Coexistence of enriched and depleted primitive melts as inclusions in olivine from Reykjanes tholeiites, Iceland

A.A. Gurenko
M. Chaussidon
CRPG-CNRS, BP 20, 54501 Vandoeuvre-lès-Nancy Cedex, France.

Introduction

Theoretical models of magma genesis (e.g. McKenzie, 1985), data from abyssal peridotites and oceanic cumulates (Johnson *et al*, 1990; Ross and Elthon, 1993), studies of MORBs and Icelandic tholeiites (Sobolev and Shimizu, 1992a,b, 1993, 1994) have shown that ultra-depleted melts (UDM) are common within the sub-oceanic lithosphere. As far as UDM really exist, one would expect the existence of enriched melts (EM) having been the first portions of mantle melting. Indeed, these (EM) have been described as olivine-hosted inclusions in FAMOUS lavas (Shimizu and Hassler, 1993). Here we report the first discovery of melts existing as olivine-trapped melt inclusions from glassy rims of rift-related tholeiitic picrites from Reykjanes Peninsula (Iceland), which have major and trace element characteristics varying from EM to UDM varieties.

Samples

Eight tholeiitic glasses from picritic pillow lavas and lava flows were collected within tholeiitic volcanic zones of Reykjanes Peninsula (Haleyjabunga and Lagafell Holocene lava shields, Reykjanes swarm) and Hengill volcanic system (Midfell and Maelifell Late Glacial eruption units). Glasses contain rounded phenocrysts of olivine ($Fo_{83.2-90.7}$) ± clinopyroxene (Mg# = 0.806–0.904) ± plagioclase ($An_{83.1-89.9}$) and spinel (Cr# = 0.31–0.53), with/without small amount of plagioclase microlites. All silicates contain primary inclusions of glass.

Results

Primary melt inclusions and host chilled glasses were analyzed for major elements with electron probe Cameca SX50 and for trace elements with ion microprobe IMS-3f (CRPG, Nancy, France). Our data show clearly that, in addition to UDM inclusions, reported previously (Sobolev and Shimizu, 1992a), olivines contain inclusions of EM, as indicated by their high K_2O/TiO_2, (La/Sm)n and Zr/Y ratios (Fig 1). These ratios are significantly higher than those of matrix glasses and exceed any published ones for the most primitive tholeiitic glasses in general (Meyer *et al.*, 1985; Tronnes, 1991). REE patterns of EM show significant enrichment in LREE and depletion in HREE (Fig.2). Trace element contents of UDM correspond to melts described

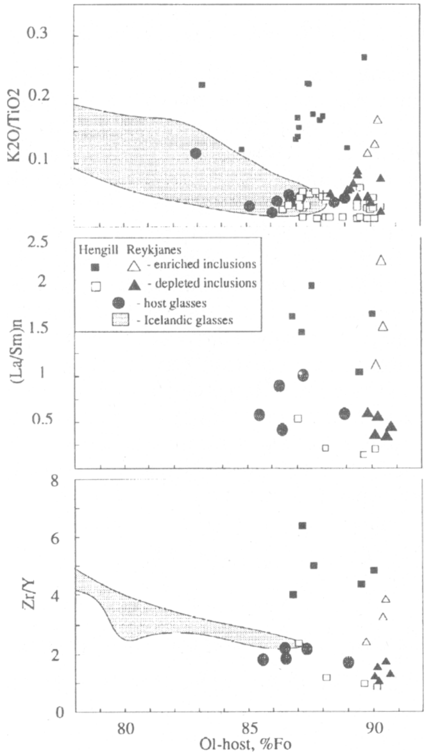

FIG. 1. Geochemistry of melt inclusions vs. composition of host olivine. For Icelandic glasses olivine composition correspond to calculated equilibrium one.

by Sobolev and Shimizu (1992a). In addition, all depleted melt inclusions and glasses show variable Sr anomalies, whose magnitudes increase with melt depletion (Fig 2).

