# Constraints on the MORB melting regime based on the Lu-Hf and Sm-Nd systematics

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Lu-Hf and Sm-Nd isotope systematics place the onset for MORB melting in the garnet field and are indicators for degree and depth of melting. In addition, recent results on U-Th partitioning indicates Th-disequilibria are also explained by placing the onset of melting in the garnet stability field. And, thirdly, Klein and Langmuir (1989) have shown that the normalized major element content of MORB also reveal information about the degree and the depth of melting. Especially $Na_8$ and $Fe_8$ are important indicators whereby $Na_8$ is an indicator for the degree of melting and $Fe_8$ is an indicator for the average depth of melting. We have taken the constrains derived from the $^{176}Hf/^{177}Hf$, $^{143}Nd/^{144}Nd$ and $^{230}Th/^{232}Th$ systematics one step further and combined the constrains derived from the isotope systematics with those derived from major elements.

The first set of four figures (Fig. 1.) shows the isotope data for two Atlantic Ridge segments with a clear 'local' trend. These two segments show positive correlations with both $Fe_8$ and $Na_8$ and the isotope melting parameters, $\delta_{(Sm/Nd)}$ and $\delta_{(Lu/Hf)}$, indicating that the smaller degree melts have a larger portion of melt generated in the garnet stability field. This is consistent with previous explanations of incomplete mixing of the different melting columns in a triangular shaped melting regime. The high $Na_8$, high $\delta_{(Lu/Hf)}$ and high $Fe_8$ melts represent a small degree of melting generated at relatively deep levels and this correspond to melts generated in of-axis melting columns. The low $Na_8$, low $Fe_8$ and low $\delta_{(Lu/Hf)}$ are large degree of melts that were generated at relatively shallow level in he mantle which represents melts from an on-axis melting column. We also analyzed mid-ocean ridge basalts erupted at different ridge depth. Klein and Langmuir (1989) interpreted the 'global' trend and its correlation with ridge depth as follows: the deep ridge segments have high $Na_8$ and low $Fe_8$ indicating a low degree of relatively low pressure melting, while the shallow ridges represent a large degree of melting and a high average pressure during melting. The Mid-Cayman Rise and the American Antarctic Discordance are two of the deepest parts of the ocean which both have high $Na_8$ and high $Fe_8$. However, both MCR and AAD

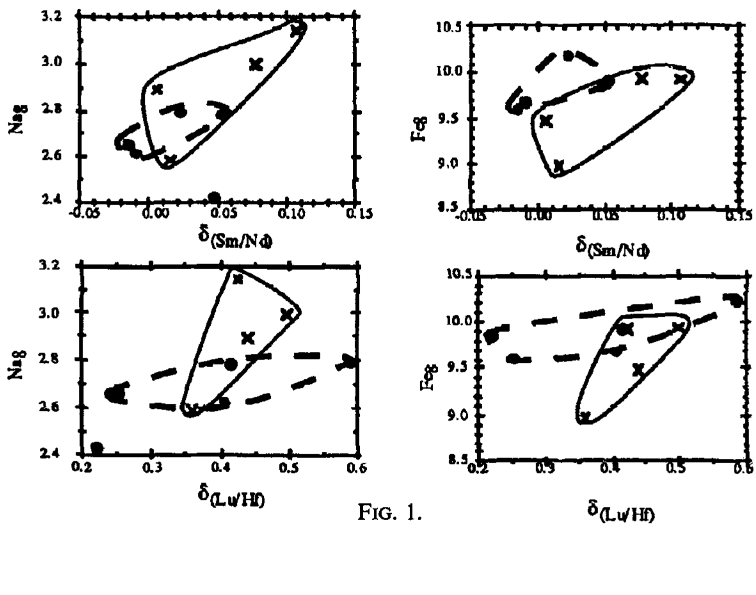


FIG. 1.

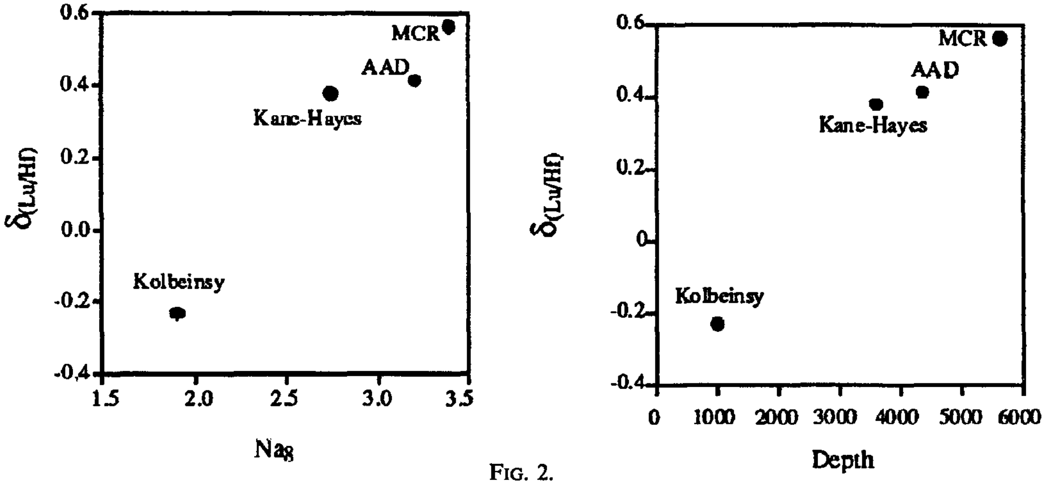


FIG. 2.

basalts have high $\delta_{(Sm/Nd)}$ and $\delta_{(Lu/Hf)}$ (Fig. 2) indicating they represent relatively small degrees of relatively high pressure melts. At the other end of the spectrum, basalts from the Kolbeinsy Ridge (shallowest part of the ocean) have negative $\delta_{(Sm/Nd)}$ and $\delta_{(Lu/Hf)}$ indicating a large degree of melting which is relatively shallow. The correlations between the major elements and the isotopes of the 'global' trend can be interpreted several ways: the larger the triangular shaped melting regime the more inefficient the melts can be collected at the ridge. Thus if melting starts deep and the melting column is long then the melts created at deepest levels furthest away from the ridge axis are not collected at the ridge. However, these edge melts carry the strongest garnet signature and have very high $\delta_{(Lu/Hf)}$. The absence of the edge melts from the pooled melt at the ridge will result in the low $\delta_{(Lu/Hf)}$ associated with low $Na_8$, and high $Fe_8$. On the other hand at the smaller melting regimes (lower degree of total melting) all melts generated in the triangular shaped melting regime are pooled and the maximum garnet signature is observed. An alternative to the above explanation is that the onset of melting for all ridges is similar, however, the depth of termination of melting varies. In this second scenario the small degree of melts (MCR and AAD) are generated from a large part in the garnet stability field and the melting stops in the spinel stability field but at a relatively deep level in the mantle. The onset for the large degree of melts (Kolbeinsy) is at a similar levels as for AAD or MCR but the melting continues for longer in the spinel stability field resulting in low $\delta_{(Lu/Hf)}$ and low $Na_8$ .

We will combine these data with U-Th systematics on basalts from the American Antarctic Discordance and the Kolbeinsy Ridge. The additional information provided by the U-Th systematics should allow us to choose between the different models.