Australian Government
Geoscience Australia

Australian Resource Reviews

Lithium 2018

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Resource figures are current as at 31 December 2017.

Lithium (Li) has a bright future in Australia. Although future global demand for lithium is difficult to forecast, most projections are for increasingly positive trends. Certainly the progression of increasing consumption over the last decade points to comparable or greater demand into the future. The primary growth in demand has been driven by the use of lithium in rechargeable batteries, not only for electronic devices but also for electric vehicles and storage of renewable and other energies. Australia is well placed to meet this demand, with many hard-rock, pegmatite-hosted lithium resources, largely in Western Australia. These include the producing Greenbushes Mine, the newly or soon-to-be producing Pilgangoora, Mount Cattlin, Early Grey, Mount Marion and Bald Hill deposits, plus other deposits with significant lithium resources.

Lithium has a range of uses in both chemical and technical applications. Lithium in various forms, such as lithium carbonate, lithium hydroxide and lithium chloride, is used in lubricant greases, pharmaceuticals, catalysts, air treatment and, particularly, in batteries—both non-rechargeable (primary) lithium metal batteries and rechargeable (secondary) lithium-ion batteries.

The major technical application for lithium is for the production of ceramics and glasses, including heat-resistant glass and ceramics such as those used in oven-wear and cook tops. Lithium is also used in fluxes and glazes as it has the highest specific heat of any solid element.

Being the lightest known metal, lithium is also used in alloys to increase strength-to-weight ratios, taking advantage of lithium's tensile strength and light weight (low-density) characteristics. Aluminium-lithium alloys, for example, are used in the aerospace and motorsport industries.

Within the lithium battery sector, growth areas have been in batteries for portable electronic devices, such as mobile phones, computers and rechargeable power tools, as well as batteries and motors for electric bikes, hybrid and electric cars, and other vehicles. Demand for lithium in the electric vehicles segment is forecast to grow rapidly worldwide as major car manufacturers launch new models to secure market share. Various government subsidies and legislation on fuel emissions that promote a decreased reliance on fossil fuels and a cleaner environment are expected to encourage consumers to gradually move towards hybrid, plug-in hybrid or fully electric vehicles. Another potential growth area for lithium usage is for large-scale, grid-connected energy storage for electricity, although ultimate demand will depend on competing energy storage solutions.

Lithium resources occur in two distinct categories: lithium minerals, largely from the mineral spodumene ($Li_2O.Al_2O_3.4SiO_2$), and salts, largely from lithium-rich brines in salt lakes. Canada, China and Australia have significant resources of lithium minerals, while lithium brine is produced predominantly in Chile, followed by Argentina, China and the USA. Lithium brines are the dominant feedstock for lithium carbonate production.

All of Australia's current resources and production are from lithium minerals, chiefly spodumene, though other Li-bearing minerals such as lepidolite are also present. These mineral deposits typically have average grades of 1 to 3% Li_2O and are commonly associated with tin, and especially, tantalum (Ta) mineralisation. Nearly all of Australia's resources are associated with granite pegmatites of Archean age, found within the Pilbara and Yilgarn cratons of Western Australia. The generally small dimensions of host pegmatites, plus poor exposure in the Yilgarn Craton, suggest significant scope for further discoveries in that region.

A 2013 Geoscience Australia study investigated the potential of Australian salt lakes for lithium and other commodities[1]. The report highlighted the Lake Frome and central Gawler regions of South Australia, and the north east Yilgarn Craton of Western Australia, as areas having potential for lithium, although the prospectivity is considered low relative to salt lakes in the Americas. The study, however, also highlighted the need for more comprehensive national groundwater datasets before a proper assessment could be made with respect to the prospectivity of brines beneath Australia's numerous salt lakes within its diverse geologic provinces.

JORC Reserves

As at December 2017, Proved and Probable Ore Reserves of lithium reported in compliance with the JORC Code amounted to 1662 kilotonnes (kt), an increase of 22% on the 2016 figures, and almost a 100% increase since 2015 (Table 1). As of December 2017, Ore Reserves accounted for about 59% of Australia's Economic Demonstrated Resources.

The large and rapid increase in lithium Ore Reserves has resulted from the new mines that have been established over the last two years. In 2017, four lithium mines operated—Greenbushes, Wodgina, Mount Marion and Mount Cattlin (Table 2)—and another four were under development—Bald Hill, Earl Grey and two called Pilgangoora.

