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The Southwest Indian Ridge: Remelting the Gondwanan Mantle

JB Dick HENRY* and Hole WOODS

Oceanographic Institution

The Southwest Indian Ridge is an ultraslow spreading ridge (~14-mm/yr) that formed ~150 Ma with the breakup of Gondwana. It extends 7700 km from the Bouvet to the Rodriguez Triple Junction, crossing over the flank of the large southern Geoid high centered over Marion and Crozet islands and the Conrad Rise. There is a fundamental break in the physiography and geochemistry of the SWIR where the SW Indian Ridge intersects the Nubia-Somalia plate boundary along the 750-km long Andrew Bain Transform on the flank of the Marion Rise.

To the west, the ridge spreads largely orthogonal to the spreading direction and is locally influenced by the Bouvet Hotspot, which is centered on the ridge axis at Speiss Ridge, just east of Bouvet Triple Junction. To the east of the Andrew Bain FZ is the 3400-km long Marion Rise, which is associated with the Marion Hotspot some 260 km to the south. The eastern two thirds of the SW Indian Ridge is oriented at an extreme oblique angle to the spreading direction, and contains many oblique amagmatic ridge segments. Mantle peridotites are exposed on the seafloor over its length, and it is evident that the crust is thin and discontinuous over the Marion Rise. The Marion Rise is dominated by the Marion Platform, which consists of a 2000-km long section of the SWIR between the Andrew Bain and Gallieni transforms, and has an average ridged depth ~1000 m shoaler than that of the entire 2000-km length of the western Southwest Indian Ridge.

The discontinuous thin crust, refractory basalt and mantle peridotites exposed over the Marion Rise show that it is supported by a large block of depleted mantle that is the residue of a prior mantle melting event associated either with the Karoo large igneous province, or an even earlier event in Earth history. This argues for denser more fertile mantle beneath the western SWIR. These differences are matched by a clear difference in isotopic composition of the basalts, with $^{206}Pb/^{204}Pb$ greatly elevated along the western SWIR. Hence, there is a major difference in both major element and isotopic composition of the mantle sources, which reflect the respective isotopic compositions of the two hotspots.

It is clear however, that the Marion Hotspot is too small to support the Marion Rise, while the bathymetric anomaly along the western SWIR associated with the Bouvet Hotspot is restricted to a ~500 km region in the immediate vicinity of this ridge centered hotspot. So it is apparent that both the Bouvet and Marion Hotspots are today reflecting the regional compositions of the respective underlying mantle sources, with only a limited effect on mantle composition and topography beneath the adjacent ridges. This then reflects a fundamental difference in the mantle that currently underlies the SW Indian Ridge. One possibility is that the asthenosphere beneath the western SWIR represents mantle emplaced into the asthenosphere beneath southern Africa during the Karoo Magmatic event, while that beneath the Marion Platform represented metasomatized cratonic lithosphere that delaminated during breakup of Gondwana and due to its inherent buoyancy, now forms the mantle substrate of the SWIR along the central SW Indian Ridge.

* Corresponding author. E-mail: hdick@whoi.edu