

Mineral Commodity Report 8 — Mercury

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Discovery and Origin of Names

The name mercury is from the Latin *Mercurius*, the swift messenger of the gods in Roman mythology. Quicksilver, liquid silver and living silver are historic names for mercury. The symbol Hg is from the Latin *hydrargyrium*, meaning liquid silver.

Mercury was known to the ancient Chinese, Greeks, Hindus and Romans, and has been found in an Egyptian tomb sealed about 3500 years ago. Aristotle described it as being like liquid silver. Pliny the Elder described ways of extracting it from cinnabar and how to amalgamate it with gold. The use of the mercury amalgamation process to purify gold and silver was known to ancient peoples and rediscovered by the Spanish in the 16th century. In both ancient and medieval times, alchemists carried out many experiments with mercury. It was first distinguished as an element in the late 1700s by the French chemist Antoine Laurent Lavoisier in his experiments on the composition of air.

Major Ores and Minerals

Mercury occurs naturally as pure liquid mercury or combined with silver in small amounts but is found most often in the form of the sulphide cinnabar HgS, the major ore mineral of mercury. Metacinnabar HgS is locally important, and in some deposits, corderoite $\text{Hg}_3\text{S}_2\text{Cl}_2$ and livingstonite HgSb_4S_7 are significant. Some polymetallic deposits containing mercurian tetrahedrite have been mined and a very small amount of mercury has been recovered as a product of gold, iron and lead-zinc mining.

Mercury combines with all the common metals, except iron and platinum, to form alloys that are called amalgams.

All major mercury deposits are mined for their mercury alone, and all contain cinnabar.

Properties

Mercury is a transition metal of Group IIB of the periodic table. At room temperatures it is a shiny, silver-coloured heavy liquid, that is a good conductor of electricity and has a specific gravity of 13.55. It remains liquid over a wide temperature range: -38.87°C to 356.57°C at atmospheric pressure. Slightly volatile at room temperature, mercury becomes solid when subjected to a pressure of 7640 atmospheres (5.8 million torrs), and this pressure is used as a standard in measuring extremely high pressures. It has a high surface tension compared with other common liquids, six times greater than that of water in contact with air. On a smooth surface it forms globules that can be made to roll about in a lively manner, coalescing into larger globules and breaking

Symbol	Hg
Atomic no.	80
Atomic wt	200.59
Specific gravity	13.55
Valence	1, 2
Melting point	-38.9°C
Boiling point	356.9°C
Crustal abundance	0.05 ppm
Preferred analysis method	atomic absorption spectroscopy
Routine detection limit	0.01 ppm

up into smaller globules again, hence the names living silver and quick silver.

Cinnabar is a vermilion-red mineral with an adamantine lustre. It is usually found in fine granular masses or disseminated through the host rock, although crystals may occasionally be found and these are usually rhombohedral or prismatic. Cinnabar has a hardness of 2.5 and specific gravity of 8.1.

Mercury is toxic, and acts as a cumulative poison which can cause irreversible brain, liver, and kidney damage in people. Poisoning may result from inhalation of the vapour, ingestion of soluble compounds, or absorption of mercury through the skin. Significant quantities of mercury have been found in some species of fish in areas of mercury polluted water, and this has resulted in the introduction of strict controls on the discharge of the metal into the environment in most developed countries.

Formation

Mercury minerals are deposited from hydrothermal fluids, usually in the epithermal environment of shallow depths and relatively low-temperatures ($50\text{--}200^\circ\text{C}$). They are common in hot-spring systems, with much of the mercury being transported as a vapour phase in steam and gas.

Uses

Mercury is used in electrical equipment such as fluorescent lamps, mercury vapour ultraviolet lamps, switches and relays, and mercury batteries. It is also used in cells for the electrolytic production of chlorine and caustic soda. It is added to some paints to make them mildew proof and as the high-grade pigment vermilion. The low freezing point of mercury, its almost constant coefficient of expansion (equal change in volume for each degree of rise or fall in temperature), and the fact that it does not wet glass, make it useful in thermometers; and its high density makes it useful in barometers, manometers, and blood pressure machines.

Other uses of mercury include catalysts for the chemical industry, agricultural fungicides, silver-mercury alloys (amalgam) for filling teeth and pharmaceuticals. Before the introduction of cyanidation in the late 1800s, the most common method used to extract gold and silver from their ores was by amalgamation with mercury (which was later removed by distillation). This method is still practised in many of the developing countries.

