IRON/MANGANESE RATIOS OF VOLCANIC ROCKS AS PROBES OF THE IRON BUDGET OF EARTH'S DEEP INTERIOR

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Introduction

Volcanic islands like Hawaii are considered to be the products of hot plumes of mantle rock rising from great depths inside the Earth, perhaps from the core-mantle boundary (2800 km depth). Chemical interactions between the Earth's iron core and the mantle are speculated to occur. We have begun a search for excess iron in mantle plume-derived volcanic rocks (basalts) by using the ratio Fe/Mn, which is known to be approximately constant in most mantle-derived rocks. We have observed high Fe/Mn ratios in lavas from Hawaii and Tahiti, but not in lavas from Iceland, relative to Fe/Mn in lavas erupted along the mid-ocean ridges (MORB) [1]. A ratio of Fe/Mn= 60±20 (2σ) was obtained from literature data for mantle peridotites [2], solid fragments of the Earth's mantle brought to the surface by lavas. Further, in the literature Fe/Mn ratios in peridotites showed no correlation with melt-depletion. We report new results for mantle peridotites from Kilbourne Hole, NM.

Experimental

We developed a new method for the determination of the Fe/Mn ratio in rocks based on inductively coupled plasma mass spectrometry (ICP-MS) (ThermoFinnigan MAT Element1, NHMFL). We directly measure the ratio of $^{54}Fe^{+}/^{55}Mn^{+}$ in solutions of mantle peridotites. Conversion of measured ion intensities to elemental ratios is accomplished by analyzing gravimetrically prepared Fe-Mn solutions with known ratios. The precision on standard solutions is ±0.5%.

Results, Discussion & Conclusions

The new data we obtained shows that the Fe/Mn ratio of mantle peridotites from Kilbourne Hole is significantly more restricted than literature data. Our Fe/Mn correlates with melt depletion indicated by MgO content, such that dunites have the highest measured Fe/Mn at MgO~48%. Our data indicate that literature Fe/Mn were compromised by poor precision obscuring trends observed here. Using our measurements we estimate Fe/Mn=60.7±1.5 (2σ) for primitive mantle (i.e. adjusted for melt depletion), an improvement in precision of an order of magnitude. This implies that the fractionation of the Fe/Mn ratio upon melting is 7±2% in the production of MORBs. Thus, if the mantle beneath Hawaii is peridotite, then Fe/Mn= 71±1 for Hawaiian mantle. Recent seismic and geodynamic models inferred comparable iron variations, which were smaller than literature uncertainties. Our data provide geochemical "ground truth" for geophysical models [3].

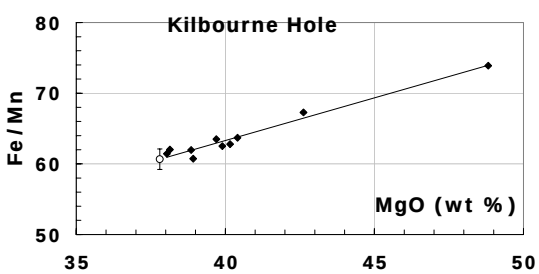

Fig. 1: Fe/Mn ratios plotted against MgO content of mantle peridotites from Kilbourne Hole, NM (solid diamonds). The open circle represents the projected primitive mantle Fe/Mn composition with 2σ error bars.

References

[1] Humayun, M., *et al*., Science, **306**, 91-94 (2004).
[2] McDonough, W. F., *et al*., Chem. Geol., **120**, 223-253 (1995).
[3] Forte, A. M., *et al*., Nature, **410**, 1049-1056 (2001).