

The Partitioning of Rhenium and Osmium into Magmatic Olivine and the Consequences for the Chemistry of Oceanic Basalts

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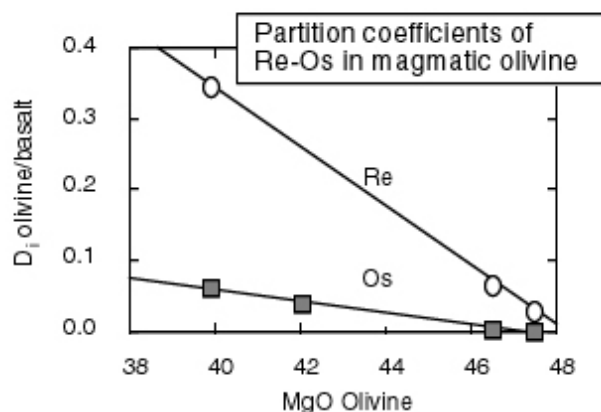
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The fractionation of Rhenium and Osmium (Re-Os) during the formation of oceanic basalts is one of the key processes controlling the distribution of these elements between the Earth's crust and mantle. Osmium is generally considered to behave as a highly compatible element, whereas Re is moderately incompatible (e.g. Pegram and Allègre, 1998; Hauri and Hart, 1997). Consequently, fractionation during basalt genesis has been attributed, in part, to Os being preferentially retained in mantle sulphide or Os-rich alloys, but also, in part, to Os compatibility in olivine during magmatic differentiation (Hart and Ravizza, 1996). Thus, Mg-Ni-Os covariations in Ocean Island basalts and the low Ni and Os contents of Mid-Ocean ridge basalts have been attributed to fractional crystallisation of olivine (Hart and Ravizza, 1996), consistent with direct measurements of magmatic olivine (Hart and Ravizza, 1996). However, others have argued for control by scavenging of Os by immiscible sulphides (Roy-Barman et al., 1998). This study presents Re and Os elemental data for magmatic olivines and their host basalt. These results offer some insights into the behaviour of Re and Os in olivine, provide precise estimates for the partition coefficient (D_{Os}) olivine/basalt, and when taken with recent data for sulphide and basalt glasses (Roy-Barman et al., 1998) enable an assessment of the role of olivine and sulphide crystallisation in producing the observed Os abundances and variations in oceanic basalts.

The studied samples range from alkali basanite (MgO = 15.93, Bandama, Grand Canaria) plagioclase phyric basalt (MgO = 8.92, FAMOUS area, N Atlantic) to trachybasalt (MgO = 5.7, Silvestri, Mt. Etna, Italy). The major element compositions of the olivines, and melt inclusion compositions, suggest that they crystallised from the host lava in a low-pressure environment (i.e. are phenocrystic) rather than being derived from a peridotite mantle source (i.e. xenocrystic). The concentration of Os in the olivines studied here is extremely low and ranges from 0.009ppt for the rim of large olivine phenocrysts from Bandama to 0.121ppt for olivine from Silvestri. These data yield partition coefficients (D_i) that range from 0.0004 to 0.064 for Os, and 0.03 to 0.34 for Re. Furthermore, the measured partition coefficients show a clear correlation with MgO content of the olivine (Figure 1) which suggests that partitioning of these elements, like Fe, Mn and Ni, occurs by substitution onto crystallographic sites (Beattie et al., 1991).

These results suggest that both Re and Os are highly incompatible in magmatic olivine, contrary to previous studies. In this case fractional crystallisation of olivine alone cannot produce the Os-Mg-Ni variations displayed by oceanic basalts, rather only parallel crystallisation of both olivine and sulphide or source heterogeneities can account for the observed trends. Taken with results for mantle silicates and sulphides (Hart and Ravizza, 1996; Burton et al., 1999) these results suggest that the compatible behaviour of Os, in both mantle and magmatic environments, is largely controlled by the presence of sulphide.

Fig. 1



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