The commercially important compounds of mercury include: mercuric sulphide HgS , used as a common antiseptic and as the pigment vermilion; mercurous sulphate HgSO_4 is used to speed up certain tests on organic compounds; mercurous chloride Hg_2Cl_2 , also called calomel, is used for electrodes, and was formerly used as a cathartic in medicine; mercuric chloride HgCl_2 , also called corrosive sublimate and bichloride of mercury, is a powerful poison that surgeons once used to disinfect wounds; mercuric oxide HgO is used in mercury batteries; mercuric fulminate $\text{Hg}(\text{OCN})_2$ is used as a detonator in most ammunition to set off its explosive; and the antiseptic Mercurochrome $\text{C}_{20}\text{H}_7\text{O}_5\text{Br}_2\text{Na}_2\text{HgO}\cdot 3\text{H}_2\text{O}$.

Price

Prices for mercury during May 1995 were US\$135–160/flask (76 lb – 34.5 kg), up from prices in the sub-US\$100 during some months of the early 1990s but much lower than the average 1985 price of US\$310.

World Production and Consumption

Annual world production of mercury during this century has ranged from 65 000 flasks (2200 t) in 1913 to a high of 290 000 flasks (10 000 t) in 1969 (Bailey, 1989). Production declined substantially in the late 1980s and early 1990s and was about 75 000 flasks (2600 t) in 1993. These figures do not include secondary recovery, which in recent years has increased to about 10 000 flasks (350 t) per year.

Bailey (1989) noted that six mines or districts have yielded three quarters of the world's production, and several thousand others have some production. Historically, the largest producers were the Almaden mines in Spain, the Idria mine in Yugoslavia, the Monte Amiata district in Italy, the Santa Barbara mine in Peru, and the New Almaden and New Idria mines in the USA. Of these, only the Almaden mines continued operating beyond 1980. A major part of the world demand is now supplied by more recently discovered deposits in China, Algeria, the Commonwealth of Independent States and the USA. Mercury is also recovered as a by-product of zinc mining in Spain, Finland, Norway and Italy; of copper mining in Slovenia; and nine gold mining operations in the USA (in Nevada, California and Utah). In 1993, the principal producers were: China (23 200 fl), Spain (18 647 fl), Algeria (13 775 fl), Kirghizstan (7250 fl), Finland (2465 fl), Tajikistan and Ukraine (2320 fl each).

Total world resources are estimated at nearly 600 000 t (approximately 17 million flasks), principally in Italy, Kyrghizstan, Russia, Slovenia, Spain and Ukraine (Masters, 1994). There are sufficient resources for more than 100 years production, especially with declining consumption rates.

Ore Processing, Smelting and Refining

Mercury with a purity of 99% or more is extracted directly from cinnabar ore containing 0.3–3.0% Hg by heating to volatilise the mercury and then condensing the vapour. Two general types of equipment are used: externally heated retorts in which there is no mixing of fuel gases with mercury vapour, and internally fired furnaces where mixing occurs. Major mines generally use furnaces rated at 100–200 t of ore per day. The ore is treated as mined or reduced to 2–3 cm in size before furnacing. In recent years, to avoid the high cost of heating all the ore, flotation has been used to prepare a 75% cinnabar concentrate before roasting. The condensing system used with furnaces yields mostly “soot”, which consists of finely divided mercury and carbon. The soot is purified by stirring with lime, which causes the mercury droplets to coalesce. The mercury is then bottled in steel vessels 45 cm long and 10 cm in diameter, containing 34.5 kg (the old Spanish hundredweight). This flask is the standard unit of international trade.

New Zealand Occurrence and Resources

The occurrence of mercury in New Zealand has been reviewed by Henderson (1922), Officers of New Zealand Geological Survey (1970), Williams (1974) and Brathwaite and Pirajno (1993). The main mercury deposits are found in sinters, lake beds and volcanic and sedimentary rocks associated with extinct and active hot springs at Huia, Puketū, Puhīpuhī and Ngāwhā in Northland and Mackaytown, Waiotapu, Ohaaki, Kakaariki, Waitahuna and Waikaka, Greenvale in the South Island.

