

IRON ORE



FEBS

FORMATION a



A raw iron ore sample

- In Western Australia, most iron ore deposits are hosted in banded iron formation rocks (BIFs). These black, red and grey banded chemical sedimentary rocks were laid down about 2,500 million years ago and consist of alternating iron-rich and silica-rich layers.
- The iron-rich layers are composed of black magnetite (Fe_3O_4) and dark grey/red haematite (Fe_2O_3), whereas the silica-rich layers comprise fine grained quartz or chert.
- 2,500 million years ago, seawater was rich in dissolved silica. This precipitated on the seafloor as white or grey chert. The iron in the black and grey/red layers was supplied by nearby volcanoes. The presence of free oxygen determined whether iron was precipitated in the oxidised form (Fe_{3+}) in mineral haematite, or the reduced state (Fe_{2+}) in magnetite.
- The iron content of BIF is about 30% – not sufficiently high enough to be considered an ore. In places throughout the Pilbara, secondary enrichment by removal of non-iron components has increased the iron content to over 60%.
- The high-grade microplaty haematite ore deposits such as Mount Whaleback, Tom Price and Paraburdoo, have been enriched to 64% iron. This enrichment occurred by the removal of silica-rich bands by descending groundwater and the oxidation of magnetite to goethite, and then to haematite with subsequent burial. Enrichment tends to be in rocks which have been folded or faulted as these structures trapped the downward-moving groundwater. These processes occurred more than 1,800 million years ago.

MINING

- Western Australia's iron ore mining operations are highly mechanised using sophisticated technology.
- The ore is mined from large open pits by progressive extraction along steps or benches 12 to 15 metres high. After the soil and overlying rock are cleared, the ore is drilled and blasted. The fractured ore is loaded by huge mechanical shovels, hydraulic excavators or front end loaders onto some of the world's biggest dump trucks and hauled to the crushing plant. Crushing and sieving reduces the ore to less than 32 mm in size. The crushed ore is then separated according to size into 'lump' or 'fines' (less than 6 mm).
- The ore is then transported hundreds of kilometres by rail to ports at Cape Lambert, Dampier and Nelson Point and Finucane Island at Port Hedland. These rail lines are the most extensive privately operated rail systems in Australia. In 2001, BHP Billiton set new world rail records for the longest (7.353km) and the heaviest (99,732.1 tonnes) train.
- Before being shipped overseas or interstate, high-grade haematite ores are blended with lower grade goethite-rich ores. This ability to blend different grades of ore to meet customer specifications is an important factor in WA's success as an iron ore exporter.
- Ongoing environmental management and rehabilitation projects aim to produce stable landforms and self-sustaining revegetation so that, on completion of mining, the flora and fauna of the area is not significantly different from the surrounds.

Mount Whaleback Mine



4000 BC

The earliest discovery of iron was from meteorites. It was highly prized and used to make ornaments, weapons and tools.



1300 BC

Use of iron increased when smelting methods were discovered - the beginning of the Iron Age. Wrought iron was produced by hammering.



1340 AD

Smelting iron to liquid form began in earnest with the development in Germany of an early form of the blast-furnace.



1840

First discovery of iron ore in Australia was made by explorer Edward J Eyre in the Middleback Ranges, South Australia.



1856

The development of the Bessemer converter allowed cast iron to be turned into steel on a large scale - the dawn of a new age for iron and steel.



1890

The WA Government Geologist stated that the Pilbara had enough iron ore to supply the whole world "but iron ore has no value" - hence the observation was not followed up.

nd LOCATION

- The softer haematite-goethite ores, such as those at Marandoo, are also a result of enrichment of banded iron formation by the chemical removal of silica bands, but this weathering process occurred about 100 million years ago. This is the dominant ore-type in the Pilbara, but due to its slightly higher phosphorus content, it is not as valuable as the microplaty haematite ores.
- The **goethite gravel ores** of Pannawonica and Yandicoogina are younger still. These deposits formed about 30 million years ago by the erosion of existing haematite-rich rock sand deposition of iron-rich gravel in ancient river channels.
- The Koolyanobbing and other deposits near Southern Cross are mostly **high-grade massive haematite** lenses in strongly folded BIFs.
- The **martite-haematite deposits** of Yampi Sound, north of Derby in the Kimberley Region, are a unique type of iron formation. The ores seem to be the product of direct sedimentary deposition of iron oxides with little secondary enrichment. The Koolan and Cockatoo Island mines in Yampi Sound have now closed.



