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Non-Metallurgical Bauxite

Applications & Markets in 2019

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Applications

- Calcined bauxite
 - Refractories
 - Abrasives – Brown Fused Alumina
 - Calcium Aluminate Cement
 - Proppants
 - Welding
 - Road Surfacing
- Raw Bauxite
 - Portland cement
 - Iron & Steel Slag Conditioner
 - Alumina chemicals
 - Mineral Wool
 - CAC again

Typical Grades Calcined Bauxite

	<u>CAC</u>	<u>Abrasives</u>	<u>Proppants</u>	<u>Refractories</u>
Alumina content	80-86%	80-86%	50-55% raw	85-90%
			70-75% calcined for intermediate density	
			80-85% calcined for high density	
Fe ₂ O ₃ content	2-7%	2-6%	1-25% (not critical)	<2%
Silica content	Max 6.5-7% and preferably 3%	4.5-7%	7-16% and up to 25% for kaolinitic grades	4-6.5%
Preferred size	Lump 50-200mm		fine	
	Finer is briquetted			
Calcining temperature	1000°C	1000°C	1000°C if calcined but raw also used and calcined during production process	1600°C

Typical Grades Non-Met Raw Bauxite

	<u>Chemicals</u>	<u>CAC</u>	<u>Portland Cement</u>	<u>Steel Slag</u>
Alumina content	55-58%	55-60%	38-55%	55-60
Fe₂O₃ content	<2%	16-25%	20-30%	20-30%
Silica content	5-12	3-5%	7-12%	2-7%
Preferred size	Fine or ground by consumer (moisture needs to be <5% for)	Lump 50-200mm		10-50mm
		Finer is briquetted		
Comments	TiO ₂ <6 and moisture must be below 5%	Diaspore/Boehmite preferred	(Silica Modulus SiO ₂ :(Al ₂ O ₃ +Fe ₂ O ₃) should ideally be 2.6-2.8)	Diaspore/Boehmite preferred, Low sulphur and phosphorus

Supply

- Total World Bauxite Production ~ 300 million tonnes
- No good statistical sources for most non-metallurgical consumption
- Total estimated to be ~ 10-11 million tonnes raw bauxite including that used for calcining
- China and Guyana main sources of calcined for refractories with some quantities from Brazil and India
- China also largest for abrasive grade but also from Brazil and India
- Greece and Turkey important sources for raw bauxite for CAC, Iron & Steel slags as well as China for their domestic market
- Portland cement tends to use cheapest delivered source of bauxite
- Chemical grade primarily China and Guyana

Refractories

- High alumina calcined bauxite with low iron and other impurities used directly in refractories
- ~ 40-50% of BFA derived from calcined bauxite also used in refractories
- Total demand for calcined bauxite in Refractories ~ 1.2 million tonnes
- BFA in Refractories ~600,000 tonnes
- Supply being limited in China because of environmental regulation and other factors
- Increased capacity announced for Guyana and some newer products offered from Brazil

Abrasives

- BFA manufactured from abrasive grade bauxite primarily in China but also elsewhere, although based primarily on Chinese calcined bauxite, with Indian and Brazilian material mainly used domestically
- Total production of the order of 1.2 million tonnes
- About 600,000 tonnes for abrasive applications
- Chemistry still important for the properties but products need to be graded to very tight size specifications
- Some calcined bauxite used directly as abrasives

CAC

- CAC uses both raw and calcined bauxite for different grades of product
- Total demand for bauxite ~440,000 tonnes
- Lump calcined from China or raw lump from Greece or Turkey preferred
- Fines can be used but need briquetting for use in reverberatory kilns at cost of ~\$25-30 per tonne but partly mitigated by lower cost of fines.

