

Cobalt

The lustrous brittle metal cobalt, with a bluish-grey colour, has similar properties to nickel. It has been renowned for centuries for the deep blue colour produced by its oxides, used for dyes and pigments. Today the metal has applications in many industries, from aerospace to medicine.

According to the US Geological Survey (USGS), the identified world cobalt resources are about 15m tonnes, yet its concentration levels are very low. The average content of cobalt in the Earth's crust is just 25 ppm. Cobalt combines with sulphur and arsenic to form a wide range of minerals, but it does not occur naturally as a native metal. It is mainly produced as a by-product of other more abundant or more valuable metals, most commonly nickel and copper.

Significant cobalt-bearing mineral deposits are found in the Democratic Republic of Congo (DRC), Zambia, Australia, Russia and Canada. Cobalt is extracted from four principal types of deposit: strata bound copper in the DRC and Zambia, nickel-copper sulphide mainly found in Russia, Canada and Australia, nickel laterite in Cuba, New Caledonia and Western Australia, and silver-cobalt sulpharsenide, now only worked by the Bou Azzer mine in Morocco.

According to USGS data, in 2003 just under 50% of cobalt was sourced from the copper ores of Central Africa – DRC

and Zambia, 14% from Australia, 10% from Russia, 8% from Canada, while smaller but significant quantities of mined production came from Cuba, New Caledonia, Brazil and Morocco. A potentially important source of cobalt in the future is in deep-sea, manganese-rich nodules and encrustation deposits in shallower waters, which contain up to 2.5% cobalt.

History

The name cobalt is derived from the German term "kobold", meaning malicious gnome. During the fourteenth century, miners in the silver and nickel mines of the Schneeberg and Harz mountains in Germany used the nickname for certain ores that were difficult to smelt and produced toxic arsenic trioxide vapours when roasted.

Cobalt was primarily used in its oxide form for colouring until the 20th century. During experiments to establish that bismuth was not the only element to colour glass blue, the Swedish chemist Georg Brandt isolated metallic cobalt in 1735. In 1916, 72% of total cobalt was still used in oxide form, whereas oxides currently account for just over 10% of world cobalt consumption. Cobalt's first metallic uses stemmed from Elwood Haynes' research into cobalt-chromium-tungsten-carbon Stellite® wear-resistant alloys in the early 1900s.

Production

Because cobalt is extracted from a wide range of minerals and ores, there is an equally extensive variety of mining, extraction and refining methods. Around 49,500 tonnes of cobalt were produced in the form of metal and compounds last year, according to the UK-based Cobalt Development Institute (CDI); some 39% of these arose as a by-product of copper metallurgy and the remainder as a by-product of nickel metallurgy. Only in Morocco is cobalt produced as a primary mined commodity from arsenide ores.

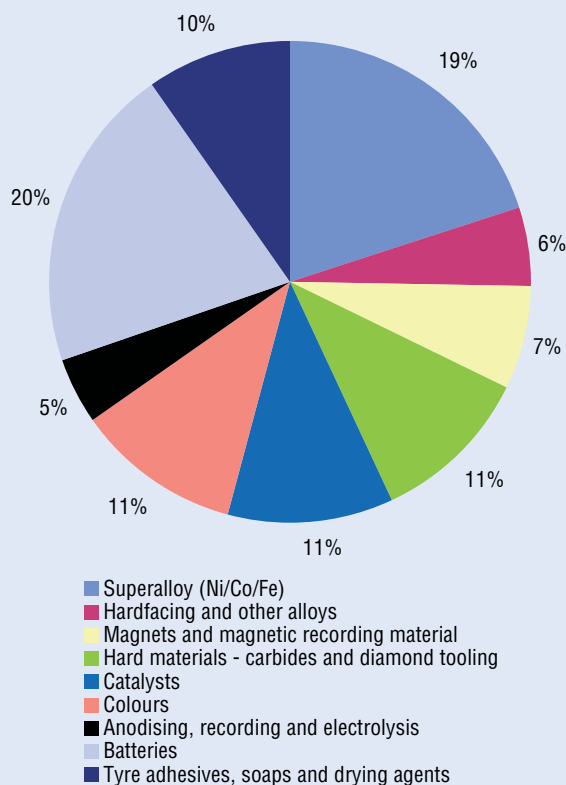
Typically, cobalt-bearing copper sulphide ore is treated by crushing and separating the ore, and then the concentrate is roasted and leached with sulphuric acid. The cobalt is separated from the pulp as cobalt hydroxide and, after the other by-product metals have been precipitated, the hydroxide is then redissolved in acid. The metal is finally extracted by electrowinning.

Cobalt-bearing nickel-copper sulphide ores are generally smelted to nickel and copper mattes. Cobalt transfers to the nickel matte, which is then crushed and leached in a similar treatment to copper sulphide ores. The oxides and silicate minerals found in nickel laterites are also smelted to a matte or receive direct hydrometallurgical methods to remove the cobalt.

About 36% of refined cobalt production is based on imported material processed by countries that have no cobalt mining production. Of the estimated 40,200 tonnes of refined cobalt produced in 2003, 19% came from Finland in the form of metal powder and salts, 16% from Zambia, 13% from Russia, and 9-11% from Norway, Canada and Australia.