● Major iron ore mining projects and infrastructure centres in WA

PROCESSING

- In 1995, BHP Billiton was the first to undertake secondary processing of iron ore in the Pilbara when it commissioned the Hot Briquetted Iron Plant at Port Hedland. The plant uses natural gas to heat iron ore fines and drive off the oxygen to produce metallic briquettes of 92% iron. At Kwinana, CRA has a research and development project, Hls melt, which is currently developing new, cutting edge technology for taking iron ore to the smelting stage. This \$150 million project began construction in 2003 and should be completed by the end of 2004.
- At the steelworks, blended 'lump' ore is fed directly into the blast furnace with coke (upgraded coal) and limestone. Iron ore 'fines' need to be fused into bigger pieces. They are mixed with powdered coke and limestone, then pass through a furnace to ignite the coke, fusing the iron ore into a clinker-like mass which can then be fed into the blast furnace.
- The raw materials are fed in alternate layers through the top of the blast furnace and a continuous flow of superheated air (1,200°C) causes the ingredients to react and melt, reducing the iron oxide to molten iron ($FeO + CO = Fe + CO_2$). The resulting 'pig iron' is drawn off at the bottom of the furnace – at this point it has few uses and is usually refined to steel.
- To make steel, molten pig iron, scrap steel and limestone are fed into large vessels where 99% pure oxygen is blown onto the materials. Heat generated by the oxygen increases the temperature to 1,700°C, which melts the scrap steel and the unwanted impurities are oxidised. Molten steel is then tapped off and alloying elements are added for strengthening.
- The cooled steel is rolled into bars, sheets or plates in readiness for further processing into the many products we use daily.

e - BHP Billiton Iron Ore



1938

The Federal Government imposed an export ban on iron ore believing that iron ore was a strategic resource for use in weapons of war.



1945

First mined in WA at North Windarling, near Southern Cross, to supply a small charcoal-iron plant at Wundowie.



1957

Mt Whaleback orebody in the Pilbara was discovered by prospector Stan Hilditch.



1960

Export embargo was lifted and work commenced on establishing the extent of the Pilbara iron ore resources.



1965

Mining operations in the Pilbara commenced at Goldsworthy



1998

BHP Billiton produces the first Hot Briquetted Iron at Port Hedland.

IRON ORE STATISTICS

TOTAL QUANTITY OF IRON ORE MINED IN WESTERN AUSTRALIA

2003 - 194,682,470 tonnes (\$5.06 billion)

2002 - 171,766,816 tonnes (\$5.064 billion)

Australia produces about 17% of the World's annual production of iron ore - WA supplies over 97% of this.

ROYALTY RECEIPTS

Royalties are payments made by mining companies to the government for the right to develop a resource.

2003 - \$290,647,904

2002 - \$272,499,984

EMPLOYMENT

During 2000, the iron ore industry directly employed 11,184 people.

PRIMARY IRON ORE PRODUCERS IN WESTERN AUSTRALIA

BHP BILLITON IRON ORE PTY LTD

Yarrie, Jimblebar, Cockatoo Island, Mining Area C, Mt Whaleback at Newman, Yandi.

PILBARA IRON

Marandoo, Mount Tom Price, Paraburdoo/Channar, Yandicoogina, Brockman no.2, Eastern Ranges, Pannawonica-West Angelas, Mesa J.

PORTMAN IRON ORE LTD

Koolyanobbing

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



IRON ORE PROPERTIES

The chemical symbol for iron is **Fe** from the Latin name ferrum.

The ferrous form of iron, Fe_{2+} , dissolves in water but the ferric form, Fe_{3+} , does not and precipitates as $Fe_2O_3(OH)$ - rust.

After aluminium, iron is the most **abundant metal** on Earth making up about 5% by weight.

The **most useful metal** known - we use 20 times more iron, in the form of steel, than all other metals put together.

Pure Iron is quite soft hence small amounts of other elements such as manganese, nickel, molybdenum, aluminium, chromium, copper and titanium are added to improve its strength, hardness and elasticity.

Cast iron is partly refined iron and contains up to 5% carbon making it very hard, but brittle. The tensile strength can be increased by including other alloying elements such as 1-3% silicon. Cast iron is used in such things as vehicle cylinder blocks.

Wrought iron is nearly pure iron mixed with a glasslike material. Unlike cast iron, it resists corrosion and is more malleable, making it better for use in outdoor furniture, porch railings and other decorative items.

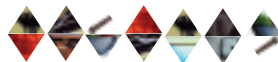
Steel, the most commonly used form of iron, contains about 1% carbon as the principal hardening element. By far the greatest use of iron in the world is as various forms of steel.

Stainless steel contains chromium as the main alloying element. It resists corrosion and hence is used in the production of motor vehicle parts, hospital equipment and razor blades.

Tool steel is an extremely hard steel used in metal-working tools. It is produced by tempering certain alloy steels by heating then cooling quickly.

MORE INFORMATION

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