Ultra-depleted melts from Iceland: data from melt inclusion studies

A.V. Sobolev
A.A. Gurenko
N. Shimizu

Vernadsky Institute of Geochemistry, Russian Ac. Sc., Moscow 117975, Kosygin str. 19, Russia; E-mail geochem@glas.apc.org
Woods Hole Oceanographic Institution, Woods Hole, MA 02543, USA.

Introduction

Melts which are ultra-depleted for highly incompatible elements (UDM) are expected to be important members of mantle derived melts if melting process approaches fractional melting, and melt fractions could avoid mixing to each other and reacting with mantle on their way to the surface. However, among basaltic lavas and glasses, the UDM is not present or very rare. The only reported UDM were found in mid-ocean ridge basalts (MORB) as inclusions in high-Mg olivines (Sobolev and Shimizu, 1993; Sobolev *et al.*, 1994). Here we present data on the UDM inclusions found in high-Mg olivines from tholeiitic picrites and olivine basalts from Iceland, which represents a mantle plume centered on the Mid-Atlantic Ridge (Schilling, 1973).

Samples and results

Samples studied here were collected from two locations of the Icelandic rift zone: Reykjanes Peninsula (picrite 14132 and two basaltic glasses 14124 and 14134), and Theistareykir volcanic field (Ol basalt 11898). Phenocryst phases are olivine (Fo_{89-92}), pyroxene (Mg# 0.88–0.90), plagioclase (An_{83-90}) and spinel (Cr# = 0.31–0.54) (Gurenko *et al.*, 1988; 1991). Melt inclusions and matrix glasses were analyzed by electron probe (at Vernadsky Institute) and by ion probe (at WHOI). The data are characterized by a significant range in *LREE* concentrations in inclusions and matrix glasses from a single sample (Fig. 1). The glasses tend to show higher concentrations while some of the inclusions have compositions similar to the UDM (Sobolev and Shimizu, 1993) with extreme depletion in *LREE* and Zr. Significant characteristics of UDM inclusions and glasses are positive Sr and negative Zr anomalies (Fig. 2). These have already been observed for most primitive Icelandic rocks (Hemond *et al.*, 1993) and also in melt inclusions from Siqueiros fracture zone (Sobolev *et al.*, 1994).

Discussion

Most geochemical characteristics of Icelandic UDM could be successfully reproduced by critical (continuous) melting model (Sobolev and Shimizu, 1992) with 2-4 wt% of melt retained the residue.

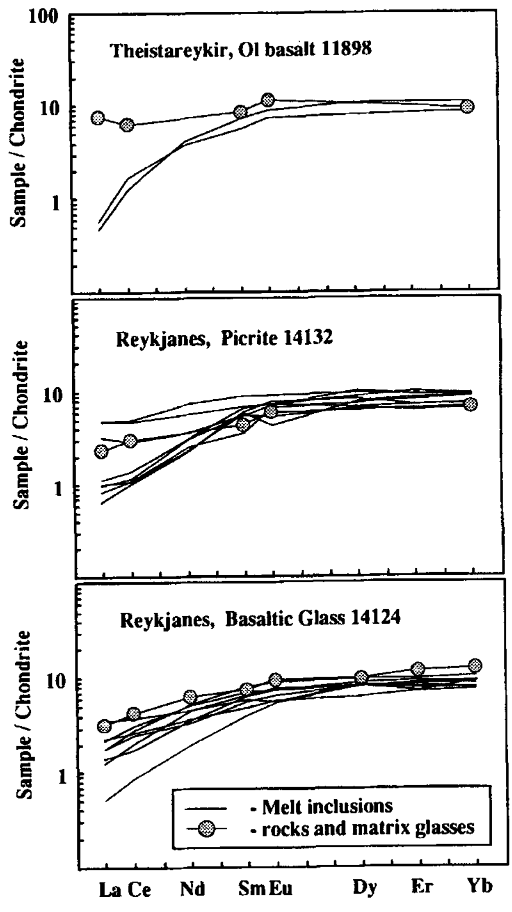

FIG. 1. Chondrite normalized (Anders and Grevesse, 1989) REE patterns for melt inclusions in olivine and host rocks or glasses.

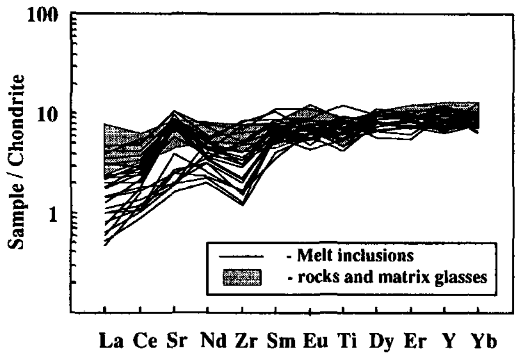

FIG. 2. Spider diagram for the melt inclusions in olivine and host rocks or glasses.

This estimate of the residual mantle porosity should be considered as maximum because of possible mixing with high-pressure melts formed in the presence of garnet (Sobolev *et al.*, 1994). The matrix glasses are significantly more depleted in LREE than it should be expected for pooled samples generated by critical melting. Thus they require lost of some enriched fractions of melt produced by low degree of melting.

The observed Sr and Zr anomalies in UDM could not be explained by melting alone, and may require reaction between melt and crustal cumulates rich in plagioclase with strongly LREE depleted clinopyroxene similar to those reported by Ross and Elthon (1993).

Conclusion

The data presented here suggest that the generation of UDM is a general feature of melting process of mantle beneath mid-ocean ridge and ridge-centered plume. This is consistent with efficient melt extraction and open system regime of melting in such environment (e.g., McKenzie, 1985; Johnson *et al.*, 1990). The presence of Sr and Zr anomalies in UDM suggests common interaction of instantaneous melts with the crustal rocks during their ascent.

Acknowledgments

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