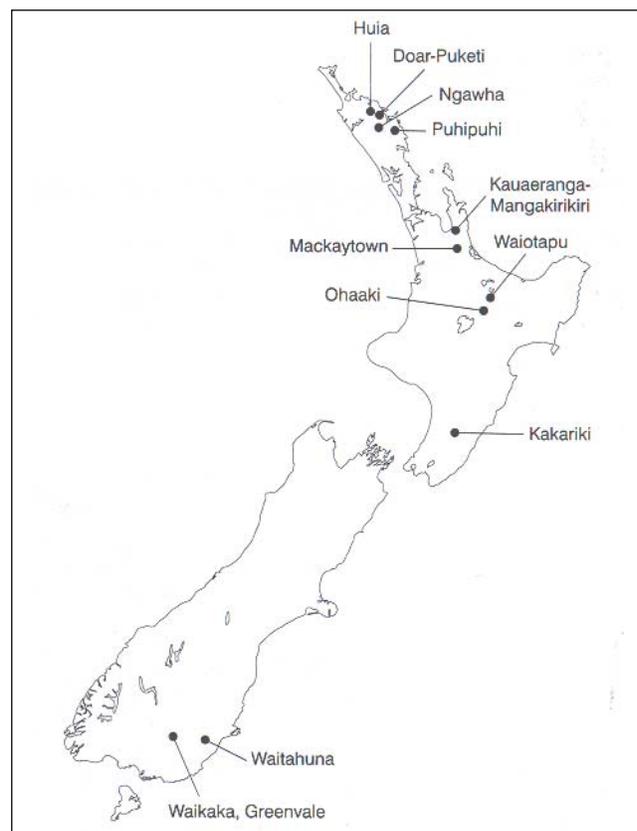


Figure 1: Location of mercury deposits in New Zealand.

Peninsula. Anomalous mercury concentrations are found in some of the active geothermal systems of the Taupo Volcanic Zone such as Ohaaki and Waiotapu. Minor occurrences of cinnabar as veinlets in fault zones have been recorded near Gabriels Gully in Otago and Greenvale in Southland.

Mercury minerals found in New Zealand include: cinnabar, coloradoite HgTe, livingstonite, metacinnabar and native mercury (Morgan, 1927; Railton and Watters, 1990).

Puhipuhi: Alluvial cinnabar was found at Puhipuhi in 1892, and in 1907 cinnabar was discovered in siliceous sinter. Four areas of mineralised rock were eventually found along a northerly trend over a distance of 6.5 km: Rising Sun, Puhipuhi, Plum Duff and Mount Mitchell (Henderson, 1944; Williams, 1974; Cranny and Hill, 1983; White, 1983, 1986). Surface and underground mining of the deposits between 1917 and 1945 produced a total of 43 t of mercury at Puhipuhi.

The deposits are epithermal, hot spring type and consist of mineralised siliceous sinter, silicified breccias and hydrothermally altered Waipapa Group greywacke country rock. The greywacke is unconformably overlain by erosional remnants of Plio-Pleistocene lake beds and Kerikeri Basalt, both of which are hydrothermally altered to varying degrees.

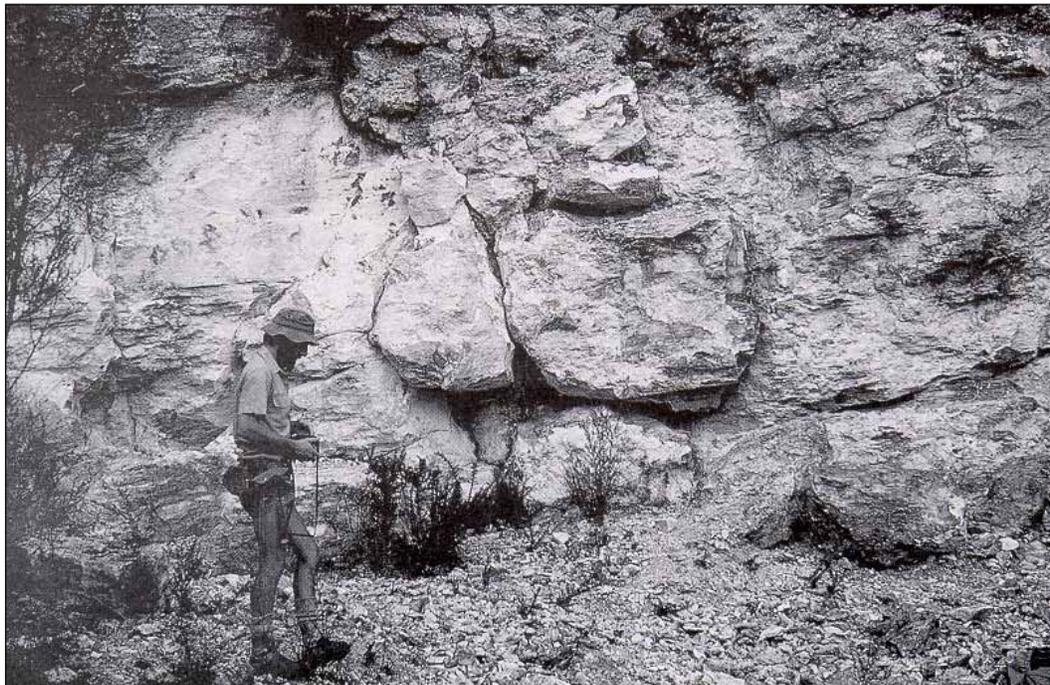
At the Rising Sun mine, cinnabar is present as paint coating joints in a thin layer of shattered, silicified greywacke. At the Puhipuhi mine, mercury was mined from silicified breccia, which White (1983) interpreted as a fossil scree. The breccia is cemented by chalcedonic quartz with vugs and partings coated by cinnabar and marcasite. Plum Duff consists of a collapsed sinter sheet containing brecciated and silicified blocks of sinter. At Mt Mitchell, a sheet of siliceous sinter contains cinnabar, stibnite, marcasite and pyrite. Silver-

