

Halogens in normal- and enriched-basalts from Central Indian Ridge (18-20°S): testing the E-MORB subduction origin hypothesis

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Basalts erupted along oceanic ridges have often been subdivided into two categories: the N-MORB and the E-MORB, the latter is anomalously enriched in highly incompatible elements. Donnelly et al. (2004) proposed that the formation of enriched sources is related to two stages of melting. The first one occurs in subduction zones where the mantle wedge is enriched by the addition of low-degree melts of subducted slab. The second stage of melting occurs beneath ocean ridges. Because of their incompatibility in basalt minerals, their relatively high concentrations and distinct elemental compositions in surface reservoirs, the halogens are good tracers to detect the slab contribution in E-MORB sources.

However, the halogen systematics in mantle reservoirs remains poorly constrained mainly because of their very low abundance in materials of interest. The innovative halogen analytical technique, involving neutron irradiation of samples to convert halogens to noble gases, provides detection limits unmatched by any other technique studies. For the first time Cl, Br and I can now be determined in appropriate samples.

We focus on the content of halogens in the glassy margins of basalts erupted along the CIR (18-20°S). Our set of samples contains both N- and E-MORB. The halogen concentration range is between 10 and 140 ppm for Cl, 30 and 520 ppb for Br, 1 and 11 ppb for I. The concentrations are not related to superficial processes such as fractional crystallisation and degassing. The strong correlation that exists between the halogens and other incompatible elements also excludes seawater assimilation prior to and during eruption as a means of supplying halogens and water. Therefore, concentrations can be directly linked to melting and mantle source features. Estimates of halogen abundances in the source of CIR depleted-mantle with 10% of partial melting, are 1.1 ppm Cl, 3.4 ppb Br and 0.1 ppb I.

Furthermore, the halogen elemental ratios show no significant variations along the ridge: $Br/Cl=0.00336\pm0.00003$, $I/Cl=0.000076\pm0.000018$ and $I/Br=0.023\pm0.006$. This similarity between N-MORB and E-MORB can be explained by a common mantle source and therefore, it is not consistent with subduction as a source of halogen enrichment.

The CIR samples display a mean K/Cl value of 26.7 ± 7.2 (12.5 ± 1.0 for global MORB). The chlorine enrichment is also well correlated with water content. The fractionation of K/Cl ratio can be caused by metasomatic enrichment via small degree partial melts, such as those that may form between the wet and dry solidi of the mantle peridotite near ridges (Galer and O'Nions, 1986). The breakdown of accessory phases in peridotite at wet solidus will control the amount of water and halogens. The very low degree melts formed at the volatile-present solidus then mixes with higher degree melts formed directly beneath the ridge.