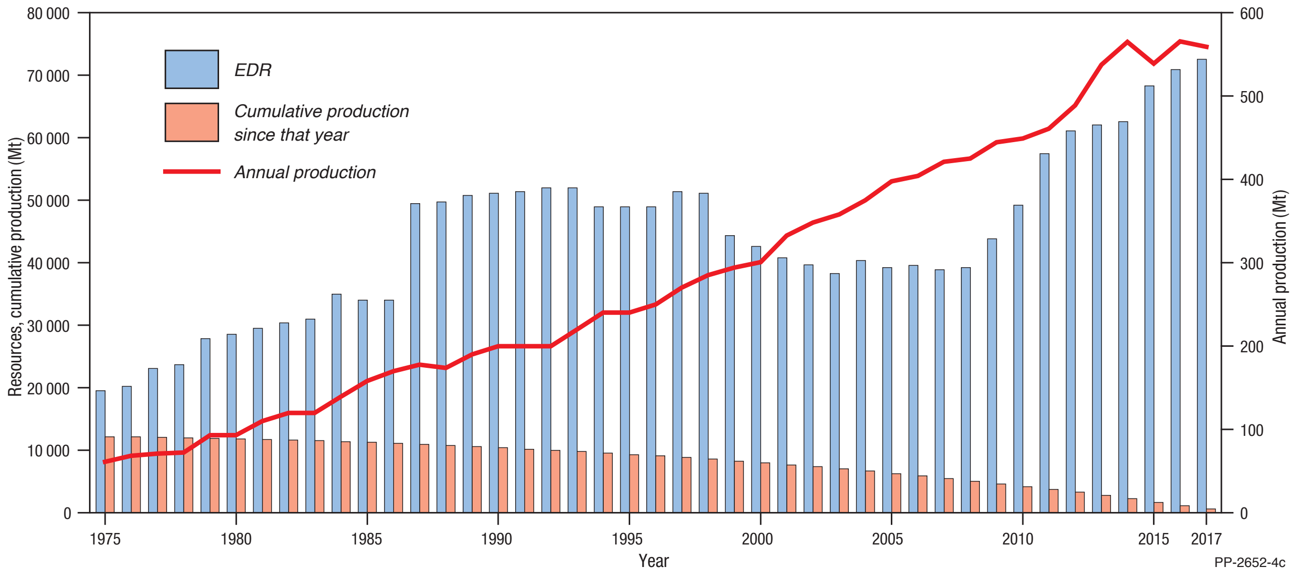


Figure 19 Economic Demonstrated Resources (EDR), annual production and cumulative production of recoverable black coal, 2002–2017.

Notes: Cumulative production is read as the amount of coal that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of coal that has been produced since 1975 is 12 190 Mt, the amount of coal that has been produced since 1995 is 9313 Mt. Mt = million tonnes.

In 2017, there was an increase in recoverable EDR of 1644 Mt (or 2.3%). Large additions came from deposits in the Sydney Basin including Bengalla (New Hope Group), Dartbrook (Australian Pacific Coal Ltd), Hunter Valley Operations (Yancoal Australia Ltd/Glencore plc), Mount Owen (Glencore plc) and Warkworth (Yancoal Australia Ltd). In the Bowen Basin, Blackwater (BHP Ltd), Collinsville (Glencore plc), Dawson (Anglo American plc/Mitsui & Co), and Wilton (Futura Resources Ltd) contributed to increased EDR. In the Surat Basin, Wandoan (Glencore plc) also reported increased resources due to the declaration of a maiden resource within MDL 414.

Figure 19 also demonstrates the vast inventory of black coal in Australia by showing that even over the longer time period of more than 40 years, cumulative production (12 190 Mt) has only mined out 63% of 19 500 Mt of resources assessed as economic back in 1975. But again, Figure 19 also shows that over the last 40 years, black coal production has increased more rapidly than the inventory. In 1975, black coal production was 61 Mt and in 2017 it was 559 Mt, an increase of more than 800%, but recoverable black coal EDR has increased only 272% over the same period (Table 11).

In 2017, Inferred Resources of recoverable black coal increased by 4209 Mt or 5%. Large additions came from deposits in the Sydney Basin including Bulga (Glencore plc), Dartbrook, Hunter Valley Operations, Mangoola (Glencore plc) and Mount Owen. In the Bowen Basin, Blackwater, Dawson, Wilton and Fairhill (Futura Resources Ltd) also contributed to the increased Inferred Resources.

In the Surat Basin, maiden Inferred Resources were added at Wandoan and another maiden Inferred Resource of 123 Mt was reported at the Karin Basin Coking Coal Project (Vitrinite Pty Ltd) in May 2017. The Wilton open-cut coking coal deposit had previously been described without specifying a JORC category, but a 2017 report was released by Gateway Mining Ltd which detailed significant JORC resources of 2600 Mt in the adjacent Wilton and Fairhill deposits.

Coal exploration expenditure remained constant in 2017 at $124 million, with more than 70% of the exploration expenditure occurring in Queensland. Thermal and coking coal prices stopped declining and increased relative to 2016. The Office of the Chief Economist expects that world thermal and coking coal trade, as well as Australian exports, will continue to increase during 2018. Thus, increased demand may stimulate increased exploration in coming years. The Queensland government continues to assess tenders and award exploration authorities as part of its ongoing Queensland exploration program.

Resource life is a snapshot in time derived by taking a reserve or resource number and dividing it by a production number. Last century, resource life (EDR) for black coal declined rapidly from more than 300 years in the late 1970s to less than half that by the year 2000 as rapidly increasing production was not matched by new resource delineation (Figure 20). Since the turn of the century, however, the reserve/production and resource/production ratios for recoverable black coal have been generally steady because companies have been demarcating new Ore Reserves and Mineral Resources at approximately the same rate that they have been increasing production (Figure 20).

At 2017 levels of production, the average reserve life at operating mines for black coal is potentially 23 years and demonstrated resource life (Measured and Indicated categories only) at operating mines is more than double that at 51 years (Table 12). If all Ore Reserves are considered, the reserve life for black coal is potentially 33 years, and if AEDR of all recoverable black coal resources are used as an indication of long-term potential supply, then at 2017 rates of production, Australia's black coal could last more than a century (Table 12).

Despite the growing popularity of alternative energy technologies, coal continues to be important for electricity generation both domestically and internationally. The percentage share of global electricity generation supplied by coal is decreasing but the World Coal Association predicts that, in absolute terms, the amount of coal-fired electricity generation will grow as the total amount of electricity generation increases worldwide, particularly in developing regions. The Office of the Chief Economist projects that the world demand for metallurgical coal imports will grow during 2019. As Indian steel production, and requirements for metallurgical coal, continues to increase, India is forecast to become the largest metallurgical coal importer by 2020.

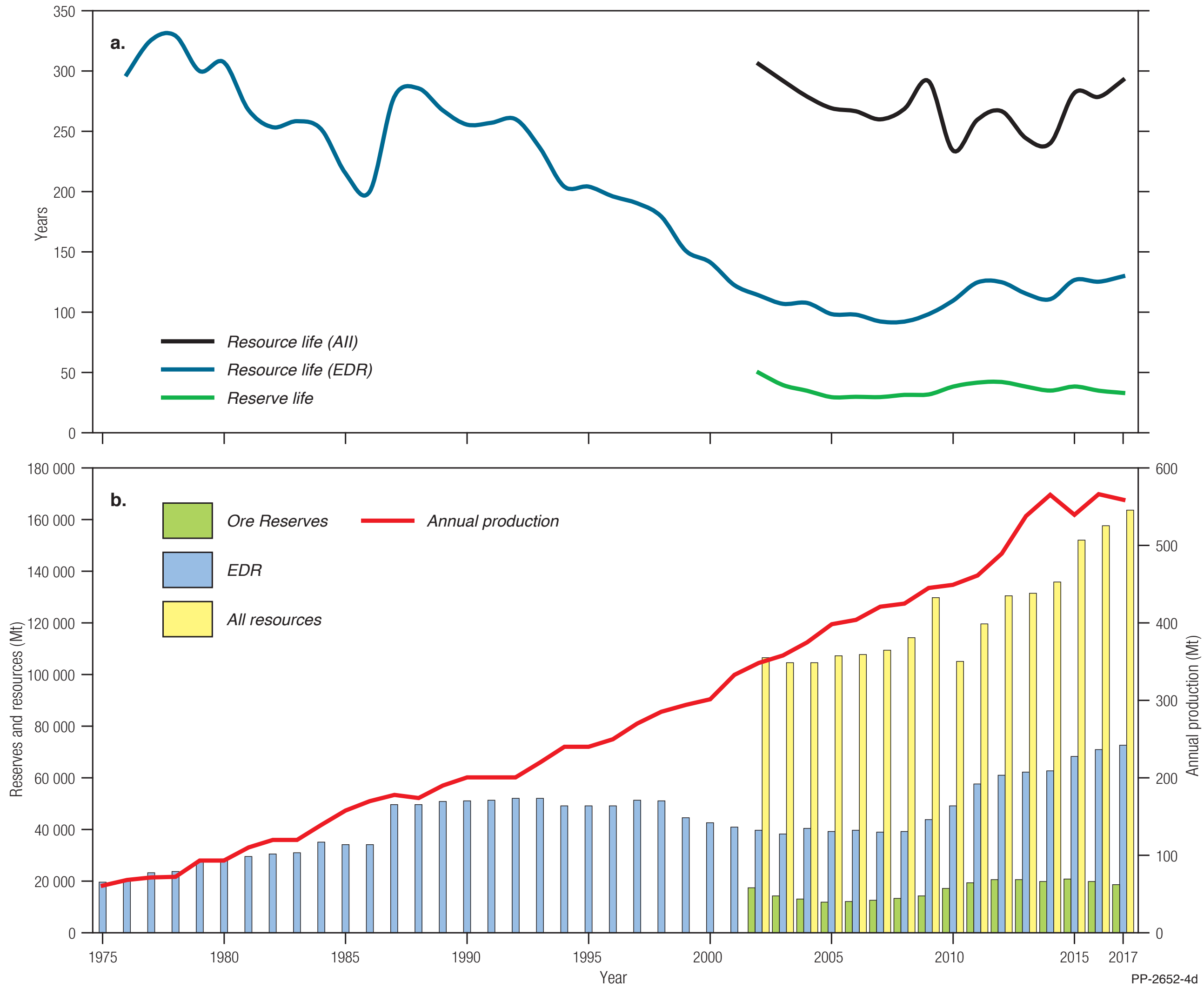


Figure 20 Trends in (a) recoverable black coal reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. Mt = million tonnes.

Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

Table 12 Average reserve life and resource life (years) for recoverable black coal as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
23	51	72	33	120	295

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources, 91% of black coal EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

IRON ORE

Australia has significant deposits of both hematite and magnetite and thus Geoscience Australia estimates the national inventory of iron in two categories: (1) iron ore and (2) contained iron. Australia's EDR of iron ore decreased by 3% to 47 987 Mt in 2017 with the EDR of contained iron estimated to be 23 251 Mt, 2% lower than the previous year (Table 3, Table 4). Within this, magnetite resources have increased by 4% to 18 520 Mt in 2017, accounting for approximately 39% of iron ore EDR. The fall in the national EDR of iron ore in 2017 was caused by the reassessment of resource deposit status and, more importantly, the continuing exploration inactivity by developing projects as a consequence of the lingering volatile market price of iron ore. Increases in EDR are mostly attributable to brownfield development and project expansion by existing producers, mainly in Western Australia, which has 92% of Australia's EDR (Figure 14), the majority of which is in the Pilbara region. Australia has the world's largest EDR with 28% of the world's iron ore (Table 8) followed by Russia (15%), Brazil (13%) and China (12%).

Australia has large Ore Reserves of iron ore amounting to 24 146 Mt in 2017 (Table 2, Figure 21) of which 9424 Mt (39%) is attributable to 33 operating mines (Table 1). These mines produced 883 Mt of iron ore in 2017, up 3% from 2016 (858 Mt). Western Australia produced almost 99% of this total (877 Mt) with the remainder produced by small operations in South Australia and Tasmania.

In 2017, iron ore prices slightly recovered but continued to fluctuate, maintaining poor sentiment for greenfield exploration drilling. The production increase of 2.9% (Table 13) was mainly attributable to the major producers, Rio Tinto Ltd, BHP Ltd and Fortescue Metals Group Ltd, as they continued to achieve their capacity guidance through expansion and ramp-up of existing operations. Rio Tinto has maintained its Pilbara iron ore production at 330 Mt and met its shipment guidance of 330 Mt. BHP's Western Australia Iron Ore operations recorded a 3% increase to 275 Mt in the 2017–18 financial year, mostly due to improvement in productivity and record production at Jimblebar and Mining Area C. For the 2016–17 financial year, Fortescue reported a 1% increase in production and mineral Ore Reserves to 169.4 Mt and at 3675 Mt, respectively.

Annual production is a small fraction of the iron ore Reserve (3.7% in 2017) but cumulative production over the last 16 years (7539 Mt) has accounted for all of the iron ore Reserve from 2002 (4100 Mt), plus another 83% (Figure 21). When EDR are considered, over the last 42 years, mining has removed only 60% of 17 800 Mt of resources assessed as economic in 1975 (Figure 22). This vast inventory of iron ore has supported a rapid increase in production, particularly from 2000 onward (Figure 22 and Figure 23).

Table 13 shows that since 1975, iron ore production has increased 801% whereas EDR has increased only 170%. Similarly, production has outstripped delineation of EDR over the last decade (195% cf. 136%). Even though EDR actually fell 3.2% in 2017 compared to the previous year, Ore Reserves have continued to rise (Table 13, Figure 21), reflecting the major companies' plans to ramp up production in coming years.

Table 13 Changes in iron ore production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Iron Ore	Change since 2016	Change since 2007	Change since start of records
Annual Production	2.9%	195%	801% (1975)
Ore Reserves	2.6%	198%	489% (2002)
EDR	-3.2%	136%	170% (1975)
All Resources	0.9%	228%	338% (1976)

Abbreviations: EDR = Economic Demonstrated Resources.

Notes: All Resources=EDR + Subeconomic Demonstrated Resources + Inferred Resources.

Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

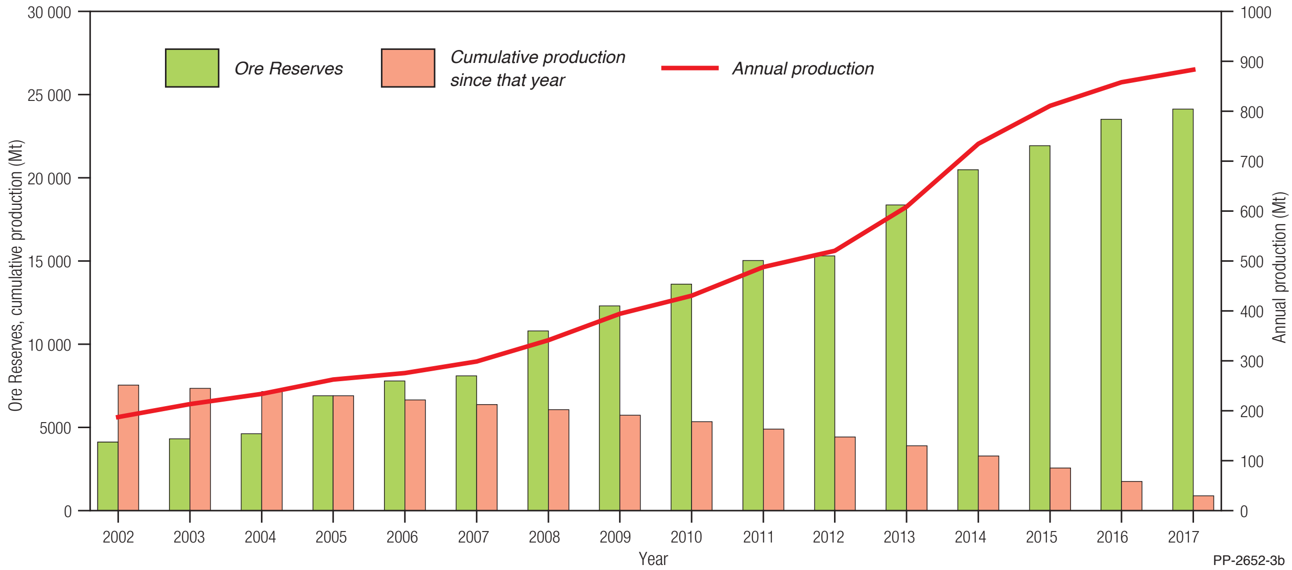


Figure 21 **Iron Ore Reserves, annual production and cumulative production 2002–2017.**

Notes: Cumulative production is read as the amount of iron ore that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of iron ore that has been produced since 2002 is 7539 Mt, the amount of iron ore that has been produced since 2010 is 5334 Mt. Mt = million tonnes.

Much of the increase in EDR occurred rapidly after a period of decline from 1994 through to 2003 (Figure 22 and Figure 23) which was caused by the combined impacts of increased rates of mine production and mining companies re-estimating reserves and resources to comply with the requirements of the JORC Code. From 2003 to 2015, EDR increased rapidly due to large increases in magnetite resources (including reclassification of some magnetite deposits to economic categories), and increases in hematite resources, mainly at known deposits. Since 2015, EDR has again declined as lower prices for iron ore has resulted in some deposits being reassessed as subeconomic.

Iron ore-exploration expenditure in Australia during 2017 totalled $290.5 million, a 1% increase on the $288 million spent in 2016. Exploration for iron ore in 2017 accounted for 17% of Australia's total mineral exploration expenditure.

Resource life is a snapshot in time derived by taking a reserve or resource number and dividing it by a production number. Resource life for iron ore is expected to fluctuate as mine production responds to market demand. This is clearly seen with the falling resource life for iron ore from the 1980s to around the turn of this century as new resource discoveries were outpaced by rising production (Figure 23). It is only since 2003 that exploration drilling has added to the resource base enabling resources to keep pace with rising production. From 2000 to 2015, the AEDR/production ratio has ranged between 60 to 80 years, but has since fallen to 55 years (Table 14).

Ore reserves for the 29 iron ore mines that operated in 2017 (Table 14) are projected to last for at least 11 years, but more likely longer as operations upgrade their resources. Development of other deposits into mines also affects reserves. The AEDR of all deposits have a resource life of 55 years with the Ore Reserves component having a life of 27 years (Table 14). These are projections; there are several factors that can influence and change the life of iron ore resources and reserves such as market stability and resumption of projects that were suspended during the downturn. But, as demand for high-grade ore rises, production of high-grade iron concentrate through development of magnetite deposits into mines can also change the projection of resources and reserves life.

Table 14 **Average reserve life and resource life (years) for iron ore as at December 2017.**

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
11	20	56	27	55	175

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. All iron ore EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

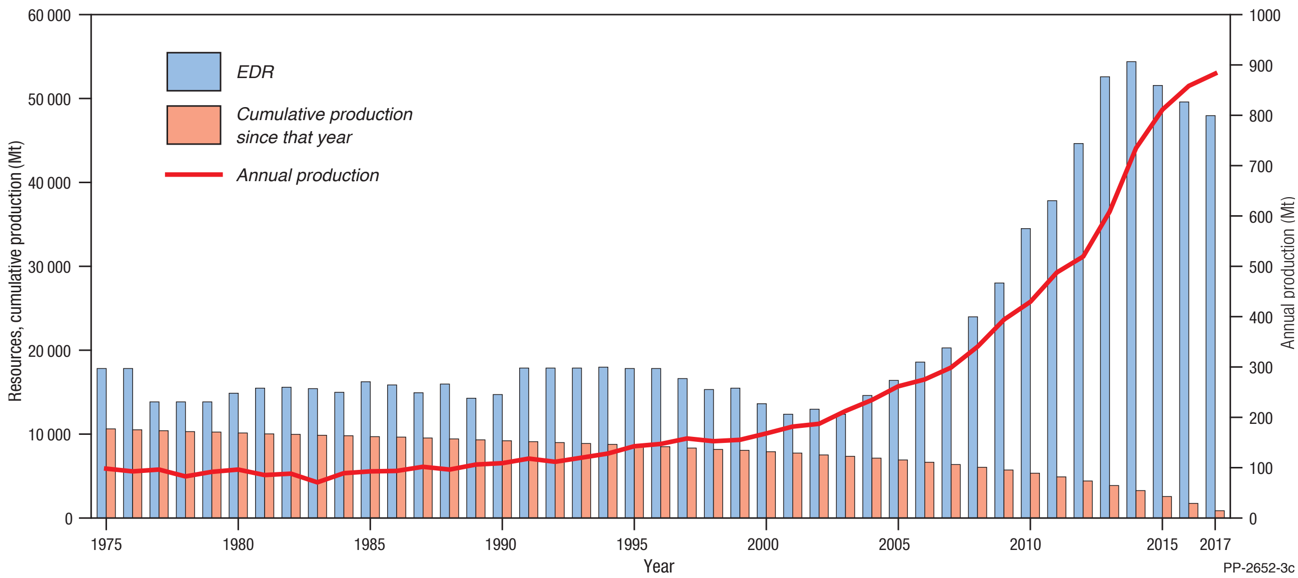


Figure 22 Economic Demonstrated Resources (EDR), annual production and cumulative production of iron ore, 2002–2017.

Notes: Cumulative production is read as the amount of iron ore that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of iron ore that has been produced since 1975 is 10 614 Mt, the amount of iron ore that has been produced since 1995 is 8645 Mt. Mt = million tonnes.

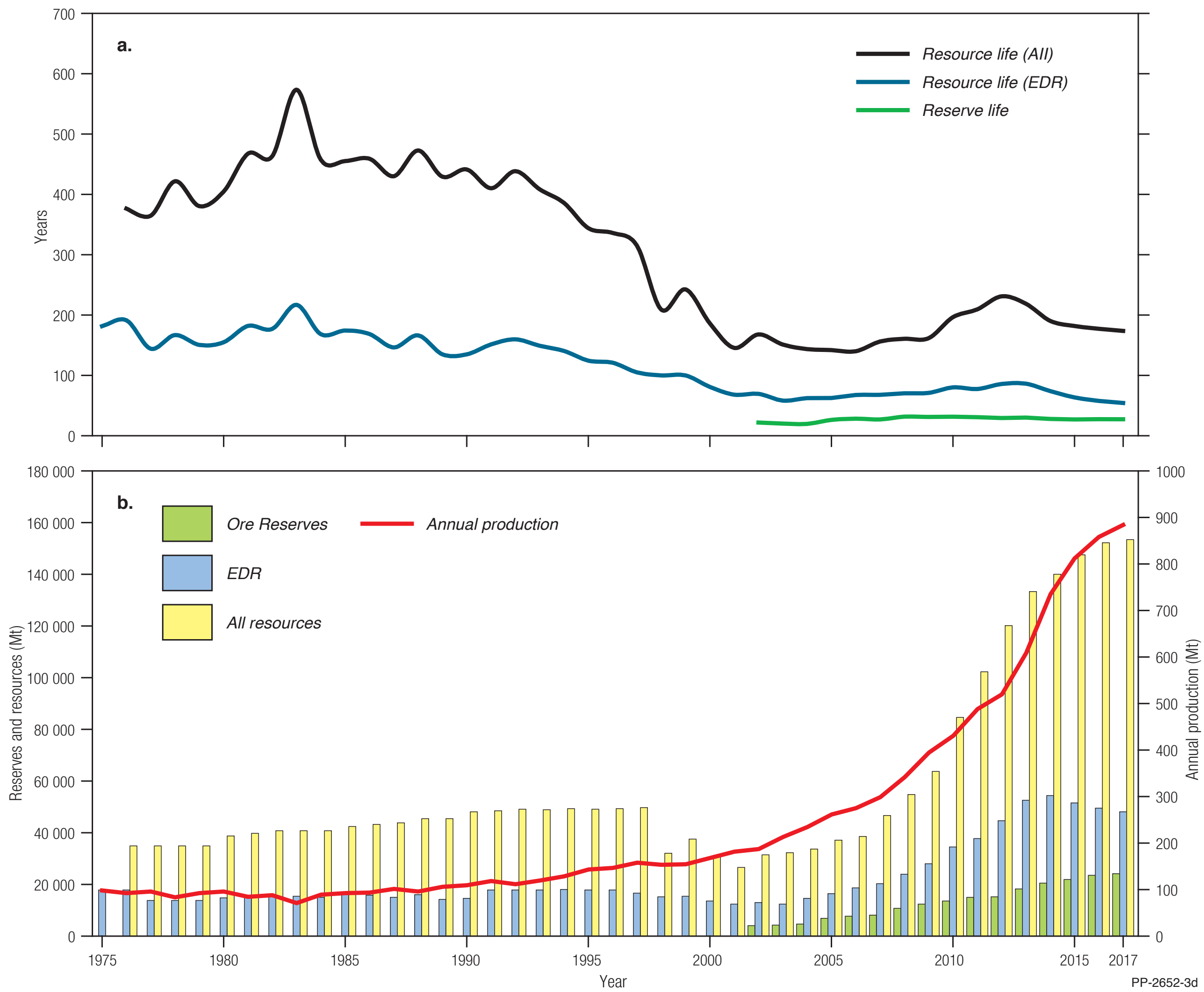


Figure 23 Trends in (a) iron ore reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. Mt = million tonnes.
Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

GOLD

National EDR of gold went up 2.4% (240 t) in 2017 to 10 070 t (Table 3, Table 4), with the majority of the rise recorded in Western Australia (234 t) followed by Northern Territory (33 t) and South Australia (27 t). Queensland had the largest fall (60 t). All other jurisdictions recorded minor fluctuations in gold EDR. Accessible EDR is approximately 30 t less than EDR as several deposits are unavailable for exploration and mining (Table 3). These include Jabiluka, Koongarra and Coronation Hill. The USGS figures for world gold resources (54 500 t; Table 3) have not changed substantially in recent years and Australian EDR (10 070 t) accounts for the largest resource by country with approximately 18% of the global total (Table 8), ahead of South Africa (11%), Russia (10%), the USA (6%) and Indonesia (5%).