Proppants

- Market for bauxite based ceramic proppants has collapsed
- Some estimates of over 1 million tonnes used only a few years ago
- Now possibly only 200,000 tonnes on a calcined basis
- As many as 200 plants in China at peak now less than 10, maybe only 2 operating. Closures outside of China as well.
- Main sources China and Brazil
- Fracing concentrated in North America with some in China, Middle East, Argentina and Australia

Other calcined bauxite uses

- Anti-skid road surfacing
- A relatively expensive road surfacing aggregate so only used in limited high wear areas near traffic lights and pedestrian crossings.
- UK traditionally seen as significant market, with other abrasive minerals used elsewhere
- Small and variable market of perhaps as little as 10,000 tonnes
- Welding requires a very well calcined product with a very low LOI and extremely low phosphorous, sulphur and carbon
- Market outside of China is estimated to be of the order of 60,000 tonnes and perhaps the same amount again within China

Portland Cement

- Very difficult to assess market size
- Bauxite only used at plants where the alumina content of the clay or shale is below optimum and consumption variable
- May be as much as 2 million tonnes worldwide but estimates vary to as low as 1 million tonnes
- Very price sensitive – to lowest cost material on a delivered basis that can suffice is utilised
- Specifications not particularly tight and various alumina containing by-product materials have been investigated as alternatives

Iron and Steel

- Raw bauxite may be used as a slag adjuster in the blast furnace for iron production.
- Increases the desulphurising power and the fluidity of the slag helping to lower the silica and sulphur content of the molten iron
- Results in an alumina rich slag, which can be used as an additive in Portland cement and in mineral wool production (slag wool)
- Bauxite may also be used to increase the alumina content of steel slags, which helps to control the viscosity of the slag
- Total demand difficult to estimate but possibly ~800,000 tonnes

Chemicals

- Most alumina based water treatment chemicals manufactured from alumina hydrate now
- Still maybe as much as 500,000 tonnes of bauxite used in China
- About 115,000 tonnes in North America
- Possibly 50,000 tonnes elsewhere including Latin America
- Only very small quantities used in Europe for specialty product
- Sources are China for domestic use and Guyana for the Americas as only significant sources of <2% Fe₂O₃ bauxite

