

Alcoa Australia Year 11 & 12 Teacher Resource

Introduction

Alcoa's Australian operations form an integrated aluminium industry that includes bauxite mines and alumina refineries in Western Australia and an aluminium smelter in Victoria. The Alcoa education program offers a wide range of activities that apply to each of the elements of the aluminium process.

Resources relevant to teachers of students in years 11-12 are available below.

Information, worksheets and activities

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Biology, Integrated Science

Mining Process

Alcoa's bauxite mining operations in Western Australia occur in the Darling Range. The bauxite occurs as a result of a lateritic weathering process and is often found on the sides of the hills. To access the bauxite there are a number of steps involved in the mining process.

Pre-mining surveys are conducted in all new mining areas to provide information on fauna and vegetation; to map the extent of dieback disease; and to identify any significant Aboriginal or European heritage sites or potential community impacts. Any identified impacts are avoided or management plans are developed.

Exploration drilling is undertaken to identify the specific location of ore bodies within the mine lease that are suitable for mining. Drilling starts at wide spacing (60m) and then focuses in on identified ore bodies.

Grade control drilling is undertaken to obtain detailed chemical composition information of the ore planned for mining. This information is used to plan when to mine different pits. The mines must supply a constant grade of ore to the refineries by mixing ore of different grades from different pits.



Mine planning takes into account any significant vegetation, fauna or heritage sites and any potential community impacts identified during the pre-mining surveys as well as avoiding the spread of dieback disease. A number of mine plans are produced, including a conceptual 25-year mine plan, a 10-year mine schedule and a detailed five-year mine plan.

The Five-Year Mine Plan and the Mining and Management Program (MMP) are submitted each year for government approval. The MMP summarises the major environmental management programs that will be undertaken to minimise the impacts of mining with emphasis on issues relevant to the next five years.

New infrastructure is developed when mining moves into a new area within the mineral lease. For example, the ore crusher is usually relocated closer to the new mine area to reduce the trucking distances. This happens about every 10-20 years. New roads are created each year to allow access to areas to be mined in the following few years.

Timber within Alcoa's mine lease belongs to the State Government. Before clearing, the Forest Products Commission takes any marketable timber from areas where mining is planned each year. Once all marketable timber has been taken by the Forest Products Commission, all remaining timber is cleared from the areas to be mined and positioned in rows. Wood waste is utilised by third parties for charcoal production, as wood chips for Alcoa sites and as fauna habitats in the rehabilitated mine areas. Some is also burnt.

Topsoil and overburden make up the soil profile. The topsoil layer contains a large store of seed and nutrients that are vital to the success of the forest rehabilitation and is about 15 cm thick.

The overburden layer is 20-80cm of gravelly sub-soil material sitting above a cemented laterite layer known as caprock.

These layers are removed separately using scrapers prior to mining. Due to the uneven nature of the caprock, the scrapers are unable to remove the entire overburden layer as some of this material will remain in the hollows in the caprock. This is known as secondary overburden.

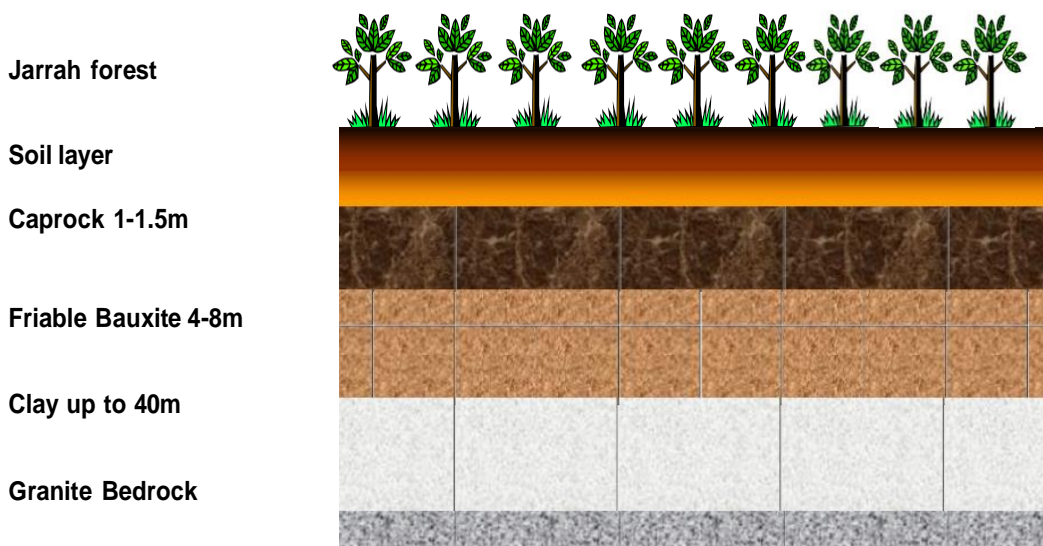
Secondary overburden is removed using a small excavator.

