Best in Class:

Australia's Bulk Commodity Giants

AUSTRALIAN IRON ORE:
When Quality Meets Opportunity

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Australia is truly in a unique position on iron ore – not only does it have proximity to the largest and fastest growing markets, but it is also endowed with vast, low cost, high quality iron ore resources.

These resources are being developed to supply products that are well suited to the high efficiency, large coastal steel mills in Asia.

Combining these attributes with a highly skilled and stable workforce of mining and metallurgical professionals has resulted in Australia having arguably the most efficient and profitable iron ore industry in the world.

The Pilbara iron ore industry is a major contributor to the Australian economy, with 2019 exports accounting for more than $97bn in revenue.

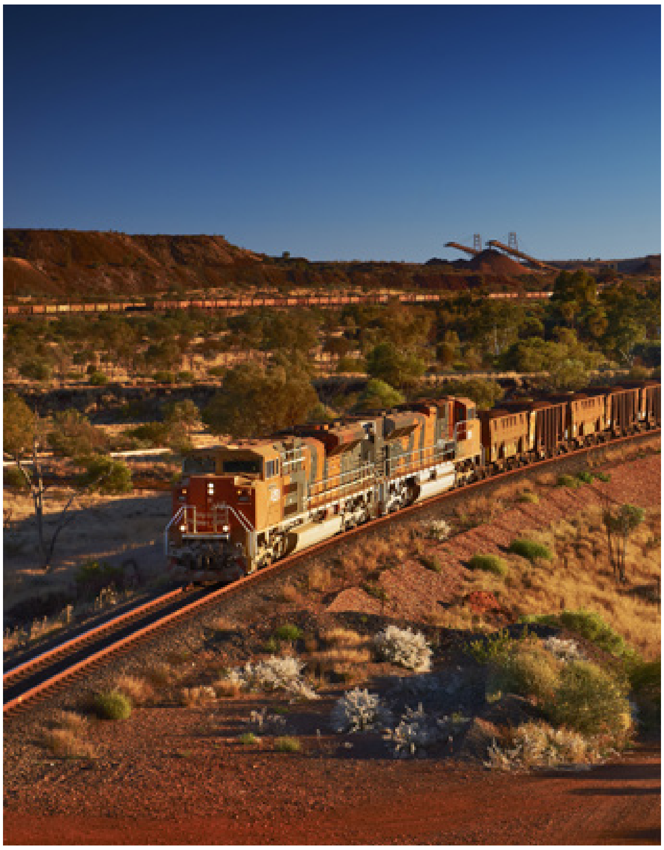
Building this massive industry did not happen overnight. It has been a six-decade journey involving painstaking exploration, loyal customer development and support, major infrastructure investments, and the development of new iron ore products from resources previously thought unsaleable.

The result is that the Pilbara has become to the global iron ore industry what the Silicon Valley is to global technology.

Australian iron ore has become almost indispensable for the world's great steel makers who in turn have enabled the great economic development of the past half century.

And at the heart of Australia's world leading iron ore industry lies the unique characteristics of Australia's iron ores and the value contained within them which has been unlocked through decades of technical collaboration between miners and steel makers.

To understand the evolution of the Pilbara iron ore industry requires an understanding of the quality attributes that have made Australian iron ores the critical iron ore supply of choice for Asian steel mills.



Pilbara iron ore exports generated $97 billion in revenue in 2019

Global seaborne iron ore

Global seaborne iron ore is characterised by major supply basins in the southern hemisphere and major consumers in the northern hemisphere.

The majority of iron ore (more than 70 per cent) trades in the seaborne market, with relatively small volumes being produced and consumed domestically.[1]

China is by far the largest importer of iron ore, representing more than two-thirds of total world trade in iron ore.[2]

Japan, the country which initiated the development of the Pilbara iron ore industry in the 1960s and 1970s – and for more than 30 years the major market for Australian producers – still represents the world's second largest market, importing close to 120 million tonnes per annum (Mtpa).

Asia as a whole represented around 90 per cent of total seaborne imports in 2019, providing Australian producers with a major advantage in terms of proximity to market, as freight can represent a sizeable proportion of the landed cost of iron ore.

In addition to the freight advantage, Australia enjoys the shortest voyage time to market (14 days from Pilbara ports to Asia vs 40 days sailing from Brazil to Asia), enabling more efficient inventory management.

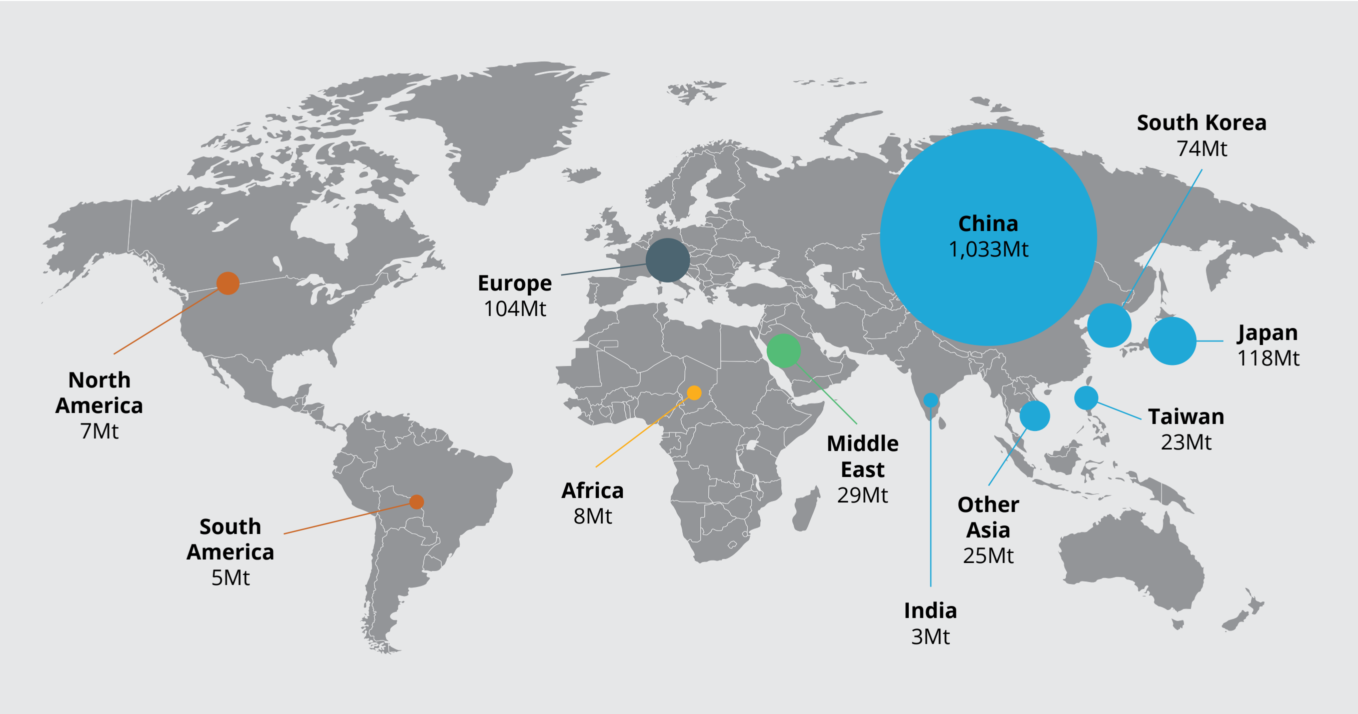
European imports have been in slow decline over the past decade as their steel industry shrinks and the global steel industry centre of gravity continues to move to Asia. North American seaborne imports are small as 70 per cent of US steel is produced from recycled steel scrap, rather than from iron ore.

Australia is by far the largest supplier, having shipped over 890 million tonnes (Mt) in 2019, exporting more than double that of Brazil, its major competitor. All of Australia's exports were sold into Asia in 2019, with more than 80 per cent going to China.

