

GEOCHEMISTRY OF METAMORPHOSED PROTEROZOIC(?) MAFIC DIKES AND SILLS, HIGHLAND MOUNTAINS, MONTANA

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Proterozoic(?) intrusions of basaltic magma into quartzofeldspathic gneiss now outcrop in the Highland Mountains of southwestern Montana in the northwestern quadrant of the Wyoming Province. These dikes, which O'Neill (1988) has called metabasites, crosscut gneissic banding with sharp contacts, indicating that the metamorphism that caused the gneissic banding predates the basaltic intrusions into cold rocks. Some dikes contain their own foliation and almost all dikes are garnet bearing, demonstrating that the dikes were metamorphosed in a second metamorphic event. Several of these fine-grained, garnet-bearing, rusty-weathering, metamorphosed mafic dikes and sills (MMDS) clearly have been folded, but many are exposed only as isolated low-outcrops.

Chemically, the Highland MMDS are subalkaline tholeiites. Fractional crystallization is evidenced by a $Mg/(Mg+Fe)$ molar ratio range from 0.37 to 0.53 and a P_2O_5 range of 0.06 to 0.15 wt%. The ratio of P_2O_5 to Zr is virtually constant, making them similarly incompatible with the fractionating minerals and indicating a common origin for the MMDS. If that is so, since both P_2O_5 and Zr vary by at least a factor of two, at least fifty percent of the liquid must have been crystallized between the first and last intrusion. Variation of major element chemistry is consistent with significant fractionation of orthopyroxene and plagioclase with lesser amounts of clinopyroxene being removed. Because SiO_2 decreases as $Mg/(Mg+Fe)$ decreases, olivine is not a significant fractionating mineral.

The MMDS of the Highland Mountains are similar in field occurrence and bulk chemistry to the MMDS of the nearby Tobacco Root Mountains. Plagioclase, orthopyroxene and clinopyroxene were also fractionated from the Tobacco Root Mountains MMDS, which intruded 2.4 Ga gneisses at 2.06 Ga during continental rifting of the Wyoming Province, and were metamorphosed at 1.77 Ga during the closing of an ocean basin in the Big Sky Orogeny (Brady et al., 2004). Because of their proximity and strong similarities, the two suites of MMDS may have a common origin. They differ, however, in the smaller ranges of TiO_2 , Ni, Zr, and P_2O_5 in the Highland Mountains MMDS compared to the ranges in the Tobacco Root Mountains MMDS.