

# TIN, TANTALUM & LITHIUM

## Introduction

Tin, tantalum and lithium are metals derived from pegmatites which have played a significant part in the history of mineral production in Western Australia.

Tin was one of the first metals mined in WA more than a century ago. However, the collapse of the world tin market in the mid 1980s heralded the emergence of an associated metal, tantalum, at Greenbushes in the State's South West and at Wodgina in the Pilbara. This helped elevate the State as a leading producer of this commodity in world markets.

Another product from the Greenbushes operation is lithium.

## Historical background

*Tin* was one of the first metals used by man more than 5,000 years ago.

Centuries before the Roman invasion of Britain, Phoenician traders from Tyre and Sidon brought their ships to Cornwall to take on cargoes of tin and copper. Both minerals occur together in Cornwall.

In ancient times when these minerals were smelted together, the product being a yellow alloy which was found to be much harder than either tin or copper, and thus more useful for making implements. This accidental discovery of ancient bronze saw the dawning of the "Bronze Age" which preceded the "Iron Age".



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Δ Glass manufacture including high-quality optics is one of the end uses of spodumene (containing lithium oxide) which is mined at Greenbushes in WA's south west.

By Roman times, tin was being fairly widely used both in bronzes and in other applications such as for plating copper vessels.

It was not, however, until the 19th century that tin was employed in industry on a large scale. In 1800, total world production of the metal was less than 9,000 tons, whereas by 1900 it had increased to 75,000 tons. This rapid increase was due mainly to the extensive use of tin cans throughout the world as containers of preserved fruit, meat, fish, petrol, paraffin, and so on.

The existence of tin in Australia was established in the 1840s, but commercial production didn't begin until 1871 in New South Wales. The 1870s saw Australia as the world's leading producer of tin.

#### **Tin in Western Australia**

The first talk of a tin discovery in WA came from the Toodyay district in 1846, but the find was never confirmed because the discoverer refused to disclose the locality unless substantially rewarded (Battye, 1913).

The earliest commercial tin deposit in WA was found at Greenbushes in 1888 by Mr D. W. Stinton after he received some instructions from the then Government geologist, Mr E. T. Hardman.

The discovery of gold in the Pilbara the same year (1888) resulted in prospectors finding tin in many streams between the Yule and Coongan Rivers.

Tin was found in the Halls Creek area in 1907 and in the Murchison and Eastern Goldfields areas in 1909. The only significant new discovery since then has been the Coondina deposit which had been known to Aborigines for some time, but was first reported in 1964.

**Tantalum** was discovered in 1802, but its commercial use did not begin until a century later when tantalum was employed for a few years as a filament material in incandescent light bulbs. It later became a strategic "war metal"



Δ *Miners sluice for tin in an old creek bed at Greenbushes in the late 1880s.*

during the 1940s and is now regarded as an important high-technology metal in, for example, the electronics industry.

**Lithium** was first mined in the United States from spodumene mines in South Dakota in 1898. Demand was stimulated during World War Two by a requirement for lithium chemicals (anhydrous lithium hydroxide – LiOH) as an absorber of carbon dioxide in submarines and gas masks. In the 1950s it was used by the U.S. Atomic Energy Commission for fusion reaction studies.

#### **Sources of Tin, Tantalum and Lithium**

##### **Tin**

The chief mineral from which tin is extracted is cassiterite (SnO<sub>2</sub>).

Cassiterite is mainly found in one of two ways:

1. Primary deposits – formed by deep-seated geological processes such as the intrusion of granite and in which the cassiterite is embedded in hard rocks such as pegmatite and quartz; or
2. Placer (alluvial) deposits – formed by the mechanical concentration of heavy cassiterite in river beds and in which the tin

ore is contained in relatively soft gravel and sand. Eight percent of the world's production is from this source.

##### **Tantalum**

The chief source of tantalum is tantalite (Ta<sub>2</sub>O<sub>5</sub>) which can be mined from either primary or placer deposits.

##### **Lithium**

In Western Australia, its main source is the mineral spodumene which occurs in the same (pegmatite) orebody as tin and tantalum at Greenbushes. However, most of the lithium produced in the world comes from brines which, in most cases, are sourced from the waters of desert lakes.

##### **Properties and Uses**

**Tin** is a silver-white metal with a slightly blue tinge. It rarely occurs as a native metal, but is found primarily as the mineral cassiterite, an oxide containing about 75% of tin metal.

Pure tin is mechanically weak. However, when alloyed with some other metals, such as copper or antimony, it becomes considerably stronger, making it extremely useful as an industrial metal. Other alloys, with metals such as lead, silver, bismuth and cadmium, have low melting points that make them suitable for solders or casting printing type.