Table 1. Australia's Ore Reserves of lithium, production and potential reserve life, 2006-2017.

Year	Proved and Probable Ore Reserves[1] (kt Li)	Production[2] (kt Li)	Reserve Life[3] (years)
2017	**1662**	**21.3**	**78**
2016	1361	14	97
2015	851	n.a.	
2014	854	n.a.	
2013	854	n.a.	
2012	854	12.7	67
2011	506	11.7	43
2010	174	7.3	24
2009	58	5.8	10
2008	n.a.	6.2	
2007	145	7.5	19
2006	145	4.7	31

Notes

kt Li = kilotonnes of lithium content. n.a. = not available.

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. Production sourced from company reports and estimated from information in Western Australian Government publications, with raw data adjusted as needed to reflect lithium content. See annual publications of Australia's Identified Mineral Resources[2] for more information.
3. Reserve life is calculated by dividing the Ore Reserve 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 reserves are never replaced.

1 http://www.ga.gov.au/corporate_data/76454/Rec2013_039.pdf
2 ga.gov.au/AIMR

Table 2. Australia's Ore Reserves and Mineral Resources of lithium at operating mines in 2017.

No. of Operating Mines[1]	Ore Reserves[2] (Li kt)	Measured and Indicated Mineral Resources[3] (Li kt)	Inferred Mineral Resources[4] (Li kt)	Mine Production[5] (Li kt)	Reserve Life[6] (years)	Resource Life 1[7] (years)	Resource Life 2[8] (years)
4	1003	1437	1161	21.3	47	67	122

Notes

kt Li = kilotonnes of lithium content.

Reserve and resource life 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. 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. Lithium production is a Geoscience Australia estimate based on Mineral and Petroleum Statistics Digest 2016–17[3], published by the Department of Mines, Industry Regulation and Safety, Western Australian Government.
6. Reserve Life = Ore Reserves ÷ Production.
7. Resource Life 1 = Measured and Indicated Resources ÷ Production.
8. Resource Life 2 = Measured, Indicated and Inferred Resources ÷ Production.

Identified Resources

Economic Demonstrated Resources (EDR) of lithium were 2803 kt at the end of December 2017, up only marginally from 2730 kt the previous year (Table 3), but increasing by 74% since 2015. The EDR of lithium has massively increased by 1600% in the last 10 years, reflecting the high level of exploration activity and exploration success over that period. Over a similar period, world EDR increase by approximately 370%. Western Australia holds nearly all (>99%) of EDR, with minor EDR (<0.5%) attributed to the Northern Territory. The majority of Australia's lithium resources (approximately 95% of Australia's EDR) occurs within the following deposits:

- Greenbushes Lithium Operations (1320 kt Li, 2013 figure), 250 km south of Perth in the Yilgarn Craton. Greenbushes is the world's largest producing spodumene deposit.
- Mount Marion (~180 kt Li), about 40 km southwest of Kalgoorlie in the Yilgarn Craton.
- Earl Grey (~525 kt Li), near Southern Cross in the Yilgarn Craton.
- Pilgangoora, 120 km south of Port Hedland in the Pilbara Craton. Pilgangoora is spilt into two resources owned by Altura Mining Ltd (~586 kt Li) and Pilbara Mining Ltd (~204 kt Li).
- Wodgina (~240 kt of Li), about 110 km south of Port Hedland in the Pilbara Craton.

Australia had no resources of lithium considered subeconomic at the end of 2017, unchanged from 2016 (Table 3). Inferred Resources of lithium in 2017 (1907 kt) were up almost 200% from 2016 (966 kt; Table 3), and a massive 27 000% over the last decade. Over 99% of Australia's current Inferred Resources of lithium are associated with pegmatite deposits–the exception being ~4 kt in the Narraburra rare earth and rare metals project, located 12 km northeast of Temora in New South Wales.

3 http://www.dmp.wa.gov.au/Documents/About-Us-Careers/AboutUs-StatisticsDigest_2016-17.pdf

Table 3. Australia's identified lithium resources and world figures for selected years, 1990-2017.

