Mineral Commodity Report 1 — Aluminium

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Symbol	Al
Atomic No.	13
Atomic wt	26.98
Specific gravity	2.70
Valence	3
Melting point	660˚C
Boiling point	2467˚C
Crustal abundance	8%
Preferred analysis method	plasma atomic emission spectroscopy
Routine detection limit	100 ppm

Discovery and Origin of Names

Sir Humphry Davy prepared an iron-aluminium alloy in 1809 and crude aluminium was isolated in 1825 by Hans Christian Orsted. Davy named the element aluminum from the Latin *alumen* for alum salts, and aluminum was later modified to aluminium. Bauxite, the ore of aluminium, was named after the locality Les Baux in Provence (France) from where it was first identified.

Major Ores and Minerals

Because of its chemical reactivity, aluminium never occurs in metallic form in nature, but its compounds are present in almost all rocks, vegetation and animals. It is the most abundant metallic element in the earth's crust, comprising about 8% by weight and exceeded in amount only by the non-metallic elements oxygen and silicon. The main ore of aluminium is bauxite which contains 35–55% Al_2O_3 (18.9–35.1% metal) and consists of a mixture of oxide minerals, principally gibbsite $Al(OH)_3$ and boehmite AlO(OH). Aluminium, to a limited extent, is also extracted from andalusite Al_2SiO_5 and alunite $KAl_3(SO_4)_2(OH)_6$. Crystalline aluminium oxide (emery, corundum) is mined as a natural abrasive or in its finer varieties as rubies and sapphires. Emery is a corundum which contains varying amounts of hematite or magnetite, quartz and spinel.

Properties

Aluminium, a member of Group IIIA of the periodic table, is a lightweight, silvery-white metal that is ductile, highly malleable, an excellent conductor of heat and electricity, non-magnetic and non-sparking. Though chemically active, aluminium is nevertheless highly corrosion resistant because in air, a hard tough oxide film forms on its surface.

Bauxite is usually found in pisolitic aggregates and in round concretionary grains, or in claylike masses. It is white, grey, yellow, or red in colour, with an earthy lustre, hardness of 1 to 3 and specific gravity of 2 to 2.5.

Corundum varies considerably in colour from blue, green-grey, brown, black to colourless. It is rhombohedral and has a hardness of about 9, whereas emery has a hardness in the range 7.5–8.5.

Formation

Aluminium is less mobile than many other elements in rocks, and in tropical and sub-tropical areas with warm and wet climates it is concentrated as bauxite in the subsoil as the intense weathering leaches out silica and other elements. These laterite-type deposits are mainly Tertiary or Quaternary in age. A second type of deposit, the karst-type, is formed where bauxite is concentrated in solution depressions on carbonate rock. Karst-type deposits are typically Mesozoic in age.

Corundum crystallises early from molten magma and is generally formed in mafic and ultramafic rocks, although the main source of production is from detrital deposits.

Uses

Aluminium is surpassed only by iron in terms of the quantity of metal used by man. The major uses are in building materials, the transport industry (cars, trucks, aircraft and boats), the electrical and communication industries (cables, transmission towers, tubing, etc.), packaging (eg cans and foil) and cooking utensils. Commercial aluminium (99.0 to 99.6% Al) has small quantities of silicon and iron which make it hard and strong. There are more than 100 commercial aluminium alloys which contain various other metals, mainly magnesium, manganese, chromium, zinc and copper. The alloys offer a wide range of combinations of mechanical strength, ductility, electrical conductivity and corrosion resistance.

Alumina is used as a refractory, an abrasive (eg corundum and emery) and in the manufacture of fire retardants, ceramics and glass.

Price

The average price for aluminium (99.7% Al) quoted by the London Metals Exchange was US$1500 per tonne over the 10 year period 1983–1992 with a maximum of US$2367 in 1988. The price is currently low because production in recent years has exceeded consumption and there is an oversupply of the material.

World Occurrence and Production

Total known world resources of bauxite are more than 20,000 million tonnes (Mt), nearly half of which are in Australia and Guinea. Large resources (more than 1000 million tonnes in each country) are also found in Brazil, Jamaica, India and Cameroon, and significant resources are also present in Indonesia, Guyana, Greece, Surinam, Ghana, Yugoslavia, Venezuela, Costa Rica, Hungary, countries of the former

USSR, Sierra Leone and China. Current annual mine production of bauxite is about 110 Mt (107.96 Mt in 1992); annual alumina production is estimated at about 35 Mt of which about 3 Mt is non-metallurgical (34.1 Mt and 3.1 Mt respectively in 1992) (Humphreys, 1993); and annual aluminium production is about 16 Mt.

The major corundum resources and production are in Zimbabwe, countries of the former USSR, India, Uruguay and South Africa. Annual production is about 18,000 t. Emery is mainly produced by Greece and Turkey, typically about 50,000 t annually.