Tin is attractive as a coating metal because it has a low melting point (232 degrees Celsius, compared with gold which has a melting point of 1,063 degrees Celsius). It also has an ability to alloy with other metals, is resistant to tarnishing in air at ordinary temperatures and is resistant to corrosion and fatigue.

About 60% of Australia's tin consumption is used for tinplating – mainly food and drink cans. Other important uses include solder, bronzes, pewter and as an alloy for bearing metal.

Most of the tin produced from Greenbushes is alloyed with antimony

and used to harden pewter and for making tin-antimony alloy bearings.

**Tantalum** is a heavy metal closely related to niobium, and is used as an alloy metal for the manufacture of high-quality steels. In excess of 40% of the tantalum produced in Western Australia ends up being used in electronic capacitors. Tantalum's corrosion-resistant qualities also place it in demand for chemical, nuclear, and aerospace applications.

**Lithium** is marketed either as a salt (usually lithium carbonate), in concentrated brine (lithium chloride), or as a concentrate of one of a number of naturally occurring minerals, with spodumene being the most common. The product from Greenbushes is exported as spodumene concentrates of different grades. It is used mainly for

the manufacture of glass, especially high-quality optics. Other uses include as a flux for the manufacture of aluminium and ceramics; for making batteries, as an additive for lubricants and pharmaceuticals; and as an alloy for strengthening aluminium.

### **Production**

#### **Tin**

Australia ranks as the eighth largest tin producer in the world. The other major tin producing countries are Malaysia, Bolivia, China, Indonesia, Thailand, Brazil and Nigeria.

Three quarters of Australia's tin production comes from the Renison mine in Tasmania, which was first worked in the 1890s.

Other minor producing areas in Australia are north-east Tasmania, the

New England area of New South Wales, the Herberton/Mt Garnet areas of northern Queensland and Greenbushes in Western Australia.

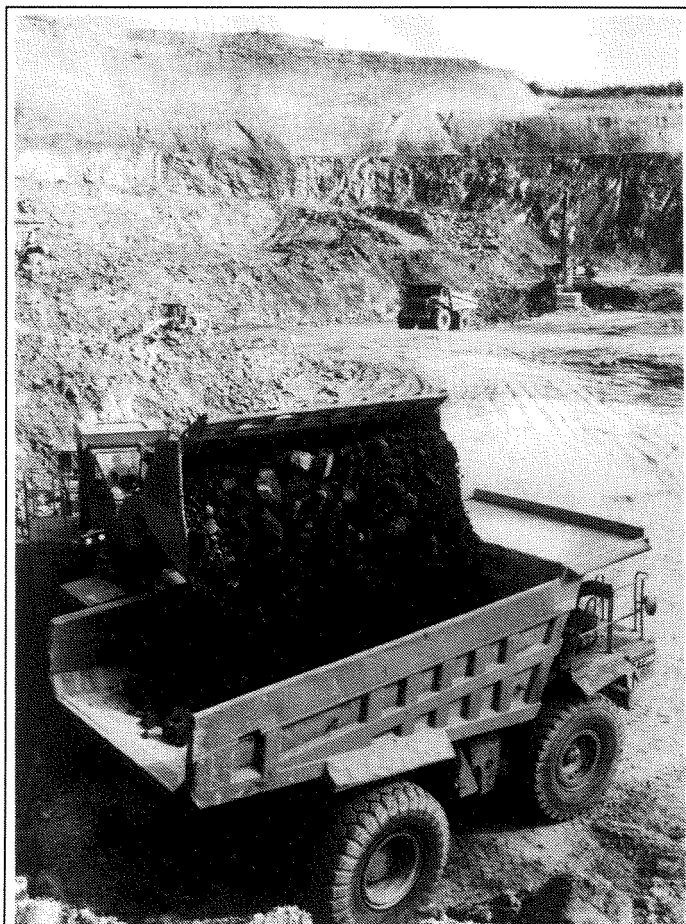
Total world production of tin amounts to about 210,000 tonnes per year, with Australian output being about 8,000 tonnes.

