The cause of 13C and 18O enrichment in the Eppawala carbonatite body, Sri Lanka :Limestone assimilation by carbonatitic magma

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Sr, Nd, C, O and S isotopic composition and an abundance of REE are reported for Sri Lanka's Eppawala carbonatite, the origin of which is still a matter of debate. The Eppawala carbonatite body is located about 20km south of Anuradhapura, Sri Lanka. Distributed in this area are metamorphic rocks of the amphibolite to granulite grade, such as hornblende gneiss, granitic gneiss and charnockite. Sm-Nd isochron ages of garnet-silimanite-biotite gneiss and migmatitic gneiss are 607+-23Ma and 626+-16Ma, respectively (Weerakoon et al., 2001). Together, these rocks are classified as the Wanni Complex. The Eppawala body is composed solely of spinel-apatite-calcite carbonatite; peralkaline silicate rocks are not observed. The striking features of the Eppawala body include the occurrence of green spinel, plastic deformation structures, and a lack of fenitization. The biotite-apatite-whole rock Rb-Sr isochron age for the carbonatite from a single locality is 493+-5Ma (Weerakoon et al., 2001).

The delta13C(PDB) and delta18O(SMOW) values of the Eppawala carbonatites range from -2.8 to -1.1 permil and from 12.8 to 16.7 permil, respectively. On the delta13C(PDB) vs. delta18O(SMOW) diagram, the values of the Eppawala carbonatites fall exactly in the middle between the field of mantle CO2 and marine limestone. The initial Sr isotope ratios of the carbonatite range from 0.7048 to 0.7055 [from 13.7 to 23.4 epsilon Sr (T)], and the initial Nd isotope ratios range from 0.51159 to 0.51169 [from -6.6 to -4.6 epsilon Nd (T)]. These data are plotted in the lower-right quadrant in the epsilon Sr vs. epsilon Nd diagram. The Eppawala carbonatites have a wide range of initial Sr isotope ratios and Sr concentrations. A positive correlation is observed between the initial Sr isotope ratios and 10000/Sr values. REE concentrations in the Eppawala carbonatites are very high and are within the range of typical carbonatite.

The C, O and Sr isotopic features of the Eppawala carbonatites are best explained by the results of assimilation. The mixing calculation indicates that primary carbonatite magma was assimilated with an equal amount of marine limestone plus crustal silicate rock. The following facts are consistent with this interpretation. The carbonatites contain abundant fragments of silicate rock and magmatic olivines. These olivines are surrounded by coronal structures generated by reaction (8olivine + 13calcite + 1H2O + 9CO2 = 1tremolite + 11dolomite). The minerals consistent with the coronal structure are tremolite and dolomite, with the latter surrounding the former. This coronal structure indicates the infiltration of water into carbonatitic magma.

Because of the very high concentrations of Sr and Nd in carbonatite magmas, their low melting temperatures and their probable rapid transport through the crust, crustal contamination of these elements is minimal in comparison to most other mantle-derived magma types. Therefore, in spite of the assimilation with crustal materials, the initial Sr and Nd isotope ratios of the Eppawala carbonatites are likely to be representative of their mantle source. The Eppawala carbonatites have high initial 87Sr/86Sr ratios and low initial 143Nd/144Nd ratios relative to bulk earth and CHUR. Thus, these isotope ratios imply a mantle enriched with alkali metal and LREE as the source, which corresponds with the EM1-type mantle.