1 CRU Market Outlook, 2020 Q2 Edition.

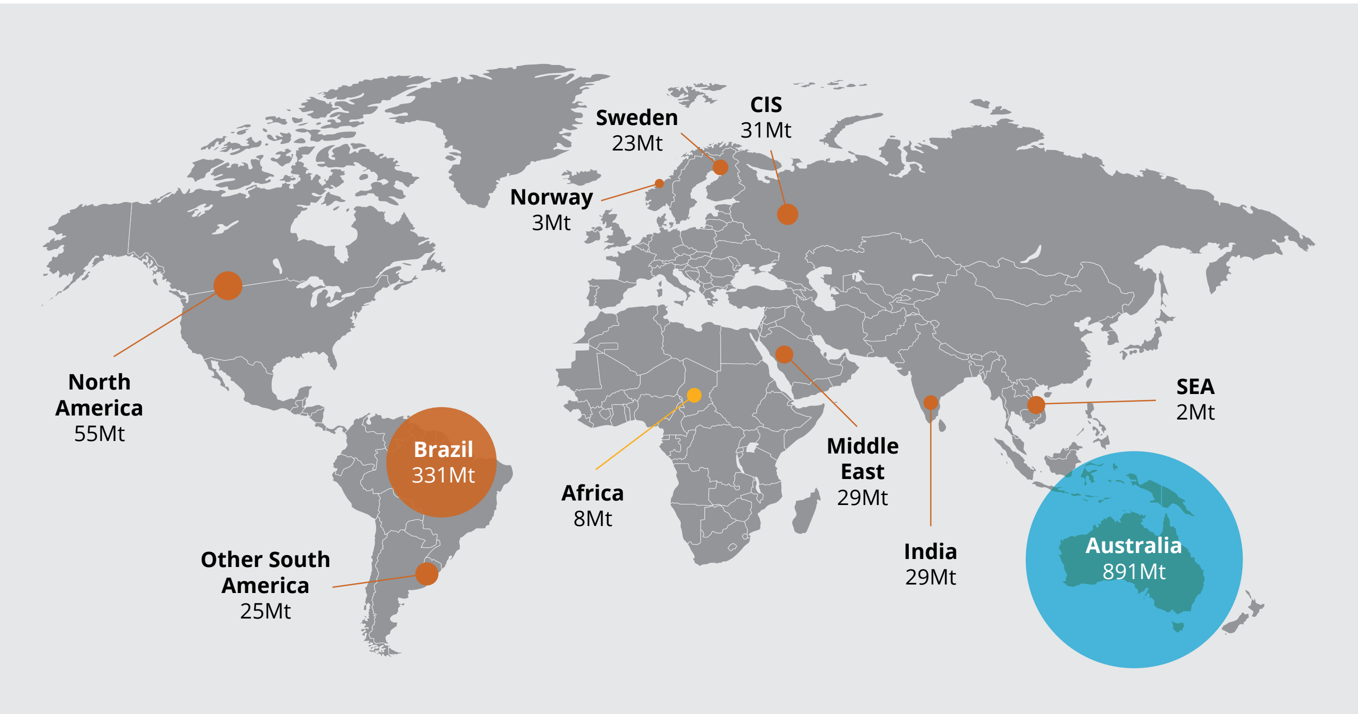
2 Department of Industry, Science, Energy and Resources, Commonwealth of Australia Resources and Energy Quarterly September 2020.

FIGURE 1: ESTIMATED SEABORNE IMPORTS 2019 (MT, WET)



Source: CRU Market Outlook.

FIGURE 2: ESTIMATED SEABORNE EXPORTS 2019 (MT, WET)



Source: CRU Market Outlook.

Iron ore resources

Ore in the ground underpins the success of all resources industries, and Australia is well endowed with large, high quality hematite resources capable of producing low cost, direct shipping ore (DSO) products suited to modern steel mill requirements.

DSO's ability to be used in a steel mill in its natural form without requiring costly grinding and concentration has been the key to the Pilbara's success. This enables the rapid development of mining projects at capital and operating cost intensities well below those of lower grade ores like the Brazilian itabirites and North American and Asian magnetites, both of which require complex capital and energy intensive processing.

Iron ore resources can vary widely in grade, from 67 per cent Fe for the highest grade hematite DSO ores typical of Vale Brazil's Northern System and BHP's Mt Whaleback mine, to less than 20 per cent Fe for the majority of China's low grade magnetite deposits.[3]

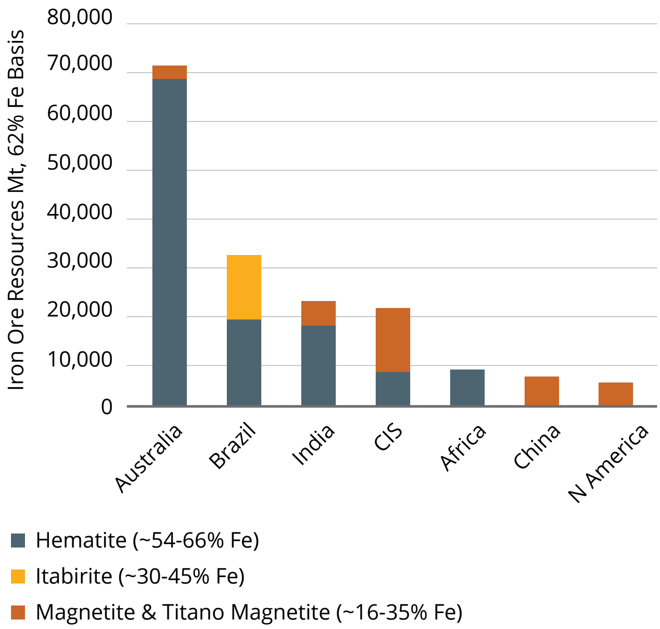
Tonnages need to be normalised for Fe content to enable valid resource size comparisons. Although not an exporting country, China produces an estimated 250 Mtpa of domestic concentrates.[3] As a substitute for seaborne imports, Chinese domestic production is a major determinant of the size of the contestable Chinese import market.

Major iron ore producing country resources

Australia has the largest iron ore resource base in terms of iron units – more than twice that of the second largest resource in Brazil on a 62 per cent Fe basis.[4]

Over 96 per cent of Australia's current Joint Ore Reserves Committee (JORC) compliant resource base is high grade hematite, capable of DSO production, requiring only simple crushing and screening to lump (-32mm +6.3mm) and fines (-6.3mm) product sizing, and in some cases including simple wet processing and beneficiation to produce saleable iron ore lump and fines products.

FIGURE 3: GLOBAL IRON ORE RESOURCES OF KEY PRODUCING COUNTRIES

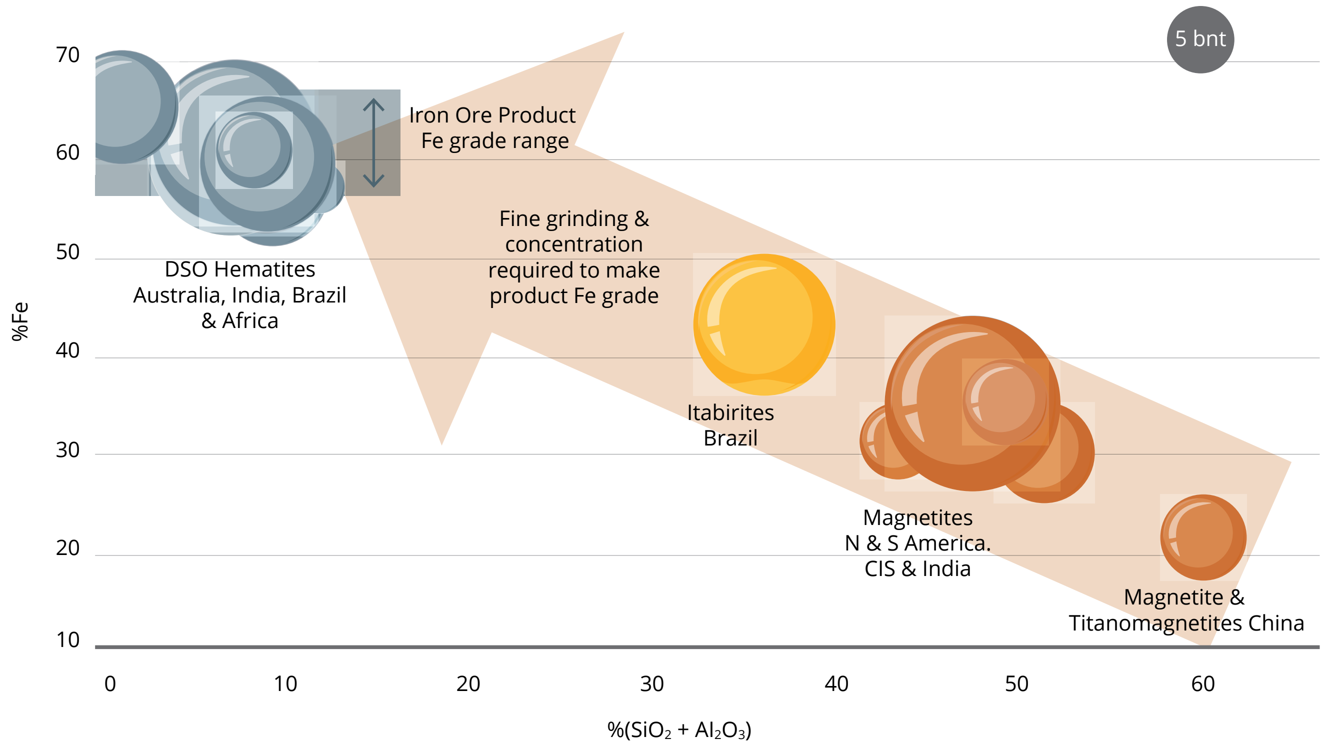


Source: Australia, Brazil, India & N America resources based on producer company resource statements and presentations; CIS, Africa and China based on a combination of company reports, CISA publications, and USGS reports from https://www.usgs.gov/centers/nmic/iron-ore-statistics-and-information.

