

Molybdenum and the Henderson Mine

Adapted, in part, from

http://www.climaxmolybdenum.com/WorldwideLocations/USA_Colorado_Henderson.htm

by Freeport-McMoRan Copper & Gold Inc., 2008

Molybdenum is an important metallic element discovered by Carl Wilhelm Scheele in 1778. The name comes from the Greek word *molybdos*, meaning lead-like. Pure molybdenum is a lustrous grey metal, somewhat heavier than iron but melting at a much higher temperature – 4730 °F versus 2795 °F for iron. “Moly” is used in desulfurization catalysts; as a corrosion inhibitor in engine coolants, water treatment chemicals, and pigments; in solid lubricants such as greases; and as an alloying material in iron and steel making, where it increases strength (especially at very high or very low temperatures), corrosion resistance, and toughness.

The steel industry consumes more than 80% of the molybdenum supply. The industry uses about 35% of its molybdenum to make alloy steels (for machine tools, trucks, mining equipment), high strength low alloy steels (for gas and oil pipelines), and high temperature steels (for heat exchangers, generators, and other equipment that must withstand great heat). Another 35% is used in stainless steels and super alloys, 13% in tool steels and high speed steels, and 13% in cast iron and castings.

Molybdenum ores are found in many locations, but only a few deposits warrant the extensive facilities necessary for economical recovery. The largest producers are the United States, Chile, and China. Canada, Peru, and the former Soviet Union also produce substantial quantities.

Molybdenum is obtained from primary mines and by-product mines. At primary mines, molybdenum recovery is the principal objective of the mining operation. Climax Molybdenum Company, a unit of Freeport–McMoRan Copper & Gold, Inc., has two primary mines in Colorado: the Henderson Mine and the Climax Mine. Freeport-McMoRan also produces moly at the Sierrita and Bagdad mines in Arizona, although recovery of copper is the primary

objective. Molybdenum is also recovered from other copper mines in the western United States and in Canada, Chile, Mexico, and Peru.

The Henderson Mine is located in Clear Creek County east of the Continental Divide, fifty miles west of Denver. The Henderson Mill is located west of the Divide, fifteen miles from the mine, in Grand County. The mine and the mill are connected by a fifteen-mile elevated belt that passes underneath the Continental Divide through an old train tunnel and then above ground to the mill. Molybdenite (the molybdenum-containing mineral) is obtained from the ore by crushing, grinding, and flotation. One ton of ore yields four to six pounds of molybdenum.

Henderson is the world’s largest primary molybdenum mine. Since 1976, Henderson has produced more than 160 million tons of ore and 770 million pounds of molybdenum. The Climax mine produced ore from 1918 until 1995. In December 2007, Freeport–McMoRan announced its intention to restart Climax. The mine is expected to produce about 30 million pounds of molybdenum per year beginning in 2010. Initial investment to open the mine and install a modern mill will be approximately \$500 million. Climax is near Leadville, about 60 miles southwest of Henderson, at an elevation of 11,400 feet.

Relevant Terms

Acid plant - A facility that recovers sulfur dioxide from discharged gases and manufactures sulfuric acid from it.

Block-caving - A process whereby large blocks of ore are undercut and allowed to fall and fracture into smaller pieces that can be loaded through chutes into mine cars and taken to the surface. It is the lowest-cost underground mining method.

Economic incentive – The factor that encourages investing \$500 million to fix an old mine. In 2001, according to the U.S. Geological Survey, the average price for molybdenum in the United States was \$2.36 per pound. In 2004, it reached \$16.65 per pound, and in 2007 it was \$29.33 per pound. If the moly price stays above \$6.50 per pound, the Climax mine could economically recover 180 million tons of ore and produce 500 million pounds of molybdenum worth (at the average moly price in 2007) \$14.7 billion. If the price stays above \$10 per pound, the site could yield an additional 466 million tons of ore.

Faith in the future – Expectation that moly will stay above \$6.50 per pound.

