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Mineralogy and Stable Isotope Geochemistry of Carbonatite Dikes in Southern Ravalli County, Montana, USA

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Approximately 20 small carbonatite "vein-dikes" have been documented in southernmost Ravalli County in southwest Montana. Dozens of similar occurrences have also been described in the neighboring Mineral Hill district of Idaho. The deposits are steeply dipping, tabular bodies several centimeters to several meters wide, and up to 150 m long. The deposits are parallel to the surrounding foliation in Precambrian amphibolite and quartz-feldspathic gneiss, and locally have internal fabrics that appear deformed. The deposits are highly enriched in Nb and light REE, and some of the larger deposits were mined at a small scale in the 1950s. Previous workers have suggested either a magmatic or a hydrothermal origin for these deposits. However, very little academic or mineral exploration work has been done since the 1960s.

Three carbonatite deposits in the Sheep Creek area were sampled in this study, only one of which could be examined in outcrop. The bulk of the carbonatite bodies consists of a granular mosaic of calcite, Fe-dolomite, barite, apatite, and quartz. REE minerals include monazite, ancylite and allanite, with subordinate REE-F-carbonates. REE also occur with Nb-Ti minerals, including aeschynite, pyrochlore, fersmite, and chevkinite. Other Nb phases include columbite and Nb-rich rutile. Concentrations of tantalum are negligible in these minerals. The carbonatites are often banded, which could be a primary igneous feature or perhaps a metamorphic overprint. Fe-oxides (magnetite and specular hematite) are common accessory minerals, and trace sulfides have been found, including pyrite, pyrrhotite, chalcopyrite, galena, molybdenite, siegenite, and cobaltite. Hornblende in the surrounding amphibolite is altered to phlogopite near the veins. However, no alteration resembling fenite is apparent.

Samples of matrix calcite and dolomite ($n = 21$), as well as a single sample of ancylite, were submitted for stable isotope analysis. The data are consistent with a primary igneous origin for the carbonates (Fig. 1), although there appears to have been some modification through interaction with high-temperature meteoric water. The S-isotope composition of pyrite and chalcopyrite ($n = 4$) is unexpectedly light, ranging from -7.9 to -6.9 per mil. Coarse barite from a different carbonatite body has $\delta^{34}\text{S} = +5.0$ to $+6.4$ and $\delta^{18}\text{O} = +6.7$ to $+7.7$. This barite is isotopically distinct from hydrothermal barite veins further north in Montana that have $\delta^{34}\text{S} = +13$ to $+35$ and $\delta^{18}\text{O} = +10$ to $+15$ per mil. Overall, the stable isotope data are consistent with a magmatic origin for the carbonatites, although more work is needed to unravel trends in the S-isotopes. Also, an important question remains as to the age of the carbonatite vein-dikes. Some early Pb-alpha dates of 90 to 99 Ma were reported by the USGS for monazite samples from the Mineral Hill district. However, these dates should be interpreted with caution considering recent studies showing that U-Pb systematics in monazite can be reset during overprinting metamorphic events. It is intriguing to speculate that the carbonatites straddling the Idaho-Montana border could be related to Nb-REE carbonatites in the British Columbia Alkalic Province.