Year	Australia						World	
	Demonstrated Resources (kt Li)			Inferred Resources[2] (kt Li)	AEDR[3] (kt Li)	Mine Production[4] (kt Li)	Economic Resources[5] (kt Li)	Mine Production[5] (kt Li)
	EDR[1]	Paramarginal	Submarginal					
2017	**2803**	**0**	**<1**	**1907**	**2803**	**21.3**	**15 700**	**45.5**
2016	2730	0	0	966	2730	14	15 130	34.7
2015	1610	0	0	426	1610	n.a	14 500	32.5
2014	1533			179	1533	n.a.	13 533	36
2013	1538		0.1	139	1538	n.a.	13 538	35
2012	1538		0.1	139	1538	12.7	13 538	37
2011	1006		0.1	131	1006	11.7	13 036	34
2010	483		0.1	90	483	7.3	12 900	25
2009	607		0.1	37	607	5.8	9927	18
2008	584		25	25	584	6.2	4514	27.4
2007	169	54	25	7	170	7.5	4269	25
2006	170	54	26	7	170	4.7	4100	21.3
2005	170	54	26	7	170	3.9	4100	21.3
2004	170	54	26	7	170	1.5	4110	14.5
2003	167	54	26	7	167	3.5	4107	14.5
2002	171	53	25	7	171	3.0	4110	15.1
2001	152	78	26	7		1.7	3403	14.6
2000	157	78	26	7		2.2	3400	13.3
1995	152		3	7		4.1	2200	6.3
1990	150		203	6.5		2.7	2210	5.5

Notes

kt Li = kilotonnes of lithium content. n.a. = not available.

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 commercial, potentially commercial, non-commercial 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. All lithium EDR is accessible.
4. Production sourced from company reports and estimated from information in Western Australian Government publications, with raw data adjusted as needed to reflect lithium content. See annual publications of Australia's Identified Mineral Resources[4] for more information.
5. Source: United States Geological Survey (Mineral Commodity Summaries)[5].

4 ga.gov.au/AIMR

5 https://minerals.usgs.gov/minerals/pubs/commodity/lithium/index.html#mcs

Accessible EDR

Some mineral resources are inaccessible for mining because of environmental restrictions, government policies or because they occur within military lands or national parks. All of Australia's EDR of lithium are considered to be accessible.

Exploration

There are numerous companies mining or exploring for lithium in Australia, largely focussed on Western Australia. Although there are no statistics available on exploration expenditure, much activity has been undertaken over the last few years, as evidenced by the large increases in EDR and Inferred Resources (Table 3).

Production

Total lithium production for 2017 is not known precisely but Geoscience Australia conservatively estimates it to be at least 21.3 kt based on the annual resources publication (2016–17) of the Western Australian Government[6]. Production for the 2017 calendar year is likely greater, driven by increasing extraction at Wodgina, Mount Marion, Mount Cattlin, in addition to Greenbushes (which produces an estimated 30% of world lithium). Production is expected to increase further in 2018 with commencement of mining at both the Pilgangoora deposits in the Pilbara, and at Bald Hill (in the Yilgarn). At a rate of production of 21.3 kt per annum, Australia's current Ore Reserves of lithium are adequate for 79 years, increasing to 133 years when available EDR of lithium are considered (Table 4).

Table 4. 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 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.
2. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents.
3. Measured and Indicated Mineral Resources, inclusive of Ore Reserves, as reported in compliance with the JORC Code, plus non-JORC Code-equivalents.
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.
5. Ore Reserves as reported in compliance with the JORC Code, plus non-JORC Code equivalents.
6. AEDR = Accessible Economic Demonstrated Resources. All lithium EDR is AEDR. Figures rounded to nearest five years.
7. All Resources for All Deposits includes EDR, Subeconomic Demonstrated Resources and Inferred Resources. Figures rounded to nearest five years.

6 Western Australian Mineral and Petroleum Statistics Digest 2016-17; Figure 58.

World Ranking

According to estimates published by the United States Geological Survey (USGS), and modified by Geoscience Australia for Australia, world lithium resources in 2017 totalled about 15 700 kt (Table 5). The resource data do not, however, include Canada. Chile holds approximately 7500 kt, or about 48% of world resources, followed by China with 3200 kt (20%), Australia with 2803 kt (18%) and Argentina with 2000 kt (13%).