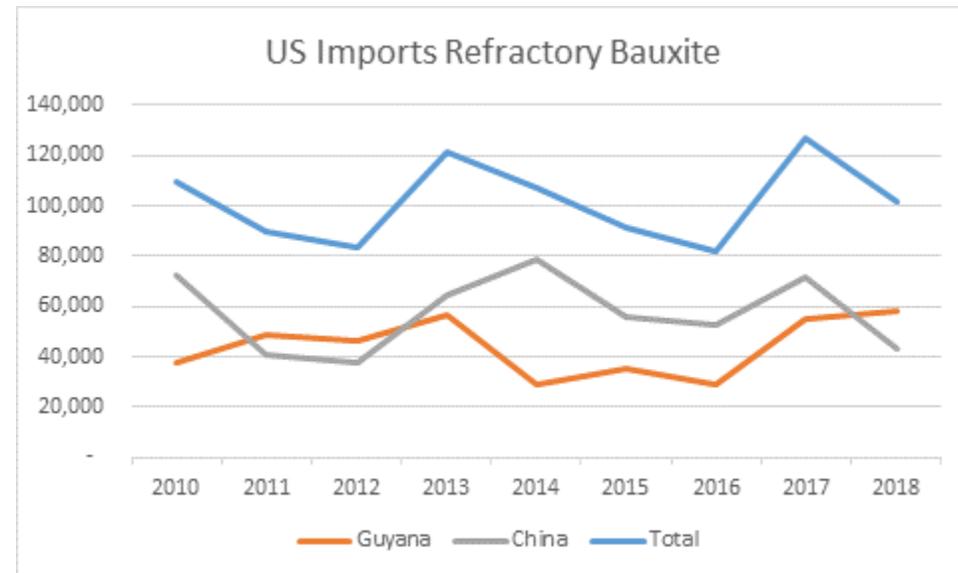
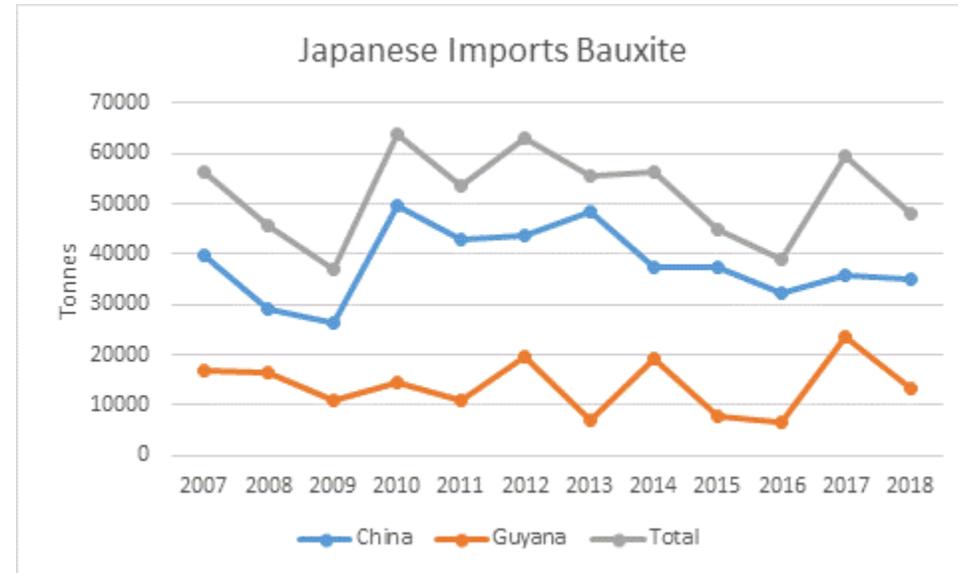
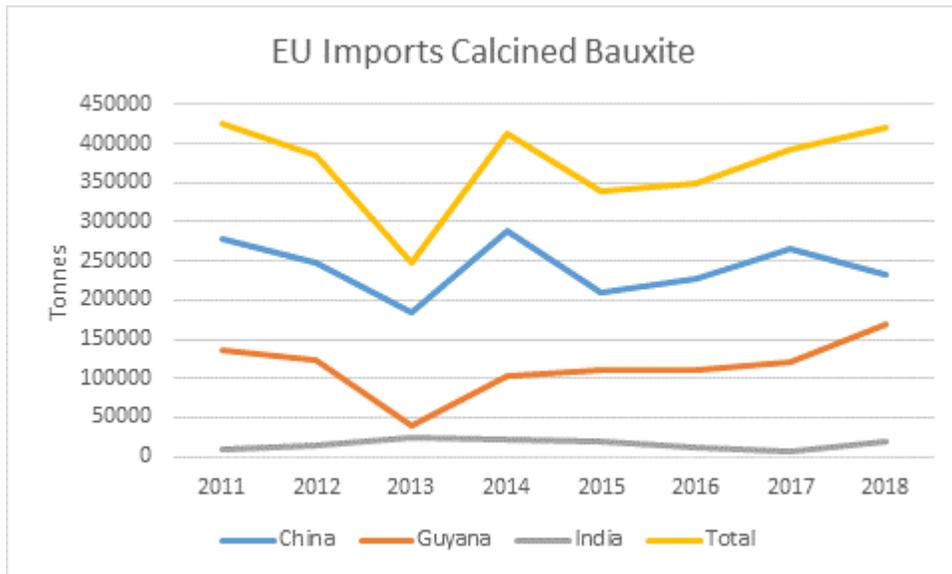
Mineral Wool

- Used to increase alumina content where the primary raw materials such as basalt have lower levels than required
- Primarily in Europe where regulations require a minimum of 18% Al_2O_3 in the mineral wool fibres
- Considerable amounts of anorthosite now used as a replacement for bauxite and some by-product aluminous materials also used
- Total bauxite usage now estimated to be only 200,000 tonnes much less than previous estimates

