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USGS Mineral Resources Program

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Cobalt—For Strength and Color

As part of a broad mission to conduct research and provide information on nonfuel mineral resources, the U.S. Geological Survey (USGS) supports science to understand

- *How and where cobalt resources form and concentrate in the Earth's crust*
- *How cobalt resources interact with the environment to affect human and ecosystem health*
- *Trends in the supply of and demand for cobalt in the domestic and international markets*
- *Where undiscovered cobalt resources might be found*

Why is this information important? Read on to learn about cobalt and the important role it plays in the national economy, in national security, and in the lives of Americans every day.

Cobalt is a shiny, gray, brittle metal that is best known for creating an intense blue color in glass and paints. It is frequently used in the manufacture of rechargeable batteries and to create alloys that maintain their strength at high temperatures. It is also one of the essential trace elements (or "micronutrients") that humans and many other living creatures require for good health. Cobalt is an important component in many aerospace, defense, and medical applications and is a key element in many clean energy technologies.

The name cobalt comes from the German word *kobold*, meaning goblin. It was given this name by medieval miners who believed that troublesome goblins replaced the valuable metals in their ore with a substance that emitted poisonous fumes when smelted. The Swedish chemist Georg Brandt isolated metallic cobalt—the first new metal to be discovered since ancient times—in about 1735 and identified some of its valuable properties.

How Do We Use Cobalt?

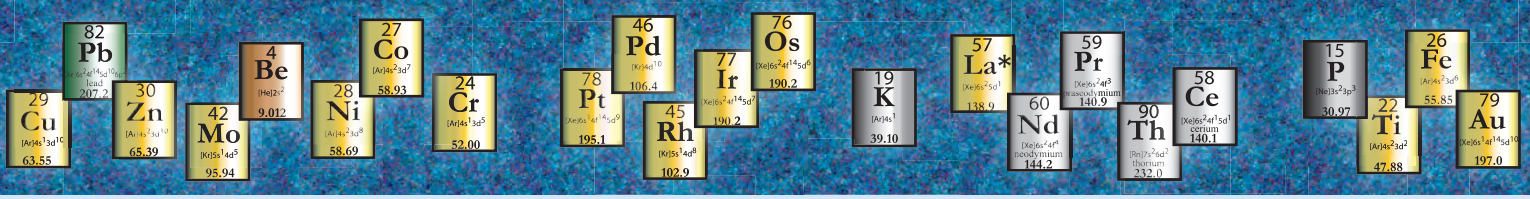
Cobalt has been used to create vivid blue colors in glass and ceramics for thousands of years and it is still an important pigment. Many other uses for cobalt have been developed during the past century. In 2010, about one-half of the cobalt consumed in the United States was used in the manufacture of superalloys, which are corrosion-resistant alloys that retain their strength at very high temperatures. Gas turbine engines and other components used in aircraft and space vehicles, chemical and petroleum plants, and powerplants depend on the high-temperature strength of superalloys. Cobalt also has impressive magnetic properties that it retains at temperatures as high as 1,121 °C. Cobalt is an important component of the magnets used in computer disc drives and in electric motors; it helps them operate more efficiently at a wide range of temperatures.

Cobalt-based superalloys are used in jet engines—including military fighter jet aircraft—because of their stability at high temperatures. Photograph courtesy of the U.S. Air Force.

Globally, the leading use of cobalt is in rechargeable batteries to help increase battery life and stability and to reduce corrosion. Mobile phones, portable computers, and hybrid and electric vehicles all depend on the energy produced by chemical reactions in these rechargeable batteries. Cobalt also plays a vital role in human and animal health; it is an essential element in vitamin B12, which helps ensure proper brain function and aids in the formation of red blood cells.

Where Does Cobalt Come From?