Caprock is a solid rock layer containing bauxite and rests above the friable bauxite layer in the soil profile. This caprock layer is usually broken by blasting.

Crushing and conveying to refineries occurs once the caprock layer has been broken and the bauxite is ready to be mined. An excavator or loader is used to load the bauxite onto haul trucks for transport to the crusher. The crusher is used to break the ore down to a smaller size suitable for transport along conveyor belts to the refineries.



Bauxite profile before mining



Rehabilitation Process

Each year, mine pits that have had the ore removed and roads that are no longer needed are rehabilitated. The long-term objective of Alcoa's mine rehabilitation is to establish a self-sustaining jarrah forest ecosystem that maintains or enhances conservation, timber, water, recreation and other forest values. Alcoa's rehabilitation process has been developed and improved since operations commenced in 1963 and currently involves a number of important steps.

Pre-ripping and landscaping take place first. Pre-ripping breaks up the compaction of the pit floor caused by heavy mining equipment. A bulldozer with a winged tine, which is like an inverted T attached, rips the floor of the pit. This helps roots to penetrate through the soil profile.

Large rocks are buried, vertical pit faces are flattened down and the pit floor is smoothed to blend the mined area into the surrounding landscape.

Soil return takes place with overburden and topsoil layers being returned. Wherever possible, fresh topsoil is returned directly to rehabilitated areas from pits that have been cleared recently. This maximises the topsoil seed store, which is important for optimising the number of plant species in rehabilitated areas.



Contour ripping is undertaken to increase the soil's water storage capacity. This contour ripping is undertaken with a multi-pronged ripper. Contour ripping creates mounds across the slopes in rehabilitation, which are important for erosion control. In flat areas and areas with a low potential to erode, the rip lines may be partially flattened by a heavy bar dragged behind the ripping dozer.

Seeding is done to encourage the return of plant species into rehabilitated areas. The seed mix is specially formulated by Alcoa and contains 50 to 80 species and is applied at a rate of about 1 kg per hectare.

Recalcitrant planting takes place to ensure the return of species that are unable to be established from the seed in the topsoil or applied seed mix. These plants include many grasses and sedges that produce little viable seed. On order from Alcoa, local suppliers grow up to 600,000 seedlings of these species through tissue culture (cloning) or cuttings and plants these seedlings by hand in the rehabilitated areas.



Fertilising is done to improve the establishment and early growth rates of trees and under storey in revegetated areas. Fertiliser is applied by helicopter to newly rehabilitated areas, usually around August.

Ongoing monitoring and management of rehabilitated areas takes place to ensure the return of plant species into rehabilitated areas. Around March each year, when the rehabilitation is about nine months old, the previous year's rehabilitation is monitored to check that the number of established plants meets targets agreed by the Department of Biodiversity Conservation and Attractions (DBCA) and Alcoa, and to identify any areas that need further treatment to control weeds or repair any erosion.

Around 15 months of age, botanical species richness (number of different plant species) is monitored against internal and government standards.

Relinquishment of mined areas to the State is the aim of rehabilitation. Government regulators in consultation with the community and other stakeholders have developed a set of Completion Criteria for rehabilitation areas. Due to improvement in rehabilitation standards and techniques, two sets of completion criteria exist for pre-1988 and post-1988 rehabilitation. These criteria were developed to allow government agencies to assess whether rehabilitation is of a satisfactory standard so that Alcoa can hand the land back to DBCA for future management.



World's best mined land rehabilitation to return a self-sustaining jarrah forest ecosystem to enhance or maintain water, timber, recreation and conservation values.

Rehabilitation is a staged process. These photos have been taken in the same area of rehabilitation and show progress over 20 years.



Six months



Four Years



13 years



20 years

Year 11 Geography Unit 2 – Global networks and interconnections – Alcoa links

To assist geography teachers address year 11 Geography curriculum Unit 2 – Global networks and interconnections, Alcoa has developed a series of questions relating to the different aspects of Depth Study One.

