SCIENTIFIC PROSPECTING

Recent Caltech discoveries may point the way to a new method of locating hidden mineral deposits

A NEW METHOD of prospecting for hidden mineral deposits may result from discoveries made recently by three Caltech scientists—geologist A. E. J. Engel, and geochemists Samuel Epstein and Robert N. Clayton. Studying clues left by nature 250 million years ago, they have found that the location of underground ore is indicated by variations in oxygen isotope ratios in surrounding rock.

It has long been known that some of the greatest base metal deposits in the world were formed when hot fluids, carrying ores with them, forced their way into carbonate rock formations such as limestone and dolomite. The intruding fluids permeated outward, heating the rock for a considerable distance and causing certain chemical changes in it. The affected areas, on which pioneer research was conducted in 1920 by Caltech geologist D. F. Hewett, are known as alteration halos. They are commonly 10 to 20 times larger than the ore deposits they surround, occasionally 1,000 times larger.

Caltech's current study began with a two-fold purpose: (1) to learn more about the physical-chemical properties of the replacement deposits and surrounding halos, and thus more about the formation of the earth's crust, and (2) to see if there was some systematic variation in the chemical make-up of the halos that would point to their hubs of ore. Such a clue would be welcome, for most surface ores are already located and being worked, and the discovery of underground ores is today too often a matter of luck.

A program of field work, supported by the U. S. Geological Survey, was begun in July, 1954, by Dr. Engel. As an experimental model he chose the Leadville limestone, a sedimentary formation in central Colorado that contains some of the country's richest silver, lead, and zinc deposits. A part of this formation near the towns of Gilman and Minturn was best for his purpose because it offered the greatest number of known factors: its lead and zinc deposits were well defined; they were surrounded by an alteration halo some 200 square miles in area; and the geology of the land was well understood.

Dr. Engel first collected rock specimens containing calcite, dolomite, and quartz from the unaltered area around the outside of the halo. He then collected from within the halo, moving in narrowing circles toward its center and finally taking samples from drill cores where the concentration of ores was heaviest.

The next step was to analyze the specimens from the unaltered beds outside the halo to see if they showed any systematic variations in texture, chemical composition, or oxygen isotope composition. They showed no variation in texture or chemical composition, and their oxygen isotope composition was uniform and consistent.

Dr. Engel then analyzed the specimens from the alteration halo. Again he found no variations in their texture or their chemical composition, regardless of their proximity to the central ore deposit.

Analysis for the isotopic composition of these, as well as the first, specimens was made in Caltech's geochemistry laboratories by Drs. Epstein and Clayton, who were already engaged in a research program to determine the variations of oxygen isotope ratios in nature and the effect of geological processes on these variations. The instrument they used for analysis was a special mass spectrometer initially developed at the University of Chicago by Dr. H. C. Urey and a group including Dr. Epstein and Charles R. McKinney, now at Caltech. The spectrometer's precision was such that it could measure, in two million units of ordinary oxygen, the addition or deletion of one unit of O^{18}.

What the mass spectrometer showed was that the ratio of O^{18} to O^{16} in each sample from the alteration halo varied directly with its distance from the ore deposit. Put another way, the oxygen isotope composition of the halo samples depended upon the extent to which they had been permeated and heated at the time of the original ore intrusion.

The analysis of oxygen isotope ratios in the Leadville limestone was the equivalent of having a geochemical thermometer capable of taking temperatures that existed there millions of years ago. According to Dr. Robert P. Sharp, chairman of Caltech's geology division, it should be a valuable tool for investigating the origins of the earth's crust. As for its practical application, that will have to be tested by further experiments in other areas.

"It is quite possible," Dr. Sharp says, "that this variation in oxygen isotope ratios will become extremely important as a means of locating 'hot' spots of rock alteration that may be associated with ore deposits. It could prove to be the basis for one of the most significant contributions to ore prospecting in fifty years."