Gold: It’s Formation, Mining, and Impact
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For millennia, gold has been in the human consciousness. We find it in our histories, religious texts, myths, and ancient paintings. Gold has launched wars, wooed lovers, and made bitter enemies out of the closest of friends. The combination of its beauty and rarity make one of the most sought after elements in the world. Despite gold’s high desirability, few people know much about it. With its formative roots in volcanism and tectonics, and its dangerous and destructive methods of extraction, gold is as dynamic and controversial as it is beautiful.

I. Formation

The formation of gold comes in a series of stages. First, the overlaying rock must be fractured and cracked. This is done by faults and other weaknesses in the rock caused by temperature and pressure changes, often found along tectonic plate boundaries. Next, hydrothermal activity forces mineral rich water and steam through those fractures and cracks in the rock. As the water and steam cools on its way through, it deposits its load of minerals along the walls of the cracks. Once the cracks fill in, the minerals crystallize, usually into sheets of quartz, which contain the other minerals from the water, including gold. These veins of minerals run throughout the rock, often for miles.

If these veins are in mountains, the yearly cycle of freezing and thawing breaks apart the minerals, and washes them down mountain streams. Since gold is heavier than many of the other particles in the water, the natural agitation separates the gold to the bottom, and deposits it along the inside corners of stream bends. There, it is covered by other sediments, and awaits discovery.
More recently, the focus has turned to disseminated gold deposits. These are deposits of large amounts of gold, sparsely dispersed among even larger amounts of gangue. The primary mechanism for the deposition of this type of gold is hot springs. The high pH and temperature lowers the solubility of the gold, allowing it to be transported easily in water and steam. The broad area affected by the hot springs means the gold isn’t confined to one specific section, as it is with a vein. These deposits are often microscopic in size, but amount to quite a bit when consolidated [Tooker, 1985].

II. Early History

Gold has been a factor in human affairs for thousands of years. As early as 4000 BC, Egyptians were making gold bars and stamping them with the name of their pharaoh [Bernstein, 2000]. Due to its desirability, gold soon became a common way to pay for goods and services. Each piece of gold had to be weighed and evaluated for purity. Eventually, governments started standardizing the sizes of the gold pieces, making transactions less difficult, leading the way for nationalized monetary systems.

Besides money, gold has long been used in the arts. The Aztec and Incan civilizations used gold to make beautiful sculptures, which consequently led to their destruction at the hands of the Spanish Conquistadors. The Egyptians sent their deceased pharaohs to rest in elaborate gold coffins, formed in their likeness. More recently, the kings of France built the palace of Versailles, which features gold as the decoration of choice: gold wallpaper, gold woven into the carpets, gold frames around every painting, and gold chandeliers.
III. Recent History

In the United States, gold played an important part in the migration west. In 1848, a man named James Marshall discovered a gold nugget in a river near Sutter’s Mill in California. The news spread, and soon thousands of people were flocking to California to make their fortunes. They came from all over the United States, as well as many foreign countries.

Initially, they found gold deposits in the rivers, which had washed down from the mountains and settled into the streambeds. The simplest way to find this sort of gold was panning: using a pan to agitate the sediments of the streambed to separate it from the gold. Others diverted entire streams to leave the bed accessible [Hill, 1999]. When this source was exhausted, the prospectors turned to other methods of extracting gold from the land. Sluicing involves putting ore gravel on a grate and running water of it. The water carries away the lighter particles, leaving the heavier gold in the grate. A system called hydraulicking was developed; using very high-pressure streams of water to wash away hillsides into sluices, where gold was separated out from the debris. More commonly, underground mines were dug and blasted, following veins or fossil streambeds. These mines were sometimes up to a mile deep, and extended for dozens of miles. Rock was blasted out using explosives, and the rubble was hauled off in buckets and carts for processing.

Stamp mills were the primary means of extracting gold from the mined rock. A stamp mill employed any number of 1000+ lbs stamps – large metal crushers, lifted by a mechanical cam and dropped by gravity – to pulverize the rocks. Water was added to the mixture, which was then poured out over amalgamation plates. These plates were coated
in mercury, and the gold formed a bond with it, called amalgamation. After the mercury became saturated with gold, it was scraped off and sent to be melted, leaving behind the gold due to its higher melting point. The leftover mixture, called tailings, was hauled off and dumped in large mounds, away from the mill.