[3] Greg Pan, *China Macro Economy and Mining Industry*, IMARC Melbourne, 2017.

[4] Australia, Brazil, India & N America resources based on producer company resource statements and presentations; CIS, Africa and China based on a combination of company reports, CISA publications, and USGS reports from https://www.usgs.gov/centers/nmic/iron-ore-statistics-and-information. Note that Australian resources are for hematite only and exclude magnetite.

FIGURE 4: IRON ORE RESOURCE QUALITY OF KEY PRODUCING COUNTRIES



Currently, 70 per cent of Australia's DSO production is crushed and screened dry, with the balance wet processed/ beneficiated. Both processing routes have low capital intensity and energy requirements as they negate the need for fine grinding.

In addition, Australian DSO operations typically have ore to product ratios around 1.2:1, compared to 5:1 typical in many Chinese magnetite mines. This enables rapid production expansion as less ore requires mining and processing for a tonne of finished product.

As well as being endowed with the world's largest iron ore resources, Australian ores sit at the high end of the quality spectrum as illustrated in Figure 4. The high Fe and low gangue (silica and alumina) of Australian resources reduces the processing required to make a saleable product, leading to lower capital and operating costs and shorter project development lead times.

The DSO hematite resources of Australia, India, Brazil and Africa are in their own league compared to the lower grade Brazilian itabirites and magnetites around the world.

The DSO resources are inside the iron ore product Fe band, where their Fe grades are sufficiently high (and gangue content sufficiently low) to be capable of producing saleable iron ore grades in their natural state, without requiring extensive processing.

The Brazilian itabirites typically contain around 35-45 per cent Fe and require capital and operating cost intensive fine grinding and concentration to produce saleable products. Still, they are superior to the magnetite deposits of North America and the Commonwealth of Independent States (CIS).

Magnetite deposits are generally finer grained and harder than itabirites, requiring significantly more energy to liberate ore from gangue prior to concentration. The Chinese magnetite and titanomagnetite deposits underpinning the current approximately 250 Mtpa of domestic production are amongst the lowest grades being mined in the world.

Advantage Australia

The lifting of the Australian embargo on iron ore exports in 1960 heralded the beginning of the Australian iron ore export industry. It unleashed the pioneering geologists to explore the remote Pilbara region of Western Australia for deposits and incentivised the entrepreneurs to initiate the iron ore developments.[5]

The industrialisation of Japan drove the early Pilbara development in the 1960s and 1970s, taking Pilbara production to more than 100Mtpa by the 1980s.[6] This was followed by the development of Taiwan and South Korea in the 1970s and 1980s, driving exports to more than 200 Mtpa by the early 2000s.

The industrialisation of China initiated the Pilbara's 21st century mining boom, increasing Australian exports to more than 800 Mtpa by 2016.

FIGURE 6: AUSTRALIA VS BRAZILIAN IRON ORE EXPORTS 2005 TO 2019 (WET METRIC TONNES)

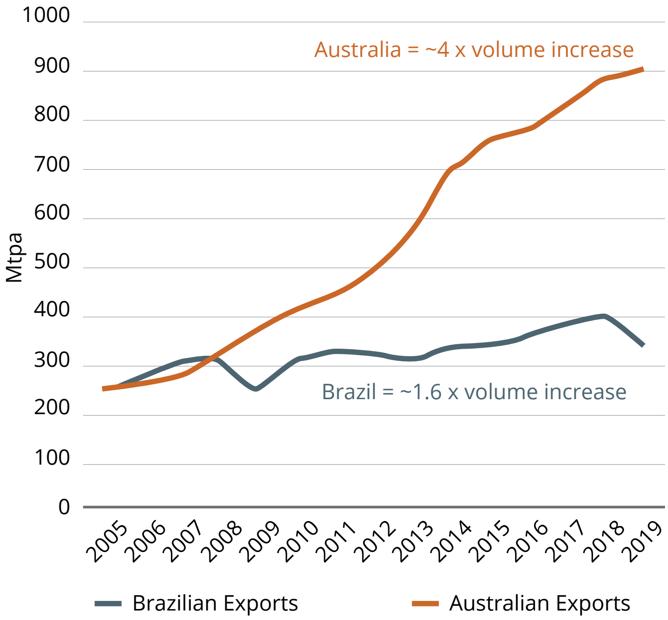
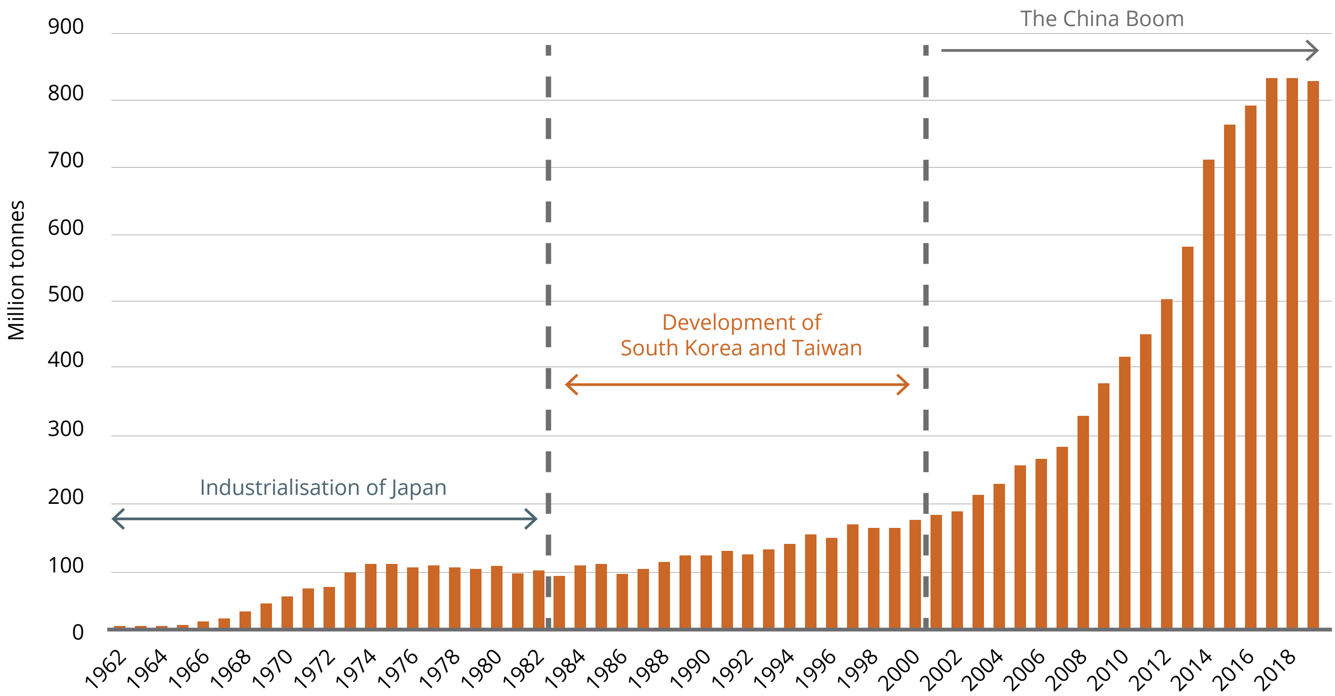


FIGURE 5: AUSTRALIAN IRON ORE PRODUCTION (DRY METRIC TONNES) 1962 TO 2019



Source: DMIRS and CoCE.

