GOLD

Au

The Chamber of Minerals & Energy Western Australia

FORMATION a

The Sealion Gold Nugget
67.7 ounces

- Gold is widely dispersed in the Earth's crust in very low concentrations, as little as 0.001 grams per tonne. For mining to be viable, gold needs to be concentrated between 2,000 and 10,000 times (2 - 10 g/tonne) to form a **gold deposit.**
- **Primary gold deposits** form deep in the Earth's crust when hot fluids containing carbon and sulphur move upwards, dissolving gold and other ore components from the rocks through which they pass. These fluids travel along faults, fractures and other weaknesses in the rocks, carrying the gold in solution as a gold-sulphur complex. Around 5 to 10 km beneath the Earth's surface, the gold-bearing fluids react with iron rich rocks, causing gold to precipitate within pyrite crystals and in quartz veins.
- **Secondary gold deposits** are in the thick layer of weathered rocks blanketing much of Western Australia. Over the millions of years since primary gold deposits formed, the land has been uplifted and eroded in a continually changing climate. Under humid tropical conditions of 100 million years ago, primary gold was dissolved by rainwater and precipitated in horizontal layers just below the water table. About 15 million years ago, the climate became increasingly arid and the water table dropped. The gold dissolved in the saline groundwater and was carried downwards. During periods when the water table was stable, gold concentrated at this level. Changes in the position of the water table have resulted in a series of layers of concentrated gold.

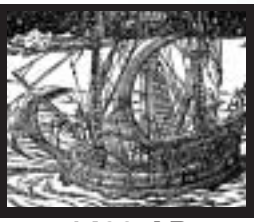
MINING

- Gold mining has come a long way from the single mine shaft plus panning and dryblowing of the original diggers. Most Western Australian gold is mined from large open cut pits or extensive underground operations.
- Open cut projects are best suited to secondary gold deposits or primary gold near the surface. The soft, weathered rocks are easier to mine, need less or no blasting, meaning gold grades as low as two grams per tonne can be economically extracted.
- Underground mining is for ore bodies that extend below 300 metres from the surface and generally requires grades of at least four grams per tonne to be viable. Many open cut mines progress to underground techniques if the gold grade is sufficient and continuous lodes or ore-shoots are found.
- Both underground and open cut projects require ore to be blasted, loaded into trucks and taken to the crusher for the first stage in separating the gold from the waste material.
- After production ceases, underground mines and open cut pits are secured against intrusion by people and animals. Processing areas and other work sites are cleared, recontoured and revegetated.
- Waste dumps are recontoured to form low hills which are covered with fertile topsoil and planted with local native vegetation. The industry has developed considerable expertise in establishing native ecosystems in the harsh, arid environment of many gold producing areas.
- Many decommissioned mines are retained by the companies for possible reworking should gold prices improve.

The Fimiston Trea
Kalgoorlie Consolidated

≈ 6000 BC
Gold first mined - one of the earliest known metals.

≈ 500 BC
Alchemy - the attempt to change base metals into gold.



1492 AD
Christopher Columbus set off in search of gold.

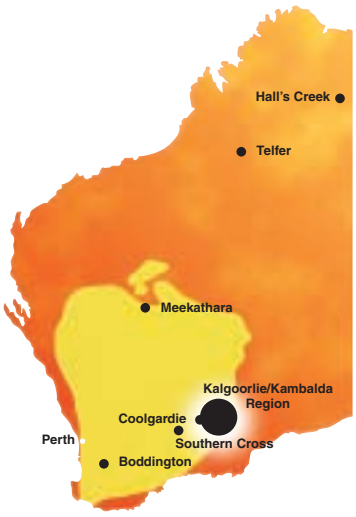
1848
First gold rush sparked by the discovery of gold in California.

1851 Feb
First discovery of gold in Australia at Hill End near Bathurst, NSW.

1851 Dec
Rich discoveries made at Bendigo and Ballarat, Victoria.

nd LOCATION

- Most gold deposits in Western Australia formed during the **Archaean Era** - more than 2,500 million years ago. Exceptions include the Telfer deposits which occur in rocks that formed 1,000 million years ago (late **Proterozoic Era**) and the Boddington deposits secondary gold enrichment which formed about 35 million years ago (**Tertiary Period**).
- Western Australia's most significant goldfields are around Kalgoorlie, Kambalda, Meekathara, Telfer and Boddington.
- The majority of gold mined in Western Australia is found in a large area known as the **Yilgarn Block**. This area comprises narrow zones of folded and metamorphosed (changed by heat and pressure) sediments and volcanic rocks surrounded by granite and granite-gneiss.
- **Gold nuggets** are derived from the break-up of exposed primary gold-rich veins, or 'grow' within the soil or weathered rock as gold is gradually deposited from the groundwater.
- The **biggest nugget** from Western Australia was found at Larkinville, near Widgiemooltha in 1931. It weighed 32.177 kg and was found just 45 cm below the surface.