Total Ore Reserves of gold reported in compliance with the JORC Code amounted to 3869 t of gold in 2017 (Table 2) of which 2903 Mt (27%) is attributable to 128 operating mines (Table 1). These mines produced 292 t of gold in 2017, up 1.4% from 2016 levels (288 t). Increases in gold production were seen in Western Australia (11 t), Victoria (2 t), Queensland (2 t) and South Australia (1 t). Minor production declines were seen in New South Wales, the Northern Territory and Tasmania.

At 2017 levels of production, average reserve life at operating mines is potentially 10 years and resource life could be 23 years (Table 15). If Ore Reserves at mines on care and maintenance, developing mines and undeveloped deposits are also considered, the reserve life of Australia's gold is potentially 13 years, and if AEDR is used as an indication of long-term potential supply, then at 2017 rates of production, gold resources could last almost 35 years (Table 15).

However, these ratios are strongly influenced by low-grade porphyry copper-gold and Olympic Dam-style IOCG deposits, which together host 66% of accessible gold EDR at operating mines yet are responsible for only 22% of production (Figure 24). Lode-gold deposits, on the other hand, comprise only 31% of EDR at operating mines yet provide 70% of Australia's gold (Figure 24). Additional production of approximately 12 t is sourced from epithermal deposits (4%), gold-antimony deposits and as a by-product of base metal mining (4%).

This skewing of Australia's gold resources and production by mineralisation style can be seen further when the resource lives of each mineralisation style are considered.

In 2017, EDR for lode-gold deposits at operating mines was 1977 t and production was 203 t, yielding an operating mines resource life of approximately ten years (Table 16). For operating porphyry copper-gold mines, this ratio was 38 years and for IOCG deposits it was a massive 191 years (Table 16).

Thus, while gold resources in porphyry and IOCG deposits are substantial, current and future mining rates of these large, generally low-grade, deposits are unlikely to lead to substantial increases in output. Gold production in Australia, therefore, continues to be dominated by lode-gold deposits and exploration success for these deposit types will need to continue to sustain current production rates into the future.

Australia's gold Ore Reserves and production have both risen since the Australian Government began recording Ore Reserve estimates in 2002 (Figure 25). Ore Reserves have increased 8% over this period and 18% over the decade (Table 18). Production in 2002 was 266 t, which was down from its peak of 311 t in both 1997 and 1998 (Figure 26). Thus gold production has increased 10% since 2002 (Figure 26) and 19% since 2007 (Table 17). Cumulative production since 2002 (4165 t) has consumed the entire gold Ore Reserve estimated in 2002 (3574 t; Figure 25), and more. Cumulative production has similarly exceeded the Ore Reserve for 2003, 2004 and 2005, yet the Ore Reserve inventory remains steady, reflecting common practice in the mining industry of upgrading Mineral Resources to Ore Reserves as needed.

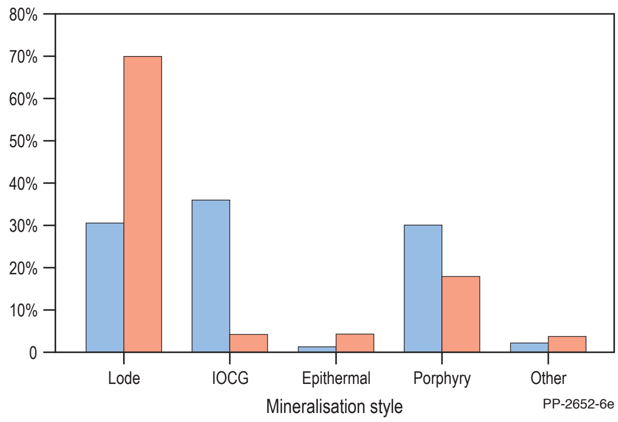


Figure 24 Distribution of gold by mineralisation style of Economic Demonstrated Resources (EDR) and annual production at operating mines, as at December 2017.

IOCG = Iron Oxide-Copper-Gold.

Table 15 Average reserve life and resource life (years) for gold as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
10	23	30	13	35	50

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources, >99% of gold EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

Table 16 Average resource life (years) of gold EDR at operating mines by mineralisation style, as at December 2017.

	Lode	IOCG	Porphyry	Epithermal	Other	All styles
Resource Life (EDR)	10	191	38	7	13	23

Notes: Resource life (EDR) = Economic Demonstrated Resources÷production.
This ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

Over the last four decades, both the resources inventory and gold production have risen significantly (Figure 26). In 1975, annual gold production was 16 t which rose to 292 t in 2017, an increase of almost 1700% (Table 17). Gold EDR has increased 6368% over the same time period and total resources of gold (EDR + Subeconomic + Inferred) have increased 5773% (Table 17). The EDR of gold has risen steadily from 1983 (394 t) to 2017 (10 070 t) with only relatively minor falls of short duration (Figure 26). This rise in EDR corresponds to a period of sustained exploration expenditure averaging approximately $500 million per annum and of improvements to extraction technologies including carbon in pulp, carbon in leach and the treatment of refractory ores. Increases in reserves, resources and production over the last decade are not as dramatic but still significant, with gold EDR in particular rising strongly (72%; Table 17). This is largely the result of favourable exchange rates raising the gold price in Australian dollars which has invigorated exploration in the gold sector as companies look to increase resource inventories. Much of this exploration expenditure was targeted at upgrading resources around existing deposits, especially converting Inferred Resources into higher resource categories.

Table 17 Changes in gold production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Gold	Change since 2016	Change since 2007	Change since start of records
Annual Production	1.4%	19%	1697% (1975)
Ore Reserves	1.1%	18%	8% (2002)
EDR	2.4%	72%	6368% (1975)
All Resources	3.1%	29%	5773% (1976)

Abbreviations: EDR = Economic Demonstrated Resources.

Notes: All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources.
Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

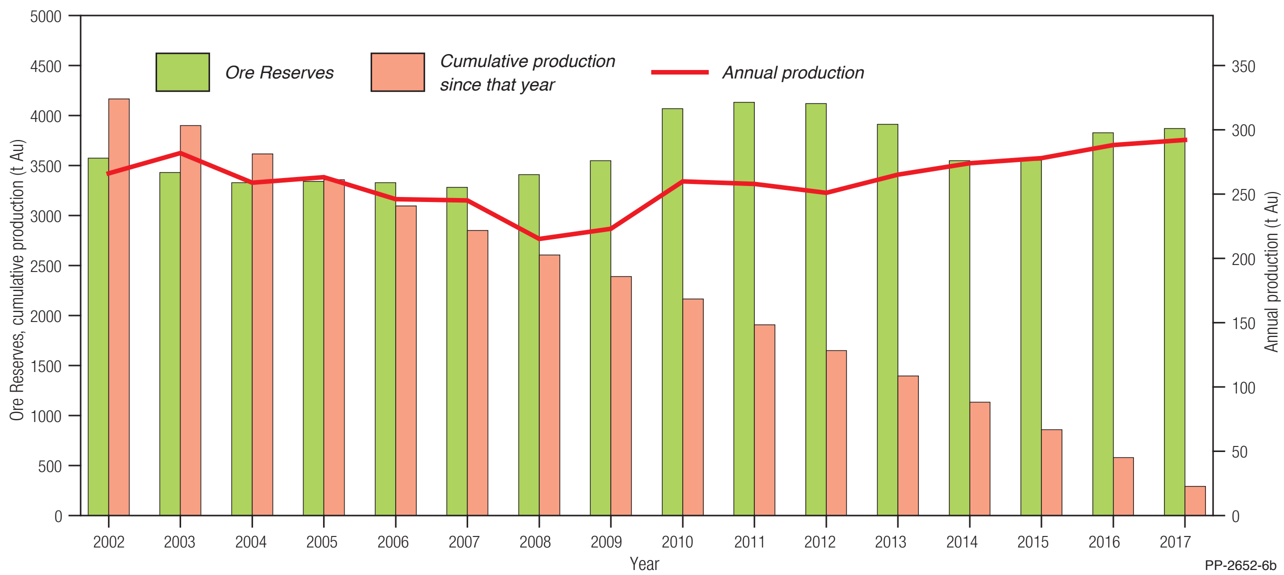


Figure 25 Gold Ore Reserves, annual production and cumulative production 2002–2017.
Notes: Cumulative production is read as the amount of gold that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of gold that has been produced since 2002 is 4165 t, the amount of gold that has been produced since 2010 is 2166 t. t Au = tonnes of contained gold.

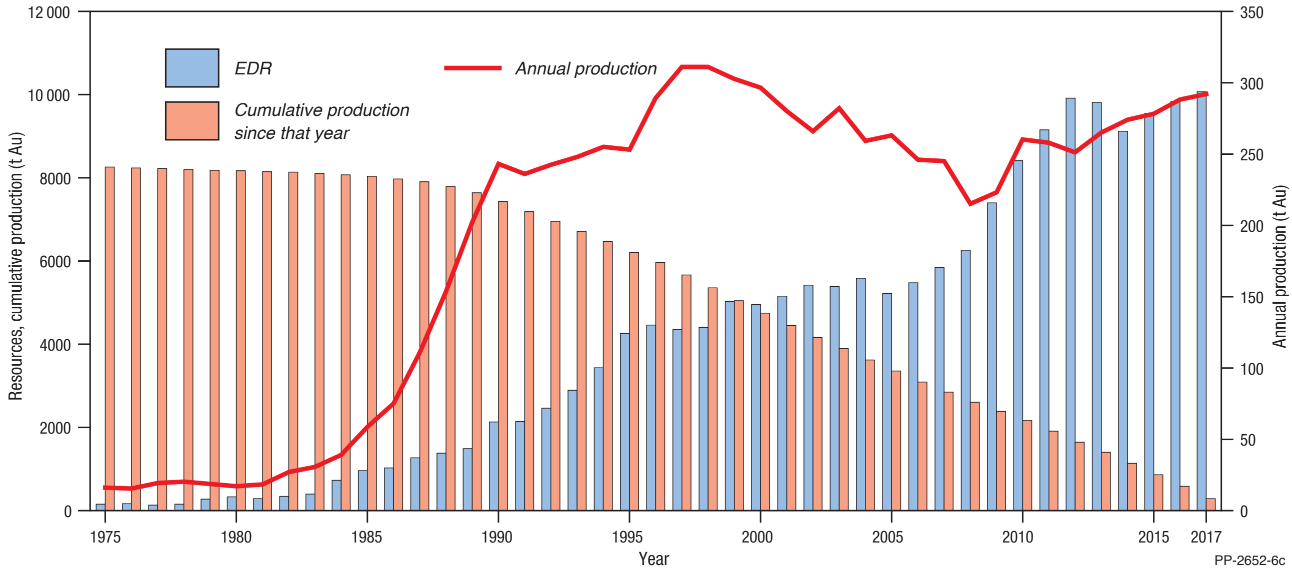


Figure 26 **Economic Demonstrated Resources (EDR), annual production and cumulative production of gold, 2002–2017.**
Notes: Cumulative production is read as the amount of gold that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of gold that has been produced since 1975 is 8255t, the amount of bauxite that has been produced since 1995 is 6208t. t Au = tonnes of contained gold.

Resource life is a snapshot in time derived by taking a reserve or resource number and dividing it by a production number. Resource life dramatically increased, briefly, during the early 1980s as the introduction of new gold extraction technologies stimulated exploration (Figure 27). Resource life then declined rapidly as gold production surged 800% from 27 t in 1982 to 243 t in 1990 (Figure 27). Since 1990, resource life for gold has generally trended upward (Figure 27) as new resource delineation has outpaced increases in production. It is only since 2012 that gold resource life has decreased owing to favourable exchange rates stimulating increased production but with slower increases in new resource delineation (Figure 27).

According to Thomson Reuters/World Gold Council, world gold production from mining went up 34 t or 1% to 3298 t in 2017; Australia accounts for approximately 9% (292 t) of this world production (Table 8). Australia continued to rank second in the world for gold production behind China (440 t) and ahead of Russia (255 t), the USA (245 t) and Canada (180 t). Imports of primary and secondary gold into Australia totalled approximately 111 t in 2017; 17 t less than in 2016. Total refined gold amounted to 328 t, down 16 t from 2016. Gold exports decreased approximately 26 t to 318 t, with a value of $16.9 billion.

The monthly average gold price commenced at US$1192.6/oz in January and concluded at US$1261.3/oz in December. The average price over the year was US$1257.1/oz, which is US$8.8/oz higher than in 2016. The highest monthly average price was recorded in September at US$1315/oz. Due to prevailing exchange rates, the price of gold in Australian dollars fluctuated between a low of $1596.4/oz (January 2017) and a high of $1682.4/oz (November 2017). Overall, the average price of gold in Australian dollars was $1640.1/oz in 2017, which is $38.4/oz lower than in 2016.

Although equity markets remained difficult throughout 2017 and resulted in reduced exploration expenditure across most commodities, gold exploration expenditure increased by 21.4% over the previous year to total $749.6 million. Gold had the highest exploration expenditure of all commodities for 2017, ahead of iron ore ($290.5 million) and other minerals ($158.9 million) reflecting the relatively strong price of gold in Australian dollars. Gold exploration expenditure in 2017 was higher than it was during the mining boom when it reached a peak of $740.9 million in 2012.

In 2017, a number of maiden resources were announced including:

- An Inferred Mineral Resource for the Jumbuck Gold Project in South Australia of 219 000 oz comprising the Golf Bore, Golf Bore North, Greenewood, Mainwood and Campfire Bore deposits. The delineation of this resource completes phase one of Tyranna Resources Ltd's exploration target of 500 000 oz of gold within trucking distance of the Challenger gold mine, which is operated by joint venture partner WPG Resources Ltd.
- Measured, Indicated and Inferred Mineral Resources announced by Red 5 Ltd of 895 000 oz at the Darlot gold mine in Western Australia. This maiden resource includes a Probable Ore Reserve of 131 000 oz.

The Australian gold sector remains strong with high exploration expenditure, increases in resources and reserves and increased production all backed by a strong gold price in Australian dollars.

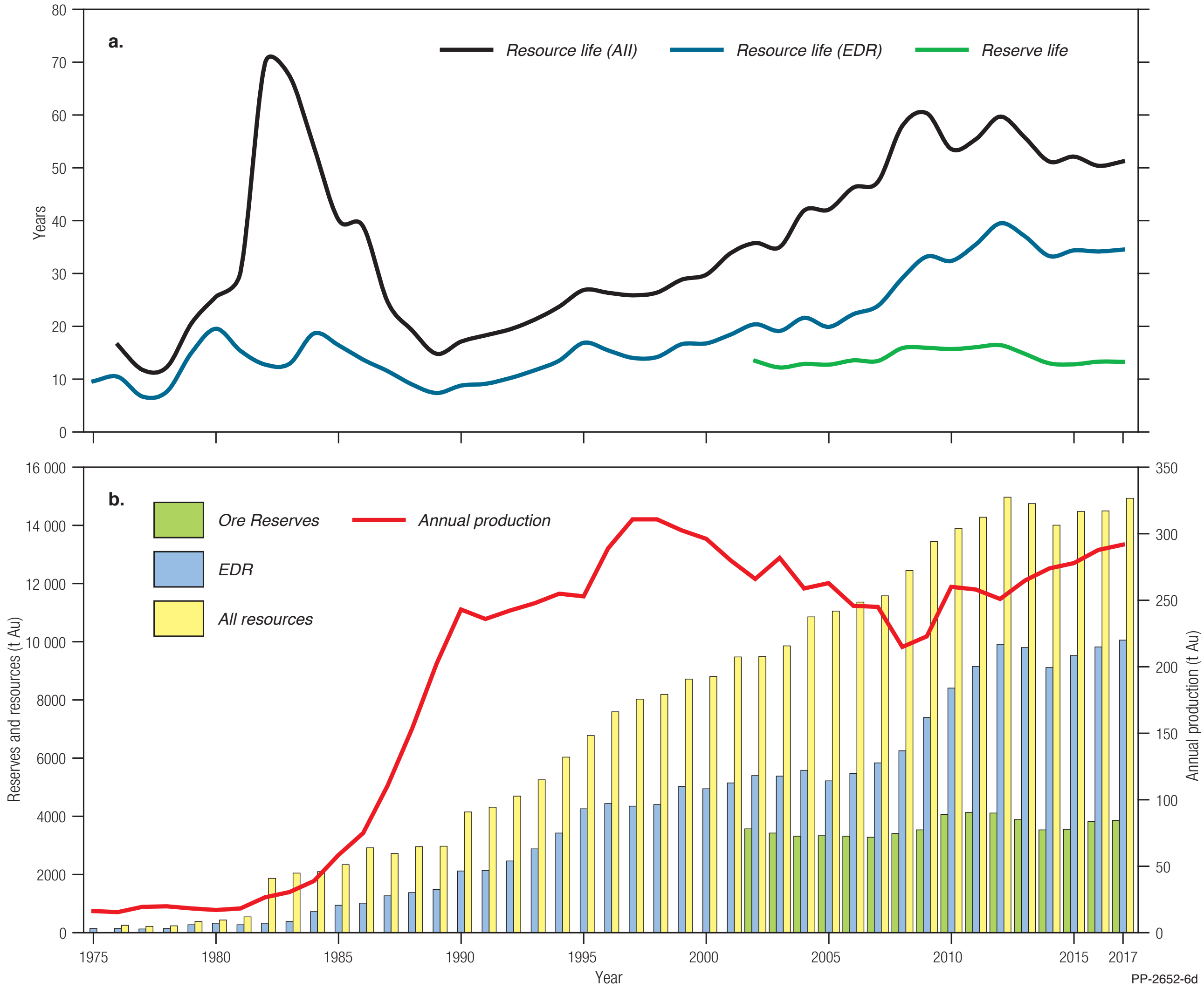


Figure 27 **Trends in (a) gold reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.**

Notes: Prior to 2002, Ore Reserves were not recorded. t Au = tonnes of contained gold.

Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

COPPER

Australia's EDR of copper in 2017 was 87.47 Mt, essentially unchanged from 87.78 Mt in 2016 (Table 3, Table 4). South Australia has 65% of the national total of EDR, mainly in the Olympic Dam deposit (which contains 59% of Australia's EDR), followed by New South Wales (15%) and Queensland (13%; Figure 14). Australia accounts for 11% of the global economic copper resource, and is ranked second in the world (Table 8) after Chile (21%) and ahead of Peru (10%) and Mexico (6%). Australia is also a major copper producer with significant production coming from the operations at Olympic Dam and Prominent Hill in South Australia; Northparkes, Cadia, Cobar and Tritton in New South Wales; Nifty, DeGrussa, Boddington, Telfer and Golden Grove in Western Australia; and Mount Isa, Ernest Henry and Lady Annie in Queensland. Smelting occurs at Olympic Dam, which has a copper concentrate processing capacity of 450 kt per annum, and at Mount Isa which has a concentrate processing capacity of 900 kt per annum. Copper cathode is produced at Glencore's electrolytic copper refinery in Townsville, which can produce up to 300 kt per annum. The copper is mainly sourced from the Mount Isa smelter.

Australia has large Ore Reserves of copper amounting to 23.03 Mt in 2017 (Table 2) of which 20.08 Mt (87%) is attributable to 35 operating mines (Table 1). These mines produced 0.860 Mt of copper in 2017, down 9% from 2016 levels (0.948 Mt). The USGS estimates that during 2017, global copper production also decreased (2%) because of disruptions at major copper mines, lower ore grades and an overall lack of new projects and mine expansions. In contrast, both supply and consumption of copper have been projected to increase as new mines and mine expansions come online to meet increasing demand from developing copper-intensive technologies such as electric vehicles.

Australian exports of copper ore and concentrates (1.775 Mt) and refined copper (0.354 Mt) were valued at $7624 million in 2017, down 1% on 2016 earnings. Copper ore and concentrates were down 2% on 2016 volume but overall value was up 1.5% reflecting higher copper prices. Refined copper exports in 2017 were down 22% on the previous year but only down 5% in export earnings, again reflecting higher prices in 2017 as copper demand outstripped supply.

Australia's Ore Reserves of copper have increased by 13% since Geoscience Australia began recording this data in 2002 (Figure 28; Table 18). Production, however, has changed little over this period (Figure 28). Over the last decade, production has fallen 1%, but Ore Reserves, EDR and other resources have increased. From 2016 to 2017, all resource categories and production fell (Table 18). Despite this recent decline in copper supply, Ore Reserves and production have remained within a relatively narrow range this century, reflecting steady near-term supply (Figure 5 and Figure 28).

When EDR are considered, rather than just the narrower, more near-term category of Ore Reserves, it is clear that Australia has a vast inventory of copper (Figure 29). Copper EDR has increased nearly 1400% since 1975 (Table 18) but this rise has not been uniform (Figure 29). The copper inventory had begun to rise in the early 1980s but fell sharply in 1989 when the JORC Code was made mandatory by the Australian minerals industry and the ASX.

In 1993, there was a sharp increase in copper EDR (Figure 29) mainly because of increased resources announced for the Olympic Dam deposit in South Australia. Additional resources were also reported for Ernest Henry in Queensland, Northparkes in New South Wales and other smaller deposits. Reassessments of copper resources by Geoscience Australia in 2002 and 2003 resulted in further transfers (reclassification) of Olympic Dam resources into EDR. In 2007 and 2008, copper resources again increased sharply at Olympic Dam after drilling outlined large resources in the southeastern part of the deposit. Since 2008, successful exploration has continued to yield new discoveries and delineate new resources, resulting in a steady increase of copper EDR, including the Carrapateena, Rocklands, DeGrussa, Hillside and Cadia East deposits.

The large rise in the copper inventory from 1993 onward is also seen in the cumulative production statistics. Figure 28 shows that cumulative production has not yet removed all of the estimated Ore Reserve from 2002, yet Figure 29 shows that over the longer timescale, cumulative production has exceeded EDR of copper every year from 1975 to 1992. So whilst, copper production has risen significantly since 1993, it has not matched the large resource increases that began at the same time (Figure 29).

Resource life is a snapshot in time derived by taking a reserve or resource number and dividing it by a production number. While copper reserve life has been broadly constant (Figure 30), resource life (EDR) increased rapidly from 30 years in 2001 to 100 years in 2009 as new resources were added to the inventory but were not matched by increasing production rates (Figure 30). Since 2009, resource life (EDR) has ranged between 90 and 100 years reflecting a congruency between production and resource replacement (Figure 30). More recently, resource life (EDR) has ticked up from 90 years in 2015 to 100 years in 2017 owing to reduced production. If production continues to fall, Australia's resource life for copper can be expected to increase.

Table 18 **Changes in copper production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.**

Copper	Change since 2016	Change since 2007	Change since start of records
Annual Production	-9.3%	-1%	291% (1975)
Ore Reserves	-4.0%	26%	13% (2002)
EDR	-0.4%	48%	1383% (1975)
All Resources	-1.5%	28%	1401% (1976)

Abbreviations: EDR = Economic Demonstrated Resources.

Notes: All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources.

Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

Figure 28 **Copper Ore Reserves, annual production and cumulative production 2002–2017.**

Notes: Cumulative production is read as the amount of copper that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of copper that has been produced since 2002 is 14.5 Mt, the amount of copper that has been produced since 2010 is 7.5 Mt.

Mt Cu= million tonnes of contained copper.