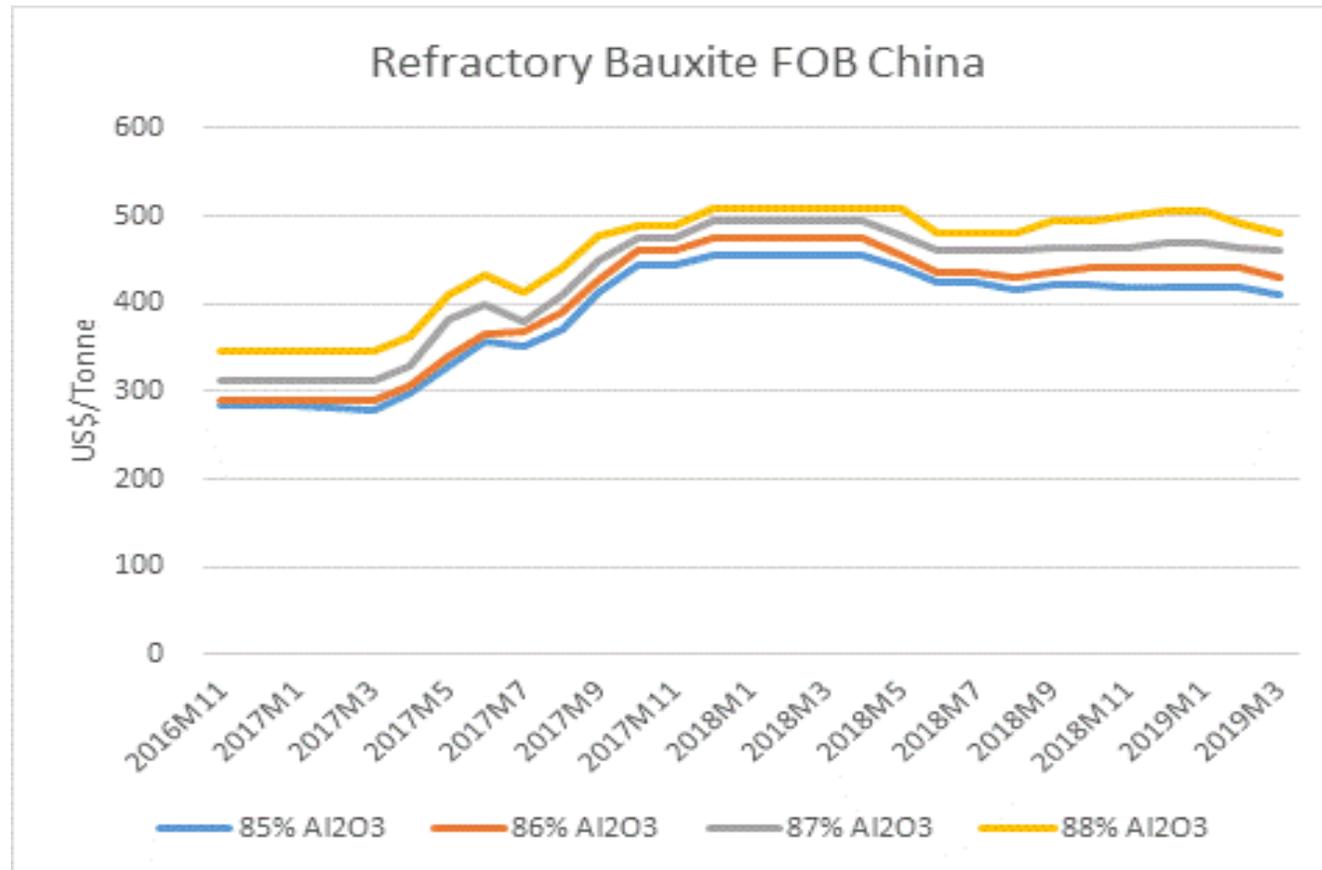
Trade

- Very difficult to interpret trade statistics for non-metallurgical use
- Chinese exports of calcined in a category that includes calcined clays
- Imports into Europe, Japan and USA from China, Guyana as well as India assumed to be mainly calcined bauxite both refractory and abrasive grade combined (low cost from Guyana to Ireland need to be excluded from European figures)
- US figures separate refractory abrasive and others but there are imports of calcined refractory recorded from Greece and Turkey that will be raw bauxite, possibly for CAC production

