What is it?

Aluminium comprises about 8% of the earth’s crust. It is the third most abundant element in the crust and the most plentiful metallic element, but is never found on its own in nature. Bauxite is the ore most commonly mined for aluminium. Bauxite is a naturally occurring material composed of 30–54% aluminium oxide, Al₂O₃, (alumina), the rest being a mixture of silica, various iron oxides, and titanium dioxide, and other impurities in minor or trace amounts.

Bauxite is mined via surface mining / open-cut methods in which the topsoil and overburden are removed by bulldozers and scrapers. The underlying bauxite is mined by front-end loaders or hydraulic excavators. Some bauxite ores are merely dried and shipped. Other bauxite is beneficiated after crushing by washing to remove some of the clay, reactive silica and sand waste and then dried in rotary kilns. The ore is then transported to refineries.

Bauxite may be as hard as rock or as soft as mud and may occur as compacted earth (both friable and re-cemented), small balls (pisolites), or hollow, twig-like material (tubules). Its colours may be buff, pink, yellow, red, or white, or any combination of these.

Not all bauxites are created equal. Some are more sought after than others. The overall chemistry of bauxite determines its commercial usage and the cost of dissolution in the process of converting metallurgical bauxite to alumina (the Bayer process). The three structural forms of bauxite are gibbsite, a trihydrate [Al(OH)₃, also written as Al₂O₃·H₂O in oxide notation], boehmite, a monohydrate [AlO(OH), written as Al₂O₃·H₂O in oxide notation] and diaspare, which is a polymorph of boehmite but is denser and harder.

What is it used for?

Bauxites are typically classified according to their intended commercial application: abrasive, cement, chemical, metallurgical, refractory, etc.

The bulk of global bauxite production (approximately 85-90%) is used in the metallurgical application as feed for the manufacture of alumina via the Bayer process. In the Bayer process, bauxite is digested (leached) with a solution of sodium hydroxide NaOH (aka caustic soda) at high temperature, under pressure.

Dissolution of monohydrate minerals requires higher temperatures, pressures and higher concentration of caustic soda.

## Processing requirements for the extraction of Alumina

<table>
<thead>
<tr>
<th></th>
<th>Gibbsite</th>
<th>Boehmite</th>
<th>Diaspare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>145°</td>
<td>250°</td>
<td>Higher</td>
</tr>
<tr>
<td>Pressure</td>
<td>75 psi</td>
<td>550 psi</td>
<td>Higher</td>
</tr>
</tbody>
</table>

The costs of alumina production are therefore significantly higher versus using trihydrate gibbsite. For this reason gibbsite is more highly sought after by alumina refineries.

Yet another factor to consider is the reactive silica content of the ore. The amount of reactive silica is particularly important as this form of silica consumes (or ‘robs’) the caustic soda needed to make alumina, increasing production costs. Thus low reactive silica is desirable.

The majority of the resulting alumina produced from this refining process is in turn employed as the feedstock for the production of aluminium metal by the electrolytic reduction of alumina in a molten bath of natural or synthetic cryolite (Na₃AlF₆), the Hall-Héroult process.

The quantities of bauxite used in the production of aluminium is as follows: 4-5 tonnes of bauxite yields 2 tonnes of alumina from which is produced 1 tonne of aluminium

## Current market snapshot

Global alumina capacity is forecast to grow by 29.6% over the next ten years, reaching 179.6M tonnes by 2024. Metallurgical grade alumina capacity expansion, primarily in China, will be the main driver for this growth. Approximately 302MT pa of bauxite supply is required to fulfill demand from the alumina industry.

### 2015 Bauxite Supply Demand Breakdown

- **2015 Bauxite Demand**: 35 MMT
- **2015 Bauxite Supply**: 46 MMT
- **Trihydrate, China 43 MMT (including transfers at a market price)**
- **Monohydrate, China 3 MMT**
- **Monohydrate, ROW 1 MMT**
- **Diaspare 0 MMT**

**China Integrated Mines**: 25 MMT
**China Third-Party Mines**: 10 MMT
**China Imports**: 55 MMT
**ROW**

**Source CRU, July 2015**
China’s net alumina investment requirement, or level of capacity additions, is expected to peak in 2025 at 10M tpy, while the world ex. China is forecast to require 15M tpy of net new alumina capacity over the period to 2040. Production of alumina, and subsequently aluminium, can only continue to grow if the sector is supplied with sufficient quantities of bauxite. However, this didn’t seem so certain in 2014 due to Indonesia's raw ore exports ban. More recently the Indonesian government has flagged the potential for some relaxation of that ban, however details are yet to be released. It is expected that export permits will only be granted to those groups who have constructed alumina refineries, or have material cash commitments to build new alumina refineries in country.

Since 2005, when China installed the first few low-temperature refineries, it generally relied on the more cost effective Indonesian gibbsite. The implementation of Indonesia’s unprocessed minerals export ban in January 2014 put an end to this.

However, Chinese refineries and traders had already amassed significant stocks of Indonesian bauxite in the run-up to the ban so this was not an immediate problem. And within months, Malaysia came to the rescue, essentially limiting any potential positive impact on bauxite prices as a result of the Indonesian ban.

