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Gold

Economic geologists are experiencing a severe depression in demand for their services. The bright spot in an otherwise gloomy picture is gold. The selling price of this metal (about \$11 per gram) is sufficient to justify an eager and expanding global search for it.

Many people have the impression that gold occurs as nuggets in streambeds and being a noble metal is only dissolved by aqua regia, a mixture of concentrated hydrochloric and nitric acids. But gold occurs in other environments and is quite mobile under some natural conditions. The concentration of gold in the earth's crust is about 5 parts per billion. Yet a combination of natural chemical and physical processes has led to chunks of gold weighing as much as 30 kilograms. Economic geologists are still arguing about the mechanisms leading to ore formation, but their fund of knowledge and new tools are leading to successes in finding ore. Much of the new gold being found is not in placers but in stratiform deposits. In many of the latter, the gold is disseminated in host rocks in such a way that it is invisible to the naked eye.

The outlines of how gold is extracted from sedimentary or volcanic rocks in which it is present at levels of 5 parts per billion are generally agreed on. Some kind of complexing agent is involved that renders the gold soluble in a hot (175° to 450°C) aqueous fluid. The fluid under great pressure finds its way to a plumbing system, for example, a fault, leading toward the surface. On the way to the surface the complexing agent reacts with wall rock or in some other way loses its solubilizing capability. Gold is not the only element mobilized by this process. Other elements include antimony, arsenic, copper, lead, mercury, molybdenum, silver, and zinc. A number of different complexing agents have been proposed, but the likeliest candidates are those involving sulfur. For example, T. M. Seward conducted experiments with 0.5 molar NaSH at 1000 bars pressure. One kilogram of a solution having a pH of 7.47 at 20°C dissolved 150 milligrams of gold at 300°C. At 175°C about 11 milligrams dissolved. The complex formed was probably Au(HS)₂⁻.

Much of the gold being mined today around the world was mobilized and processed to form placer deposits about 2800 million years ago. The largest occurrences are located at an unconformity between Archean and Proterozoic strata. In the United States the new gold being found was emplaced much later.

The Canadians have been using tools that could be applicable elsewhere.* They have been taking advantage of the fact that vegetation takes in gold. The presence of the element in leaves and woody material can be detected by neutron activation analysis. As little as 1 part per billion can be found in 10 grams of wood ash. This procedure is particularly applicable in Canada because most of the solid rock is covered by glacial till. However, roots of the trees reach deep into the soil. Apparently the roots contain or exude complexing agents that dissolve gold. At any rate, when the sap rises in the spring it carries with it the element. Subsequently during the growing season the concentration of gold diminishes somewhat and varies in different parts of the tree. Some remains at the end of the season. Extensive measurements have been made of trees over gold deposits. The gold concentrations found in the ash of samples from trees growing in glacial till above mineralization often exceed 100 parts per billion when the specimens are collected in early spring. The ash of trees not above mineralization has concentrations about a third as much. One informant was especially enthusiastic about this method. He pointed out that sampling the ground during the winter was difficult and that in summer "the flies eat you." But the vegetation could be harvested at any time. Another informant told of sampling trees from a helicopter.

Although most of the gold known in the United States is in the west, a recent find at Cobalt, Connecticut, indicates that the resources of the east may be substantial. A student field party from the University of Connecticut, led by Professor A. R. Philpott, has found a gold-containing specimen assaying at the level of 190 grams per ton. The find is located at a fault a short distance from an ancient cobalt mine.—PHILIP H. ABELSON

*See D. Carlisle, W. L. Berry, I. R. Kaplan, J. R. Watterson, Eds., *Mineral Exploration: Biological Systems and Organic Matter* (Prentice-Hall, Englewood Cliffs, NJ, 1986).