Large local heterogeneities of the MORB source mantle: Melt inclusion Pb isotope studies

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The scale of heterogeneity in the source of mantle-derived magmas is one of the outstanding questions in geochemistry. Applications of ion-probe techniques for in-situ determination of Pb isotopic composition have shown that large isotopic variations exist in individual plume-derived basalt lavas (Saal et al., 1998) and suggest that large local isotopic heterogeneity exist for plume mantle sources. Reported here are results of three separate Pb isotope studies of olivine-hosted melt inclusions in basalts from the Mid-Atlantic Ridge. Two early studies focussed on E-MORBs from 14°N, and T-and E-MORBs from the FAMOUS area (36.8°N), whereas a new set of data was obtained for N-MORBs in a sample dredged at 17.1°N. Ranges of Pb isotopic variations in the 14°N single-lava melt inclusion suite cover more than 50% of the entire spectrum for the Atlantic MORB (208/206 from 1.991 to 2.075, 207/206 from 0.803 to 0.855) and display a quasi linear array between DMM and HIMU endmembers. The FAMOUS suite displays a similarly large variations also along the DMM-HIMU join. These isotopic variations are consistent with a notion that the source mantle for T- and E-MORB magmas is heterogeneous due to the presence of recycled crust components in a "marble cake" fashion. The N-MORB suite shows large and more complex isotopic variations. Ranges observed are slightly larger than those of the 14°N suite (208/206 from 2.009 to 2.114, 207/206 from 0.822 to 0.873), along both the HIMU-DMM and DMM-EM1 joins. The least radiogenic composition among melt inclusions is identical to that of the host glass (Dosso et al., 1993) and resembles the Koolau endmember of the Hawaiian plume (Eiler et al., 1998). It is clear that the MORB source mantle contains complex mixtures of materials with diverse geochemical prehistories on small spatial scales, and magnitude of isotopic heterogeneity is very large regardless of the type of magmas produced.

References

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Genetic relation between nakhlites and shergottites: Implications from REE compositions of Martian meteorites

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It has been widely accepted that shergottites, nakhlites and chassignite (SNC meteorites) are from Mars. In addition, many researchers consider that the nakhlites and the chassignite would be petrogenetically linked. The relation between the nakhlites and the shergottites, on the other hand, is not clear because of following reason, i.e., while the parent magmas of the nakhlites and the shergottites have complimentary trace element patterns (Longhi, 1991), the isotopic compositions of these magmas, in particular $^{142}\varepsilon Nd$ ratios, indicate that they derived from different source mantle regions (Harper et al., 1995).

In order to evaluate the genetic relation between the nakhlites and the shergottites, we determined REE compositions of pyroxenes of the Y000749 (nakhlite) and Dhofar 378 (basaltic shergottite), with the Cameca IMS-1270 ion microprobe. The obtained REE patterns of these meteorites are consistent with previously reported REE patterns, namely, parent magmas of Dhofar 378 and Y000749 are LREE-depleted and LREE-enriched, respectively.

Here, we propose a new model of two-stage melting of a single diapir at different depth that can explain the trace element and isotopic compositions of SNC meteorites. At first stage, the diapir induced melting at deeper mantle with residual garnet to produce the nakhlite and chassignite melts. The upwelling diapir, then, started second-stage melting at shallow mantle without residual garnet to produce shergottite melts. The assimilation of parent shergottite melt not with crust but with shallow mantle material would be a plausible explanation for the isotopic variation of shergottites, because Martian crust, i.e., the basaltic shergottite, has LREE depleted REE pattern suggesting depleted isotopic composition of the crust. Thus we consider the enriched isotopic signature of shergottite would be produced by the mixing of the primary melt with the shallow mantle material of which chemical character is originally derived from Martian magma ocean.

References

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