Around these stamp mills would form mining towns. These towns were built quickly, and often consisted of thousands of buildings and tens of thousands of people. One such town is Bodie, in eastern California. Founded around a stamp mill in 1861, the town grew from 3,000 people in 1878 to over 10,000 just a few months later. Over time, the mines became less productive, and newer, more efficient ways to extract gold were invented, and the towns died out. All that is left of Bodie are a few dozen buildings, and the stamp mill. It was converted into a State Historical Park in the 1960’s [www.bodie.com, 2005].

IV. Current Mining

The U.S. is currently one of the top gold producing nations in the world. Nevada produces more than 25 times the amount of gold than any other state [Earl B. Amey, 2003]. The Homestake mine, in South Dakota, is the deepest in the country, at more than 2,000 meters [Caddey et al., 1991]. California still has around 16 active gold mines [CGS, 2001], some of which are centered on the original Mother Lode find.
The value of a mine is determined by the ratio of gold to ore, expressed in grams of gold per ton of ore (g/t). High yield mines produce gold at a rate of 9 to 11 g/t, though some mines yield only 1 to 4 g/t [World Gold Council, 2005].

Obtaining the ore is handled much the same as it always has: explosives or mechanical diggers tear up the earth, which is then crushed into smaller particles called concentrate. The concentrate is delivered for gold recovery. Modern methods of recovering gold from ore take one of two forms: gravity separation or chemical separation.

The forms of gravity separation are many. Panning and simple sluicing are still used, though usually by individuals and are not part of major mining operations. For larger tasks, variations on the sluice can be used. These variations include spiral concentrators, pinched sluices, and rotary concentrators. All of these use water to filter out the heavier particles of gold. Another gravity-based device is the jig. The operation of the jig is complex, can be explained simply. Concentrate and water flow into a tub, over a filter. Under the filter, pistons agitate the water, and the heavier particles fall through the screen to the bottom of the tub, while the lighter particles stay above the
filter. Centrifugal concentrators are also used, spinning bowls at high speeds to send the lighter particles out over the edge while heavier particles are trapped in the bowl.

Chemical separation requires the use of highly dangerous materials. First, the concentrate is dumped into a cyanide leaching pond. The cyanide reacts with the gold and liquefies it. This cyanide-gold solution is drained, and either another metal, like zinc, is added to the solution, or a metal electrode is put in, and the gold is precipitated out of the solution. The cyanide is then reclaimed for reuse, and the gold is sent to be refined. This process is either done in large vats, or in leach-heaps, which are very large, outdoor ponds.

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Figure x. Range of particle size effectively treated by various types of separation equipment
*Figure reproduced from Michael Silva [1986] (exact reproduction)*
V. Impact of mining

The mining of gold makes a considerable impact, from simple aesthetics to environmental and ecological problems. From an aesthetics standpoint, gold mines are ugly. Open pit and strip mines tear up large sections of earth, exposing bare rock and making large holes in the ground.

Environmentally and ecologically, the affects are more dire. Each of the mining methods has its consequences. Hydraulicking washes massive amounts of sediment down into the streams and deposits them in valleys, choking the waterways [Hill, 1999]. Blasting increases the amount of airborne particles. Both of them contribute to erosion. The systems used to recover gold from ore are problematic. Gravity-based concentrators require large amounts of clean water constantly running through. The hazardous
chemicals used in amalgamation and leaching pose a significant risk if they are released from containment. Several major cyanide spills have occurred just in the past few years, leaking the poisonous chemical into water supplies, killing animals and people [Mineral Policy Institute, 2005].

Due to these problems, mining has become heavily regulated, and companies are more mindful of their impact. Laws now severely limit the use of hydraulicking. Mercury is considered an hazardous air pollutant, and has to be safely contained. Australia and Wisconsin have proposed laws banning the use of cyanide leaching. Mining companies are inventing ways to recycle the water they need, cutting their water usage by 30-60% [Ripley et al., 1996] and doing in-depth environmental impact studies before proceeding with mining operations.

While still destructive, mining has progressed quite a bit in the past century, due to government intervention and an increase public consciousness of environmental issues. Gold will always be in demand, and mining will always take place. Through responsible use of resources and proper care of hazardous materials, mining’s impact can be limited.

VI. References


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