Discussion

The occurrence of both EM and UDM in Icelandic tholeiites can be explained by different melting conditions of mantle source with element concentrations initially that of primitive mantle (Sun and McDonough, 1989). EM corresponding to the first portions of melts can be produced by 7–8 % critical (continuous) melting (with 2–4 wt.% of melt retained in the residue) of garnet-bearing mantle peridotite using the model of Sobolev and Shimizu (1992b). The presence of garnet in the source is inferred from the high depletion of EM in HREE and Y. Major element compositions of EM corrected for crystallization of host olivine also indicate high pressures of equilibrium with mantle lherzolite (up to 20 kb using the approach of Takahashi and Kushiro, 1983). REE patterns of UDMs may be satisfactory modelled by 13–17 % melting of Sp-peridotite. The presence of a widespread Sr anomaly in the present melts does not bring further constraints on the melting processes, because it is likely due to interaction of the melts with plagioclase bearing rocks at shallower levels (Sobolev *et al.*, 1994).

Conclusion

The most important result derived from this study is that the low fractions of enriched melts can be extracted from Ga-bearing mantle source and that these melts can migrate to shallow magma chambers remained sufficiently isolated from the subsequent mixing within the thicker Icelandic crust. EM and UDM are due to melting of mantle column at depths varying within the Ga and Sp stability fields.

Acknowledgements

This work is a part of Post-doctoral research fellowship supported by Ministère de la Recherche et de la Technologie (France). We would like to thank Dr. A.V. Sobolev for constructive reviews and comments and Dr. T.H. Hansteen for providing us two glass samples from Maelifell area.

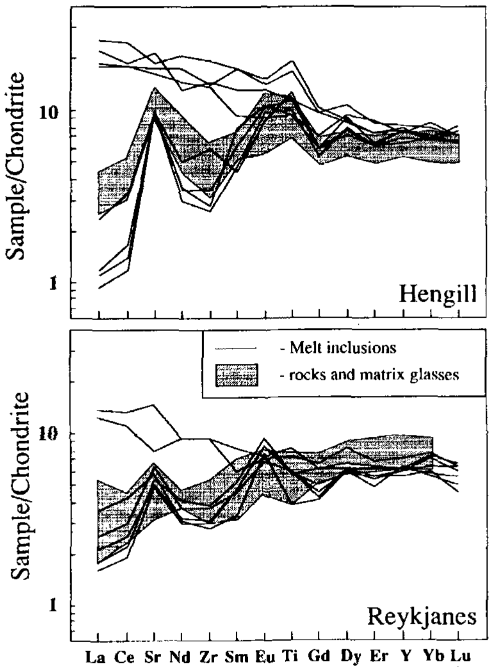

FIG. 2. Spider diagrams for melt inclusions, rocks and host glasses.

References

Johnson, K.T.M., Dick, H.J.B. and Shimizu, N. (1990) *J. Geophys. Res.*, **95**, 2661–78

Meyer, P.S., Sigurdsson, H., Schilling, J.-G. (1985) *J. Geophys. Res.*, **90**, 10043–72.

McKenzie, D. (1985) *Earth Planet. Sci. Lett.*, **72**, 149–57

Ross, K. and Elthon, D. (1993) *Nature*, **365**, 826–9.

Shimizu, N. and Hassler, D. (1993) *EOS*, **74**, 644–5.

Sobolev A.V. and Shimizu N. (1992a) *Abstracts 29th IGC, Kyoto, Japan*, **58**, 1921.

Sobolev A.V. and Shimizu N. (1992b) *Doklady Acad. Sci. Russia*, **236**, 354–60.

Sobolev A.V. and Shimizu N. (1993) *Nature*, **363**, 151–4.

Sobolev A.V., Casey J.F., Shimizu N. and Perfit M.R. (1994) *Science*, in press.

Sun, S.-s. and McDonough W.F. (1989) In *Magmatism in the Ocean Basins*, (A.D.Saunders and Norry, M.J. eds) 42, 313–45.

Takahashi, E. and Kusiro, I. (1983) *Amer. Mineral.*, **68**, 859–79

Tronnes, R.G. (1991) *J. Geophys. Res.*, **95**, 15893–910.