Depth Study One

Using fieldwork and/or secondary sources students investigate the reasons for, and consequences of, the changing spatial distribution of production and consumption (and, where appropriate, reuse) of **at least one** commodity, goods or services from **one** of the following groups:

- ✓ a mineral ore or fossil-based energy resource – iron ore, coal, **bauxite**, natural gas or oil

Investigate:

<p><i>The nature of the commodity, good or service</i></p>	<ul style="list-style-type: none"> ✓ Describe bauxite as a commodity including location. ✓ Where else in the world is bauxite located? ✓ Describe the processes used in mining bauxite.
<p><i>The process of diffusion of the commodity, good or service and its spatial outcomes</i></p>	<ul style="list-style-type: none"> ✓ What are the markets for the bauxite? ✓ What does value add mean? ✓ How does Alcoa value add bauxite? ✓ What are the markets for alumina? ✓ How does Alcoa value add alumina? ✓ Define: upstream, midstream and downstream.
<p><i>The changes occurring in the spatial distribution of the production and consumption of the commodity, good or service in Australia and overseas, and the geographical factors responsible for these changes</i></p>	<ul style="list-style-type: none"> ✓ Describe how the spatial distribution of bauxite production changes and the geographical factors responsible. ✓ Where does the downstream consumption of bauxite take place? ✓ What geographical factors influence the location of Alcoa's alumina refineries in Western Australia? ✓ Where are the markets for alumina? ✓ What geographical factors influence the distribution of these markets? ✓ What further consumption takes place downstream?
<p><i>The role played by technological advances in transport and/or telecommunications in facilitating these changes in the spatial distribution</i></p>	<ul style="list-style-type: none"> ✓ Describe the transport system used for bauxite and the technological advances that are utilised. ✓ What additional technological systems are used in the production of bauxite? ✓ What telecommunication tools are utilised by the company that make it easier to operate globally?

Year 11 Geography Unit 2 – Global networks and interconnections – Alcoa links continued

<p><i>The role played by governments and enterprises in the internationalisation of the production and consumption of the commodity, good or service, such as the reduction or elimination of the barriers to movement between countries</i></p>	<ul style="list-style-type: none"> ✓ How does government influence global operations? ✓ How is the business structured to operate globally?
<p><i>Implications of the changes in the nature and spatial distribution of the production and distribution of the commodity, good or service for people, places and the biophysical environment at a variety of scales, including the local</i></p>	<ul style="list-style-type: none"> ✓ What variations can occur in bauxite that affect production? ✓ What are the implications of changes in the spatial distribution of bauxite at a local level? ✓ What impact does mining have on the biophysical environment? What is done to reduce impacts?
<p><i>Likely future changes in the nature and spatial distribution of the production and consumption of the commodity, good or service</i></p>	<ul style="list-style-type: none"> ✓ What are the potential changes to the distribution of bauxite as a commodity?
<p><i>The impact of these changes on less developed countries (LDC) in terms of sustainability</i></p>	<ul style="list-style-type: none"> ✓ What are the limitations less developed countries face when mining bauxite?
<p><i>The ways people and places embrace, adapt to, or resist the forces of international economic integration, and the spatial, economic, social and geopolitical consequences of these responses</i></p>	<ul style="list-style-type: none"> ✓ How does the global economy impact on alumina markets? ✓ How has Alcoa adapted to the international economy? ✓ What influence does Alcoa have on the local economy? ✓ How does Alcoa demonstrate corporate social responsibility? ✓ Are there any geopolitical influences that impact the production of bauxite?

Year 12 Geography Unit 3 – Global environmental change – Alcoa links

To assist geography teachers address year 12 Geography curriculum Unit 3 – Global environmental change, Alcoa has developed a series of questions relating to the different aspects of Depth Study Two.

Depth Study Two

Using fieldwork and/or secondary sources, students investigate how the impacts of land cover change are being addressed and evaluated.

<i>approach to land cover restoration and rehabilitation, and the mitigation of future land cover changes, including preservation strategies</i>	<ul style="list-style-type: none"> ✓ Describe the processes used prior to the commencement of mining activity to mitigate potential land cover changes
<i>the current and proposed strategies, at local to global levels, implemented to mitigate the adverse effects of either global climate change or loss of biodiversity</i>	<ul style="list-style-type: none"> ✓ Describe the rehabilitation process ✓ What research is undertaken to mitigate potential impacts on biodiversity?
<i>how human activity has adapted, or may be required to adapt, to either global climate change or loss of biodiversity</i>	<ul style="list-style-type: none"> ✓ How have approaches to rehabilitation changed since the commencement of Alcoa mining operations on WA? ✓ Describe strategies that have been introduced to minimise potential impacts prior to rehabilitation
<i>a program designed to address the impacts of land cover change on local and regional environments</i>	<ul style="list-style-type: none"> ✓ In addition to site rehabilitation, what additional programs exist to address impacts of land cover change on local and regional environments?
<i>an evaluation of the program, giving consideration to environmental, economic and social benefit and costs</i>	<ul style="list-style-type: none"> ✓ Compare and contrast an area of rehabilitation to an area not cleared for mining ✓ Sketch
<i>an evaluation of at least one alternative approach to the management of land cover change in the area being studied, using the concept of sustainability to determine the extent to which the approach has the potential to address the issue into the future</i>	<ul style="list-style-type: none"> ✓ Compare

