

ALUMINIUM



AAI



FORMATION a



- Aluminium is the most abundant metal in the earth's crust and the third most abundant element. It occupies about 8.3% of the Earth's crust. Combined with oxygen and hydrogen, Aluminium forms bauxite ($\text{Al}_2\text{O}_3 \cdot n\text{H}_2\text{O}$) which is the most commonly mined aluminium-bearing ore. The world has reserves of 30,000 million tonnes of bauxite. Australia has about one-fifth of the world's known reserves of bauxite.
- Common rocks are not mined for aluminium, because it is so strongly bonded to oxygen and other elements that the energy required to break these bonds and separate the aluminium makes the process too costly for commercial production.
- Bauxite is found within 30 million-year-old (Cenozoic Era) weathered dolerite and granite parent rock which has broken down to leave a high proportion of aluminium-bearing minerals.
- In high rainfall areas with marked dry seasons such as tropical monsoonal and some Mediterranean climates, the combination of the alternate saturation and drying of the ground surface and organic acids causes intensive weathering of the surface soil and rock. The severe weathering effectively leaches most minerals from the top few metres and leaves behind only a reddish soil known as laterite composed of the most insoluble materials, iron and aluminium oxides, clay minerals and quartz. Laterite is found throughout most tropical monsoonal areas today.

MINING

- Bauxite is mined by surface methods (open-cut mining) which involves the removal of the topsoil and overburden by bulldozers/scrapers to expose the ore.
- The underlying cap rock is broken by bulldozers or explosives. The bauxite is mined by front-end loaders, power shovels, or hydraulic excavators and loaded in large trucks which can carry 50 to 100 tonne loads.
- Sometimes the bauxite is crushed and washed to remove some of the clay and sand waste and then dried in rotary kilns. Other bauxites may just be crushed or dried. The crushed bauxite is easier to transport to the alumina refinery and is the first stage of the refining process. The ore is then loaded into trucks, railway cars, or conveyor belts and transported to ships or refineries. Western Australia has four alumina refineries (three are operated by Alcoa World Alumina Australia at Wagerup, Pinjarra and Kwinana) while the fourth is operated by Worsley Alumina at Collie.
- When all the bauxite has been extracted, the mine is rehabilitated to restore the ecology of the mined areas. The topsoil and overburden which has been stockpiled is used for revegetating the mined area. Trees are planted and seeds from native plants are spread to start a new forest. Sometimes the cleared ground is converted into agricultural land.

Alcoa's
Aluminium



1821

Bauxite first discovered in the French district of Les Baux, after which it was named.



1825

The Danish physicist and chemist, Hans Christian Oersted was the first to person obtain aluminium metal by treating alumina.



1845

German physicist, Friedrich Wohler, produced particles of aluminium and was the first to determine many of its properties. Aluminium was classed as a semi-precious metal due to high production costs.



1855

In the 1855 Paris Exposition where the metal was on display the great potential of this new lightweight metal was recognised. Over the following decades it emerged as the wonder metal of the 20th century.



1886

American Charles Hall and Frenchman Paul Heroult both found a method of producing aluminium by electrolysis. The Hall-Heroult process is still the basis of aluminium metal production today.



1888

Karl Bayer develops a refining process for extracting alumina from bauxite in four stages: Digestion, Clarification, Precipitation and Calcination. The Bayer process is still used today.

and LOCATION

- Where aluminium oxides exceed 27% the ore is economic to mine. The most significant deposits of bauxite in Australia are at Weipa in Queensland, Gove (Northern Territory) and in the Darling Range and Mitchell Plateau areas of Western Australia. Bauxite deposits have been developed in the Darling Range south east of Perth and Mt Saddleback near Boddington. Significant deposits have been discovered in the Kimberley region at Cape Bougainville and the Mitchell Plateau, but they have not been developed.
- The main minerals in bauxite are gibbsite ($\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$), boemite ($\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$) and diaspore, which has the same composition as boehmite but is denser and harder. The pure anhydrous oxide of aluminium, alumina (Al_2O_3), contains 52.9% aluminium and 47.1% oxygen. Bauxite may be as hard as rock or as soft as mud and it 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, depending on the content of iron and other minerals. Bauxite pisolites are each made up of numerous concentric layers of bauxite minerals deposited on a sand grain.
- Bauxite is found on just about all the continents of the world.