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5 *Iron Country: Unlocking the Pilbara*, David Lee, Minerals Council of Australia, June 2015.

6 Western Australia Government, Department of Mines, Industry regulation and Safety, Latest Statistics Release, 2019-20.

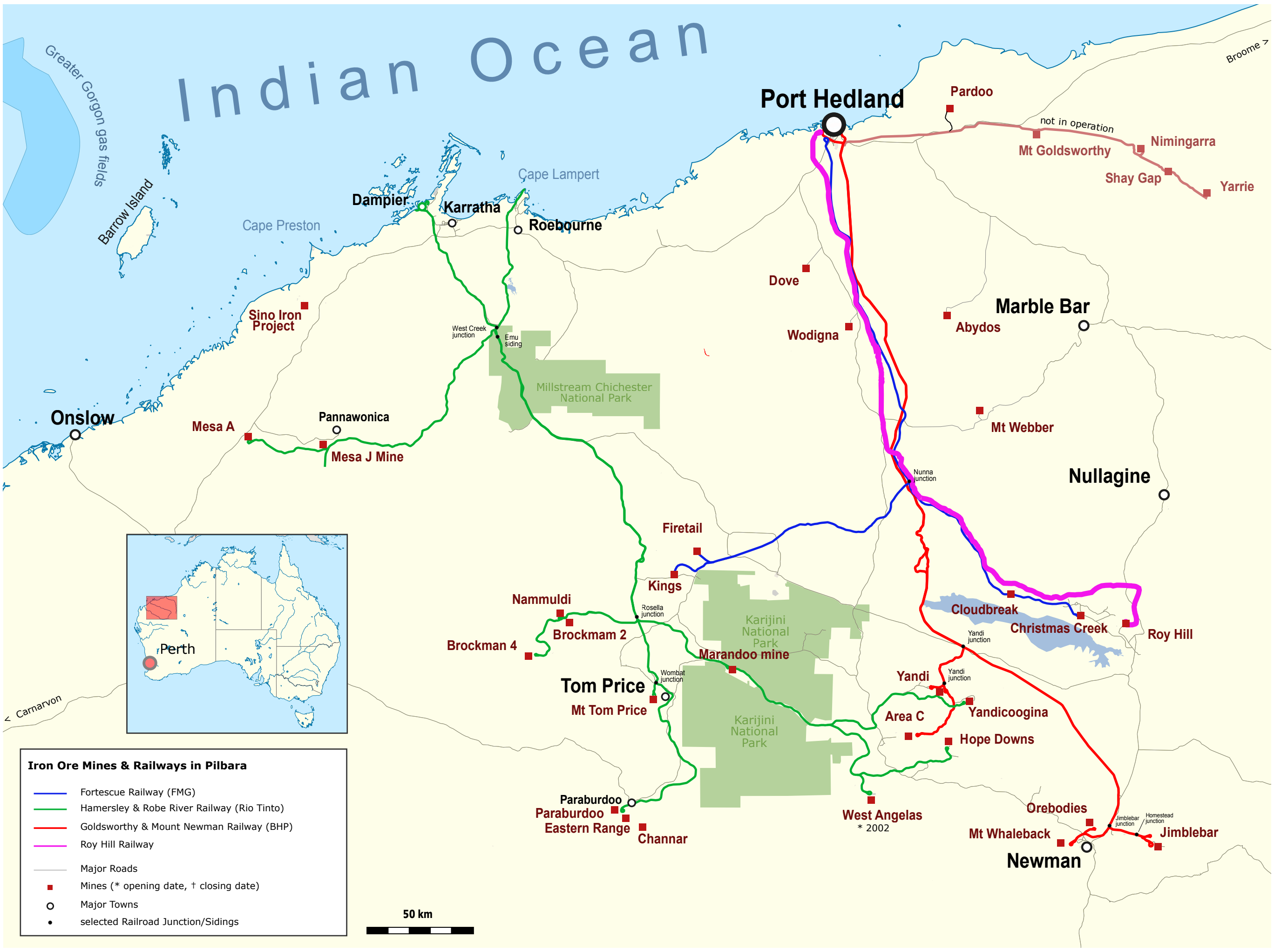
Australian producers were quick to capitalise on the rapid increase in Chinese demand, overtaking Brazil as the largest iron ore exporting country around 2007-08.

Australian production grew almost fourfold during the period 2002- 2018, while Brazilian exports only increased by 1.6 times. The speed of development was unprecedented in Australian mining history.

During this period over US$93 billion was invested in Pilbara iron ore projects, with two major new producers – Fortescue Metals Group (FMG) and Hancock Prospecting's Roy Hill – emerging, complete with their own mine, rail and port infrastructure.

The Pilbara today is home to a vast network of mines, heavy haul rail and port infrastructure exporting almost 2.5 Mt of iron ore each day.

FIGURE 7: MAP OF THE IRON ORE MINES & RAILWAYS IN THE PILBARA REGION OF WESTERN AUSTRALIA



Source: Main map was created using Open Street Map Data, rendering with Maperitive and editing with Inkscape.

Iron ore quality impacts on iron and steelmaking

Most iron ore is produced in fines form (-6.3mm). Iron ore is charged into a blast furnace (BF) however must be 'nugget' sized (around 6 x 32mm) in order for the furnace to remain permeable (allowing hot air to be blown through it without choking).

Accordingly, fines need to be agglomerated. Depending on ore characteristics, this is done usually via conversion into pellets at mine sites or loading ports, or via conversion into sinter by iron makers at steel plants.

Lump ore is highly prized as it is sized for direct charging, not requiring agglomerating costs, and strong enough to not breakdown and choke the BF.

Iron ore chemistry has the most influence on steel mill performance and costs, followed by metallurgical and physical properties.

The development of cost effective hot metal De-Phos technology in the 1990s has been key to unlocking development of the vast high phosphorus Pilbara resources

Gangue and phosphorus

Key chemical attributes of iron ore impact iron and steelmaking costs. In particular, gangue content (predominantly alumina and silica) determine BF efficiency and productivity.

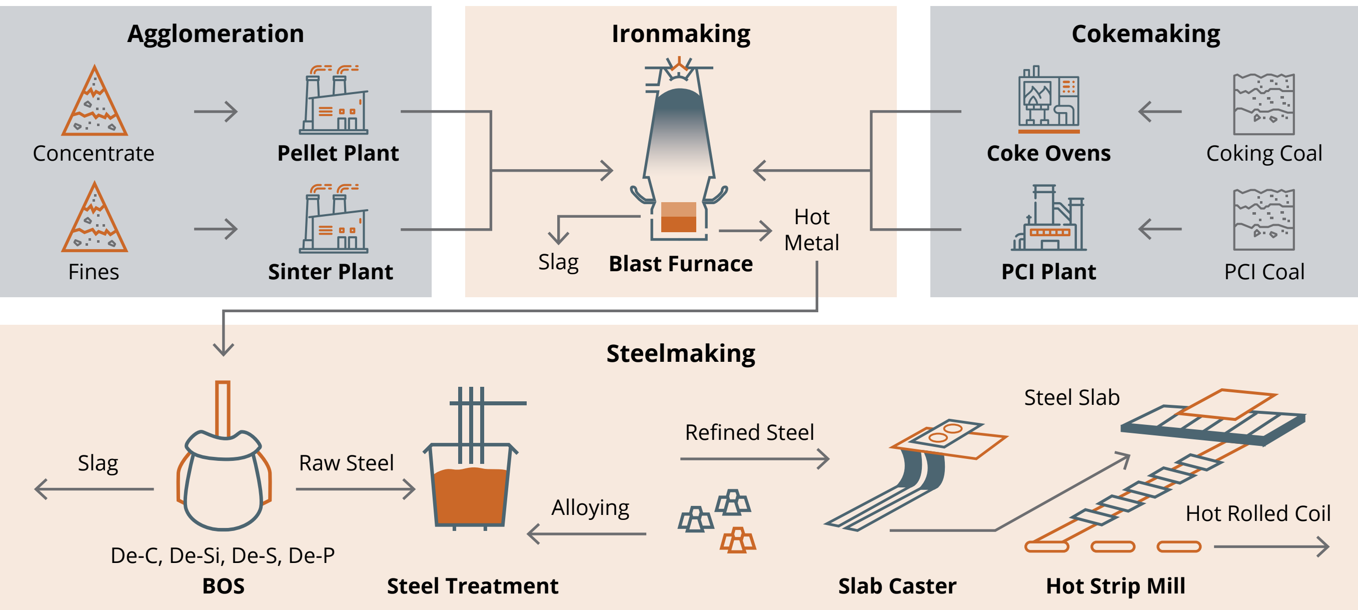
High gangue ores increase fluxing requirements, leading to increased slag volumes and higher coke rates to melt the slag.

