Green Rust and Invisible Gold

One of my first experiences in mineral I.D. happened when I was a teen-ager working at my Dad's store. A customer showed me a specimen of gold ore given him at the Homestake Mine in Lead, South Dakota. It had lots of brassy grains. I correctly identified them as pyrite, or, as I undiplomatically told him, fools gold. He was furious. "It has to be real gold", he said, "it's from a real gold mine!" What he didn't know was that the gold at the Homestake averages 0.345 ounces per ton – about 0.001% by volume of the rock. This is true of most modern gold mines – the gold is in very tiny grains. This "invisible gold" can't be seen with the eye or even with a hand lens. It is still economic to mine by modern techniques.

The nature of the gold grains in any ore is important to its mining and recovery. Much gold is recovered in modern mining by grinding up the ore and leaching it with cyanide solutions. If the ore is not ground fine enough, or if the gold is included in minerals impervious to the cyanide solutions, as much as 20% of the gold may wind up dumped in the tailings. On the other hand too much grinding is very expensive and can also make mining an ore unprofitable. Thus research on the position and nature of this invisible gold is very important.

Recently researchers at the University of Bristol in the U.K. (Heasman, et. al., 2003) looked whether sulfides and iron oxides can remove gold in solution and tie it up as tiny grains. We often think of gold as insoluble, but it does dissolve if conditions are right. This means linking gold up with chlorine or sulfur and moving as a "complex", rather than as independent "naked" gold atoms. Even so, the concentration of gold in these natural fluids is very low. The problem is: what draws the gold out of solution and locks it up as a solid in a rock we can mine?

Heasman and his colleagues experimented with exposing gold-bearing fluid to finely ground sulfide minerals such as pyrite, chalcopyrite and stibnite. They found the gold plated out on these mineral's surfaces as grains 29-77 Angstroms across. (That's about 0.0000002 inches. Invisible? Close enough.) This mimics in the lab the occurrence of invisible gold in many natural deposits.

Invisible gold also occurs in the weathering zones above many ore deposits, where it is associated with iron oxides. The iron oxides form by the breakdown of pyrite and similar minerals. This process is not simple. If you've ever had a pyrite or marcasite specimen break down on your shelf to a pile of noxious greenish-white goo and fibers, you've seen that the process. It doesn't make nicely crystalline hematite and goethite. "Green

rust" describes this poorly crystalline mixture of iron hydroxides and sulfates. This material was first described in studies of steel corrosion. Heasman and his co-workers exposed gold –bearing solutions to green rust and found that gold plated out on the surface of these minerals too. The gold complexes reacted with the partially oxidized iron, which causes them to break down and release the gold.

This goes to show that not all that glitters is gold, not all fool's gold is worthless, and even icky-looking alteration products can hide real gold.

- Dr. Bill Cordua, University of Wisconsin-River Falls

References:

Heasman, D.M.; D. Sherman, and K. Ragnarsdottir, 2003, "The reduction of aqueous Au by sulfide minerals and green rust phases", American Mineralogist, vol. 88, p. 725-738.