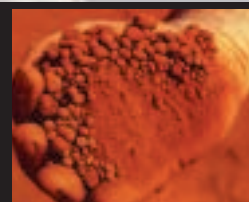


● Major bauxite mining and resource areas in W.A.

PROCESSING

- Digestion** - Crushed bauxite is fed into a caustic soda solution. This bauxite slurry is mixed and heated in vessels (digesters). The mixture is kept at 143°C for 30 minutes at a pressure of 500 kilopascals. Under these conditions the aluminium oxide and caustic soda readily react to produce a solution called 'green liquor'.
 $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O} + 2\text{NaOH} \rightarrow 2\text{NaAlO}_2 + 4\text{H}_2\text{O}$ - The 'Digestion' process.
 Gibbsite + Caustic Soda → Sodium aluminate + Water
 Silica is a most undesirable impurity in alumina and must be removed by 'desilication'.
- Clarification** - The coarse sand (waste containing undissolved iron oxides, silica and other trace materials) and fine mud (mostly iron oxide and fine quartz) are separated from the alumina bearing 'green liquor' by settling and then passing it through filters.
- Precipitation** - The chemical process in which alumina is removed from the liquor leaving alumina hydrate crystals. The 'green liquor' is cooled by passing through a heat exchanger and then through tall vessels where it is precipitated. The process is accelerated by adding hydrate 'seeds'.
 $2\text{NaAlO}_2 + 4\text{H}_2\text{O} \rightarrow \text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O} + 2\text{NaOH}$
 Sodium aluminate + Water → 'Hydrate' + Caustic Soda
- These hydrate crystals are pumped from the tank as a slurry into large conical vessels called classifiers, where they are separated into big and small crystals. The small crystals are returned to the tanks, and the large crystals are pulled out by the classifier system. The remaining liquor is recycled in the original digesters.
- Calcination** - The sized hydrate is washed and dried, then heated to about 1000 degrees Celsius to drive off chemically combined water. The final product is alumina (Al_2O_3), a dry pure white, sandy material which has a chemical composition of aluminium (52.9%) and oxygen (47.1%) - the feedstock for aluminium smelters and also used to supply a wide range of manufacturing processes, collectively called alumina chemicals. These are used, for example, in water treatment, plastics, refractories, ceramics, abrasives and glassmaking.
 $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O} \rightarrow \text{Al}_2\text{O}_3 + 3\text{H}_2\text{O}$
 Hydrate (heated) Alumina + steam
- All commercial production of aluminium is based on the Hall-Heroult smelting process. An electric current is passed through a molten solution of alumina and cryolite (sodium aluminium fluoride) in a series of reduction cells which are lined at the bottom with carbon (the cathode). Inserted into the top of each pot are carbon anodes, the bottoms of which are immersed in the molten solution. The electric current causes the oxygen from the alumina to combine with the carbon of the anode forming carbon dioxide gas. The molten aluminium settles at the bottom of the pot and is drawn off by a vacuum crucible. Once formed, the aluminium is siphoned from the furnaces, often alloyed, and cast into various shapes.

Pinjarra
n Refinery



1901

In Western Australia, government mineralogist Edward Simpson is credited with being the first person to recognise "the aluminous nature of some Darling Range laterites".



1938

The widespread occurrence of the aluminium mineral bauxite throughout the Darling Range laterites was recognised.



1953

Western Mining Corporation was the first company to begin a detailed study of the Darling Range bauxites and the following year it became Western Aluminium NL.



1963/65

The first WA mine at Jarrahdale is opened and Alcoa began production of alumina at Kwinana. Amax discovered the Mitchell Plateau and Cape Bougainville deposits in the Kimberley region.



1972

Alcoa began producing alumina from the Huntly/Pinjarra operation.