As BFs are generally liquid volume constrained, increases in slag volume lead to commensurate decreases in hot metal production, lowering productivity.

Phosphorus (present as P_2O_5 in iron ore), an impurity, reports to the hot metal rather than slag and therefore needs to be removed in the subsequent Basic Oxygen Steelmaking (BOS) process.

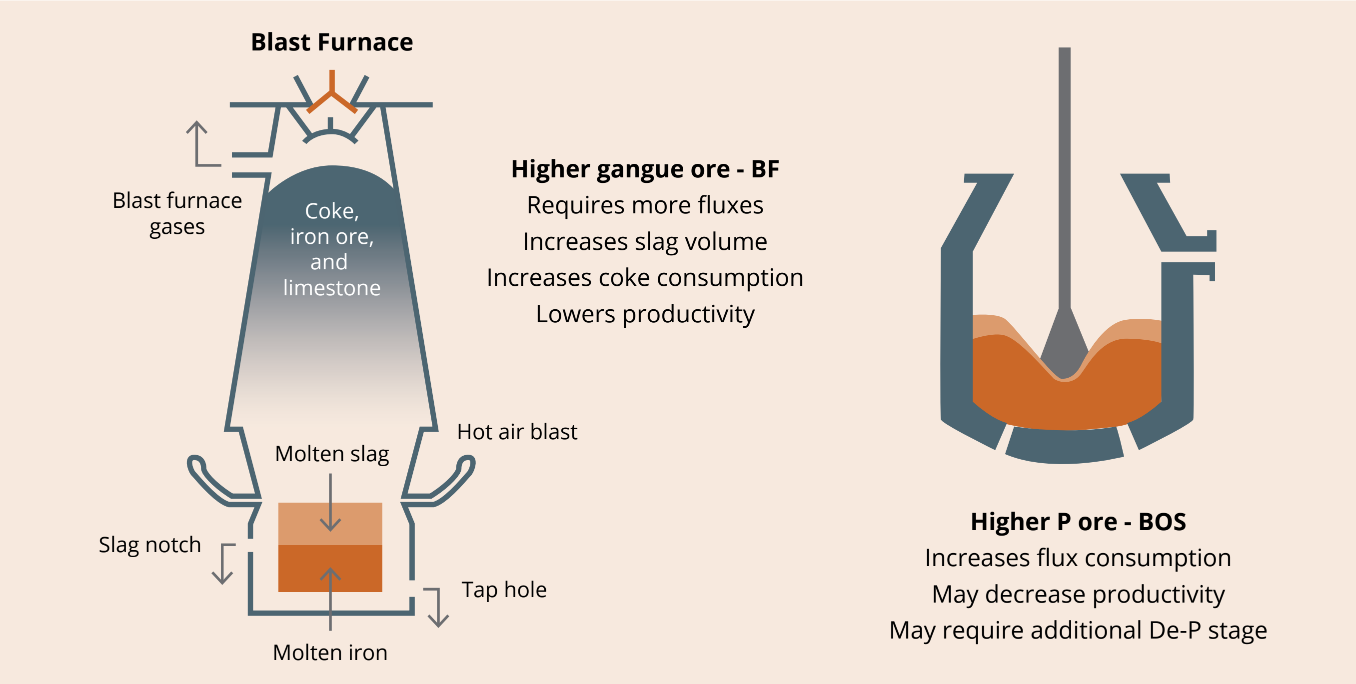
Many Asian mills have installed an additional De-Phos stage in their steelmaking shops in response to rising Pilbara phosphorus levels over time and the increasing proportion of Pilbara ores in their blends.[7] The development of cost effective hot metal De-Phos technology in the 1990s has been key to unlocking the development of the vast high phosphorus Pilbara resources, previously considered unsaleable.

FIGURE 8: STEELMAKING VIA THE BLAST FURNACE ROUTE



[7] Allan Trench, *The state of the global iron ore market*, IMARC, Melbourne, 1 Nov 2017.

FIGURE 9: LOWER QUALITY ORE = HIGHER STEEL MILL COSTS



Slag chemistry and basicity

The key slag chemistry constraints are the maintenance of a CaO/SiO_2 ratio (referred to as the Basicity ratio) of 1.2 for effective desulphurisation and hot metal chemistry control, and ensuring that slag alumina content does not exceed 15 per cent to maintain slag fluidity.

Beyond this 15 per cent alumina limit, slag viscosity increases rapidly, leading to operational instabilities and major impacts on BF productivity and operability.

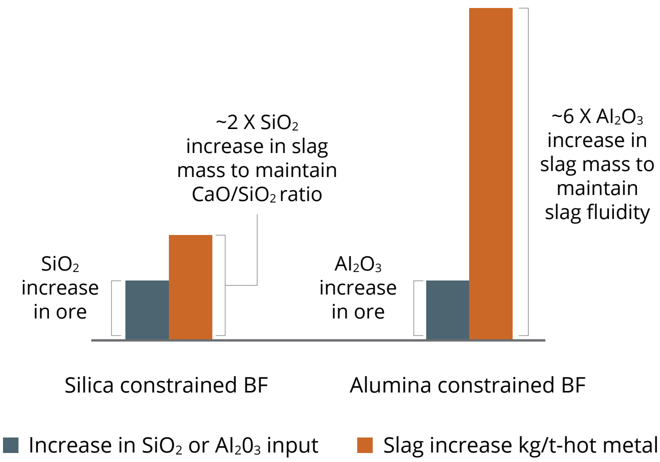
When the BF slag alumina content is below the 15 per cent limit (depending on furnace size and operating conditions), the BF is said to be in 'silica constrained' mode and more sensitive to increases in ore silica than alumina at this slag composition. In this mode of operation, an additional tonne of silica in the ore results in a two tonne increase in slag mass, increasing BF operating costs and reducing productivity.

However, as soon as the slag alumina reaches the 15 per cent threshold, the BF then becomes 'alumina constrained' and is much more sensitive to ore alumina than silica content. In this mode of operation, an additional tonne of alumina in the ore results in a six tonne increase in slag mass, leading to substantially higher BF operating costs and lower productivity.

Accordingly, the realised price for an iron ore is generally more sensitive to ore alumina than silica content.

FIGURE 10: MAGNIFICATION OF ORE GANGUE LOADS IN THE BLAST FURNACE

	SiO_2	Al_2O_3	CaO	MgO	CaO/SiO_2 Ratio
Coastal Asian BF slag	~33 - 35%	~13 $\boxed{- 15\%}$	~40 - 42%	~6 - 8%	$\boxed{\sim 1.2}$



Source: A. Brent, *Optimising Value – Unlocking Potential on the Revenue Side of the Value Equation*, Iron Ore 2019 Keynote presentation, https://ausimm.com/product/optimising-value-unlocking-potential-on-the-revenue-side-of-the-value-equation/.

Quality attributes of Australian iron ore

Pilbara ore types

As with most mineral resources, Pilbara iron ore production began in the 1960s with development of the highest grade deposits. These were the high lump yielding, low phosphorus Brockman deposits of Mt Goldsworthy, Tom Price and Mt Whaleback, foundation orebodies supplying the Japanese steel mills.

The high lump yield from these ores was particularly attractive and unique – a key cost saver for the Japanese steel industry.

These premium low phosphorus Brockman ores were the mainstay of Pilbara production throughout the 1970s, 1980s and into the 1990s when development of the low alumina pisolite deposits at BHP's Yandi and Rio Tinto's Yandicoogina mines began.

Originally viewed as 'low grade' and challenging to sinter given their relatively low natural Fe and high loss on ignition (LOI), Yandi production ramped up to over 30 Mtpa within a decade, representing almost 20 per cent of Pilbara exports by 2000. Low alumina Yandi Fines products were sought after by the increasingly alumina constrained Japanese, Korean and Taiwanese steel mills as a cost effective low alumina substitute for more expensive Brazilian ores. Their low alumina quality raised the share of Australian iron ore these north Asian markets could physically use.