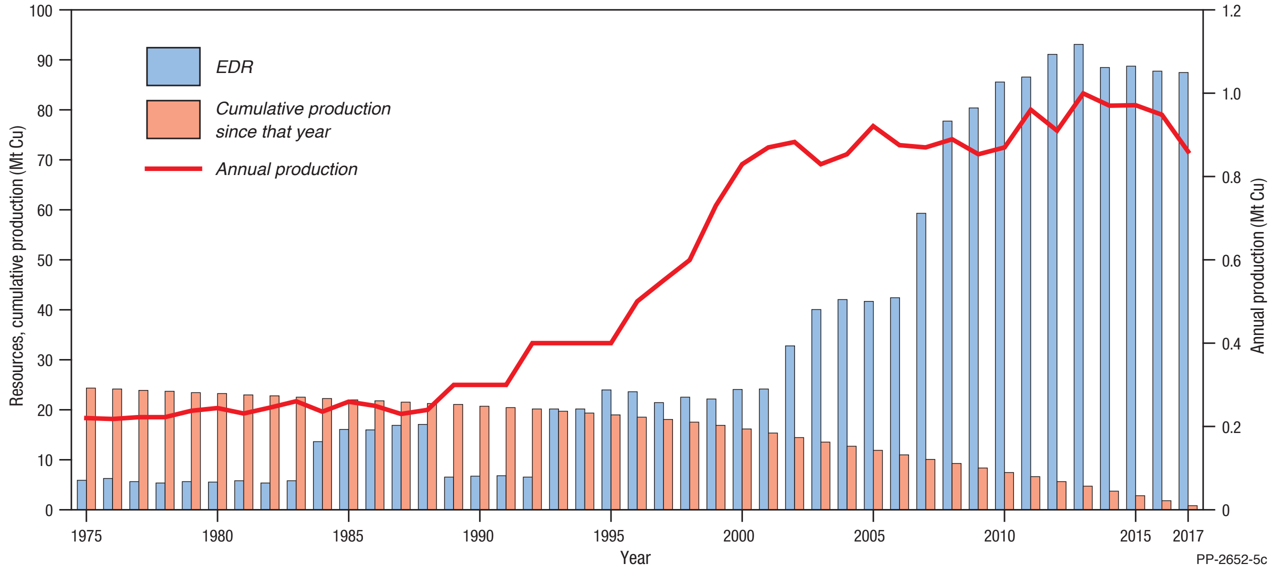


Figure 29 Economic Demonstrated Resources (EDR), annual production and cumulative production of copper, 2002–2017.

Notes: Cumulative production is read as the amount of copper that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of copper that has been produced since 1975 is 24.4 Mt, the amount of copper that has been produced since 1995 is 18.9 Mt. Mt Cu= million tonnes of contained copper.

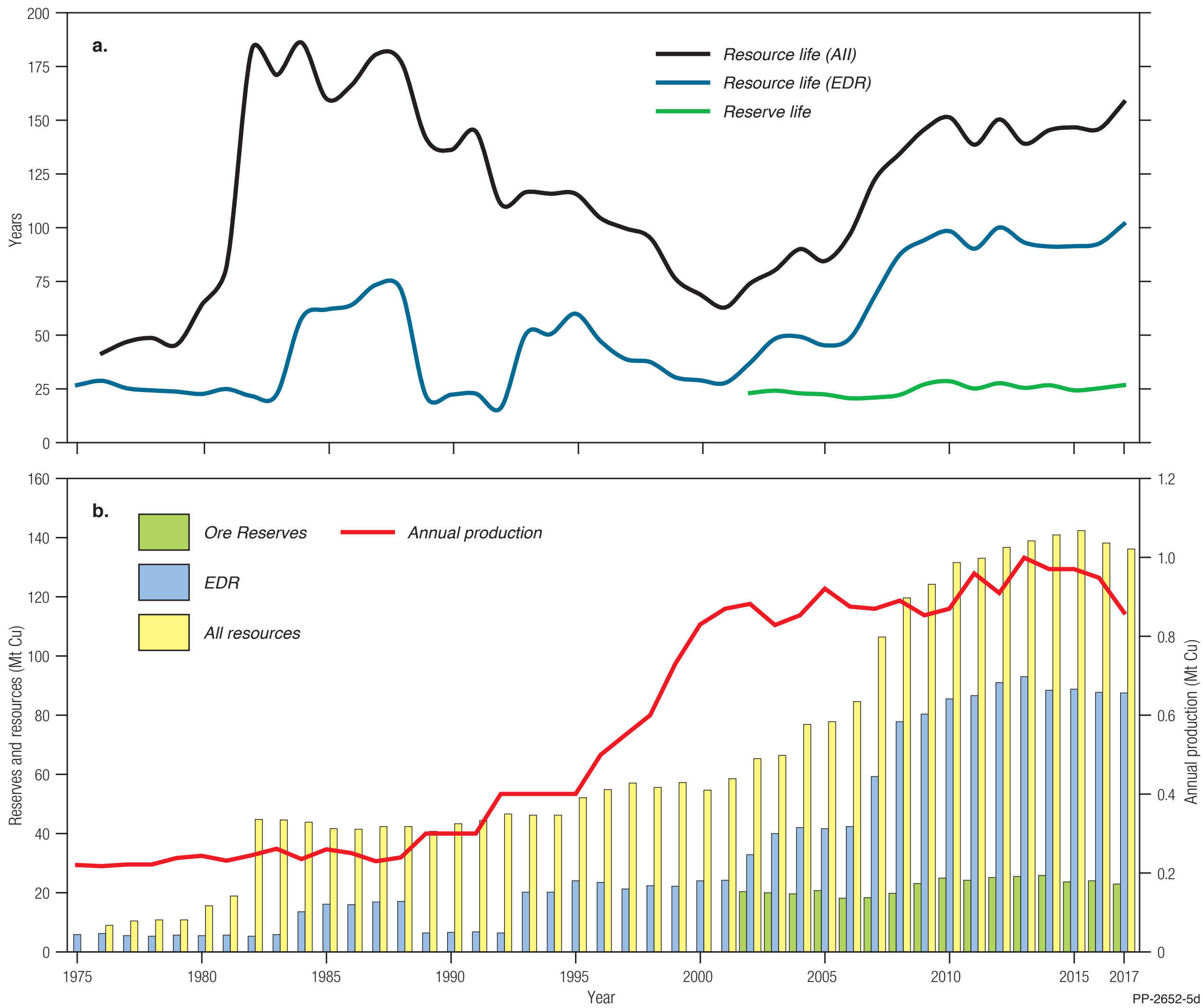


Figure 30 Trends in (a) copper reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. Mt Cu= million tonnes of contained copper.

Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

At 2017 rates of copper production, average reserve life at operating mines is potentially 23 years and demonstrated resource life (Measured and Indicated Resources only) could be 82 years (Table 19). If Ore Reserves at mines on care and maintenance, developing mines and undeveloped deposits are also considered, the reserve life of copper is potentially 27 years and if AEDR is used as an indication of long-term potential supply, then at 2017 rates of production, Australia's copper resources could last more than 100 years. Thus, at current rates of production, and even if production rates increase in the future, Australia has the potential to produce copper for many decades to come.

Spending on copper exploration in 2017 was $155 million, a 15% increase on 2016 ($136 million), with increases in exploration expenditure for copper occurring over the last two years but still not reaching the levels seen in 2012 ($414 million). Exploration activity in 2017 included drilling at Deflector (Doray Minerals Ltd) and Whundo (Artemis Resources) in Western Australia, and at Wirlong (Peel Mining Ltd) in New South Wales. New resource estimates were released for Tritton (Aeris Resources Ltd) and Cadia (Newcrest Mining Ltd) in New South Wales, as well as Kanmantoo (Hillgrove Resources Ltd) and Prominent Hill (Oz Minerals Ltd) in South Australia.

Table 19 Average reserve life and resource life (years) for copper as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
23	82	117	27	100	160

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. All copper EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

URANIUM

Australia's EDR of uranium (equivalent to Reasonably Assured Resources that can be produced at costs of less than US$130/kg U) were estimated to be 1290 kt at December 2017 (Table 3), similar to the previous year's estimate of 1270 kt (Table 4). Australia's EDR of uranium is the world's largest, accounting for 29% of the global estimate (Table 8) followed by Kazakhstan (13%), Canada (9%), Russia (9%) and South Africa (6%).

Australia has large Ore Reserves of uranium amounting to 285 kt (Table 2) in 2017 of which 271 kt (95%) is attributable to three operating mines (Table 1). These mines, Olympic Dam and Four Mile in South Australia and Ranger in the Northern Territory, produced 5.344 kt U (6.302 kt U_3O_8) in 2017, a 15% decrease on that reported in 2016 (6.314 kt U). In addition, Australia has an estimated 840 kt of Inferred Resources of uranium and another 34 kt regarded as subeconomic (Table 3).

Ore Reserves and production of uranium have gradually decreased over the last 15 years, despite a number of rises and falls during this period (Figure 31). Ore Reserves of uranium have fallen 14% since the Australian Government began recording these estimates in 2002 and are down 13.3% since 2016 (Table 20). They are, however, 25% higher than they were a decade ago (Table 20). Production in recent years has also fallen, down 15.4% since 2016 and down 38% since 2007 (Table 20).

When EDR, rather than just Ore Reserves, are considered, the vast inventory of uranium in Australia becomes apparent (Figure 32). Even over the longer time period of more than 40 years, cumulative production has mined out only 86% of the 243 kt of resources assessed as economic in 1975—EDR that was estimated before the first resource assessments were released for Olympic Dam, the largest known uranium deposit in the world.

The majority of Australia's uranium deposits were discovered from 1969 to 1975 when approximately 50 deposits, including 15 with significant resource estimates, were found. Since 1975, only five additional deposits have been discovered and, of these, only three (Kintyre in the Paterson Province of Western Australia, Junnagunna in Queensland and Four Mile in South Australia) have EDR.

Table 20 Changes in uranium production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Uranium	Change since 2016	Change since 2007	Change since start of records
Annual Production	-15.4%	-38%	1389% (1976)
Ore Reserves	-13.3%	25%	-14% (2002)
EDR	1.6%	31%	431% (1975)
All Resources	-2.4%	34%	675% (1976)

Abbreviation: EDR = Economic Demonstrated Resources.

Notes: All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources.

Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

EDR from 2009 onward is equivalent to Reasonably Assured Resources recoverable at costs of less than US$130/kg U. Prior to 2009, EDR is equivalent to Reasonably Assured Resources recoverable at costs of less than US$80/kg U.

As a result, the progressive increases in Australia's EDR for uranium from 1975 to the present (Figure 32 and Figure 33) are largely because of the ongoing 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 in Figure 32 and Figure 33 occurred:

- In 1983, when initial resource estimates for Olympic Dam and Ranger No. 3 Orebody were made by the former Australian Atomic Energy Commission.
- In 1993, when further increases in EDR for Olympic Dam and the first assessment of resources for the Kintyre deposit were made by Geoscience Australia's predecessor, the Bureau of Mineral Resources.
- In 2000, when increases were due to continuing additions to the Olympic Dam resources.
- And from 2007 to 2009 when a significant increase in EDR for Olympic Dam was made after drilling outlined major extensions to the southeast part of the deposit.

From 2010 to 2014, higher costs of mining and milling uranium ores resulted in generally decreasing EDR (Figure 32 and Figure 33). In addition, prior to 2009, Reasonably Assured Resources in the cost category of less than US$80/kg U were considered to be economic. From 2009, in response to changes in uranium prices and costs increases, the definition of economic resources was adjusted to include resources within the cost category of less than US$130/kg U.

Resource life is a snapshot in time derived by taking a reserve or resource number and dividing it by a production number. After the flurry of discoveries in the 1970s, resource life (EDR) for uranium was more than 800 years in 1977 but this declined rapidly to around 100 years after uranium production increased in the 1980s (Figure 33). Resource life again ticked up in the early 1990s when the Kintyre and Olympic Dam resources were further delineated, and then decreased when production again rapidly increased from 1995. Since the turn of this century, resource life has again been increasing owing to a gradual increase in resources and a concurrent decline in production (Figure 33).

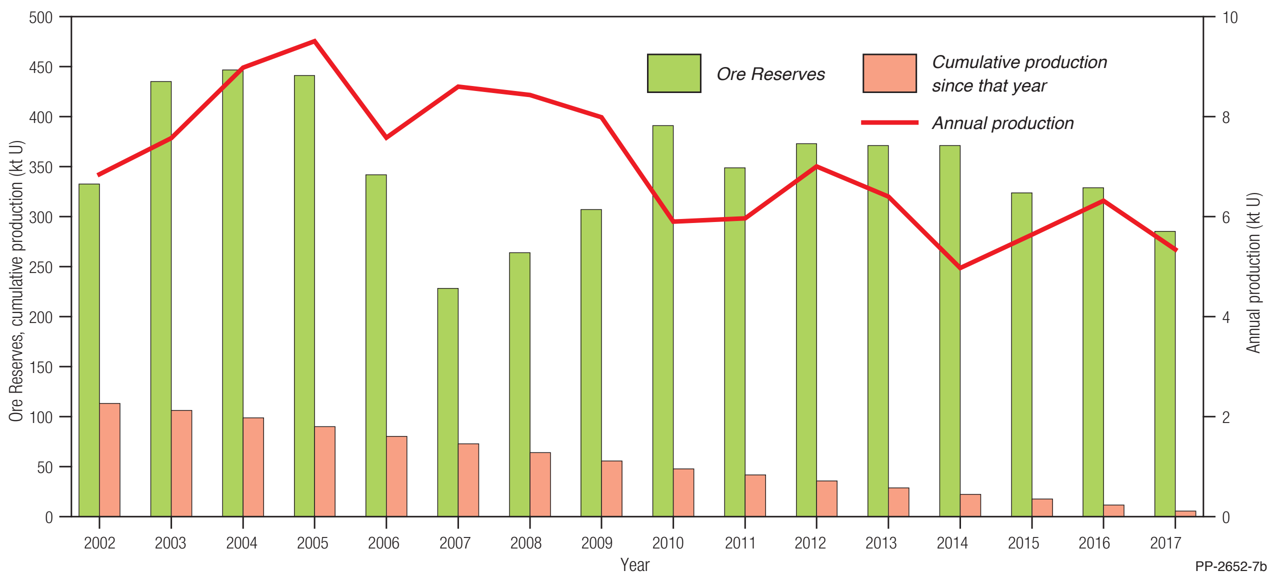


Figure 31 Uranium Ore Reserves, annual production and cumulative production 2002–2017.

Notes: Cumulative production is read as the amount of uranium that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of uranium that has been produced since 2002 is 113 kt, the amount of uranium that has been produced since 2010 is 48 kt. kt U = thousand tonnes of contained uranium.

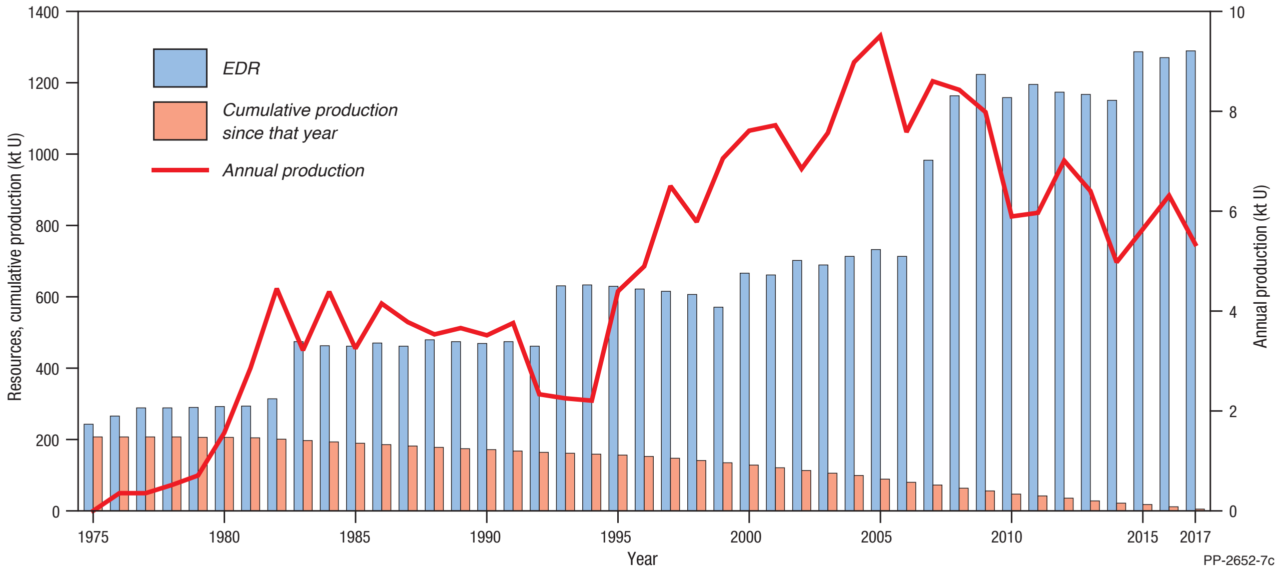


Figure 32 Economic Demonstrated Resources (EDR), annual production and cumulative production of uranium, 2002–2017.

Notes: Cumulative production is read as the amount of uranium that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of uranium that has been produced since 1975 is 208 kt, the amount of uranium that has been produced since 1995 is 157 kt. kt U = thousand tonnes of contained uranium. EDR from 2009 onward is equivalent to Reasonably Assured Resources recoverable at costs of less than US$130/kg U. Prior to 2009, EDR is equivalent to Reasonably Assured Resources recoverable at costs of less than US$80/kg U.

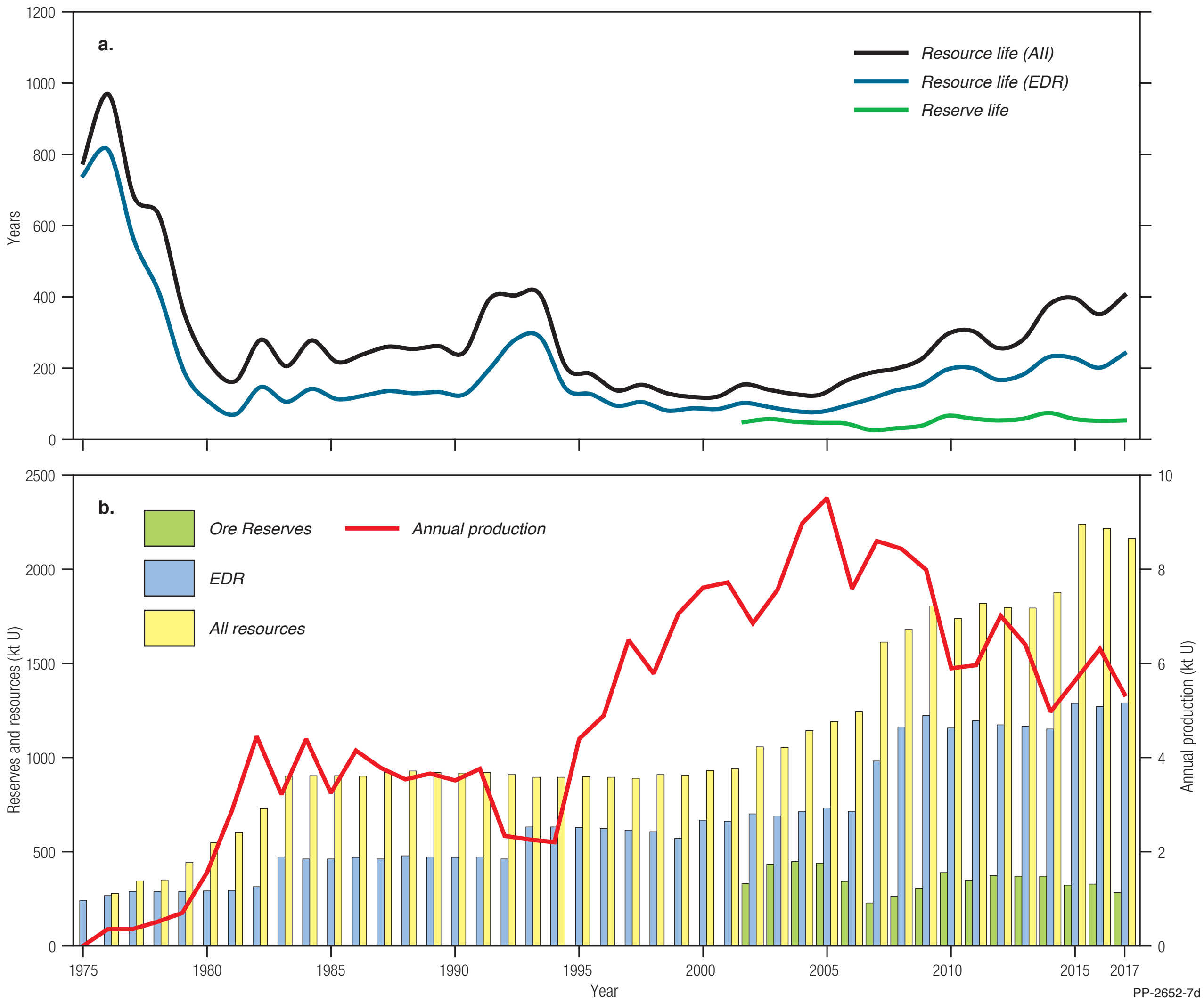


Figure 33 Trends in (a) uranium reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. kt = thousand tonnes of contained uranium.

Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

EDR from 2009 onward is equivalent to Reasonably Assured Resources recoverable at costs of less than US$130/kg U. Prior to 2009, EDR is equivalent to Reasonably Assured Resources recoverable at costs of less than US$80/kg U.

At 2017 uranium production rates, the average reserve life at operating mines is potentially 51 years and when all deposits are included, reserve life is 53 years (Table 21). Resource life (all categories) shows that at 2017 rates of production, and even if production rates increased in the future, Australia has the potential to remain a top global producer of uranium for the next century or more.

Australian exports of uranium (7.414 kt U_3O_8) in 2017 had a value of $594 million, down from $731 million in 2016. This is also down from previous years as market prices for uranium progressively decreased from 2011 to 2014. After a slight uptick in 2015, prices fell further in 2016, but may have stabilised, with industry sentiment suggesting that this may be the bottom of the market. From 2011 to 2017, spot prices remained below the level required to stimulate exploration with exploration expenditure for uranium in 2017 totalling $19.8 million, down 91% from the relative high of 2008 ($221 million).

The uranium spot market, however, only provides a short-term indicator of the outlook for uranium as this market is predicated on long lead times and significant infrastructure development costs for plant construction. As a result, uranium buyers and sellers generally negotiate private contracts. A number of companies in Australia are working through regulatory development and approvals processes and are upgrading their mineral resource assessments in anticipation of improving market conditions. In June 2017, the incoming Western Australian government announced a ban on uranium mining, with the caveat that those projects already approved—Mulga Rock, Wiluna, Yeelirrie and Kintyre—would be able to proceed with development. Uranium mining remains banned in Queensland and New South Wales, limiting the potential for new discoveries and future growth of Australian resources.

Table 21 Average reserve life and resource life (years) for uranium as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
51	284	488	53	230	405

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

The resource life of operating mines appears to be larger than resource life of all deposits. This is because the resource/production ratio for operating mines is based on industry-reported Measured, Indicated and Inferred Resources whereas the Geoscience Australia estimates of EDR and AEDR have had recovery factors applied.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources, 95% of uranium EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

NICKEL

Australia's EDR of nickel in 2017 was 19.7 Mt (Table 3) up from the 2016 estimate of 18.5 Mt (Table 4). Western Australia holds the bulk (95%) of the national total of EDR with the remainder occurring in Queensland and New South Wales (Figure 14). Australia has the world's largest economic nickel resources with 26% of known economic resources (Table 8), followed by Brazil (16%) and Russia (10%). Australia is the world's sixth largest nickel producer (Table 8) with all 0.179 Mt of Australian nickel production occurring in Western Australia. Ten mines produced nickel in 2017 (Table 1) with the most significant producers being Mount Keith, Murrin Murrin, the Forrestania mines, Leinster and Nova-Bollinger. These mines also produced 5.8 kt of cobalt as a by-product of nickel production in 2017 (Table 3).

In addition to mining, downstream processing of nickel continues in Australia. The Kalgoorlie smelter, part of BHP Ltd's Nickel West operation, is one of the largest nickel matte producers in the world (with a capacity of 110 kt per annum), receiving concentrates from the Cliffs, Mount Keith and Leinster mines and the Kambalda concentrator. The smelter also produces some 550 kt of sulphuric acid each year. The Kalgoorlie smelter is connected to the Kwinana Nickel refinery via rail. Kwinana Nickel is one of the largest producers of finished nickel in the world (capacity of 65 kt per annum) and also produces mixed nickel and cobalt sulphide, copper sulphide and ammonium sulphate. Glencore plc's Murrin Murrin refinery, 50 km east of Leonora, also produces finished nickel and cobalt briquettes as well as mixed nickel and cobalt sulphide and ammonium sulphate. The Yabulu refinery in Townsville (previously run by Queensland Nickel Pty Ltd) remained on care and maintenance in 2017.

