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Investigating REE Mineralization Within Fenites and Mineralized Carbonatites Using Geochemical Data and B, Sr, Nd, and Pb Isotope Signatures

BENNETT SCHMITT[1], ANTONIO SIMONETTI[1] AND WEI CHEN[2]

[1]University of Notre Dame
[2]China University of Geosciences, Wuhan
Presenting Author: bschmit2@nd.edu

The petrogenesis of fenites, the metasomatically altered host rocks surrounding alkaline complexes, have been far less investigated compared to their associated magmatic rocks. This study investigates the distribution and concentration of REEs within fenites and mineralized (Nb-REE) carbonatites from three alkaline complexes in China (Miaoya, Maonuiping-Dagudao, and Bayan Obo), comparing their respective chemical (major and trace) characteristics and Sr, Nd, Pb, and B isotope signatures with those of their corresponding magmatic rocks. To our knowledge, this study is the first to report B concentrations and their corresponding isotope ratios for fenites.

Bulk rock analysis of fenites from the Maonuiping-Dagudao and Bayan Obo complexes reveal extreme REE enrichment (>100,000 times chondrite), whereas Nb-REE-mineralized carbonatites from Miaoya contain lower REE contents relative to their corresponding magmatic rocks. Boron abundances for the fenites and mineralized carbonatites range between 2 and 7 ppm, which are higher than those typical of mantle-derived rocks (<1 ppm). Overall, B abundances for the fenites and mineralized carbonatites do not correlate with their total REE contents, whereas ^{11}B values, which range between ~+1 and ~+22 ‰, correlate positively with their B abundances for fenites from Bayan Obo and Maonuiping-Dagudao complexes. Bulk rock Sr, Nd, and Pb isotopic ratios obtained for both the fenites and published data from their associated carbonatite/alkaline rock samples yield large ranges and partly overlapping ratios, and therefore indicate both open-system behavior and a petrogenetic link between these rocks in their formation. The highly variable Pb isotope ratios define linear arrays in Pb-Pb isotope plots that most likely reflect fluid-crustal interaction. The combined chemical and isotope data support the hypothesis that metasomatizing fluids emanating from carbonate/alkaline magmas played a significant role in the alteration of the country rocks and in exerting a control of the observed REE enrichment. However, the B abundances and their corresponding ^{11}B values reported here are difficult to reconcile solely with simple, two-component binary mixing between mantle-derived fluids and their host rocks. Thus, the heavy ^{11}B values for the fenites and mineralized carbonatites investigated here may also reflect fractionation incurred at varying and lower temperatures of formation compared to mantle-derived fluids.