

NICKEL

Introduction

The ancient Chinese used nickel in metal alloys, but it was not until about 1823 that Europeans discovered the usefulness of such alloys for tableware. Until then, nickel-rich minerals were considered a nuisance that spoilt valuable copper ores and were thus associated with the misdemeanours of the devil or "old Nick". Today, nickel is a valuable commodity with a wide range of industrial and commercial applications.

Properties and uses of nickel

Nickel is a bright, white metallic element that shares many close chemical and physical properties with iron and cobalt. It resists corrosion and its ability to impart corrosion and heat-resistance, strength, hardness and other physical properties to alloys, results in many applications in industrial and consumer goods.

There are more than 3000 alloys containing nickel. Stainless steel, which contains about 8% nickel, is the best known nickel-bearing product. It is used extensively for cutlery, kitchenware, tools and coinage.

The chemical and petroleum refining industries use large amounts of corrosion and heat-resistant alloys which contain more than 8% nickel. Monel metal, which contains 67% nickel, is a highly corrosion-resistant alloy used in shipbuilding, food processing equipment, hospitals and laundries. Nickel also rates as a strategic metal, and is important in steels used for armour plate, gun forgings, shells and bullets. Being corrosion resistant, such alloys are also important ingredients of aircraft engines and frames as well as the electroplated parts of aircraft and motor vehicles. Kovar, an alloy of nickel, iron and cobalt, has a similar coefficient of thermal expansion to glass and provides gastight glass-metal seals for electrical equipment.



DEPARTMENT OF
MINERALS AND ENERGY
WESTERN AUSTRALIA



△ The underground/open pit nickel mine at Leinster, 650 km north-east of Perth.

Compared with the use of nickel in alloys, chemical uses of nickel or its compounds are not so extensive. It is presently used in alkaline batteries, dyes, ceramic pigments, insecticides or as a catalyst, but the current development of a commercial nickel-zinc battery for electric vehicles represents an enormous potential demand.

Historical background

Nickel metal was first isolated in 1751 by the Swedish chemist Axel Cronstedt. Although extracting metallic nickel from the arsenide gersdorffite, Cronstedt named the metal after the arsenide niccolite, which at that time appeared to be the chief ore of nickel.



Mining of nickel did not begin in earnest until the 1840s when deposits were exploited in France, Germany and Scandinavia. Gabbro-associated sulphide deposits in Norway were the largest producers. Small deposits in Greece, Italy, Sweden, Russia and the United States of America were also worked intermittently in the mid-19th century. Added demand was placed on nickel when the metal found use in electroplating and coinage. This demand ensured that the discovery, in 1863, of nickel silicate ("garnierite") lateritic ores in New Caledonia heralded an era of large-scale nickel production.

The Sudbury district of Canada became the world's principal source of nickel following discovery there in 1856. One of several samples taken from a gossan-stained ridge assayed at 2% copper and 1% nickel, but the area was too remote and the find was forgotten. Mineralised outcrops in the area were accidentally found in 1883, during the

construction of the Canadian Pacific Railway, and the intensive exploration that resulted led to the re-discovery of the gossan-stained ridge, in 1886. By 1905, Canada had replaced New Caledonia as the world's largest nickel producer and maintains that position today. The largest producing company in Canada is INCO, whose operations are based at Sudbury.

Nickel in Australia

In 1992 Australia ranked as the world's sixth biggest producer of nickel behind the former Soviet Union which contributed 24.8% of total production, Canada 21.7%, New Caledonia 11.3%, Indonesia 8.7% and Botswana 6.7%. Australia contributed 887, 200 tonnes or 6.5% of world production in 1992.

Nickel-bearing minerals had been noticed in gold-rich veins in the Eastern Goldfields of Western Australia as early as 1897. It was not until the 1950s, however, that deposits were sought in



Δ *Stainless steel items such as coins, tools, pots, cutlery and other kitchenware are among the major uses of nickel.*

the State. In 1955, Southwestern Mining Co. Ltd (a subsidiary of International Nickel Co. Ltd) started exploration for nickeliferous laterite (nickel ochre) at Wingelina near the intersection of the Western Australian, South Australian and Northern Territory borders. The evaluation of the Wingelina laterites was terminated in 1972 when Nickel Mines of Australia Ltd concluded that the remote location would render mining uneconomic.

Consequently, prior to the discovery of high-grade nickel sulphide ore at Kambalda in 1966, Western Australia had virtually no nickel reserves. However, rising world nickel prices and a prolonged strike at the giant International Nickel mine at Sudbury in Canada, meant that the discoveries made at Kambalda were rapidly developed, and the famous 'nickel boom' of 1967-71 ensued. Many further discoveries were made during this period in a belt between Norseman and

Wiluna, which is now recognised as one of the world's major nickel provinces.