Australia's Ore Reserves of nickel were 5.4 Mt in 2017 (Table 2), down 10.0% from 6.0 Mt in 2016 (Table 22). Of the 2017 Ore Reserves, 5.1 Mt (94%) is attributable to the ten operating mines (Table 1). These mines produced 0.179 Mt of nickel in 2017 (Table 1), down 12.3% from 0.204 Mt in 2016 (Table 22). The USGS notes that production also fell in Brazil, Canada and the Philippines. However, world production in 2017 was only slightly lower overall after these losses were offset by increased production from Indonesia which partially relaxed its ban on direct-shipping ore.

Over the last ten years, Ore Reserves of nickel have decreased 18% and nickel production has decreased 3% (Table 22). During this time, the lowest nickel production (0.165 Mt) occurred in 2009 following the global financial crisis (Figure 34). From this low, nickel bounced back quickly and record production was achieved in 2012 (0.244 Mt) and again in 2014 (0.246 Mt; Figure 34 and Figure 35).

Taking a longer term view, over the last 40+ years, both nickel production and EDR have risen significantly, particularly from the mid-1990s (Figure 35). Geoscience Australia's time series shows that since 1975 nickel production has increased 136% and nickel EDR is up 916% (Table 22). The rise in Australia's EDR of nickel has, however, not been uniform over these 40+ years (Figure 35).

Between 1995 and 2001, nickel EDR increased by 18.2 Mt. This resulted mainly from progressive increases in resources of lateritic deposits at Bulong, Cawse, Murrin Murrin, Mount Margaret and Ravensthorpe, all in Western Australia, Marlborough in Queensland, and Syerston and Young in New South Wales. Australia's EDR of nickel nearly doubled in 2000 compared to the level at the end of 1999. This dramatic rise was due to large increases in resources at the Mount Margaret and Ravensthorpe deposits, and other lateritic deposits in the Kalgoorlie region of Western Australia. In addition, during the period 1995 to 2001, there were increases in Western Australian sulphide resources at Yakabindie and the discoveries of the Silver Swan and Cosmos high-grade sulphide deposits.

From 2001 onwards, sharp rises in the nickel price led to increased expenditure on exploration and evaluation drilling at many known deposits. This contributed to further increases in total EDR for sulphide deposits at Perseverance, Savannah, Maggie Hays, Anomaly 1, Honeymoon Well and deposits in the Forrestania area, as well as new deposits at Prospero and Tapinos in Western Australia, Avebury in Tasmania and remnant resources at several sulphide deposits in the Kambalda region including the Otter-Juan and Lanfranchi groups of deposits. The increase in EDR from 2001 to 2008 was, however, at a slower rate than prior to 2001 (Figure 35). This was mainly because of the absence of further discoveries of lateritic nickel deposits and as a result of increases in resources for some deposits being offset by companies reclassifying their lateritic nickel resources to lower resource categories pending more detailed drilling and resource assessments. Decreases in nickel EDR from 2009 onwards reflect reclassification of nickel resources in response to sharp falls in nickel prices following the 2007–08 global financial crisis followed by only partial recovery in prices from 2009 onwards.

The rapid delineation of nickel resources that began during the 1990s is echoed by the cumulative production data (Figure 34 and Figure 35). Cumulative production of nickel over the last 16 years (3.206 Mt) accounts for just 14% of the nickel Ore Reserve from 2002 (22.2 Mt; Figure 34) but a longer time series (Figure 35) shows that cumulative production has exceeded EDR every year from 1975 to 1995. This indicates a disparity between the period of successful exploration drilling and resource delineation that occurred from the mid-1990s to the global financial crisis of 2007–08 and the subsequent lack of funding for developing these new nickel resources and increasing production from 2009 onwards.

Table 22 Changes in nickel production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Nickel	Change since 2016	Change since 2007	Change since start of records
Annual Production	-12.3%	-3%	136% (1975)
Ore Reserves	-10.0%	-18%	-42% (2002)
EDR	4.3%	-25%	916% (1975)
All Resources	-6.7%	-15%	477% (1976)

Abbreviations: EDR = Economic Demonstrated Resources.

Notes: All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources.

Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

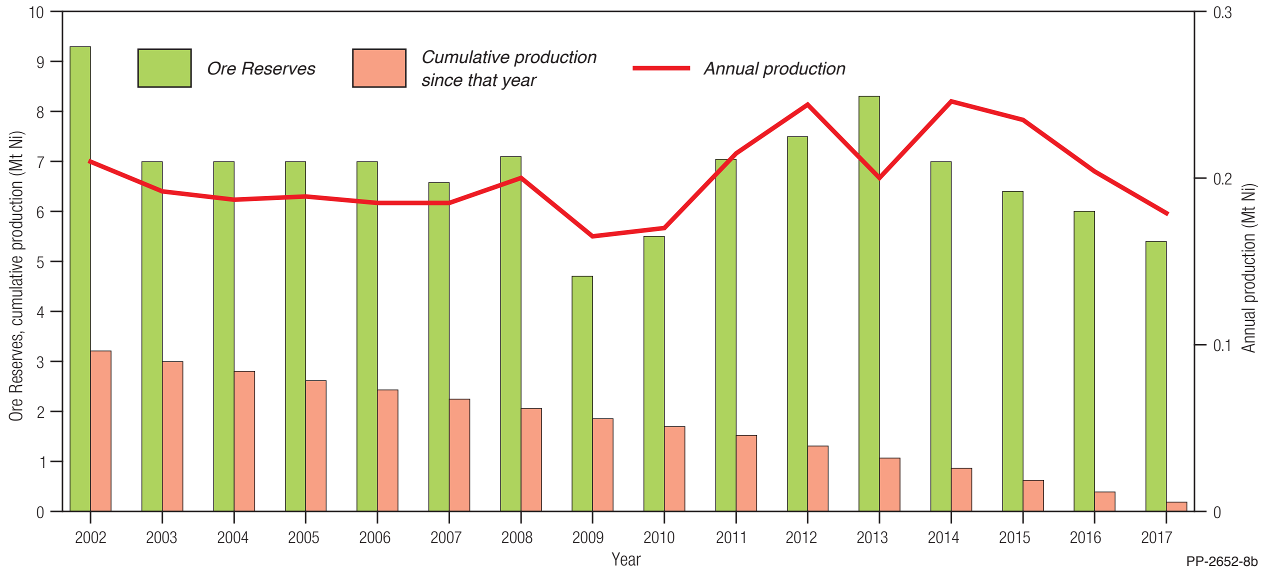


Figure 34 **Nickel Ore Reserves, annual production and cumulative production 2002–2017.**

Notes: Cumulative production is read as the amount of nickel that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of nickel that has been produced since 2002 is 3.2 Mt, the amount of nickel that has been produced since 2010 is 1.7 Mt. Mt Ni = million tonnes contained nickel.

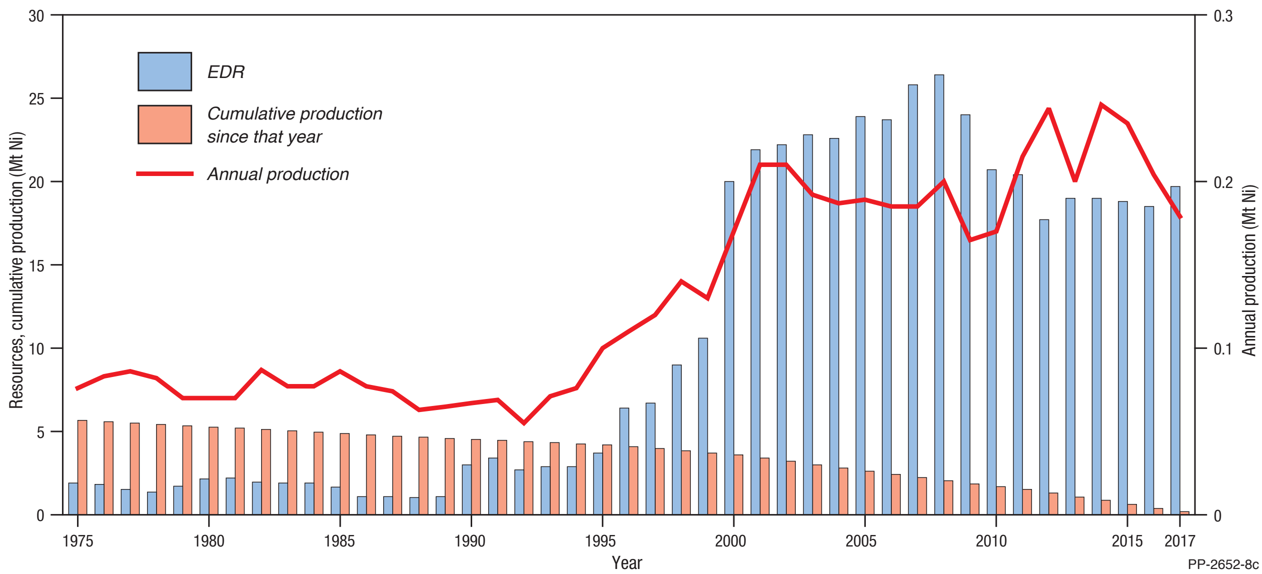


Figure 35 **Economic Demonstrated Resources (EDR), annual production and cumulative production of nickel, 2002–2017.**

Notes: Cumulative production is read as the amount of nickel that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of nickel that has been produced since 1975 is 5.7 Mt, the amount of nickel that has been produced since 1995 is 4.2 Mt. Mt Ni = million tonnes contained nickel.

Declining stockpiles on the London Metals Exchange and the subsequent 28% increase in nickel prices over 2017 resulted in renewed interest in the sector. Spending on nickel (and cobalt) exploration in 2017 was $139 million, up 170% on the previous year ($52 million) but still well down from peak expenditure of $324 million in 2008. Recent nickel exploration includes drilling at Coronation Dam (White Cliff Minerals Ltd), Collerina (Helix Resources Ltd), Collurabbie Hills (Rox Resources Ltd), Mount Alexander (St George Mining Ltd), Girilambone (Alchemy Resources Ltd), Homeville (Collerina Cobalt Ltd), Mount Edwards (Neometals Ltd), Quicksilver (Golden Mile Resources Ltd), Radio Hill (Artemis Resources Ltd), SCONI (Australian Mines Ltd) and West Musgrave (Cassini Resources Ltd).

In 2017, exports of nickel ore and concentrates (0.172 Mt) and intermediate and refined nickel (0.173 Mt) had a combined export value of $2445 million, slightly up from $2298 million in 2016 owing to improved nickel prices, despite lower production.

Resource life is a snapshot in time derived by taking a reserve or resource number and dividing it by a production number. This ratio for nickel shows that reserve life has been in general decline since 2002 because companies have been replacing Ore Reserves at a slower rate than production has been depleting them (Figure 36). Resource life for nickel gradually rose from 1990 to 2009 because companies delineated new resources faster than they increased production (Figure 36). Since the 2009 peak, resource life has declined but has begun to increase again in recent years owing to falling production (Figure 36).

At 2017 rates of nickel production, the average reserve life at operating mines is ten years and demonstrated resource life (Measured and Indicated categories) is 29 years (Table 23). If Ore Reserves at mines on care and maintenance, developing mines and undeveloped deposits are also considered, the average reserve life of nickel is potentially 30 years and if AEDR is used as an indication of long-term potential supply, then Australia's nickel resources could last 110 years at 2017 rates of production (Table 23). When Inferred Resources are also included in the calculations, then the resource/production ratio at operating mines in 35 years and for all deposits it is 240 years (Table 23). Thus, at 2017 rates of production, and even with increased rates of production, Australia has the potential to produce nickel for many decades into the future.

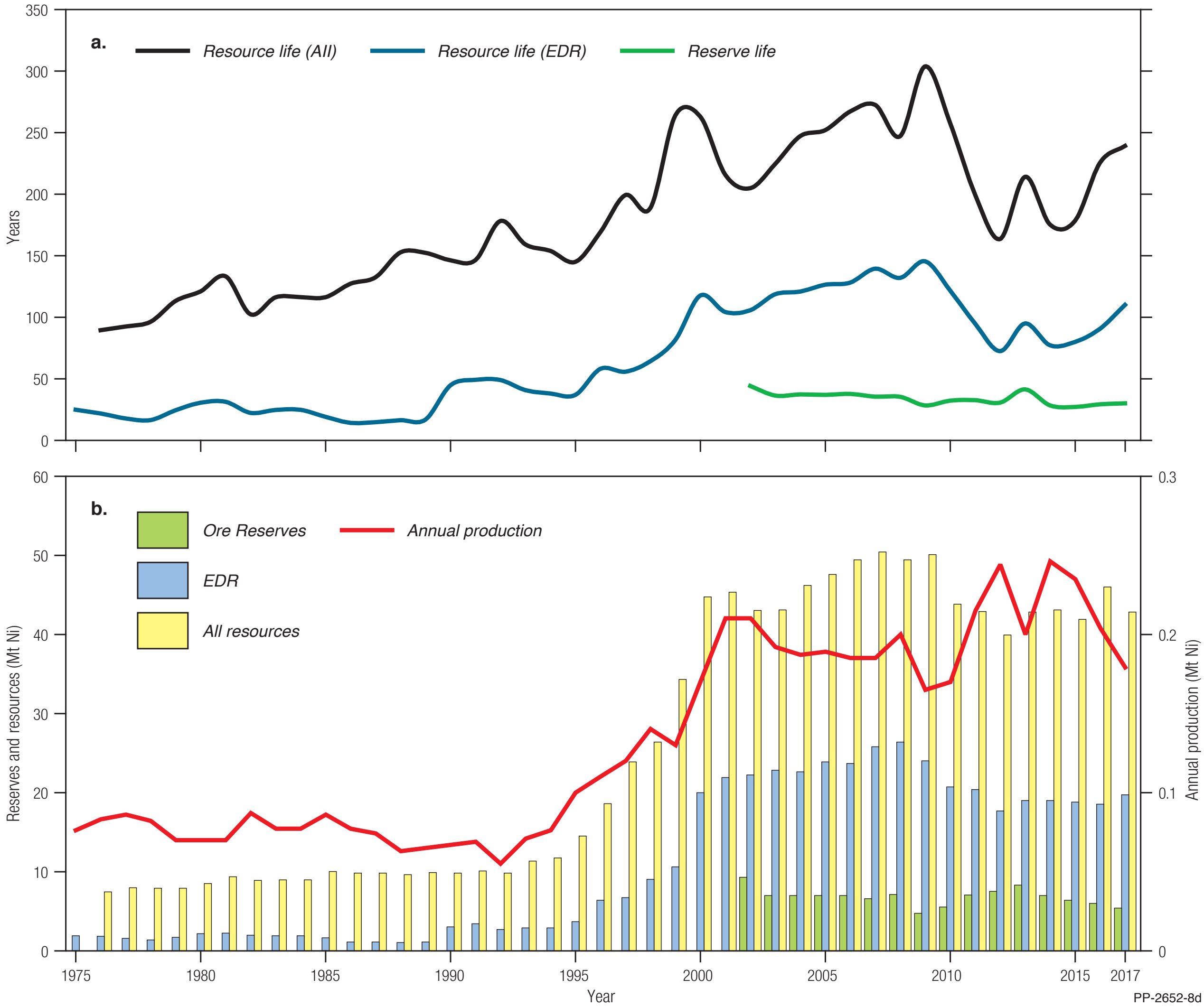


Figure 36 Trends in (a) nickel reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. Mt Ni= million tonnes of contained nickel.

Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

Table 23 Average reserve life and resource life (years) for nickel as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
10	29	35	30	110	240

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. All nickel EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

LEAD, ZINC AND SILVER

Lead and zinc typically occur together in many mineral deposits because they have very similar geochemical behaviours in hydrothermal fluids. Silver also commonly occurs with zinc and lead for similar reasons, and it also frequently occurs as a trace element in galena, the main ore mineral for lead, or in tetrahedrite, which is commonly associated with galena and sphalerite.

In 2017, Australia's EDR of lead increased 4% to 36.42 Mt from 35.09 Mt in 2016 (Table 4). Zinc also increased slightly in 2017 to 67.52 Mt up from 63.50 Mt in 2016, and silver increased to 90.31 kt from 89.29 kt in 2016 (Table 4). Queensland has the dominant share of lead, zinc and silver in Australia with 61% of the EDR of lead, 60% of the EDR for zinc and 58% of the EDR for silver (Figure 14), mainly in the Mount Isa region. The Northern Territory also has substantial resources with 24% of the national total of EDR for lead, 27% for zinc and 10% for silver (Figure 14), most of which are at the McArthur River mine.

Globally, Australia is a major producer of lead and zinc, ranking number 2 and number 5, respectively (Table 8). Australia produced 4% of the world's silver in 2017, ranking number 6 (Table 8). In addition to mining activities, Australia also produces lead bullion at Mount Isa (Queensland), smelts and refines these metals at Port Pirie in South Australia, and produces zinc metal at Risdon in Tasmania (one of the world's largest zinc refineries). Australia's economic resources of both lead and zinc are the world's largest (41% and 28% of the global resource respectively), while Australia has the second largest economic resource of silver (17%; Table 8), almost level with Peru. Other significant holders of lead and silver resources are China, Russia, Peru and Mexico, with China, Peru and Mexico also noted for their zinc resources.

Australia has large Ore Reserves of lead, zinc and silver (Table 2). Lead Ore Reserves in 2017 amounted to 11.60 Mt of which 9.95 Mt (86%) is attributable to 12 operating mines (Table 1). Zinc Reserves in 2017 amounted to 25.30 Mt of which 18.54 Mt (73%) is attributable to 12 operating mines (Table 1). Eleven mines produced both lead and zinc with Peak (New South Wales) the twelfth lead mine and Bentley (Western Australia) the twelfth zinc mine. Silver Ore Reserves in 2017 are estimated at 24.82 kt (Table 2) of which 19.25 kt is associated with 21 operating mines for which silver is a primary product or co-product. There are more silver mines than lead-zinc mines because silver is associated with other mineral commodities, notably gold. In addition, minor amounts of silver are produced as a by-product at many Australian gold and copper mines, but these are not included in the mine count.

Australian mines produced 0.459 Mt of lead and 0.841 Mt of zinc in 2017 (Table 1), which is similar to 2016 production, but significantly down from 2015 levels and, indeed, to production a decade ago (Figure 37 and Figure 38). This reduction in Australian lead and zinc production is a result of Glencore plc's decision to decrease production from its deposits in northwest Queensland and the Northern Territory.

Exports of lead concentrates (155 kt), lead bullion (127 kt) and refined lead (219 kt) had a value of $1597 million in 2017, down from $1623 million in 2016, which was also down from $1970 million in 2015. Conversely, the value of exports of zinc concentrates (1551 kt) and refined zinc (435 kt) in 2017 was up with a total value of $3431 million in 2017 compared to $2275 million in 2016 and $3061 million in 2015. The significant increase in zinc export income can be largely attributed to a 10% increase in exports of the more valuable refined zinc. In 2017, exports of refined silver (513 t) were valued at $369 million, significantly up from 2016 levels (36 t valued at $35 million).

Exploration expenditure on zinc, lead and silver in 2017 was $86.2 million, up 85.6% from $46.5 million in 2016. This is a return to 2011 and 2012 mining boom expenditure levels ($82.7 million and $83.3 million, respectively), but is much lower than expenditure in 2007 ($187.4 million).

Ore Reserves of lead increased from 2002 to 2012 but have since declined (Figure 37). Zinc Ore Reserves were reasonably constant from 2002 to 2011 but sharply increased in 2012. Like lead, they have since decreased (Figure 38). Ore Reserves of silver also peaked in 2012 and have also fallen since (Figure 39). In recent years, production of all three commodities has also decreased (Figure 37, Figure 38 and Figure 39).

Despite falling production, cumulative production of lead since 2002 (10.3 Mt) accounts for 99% of the Ore Reserves delineated that year (10.4 Mt, Figure 37). Similarly, the cumulative production of zinc since 2002 (21.7 Mt) is equal to 91% of the 2002 Ore Reserve (23.8 Mt, Figure 38) and the cumulative production of silver since 2002 (28.6 Mt) is also 99% of the Ore Reserve estimated that year (28.9 Mt; Figure 39).

Figure 40, Figure 41 and Figure 42 demonstrate the large Australian inventory of lead, zinc and silver. Since 1975, cumulative production of lead (23.9 Mt), zinc (44.1 Mt) and silver (56.9 kt) have exceeded the 13.9 Mt of lead resources, the 19.3 Mt of zinc resources and the 24.3 kt of silver resources assessed as economic in that year. Indeed, cumulative production of lead and zinc has exceeded estimates of EDR for every year from 1975 to 1992, and cumulative production of silver has exceeded estimates of EDR for every year from 1975 to 1993.

Gains in EDR for lead, zinc and silver since 1975 have been irregular (Figure 40, Figure 41 and Figure 42). 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 reassessments of resource data for other deposits by Geoscience Australia's predecessor, the Bureau of Mineral Resources. This resulted in a fall in Australia's lead, zinc and silver EDR in 1989. Increases in EDR for lead, zinc and silver in 1993 resulted from the reclassification of paramarginal demonstrated resources into EDR for the McArthur River deposit in the Northern Territory and the George Fisher deposit in Queensland. Additional resources were also reported for the Century and Cannington deposits in Queensland. Increases in EDR in 2008 and 2009 were associated with the reassessment of resources at the McArthur River mine and the Dugald River deposit, as well as the reporting of additional resources for the George Fisher deposit.

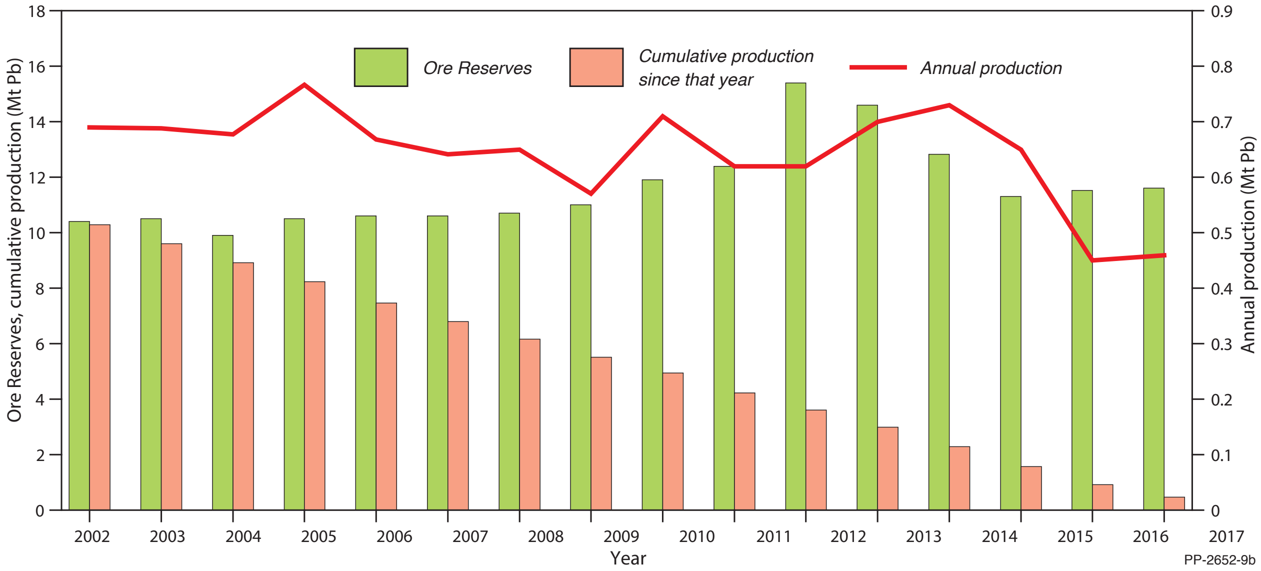


Figure 37 Lead Ore Reserves, annual production and cumulative production 2002–2017.

Notes: Cumulative production is read as the amount of lead that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of lead that has been produced since 2002 is 10.3 Mt, the amount of lead that has been produced since 2010 is 4.9 Mt. Mt Pb = million tonnes of contained lead.