New Zealand Occurrence and Resources

Bauxite deposits are found in Northland, within a triangular area between Kerikeri, Kaikohe and Kaeo (Figure 1). Late Pliocene to early Pleistocene Horeke Basalt has been extensively altered to halloysite and where rainfall and leaching has been sufficient, gibbsite (bauxite) has been produced from the halloysite (Carr *et al.*,1980). The typical profile consists of a dark humic soil, about 20 cm thick, above a layer of ironstone nodules, which is underlain by pale clay with gibbsite nodules (Carr *et al.*, 1980). At Otoroa (Matauri Bay area), 17 km north of Kerikeri, where the largest resources are known, the average thickness of the gibbsite-rich profiles is between 3 m and 4.6 m, and the maximum thickness is 12 m.

Initial prospecting by the DSIR (Kear *et al.*,1960), consisted of the drilling of 53 auger holes in the Otoroa area. A resource of 20 Mt of bauxite was estimated to be present in a 294

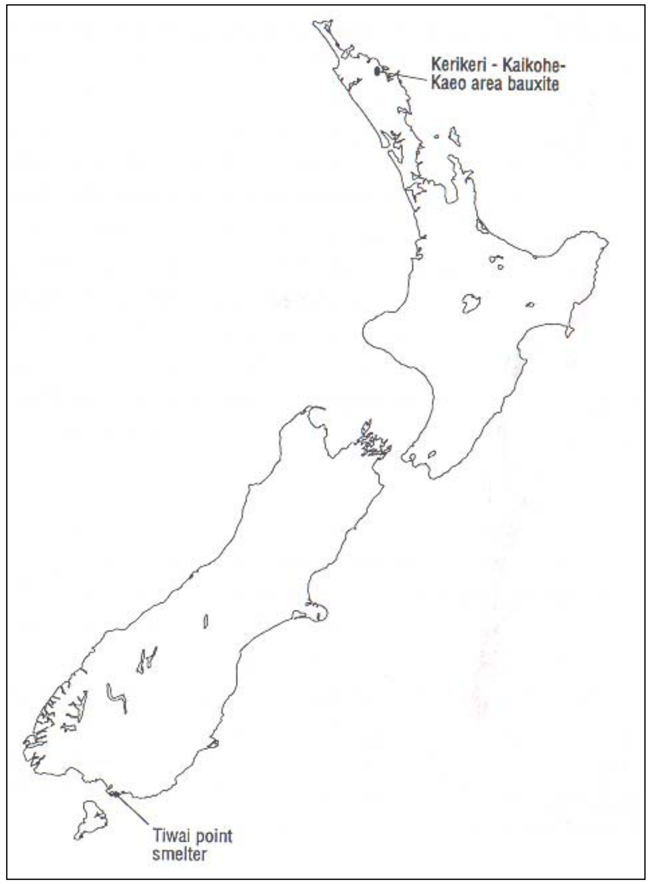

Figure 1: Location of bauxite deposits in Northland and the Tiwai Point smelter in Southland, where aluminium is produced by electrolytic smelting alumina imported from Queensland, Australia.

