ISOTOPE AND TRACE ELEMENT CHARACTERISTICS OF WALVIS RIDGE BASALTS: SUBCONTINENTAL LITHOSPHERE?

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Introduction

Walvis Ridge is the "type" locality for Enriched Mantle I compositions [1]. We re-sampled the DSDP cores and have determined the trace element and isotopic compositions of Walvis Ridge basalts to better determine the geochemical characteristics of the enriched mantle end member. Based mainly on the low $^{143}Nd/^{144}Nd$ isotope ratios and high $^{206}Pb/^{207}Pb$ for given $^{206}Pb/^{204}Pb$ it is thought this end member includes a significant contribution from recycled pelagic sediments. However, complete characterization of the Walvis Ridge basalts has been lacking up till now. Characteristic for pelagic sediment contribution is a shallow slope on a Hf-Nd isotope correlation diagram in combination with high $^{207}Pb/^{204}Pb$ for the lowest $^{143}Nd/^{144}Nd$.

Results and Discussion

For Walvis Ridge basalts εHf varies from –2 to +12 while εNd varies from –4 to 6. This range is larger than previously published results and results in a well-correlated array (R^2=0.87) with a steeper slope than the general ocean island basalt (OIB) array. In fact compared to other ocean island basalt arrays Walvis Ridge basalts exhibit one of the steepest slopes in Hf-Nd isotope space. Walvis Ridge Pb-isotope variation is also large $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ range from 17.5 to 18.5 and 15.46 to 15.53 respectively. The low $^{206}Pb/^{204}Pb$ basalts also show low Hf and Nd isotopic characteristics and in general Nd-Sr-Hf-Pb isotopic compositions are well correlated indicating two component mixing.

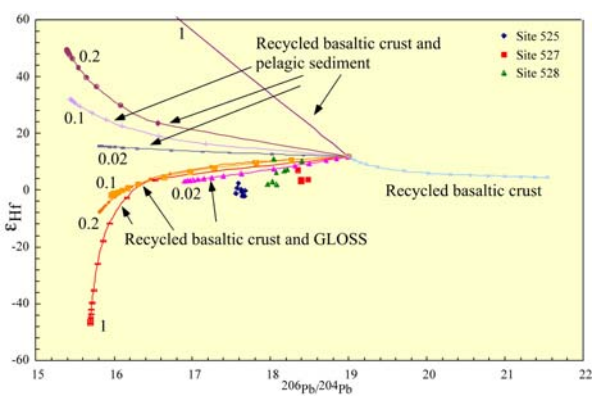

Figure caption: Mixing curves for a depleted end member and various recycled component. GLOSS is average Global Oceanic Sediments. Numbers at curves indicate fraction of sediment in the sediment basalt crust mix.

The Walvis Ridge basalts also show a large range in trace element compositions: Ce/Yb 4.68-25.52; Sm/Hf 1.11-1.58; La/Nb 0.72-1.63, La/Sm 1.59-5.13; U/Th 0.10-0.53 all well outside the range of what is expected for variations related to degree of melting and crystallization. Isotopic and trace element characteristics of the basalts are well correlated with low epsilon-Hf basalts showing low Sm/Hf, high Ce/Yb and high U/Th. The trace element data confirm the isotopic data as most of their variations can also be explained by mixing of just two components.

The isotopic variations as well as the coupled trace element-isotope variations, especially the steep slope on the Hf-Nd isotope correlation diagram and the positive correlation between Sm/Hf and Hf-isotopic composition, argue strongly against pelagic sediment involvement. We tried to model the data as a mixing between a depleted end member and various combinations of recycled components that included igneous ocean crust, pelagic sediment and GLOSS (global average of oceanic sediment, see figure). In this model we allowed the sediment and igneous crust to be modified by a subduction zone process (dehydration for igneous crust and dehydration or melting for sediments) but found that no combination could reproduce the isotopic and trace element characteristics of the Walvis Ridge basalts. This comprehensive modeling indicates that the trace element and isotope variations show that the data are hard to reconcile with the involvement of recycled components.

Conclusions

We therefore conclude that the EMI signature of the Walvis Ridge basalts is a remnant of continental lithosphere (indicated by the high La/Nb and Sm/Hf) or is produced by internal mantle differentiation.

References

1 A. Zindler and S.R. Hart, Ann. Rev. Earth Plan. Sci. 14, 493-571, 1986.