Major gold mining areas - The Yilgarn Block in yellow

PROCESSING

- Most gold ore is processed, with the collected gold smelted to over 75% purity at or near the mine site.
- Gold is mainly separated from ore using the "carbon in pulp" process. Ore is crushed to a fine silt, then mixed with water and sodium cyanide to form a slurry. The gold reacts to form a gold cyanide complex which dissolves in the solution. Where gold is trapped in sulphides such as pyrite, roasting is required to convert the sulphides to oxides before being mixed with sodium cyanide.
- The slurry is filtered to remove non-soluble waste material, then mixed with carbon pellets to which the gold cyanide complex attach. The carbon pellets are removed from the process tanks and the gold stripped from them using a small volume of hot cyanide solution.
- The gold is collected from the cyanide solution by electrolysis. Steel wool cathodes become coated in gold in response to electricity being passed through the hot cyanide solution. Excess steel wool is dissolved using hydrochloric acid (HCl).
- The collected gold is purified by smelting. It is heated until it melts, impurities are skimmed off when they float to the surface. The molten gold is cast into bars, and transported to the refinery.
- Refining is the final stage - the gold bars are remelted in a crucible aerated with chlorine gas. The melted impurities, such as silver, nickel and copper, form chloride compounds which are skimmed off the surface for reprocessing. The remaining gold is poured into moulds.
- Recent advances in technology have developed biological oxidation of sulphide ores. Bacteria oxidises the sulphides releasing the gold and removing the necessity of roasting, hence also reducing sulphur dioxide (SO_2) atmospheric pollution.
- Although the carbon in pulp extraction process revolutionised the industry, it employs the use of highly toxic chemicals. Research is being undertaken to find an equally efficient, but more environmentally-secure method of extraction.

tment Plant at
l Gold Mines Pty Ltd

1870
Charters Towers and Palmer River, North Queensland.

1885
Gold was first discovered in Western Australia at Halls Creek.

1888
Southern Cross, Western Australia. The first of the major gold finds on the Yilgarn Block.

1892
Bayley and Ford discovered the phenomenal riches at Coolgardie, Western Australia.

1893
Kalgoorlie, Western Australia - last and most significant gold rush in Australia.

1995
Western Australia experienced another gold boom - output jumping from 15 tonnes in 1980 to 189 tonnes in 1995.

GOLD STATISTICS

Total Quantity of Gold Mined in Western Australia

Western Australia supplied around 66% of Australia's total gold production in 2003 and about 7% of the world's gold production.

Western Australia on its own is the world's third largest producer.

In 2003 the top four export destinations were the United Kingdom (48%), India (21%) and South Korea (13%).

In 2002, 187,284 kilograms of gold was mined worth around $3.61 billion.

Employment

In 2003 the gold industry directly employed 12,801 people.

Primary Gold Producers in Western Australia

ANGLOGOLD AUSTRALIA LTD
Sunrise Dam.

BARRICK GOLD OF AUSTRALIA LTD
Darlot, Lawlers, Plutonic.

GOLD FIELDS AUSTRALIA PTY LTD
St Ives.

KALGOORLIE CONSOLIDATED GOLD MINES PTY LTD
Fimiston Open Pit (Super Pit).

NEWMONT AUSTRALIA
Jundee-Nimary.

PLACER DOME ASIA PACIFIC LIMITED
Kanowna Belle, Paddington, Kunduna.

PLACER (GRANNY SMITH) PTY LTD
Granny Smith.

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

GOLD PROPERTIES

The chemical symbol for gold is **Au** - from the Latin word - Aurum meaning 'shining dawn'.

Gold is the only **yellow metal**, it is named after the old English word for yellow - Geolu.

It has a very high **specific gravity** - 19.3 - nearly twice that of lead.

Gold doesn't **oxidise** at ordinary temperatures, so no oxide film dulls its surface.

Highly **resistant** to attack by acids, gold can only be dissolved in 'aqua regia'.

Gold is highly **malleable.** That is it can be rolled into very thin gold leaf.

Gold is extremely **ductile**. It can be drawn into thin wires, and is used for neurosurgical probes and in electrical circuitry.

It is an excellent **conductor of electricity** and is used in microchips.

The high **reflective properties** of gold make it useful for heat protection on solar vehicles and for applications in the space program.

Pure gold is very **soft.** To increase it's tensile strength it is alloyed with other metals.

Its **rarity** and **inertness** makes gold an obvious choice as the medium for coinage.

Primary gold is often **electrum** (natural alloy of Au and Ag) with silver content as high as 25%.

Fineness describes the purity of gold. Secondary gold usually has a higher purity than primary gold. Purity of alloyed gold is measured in **carats** - pure gold is 24 carats; 9 carat gold is 9 parts pure gold and 15 parts other alloy metals.

MORE INFORMATION

- **Evans, Anthony M.** — *An Introduction to Ore Geology*, c1992, Blackwell Scientific Publications
- **Minerals Council of Australia** — *Gold Fact Sheet* (brochure), 1999, Canberra, ACT

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