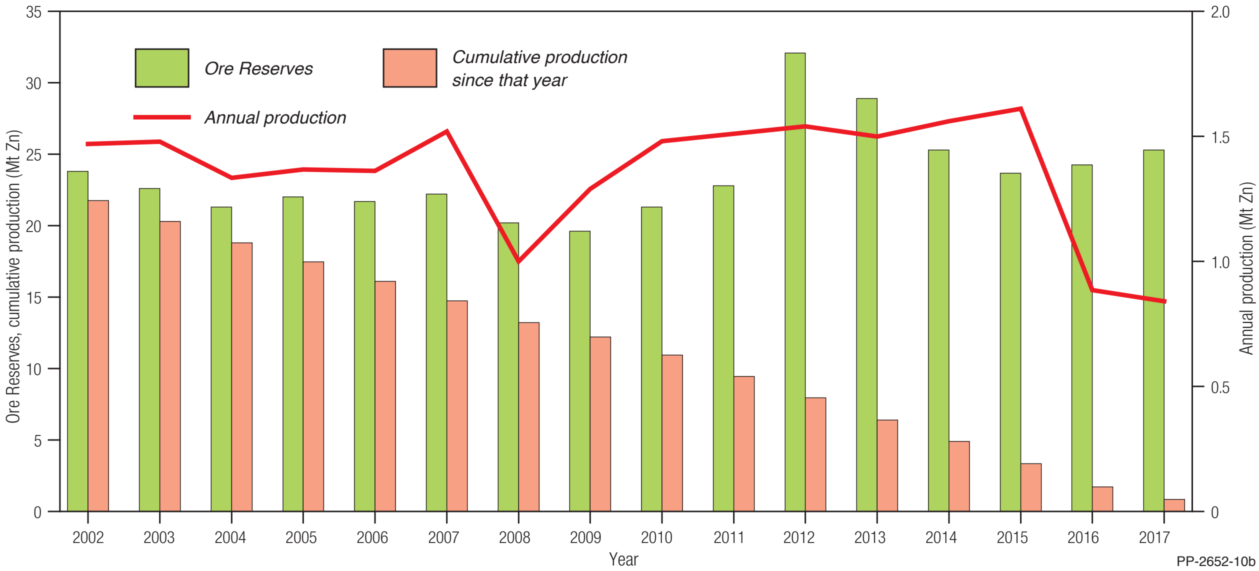


Figure 38 Zinc Ore Reserves, annual production and cumulative production 2002–2017.

Notes: Cumulative production is read as the amount of zinc that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of zinc that has been produced since 2002 is 21.7 Mt, the amount of zinc that has been produced since 2010 is 10.9 Mt. Mt Zn = million tonnes of contained zinc.

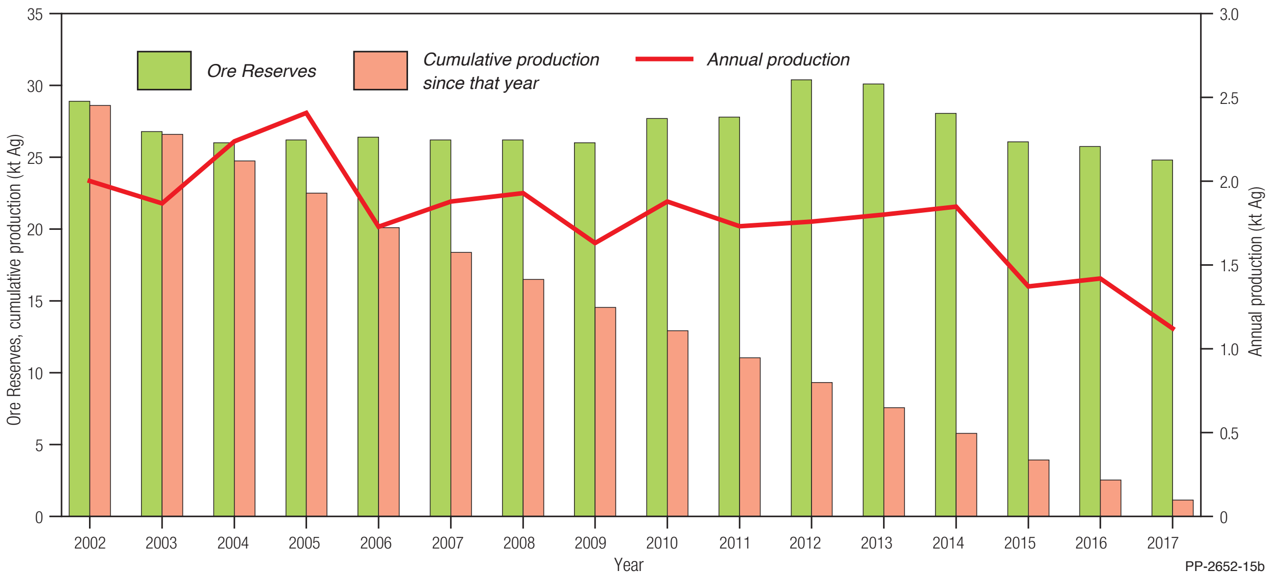


Figure 39 Silver Ore Reserves, annual production and cumulative production 2002–2017.

Notes: Cumulative production is read as the amount of silver that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of silver that has been produced since 2002 is 28.6 kt, the amount of silver that has been produced since 2010 is 12.9 kt. kt Ag = thousand tonnes of contained silver.

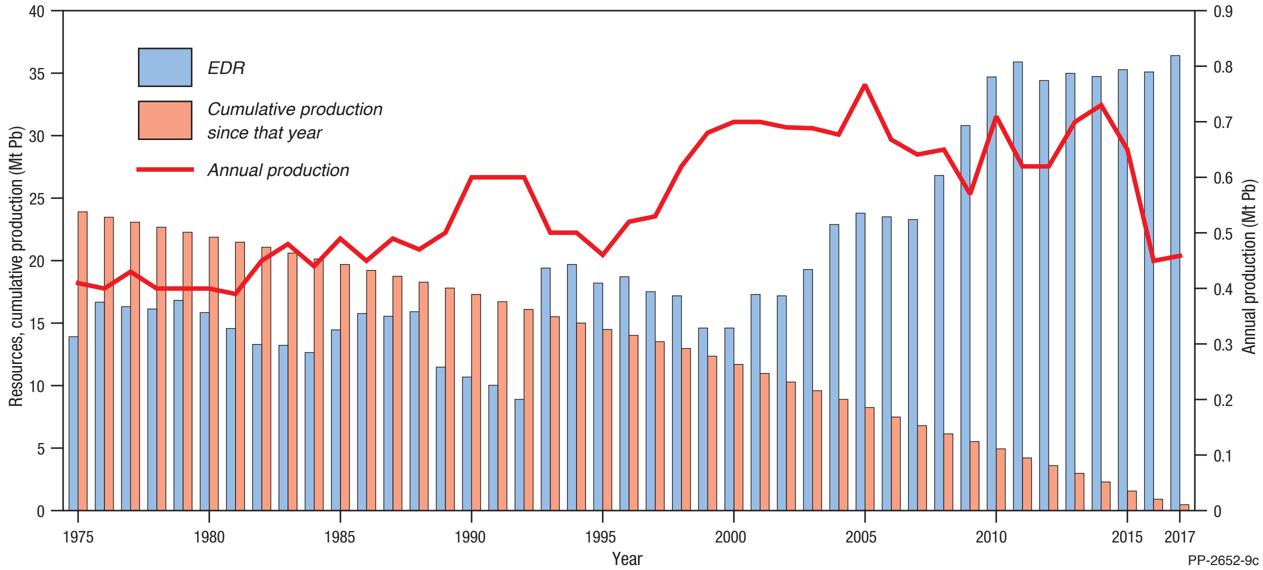


Figure 40 **Economic Demonstrated Resources (EDR), annual production and cumulative production of lead, 2002–2017.**

Notes: Cumulative production is read as the amount of lead that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of lead that has been produced since 1975 is 23.9 Mt, the amount of lead that has been produced since 1995 is 14.5 Mt. Mt Pb = million tonnes of contained lead.

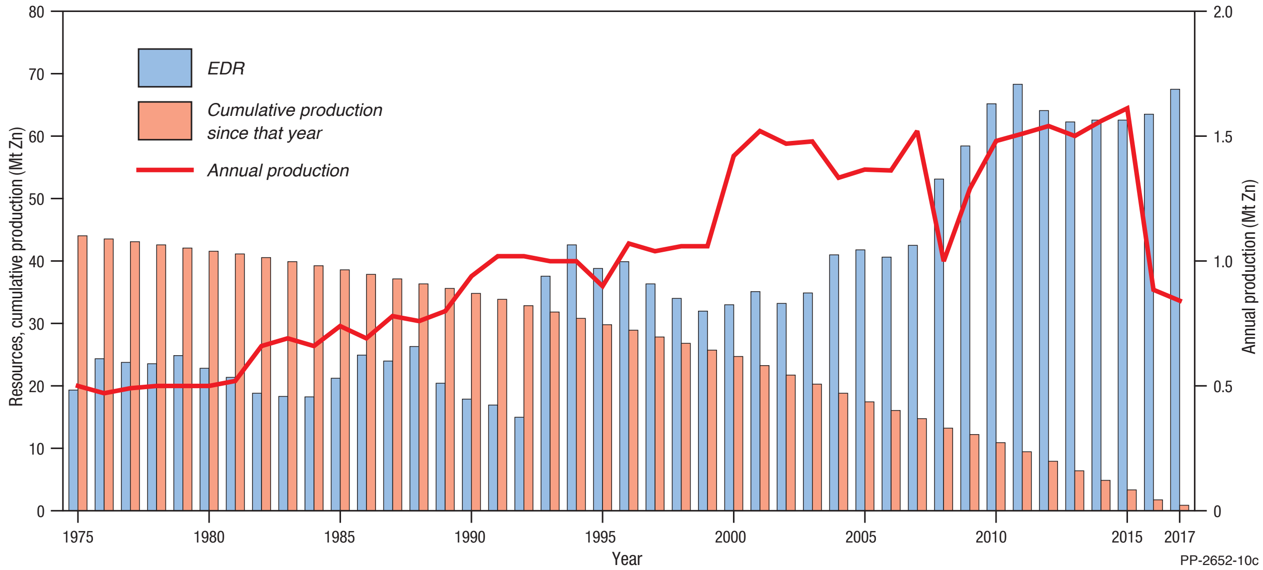


Figure 41 **Economic Demonstrated Resources (EDR), annual production and cumulative production of zinc, 2002–2017.**

Notes: Cumulative production is read as the amount of zinc that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of zinc that has been produced since 1975 is 44.0 Mt, the amount of zinc that has been produced since 1995 is 29.8 Mt. Mt Zn = million tonnes of contained zinc.

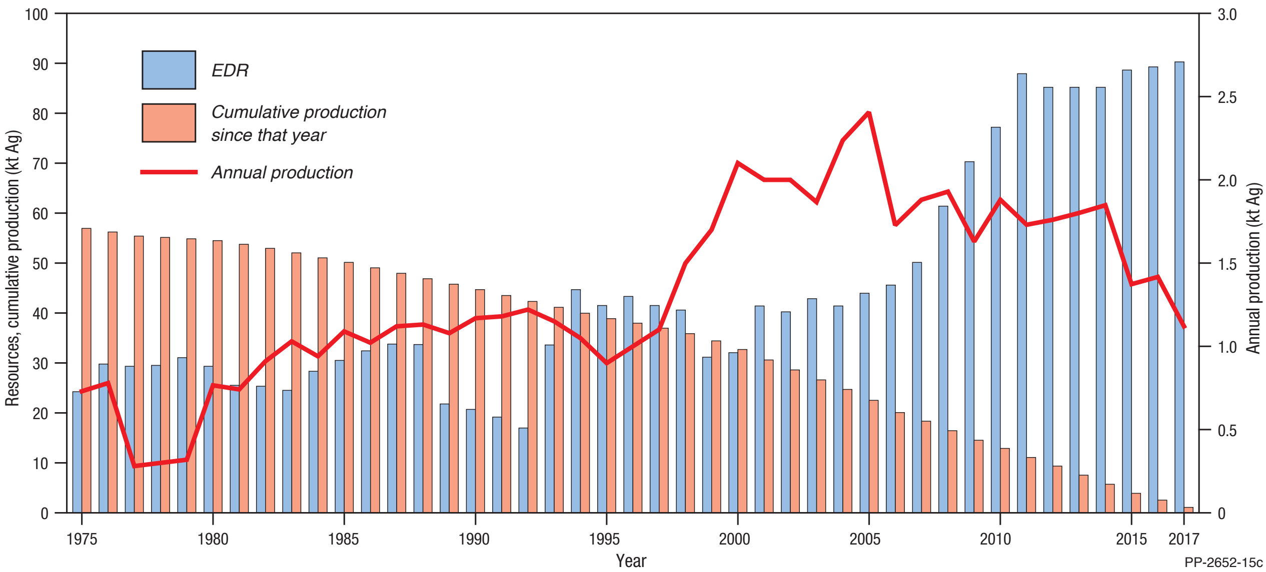


Figure 42 **Economic Demonstrated Resources (EDR), annual production and cumulative production of silver, 2002–2017.**

Notes: Cumulative production is read as the amount of silver that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of silver that has been produced since 1975 is 56.9 kt, the amount of silver that has been produced since 1995 is 38.9 kt. kt Ag = thousand tonnes of contained silver.

Table 24 shows the percentage increases and decreases for all resources, EDR, Ore Reserves and annual production since the previous year, over the last decade and since the start of Geoscience Australia's time series. These tables show that EDR for all three commodities is up over all three time periods. Production however is variable by both commodity and time period. Production of zinc and silver has grown more than 50% since 1975 but lead production is only up 12%. Conversely, over the last decade, all three commodities have seen a decline in production, zinc most significantly by 45%.

Annual production of lead, zinc and silver has been variable since Geoscience Australia's time series began in 1975, resulting in marked swings in the trend of resource life for the three commodities (Figure 43, Figure 44 and Figure 45). Prior to 2008–09, resource life (EDR) for lead and zinc usually ranged from 20 to 40 years and for silver, from 15 to 40 years. Since 2008–09, the trend has been generally up, reflecting falling production of all three minerals (Figure 43, Figure 44 and Figure 45).

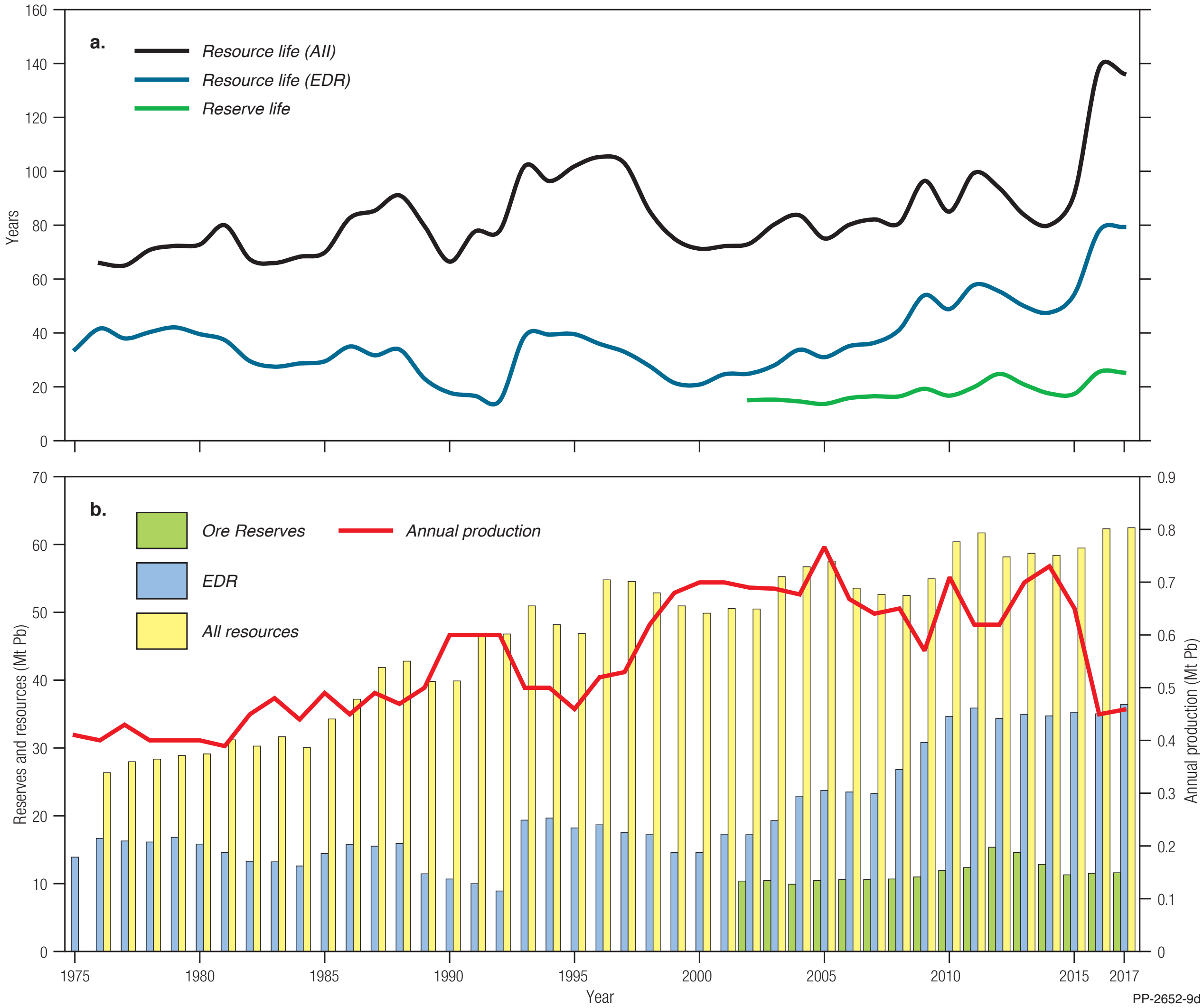


Figure 43 Trends in (a) lead reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. Mt Pb= million tonnes of contained lead.

Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

Table 24 Changes in lead, zinc and silver production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Commodity		Change since 2016	Change since 2007	Change since start of records
Lead	Annual Production	2.0%	-28%	12% (1975)
	Ore Reserves	0.7%	9%	12% (2002)
	EDR	3.8%	56%	162% (1975)
	All Resources	0.4%	19%	137% (1976)
Zinc	Annual Production	-4.9%	-45%	68% (1975)
	Ore Reserves	4.3%	14%	6% (2002)
	EDR	6.3%	59%	250% (1975)
	All Resources	2.1%	22%	129% (1976)
Silver	Annual Production	-21.0%	-40%	53% (1975)
	Ore Reserves	-3.7%	-5%	-14% (2002)
	EDR	1.1%	80%	272% (1975)
	All Resources	-6.9%	22%	230% (1976)

Abbreviations: EDR = Economic Demonstrated Resources.
Notes: All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources.
Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

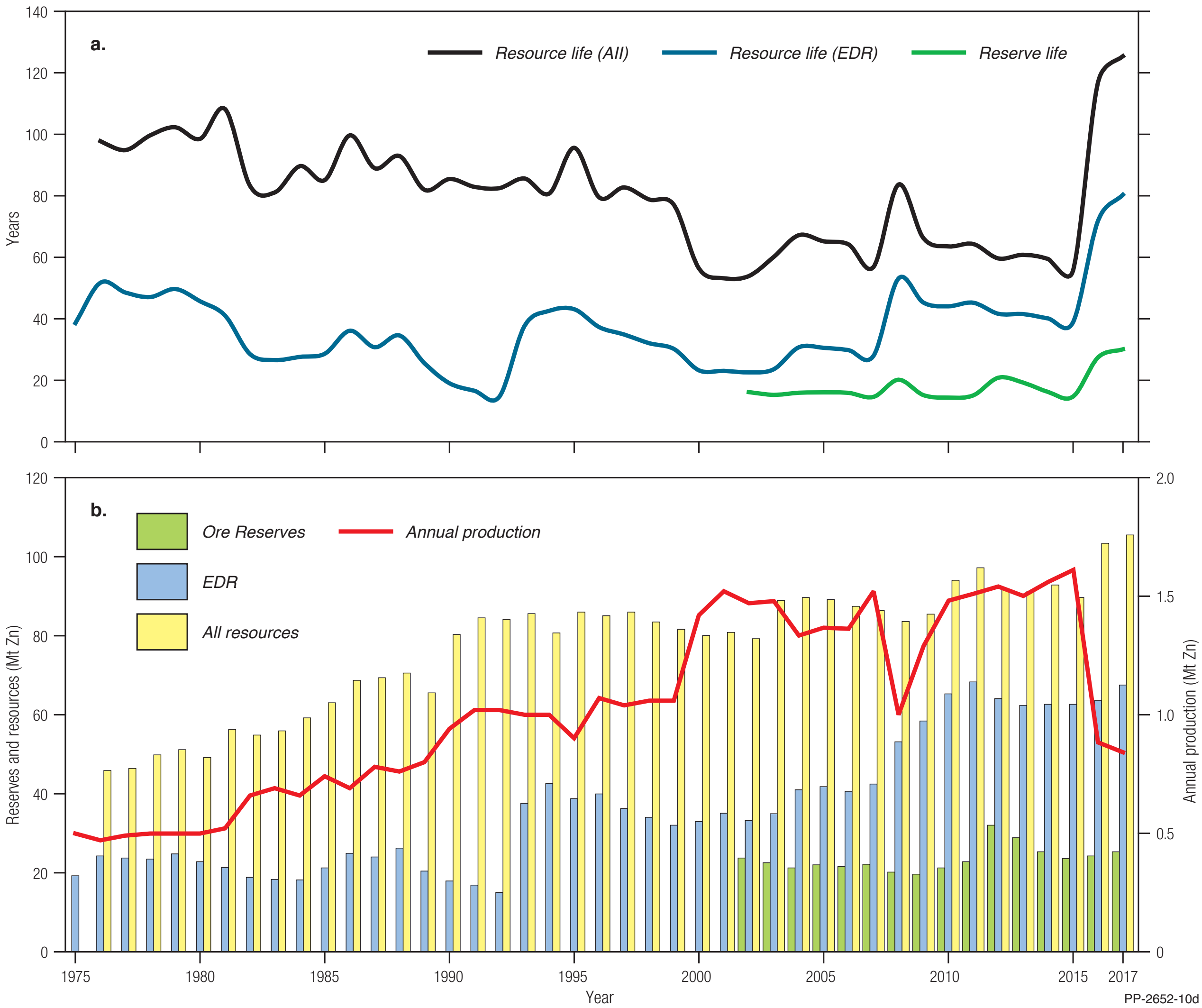


Figure 44 Trends in (a) zinc reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.
Notes: Prior to 2002, Ore Reserves were not recorded. Mt Zn= million tonnes of contained zinc.
Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

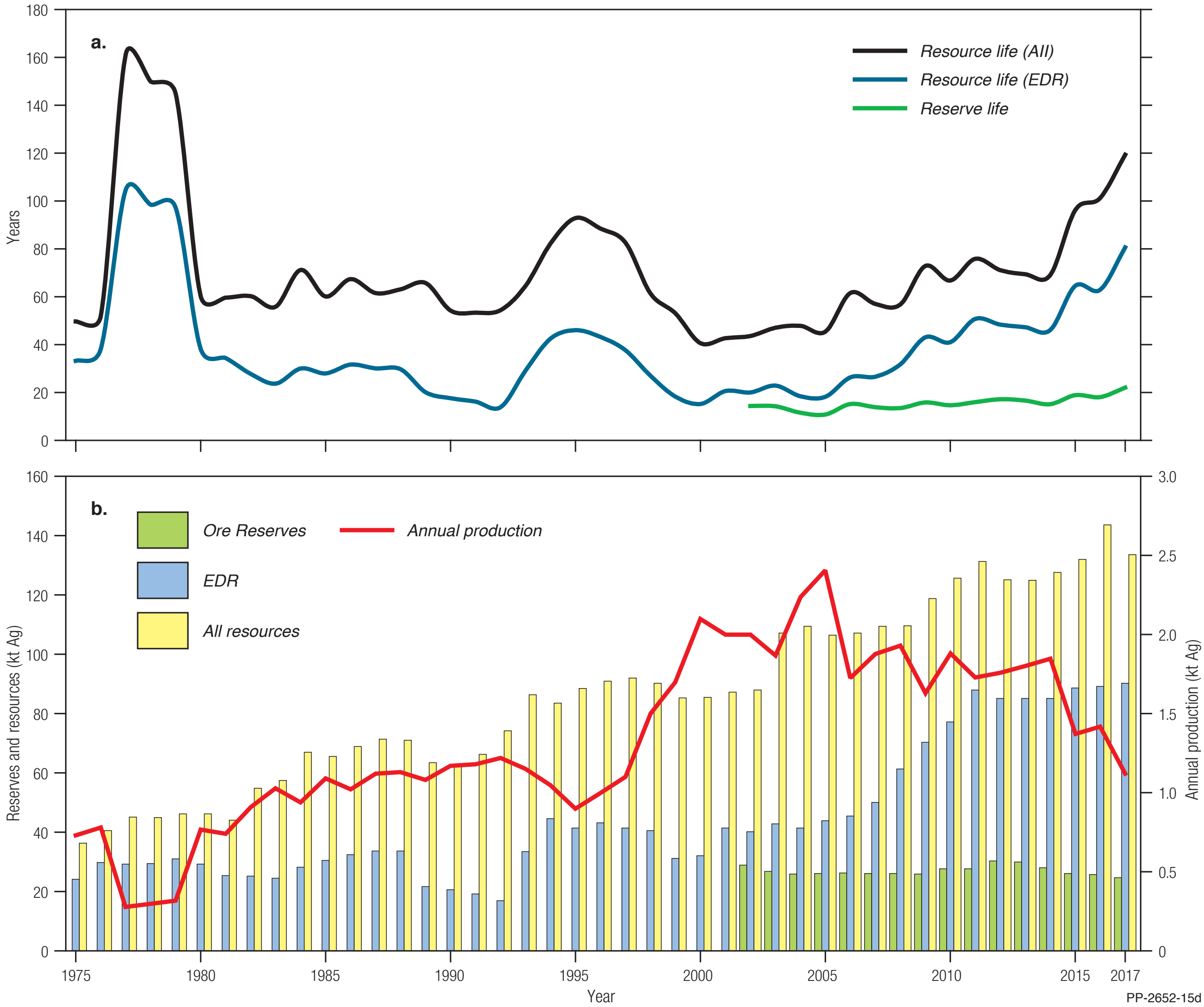


Figure 45 Trends in (a) silver reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. kt Ag= thousand tonnes of contained silver.

Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

At 2017 rates of lead production, average reserve life at operating mines is potentially 22 years and demonstrated resource life (Measured and Indicated categories) could be 66 years (Table 25). If Ore Reserves at mines on care and maintenance, developing mines and undeveloped deposits are also considered, the reserve life of lead is potentially 25 years and if AEDR is used as an indication of long-term potential supply, then at 2017 rates of production, Australia's lead resources could last about 80 years (Table 25). The addition of Inferred Resources to the calculation results in a resources/production ratio of 80 years at operating mines and 135 years for all deposits (Table 25).

For zinc, the potential average reserve life at operating mines is also 22 years but resource life (Measured and Indicated) is slightly lower than zinc at 56 years (Table 25). When all deposits are considered, the reserve life is 30 years and, using AEDR, the long-term potential outlook is approximately 80 years at current rates of production (Table 25).

The addition of Inferred Resources to the calculation results in a resources/production ratio of 70 years at operating mines and 125 years for all deposits (Table 25).

Silver has a calculated reserve life of 17 years and resource life of 59 years at operating mines (Table 25). When all Ore Reserves are considered, not just those at operating mines, the reserve life is 22 years and the long-term outlook using AEDR is 80 years (Table 25). The addition of Inferred Resources to the calculation results in a resources/production ratio of 75 years at operating mines and 120 years for all deposits (Table 25).

The long-term outlook provided by AEDR, and the even longer term outlook provided by All Resources at all deposits, show that at 2017 rates of production, and even with increased rates of production, Australia has the potential to produce lead, zinc and silver for many decades to come.

Table 25 Average reserve life and resource life (years) for lead, zinc and silver as at December 2017.

Commodity	Operating Mines[1]			All Deposits		
	Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
Lead	22	66	80	25	80	135
Zinc	22	56	70	30	80	125
Silver	17	59	75	22	80	120

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. All lead, zinc and silver EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

MINERAL SANDS

Australia's heavy mineral sand resources, containing the minerals ilmenite, rutile and zircon, are primarily hosted in the Murray Basin (Victoria, New South Wales and South Australia), Eucla Basin (South Australia and Western Australia) and the Perth and Canning basins (Western Australia). In 2017, mineral sand exploration expenditure was approximately $21 million, an increase of 5% since 2016, however still 39% below the 2012 expenditure peak. In 2017, an estimated 970 kt of ilmenite concentrate, 288 kt of rutile concentrate and 970 kt of zircon concentrate were exported from Australia, up 59%, 32% and 73%, respectively, on 2016 export figures.

Australia's 2017 mineral sand EDR were estimated to be 276.5 Mt for ilmenite, 32.9 Mt for rutile and 78.3 Mt for zircon (Table 3). These estimates are largely unchanged from 2016 EDR estimates (Table 4). Australia has the world's largest EDR of rutile (49% of the global economic resource; Table 8) followed by Kenya (20%), South Africa (13%) and India (12%). Australia also has the world's largest EDR of zircon (66%; Table 8) followed by South Africa (18%) and the second largest EDR of ilmenite (21%; Table 8) after China (28%) and ahead of India (11%). In addition, Australia has large Inferred Resources of ilmenite (236.5 Mt), rutile (34.8 Mt) and zircon (62.3 Mt) plus smaller amounts that are regarded as subeconomic (Table 3).

Australia also has large mineral sand Ore Reserves (Figure 46, Figure 47 and Figure 48) amounting to 57.1 Mt, 6.7 Mt and 20.0 Mt of ilmenite, rutile and zircon, respectively (Table 2). In 2017, there were ten operations producing ilmenite, eight producing rutile and nine producing zircon (Table 1). These mines accounted for 28%, 33% and 24% of Australia's ilmenite, rutile and zircon Ore Reserves, respectively. In 2017, they produced 1.5 Mt of ilmenite, 0.3 Mt of rutile and 0.5 Mt of zircon, largely unchanged from 2016. In just 16 years, cumulative production of mineral sands has exceeded the 2002 estimated Ore Reserves for ilmenite (Figure 46), rutile (Figure 47) and zircon (Figure 48).

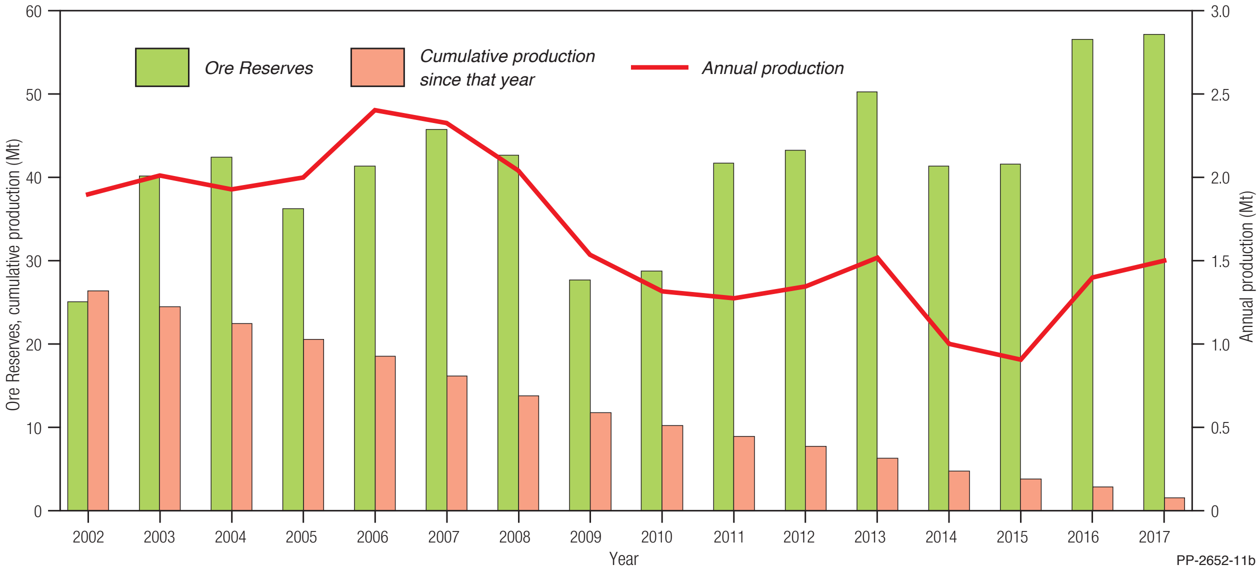


Figure 46 Ilmenite Ore Reserves, annual production and cumulative production 2002–2017.

Notes: Cumulative production is read as the amount of ilmenite that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of ilmenite that has been produced since 2002 is 26.4 Mt, the amount of ilmenite that has been produced since 2010 is 10.3 Mt. Mt = million tonnes.

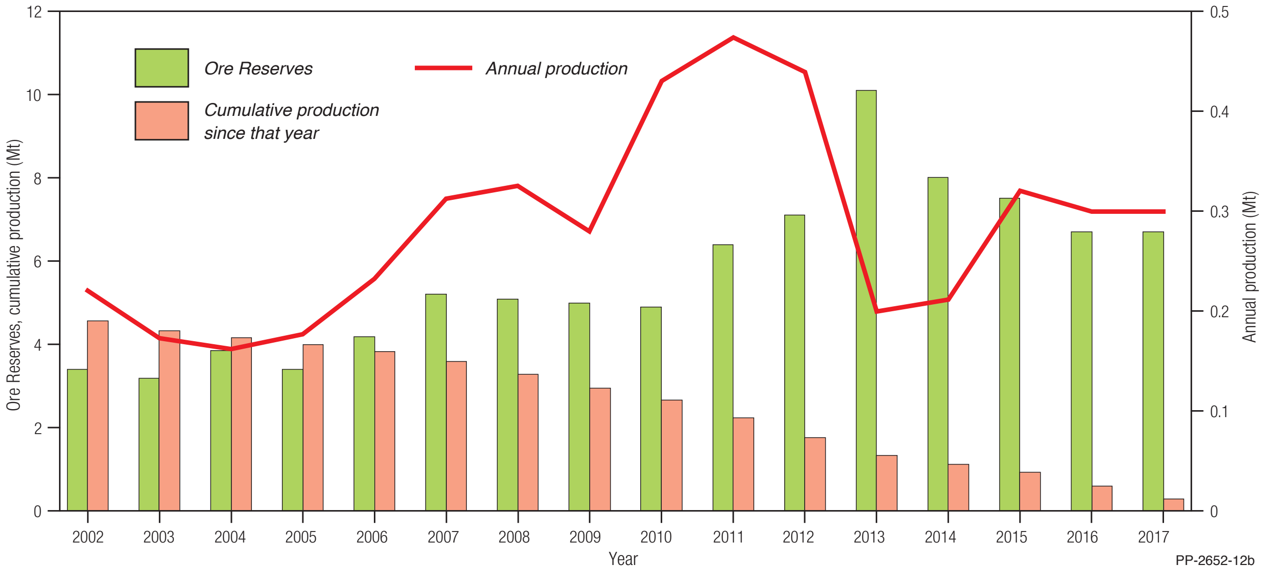


Figure 47 Rutile Ore Reserves, annual production and cumulative production 2002–2017.

Notes: Cumulative production is read as the amount of rutile that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of rutile that has been produced since 2002 is 4.6 Mt, the amount of rutile that has been produced since 2010 is 2.7 Mt. Mt = million tonnes.

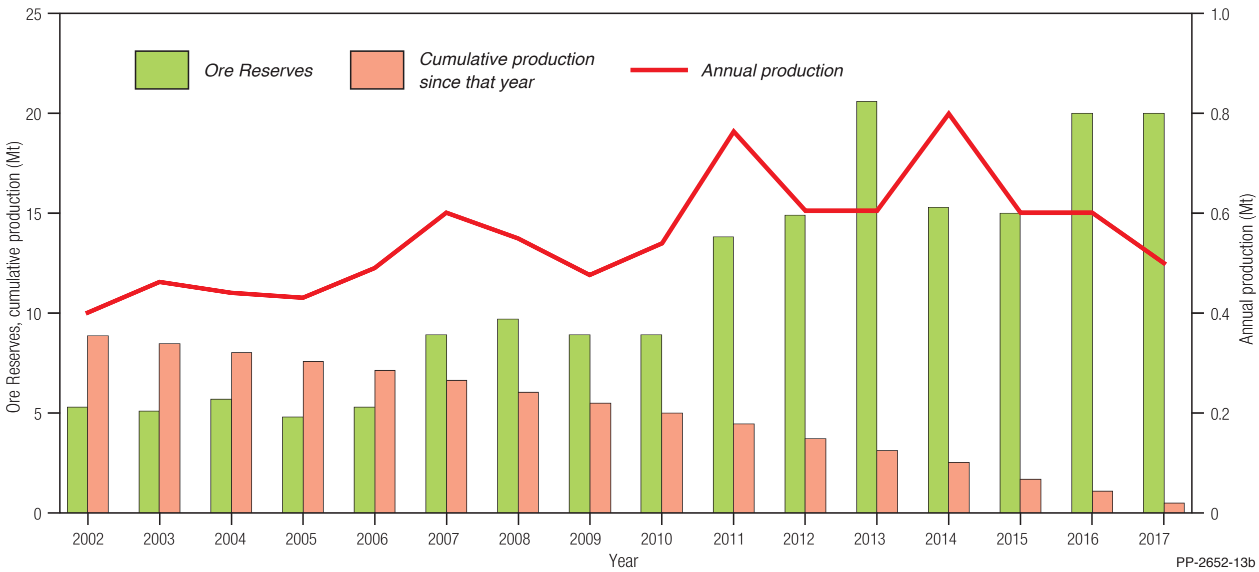


Figure 48 Zircon Ore Reserves, annual production and cumulative production 2002–2017.

Notes: Cumulative production is read as the amount of zircon that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of zircon that has been produced since 2002 is 8.9 Mt, the amount of zircon that has been produced since 2010 is 5.0 Mt. Mt = million tonnes.

Over the last decade, Ore Reserves and EDR of mineral sands have risen substantially, particularly for zircon which has more than doubled (Table 26). Production over the same period has, however, decreased (Table 26). The global financial crisis of 2007–08 markedly impacted ilmenite production with some heavy mineral sand producers closing low-grade ilmenite operations to concentrate on deposits with higher zircon content or those that were more readily amenable to beneficiation. Thus, in 2017, despite rising output over the last two years, ilmenite production remained 36% lower than at its peak ten years ago (Table 26, Figure 46). Australia's rutile and zircon industries fared better following a short-lived decline associated with the financial crisis, with output rising strongly to peaks in 2011 and then again in 2014 for zircon (Figure 47 and Figure 48). Since 2011, rutile and zircon production has generally fallen as prices have remained soft.

Taking a longer term view, over the last 40+ years, Australia's mineral sand EDR have risen significantly (Figure 49, Figure 50 and Figure 51) as have Inferred Resources (Figure 52, Figure 53 and Figure 54). Increases in mineral sand resources from 1996 to 2003 resulted from the discovery and subsequent evaluation drilling of deposits in the Murray Basin which include the Ginkgo and Snapper deposits in New South Wales, the Douglas- Bondi and Woornack deposits in Victoria, and the Mindarie project in South Australia. In addition, from 1998 onwards, there were progressive resource upgrades for mineral sand deposits at Jacinth-Ambrosia and Cyclone in the Eucla Basin, in the North Swan Coastal Plain area north of Perth and the Blackwood Plateau region in Western Australia. From 2007 to 2012, the EDR of ilmenite declined (Figure 49) due to reclassification of some resources to lower resource categories, but has since increased as a result of new resource delineation, particularly in Western Australia.

Production since 1975, however, shows no such clear upward trend with ilmenite, rutile and zircon output rising and falling a number of times. In fact, while 2017 ilmenite production was 52% up on 1975 levels, zircon production was only 20% up and rutile production was actually down 24% (Table 26).

Figure 49, Figure 50 and Figure 51 demonstrate the vast Australian mineral sand inventory and the strong growth in mineral sand EDR estimates since 1975. Cumulative production of ilmenite (68.2 Mt), rutile (10.9 Mt) and zircon (20.5 Mt) since 1975 has exceeded the EDR estimated in that year (58.4 Mt for ilmenite, 9.2 Mt for rutile and 15.7 Mt for zircon).

Table 26 Changes in mineral sand production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Mineral Sand Commodity		Change since 2016	Change since 2007	Change since start of records
Ilmenite	Annual Production	7.1%	-36%	52% (1975)
	Ore Reserves	1.1%	25%	127% (2002)
	EDR	-0.2%	25%	373% (1975)
	All Resources	0.1%	40%	748% (1976)
Rutile	Annual Production	0.0%	-4%	-24% (1975)
	Ore Reserves	0.0%	29%	97% (2002)
	EDR	-0.3%	42%	258% (1975)
	All Resources	0.7%	7%	487% (1976)
Zircon	Annual Production	-16.7%	-17%	20% (1975)
	Ore Reserves	0.0%	125%	277% (2002)
	EDR	-0.4%	101%	398% (1975)
	All Resources	0.5%	58%	652% (1976)

Abbreviations: EDR = Economic Demonstrated Resources.
Notes: All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources.
Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

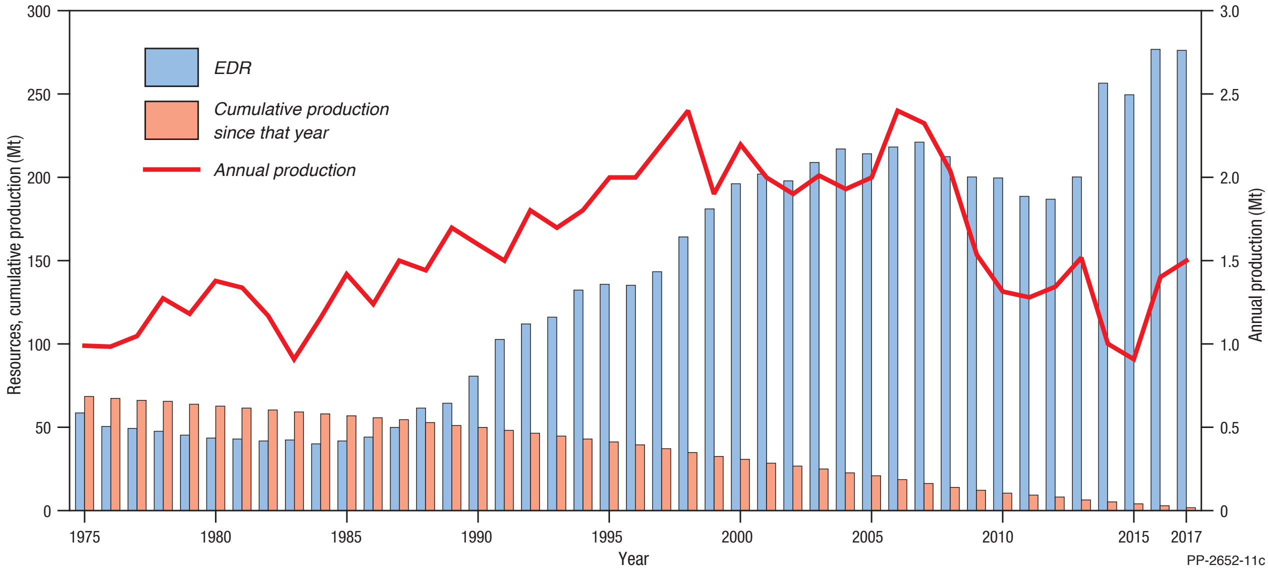


Figure 49 Economic Demonstrated Resources (EDR), annual production and cumulative production of ilmenite, 2002–2017.

Notes: Cumulative production is read as the amount of ilmenite that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of ilmenite that has been produced since 1975 is 68.2 Mt, the amount of ilmenite that has been produced since 1995 is 41.1 Mt. Mt = million tonnes.

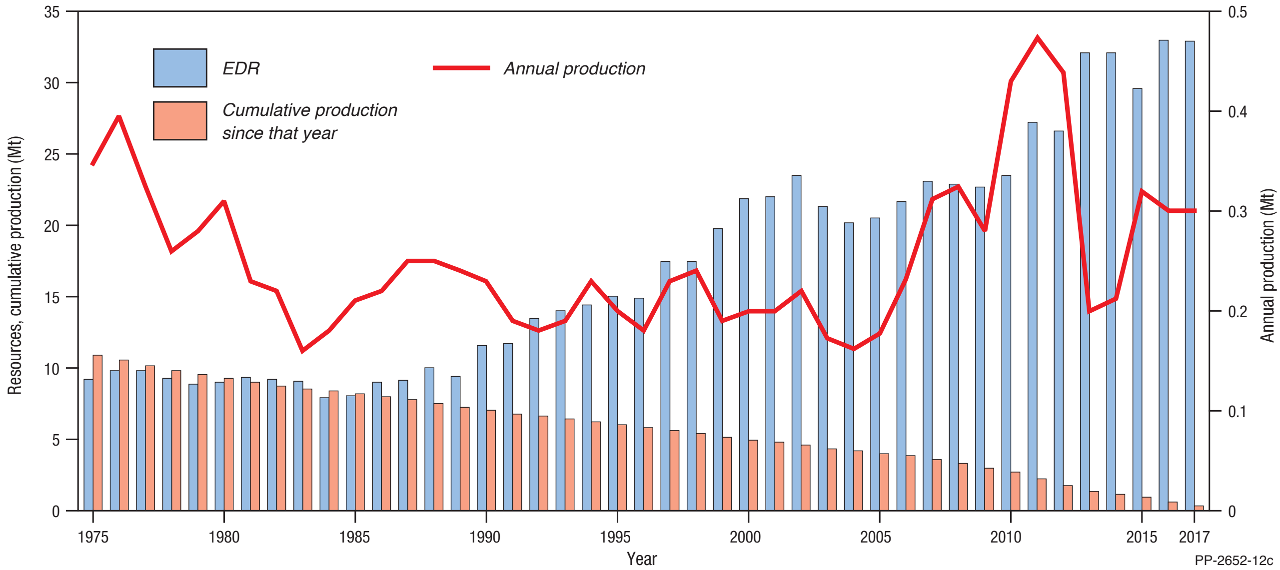


Figure 50 Economic Demonstrated Resources (EDR), annual production and cumulative production of rutile, 2002–2017.

Notes: Cumulative production is read as the amount of rutile that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of rutile that has been produced since 1975 is 10.9 Mt, the amount of rutile that has been produced since 1995 is 6.0 Mt. Mt = million tonnes.

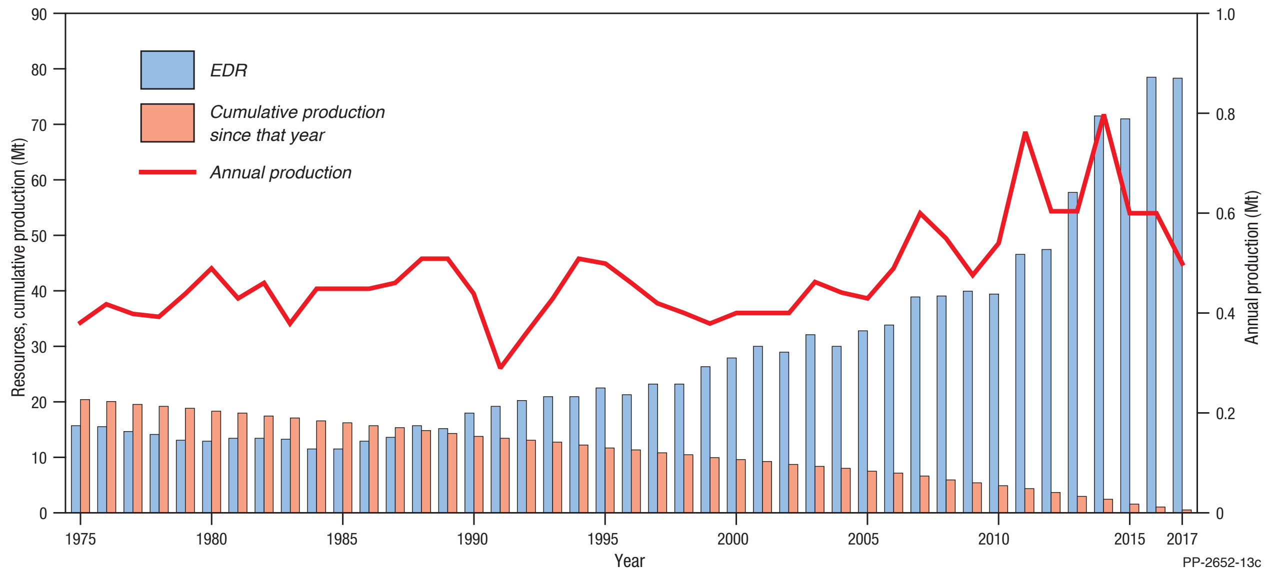


Figure 51 Economic Demonstrated Resources (EDR), annual production and cumulative production of zircon, 2002–2017.

Notes: Cumulative production is read as the amount of zircon that has been produced from 2017 to each year on the chart, so it increases going back in time, e.g. the amount of zircon that has been produced since 1975 is 20.5 Mt, the amount of zircon that has been produced since 1995 is 11.8 Mt. Mt = million tonnes.