bearing quartz veins in the basement greywacke, 2 km to the northwest and probably 100 m below the level of the cinnabar deposits, represent a deeper level exposure of the Puhipuhi epithermal system.

Lime & Marble Ltd carried out drilling in the Mt Mitchell area (Braithwaite and Ball, 1969), and IMC Corp. explored the Puhipuhi mine area defining an inferred resource of 85 t of mercury (Carlson and Main, 1971). Recent exploration of the Puhipuhi field has targeted gold mineralisation (Cranney, 1985; BHP Gold, 1988; Brown, 1989).

Ngawha: Mercury deposits at Ngawha are related to active hot springs, vapour emanations, and mud pools in the Ohaeawai area (Bell and Clarke, 1909; Henderson, 1944; Williams, 1974; Davey and van Moort, 1986). The mercury, as cinnabar and native mercury, is associated with one or more of marcasite, stibnite, realgar, hydrocarbons and bituminous matter. The ore-bearing rock is late Pleistocene lacustrine mudstone and sandstone, deposited in a valley formed as a result of damming by lava flows. The deposits were worked in the 1890s and also from 1927–34 and 1941–45, for a total yield of about 33 t of mercury.

Huia Hill prospect: Prospecting, including shallow auger drilling by Western Mining Corporation in the early 1970s, has defined four lenses of cinnabar mineralisation in hydrothermally altered, bedded andesitic tuffs (Wairakau Andesite) at Huia Hill, near Kaeo (Shugg, 1973; Bell, 1982; McOnie, 1985; Brown, 1987, 1989). The lenses are 1–5 m thick and up to 25 m in length, with average grades of 0.47–1.3% Hg (Shugg, 1973). Within the lenses, the cinnabar occurs in veins and veinlets. At Tairaire, 2 km southeast of Huia, diamond drilling outlined small lenses of low grade (<1.0% Hg) cinnabar mineralisation in argillically altered andesitic breccias and tuffs (Bell, 1982; Canyon Resources, 1986).



Bedded mercury- and antimony-bearing sinter at the Mt Mitchell quarry, Puhipuhi, Northland (Photo: Tony Christie).

Doar prospect, Puketi: Disseminated cinnabar mineralisation, grading 0.18–0.49% Hg, is present in the lower 3 m of a 9 m thick Eocene greensand bed, which is overlain and underlain by mudstone (Shugg, 1973). White (1983) noted that the mercury mineralisation is associated with pyritic clay-silica alteration in the adjacent greywacke basement, and is related to a regional fault zone.

Mackaytown: Cinnabar deposits, principally the Ascot Cinnabar mine, occur in silicified rhyolitic tuff and siltstone that forms a thin (c. 30 m) capping on propylitised andesite (Bell & Fraser, 1912; Russell, 1980; Brathwaite, 1989). At the Ascot mine, the cinnabar mineralisation occurs predominantly in a 1.5 m thick kaolinised horizon, sandwiched between two “sinter beds”, as red puggy seams, pug-filled cavities (often lined with drusy quartz), whitish flinty quartz veinlets, and in a fairly persistent thin quartz vein (<30 cm thick) located near the base of the horizon.