Cobalt is not a rare element even though pure cobalt is not found in nature. Cobalt occurs in conjunction with other elements in such minerals as carrollite [a copper-cobalt-(nickel) sulfide], skutterudite (a cobalt-nickel arsenide), and asbolane (a nickel-cobalt-manganese oxide). Most cobalt is produced as a byproduct of the processing of copper and nickel ores. Cobalt is obtained from the following three main types of ore deposits: (1) sediment-hosted stratiform copper deposits, such as those in the central African copperbelt in the Democratic Republic of the Congo (DRC) and Zambia; (2) magmatic nickel sulfide deposits, such those found at Sudbury, Canada, and at Norilsk, Russia; and (3) nickel laterite deposits, which are found in such tropical regions as New Caledonia. Cobalt is also found in manganese nodules and crusts on the deep seafloor, but seafloor deposits are not currently being mined. The sediment-hosted copper deposits are formed when salt-bearing fluids flush metals, including copper and cobalt, out of oxidized (red) sediments; if the metal-bearing fluids then react with reduced (black) rock or oil or natural gas, they deposit minerals containing copper and cobalt. Magmatic nickel sulfide deposits form when a magnesium- and iron-rich magma becomes saturated with sulfur. Metals in the magma, such as nickel and cobalt, may then move into a separate dense sulfide-rich fluid that sinks to the bottom of the magma chamber where the metal sulfides are then deposited. Laterite deposits form in warm, humid, tropical or subtropical environments where igneous rocks with very little silica are broken down by chemical weathering; in these types of deposits, cobalt is concentrated in the weathered rock.



Did you know... ***Persians used cobalt to color glass by as early as 2250 B.C.E.***

Worldwide Supply of and Demand for Cobalt

In 2010, the United States imported cobalt from, in order of amount imported, China, Russia, Norway, Finland, and other countries, and it obtained about one-quarter of the amount it consumed from recycled materials. Although only negligible amounts of cobalt were mined in the United States in 2010, construction of a new cobalt mine about 40 miles from Salmon, Idaho, is underway and is expected to be completed in late 2012. Almost one-half the world's known reserves of cobalt—some 3.4 million metric tons—are located in the DRC; Australia, Cuba, and New Caledonia also have substantial cobalt reserves. Approximately one-half of the estimated global mine production of cobalt in 2010 was from the DRC; together, China, Russia, and Zambia provided another one-quarter of the world's production. China was the world's leading producer of refined cobalt in 2010, using domestic ores from China and imported materials from the DRC.

The silvery-gray mineral carrollite is a compound of sulfur, copper, and cobalt. This sample is from the Democratic Republic of the Congo. Photograph by Murray W. Hitzman, Colorado School of Mines, 2011, used with permission.

Did you know... ***A manmade radioactive isotope of cobalt (cobalt-60) is used to sterilize medical equipment, in radiation therapy to treat cancer, and in "cold pasteurization" to kill bacteria and other pathogens in food.***

How Do We Ensure Adequate Supplies of Cobalt for the Future?

The global supply of cobalt is expected to meet or exceed demand for the next few years. Nonetheless, the supply of cobalt is at risk of disruption for the following reasons: the global market is relatively small; there are limited sources of production; and, because most cobalt is a byproduct of copper or nickel mining, the supply is dependent on the markets for these more abundant metals. In addition, some countries that control significant portions of the cobalt supply chain are areas of political uncertainty. Restrictions in the global supply of cobalt could affect the United States' defense, energy, and manufacturing capabilities. Consequently, the U.S. Government held approximately 300 metric tons of cobalt in the National Defense Stockpile in 2010 for use in case of a national emergency.

To help predict where future cobalt supplies might be located, USGS scientists study how and where cobalt resources are concentrated in the Earth's crust and use that knowledge to assess the likelihood that undiscovered cobalt resources may exist. Techniques to assess mineral resource potential have been developed by the USGS to support the stewardship of Federal lands and to better evaluate mineral resource availability in a global context.

Open-pit copper-cobalt mining near Kolwezi in the Democratic Republic of the Congo (DRC). Approximately one-half the world's estimated cobalt production came from the DRC in 2010. Photograph by Murray W. Hitzman, Colorado School of Mines, 2008, used with permission.

Did you know... ***Cobalt compounds bond rapidly with cyanide and are used as an antidote to cyanide poisoning.***

For More Information

- On production and consumption of cobalt: http://minerals.usgs.gov/minerals/pubs/commodity/cobalt/
- On sediment-hosted copper deposit models: http://pubs.usgs.gov/of/2003/of03-107/
- On magmatic sulfide-rich nickel-copper deposit models: http://pubs.usgs.gov/of/2010/1179/
- On metasedimentary rock-hosted cobalt-copper-gold deposit models: http://pubs.usgs.gov/of/2010/1212/
- On nickel-cobalt laterite deposit models: http://pubs.usgs.gov/of/2011/1058/

The USGS Mineral Resources Program is the sole Federal provider of research and information on cobalt and other nonfuel mineral resources. For more information, please contact:

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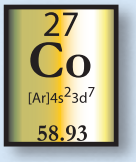

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Did you know... ***Cobalt alloys are used in some artificial hip and knee joints to make them strong and wear resistant.***