World production, based on USGS estimates and modified for Australian production, was estimated to be 45.5 kt of contained lithium in 2017 (Table 6). This total, however, excludes USA production. Australia was the world's largest producer—21.3 kt for 47% of world production—followed by Chile (14.1 kt; 31%), Argentina (5.5 kt, 12%) and China (3 kt, 7%).

Table 5. World economic resources of lithium 2017.

Rank	Country	Lithium (kt Li)	Percentage of world total
1	Chile	7500	48%
2	China	3200	20%
3	Australia	2803	18%
4	Argentina	2000	13%
5	Portugal	60	<1%
6	Brazil	48	<1%
7	USA	35	<1%
8	Zimbabwe	23	<1%
	Total	**15 700**	

Notes

kt Li = kilotonnes of lithium content.

Source: United States Geological Survey[7] and Geoscience Australia. National figures other than Australia are rounded, as is the final total. Percentages are also rounded and might not add up to 100% exactly.

Table 6. World production of lithium 2017.

Rank	Country	Lithium (kt Li)	Percentage of world total
1	Australia	21.3	47%
2	Chile	14.1	31%
3	Argentina	5.5	12%
4	China	3.0	7%
5	Zimbabwe	1.0	2%
6	Portugal	0.4	1%
7	Brazil	0.2	<1%
	Total	**45.5**	

Notes

kt Li = kilotonnes of lithium content.

Source: United States Geological Survey[6] and Geoscience Australia. National figures other than Australia are rounded, as is the final total. Percentages are also rounded and might not add up to 100% exactly.

7 https://minerals.usgs.gov/minerals/pubs/commodity/lithium/index.html#mcs

Industry Developments

Western Australia

Greenbushes: In Australia, Talison Lithium Ltd (51% owned by the Chengdu Tianqui Industry Group and 49% by US-based Albemarle Corporation), is the world's largest producer of hard-rock spodumene, from the Greenbushes Lithium Operations, 250 km southeast of Perth. Mineralisation at Greenbushes occurs within a large Archean pegmatite body in the Yilgarn Craton. Historical mining, largely for tin, has been undertaken in this area since the late 1800s. Lithium mining at Greenbushes commenced almost a century later, in the early 1980s, with the first lithium processing plant commissioned in 1985.

The most recent publicly reported resource figures for Greenbushes date from September 2012, when Talison Lithium Ltd (prior to its acquisition), reported combined Measured and Indicated Resources of 118.4 million tonnes (Mt) grading 2.4% lithium oxide (Li_2O), containing Proved and Probable reserves of 61.5 Mt grading 2.8% Li_2O.

In early 2013, Talison was 100% acquired by the Chinese company Chengdu Tianqi Industry (Group) Co Ltd (Tianqi) through its Australian incorporated, wholly-owned subsidiary, Windfield Holdings Pty Ltd. Tianqi's subsidiaries include Sichuan Tianqi Lithium Industries, the world's largest lithium chemical producer from spodumene, and Sichuan Tianqi Industry Co Ltd, which distributes technical-grade lithium concentrates and is the sole distributor for Talison's technical-grade lithium concentrate in China. In May 2014, Rockwood Lithium Inc (a lithium producer from brines at operations in Chile and in Nevada, USA) acquired a 49% share in Talison Lithium Pty Ltd from Tianqi. In January 2015, it was announced that Rockwood Holdings (a US-based specialty chemicals and advanced materials company), the parent company of Rockwood Lithium, had become a wholly owned subsidiary of Albemarle Corporation, a speciality chemical company, under a merger agreement reached in mid-2014.

In 2017, Talison announced a $320 million expansion to increase plant size and capacity, due for completion 2019, to increase lithium concentrate production capacity of the Greenbushes project to 1.34 Mt per annum (Mtpa). In June 2018, a $516 million, second-stage expansion of Greenbushes was announced, including two additional chemical-grade plants. The latter upgrade, once completed (late 2020), will increase Greenbushes production capacity to 2.7 Mtpa of lithium concentrate (from approximately 9.5 Mtpa of spodumene ore).