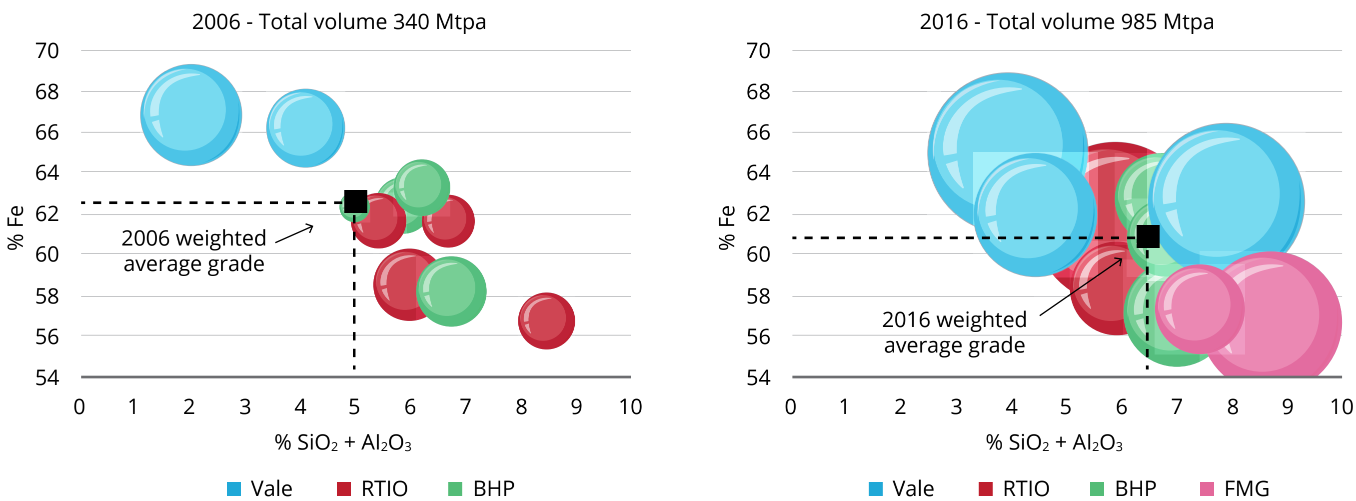
In the early 2000s, the development of Rio Tinto's West Angelas (2002) and BHP's Mining Area C (2003) enabled large volumes of discrete Marra Mamba products to come to market. Initially discounted to the premium low phosphorus Brockman ores to stimulate steel mill interest, the Pilbara Marra Mamba ores quickly established themselves in the market as mainstream products.

These developments coincided with the rapid increase in Chinese demand in the early to mid-2000s, leading producers to develop further similar deposits as the traditional low phosphorus Brockman deposits were depleting.

Marra Mamba and high phosphorus Brockman ores became complementary, with the former diluting the latter's phosphorus content and the latter diluting the former's ultra-fines.[8]

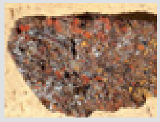
The boom in Chinese demand also drove the development of higher alumina Marra Mamba and Channel Iron Deposit orebodies, and gave birth to new suppliers supporting their own infrastructure and novel operational technology development.[9] The rapid increase in Pilbara production during the China boom, coupled with Brazilian supply growth, led to significant changes in the Asian seaborne iron ore quality spectrum, as illustrated in Figure 11.[10]

FIGURE 11: ASIAN SEABORNE IRON ORE QUALITY EVOLUTION 2006-2016



Source: A. Brent, *Optimising Value – Unlocking Potential on the Revenue Side of the Value Equation*, Iron Ore 2019 Keynote presentation, https://ausimm.com/product/optimising-value-unlocking-potential-on-the-revenue-side-of-the-value-equation/.

TABLE 1: PILBARA HEMATITE DSO ORE TYPES

	BANDED IRON FORMATION DERIVED IRON ORES				CHANNEL IRON DEPOSITS	
	Brockman		Marra Mamba			
Ore Type	**Low P BKM**	**High P BKM**	**Competent Dense MM**	**Friable, Ocherous Goethitic MM**	**Low Al/Si CID**	**High Al/Si CID**
Appearance						
Typical head grade chemistry Fe P Al_2O_3 SiO_2 LOI	60-67% 0.06-0.1% 1.4-2.2% 3.5-4.0% 2-3%	58-65% 0.1-0.15% 1.8-3.0% 3.5-5.0% 4-5%	58-63% 0.05-0.07% 1.8-2.8% 3-5% 4-6%	56-62% 0.05-0.07% 2-4% 4-6% 6-8%	55-59% 0.03-0.06% 1-2% 4-7% 9-10%	55-57% 0.03-0.06% 2-5% 5-8% 9-10%
Natural Lump Yield	40-55%	40-50%	35-50%	5-20%	Fines only products	20-35%
Key product attributes	The premium Pilbara ore with highest Fe, low gangue and P with the highest lump yield. The highest quality Pilbara ore and the foundation deposits for early exports to Japan, now approaching depletion.	High Fe, low gangue with good lump yield; a drawback is its high P content which delayed large scale exploitation until the early 2000s. Now a key blend component with MM ores and a major portion of the remaining Pilbara DSO resource.	Favourable Fe with low gangue and reasonable lump yield. Not significantly exploited until early 2000s but now a major blend component with BKM ores to dilute high P BKM P content.	Mid range Fe with low to zero lump yield. Some deposits higher in alumina. High reactivity/rapid assimilation in sintering, and a key P diluent for high P BKM ores in Pilbara blended products	High calcined Fe, low alumina and P product well suited to alumina constrained mills. Modified sintering practices required to accommodate high LOI. Exploited from early 1990s.	High calcined Fe with low P and relatively high alumina content. Modified sintering practices required to accomodate high LOI.
Beneficiability	High	High	Medium	Poor, low recovery	Medium-poor	Medium-poor
Example Deposits	Mt Whaleback, Tom Price, Parabadoo	Hope Downs 4, Brockman 2 and 4, Jimblebar, Packsaddle	Roy Hill, MAC North & South Flank, West Angelas above water table ore	FMG Chichester Hub, Newman OB29, 30 and Hope Downs 1 below water table ore	BHP Yandi and RTIO HIY	Mesa A & J
Example Products	**BKM/MM Blends:** RTIO's Pilbara Blend Lump and Fines, BHP's Newman Fines, MAC Fines, Newman Blend Lump **MM:** FMG Fortescue Blend Fines, Super Special Fines, Roy Hill Lump and Fines				BHP's Yandi and RTIO's HIY Fines	RTIO's Robe River Lump and Fines

8 Australian Mining, *High Hope for Pilbara blend*, 3 Jul 2007.

9 J M F Clout, *Beneficiation of Fine Iron Ores using the Desand Process*, AusIMM Iron Ore 2013 Conference, Perth, Aug 2013.

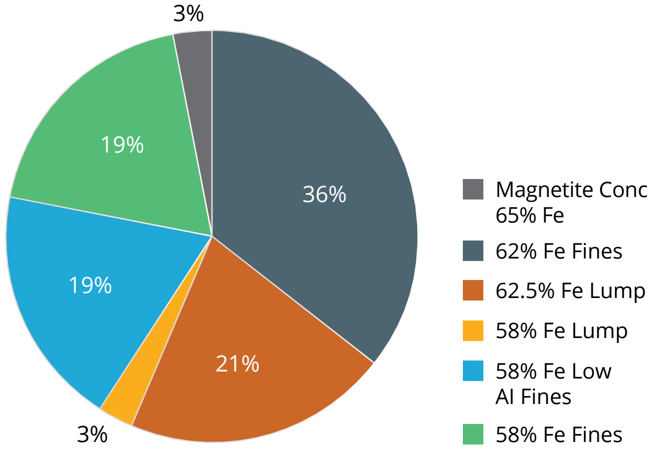
10 A Brent, *Back to the Future – Resilience in Historical Context and Implications for the Future*, AusIMM Iron Ore 2017 conference, Perth, Jul 2017.

The seaborne iron ore quality deterioration which accompanied the China boom volume growth resulted in a 27 per cent increase in gangue and a 30 per cent increase in phosphorous between 2006 and 2016. These changes were primarily driven by development of the vast Pilbara high phosphorus Brockman, Marra Mamba and Channel Iron Deposit resources, coupled with a deterioration in Brazilian ore quality as producers moved to increase volumes to meet the rapidly rising Chinese demand.

Asian mills have adapted sintering and blast furnace practices to the evolving supply quality spectrum, and the new products introduced during the China boom are now a core component of mainstream seaborne supply.[11]

The majority of Australian iron ore production falls into the 62 per cent Fe and 58 per cent Fe sinter fines categories, and around 21 per cent lies in the premium 62.5 per cent Fe lump direct charge category. This represents the bulk of seaborne supply and the benchmarks for quality and pricing in each of their respective categories.