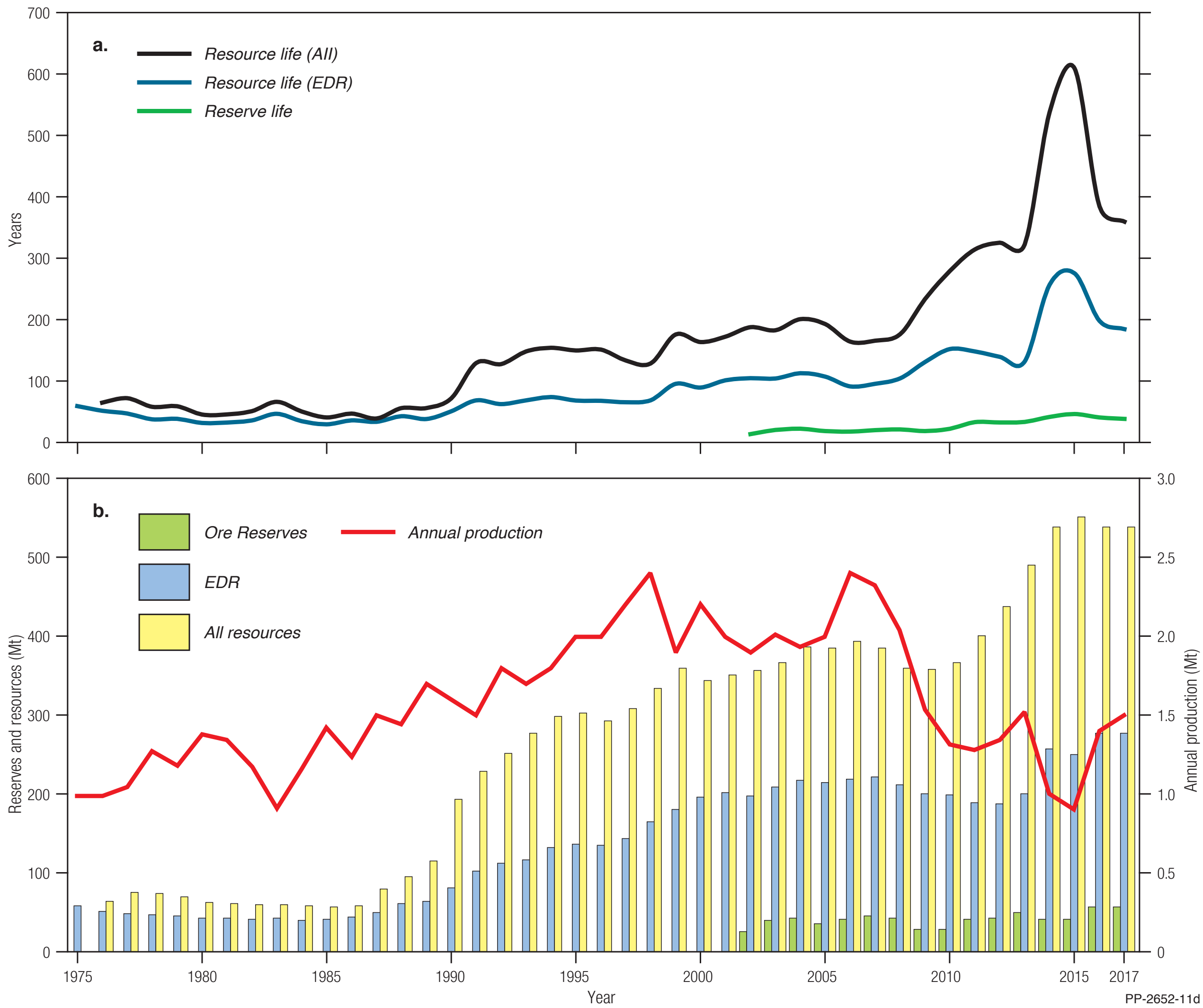


Figure 52 **Trends in (a) ilmenite reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.**
Notes: Prior to 2002, Ore Reserves were not recorded. Mt = million tonnes.
Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

Resource life estimates are a snapshot in time obtained by dividing an annual resource or reserve estimate by its corresponding production estimate. New mineral sand discoveries resulted in significant increases in resource life estimates around 1990 (Figure 52, Figure 53 and Figure 54). From 1990, ilmenite production almost kept pace with new discoveries so the increasing resource/production ratio was gradual until it was boosted in the 2000s by lower than average production rates (Figure 52). Ilmenite resource life has again been boosted in recent years with new resource delineation from 2011 onward combining with dramatically decreased production from 2014 (Figure 52).

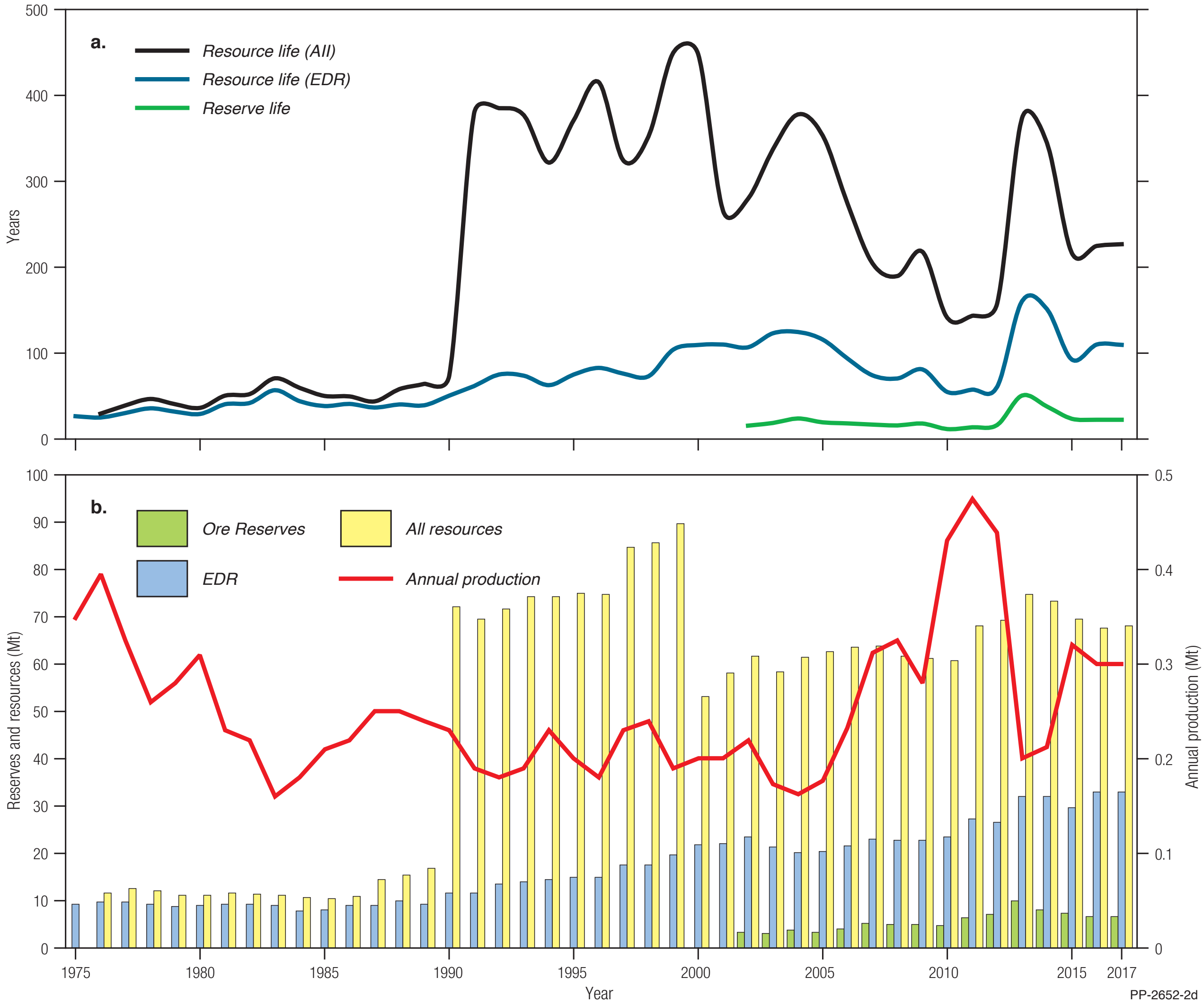


Figure 53 Trends in (a) rutile reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. Mt = million tonnes.

Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

Rutile and zircon production rates from around 1987 to 2006 decreased slightly or were steady. As a result, the significant increases in resources estimates from around 1990, particularly for Inferred Resources, caused dramatic increases in resource life (Figure 53 and Figure 54). Since 1990, the resource/production ratios for rutile and zircon have varied conspicuously in response to variable production rates. More recently, as with ilmenite, increased resource delineation of zircon combined with lower production has led to an increasing trend in resource life (Figure 54). Rutile, however, has a lower resource life compared to around 2013 but given that its EDR is largely similar to that of recent years and production fluctuates strongly from year to year, it is not entirely clear whether the trend for resource life is up or down (Figure 53).

At 2017 rates of production, the average reserve life at operating mines is potentially 11 years for ilmenite, 7 years for rutile and 9 years for zircon (Table 27). Demonstrated resource life (Measured and Indicated categories only) at operating mines for ilmenite, rutile and zircon is more than triple the reserve life at 39 years, 27 years and 29 years, respectively (Table 27). If Ore Reserves at mines on care and maintenance, developing mines and undeveloped deposits are also considered, the reserve life for ilmenite, rutile and zircon is potentially 38 years, 22 years and 40 years, respectively. If AEDR or All Resources are used as an indication of long-term potential supply then, at 2017 rates of production, Australia's minerals sands resources could last more than a century (Table 27).

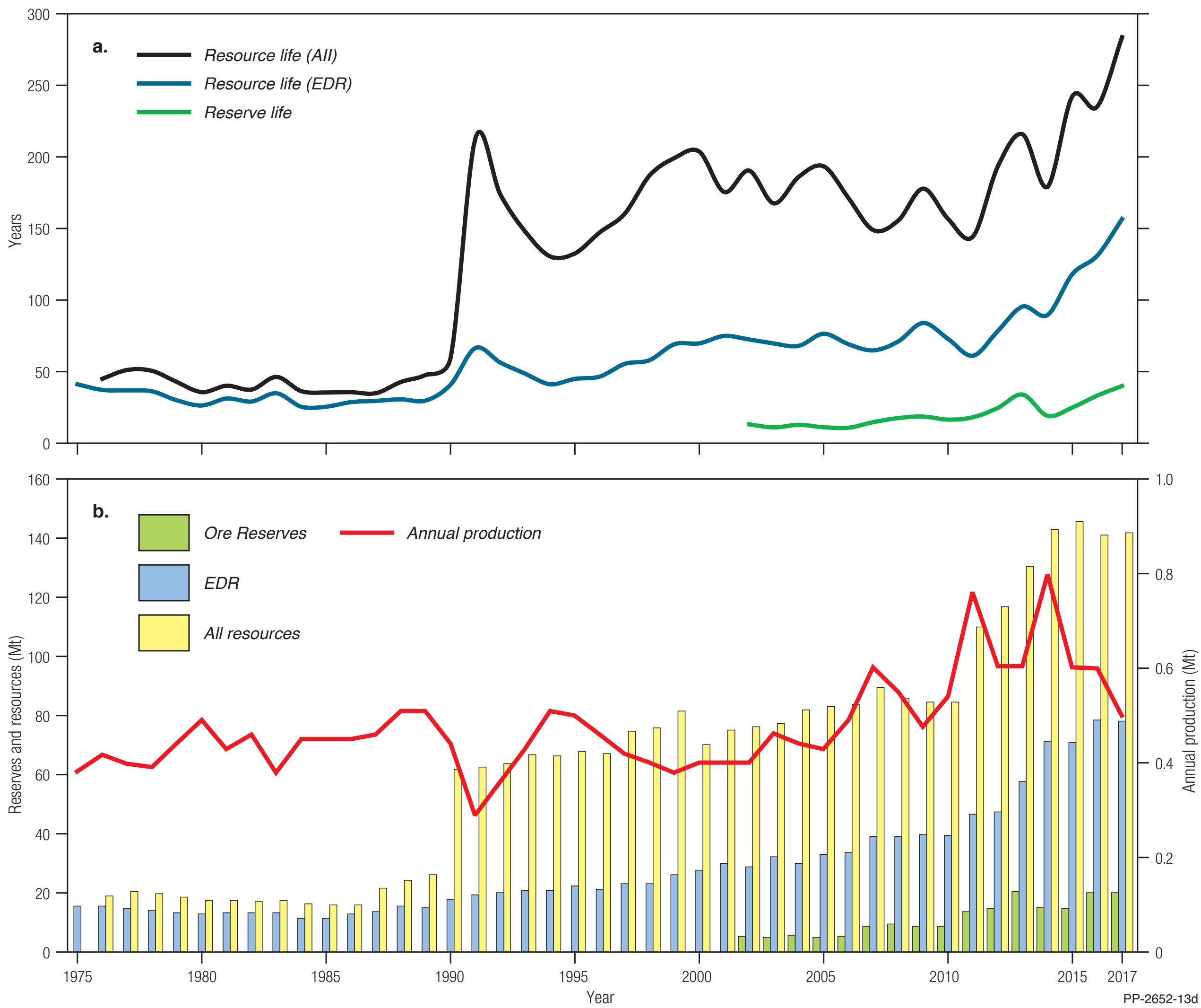


Figure 54 Trends in (a) zircon reserve and resource life derived from (b) Ore Reserves, Economic Demonstrated Resources (EDR), all resources (EDR + Subeconomic Demonstrated Resources + Inferred) and annual production, 1975–2017.

Notes: Prior to 2002, Ore Reserves were not recorded. Mt = million tonnes.

Reserve Life = Ore Reserves÷production; Resource Life (EDR) = EDR÷production; Resource Life (All) = all resources÷production.

Table 27 Average reserve life and resource life (years) for mineral sands as at December 2017.

Commodity	Operating Mines[1]			All Deposits		
	Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
Ilmenite	11	39	51	38	165	360
Rutile	7	27	34	22	95	225
Zircon	9	29	34	40	145	285

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources, 11% of ilmenite EDR, 12% of rutile EDR and 8% of zircon EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

Wind turbines are an important generator of renewable energy. The infrastructure required to capture wind power needs mineral commodities, as do solar panels, batteries and all other energy technologies, new and old. Wind turbines are mostly comprised of steel (iron) and concrete but also contain smaller, but significant, amounts of copper, aluminium, zinc, molybdenum and rare earths.

6. IDENTIFIED RESOURCES OF OTHER COMMODITIES

BROWN COAL

The 2017 estimate of Australia's recoverable brown coal EDR remains unchanged from 2016 at 76 508 Mt (Table 3, Table 4). Nearly all of Australia's recoverable brown coal EDR is located in Victoria with more than 93% in the Latrobe Valley alone. The most recent available global data (2016)[9] indicates that Australia is ranked second in the world in terms of recoverable brown coal, accounting for 24% of the world's resources (Table 8), behind Russia (29%) and followed by Germany (11%) and the USA (10%).

The estimate of Australian brown coal production for 2017 is 53 Mt (Table 3), ranking Australia sixth in the world (Table 8) behind Germany, Russia, Turkey, the USA and Poland. Brown coal mined in Australia is used almost exclusively for domestic electricity generation in Victoria; although a small mine at Maddingley, 50 km northwest of Melbourne, uses brown coal to produce agricultural products. At 2017 rates of extraction, the accessible resource base will support over 1000 years of production.

Recent years have seen the ongoing closure of brown-coal fired power stations and an associated reduction in brown coal production and consumption. The most recent closure, in March 2017, was the Hazelwood mine and power station. However, the Loy Yang A, Loy Yang B and Yallourn Valley power stations, all located in the Latrobe Valley, remain operational and continue to contribute to the National Electricity Market.

DIAMOND

In 2017, Australia's total EDR of diamond resources was 39.68 Mc (Table 3), significantly down from 115.84 Mc in 2016 (Table 4). This is largely due to resources at Argyle being depleted and written off following revised economic assessments. Total production increased from 14.0 Mc in 2016 to 17.14 Mc in 2017. The combination of declining resources and increasing production has resulted in an Australian diamond resource life of only three years or less (Table 28). The Argyle lamproite pipe in the east Kimberley region of Western Australia was responsible for all diamond production in Australia. Test mining operations at the Merlin mine in the Northern Territory were ongoing in 2017, but did not produce significant quantities of diamond.

Table 28 Average reserve life and resource life (years) for diamonds as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
2	2	3	2	2	3

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. All diamond EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

9 Federal Institute for Geosciences and Natural Resources, Germany (Energy Study 2017).

GRAPHITE

Australia's EDR of graphite is estimated to be 7.14 Mt in 2017 (Table 3), a 636% increase since last reported in 2013 (0.97 Mt; Table 4). Graphite deposits occur across Queensland, Western Australia and South Australia. South Australia hosts 66% of graphite EDR (4.72 Mt), followed by Queensland (18%; 1.32 Mt) and Western Australia (15%; 1.10 Mt). Graphite deposits include Uley Graphite, Oakdale, Siviour, Kookaburra Gully and Campoona in South Australia, Mount Dromedary in Queensland and Longtom, Munglinup Graphite and Yalbra Graphite in Western Australia. Inferred Resources of graphite have also significantly increased, up 460% from 1.08 Mt in 2013 to approximately 6.05 Mt in 2017 (Table 3). Inferred Resources occur in the deposits above and also at Barracuda, Wahoo and Yalba in Western Australia and at Wilclo South and Koppio in South Australia.

LITHIUM

Australia's EDR of lithium was 2803 kt in 2017 (Table 3) up 3% from 2730 kt in 2016 (Table 4). Australia ranks third globally with 18% of the world's economic resources (Table 8), behind Chile and China, and first for production (47%; Table 8). All of Australia's EDR of lithium occur within hard-rock pegmatite deposits and most deposits occur in Western Australia. The Greenbushes deposit, 200 km south of Perth, is the world's largest and highest-grade spodumene deposit; it contains approximately 34% of Australia's lithium EDR. Other resources occur at Mount Cattlin, Mount Marion, Bald Hill and Earl Grey in the Yilgarn region of Western Australia, at Wodgina and the two Pilgangoora deposits in the Pilbara region of Western Australia, and at the Grants deposit (Finniss project) in the Northern Territory.

The last few years has seen heightened activity in the Australian lithium industry with significant increases in resources as well as the commencement of production from a number of deposits in Western Australia: Wodgina, Pilgangoora (both deposits), Mount Cattlin, Mount Marion and Bald Hill. In addition, lithium processing plants are being built (Tianqi) or are planned (e.g. Albemarle) in Western Australia.

The relatively rapid growth in lithium in Australia is also evidenced by the large increases in Ore Reserves (1550%), EDR (1559%) and all resources (1747%) over the last ten years (Table 29). Increases in annual production have also been significant, up 50.0% since 2016, and 5150% since 1986 (Table 29). Current Ore Reserves at operating mines, based on 2017 production rates, have a reserve life of 47 years which extends to 79 years when reserves at other deposits are included (Table 30).

Table 29 Changes in lithium production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Lithium	Change since 2016	Change since 2007	Change since start of records
Annual Production	50.0%	unknown	5150% (1986)
Ore Reserves	22.1%	1550%	1008% (2002)
EDR	2.7%	1559%	393% (1987)
All Resources	27.4%	1747%	725% (1987)

Abbreviations

EDR = Economic Demonstrated Resources.

Notes

All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

Production data for lithium in 2007 is not publically available.

MAGNESITE

In 2017, Australia's EDR of magnesite was 316 Mt, almost unchanged from the previous year (Table 3, Table 4), representing approximately 4% of the world total (Table 8). The Department of Premier and Cabinet South Australia reported magnesite production of 3241 t in 2017, significantly down from 6554 t in 2016. The Queensland Department of Natural Resources Mines and Energy reported magnesite production of 207 603 t in 2016–17, also significantly down from 462 901 t in 2015–16. Apart from South Australia and Queensland, magnesite EDR also occurs in New South Wales, Western Australia and the Northern Territory.

Table 30 Average reserve life and resource life (years) for lithium as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
47	67	122	79	133	224

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. All lithium EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

MANGANESE ORE

Australia's EDR of manganese ore increased by 12 Mt in 2017 to 231 Mt with new Indicated Resources reported at Yanneri Ridge in Western Australia. All of Australia's EDR of manganese ore occurs in the Northern Territory (64%) and Western Australia (36%; Figure 14). Australia's resources of manganese are the world's fourth largest (Table 8) behind South Africa, Ukraine and Brazil. Australia's mine production of manganese ore in 2017 was 5.6 Mt (Table 3), which ranks Australia third (Table 8) behind China and South Africa in terms of manganese content. This is up from 2016's fourth position owing to increased production from the Northern Territory at Groote Eylandt as well as Bootu Creek coming out of care and maintenance in early 2017. Woodie Woodie in Western Australia also came out of care and maintenance in late 2017 but production numbers were not available at the time of publication, hence the 2017 manganese ore production (5.6 Mt) is a minimum estimate. At 2017 rates of production, Australia's resources of manganese ore have the potential to last many decades (Table 31).

MOLYBDENUM

Australia's EDR of molybdenum in 2017 was 160 kt (Table 3), a 24% decrease from 210 kt in 2016 (Table 4). Australia ranks sixth globally for economic molybdenum resources but only hosts approximately 1% of the world resource (Table 8), which is dominated by China, the USA, Peru and Chile. The bulk of Australia's EDR of molybdenum occurs in Queensland (86%), followed by Western Australia (8%) and the Northern Territory (3%). New South Wales also has molybdenum deposits but accounts for less than 1% of Australia's EDR. Another 1272 kt of molybdenum in Australia is categorised as paramarginal (Table 3).

NIOBIUM

Australia's EDR of niobium decreased to 216 kt in 2017, down from 286 kt in 2016 (Table 3, Table 4) following a downgrade at Mount Cattlin in Western Australia. This is after increasing 40% from 2015 figures owing to new resource estimates at the Hastings deposit in Western Australia. The Hastings deposit accounts for 37% of Australia's EDR of niobium with the remainder occurring at the Toongi deposit, 20 km south of Dubbo in New South Wales. Paramarginal resources occur in the Mount Weld and Mount Deans deposits (both in Western Australia) and other resources occur at Narraburra in New South Wales and in the Greenbushes tantalum deposit in Western Australia. World data are scarce but Australia's resources of niobium could be the second largest globally (5%), behind Brazil (Table 8).

OIL SHALE

Resources of oil shale predominantly occur in sedimentary basins around Gladstone, Mackay and Proserpine in central Queensland. Paramarginal and Submarginal (contingent) Resources are estimated at 2287 GL (14 385 million barrels), and Inferred (prospective) Resources are estimated at 1472 GL (9261 million barrels) in 2017. Australia currently has no EDR of oil shale, with all resources being assessed as subeconomic (Table 3). There is currently no production from oil shales in Australia.

PHOSPHATE

Geoscience Australia assesses both phosphate rock (phosphorite and guano) and contained P_2O_5 which, as well as being a component of phosphate rock, can be found in other rock types in which alternative minerals are the primary target. Australia's EDR of phosphate rock was 1170 Mt in 2017 (Table 3), slightly up from 1072 Mt in 2016 (Table 4). Contained P_2O_5 EDR in 2017 increased to 198 Mt (Table 3) up from 180 Mt the previous year (Table 4). The phosphorites of the Georgina Basin (Queensland and the Northern Territory) account for almost all of Australia's EDR of phosphate rock and 93% of Australia's EDR of contained P_2O_5. The remaining phosphate rock occurs at Christmas Island. The rare earth deposits at Mount Weld (Western Australia) and Nolans Bore (Northern Territory) also have EDR of contained P_2O_5. Australia hosts less than 2% of the world's economic resources of phosphate rock (Table 8) with Christmas Island and Phosphate Hill (Queensland) the only significant producers.

Table 31 Average reserve life and resource life (years) for manganese ore as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
18	35	41	18	40	140

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. All manganese ore EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

PLATINUM GROUP ELEMENTS

Australia's EDR of platinum group elements increased 370% from 5.3 t in 2016 to 24.9 t in 2017 (Table 3, Table 4). Much of this increase was due to Cassini Resources Ltd upgrading an Inferred Resource at Nebo Babel in Western Australia to an Indicated Resource. Australian EDR represents <1% of the world total, estimated by the USGS to be some 69 Mt. Australia also has Inferred Resources of 125.5 t and Paramarginal Resources of 136.7 t (Table 3). In addition to public reports of PGE resources, Australian deposits may contain unreported resources that are recovered as by-products to the primary commodity being mined (usually from nickel sulphide ores). The Western Australian Department of Mines and Petroleum reported that 783 kg of platinum and palladium was produced during 2016–17, up from 687 kg in 2015–16. The bulk of Australia's EDR of platinum group elements occurs in Western Australia (89%).

POTASH

Potash is a generic term covering a variety of potassium-bearing ores, minerals and refined products. Nearly all of Australia's potash resources occur in Western Australia, with the exception of Karinga Lakes in the Northern Territory and Lake Mackay which occurs on the border between the two jurisdictions. In addition, nearly all Australian potash resources occur in lake brines with resources also delineated at Kalium Lakes, Lake Chandler, Lake Disappointment, Lake Hopkins, and Lake Wells. Minor potash also occurs in the Dandaragan (greensands) deposit and the Oxley deposit; the latter is a new type of potash deposit hosted in ultrapotassic microsyenite lava flows. However, none of these resources have yet been upgraded to an Ore Reserve.