Both Tianqi and Albemarle are in the process of building plants in Western Australia, utilising their respective shares of the lithium concentrate from Greenbushes to produce (higher value) battery-grade lithium hydroxide. In 2016, Tianqi announced that it would build a $400 million, lithium hydroxide processing plant in Kwinana, Western Australia, due to be completed late 2018. In October 2017, Tianqi gave the go-ahead for the $300 million Stage 2 of the Kwinana plant, with scheduled commissioning in late 2019. The company indicates the plant will have a capacity of 48 kt per annum (ktpa) of battery-grade lithium hydroxide, making the Kwinana plant the world's largest lithium hydroxide producer. Albemarle plans to build its lithium hydroxide plant at Kemerton, 17 km southeast of Bunbury, Western Australia. Initial capacity would be 20 ktpa, with possible staged expansion over 10 years, up to 100 ktpa.

Mount Cattlin: The Mount Cattlin lithium-tantalum mine (hard-rock spodumene) near Ravensthorpe is 100% owned by Galaxy Resources Ltd. The Mount Cattlin ore body is located within flat-lying pegmatites. The deposit recently recommenced production following an earlier period of mining between 2010 and 2012. During the first phase of mining, the Mount Cattlin deposit had a reported JORC Code Mineral Resource

(Feb 2011) of 18 188 kt at an average grade of 1.08% Li_2O, containing an estimated 197 kt of Li_2O. Production at the Mount Cattlin deposit ceased in July 2012, with a year's supply of spodumene feedstock stockpiled. Prior to cessation, Galaxy was producing lithium from the deposit as spodumene feedstock to its wholly-owned lithium carbonate plant in the Jiangsu Province of China. In March 2013, Galaxy signed a three-year agreement with Talison to purchase spodumene feedstock for the Jiangsu plant from Talison, rather than producing it themselves from Mount Cattlin. Until operations were suspended, the Mount Cattlin deposit had mined 616.714 kt of ore grading 1.11% Li_2O for 63.863 kt of spodumene grading 6.18% Li_2O. In April 2014, Galaxy entered into an agreement, revised in February 2015, for the sale of 100% of the Jiangsu lithium carbonate plant in China to Sichuan Tianqi Lithium Industries Inc.

In 2015, Galaxy Resources entered into an agreement (with a purchase option) with General Mining Corporation Ltd for the latter to take over the operation of Mount Cattlin, with the aim of bringing the deposit back into production. The agreement was modified in early June 2015, with General Mining to supply the resources needed to recommence production at Mount Cattlin by March 2016. General Mining was to earn 50% equity interest and to be sole operator and manager. In May 2016, Galaxy via a successful takeover of its Mount Cattlin joint venture partner General Mining resumed 100% ownership of the project.

Following upgrading, the recommissioned facility was reopened with production recommencing in April 2017. Reported production was approximately 156 kt of lithium concentrate for the 2017 calendar year. In June 2018, the Mount Cattlin deposit had a reported JORC Code Mineral Resource of 11.8 Mt at an average grade of 1.25% Li_2O and 174 grams per tonne (g/t) tantalum pentoxide (Ta_2O_5), containing an estimated 148 kt of Li_2O, based on a cut-off grade of 0.4% Li_2O. These figures include 10.4 Mt in the Measured and Indicated categories.

Mount Marion: The Mount Marion lithium project, 40 km southwest of Kalgoorlie is held by Reed Industrial Minerals (RIM) Pty Ltd. The company is jointly owned by Mineral Resources Ltd (43.1%), Neometals Ltd (13.8%) and Chinese company Jiangxi Ganfeng Lithium Co Ltd (43.1%). The Mount Marion deposit consists of a series of shallow-dipping, parallel sheets of spodumene-bearing pegmatites within mafic-ultramafic volcanic rocks. The pegmatite sheets are more than 20 m thick.

Initial mining at Mount Marion commenced in late 2016 with the first shipment of 6% and 4% Li_2O concentrates in February 2017. Production rates at that time were targeting 400 ktpa of a mix of 6% and 4% concentrates. Reported export production for the 2017-18 financial year was 209 kt of 6% concentrate and 173 kt of 4% concentrate. Forecast production for the 2018-19 financial year is for approximately 370 kt of 6% concentrate and approximately 70 kt of 4% concentrate. The company is installing additional processing facilities (commenced 2018) targeting nameplate 450 ktpa with all spodumene concentrate produced with a 6% lithium content, by the first quarter of 2019.

As at October 2018, the deposit has total JORC resources of 71.3 Mt at 1.37% Li_2O for a contained Li_2O resource of approximately 970 kt, based on a cut-off grade of 0.5% Li_2O. Indicated Mineral Resources account for 31% of the total JORC resources. Depletion of the resource by mining since the previous resource figures (October 2016) is estimated at 6.9 Mt.