Kauaeranga (Mangakirikiri): A “sinter” deposit, located on the southern side of the Mangakirikiri Stream valley, consists of opaline silica with associated pyrite-marcasite, arsenopyrite, and cinnabar, and rare stibnite and chalcopyrite (Watson, 1989). The “sinter” is interbedded with sporadically mineralised andesitic pyroclastic rocks and sediments with local propylitic and argillic alteration. Watson (1989) considered that the deposit was probably part of the same geothermal system that formed the Waikato Creek pyrite deposit, 7 km along strike to the northwest (Kear, 1957). Freedman (1985, 1990) sampled the adits and outcrop and reported analyses for Hg (up to 2.64%), Au (up to 0.08 ppm) and As (up to 440 ppm). Silver and antimony were not detected.

Hauraki gold-silver-copper-lead-zinc quartz veins: Mercury is present in several of the epithermal gold-silver deposits of the Hauraki Goldfield as thin coatings of cinnabar on vuggy quartz crystals and fracture surfaces. Examples include: Thames (Merchant, 1978), Owharoa (Morgan, 1924), Tui (Wodzicki and Weissberg, 1970) and Waiorongomai (Henderson and Bartrum, 1913).

Geothermal systems of the Taupo Volcanic Zone: Mercury is present as amorphous sulphides in sinter sheets associated with hot springs in several geothermal fields, including Champagne Pool at Waiotapu and Ohaaki Pool. Concentrations of up to 2000 ppm Hg have been reported along with up to 2% As, 10% Sb, 85 ppm Au, 500 ppm Ag and 1000 ppm Tl, in layers up to 2 cm thick (Weissberg, 1969; Hedenquist, 1986).

Kakariki Stream, Wairarapa: A 30 cm diameter boulder of variolitic spilite found in Kakariki Stream (ca. T25/337656), averaged about 13% mercury, with lenses up to 23% (Reed and Cornes, 1952). The mineralisation consists of cinnabar, native mercury and pyrite. Cinnabar was subsequently discovered in a nearby outcrop of jaspilite and spilite (Shaw, 1957).

Waitahuna, Otago: Mercury mineralisation occurs near Waitahuna in a lode-type formation (a 1.3 m wide

crush zone in the Haast Schist), and although locally of high grade (Marshall, 1918), it is patchy and discontinuous.

Waikaka, Southland: Henderson (1923) described three cinnabar veinlets in a 3–3.6 m wide crush zone in weathered greywacke in the east branch of Waikaka Stream, 0.8 km north of Greenvale. The veinlets are slightly silicified in places and have associated pyrite. The greywacke is part of the Caples Group which includes green tuffaceous greywacke, argillite and a few lenses of basic volcanic flows.

Placer cinnabar in Otago: Henderson (1922), Morgan (1927), Williams (1974) and Railton and Watters (1990) listed minor alluvial occurrences of cinnabar including: the upper reaches of the Nevis River, in the high country extending from this valley to the Nokomai, in the Dunstan and Old Man Ranges in Otago, and in the Waikaia and Waikaka valleys in Southland. Cinnabar occurred in many of the alluvial gold workings between Waitahuna and Waipori (Marshall 1918).

Past Production, Resources and Future Potential

In the 1890s, and from 1927–34 and 1941–45, about 33 t of mercury were recovered at Ngawha from ore grading 0.2% Hg. The Puhipuhi deposit has produced 43 t of mercury, from ore grading 0.17–1.0% Hg, mined intermittently between 1917 and 1945. At Mackaytown, 0.5 t of mercury were recovered from 70 t of ore in 1910.

Small resources of mercury have been identified at Puhipuhi (85 t), Huia (230 t) and the Doar prospect at Puketi (87 t). A proposal to mine the Huia and Puketi deposits in 1987 did not go ahead (Brown, 1987, 1989). The Northland area seems to offer the best potential and although any new deposits discovered in the future are likely to be small, several deposits could be worked as a small operation.

Future Trends

Mercury is an essential element in industry although demand has been falling over recent years. Environmental concerns have led to a reduction of use of mercury in some applications and elimination in others, and this trend is expected to continue in the developed nations. However, countries like China and India have shown increased demand for mercury over recent years because of less stringent environmental controls and the continued use of mercury in their batteries, chemicals, and chlorine and caustic-soda production.

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