Geochemistry of Basalts from the Asymmetric Spreading Ridge Segment at 16.5ºN on the Mid-Atlantic Ridge

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Introduction

Spreading on the MAR from 16°25'N to16°50'N is asymmetric, dominated by detachment faulting that result in oceanic core complexes west of the ridge and basaltic crust on the east side of the ridge. During the R/V Knorr 205 expedition in the spring of 2013 this ridge segment was investigated through detailed mapping by AUV Sentry, imaging by TowCam and sampling by dredging. Samples are from a 60 km by 40 km area, mainly from the west side of the spreading axis, with the oldest sample being 1.6 Ma. .

Experimental

LA-ICP-MS analysis for major and trace element concentrations were performed on approximately 100 basalts using an ESI New Wave™ UP193FX excimer LA-ICP-MS system coupled to a ThermoFisher ELEMENT XR at the Geochemistry Program (NHMFL). The spot size was 20 µm, with 5-second dwell time at 50 Hz, and 1.7 GW/cm^{2}power density. Analysis were calibrated using well known standards using established techniques [1]. In addition a subset of the basalts were analyzed for Sr, Nd, Hf and Pb isotopic composition using established separation techniques [2]. Nd, Hf and Pb isotopic compositions were measured using a ThermoFisher Neptune multi-collector ICP-MS. Sr isotopic composition were determined on a Finnegan Mat 262 multi collector thermal ionization mass spectrometer.

Results and Discussion

Basalts range in Na_2O from 2.5-3.3 wt%, FeO from 8.3-12.8 wt%, SiO_2 from 45-52 wt%, TiO_2 from 1.0-2.2 wt% at 8 wt% MgO, $[La/Yb]_{C1}$ values ranging from 0.5 to 2.3 and $[La/Sm]_{C1}$ values range from 0.55-1.35. The majority of the analyzed samples are LREE enriched. K_2O/TiO_2 ranges from 0.07- 0.41 at 8 wt% MgO. Thus most of the basalts are transitional (T) or enriched (E) MORB. Dredges are relatively uniform in composition, but few show both LREE enriched and LREE depleted patterns.

In contrast to the enriched trace element nature of the basalts, the isotopic compositions fall towards the depleted end of the MORB range with $^{87}Sr/^{86}Sr$ between 0.70233 and 0.70283, ε_{Nd} between 8.6 and 12.6, ε_{Hf} between 1 and 19.5 and $^{206}Pb/^{204}Pb$ ranging from 18.16 to 18.96. These isotopic compositions are among the most depleted in the Atlantic. Trace elements and isotopes are, in general, correlated with the most incompatible enriched basalts having the radiogenic Sr and Pb isotopes and unradiogenic Nd and Hf.

Compared to the samples from the asymmetric spreading segment at 13.3°N on the mid Atlantic Ridge [3], the LIL enrichments at 16.5°N are not as strong, and the isotopic composition is more depleted. The oldest sample at 13.3°N is also approximately 1.6 Ma.

Conclusions

We propose that the observed incompatible element enrichments are a direct effect of low extents of melting of the depleted mantle, in agreement with the observed morphology and geology of the segment.

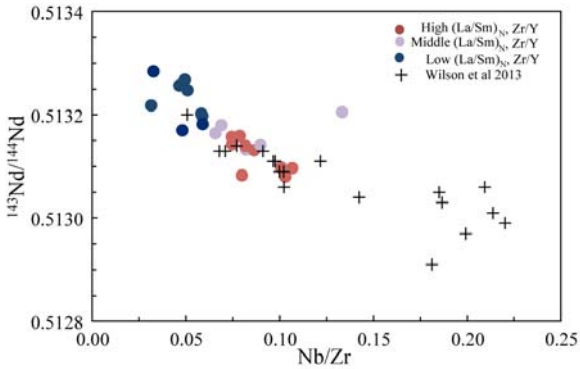

Figure 1: Nb/Zr versus Nd-isotopic composition. Decreasing degree of melting results in higher Nb/Zr. Lowest Nb/Zr in basalts is similar to N-MORB source value (0.26), indicating a depleted source.

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References

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