Nickel ores in Western Australia are divided between sulphide ores and lateritic ores. Nickel sulphide deposits associated with volcanic ultramafic rocks (komatiites) make up the largest proportion of the sulphide resource and are also the most important economically. Nickel sulphide deposits associated with intrusive ultramafic rocks are next, both in terms of reserves and production.

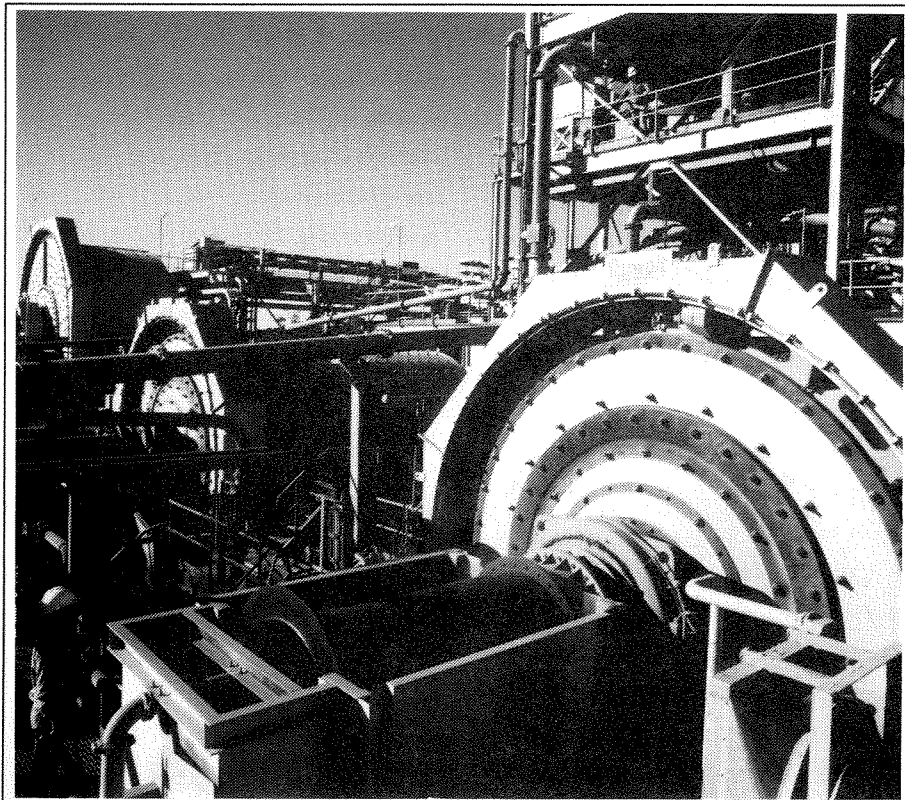
Current production in Western Australia comes from mines at Kambalda and Leinster (formerly Agnew), both operated by Western Mining Corporation Ltd (WMC), and at Forresteria which is operated by Outokumpu Australia Ltd. A large low-grade deposit at Mount Keith is expected to open in late 1994. Mines operating in 1992 produced almost 48,000 tonnes of nickel. Exported either

as a fully-refined metal or as a mineral concentrate, the value of the product was close to \$462 million.

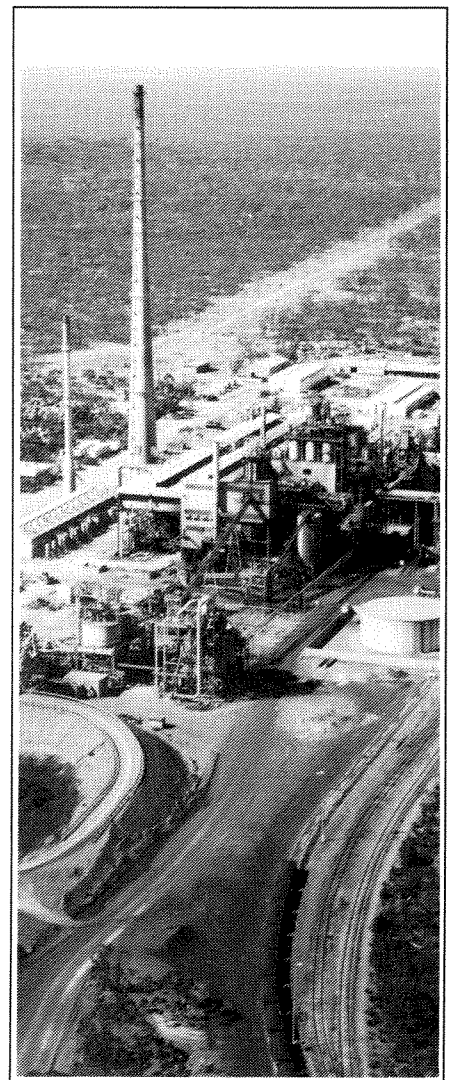
Mining and treatment

Nickel is mined by both opencut and underground methods. Opencut methods are used where ore bodies are close to the surface. Low operating costs allow low-grade deposits to be considered as ore bodies. Deeper deposits must be of higher grade to warrant the additional cost inherent in underground mining.

