ISOTOPIC AND TRACE ELEMENT REMOTE SENSING OF MONTANA CONTINENTAL LITHOSPHERE FROM ERUPTED MAGMAS.

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In a continuing effort to characterize mantle-derived magmas in Montana and the evolution of the subjacent mantle, we have obtained isotopic and trace element data for many late Cretaceous to Oligocene mafic volcanic and shallow intrusive rocks throughout west-central Montana. Most, but not all, of the provinces sampled have been radiometrically dated.

All these rocks are light REE-enriched, and span a range in La abundances from 50-90x chondrites (Adel Mt. Volcanics) to 270x chondrites (Garnet Range). Sr and Nd initial isotopic compositions (Figure 1) range from near Bulk Earth, through slightly enriched to more extreme values, which overlap and extend the fields determined previously for rocks from the Crazy, Highwood and Bearpaw Mountains and Missouri Breaks (e.g., Dudas et al., 1987; Scambos and Farmer, 1988; Dudas, 1991; O'Brien et al., 1991). The more enriched samples have ϵ_{Nd} mostly between -10 and -20, but have a wide range in $^{87}Sr/^{86}Sr$ from 0.7055 (Garnet Range) to 0.7095 (Dillon).

Isotopic composition is partly correlated with eruption age and magma type, but there is considerable variation both in space and time. Most of the Eocene (53-45 Ma) mafic magmas so far analyzed from west-central Montana have $\epsilon_{Nd} < -10$ and $^{87}Sr/^{86}Sr > 0.705$. Exceptions are the kimberlitic and alnoitic magmas from the Missouri Breaks and Haystack Butte (Scambos and Farmer, 1988) that may have ascended explosively because of high CO_2 contents. Mid-Oligocene lavas from Indian Flats (IF, 39 Ma) plot near Bulk Earth, whereas those from Virginia City (VC, 33 Ma) overlap isotopically with rocks from the Highwood and Bearpaw Mountains. In the late Oligocene, isotopic compositions range from near Bulk Earth at Volcano Butte (29 Ma), to ϵ_{Nd} of -5 at Black Butte (BB, 24 Ma), to much more negative ϵ_{Nd} in the Smoky Butte lamproites (27 Ma) of eastern Montana.

Following our studies in the Highwood Mountains (Irving et al., 1989; O'Brien et al., 1991), we interpret the isotopic array mostly in terms of assimilative interaction between asthenospheric melts (with isotopic compositions near Bulk Earth) and the Wyoming Craton lithospheric mantle keel. This model differs from that proposed by Eggler et al. (1988) and Dudas (1991), who contend that the magmas originate entirely within the ancient lithospheric mantle. We believe that mass flux of magma into the lithosphere is required in order to partially melt or assimilate cold, residual peridotite. In either case the geochemistry of the magmas provides indirect information on the nature of the lithosphere (e.g., Menzies, 1989). The observed variation in isotopic composition of the magmas requires that the Precambrian lithospheric mantle is regionally variable in isotopic/trace element composition and possibly in age. However, interpretation of the isotopic data is complicated further by the possibility that rates of magma ascent through the lithosphere may have been spatially variable, and/or that thinning of the ancient lithosphere (by thermal erosion or possibly by extension) was widespread by the mid-Oligocene.

The very radiogenic strontium coupled with the presence of quartz xenocrysts in the lavas from the Dillon area may signify contribution from a crustal component. Nevertheless, we believe that the dominant source of the enriched isotopic characteristics throughout the province is ancient lithospheric mantle, based on the extreme compositions (ϵ_{Nd} = -16 to -40, $^{87}Sr/^{86}Sr$ = 0.7149 to 0.7693) of mantle xenoliths from minette in the Highwood Mountains (Irving and Carlson, this volume).

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