In 2017, Australia's EDR of potash was 58 Mt K_2O (Table 3), slightly up from 56 Mt K_2O in 2016 (Table 4). Significant industry activity continued at the Beyondie, Lake Disappointment and Lake Wells projects. At Beyondie, Kalium Lakes Ltd completed its bankable feasibility study, published an updated resource estimate in 2018 and was granted a licence to construct and operate a gas pipeline to the project. At Lake Disappointment, Reward Minerals Ltd published a prefeasibility study that claims the project is the largest sulphate of potash brine project outside of China. At Lake Wells, both Salt Lake Potash Ltd and Australian Potash Ltd have progressed their separate projects. They have also entered into a Memorandum of Understanding in which they plan to explore the potential benefits of shared infrastructure and costs.

Australia's potash resources remain small by world standards (2%, Table 8) with Canada (26%), Belarus (19%) and Russia (13%) leading supply. Apart from some experimental production at the developing projects above, potash was not mined in Australia in 2017.

RARE EARTHS

Geoscience Australia assesses rare earth oxides and yttrium oxide (Y_2O_3) collectively as 'rare earths'. In 2017, Australia's EDR of rare earths fell slightly to 3.27 Mt (Table 3) down from 3.43 Mt in 2016 (Table 4). This accounts for approximately 3% (Table 8) of the 121 Mt (USGS estimate) world total, with China holding the greatest economic resource of any country (>36%). China also dominates world production (>80%), but Australia is the second largest supplier (13%, Table 8). In Western Australia, Lynas Corporation Ltd mines the Mount Weld deposit on a campaign basis, completing its second campaign in May 2017 and commencing a third in September 2017. Mined mineral concentrate is supplied to the Lynas Advanced Materials Plant in Malaysia for the production of separated rare earth oxides. In 2017, the plant produced approximately 17 kt.

In early December 2017, Northern Minerals Ltd announced it had mined 205 kt of ore at its Browns Range Heavy Rare Earths Project in Western Australia and that construction of its pilot plant was progressing. Arafura Resources Ltd announced in September 2017 that it had progressed various pilot phases intended to demonstrate technical and operational viability at Nolans Bore in the Northern Territory. Alkane Resources Ltd confirmed in its 2016 Annual Report that its Dubbo Project (Toongi deposit) in New South Wales is ready for construction with a well-established flowsheet. In November 2017, Hastings Technology Metals Ltd announced the successful completion of a definitive feasibility study at Yangibana in Western Australia. These examples highlight that Australia has the potential to further its global standing as an alternative supplier to China of both light and heavy rare earths.

TANTALUM

Australia's EDR of tantalum was 55.4 kt in 2017 (Table 3), a 27% decrease from 75.7 kt in 2016 (Table 4), largely reflecting a downgrade for the Wodgina deposit in Western Australia. World data are scarce, but Australia could rank first in the world ahead of Brazil for identified tantalum resources (Table 8). However, there is considerable uncertainty around tantalum resources in other countries, particularly Africa. The bulk of tantalum EDR in 2017 was located in Western Australia, mainly at the Greenbushes (54%) and Pilgangoora (18%) deposits with smaller resources at Wodgina, Tabba Tabba, Bald Hill and Dalgaranga. Outside of Western Australia, the Toongi deposit (Dubbo Project) in New South Wales contains 19% of Australia's tantalum EDR.

TIN

Australia's EDR of tin decreased to 415 kt in 2017 (Table 3), down from 486 kt in 2016 (Table 4). Australia's resources are the world's fourth largest (9%) behind China (23%), Indonesia (17%) and Brazil (15%) but Australia accounts for only 2% of global tin production (Table 8). Australia's EDR of tin occurs in Tasmania (76%), Queensland (12%), New South Wales (11%) and Western Australia (1%). The majority of Australia's EDR of tin is contained in the Renison Bell (52%) and Cleveland (11%) deposits in Tasmania and the Taronga (11%) deposit in New South Wales. More than 95% of Australian tin production is from Renison Bell in Tasmania. In addition, some (unreported) tin is produced as a by-product from some Western Australian tantalum deposits.

Significant increases in Australia's annual tin production (240%) have occurred over the last ten years, which are not matched by the much smaller increases in all resources and Ore Reserves (10% and 18% respectively; Table 32). EDR has increased by approximately 70% in the same time, reflecting upgrading of resource categories. The 2017 Ore Reserves and production figures indicate a 24-year reserve life for operating mines which increases to 36 years when all Ore Reserves are considered (Table 33). Resource life (AEDR) at 2017 production figures is 60 years (Table 33).

Table 32 Changes in tin production, resources and reserves since the previous year (2016), over the past decade (2007) and since records began.

Tin	Change since 2016	Change since 2007	Change since start of records
Annual Production	0.1%	240%	-30% (1974)
Ore Reserves	0.0%	18%	200% (2002)
EDR	-14.6%	70%	25% (1975)
All Resources	0.0%	10%	90% (1975)

Abbreviations: EDR = Economic Demonstrated Resources.

Notes: All Resources = EDR + Subeconomic Demonstrated Resources + Inferred Resources.
Changes since 2016 are more sensitive than those of longer timeframes and are thus presented with a higher level of confidence.

Table 33 Average reserve life and resource life (years) for tin as at December 2017.

Operating Mines[1]			All Deposits		
Ore Reserves[2]	Measured & Indicated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
24	30	43	36	60	125

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. All tin EDR is AEDR (see Table 3). Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

TUNGSTEN

Australia's EDR of tungsten was 386 kt in 2017 (Table 3) down slightly from 391 kt in 2016 (Table 4). Australia holds 12% of the world's economic resources of tungsten (Table 8), and is ranked second behind China and ahead of Russia and Vietnam. Australia's EDR of tungsten occur in Western Australia (52%), Tasmania (27%), Queensland (18%), the Northern Territory (2%) and New South Wales (<1%). Nearly half of Australia's EDR (48%) is contained within the O'Callaghans multi-commodity deposit in Western Australia with large resources also occurring at Dolphin (18%) in Tasmania and at Watershed (11%) and Mount Carbine (7%) in Queensland. The Kara mine in Tasmania (Tasmania Mines Ltd) is Australia's only operating tungsten mine, although the Dolphin project on King Island is under development.

VANADIUM

A key driver of vanadium exploration in Australia has been the increasing interest in battery storage technology in recent years. The present momentum has attracted explorers and developers across areas with historically high vanadium prospectivity. Australia's vanadium EDR increased by 88% in 2017 to 3965 kt (Table 3, Table 4). This represents approximately 18% of the estimated global vanadium resource, ranking Australia third in the world (Table 8). Most of the EDR increases were from companies conducting resource drilling of deposits previously mothballed as they were uneconomic for development. Vanadium EDR in Australia are mostly located in Western Australia at deposits such as Windimurra, Balla Balla, Speewah, Barrambie and Gabanintha, Mount Peak in the Northern Territory and Debella Vanadium in Queensland. Windimurra was once Australia's sole producer but production ceased in February 2014 following fire damage to the plant.

By 2030, the United Nations predicts that 60% of the world's people will live in urban areas and one in three will live in a city of more than half a million inhabitants. Australia is a major supplier of mineral resources used for infrastructure development in Asia and has the potential to continue to be a trusted supplier to new markets over the coming decades. For this, it will be necessary to attract investment to develop Australia's known mineral deposits and to discover the next generation of world-class ore bodies. Australia is a world leader in ethical mineral supply with strong regulations for balancing environmental, social, economic, legal, financial, political and technological support for sustainable resource extraction.

Los Angeles, USA

7. SUMMARY OF RESERVE AND RESOURCE LIFE

Australia has vast resources of many of the 35 major and minor mineral commodities covered in this report as well as unquantified resources of many other minerals, some of which are considered critical for modern and emerging technologies and by trading partners.

It is impossible to state with any certainty how long Australia's resources will last because production rates vary, the economic viability of deposits may change in the future and the rate of new resource delineation rarely matches resource depletion. However, a general impression of the range of possibilities can be gained by deriving the ratio of the various 2017 reserve and resource estimates to 2017 production figures (Table 34). Operating mines have provided the production rates and the ranges for these mines is an average mine life that assumes no new mines are ever developed, no mines are closed or, if so, other mines make up the shortfall in production. Of course, this scenario is highly unlikely to eventuate.

The reserve and resource life estimations for 'all deposits' provide an impression of longer term potential mineral supply in Australia. Using the AEDR/production ratio as the best proxy for a long-term outlook, it is only diamond, gold and manganese ore that have resource lives of less than 50 years (Table 34). The impending depletion and closure of the Argyle mine in Western Australia means the supply outlook for diamonds is particularly grim. Gold is also potentially vulnerable as 70% of gold is extracted from lode-gold deposits, which comprise only 31% of resources (Figure 24).

Table 34 Average reserve life and resource life (years) for selected commodities as at December 2017.

Commodity	Operating Mines[1]			All Deposits		
	Ore Reserves[2]	Demonstrated Mineral Resources[3]	All Resources[4]	Ore Reserves[5]	AEDR[6]	All Resources[7]
Bauxite	9	25	54	25	70	110
Black Coal	23	51	72	33	120	295
Copper	23	82	117	27	100	160
Diamond	2	2	3	2	2	3
Gold	10	23	30	13	35	50
Ilmenite	11	39	51	38	165	359
Iron Ore	11	20	56	27	55	175
Lead	22	66	80	25	80	135
Lithium	47	67	122	79	133	224
Manganese Ore	18	35	41	18	40	140
Nickel	10	29	35	30	110	240
Rutile	7	27	34	22	95	227
Silver	17	59	75	22	80	120
Tin	24	30	43	36	60	125
Uranium	51	284	488	53	230	405
Zinc	22	56	70	30	80	125
Zircon	9	29	34	40	145	283

Notes: Reserve and resource life for each mineral commodity is calculated by dividing the inventory by production. The resulting ratio is a snapshot in time that can only be used for general impressions because it is an average and it assumes (1) that production rates in the future will remain the same as those used in the calculation, (2) deposits deemed economic/uneconomic remain so in the future and (3) that depleted resources are never replaced.

1. Operating mines includes all mines that operated during 2017 and thus contributed to production (see Table 1).
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 1).
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
4. All Resources for Operating Mines includes Measured, Indicated and Inferred Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents (see Table 1).
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents (see Table 2).
6. AEDR = Accessible Economic Demonstrated Resources. Figures rounded to nearest five years.
7. All Resources for All Deposits = EDR + Subeconomic Demonstrated Resources + Inferred Resources. Figures rounded to nearest five years (see Table 3).

Today's social, communication, financial and trading networks are more connected than at any other time in human history. Australia is an important global supplier of the minerals that underpin the modern technology that connects us. Australian mineral exports bring prosperity both to the nation and its trading partners.

8. VALUE OF AUSTRALIAN MINERAL EXPORTS

In 2017, Australian mineral exports (excluding petroleum products) amounted to approximately $179 billion, which was more than 59% of all export merchandise and 46% of all exported goods and services (Table 35). Domestically, mining industries accounted 8.1% of gross domestic product in the 2017 calendar year.

In 2017, mineral export earnings were up 19% on 2016, continuing the previous year's gains. From 2011 to 2015, the Australian economy was subject to large price falls for many mineral commodities, particularly for iron ore and coal. Many commodity prices reached a low in late 2015/early 2016 but subsequent price improvements, together with greater iron ore production, have resulted in increased mineral export revenue in 2016 and again in 2017. Gold has been the exception to the general downward price trend for commodities since 2011. While the gold price in US dollars also peaked in 2011 before falling away, the US-AUD exchange rate has kept the price high in Australian dollars, resulting in strong production and export income.

Quarterly reports published by the Office of the Chief Economist show that the main mineral export earners in 2017 were iron ore (35.3% of total mineral export earnings), black coal (31.9%), gold (9.4%), copper (4.3%), alumina (4.2%), aluminium (1.9%) and zinc (1.9%; Table 36). These same minerals were the main income earners in the previous year (Table 37). However, in 2017, black coal comprised a greater share of mineral export income than in 2016 (up from 26.3%; Table 37). Gold export income in 2017, however, was down 3% from 2016 when it contributed 11.7% to Australia's mineral export income (Table 37). Australia's exports of bauxite increased 17% on the previous year but lower prices meant that this only increased earnings by 12% (Table 37). In contrast, higher prices for alumina in 2017 (up 33%) resulted in Australia's alumina export income also increasing 33% despite no significant change in export volume.

Export earnings in 2017 also increased for iron ore (18%), silver (954%), tin (23%), zinc ore (48%) and refined zinc (55%), despite zinc export volumes only slightly increasing and tin actually falling 56% (Table 37). On the other hand, copper was down in both export volume (-20%) and earnings (-5%) as were lead, gold and nickel (Table 37).

Coal experienced the most significant gains in 2017. Large increases in the coal price resulted in a 51% increase in export earnings for metallurgical coal and a 31% increase in export earnings for thermal coal, despite export volumes of these commodities declining 9% and 1%, respectively (Table 37).

Comparing export earnings to export volume, it is clear that processed mineral commodities are worth more per unit than raw minerals or concentrates, often significantly so. Bauxite in 2017, for example, was worth $40/t whereas alumina was worth $421/t (Table 36). This is a ten-fold increase on the price of alumina; bearing in mind it takes two-to-three tonnes of bauxite to make one tonne of alumina. Further, it takes two tonnes of alumina to make one tonne of aluminium metal which was worth $2589/t in 2017. This is a six-fold increase on the price of alumina and a massive 65-fold increase on the price of bauxite. Similar value-adding is seen in the copper, iron and zinc sector and, to a lesser extent, in the lead sector. Thus any appraisal of the strength of Australia's minerals industry must also include domestic downstream processes, such as refining and smelting, in addition to mineral discovery, mining and raw material exports.

Table 35 Export value ($million) of mineral commodities, resources and energy, merchandise and goods and services, 2011 to 2017.

Category	2011	2012	2013	2014	2015	2016	2017
Total Mineral Exports ($m)	167 867	149 879	162 572	158 312	140 885	150 186	178 999
Total Resources and Energy Exports ($m)	194 607	179 007	190 323	190 859	166 131	175 645	213 046
Total Merchandise Exports ($m)	263 222	249 678	263 456	266 739	250 334	259 071	301 998
Total Goods and Services Exports ($m)	319 539	306 237	323 442	332 120	323 136	336 894	386 677

Note: Total mineral exports includes: metallic minerals, energy minerals (coal and uranium), gemstones, mineral sands and refined minerals (concentrates, bullion, ingot metals).

Source: Office of the Chief Economist (Resources and Energy Quarterly June 2018).

Table 36 Australian export volumes and values of mineral and metal commodities 2017.

Commodity	Export volume	Export earnings ($million)	Value ($/t or $/c)	Percentage of total mineral export earnings
Aluminium—Bauxite	27 199 kt	1099	40	0.6%
Aluminium—Alumina	17 872 kt	7528	421	4.2%
Aluminium—Ingot Metal	1303 kt	3374	2589	1.9%
Black Coal—Metallurgical	172 675 kt	36 300	210	20.3%
Black Coal—Thermal	200 338 kt	20 830	104	11.6%
Copper—Ore and Concentrates	1775 kt	4782	2694	2.7%
Copper—Refined	354 kt	2842	8028	1.6%
Diamonds—Unsorted	16 197 000 c	252	16	0.1%
Diamonds—Sorted Gem	69 000 c	281	4072	0.2%
Gold—Refined	318 t	16 891	53 116 352	9.4%
Iron—Ore	827 186 kt	63 102	76	35.3%
Iron—Crude Steel	390 kt	920	2359	0.5%
Iron—Scrap	1958 kt	819	418	0.5%
Lead—Concentrates	155 kt	442	2852	0.2%
Lead—Refined	219 kt	662	3023	0.4%
Lead—Bullion	127 kt	493	3882	0.3%
Nickel—Ore and Concentrates	172 kt	275	1599	0.2%
Nickel—Refined and Intermediate	173 kt	2170	12 543	1.2%
Silver—Refined	513 t	369	719 298	0.2%
Tin—metal content	6989 t	166	23 752	0.1%
Uranium—Oxide (U_3O_8)	7414 t	594	80 119	0.3%
Zinc—Ore and Concentrates	1551 kt	1800	1161	1.0%
Zinc—Refined	435 kt	1631	3749	0.9%

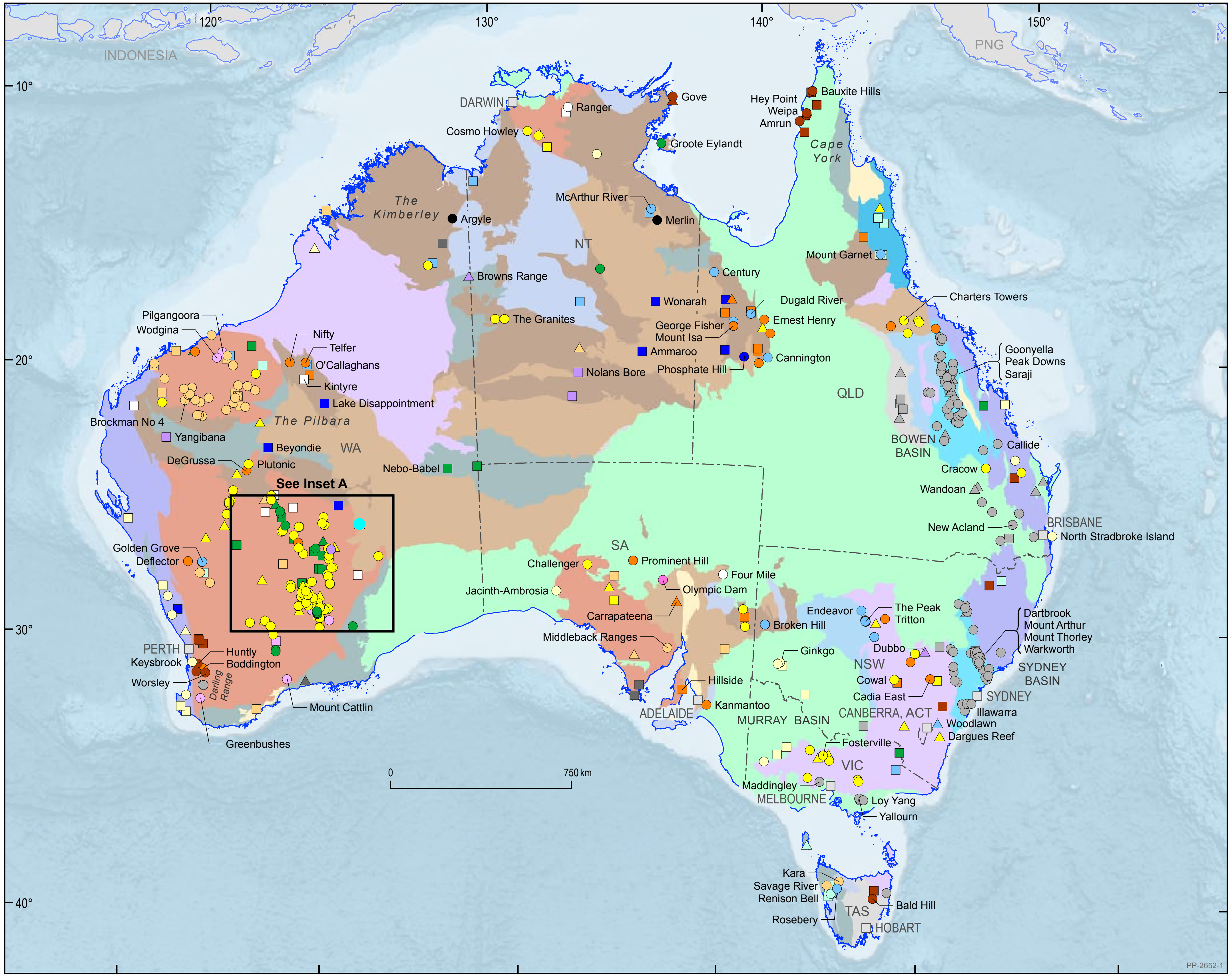
Note: Total mineral export earnings in 2017 were $178 999 million (see Table 35). | **Source:** Office of the Chief Economist (Resources and Energy Quarterly June 2018).

Table 37 Changes in Australian minerals and metal export volumes, earnings and values from 2016 to 2017, along with percentage share of export earnings in 2016 and 2017.

Commodity	Export volume (%)	Export earnings (%)	Value (%)	Percentage of total mineral export earnings 2016	Percentage of total mineral export earnings 2017
Aluminium—Bauxite	↑ 17%	↑ 12%	↓ -4%	0.6%	0.6%
Aluminium—Alumina	0%	↑ 33%	↑ 33%	3.7%	4.2%
Aluminium—Ingot Metal	↓ -9%	↓ 6%	↑ 16%	2.1%	1.9%
Black Coal—Metallurgical	↓ -9%	↓ 51%	↑ 66%	15.8%	20.3%
Black Coal—Thermal	↓ -1%	↑ 31%	↑ 33%	10.5%	11.6%
Copper—Ore and Concentrates	↓ -2%	↑ 2%	↓ -25%	3.1%	2.7%
Copper—Refined	↓ -22%	↓ -5%	↑ 21%	2.0%	1.6%
Diamonds—Unsorted	↑ 17%	↓ -22%	↓ -32%	0.2%	0.1%
Diamonds—Sorted Gem	0%	↓ -12%	↓ -12%	0.2%	0.2%
Gold—Refined	↓ -3%	↓ -5%	↓ -2%	11.7%	9.4%
Iron—Ore	↑ 2%	↑ 18%	↑ 16%	35.5%	35.3%
Iron—Crude Steel	↓ -39%	↑ 77%	↑ 189%	0.3%	0.5%
Iron—Scrap	↑ 24%	↑ 50%	↑ 20%	0.4%	0.5%
Lead—Concentrates	↓ -18%	↓ -14%	↑ 4%	0.3%	0.2%
Lead—Refined	↓ -10%	↑ 13%	↑ 25%	0.4%	0.4%
Lead—Bullion	↓ -17%	↓ -5%	↑ 14%	0.3%	0.3%
Nickel—Ore and Concentrates	↓ -18%	↓ -5%	↑ 17%	0.2%	0.2%
Nickel—Refined and Intermediate	↓ -2%	↑ 8%	↑ 10%	1.3%	1.2%
Silver—Refined	↑ 1325%	↑ 954%	↓ -26%	<0.1%	0.2%
Tin—metal content	↓ -56%	↑ 23%	↑ 176%	<0.1%	0.1%
Uranium—Oxide (U_3O_8)	0%	↓ -35%	↓ -34%	0.6%	0.3%
Zinc—Ore and Concentrates	0%	↑ 48%	↑ 49%	0.8%	1.0%
Zinc—Refined	↑ 10%	↑ 55%	↑ 41%	0.7%	0.9%

Notes: Total mineral export earnings in 2016 were $178 999 million. Value refers to dollars per unit of product, i.e. $/c for diamonds and $/t for all other commodities.
Source: Office of the Chief Economist (Resources and Energy Quarterly June 2018).

MAP OF MAJOR MINES AND MINERAL DEPOSITS IN AUSTRALIA



Geological regions

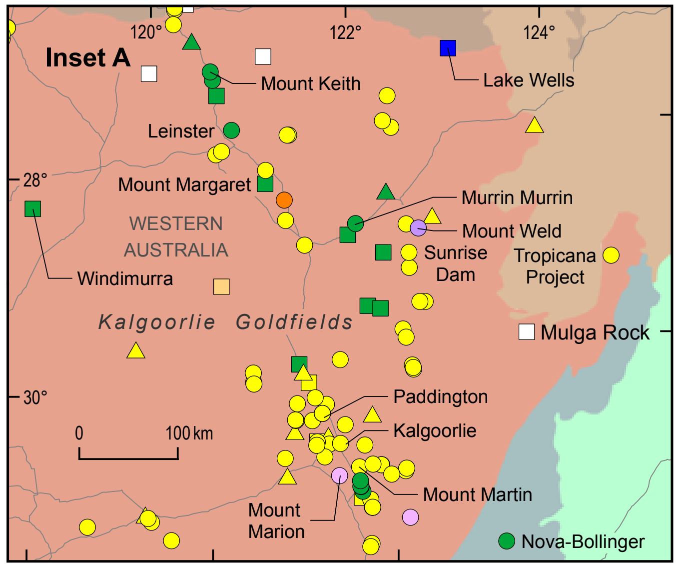
- Cenozoic
- Mesozoic
- Permian
- Carboniferous
- Devonian
- Silurian
- Ordovician
- Cambrian
- Paleozoic
- Neoproterozoic
- Mesoproterozoic
- Paleoproterozoic
- Archean

Commodity type

- Base metals - Cu (Zn, Pb, Ag, Au)
- Base metals - Cu, Au, U
- Base metals - Zn, Pb (Cu, Ag)
- Battery/alloy metals - Ni, Co, Mn, V, Mo
- Bauxite
- Coal
- Diamond
- Fertiliser elements - P, K
- Graphite
- Heavy mineral sands
- Iron ore
- Lithium
- Other metals - Sn, W, Ta
- Precious metals - Au, Ag
- Rare earth elements
- Uranium

Mine status

- Operating mine
- Developing mine
- Mineral deposit



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