FIGURE 12: PILBARA 2019 IRON ORE QUALITY DISTRIBUTION



Source: Estimated from producer company annual reports and WA Dept of Mines, Industry Regulation and Safety data and reports.

Australia supplies almost 90 per cent of the world's high grade lump ore

TABLE 2: IRON ORE QUALITY SPECTRUM AND POSITIONING OF MAJOR AUSTRALIAN PRODUCTS

	FINES (SINTER FEED)			LUMP AND PELLET (DIRECT CHARGE)	
% Fe	**58**	**62**	**65**	**62.5 Lump**	**65 BF Pellet**
Examples of Iron Ore Price Indices	Platts 58, MB 58, Mysteel 58	Platts 62, MB 62, Mysteel 62	Platts 65, MB65, Mysteel 65	Platts & Mysteel 62.5 Lump	Platts & Mysteel 65 BF pellet
Typical Products (Australian products in italics)	**RTIO:** *HIY Fines (Low Al premium), Robe Fines* **BHP:** *Yandi Fines (Low Al premium)* **FMG:** *Fortescue Blend Fines, Super Special Fines*	**RTIO:** *Pilbara Blend Fines* **BHP:** *Newman, MAC, Jimblebar Fines* **Roy Hill:** *Roy Hill Fines* **FMG:** *West Pilbara Fines* **Vale:** Brazilian Blend Fines **Kumba:** Sishen Fines	**Vale:** Carajas Fines	**RTIO:** *Pilbara Blend Lump* **BHP:** *Newman Blend Lump* **Roy Hill:** *Roy Hill Lump* **Kumba:** Sishen Lump	**Vale:** BF Pellets

[11] G Beros, *Not all sub 60 per cent Fe ores are the same: the link between processing and sintering of Fortescue ores*, AusIMM Iron Ore 2019 Conference, Perth, Jul 2019.

Lump ore – a uniquely Australian competitive advantage

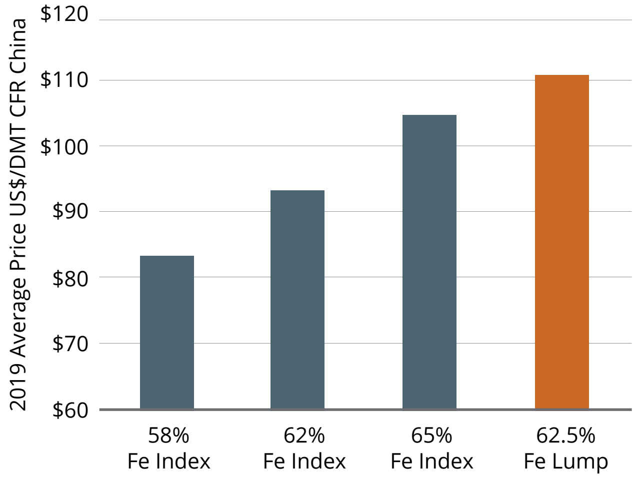
In 2019, the price for 62.5 per cent Fe lump was significantly higher than that of 62 per cent Fe premium grade and 65 per cent Fe Brazilian sinter fines, despite the Australian lump being lower in Fe and higher in gangue.[12]

This is because lump is a direct charge material, saving steelmakers sintering costs and enabling higher steel production for mills that are sinter plant constrained (i.e. plants for which the sinter plant is the bottleneck in their ironmaking process). The value uplift over fines pricing generated a significant revenue premium for Australia.[13]

Australia supplies approximately 86 per cent of the world's high grade lump, from Brockman and Marra Mamba Pilbara DSO ores with a 30-40 per cent natural lump yield of high quality lump with excellent metallurgical properties well suited to the large efficient Asian steel mills. This ability to produce large volumes of high quality lump is a key competitive advantage which Australia enjoys over competitors – the Brazilian hematite ores in Vale's Northern System, while of higher Fe grade and lower gangue than Pilbara deposits, are also softer and more friable, and hence unable to produce material quantities of lump acceptable to the Asian market.

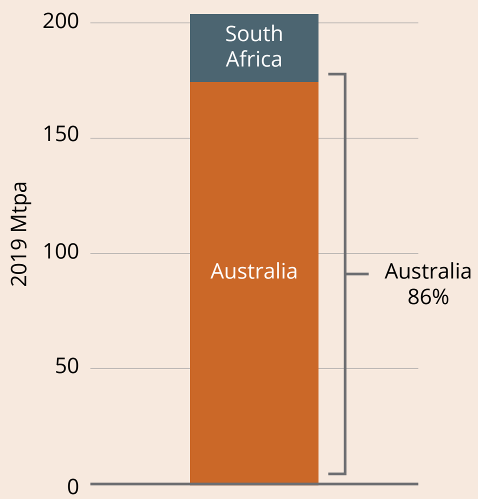
As lump costs essentially the same as fines to produce but sells at a significant premium, it is Australia's highest margin iron ore product, and even small increases in lump yield can generate significant additional revenue.

FIGURE 13: 2019 IRON ORE AVERAGE FINES AND LUMP PRICES



Source: Mysteel.

FIGURE 14: 2019 SEABORNE HIGH GRADE LUMP



2019 LUMP PREMIUM VALUE TO AUSTRALIA

Australian 62.5 per cent Fe estimated lump production: 174 Mt

Lump Premium (US$/DMT): US$17

Lump Premium Value (US$M): US$3.0 bn revenue

Value of one per cent increase in lump yield: US$30M

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12 Mysteel, Iron Ore index Daily, 2019.

13 Lump production from Company Production and Sales reports (Rio Tinto Iron Ore, BHP, Kumba) and Roy Hill lump production estimated based on Media releases. Lump Premium price data from Mysteel.

14 Global Minerals Marketing Value in Use (VIU) Modelling based on typical Australian 62.5% Fe Lump and Asian sinters.

GREEN LUMP

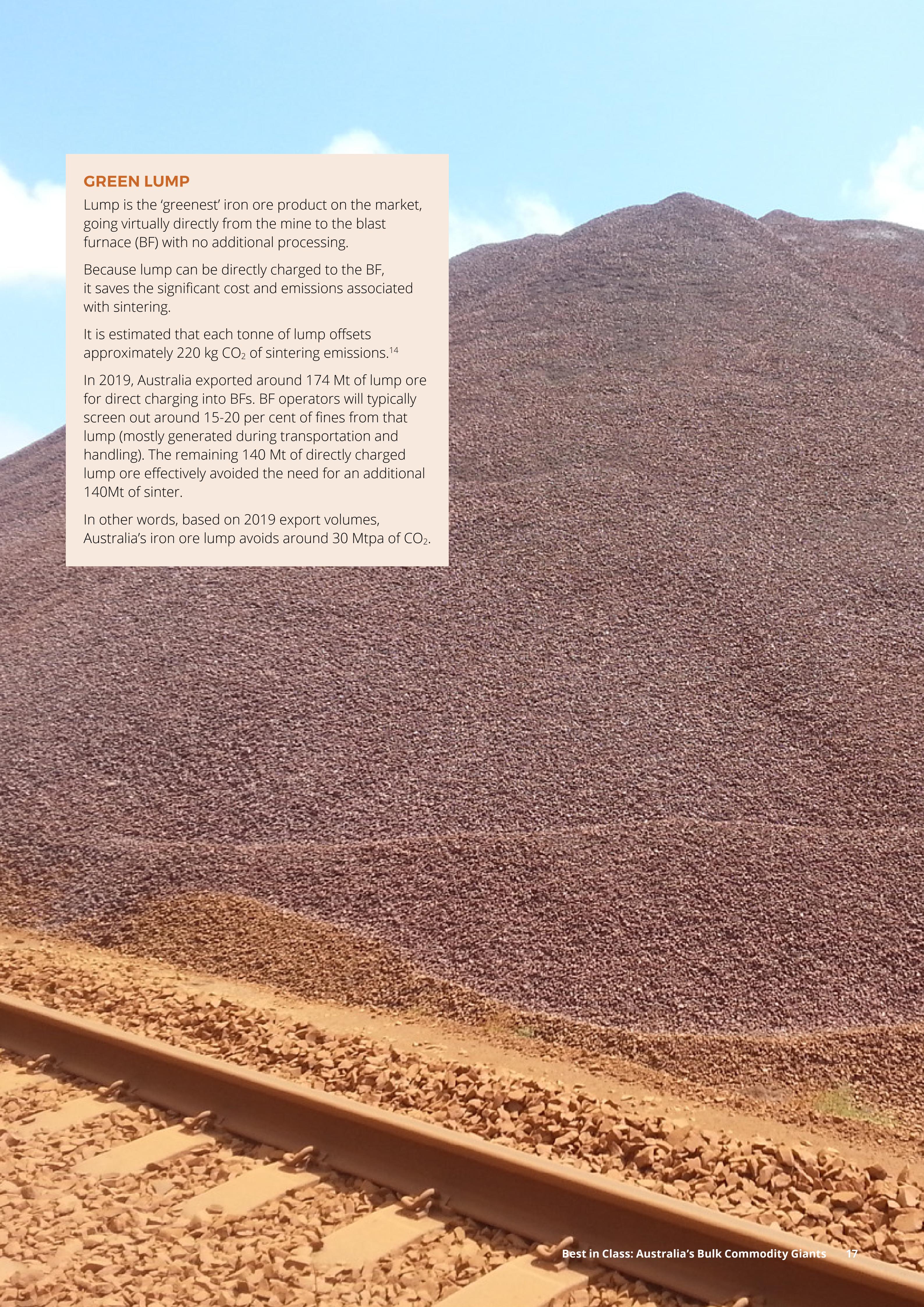
Lump is the 'greenest' iron ore product on the market, going virtually directly from the mine to the blast furnace (BF) with no additional processing.

