Butler

Titanohematite, rather than magnetite, is the dominant magnetic mineral in the San Juan Basin; rocks shown at left are at the basin's Angel Peak. Below, a hexagonal grain of titanohematite, 15 microns wide, sits in the center of a photomicrograph of a polished grain from the basin sediments.

property of the lava flow as it is trying to seek its way to the surface of the earth, he says.

The issue is important because it speaks to the ultimate usefulness of titanohematites as a geochemical tool for unearthing the chemical and physical history of magmas as they flow from depth to the surface. As yet, however, Champion has been unable to interest volcanologists. "If we could make some necessary association that tells them something about their [volcanic] system merely by identifying this mineral, then they'd be damn interested," he says. "But that remains to be shown."

One possible reason for the relatively few findings of self-reversing minerals in lava beds may be that these kinds of rocks are very easy to erode, says Robert F. Butler at the University of Arizona in Tucson. Butler and Everett H. Lindsay will soon publish a paper in THE JOURNAL OF GEOLOGY describing their discovery of titanohematite in 750 meters of sediment, representing about 15 million years of erosion deposits, in the San Juan Basin in New Mexico. These 70-million-year-old sediments are reported to contain virtually no magnetite. And in the northwest corner of Wyoming, the paleomagnetists have also found waves of titanohematite flooding sedimentary sections of the Big Horn Basin, where some magnetite is present but only in extremely small amounts. "It seems odd to people that we would have this family of minerals that we have become accustomed to thinking are very rare and now they seem to be turning up as the major magnetic constituent in some rather important sedimentary basins in North America," says Butler. "And these sediments I'm looking at seem to be the eroded counterparts of the kind of volcanic rocks that Duane [Champion] is seeing."

Easy erosion would also account for the fact that Butler has yet to find traces of the volcanos from which the titanohematites might have originated, even though other volcanic fields of about the right age have been found.

Butler and Champion believe that the titanohematite sediments in the Rocky Mountain region do have a direct volcanic origin and that they came from one volcano. They speculate that titanohematites formed in the magma from this volcano — as well as from those at Mt. Shasta and Mt. Haruna — because the magma had to eat its way up through preexisting continental crust and in so doing perhaps had its chemistry altered. In the San Juan Basin, for example, sediments were deposited after the Rocky Mountains were created in the collision of an oceanic plate with North America, an event called the Laramide orogeny. The pulling down (subduction) of the oceanic plate beneath North America is thought to have caused increased volcanic activity. This means that the "Bunsen burner" marched farther inland than usual, says Champion. Magmas came up through granite and other kinds of Precambrian basement rocks, and in the process may have been adjusted in some way so that they came out of the earth bearing titanohematites.

"If we're anywhere near correct about the origin of these minerals, then any of these basins that have a significant amount of their sediments derived from volcanic rocks should have a significant amount of self-reversing minerals in them," adds Butler. Next summer, he plans to study other Laramide basins in North America to see if the same kind of self-reversers show up there as well. Champion, too, is planning to hunt for titanohematites in lava flows from other explosive volcanos such as the 12,000-year-old bed near Glacier Peak in Washington.

"I'm guessing that in the greater scheme of things, self-reversing minerals are still rare. They're just not as rare as we thought," he concludes. "But I don't think we know. And nobody's looking for them because I don't think anyone believes they're out there." □

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