Western Mining Corporation commissioned the Kalgoorlie Nickel Smelter in 1972 and upgraded it in 1978 to accommodate the treatment of



Δ Part of the grinding circuit at a nickel treatment plant in Western Australia.



Δ The Kalgoorlie nickel smelter.

concentrates from its Leinster operations. WMC also operates its own nickel refinery at Kwinana.

There are three stages used in refining nickel ore: concentrating, smelting and refining.

Concentrating is done in a concentrating plant at the mine site. This involves crushing the ore to a very fine powder, mixing the powder with water to make a slurry and feeding it into a flotation cell containing selected chemicals. When the mixture is agitated with compressed air and a propeller, the fine nickel-rich particles adhere to bubbles and float to the surface where they are collected, concentrated and dried. Over 90% of the nickel in the initial ore is recovered into a concentrate that contains around 10 to 12% nickel.

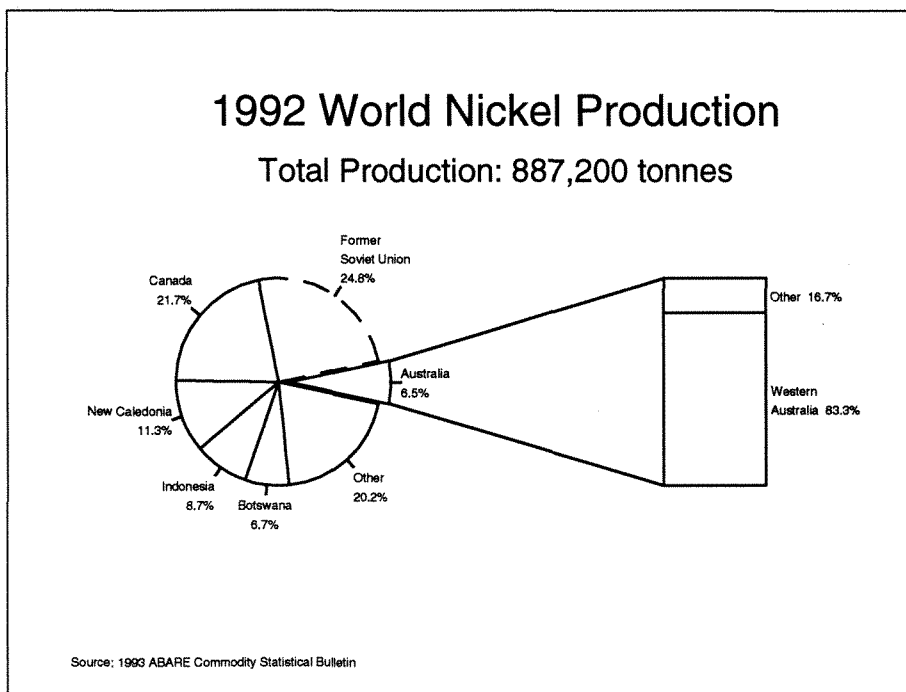
The concentrate is transported by rail to the Kalgoorlie nickel smelter where it is passed through a flash smelter operated by Outokumpu Oy. This produces nickel "matte" containing about 72% nickel. After being dried, granulated and packaged the matte is either exported or transported to the nickel refinery at Kwinana.

The Kwinana nickel refinery uses the Sherritt Gordon hydrometallurgical process which produces pure nickel metal in the form of a powder. This is washed, dried and either packaged for sale or pressed into briquettes.

Co-products produced at the refinery include copper sulphide, nickel-cobalt sulphide and fertiliser-grade ammonium sulphate. Precious metals are also recovered.

The environment

Nickel companies, in keeping with public expectations and government



policy, have a heavy commitment to the environment.

Guidelines are set by the Department of Mineral and Energy to assist companies in adopting adequate measures to protect the environment during exploration and mining. In turn, companies are required to lodge bonds to ensure that they comply with recognised rehabilitation standards.

Areas disturbed during exploration and mining are, in most places, revegetated with local plant species. Nurseries and seed collection programmes are normally established to assist with this work.

Water is reclaimed from tailing dumps and sewage effluents and dams established to store storm water. These sources now provide about half the water requirements for mineral processing. Emissions from the smelters are monitored to minimise the risk of polluting nearby towns and the surrounding vegetation.

Future

After a period of depressed prices during the early 1990s, nickel is poised for a resurgence.

With expectations of a higher world demand for nickel, Western Mining Corporation has embarked on a programme to substantially increase production of the metal in Western Australia. This will be achieved by commencing production from its low-grade nickel operation at Mt Keith and by lifting the capacity of its Kalgoorlie nickel smelter and Kwinana nickel refinery by 50%. After this work is completed in late 1994, Western Mining will become the world's second biggest producer of nickel.

Another potentially large-scale nickel operation north of Mt Keith is CRA's Honeymoon Well project which is currently the subject of a feasibility study.

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