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Ultra-slow spreading ridges and mantle heterogeneities

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Abyssal peridotites from the ultra-slow spreading oblique supersegment of the Southwest Indian Ridge have greater compositional variations than are observed in peridotites from faster spreading ridges. Variations in rare earth element (REE) concentrations in peridotite clinopyroxenes indicate degrees of melting ranging from <1% to ~10%, at length scales of <100 km. This small scale variation may reflect primary mantle heterogeneities or may be associated with mechanisms of melt generation and focussing. However, the possible presence of primary pyroxene compositional layering in a peridotite dredge suite suggests that mantle veins may play an important role in ultra-slow spreading ridge processes.

Light REE concentrations in peridotite clinopyroxenes from the oblique supersegment, with an effective half spreading rate of ~4mm/yr, vary by up to two orders of magnitude between samples which have no evidence for later melt impregnation. Peridotite REE variations are accompanied by basalt REE variations and by LREE enrichments indicative of low degrees of melting. At faster spreading rates or close to hotspots, mantle melt production is higher and significant trace element variations in abyssal peridotites are not observed. SWIR peridotites from the Atlantis II Fracture Zone, with an effective half spreading rate of ~8mm/yr, vary in clinopyroxene LREE concentrations by one order of magnitude. Peridotites from the East Pacific Rise and from the Bouvet hot spot are extremely depleted, with less than an order of magnitude variation in LREE concentrations.

Peridotites from one dredge haul close to the intersection of the oblique supersegment with the Shaka Fracture Zone contain pyroxene veins which may represent primary compositonal layering of the mantle. Samples contain pyroxene rich bands with porphyroclastic textures and evidence for later melt impregnation. One sample has undepleted clinopyroxene REE patterns in both the pyroxene rich layer and the matrix, similar in concentration to the estimated source composition of mantle clinopyroxenes. The absence of an Eu anomaly in the clinopyroxenes suggests that the pyroxene layer is not a shallow level melt impregnation feature, which would be accompanied by plagioclase crystallization. This compositional layering is similar to that observed in orogenic lherzolites and ophiolites, and may be the source of mantle heterogeneities included in many models of melt generation at mid-ocean ridges.

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Local and regional geochemical variability on the Southwest Indian Ridge (SWIR) and its geophysical context

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Previous studies have divided the SWIR into 3 zones based on geophysics, geochemistry and ridge morphology. Thus, zone C lies between the Bouvet triple junction and the Gallieni FZ (52°20'E); zone A lies between the Melville FZ (62°E) and the Rodriguez triple junction (70°E), with zone B between the two fracture zones. The SWIR spreads faster near the Bouvet triple junction (1°W), and geophysical data (magnetic, gravity and multi-beam bathymetry) suggest that the mantle is hotter and the lithosphere thicker in this region [1] Major element data for zone C exhibit low average $Na_{8.0}$ values implying a higher degree of partial melting compared with the other zones of the SWIR. Geochemical indicators of high melt percentages (e.g. low $Na_{8.0}$) coincide with the low mantle Bouguer anomaly (MBA) of the Bouvet hotspot on the western extremity of zone C and are geographically restricted (west of 5°E). Enriched Pb and Nd isotope ratios indicate that the geochemical influence of the plume is restricted to the area defined by the geophysical anomaly. Further east in zone C (39-41°E), a restricted region with high $^{87}Sr/^{86}Sr$, low $^{143}Nd/^{144}Nd$ and low $^{206}Pb/^{204}Pb$ previously documented and attributed to entrained Madagascar lithosphere at [2] does not appear to have a geophysical signature. New geochemical data from the Atlantis II FZ (zone B) continue and extend the regional isotopic trends seen in zones C and B (progressively more depleted isotopic signatures eastwards). Thus, Nd and Pb isotope ratios in basalts and gabbros from the Atlantis II FZ extend to the most depleted values observed in the SWIR MORB, overlapping slightly with published data for abyssal peridotites from the Atlantis II FZ [3]. Several low $^{143}Nd/^{144}Nd$ basalts are restricted to an east-west trending zone across the centre of the Atlantis Platform. Importantly, longitudinal variations in mantle sources inferred from large-scale regional isotopic trends through zones C and B do not appear to have a geophysical expression.

References

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