Mapping Bauxite

Topic: Mining

Background Information:

Bauxite occurs through a weathering process of granite and laterite over millions of years. In Western Australia, bauxite is formed on the sides of hills starting at a depth of approximately 0.5m and reaching an average depth of 4-5m including the caprock. Bauxite is also located in other regions of the world.

You will need:

- Global map showing mineral deposits
- Paper
- Pencils

What you need to do:

- Find the different locations of bauxite around the world.
- Draw a Venn diagram showing similarities and differences between the locations.
- Is there a pattern to the locations?

Extension/Alternatives

- Which of these areas have active mining?
- Compare and contrast the communities where mining operations exist and have existed.
- What are the longitudes and latitudes for the different locations?
- Using a blank map, shade the areas where bauxite is located.
- What other minerals can be found in these regions?

Final question

What can you deduce from the presence of bauxite in these regions?

Curriculum Links:

Geography

Reference

Lateritic Bauxites

G. Bardossy and G.J.J. Aleva

Developments in Economic Geology No. 27

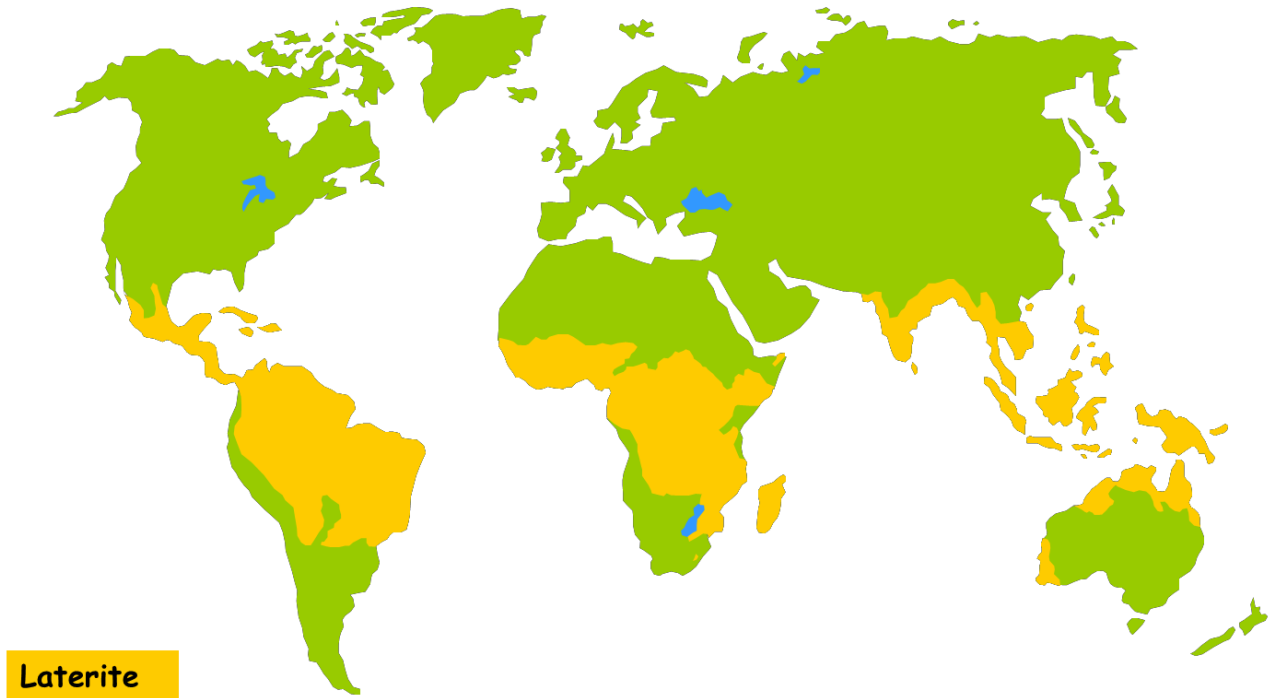
Elsevier Press 1990

Mapping Bauxite continued

Teacher resource:

After Bardossy / Aleva, 1990

Global Laterite Distribution



Geology of Bauxite

Topic: Mining

Background Information:

There are 3 different types of rock: igneous (volcanic), sedimentary and metamorphic. The Bauxite of the Darling Ranges is predominantly formed from igneous rock, mainly granite that has been altered through a weathering and leaching process.