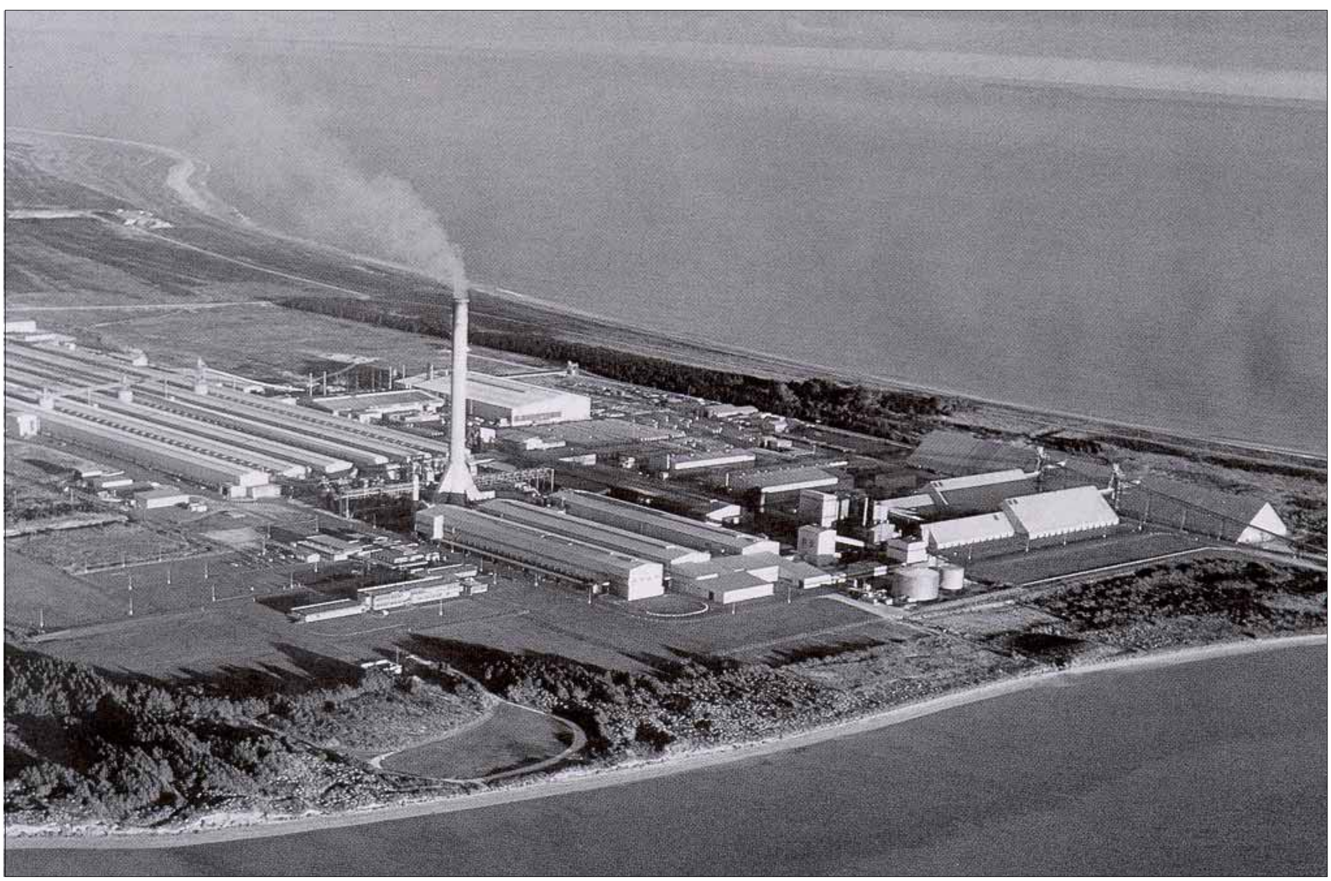

Figure 2: Tiwai Point aluminium smelter, Bluff, Southland (Photo: Comalco).

hectare area. Kear *et al.* (1960) considered that the material typically contained 37.4% Al_2O_3 (equivalent to 30.6% extractable alumina), 5.5% SiO_2, 23.3% Fe_2O_3, 2.3% FeO and 6.4% TiO_2. Additional auger drilling by Comalco/ Consolidated Zinc (Berkman, 1962; Evans, 1963), and later Magellan (Manix, 1971; Rolston, 1971a, 1971b; Pearson, 1973), confirmed the DSIR resource estimate of the Otoroa deposit and identified another 15 small deposits nearby, collectively containing about 9.25 Mt of bauxite with 30% alumina or better. The largest of these deposits contained about 2.4 Mt. Beneficiation tests showed that the Otoroa bauxite could be upgraded from 30% extractable alumina to approximately 44% by wet screening, but this increase in grade was coupled with a more than 40% reduction in the tonnage of the alumina resource.

Corundum has been recorded from contact zones of metamorphosed ultramafic rocks, or in gravels derived from these, mainly near Richmond Flat (Parapara district, West Nelson) and in Westland (near Hokitika, and in the Arahura and Whitcombe valleys) (Railton and Watters, 1990). Similarly, sub-gem quality sapphire and ruby have also been found in ultramafic rock gravels: sapphire in Collingwood, Greymouth and Hokitika districts, and in Slatey Creek (Kakanui, east Otago); and ruby in Westland (Rimu, Kaniere, Kaniere Forks and Olderog Creek).

Imports, Production and Exports

No bauxite has been mined in New Zealand, but aluminium is smelted at Tiwai Point (Figure 2) in Southland from alumina (Al_2O_3) imported from Queensland, Australia. Bauxite from Weipa, one of the world's largest bauxite deposits, is shipped to Gladstone where it is refined into alumina. The alumina is then shipped from Australia to Tiwai Point for electrolytic smelting into aluminium by New Zealand Aluminium Smelters Ltd (a subsidiary of Comalco). The Tiwai Point plant has three pot lines with a design capacity for producing 259,000 t of aluminium annually, representing about 1.6% of the world's total supply. Production of this quantity of aluminium requires the consumption of 504,000 t of alumina (Australia), 96,000 t of petroleum coke (USA), 25,000 t of pitch (Australia), 8000 t of cryolite (Japan) and associated bath material, 20 million litres of fuel oil and 500 megawatts of electricity (Manapouri). Products include extrusion billet, rolling block, pure and foundry ingot and T bar (Figure 3). The average annual production for the 5 years from 1988 to 1992 was 255,068 t with the largest output being 259,408 t in 1990 (Comalco, 1993). Currently, about 9% of the output is used within New Zealand and the remainder is exported, making up about 5% of New Zealand's total exports by value.

Potential and Prospectivity

The Northland deposits have been regarded as subeconomic in both size and grade, however the exploration programmes have acknowledged that the resource estimates are based on wide-spaced drilling. There may be potential for further investigation if there was a strategic advantage in using the New Zealand resource.

Figure 3: Aluminium ingots produced at the Tiwai Point smelter (Photo: Comalco).

Future Trends

Aluminium's lightness, strength, corrosion resistance, high electrical and thermal conductivity and ease of fabrication, ensure that it will continue to be a major industrial metal. World resources are adequate to supply forecast increases in demand and recycled aluminium makes up a significant portion of the current consumption.

Acknowledgements

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