Flotation - A metallurgical method for extracting valuable minerals from ore. Finely ground ore is agitated with water and chemical reagents to create a froth, which floats to the surface. Depending on the ore, the froth may contain the valuable minerals, or it may contain the worthless residue, or gangue. In either case, the valuable particles are collected and dried, and the resulting concentrate is sent to a smelter for refining.

Hydrometallurgy - The treatment of ores, concentrates and other metal-bearing materials by a wet process, such as SX/EW. This process is distinct from the pyrometallurgy of a smelter.

Leaching - A process for removing soluble minerals by washing ore with a solvent, often used for low-grade oxide and sulfide ores.

Mill - A facility in which ore is crushed, ground, and otherwise processed to extricate valuable minerals.

Mining district - An area of land described for legal purposes and containing valuable minerals in payable amounts.

Open-pit mining - Surface mining method in which overlying rock, or overburden, is removed to expose the ore body, which is then drilled, blasted, and loaded into trucks (or, formerly, railroad cars) and hauled from the pit.

Ore - Rock containing minerals in sufficient concentration, quantity, and quality to be mined at a profit. As technology improves or prices rise, once valueless rock can become valuable ore.

Overburden - Rock material of little or no value that lies above an ore deposit and must be removed before the ore can be mined.

Prospect - Mineral workings of unproven value.

Raise - A mine shaft driven from below upward.

Shaft - A vertical or nearly vertical opening into the earth for mining.

Skip - A container used to lift ore through a shaft and to the surface above a mine.

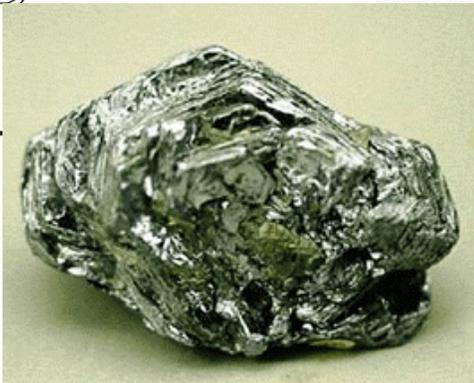
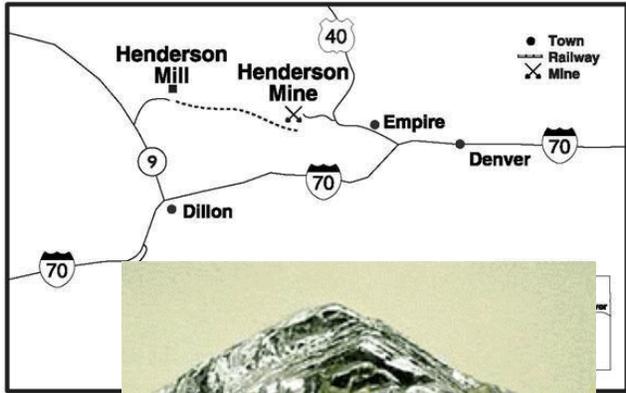
Slag - The waste product of a smelter.

Smelter - A metallurgical complex where ores are melted to remove impurities from a metal.

Stope - Underground opening from which ore is extracted.

SX/EW - Solvent-extraction – electrowinning: a two-stage hydrometallurgical process that extracts copper ions from low-grade leach solutions and concentrates them into an electrolyte, and then deposits pure copper onto cathodes using electrolysis.

Tailings - Finely ground solid residues remaining after milling is complete.



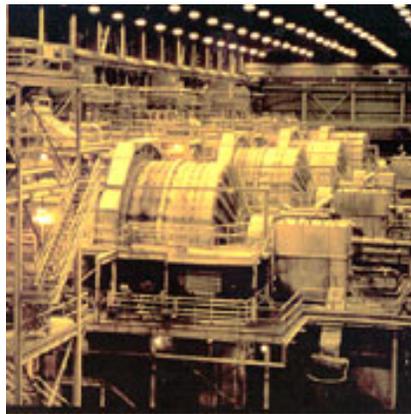
Molybdenite Nodule



Climax Mine in Summer 1999



Conveying & Surge Storage



Size Reduction



Flotation Cells