Darling Range bauxite is found by taking samples of laterite in possible mining areas along the scarp. Laterite is the remains of granites and some dolerites that have been chemically and physically altered by a weathering process over millions of years. Where there is enough Gibbsite (Alumina mineral) concentrated in the laterite it is called bauxite. Most bauxite is formed on the sides of hills starting at a depth of approximately 0.5m and reaching an average depth of 4-5m including the caprock.

Alumina is refined from bauxite, aluminium is then smelted from the alumina.

You will need:

- ✓ Personal Protective Equipment (PPE)
- ✓ Closed in shoes, long trousers and long sleeves
- ✓ Paper
- ✓ Pen/pencil
- ✓ Container for samples

What you need to do:

Collect a sample of:

- ✓ Caprock
- ✓ Friable bauxite
- ✓ Clay zone

Compare samples, describe colour, texture, size, any patterns etc.

Note the differences and similarities between the areas where they have been collected from.

Create a table that shows the physical properties of the rocks.

Extension / Alternatives

- ✓ Draw a sample of caprock and label components – iron rich elements, gibbsite, quartz grains
- ✓ Create a profile using the samples
- ✓ Create a poster noting the physical properties of the samples and showing the profile.

Curriculum Links:

Earth and Environment Science, Integrated Science

Geology of Bauxite continued



	Sketch	Describe	Compare
Soil			
Caprock			
Friable Bauxite			
Clay			
Granite			

Simulated Bayer Process

Topic: Refining

You will need:

- Borax
- Sand
- Mud / Soil
- Distilled water
- 150ml Beakers / stirring rod
- Plastic cup
- Filter paper or syringe with filter attachment
- Microwave

What you need to do:

Create the slurry

- Mix the borax, sand and mud together in equal quantities – this simulates ‘bauxite ore’
- Weigh 100g of ‘bauxite ore’
- Place into 150ml beaker
- Add 100ml of distilled water

Digestion

- Place in microwave on 100% power for 45 seconds
- Remove carefully
- Stir with stirring rod
- Allow to stand for 10 seconds

Clarification

- Decant into a plastic cup (note sand in bottom of beaker)
- Assemble syringe filter
- Draw 35ml solution from plastic cup
- Expel first 20ml of this back into a beaker
- Alternatively use the filter paper to filter the solution
- Once filtrate is clear, transfer remainder into a fresh 150ml beaker

Precipitation

- Cool on crushed ice until crystals first appear (after temperature drops to 40°C, leave for about 2 minutes)

Extension/Alternatives

- Describe the process in your own words.
- What else could you use to simulate the Bayer process?

Discussion:

- The filtrate is supersaturated. As it cools, crystals will precipitate out until new solubility equilibrium is reached.
- Stir and note what happens.

Curriculum Links:

Chemistry, Integrated Science

Flora Survey - Quadrat Activity

Topic: Rehabilitation and Rehabilitation

Background Information:

In Western Australia bauxite mining occurs in the Jarrah Forest. The Jarrah Forest is a biodiversity hot spot and some plant species can vary between locations. As part of the mine planning and approval process, flora surveys are conducted to map vegetation types and identify rare and priority species in the areas proposed for mining.

Once rehabilitation has taken place flora monitoring is conducted to measure the success of mine rehabilitation and its similarity to unmined forest.

You will need:

- ✓ Tape measure
- ✓ String
- ✓ Writing/sketching materials,
- ✓ Camera (not essential).

What you need to do

- ✓ Pick a large vegetated area and estimate the size
- ✓ Use the string to create a quadrat that is a minimum of one metre square
- ✓ Record the number and species of flora within the quadrat.

Extension / Alternatives

- ✓ Graph the results
- ✓ Survey multiple quadrats and calculate the average to estimate species richness (i.e. number of species)
- ✓ Calculate the number and variety of plant species within the larger area, based on an analysis of the quadrat information
- ✓ Choose some samples to sketch. You may even like to collect some samples to press in a book and write descriptions of
- ✓ Create a transect 5-10 metres in length, apply markers each metre. Sketch plant the profile of the transect showing the different heights and species of plants

Curriculum Links:

Biology, Integrated Science