Small Length Scale Heterogeneity Beneath the East Pacific Rise

Soumen Mallick[1], Vincent J.M. Salters[1], and Michael Perfit[2]
[1]NHMFL and Department of Geological Sciences, Florida State University
[2]Department of Geological Sciences, University of Florida

We found two areas (~1.80°N and Siqueiros Transform Fault) on the East Pacific Rise (EPR) where ridge basalts show large variation in chemical and isotope compositions in compared to the other EPR basalts.

Samples from ~1.80°N show a relatively large range in trace element abundances (Ba/Zr = 0.11- 0.80, Ce/Yb = 2.64-7.77) and isotope ratios ($^{87}Sr/^{86}Sr$ = 0.70226-0.70282, $^{143}Nd/^{144}Nd$ = 0.513070-0.513275, $^{176}Hf/^{177}Hf$ = 0.283105-0.283281, $^{206}Pb/^{204}Pb$ = 17.54-18.62) encompassing ~70% of the variability displayed by EPR ridge basalts even though they are collected from < 25 km long ridge section. One end of the spectrum has high $K_2O/TiO_2 \geq 0.22$, $Ce/Yb \geq 6.41$, LREE enrichment; La/Sm>2 higher than most EPR basalts but with $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ similar to EPR basalts. The other end of the spectrum has trace elements characteristics similar to EPR basalts but is more depleted in isotopic compositions. They are similar to the Garrett transform lavas. The degree of isotopic variation observed along this 25km ridge segments is similar in amplitude as observed in EPR seamounts. The large variation in a small area indicates the presence of significant small-scale heterogeneities in the sub-ridge mantle. The ridge basalts average melt from a smaller area of a mantle than the proposed length scale of melting (100km) and points at efficient melt extraction and inefficient mixing of melts.

Samples from Siqueiros Transform Fault also show a wide range in chemical compositions (Ba/Zr = 0.03-0.79, Ce/Yb = 1.83-11.65) and isotope ratios ($^{87}Sr/^{86}Sr$= 0.70233-0.70285, $^{143}Nd/^{144}Nd$ = 0.513011-0.513189, $^{176}Hf/^{177}Hf$ = 0.283043-0.283225, $^{206}Pb/^{204}Pb$=18.12-18.66) within the range of in NEPR basalts, but lacking depleted isotopic composition as observed at the Garrett FZ. Previous studies have shown that the Siqueiros basalts are derived from the shallow mantle (<1GPa). This suggests that this shallow mantle must have been able to either retain or regain its more fertile composition during melting beneath the ridge.

Basalts from western part of the transform fault have isotopic compositions similar to the adjacent ridge basalts suggesting a similar source. Some basalts from west (W) part of the ridge transform intersection (RTI) are enriched in incompatible elements (La/Sm =2.46-2.82, Ba/Th ~ 105) and enriched isotope ratios ($^{87}Sr/^{86}Sr$ ~ 0.702842, $^{143}Nd/^{144}Nd$ ~ 0.513013, $^{176}Hf/^{177}Hf$ ~0.283043) in comparison to the other Siquerios basalts. Basalts erupted within the transform are, in general, LREE depleted ($La/Sm \leq 1.03$) depleted in isotopic composition, $^{87}Sr/^{86}Sr$ as low as 0.70233, $^{143}Nd/^{144}Nd$ and $^{176}Hf/^{177}Hf$ as high as 0.513184 0.283199 respectively. Some of these basalts have La/Sm as low as 0.45. Major element characteristics indicates the transform fault basalts are shallow melts thus they are most likely derived from a previously depleted source. The majority of the Siquerios basalts can be explained by mixing of two components. However, basalts from eastern part of RTI and one basalt within the transform are outside this mixing array and a third component is required. This, again, indicates that small scale heterogeneities (<25km) are present in the subridge mantle.