

ARSENIC IN TAILINGS AND DRAINAGE WATERS FROM LODE GOLD DEPOSITS, SIERRA NEVADA REGION, CALIFORNIA

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The main environmental problem associated with lode gold mines in the Sierra Nevada is high levels of arsenic in mill tailings located in areas that have been developed for residential use.

The gold deposits are classified as low-sulfide gold-quartz veins. These are quartz-carbonate veins that contain gold, pyrite, arsenic-bearing minerals, and minor base metal sulfides. Sulfide contents are generally less than five percent. The arsenic-bearing minerals present vary geographically and with host rock type. The most common arsenic mineral is arsenopyrite, but in some mining districts arsenopyrite is rare or absent, and most of the arsenic is in pyrite. Sulfosalt minerals account for much of the arsenic in some districts, and nickel and cobalt arsenides and sulf-arsenides occur where there are altered serpentinite host rocks.

Arsenic concentrations in ores (rocks containing more than 1 mg/kg gold) vary greatly throughout the Sierra Nevada region, ranging from less than 100 to more than 10,000 mg/kg, but show a narrower range of values in individual mining districts. Where arsenopyrite is abundant, ores commonly contain more than 1000 mg/kg arsenic. Where arsenopyrite is scarce or absent, ores rarely contain more than a few hundred mg/kg arsenic.

Concentrations of arsenic in mill tailings are related to ore treatment methods as well as to ore mineralogy and abundance of arsenic in the ores. Most of the mines used stamp mills to crush the ore, and amalgamation with mercury to recover released gold. A significant proportion of the gold was associated with sulfides, especially pyrite, and various mechanical and gravity separation methods were used to recover the sulfides. Sulfide concentrates were often shipped to an off-site smelter. By 1912, when mines in California were first required to impound tailings, most mines produced sulfide concentrates or employed cyanidation. In the 1920's and 1930's, tailings at some of the larger mines were reprocessed using cyanidation to recover gold remaining after earlier milling. In the 1930's, some mines used froth flotation for more efficient removal of sulfides. Because most sulfides were removed, arsenic concentrations are commonly 100-1,000 mg/kg in tailings from ores treated by amalgamation and gravity separation methods. Where ores or tailings were subjected to cyanidation or flotation, or both, arsenic concentrations may be as low as 10-100 mg/kg.

Mine drainage waters and waters in contact with mill tailings from low-sulfide gold-quartz veins are usually neutral or slightly alkaline, owing to presence of carbonate minerals. The arsenic-bearing sulfides can contribute substantial amounts of arsenic to these waters, even though sulfide minerals are not usually abundant in ores, altered wall rocks, or tailings. Arsenic levels range from less than 0.01 to more than 1.0 mg/L in waters in contact with mill tailings. Mine drainage and mine pit waters show a similar range of values.