Why is there so much native copper in Michigan?

Each year many rockhounds, travel to the Keweenaw Peninsula of Michigan to collect copper, silver, datolite, etc. This peninsula contains the most famous outcrops of the volcanic rocks of the Keweenawan rift, which extends south to Taylor's Falls, and north to Duluth and Thunder Bay. In the years between 1845 and 1968 Michigan's Keweenaw Peninsula produced over $1 billion worth of copper. Why is there so much copper in Michigan and relatively little in similar rocks throughout Wisconsin and Minnesota?

The copper of the Keweenaw Peninsula occurs in the rocks of the Portage Lake volcanics, a sequence of over 200 lava flows forming a volcanic pile over 11,000 feet thick. This old volcanic pile has been lifted up along a large fault along the southeast side of the peninsula, so that the lava flows tilt toward the northwest. As one walks from northwest to southeast one goes from lavas that were not deeply buried to those thatwere buried under thousands of feet of hot lava. The deeper the burial, the more the rocks have changed mineralogical and chemically by processes geologists call burial metamorphism. This also controls where the copper occurs. The copper specifically is found in the broken up tops of lava flows, in conglomerate beds deposited by rivers active between volcanic eruptions or in veins along faults that cut across the lavas. The copper came from the lower part of the volcanic pile where hot fluids active during burial metamorphism leached out scattered copper. These fluids then deposited the copper higher in the pile along zones where the fluids moved and cooled.

The burial metamorphism produced minerals other than copper. Where the lava flows are not so deeply buried (less than 2,000 feet) zeolites such as laumontite form. Below this, zeolites are not stable and break down. Prehnite and pumpellyite become the dominant minerals that form from about 2,000 to 8,000 feet. When the lavas were buried deeper than 8,000 feet, epidote is dominant and prehnite and pumpellyite become increasingly rare. On the Keweenaw Peninsula the fluids preferentially deposited the copper in the prehnite-pumpellyite zone. The temperatures in that zone were apparently such that the fluids become saturated in copper.

The rocks on Lake Superior's North Shore are full of zeolites, meaning that we are not seeing very deeply into the volcanic pile. The prehnite-pumpellyite zone and presumably any major copper deposits are thus buried a thousand feet or more below the surface. In the Taylor Falls area, we are deep into the epidote zone, with no prehnite or pumpellyite. If there were large copper deposits in these rocks they were in lava flows long since eroded away.

So, it is not enough just to find Keweenawan-age lava flows. One has to find flows that experienced the right degree of burial metamorphism and interacted with the right composition of fluids. If it wasn't for having to little erosion-or too much-we might not have to drive all the way to the Keweenaw Peninsula for copper, silver, prehnite, pumpellyite or datolite.

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