Trade charts



Calcined Bauxite Prices



Raw Bauxite prices

- Low Silica Lump for CAC ~\$50-70 per tonne from Greece or Turkey
- Chemical grade ~\$55-65 per tonne FOB Guyana
- Cement Grade – as low a price as possible on a delivered basis
 - Prices similar to those of metallurgical grades on an FOB basis
- Iron and steel ~ \$45-65 FOB Greece or Turkey

Market Drivers

- Refractory demand and slag adjusters strongly related to crude steel production. Currently growth slowing – expected to stabilise in short term and longer term stable to slowing in China and developed countries with strong growth in India and other developing nations
- Abrasives related to industrial activity
- CAC related to both construction markets in the case of lower grades and refractories for higher alumina content products
- Portland cement related to construction activity
- Water treatment chemicals mature market and possibly continuing replacement by alumina hydrate as raw material
- Proppants after large decline may stabilise with growth related to fracking activity
- Mineral wool sector growing strongly but use of alternatives to bauxite



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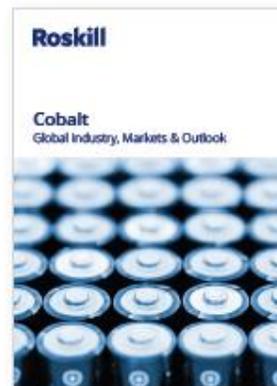
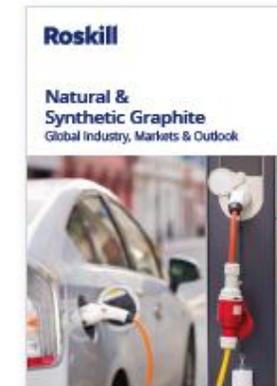
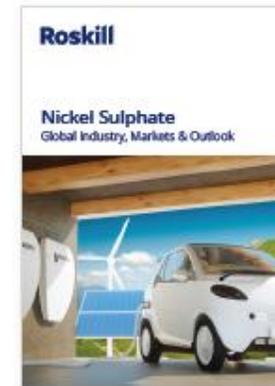
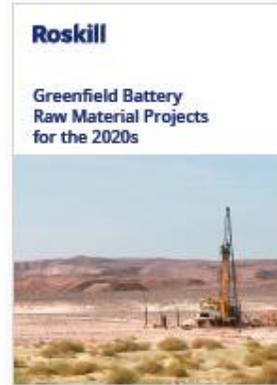
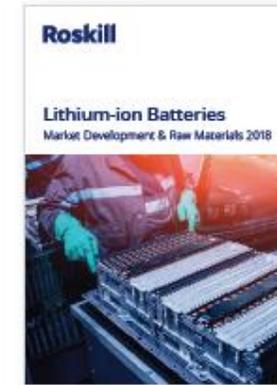
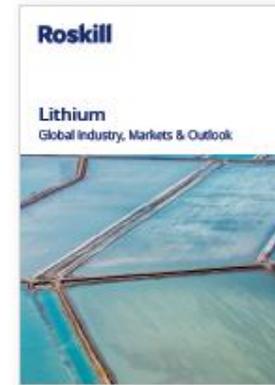


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Roskill's report and consulting offer

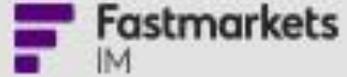
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 - Cost and supply chain analysis
 - Socio-economic impact assessments

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