The emergence of Malaysia as a strong bauxite supplier was short lived as new mines caused conflicts over land use and pollution from unregulated mining and transporting of bauxite. As a consequence the Malaysian government banned all bauxite mining activity in the main production area around Kuantan in early 2016 and with subsequent extensions the ban remains in place to the end of March 2017.

The industry-wide consensus is that Malaysia won't be able to resume significant bauxite exports due to social issues, an inability to reliably supply product and a lack of bauxite resources near to existing ports. The research team at Wood Mackenzie believes the country’s supplies will dry out in the medium-term i.e. between 2017 and 2018. So from where will they source bauxite? While Indonesia recently again relaxed the ban on bauxite ore exports, the shifting regulatory environment has undermined Indonesia’s position as a reliable supplier of bauxite.

In light of the supply uncertainty from Indonesia and Malaysia, Chinese buyers have been driven further afield to secure supply. This has seen Guinea, in West Africa, receive substantial attention. Guinea currently exports circa 10Mtpa to China. While Guinea has plans to increase production and ample bauxite resources – estimated at 7 billion tonnes – the shipping distances to China are vast and its status as a reliable supplier is not proven. Rio Tinto’s issues in Guinea have been well documented. Furthermore, the 2015 Fraser Institute of Survey of Mining Companies ranked Guinea as one of the least attractive investment destinations globally – coming in at 103 out of 109 locations based on the level of regulatory and environmental uncertainty, amongst other indicators.

Who produces it?

In 2015 the production of bauxite was 302 million tonnes. The bauxite market is very fragmented in terms of supply. The top 5 producers for example account for around 40% of total supply. Below is a representation of the major global bauxite trade flows

Historically, there has been a distinct separation of markets into Atlantic and Asia-Pacific basins whereby Australia and Indonesia had been the key suppliers to China while Brazil and West African product is sent to the US and European markets.

However, this traditional bifurcation has begun to blur somewhat. As noted previously, Chinese demand and supply issues encountered by traditional producers has seen increasing volumes from Guinea exported to China. Also a portion of future Guinean supply is committed to planned refineries located in the Middle East.

Who consumes it?

China completely dominates the consumption of bauxite. This is a function of the rapid and vast buildout of aluminium production capacity in China in the last decade. China’s imports of bauxite have grown from 2.2MTs in 2005 to 50MTs in 2015 at the same time as Chinese domestic bauxite quality and sources of domestic supply have deteriorated.

How is it traded and priced?

Bauxite is not an exchange traded product, nor is its pricing set under long term benchmark transactions. Most pricing is done under bilateral negotiations between the miner and the off-taker for mutually agreed terms and with the price subject to a premium or discount to a reference price based on established benchmarks and available alumina (Al203) in the ore.

The reference price commonly used is the CBIX Index run by CM Group. It is an independent and impartial assessment of China’s imported bauxite market based on a value in use.
What have prices been doing historically?

On a CIF basis bauxite prices have traded between the low US $40s per tonne to the mid US$70s per tonne over the last 5 years. Below is a chart of the CBIX Index price, highlighting the price drivers over this period.

What have prices been doing very recently?

Below is the most recent price data from CBIX as of late January 2017.

Current industry trends and issues

The global market outlook for bauxite demand is positive with a genuine supply gap emerging. As the chart below from CRU highlights, from 2017 onwards the bauxite market will need all probable projects to proceed in order to meet forecast demand.

Post 2020 the supply outlook becomes even less certain with all possible projects being required to meet expected demand. Rarely is supply added to any commodity market without delays being encountered.

There are several market trends evident that auger well for the bauxite price outlook. Firstly, the growth in global aluminium demand driven by global GDP growth – especially from the auto and aircraft industries - is supportive of continued growth in bauxite requirements. Forecast aluminium production growth rates will require nearly 26% growth in bauxite supply by 2020 alone.

Secondly, there is China’s ever growing requirements. China is not naturally well endowed with quality bauxite. Its bauxite reserves are estimated at 830MT, accounting for only 3% of the global reserve according to the USGS.
However, China’s domestic sources of bauxite are falling as product quality deteriorate and mines get deeper. The decline in domestic open pit sources of bauxite in China has improved the cost competitiveness of imports from suppliers such as Australia significantly.

China’s quest for raw materials for its aluminium smelters and alumina refineries promises to deliver a 15-year boom for exporters of bauxite, according to Rio Tinto Group. Chinese bauxite imports are expected to rise 40-45% in the next five years according to Alumina Ltd to reach close to 80MT a year by 2021 from 56mt imported in 2015. Over the next 20 years bauxite imports could be as high as 160mt/year.

As China’s appetite for bauxite has increased its reliance on imports of ore from Indonesia likewise increased rapidly with approximately 80% of its bauxite supply coming from the by 2011/2012. As noted earlier, China is working hard to identify alternative supply sources. This offers an opportunity for bauxite producers in Australia to increase market share into China further.

What is the cost curve?

According to CRU, the final tranche of global annual demand is currently being met by a very steeply increasing cost curve as the below chart highlights. The marginal cost of production is approaching US$50/dmt.