Earl Grey: The Earl Grey deposit (Mount Holland Lithium Project), jointly owned by Kidman Resources Ltd (50%) and Chilean-headquartered Sociedad Quimica y Minera de Chile (SQM; 50%) is located close to Southern Cross, in Western Australia. In early 2016, Kidman acquired the Mount Holland gold project in the Forrestania Greenstone Belt, initially for gold exploration. In April 2016,

Kidman announced the identification of lithium in pegmatites at Mount Holland and the commencement of a technical review investigating the lithium potential. Analysis (May 2016) of available drill core through the pegmatites confirmed the potential. Drill testing commenced in mid-2016 and Kidman announced an initial resource for the Earl Grey deposit in December 2016. The deposit is located within shallow-dipping, spodumene-petalite-bearing pegmatite sills, including beneath the historic Earl Grey gold pit. The resource estimate (March, 2018) for Earl Grey comprises 189 Mt at 1.50% Li_2O of which 91% is in the Measured or Indicated categories.

In September 2017, Kidman announced that the company had entered into a 50/50 joint venture with SQM—Western Australia Lithium Pty Ltd (WAL)—to build a mine and concentrator adjacent to the Earl Grey deposit. The joint venture would also investigate the possible development of a refinery for lithium hydroxide and/or lithium carbonate production, using spodumene concentrate from the Earl Grey deposit. In mid-2018, Kidman announced that WAL had options for a site in Kwinana as the location for the planned lithium hydroxide refinery and would be undertaking a definitive feasibility study (DFS). According to WAL, the refinery would be commissioned by 2021 with an initial nameplate capacity of approximately 45 ktpa of lithium hydroxide. A favourable prefeasibility study on the refinery, along with an updated scoping study on the mine and concentrator, was released in October 2018.

Bald Hill: The Bald Hill lithium and tantalum deposit (100% owned by Alliance Mineral Assets Ltd; previously owned equally by Alliance and Tawana Resources NL) is located approximately 105 km southeast of Kalgoorlie. It was initially mined for tantalum with some 820 000 pounds (lb; converts to 372 t) of Ta_2O_5 produced between 2002 and December 2005 (Haddington Resource Ltd, now Altura Mining). The region was also mined for alluvial tantalum in the 1970s and 1980s.

Alliance announced in late 2016 that spodumene was present in tantalite ore at the pegmatite deposit and commenced metallurgical test work and exploration and resource drilling. A maiden lithium mineral resource was released in mid-2017. Using a cut-off above 0.3% Li_2O, the deposit (as of June 2018) has total lithium resources of 26.5 Mt at 1.0% Li_2O of which 11.3 Mt at 1.0% Li_2O and 160 parts per million (ppm) Ta_2O_5 are classed as Ore Reserves. Using cut-offs below 0.3% Li_2O and above 200 ppm Ta_2O_5, the deposit also has a tantalum Ore Reserve of 2.0 Mt at 313 ppm Ta_2O_5. Initial production of lithium and tantalum commenced at Bald Hill in March 2018 with the first shipment of concentrates in May that year. Alliance report production for the 2018 calendar year of approximately 68.5 wet metric tons of spodumene concentrates (6% Li_2O) and approximately 95 000 lb (43 t) of Ta_2O_5. The company is targeting production of 180 kt of spodumene concentrates (6% Li_2O) and 330 000 lb (150 t) of Ta_2O_5 in 2019, increasing to 240 kt and 470 000 lb (213 t), respectively, in 2020.

Wodgina: The Wodgina deposit (100%-owned by Mineral Resources Ltd) is located approximately 110 km south of Port Hedland. It has a long history of production, since discovery in the early 1900's, being mined for tin and, more significantly, as one of the world's largest tantalum deposits. Tantalum was mined for many years until its closure in 2012 by then-owner Global Advanced Metals Pty Ltd (GAM). Tantalum and lithium are both located within a series of mostly flat to shallow-dipping pegmatites. Mineral Resources Limited (Min Res) purchased the Wodgina deposit and tenements and associated infrastructure from GAM in late 2016, with GAM retaining tantalum rights. Following the purchase, Min Res undertook exploration and development, releasing an updated mineral resource in July 2017. Taking advantage of the existing mine and infrastructure, the company commenced lithium mining at Wodgina in March 2017, with

first shipment of direct shipping ore (DSO) in April 2017. The company exported some 720 kt DSO in the 2016–17 financial year and 3482 kt DSO in 2017–18.

