

carbonates next, and finally oxides. Ridler has been able to trace exhalite patterns for hundreds of kilometers along mineral belts in Canada. These markers of past hydrothermal systems are now being used in exploration.

What is still unexplained, as far as the role of seawater in leaching metals from submarine volcanic rocks is concerned, is exactly what controls which metals are leached, and a number of theoretical and experimental investigations of the geochemistry of hydrothermal systems are under way. Nonetheless this process has been proposed as responsible for the Troodos-type ores found on Cyprus, which are associated with spreading centers; the young, massive sulfide ores associated with island arcs above subduction zones; and many older massive sulfide and precious metal deposits.

The interaction of seawater and crustal materials, and its implications for ore formation, may go beyond the presence of hydrothermal systems. Fyfe believes that chemical reactions involving seawater are not restricted to the area around spreading centers but continue as the oceanic plate moves. In particular, he believes that rocks in the upper portion of oceanic crust continue to change composition and to become more hydrated, locking in large volumes of water and other volatiles. Since most newly formed oceanic crust is eventually subducted and returned to the mantle, the plate tectonic process removes water from the oceans at a rate that, according to Fyfe, would deplete the oceans every 300 to 500 million years if it did not return. Thus Fyfe envisions a massive exchange of water and other volatiles between the crust and the hydrosphere which may be important in the production of volcanic and igneous rocks and their ore deposits above subduction zones. For example, melting of the oceanic crust being subducted is thought to be facilitated by the presence of seawater in the upper portion of the slab.

The ongoing reevaluation of ore formation processes in the context of plate tectonics is so broad that in some cases it is difficult to distinguish between it and more fundamental investigations of the earth's evolution. Some researchers, for example, are looking into the idea that the earth's oceans did not gradually evolve by degassing of the mantle but instead formed early in the planet's history and have been gradually diminished since then—a possibility suggested to them by mineral evidence. Thus whether or not the new metallogenic ideas improve our ability to find and extract metals, and they probably will, they promise to enliven geology for years to come.—ALLEN L. HAMMOND



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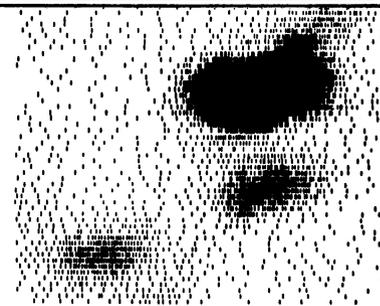
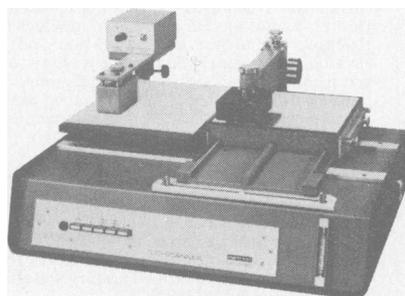
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