A significant proportion of the cobalt residue was not recovered for technical or economic reasons during past

Key applications



Source: Cobalt Development Institute

by-product cobalt mining operations. Now more old waste tips and slag heaps are being processed to recover their cobalt content.

Applications

The pure metal has few applications, but it is used as an alloying constituent or as a chemical compound in a wide-range of commercial applications. The largest contemporary uses of cobalt are in rechargeable batteries and superalloys for jet turbines parts, according to the CDI.

When used as an alloying element, cobalt allows use at elevated temperatures and it is more resistant to corrosion by sulphur than nickel. The metal is used in electroplating because of its appearance, hardness, and resistance to oxidation. Cobalt's melting point (1,493°C) makes it attractive for high-speed alloys for cutting tools. The metal's ferromagnetic properties make it an important constituent of permanent magnets such as aluminium-nickel-cobalt and samarium-cobalt (see page 42). Cobalt is valued for its high Curie point of 1,121°C, the temperature at which it loses its ferromagnetism.

Cobalt has found applications in medicine to treat cancer and in measurement systems after it has been converted into a gamma ray source by neutron irradiation. Vitallium (Co-Cr-Mo-C) – an alloy fully compatible with human tissues and bones – is used in prosthesis systems and as a dental alloy.

End-use sectors that are expected to show consistent growth are super- and hard-facing alloys and catalysts for the production of synthetic liquid fuels. Both the British Geological Survey and the USGS forecast that the increase in demand for cobalt in rechargeable batteries – used in portable electronic devices and hybrid electric vehicles – may dampen as cobalt is substituted in lithium-ion cells by cheaper metals like manganese and nickel.

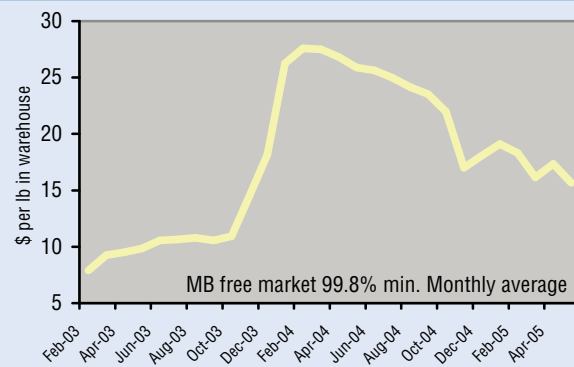
Markets

Since it is a by-product, cobalt has historically been slow to respond to sudden changes in demand, leading to significant price volatility. For instance, in the last quarter of 2003 and into last year the price more than doubled because of perceived supply tightness. Until recently supply has grown, but as demand has remained strong, prices have continued to remain relatively high

But for the first time since November 2003, prices this June have dramatically dipped below \$12 per lb for low-grade material. The initial impetus for this fall came from Russian Norilsk Nickel sales at low prices in May. There has been some speculation that the US Defense Logistics Agency may keep some of its cobalt stockpile, which could help stabilise the current market.

The USA is the world's third largest consumer of cobalt behind Japan and China, with apparent consumption last year of 10,200 tonnes. As the country currently has no domestic mine or refinery production, and only a negligible amount of by-product cobalt is produced by a small number of mining operations, the country is reliant on imports (76%), of which 31% of this is recycled scrap cobalt.

Cobalt prices



Source: Metal Bulletin

Major cobalt producers in 2004

Source	Production in tonnes	Locations
China (excluding Umicore)	8,000	
OM Group	7,893	DRC
Falconbridge	4,670	Canada
Norilsk	4,524	Russia
Chambishi	3,769	Zambia
ICCI	3,225	Various
Umicore	2,947	China
Mopani Copper	2,022	Zambia
Murrin Murrin	1,979	Australia

Source: Cobalt Development Institute

Outlook

Indian production doubled in 2004 to 545 tonnes and China massively increased its production to 8,000 tonnes. Indian cobalt and nickel producer Nicomet industries is boosting output from 5-10 tpm at the beginning of the year to 90 tpm by year's end, while Jinchuan, China's largest nickel and cobalt producer, announced its plans to triple production to 6,000 tpy by next year. Australian junior miner Tiger Resources will complete a feasibility survey on its newly acquired 3.7m tpy copper/cobalt resource at Kabolela, DRC. But the Congolese state-owned mining company Gécamines saw its lowest ever production, reflecting socio-economic instability in the DRC.

World supply and demand for cobalt are forecast to continue growing in the coming years, according to the USGS. The increase in supply is expected to come from new nickel operations as well as African copper and primary cobalt projects. Industry analysts predict that the larger projects will commence operations within a few years. These include: Voisey's Bay, Japanese companies Sumitomo and Mitsui's nickel plant in Goro, New Caledonia, and the copper-cobalt reclamation project at Kolwezi, DRC, run by Kingamyambo Musonoi Tailings, which is owned by Adastra Minerals (82.5%), Gécamines, and the DRC government. ■

Metal Bulletin is launching a new cobalt pricing service for approved producers, traders and consumers to display their latest sales, purchases and offers via MB's MarketWatch platform and www.metalbulletin.com.