Min Res announced in June 2018 that it would slow DSO production and exports to concentrate on producing spodumene concentrates. Min Res is currently upgrading its facilities for this purpose (commenced late 2017), with planned annual production of 750 ktpa of 6% Li_2O spodumene concentrate. Commissioning is currently expected to be in the first half of 2019. Estimated production for the 2018–19 financial year is 660 kt DSO and 244 kt spodumene concentrate. The company is targeting steady state production of 750 ktpa of spodumene concentrate by mid-2019.

Current resource figures (Oct 2018) for the Wodgina pegmatite are 236.92 Mt at 1.19% Li_2O (and 0.016% Ta_2O_5), based on a 0.50% Li_2O cut-off, of which 177.04 Mt at 1.19% Li_2O are in the Indicated category. Of these resources, 151.94 Mt at 1.17% Li_2O are classified as Probable Reserves. The deposit also has resource figures for the tailings (from previous tantalum production) of 22.27 Mt at 0.96% Li_2O (and 0.019% Ta_2O_5), of which 19.87 Mt at 1.02% Li_2O are in the Indicated category.

Min Res is currently undertaking a prefeasibility study into a lithium hydroxide plant. The company is investigating two 28.4 ktpa lithium hydroxide modules, aiming to convert at least 51% of spodumene concentrate from Wodgina. In May 2018, Min Res announced it was looking for partners to take up joint venture of the deposit and infrastructure. The company entered into a non-binding exclusivity agreement signed with USA-company Albemarle Corporation in November 2018 for potential purchase of 50% of the Wodgina Lithium Project and formation of a 50/50 joint venture producing spodumene concentrate (tantalum rights at the deposit would stay with GAM). The joint venture would also jointly fund, design and build a lithium hydroxide plant at Wodgina, with expected final production of 100 ktpa of lithium hydroxide.

Pilgangoora (Pilbara Minerals Ltd): In July 2014, Pilbara Minerals Ltd announced that it had completed acquisition of the Pilgangoora tantalum-lithium project, 150 km southeast of Port Hedland, from Global Advanced Metals Wodgina Pty Ltd. The project is centred on a swarm of Archean pegmatite dykes (Pilgangoora pegmatite field) in the Pilbara region and is along strike from Altura Mining's Pilgangoora lithium project. Mineralised zones within the pegmatites contain spodumene and the lithium-bearing mica lepidolite, as well as tantalum- and tin-bearing minerals.

Pilbara Minerals announced an increase in resources (Sept 2018) to 226 Mt at 1.27% Li_2O and 116 ppm Ta_2O_5, for a contained 2.87 Mt of Li_2O, (including 1.76 Mt in the Measured and Indicated categories). These figures include both **Pilgangoora** and **Lynas Find** deposits. Previously, the Ore Reserve (Sept 2017) had increased significantly to 108.2 Mt at 1.25% Li_2O and 120 ppm Ta_2O_5 for a contained 1.36 Mt of Li_2O, of which 22.1 Mt at 1.30% Li_2O and 135 ppm Ta_2O_5 were in the Proved category.

Pilbara Minerals completed Stage 1 of a 2 Mtpa DFS in September 2016. Construction of Stage 1 was completed in mid-2017, with first production of spodumene and tantalite concentrates in mid-2018. Stage 1 was designed to achieve an annual production rate of 330 ktpa of 6% Li_2O spodumene concentrate and approximately 300 000 lb (136 t) of tantalite concentrate, with full capacity expected to be realised in early 2019. Pilbara Minerals followed up on Stage 1 with a feasibility study for a Stage 2 expansion that would increase processing capacity to 5 Mtpa, and allow it to produce up to 850 ktpa of 6% Li_2O spodumene (and up to a 1 000 1000 lb of Ta_2O_5 per annum). The positive DFS was released in August 2018 with results indicating that Pilgangoora would have an estimated 17-year mine life.