Because lump can be directly charged to the BF, it saves the significant cost and emissions associated with sintering.

It is estimated that each tonne of lump offsets approximately 220 kg CO_2 of sintering emissions.[14]

In 2019, Australia exported around 174 Mt of lump ore for direct charging into BFs. BF operators will typically screen out around 15-20 per cent of fines from that lump (mostly generated during transportation and handling). The remaining 140 Mt of directly charged lump ore effectively avoided the need for an additional 140Mt of sinter.

In other words, based on 2019 export volumes, Australia's iron ore lump avoids around 30 Mtpa of CO_2.



The future of Australian iron ore

A resource base capable of sustaining production for decades

Australia still has an estimated 70 billion tonnes of JORC compliant resources remaining on a 62 per cent Fe basis, capable of sustaining production for decades to come.

The remaining resources of the Australian and Brazilian major producers split by ore type, converted to a 62 per cent Fe basis to enable direct Fe content comparison, confirms their substantial remaining resource lives.

The Pilbara producers have the largest proportion of high Fe grade, low cost DSO hematite, the key quality attribute that has underpinned Australia's rise to become the world's largest iron ore producer.

The remaining resource lives of all major producers are substantial, with the production and tonnes of weighted average remaining resource life for the major Pilbara producers estimated at 65 years.

While the remaining Pilbara resource base is extensive and able to support high production levels for many decades to come, the ore product mix will continue to evolve over time as it has in the past, reflecting the replacement of depleting ore types with those in the remaining resource base.

The future evolution of the Australian iron ore product suite

The majority of the remaining Pilbara resource (around 65 per cent) consists of the Brockman and Marra Mamba ore types, with the former component being predominantly high phosphorus ore. The low alumina Channel Iron Deposit ores only represent three per cent of the remaining resource.

The replacement of some 80 Mtpa of low alumina Yandi Fines Channel Iron Deposit ore with BHP's South Flank Marra Mamba, coupled with the introduction of further high phosphorus Brockman ore from Rio Tinto's 42 Mtpa Koodaideri project under construction as well as product changes flagged by FMG with the development of their Eliwana mine and Iron Bridge magnetite project, will significantly change the iron ore product suite of the major Pilbara producers over the coming years. [15,16,17]

The proportions of Brockman and Marra Mamba ores in the Pilbara product suite will likely continue to increase over time to reflect the remaining resource split by ore type, underpinning Australia's position as the world's number one producer of the high quality 62 per cent Fe fines and 62.5 per cent Fe lump product categories.

FIGURE 15: AUSTRALIAN AND BRAZILIAN IRON ORE RESOURCES AND ESTIMATED MINE LIVES AT CURRENT PRODUCTION LEVELS

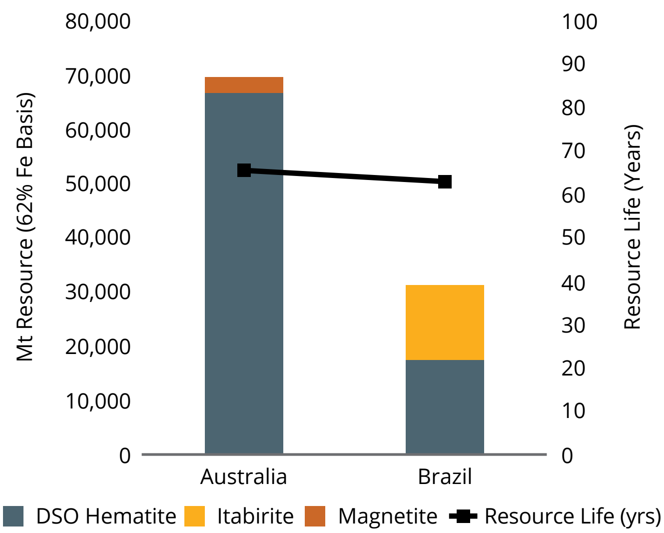
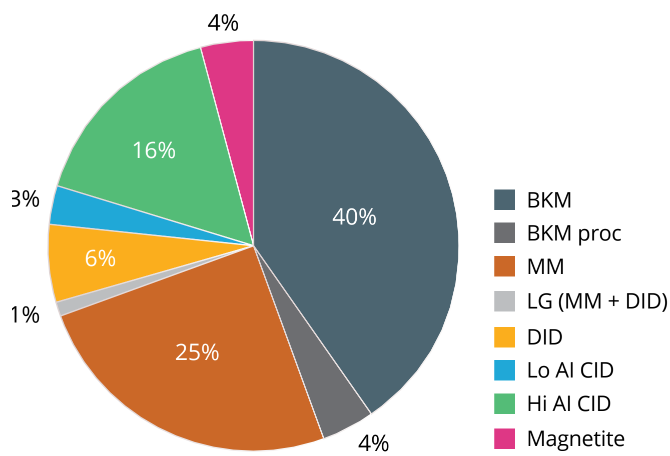


FIGURE 16: EST. PILBARA IRON ORE JORC DSO RESOURCES (62% FE BASIS)



15 BHP media release, BHP approves South Flank project, 14 Jun 2018.
16 Rio Tinto media release, Rio Tinto approves $2.6bn investment in Koodaideri iron ore mine, 29 Nov 2018.
17 FMG FY20 Full Year Results, 24 August 2020.

Future challenges and opportunities for Pilbara producers

Notwithstanding the Pilbara's vast resource base and installed infrastructure, there are some challenges looming which will influence the future of Australian iron ore production.

A more competitive market environment is evolving as new supply enters the market. Australian producers are well placed to continue to prosper in this situation, given the large, high quality, low cost DSO resource base, coupled with the substantial installed infrastructure and proximity to market advantage over competitors. Thus far, these have combined to firmly position Australia at the bottom of the industry cost and freight curve.

The intensifying global focus on greenhouse gas emissions has implications for iron ore. Steel mills are increasingly seeking higher Fe, lower gangue products, and this is being reflected in the relative product pricing between the quality categories. This trend will likely incentivise more beneficiation in the Pilbara, particularly for alumina reduction of the more responsive Brockman and dense Marra Mamba ore types. These generally upgrade well with simple gravity beneficiation and avoid the need for costly grinding.

The increasing development of more challenging below water table Marra Mamba ores will be required as above water table deposits deplete. This will lead to an increasing need for wet processing, progressively replacing some of the dry processing infrastructure currently installed.

Nevertheless, there are also opportunities on which the industry can capitalise.

There is potential to further creep capacity by developing new deposits proximate to existing infrastructure.

There is also opportunity to further increase production and reduce costs through increased process and supply chain optimisation and automation. These are areas in which the Pilbara is already considered an industry benchmark.

The potential to increase DSO quality through more beneficiation, particularly for the more responsive Brockman and dense Marra Mamba ores is real. Ongoing research into the quality uplift of more challenging ores to beneficiate such as the lower density friable/ocherous Marra Mamba ores may be very fruitful, as may be further optimising the lump yield to capitalise on the lump premium and increased revenue.

The extensive resources and infrastructure network, coupled with the industry leading mining skills and workforce base built up over decades, has Australia well positioned to rise to the challenges and to seize the opportunities ahead.

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