1984

Worsley Alumina Pty Ltd started mining bauxite from Mt Saddleback near Boddington. Alcoa began producing alumina from the Willowdale/Wagerup operation.

ALUMINIUM STATISTICS

Total Quantity of Alumina Produced in Western Australia

2003 - 11.22 million tonnes - A\$3.14 billion.

WA contributes about 67% of Australia's Alumina production and 20% of world production.

2003 - over 90% of WA's alumina was exported overseas from Kwinana and Bunbury.

The largest export markets for WA's alumina were China (22%), Canada (18%), South Africa (14%) and Bahrain (10%).

Exported alumina is largely smelter grade product. The remainder is processed at aluminium smelters at Port Henry and Portland in Victoria.

Employment

In 2003, 7,015 people were employed by the bauxite/alumina mining and processing industry in W.A.

Primary Bauxite/Alumina Producers in Western Australia

ALCOA WORLD ALUMINA AUSTRALIA

Huntly, Willowdale - mines.
Kwinana, Pinjarra, Wagerup - refineries.

WORSLEY ALUMINA PTY LTD

Boddington - mine.
Collie (northwest) - refinery.

Current statistics are available from the Statistics Digest on the Department of Industry and Resources website at www.doir.wa.gov.au

ALUMINIUM PROPERTIES

Sir Humphrey Davy first named the metal aluminum in 1805. Even though he could not isolate it, he was convinced that it existed and named it anyway. Later the name was changed to aluminium to be consistent with other metals. North Americans still use the old spelling.

Bauxite is used in the production of high-alumina cement, as an absorbent or catalyst in the oil industry, in welding rod coatings and as a flux in making steel and ferroalloys.

Over 90% of alumina is refined into aluminium. It is also used as an abrasive, in the manufacture of ceramics and glass and as a refractory material. Hydrated alumina is used to make chemicals for water purification, in pharmaceuticals, as a fire retardant in the backing of carpets, in detergents and in paper making.

Aluminium is **lightweight** (specific gravity of 2.7), **resistant to atmospheric corrosion**, a good **conductor of electricity** and is versatile and strong when alloyed with other metals. Aluminium has practically replaced copper in high-voltage transmission lines. Aluminium metal is ideal for the manufacture of cars, trucks, aircraft, trains and ships. Most of our road signs are also made of aluminium.

Aluminium is very **ductile** and **malleable** it can be shaped, cast, rolled, forged, extruded, drawn and machined. It can be joined, welded or soldered. It is second to iron as the most useful metal. Aluminium's natural **attractiveness** is enhanced by polishing, burnishing, painting and enamelling. In Australia, the construction industry is the biggest single user of aluminium.

Aluminium is a **good conductor of heat**, and **very chemically stable**. It will not react with most foods and is a popular material for household pots and pans, foil, and lightweight oven dishes. It is also extensively used for food and cool drink packaging. Purified aluminium oxide increases strength and whiteness of table china.

The aluminium industry initiated the recycling of aluminium primarily because it takes 5% of the energy to produce secondary aluminium as it does to produce molten aluminium from bauxite. Each tonne of recycled aluminium means a saving of seven tonnes of bauxite. In Australia over 25% of aluminium production is from recycled material.



MORE INFORMATION

Blainey, G.

Coghill, I.

Hughes, F.E., (Ed)

Raggat, H.G.

Woodcock, J.T. and Hamilton, J.K., (Eds)

The Rush That Never Ended : A History of Australian Mining, 4th Edition, (1993), Melbourne University Press, Melbourne.

Australia's Mineral Wealth, (1971), Sorrett, Melbourne.

Geology of the Mineral Deposits of Australia and Papua New Guinea, (1990), Australasian Institute of Mining and Metallurgy, Monograph 14.

Mountains of Ore, (1968), Lansdowne, Melbourne.

Australasian Mining and Metallurgy : The Sir Maurice Mawby Memorial Volume 2, (1993), The Australasian Institute of Mining and Metallurgy, Melbourne.

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