The mine officially opened in November 2018. Pilbara Minerals has been producing DSO from early 2018 as part of a mine-gate sales agreement with Atlas Iron Ltd. Atlas made their first shipment of Pilgangoora lithium DSO in June 2018. By mid-2018, Pilbara Minerals had produced their first spodumene and tantalum concentrates, with their first shipment (approximately 8.8 kt of 6% Li_2O spodumene concentrate) in October 2018. According to company figures, Pilbara Minerals had produced some 28 kt of 6% Li_2O spodumene concentrate by early November 2018.

As part of Stage 2 off-take agreements, Pilbara Minerals, through their agreement with the South Korean industrial company POSCO (listed on the Korean Stock Exchange), has the opportunity to participate in a joint venture (30%) for a downstream (30 ktpa) lithium carbonate/lithium hydroxide plant in South Korea.

Pilgangoora also produces a tantalum by-product (June 2017 Ore Reserve of 22 000 000 lb of Ta_2O_5). Initial offtake of the tantalum concentrate (100 000 lb of contained Ta_2O_5 as 4-5% concentrates) has been secured (in part) by Global Advanced Metals Pty Ltd. Pilbara reports that additional tantalite concentrate is expected to be sold as 25-30% Ta_2O_5 final concentrate, as production capacity increases. Pilbara Minerals also holds lithium tenements in the Mount Francisco and Lynas Find regions in the Pilbara.

Pilgangoora (Altura Mining Ltd): The Altura Lithium Project at Pilgangoora, 90 km south of Port Hedland in the Pilbara region of Western Australia is wholly owned by Altura Mining Ltd. Mineralisation at Pilgangoora comprises 15 outcropping-to-shallow, spodumene-bearing pegmatites. The Altura Pilgangoora Mineral Resource (as of May 2018) was 50.5 Mt at 1.01% Li_2O, for a contained 512 kt of Li_2O. This resource includes 38 Mt and 8.7 Mt in Indicated and Measured categories, respectively. Ore Reserve estimates (May 2018) were 41.4 Mt at 1.05% Li_2O for 432 kt of contained Li_2O (including 8.3 Mt in the Proved category).

Following positive scoping studies, Altura undertook a DFS, completed in September 2016, which confirmed the viability of the project. Construction of Stage 1 commenced in March 2017 with mining starting in May that year. Production of lithium concentrate commenced July 2018 and the mine was officially opened September 2018. In October 2018, Altura completed its first shipment of approximately 5 kt of spodumene concentrate (>6% Li_2O) and by December 2018 it had shipped 24 kt. The mine has a Stage 1 production capacity of 220 ktpa of spodumene concentrate and the company plans to dispatch two shipments per month once nameplate capacity is achieved. In April 2018, Altura completed a positive DFS on a potential Stage 2 expansion to approximately 440 ktpa, with a final investment decision yet to be made. The Stage 2 DFS indicated an estimated mine life of 13 years.

Northern Territory

Finniss project: The Finniss Lithium Project, approximately 15 km south of Darwin, is 100% owned by Core Lithium Ltd (previously Core Exploration). The project area is within the Bynoe pegmatite field, a belt of more than 100 pegmatites previously mined for tin and tantalum. As documented by Core, initial exploration in this region for lithium was hampered by lack of surface expression and the extent of mineralisation was not realised until deeper drilling was undertaken in 2016.

The pegmatite field comprises a number of prospects. Core released a maiden resource for the **Grants** prospect in May 2017 with Indicated Resources of 492 kt at 1.5% Li_2O and Inferred Resources of 1312 kt at 1.5% Li_2O. In January 2019, Core released updated resource figures for the the Grants, **BP33**, **Sandras**, **Carlton** and **Hang Gong** deposits, with a total resource of 8.55 Mt at 1.44% Li_2O of which 2.54 Mt are in the Indicated or Measured categories. More than

one third of the total resource is contained within the Grants deposit; 2.89 Mt at 1.48% Li_2O, of which 1.91 Mt is Measured or Indicated.

A positive prefeasibility study was completed in June 2018, centred on production from the Grants deposit. Key outputs included an initial mine life of 26 months, producing 400 kt of spodumene concentrate, with a payback period of 12 months. Core is presently focussed on developing the Finniss project with construction suggested to commence in mid to late 2019 and production shortly after. The company is presently undertaking a DFS, due for completion in early to mid-2019. Core was granted a Mineral Lease in late 2018.

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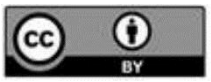

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