#### **Tantalum**

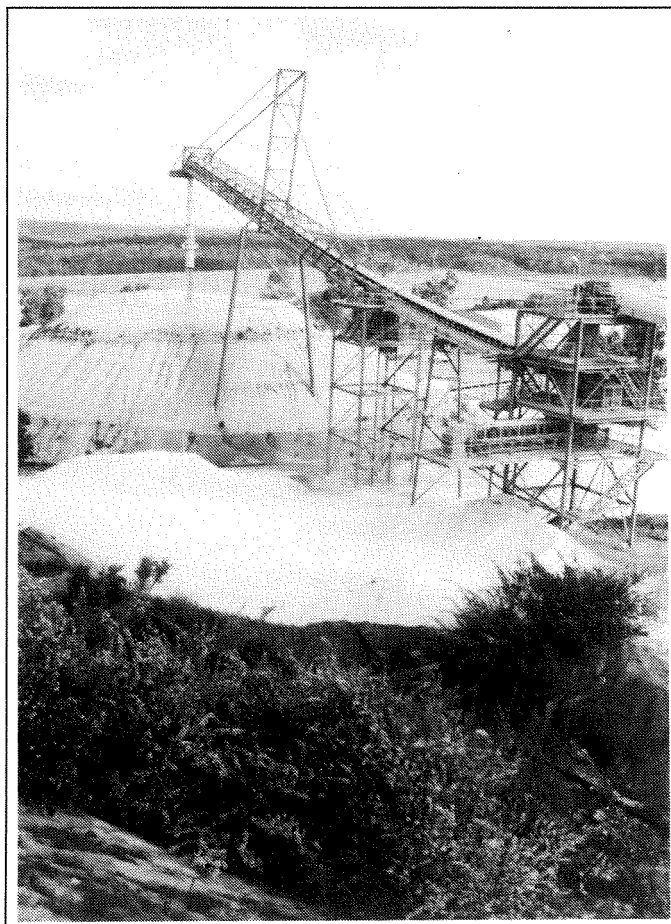
Australia accounts for almost half of the world's annual output of around 930 tonnes of tantalum. Other significant producers are Brazil, Thailand, Canada, Zimbabwe and Zaire. All Australian tantalum comes from Western Australia, the two producing centres being Greenbushes and Wodgina.

#### **Lithium**

Australia produces about 10 per cent of the world's requirements of lithium,



Δ An open-cut operation at Greenbushes where tin, tantalum and lithium are mined.



Δ Tantalum and spodumene stockpiles at Greenbushes.

with all output coming from Greenbushes in Western Australia. Other major producers are the USA, Canada, Chile, former USSR, Zimbabwe and China.

Most of the world's lithium production comes from brines. However, the product from Greenbushes is in the form of a spodumene concentrate extracted from pegmatite.

## Mining methods

### *Tin and Tantalum*

There are four main methods used around the world for mining tin and tantalum. They are:

1. Open cut mining is employed to access shallow orebodies which are excavated from the surface using bulldozers, mechanical shovels and other large mining equipment;
2. Underground mining is used to extract ores that are too deep for open cut operations; it involves sinking shafts, breaking the ore with explosives, and transporting it out of the mine to be treated.

The Renison mine in Tasmania uses the underground mining method and is the largest underground tin mine in the world. However, Greenbushes, in Western Australia, operates an open-cut mining method.

3. Dredging is used to mine placer deposits that are under water. The sands and gravels beneath the water are dug up by means of a *string of buckets attached to a moving chain* and then treated by jigs or cyclones mounted on the dredge itself. The preliminary concentrate produced in this way is usually sent to shore for further treatment while the waste material is pumped overboard.
4. Gravel Pumping involves breaking up the tin or tantalum-bearing sands and gravels with very high pressure

water jets and pumping them as a slurry to a sluice. The mixture is then washed down the sluice, where the heavy cassiterite and tantalite settle out and are caught in special traps, while the lighter sand and stones pass on to the waste dump.

Dredging and gravel pumping were formerly employed extensively in the Eastern States tinfields. While the drier climate of Western Australia restricts their use here, tin dredging did take place at Greenbushes in the 1960s in an artificially constructed lake.

*Lithium* ores are not heavy, so do not form placer deposits amenable to dredging or gravel pumping. They are, however, mined by open cut and underground methods.

In addition, much of the world's lithium is extracted from brines associated with evaporite minerals, by pumping them to the surface and allowing them to evaporate to precipitate their dissolved salts. Lithium salts stay in solution longest, and it is possible to allow all other minerals to settle out so that the final brine is a concentrated lithium solution that can be sold as such.

## Treatment

### *Tin and Tantalum*

After mining, the tin and tantalum ores are broken up by crushing. They are then upgraded using jigs, shaking tables and a spiral concentrator to separate the heavy minerals from the lighter components. The minerals are then separated using electromagnetic and electrostatic techniques.

The tantalite minerals are subsequently roasted to remove minor tin or antimony contamination.

The tin minerals are roasted to remove minor traces of arsenic. The tin minerals are further processed through a smelter using submerged arc electric furnaces to produce tantalum-rich slag and tin-antimony alloy.

## *Lithium*

After mining, the spodumene mineral is already fairly pure. From there silica and clay are separated by gravity and flotation methods to upgrade the product to spodumene concentrate (which has a 5-7% lithium oxide content).

## Exports

About 95% of the tin-alloy is exported to the United States and Europe. About 5% goes to the tin-pewter trade in Australia.

Virtually all the tantalite produced in Western Australia is exported in either a slag or tantalum mineral form to the United States or Europe.

Spodumene concentrate, a white powdery material containing between 5-7% lithium, is packed in bags and exported to markets in Japan, the United States and Europe.