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Magmatism on the SW Indian Ridge – Remelting the Gondwanan Mantle

Dick, H.J.B.[1], Zhou, H.[2]., Standish, J.[1], Gao, C.[1,2]

[1]Woods Hole Oceanographic Institution, Woods Hole, MA 02543, hdick@whoi.edu
[2]State Key Laboratory of Marine Geology, Tongji University, Shanghai China

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The Marion Rise on the SW Indian ridge is one of the two largest oceanic rises in the world. Sampling shows that Southwest Indian Ridge crust is generally thin and discontinuous, even over the rise itself. Thus, in the absence of thickened crust, the Marion Swell at the top of the rise should be supported by previously melted buoyant depleted mantle (1). Though basalts and peridotites are more refractory up the rise, the degree of melting inferred from peridotite Cr spinel and basalt $Na_{8.0}$ is only moderate. The peridotites, however, have substantially lower bulk alumina than those sampled to the east and west. Thus, the Marion platform mantle source must be garnet-poor and therefor highly buoyant compared to more aluminous peridotites along the SW Indian Ridge to the east and west. Most abyssal peridotites lie along a single trend in olivine-clinopyroxene-orthopyroxene space controlled by the dry melting reaction point. Moving off this trend requires removal of high-silica melts during an earlier wet melting event, causing excess pyroxene depletion, consistent with a hydrous back-arc or arc environment.

Plate reconstruction and modelling the mantle flow field based on mantle seismic anisotropy (2) shows that the Marion Swell corresponds to mantle pulled from beneath the Pan-African Orogenic Belt, during breakup of Gondwana, while SWIR mantle to the east and west originated beneath Archean cratonic lithosphere. The Pan-African Orogenic belt is a 650 to 500 Ma ~1000-km wide terrain consisting of accreted micro-continental fragments and juvenile island arcs formed by subduction and closure of the Mozambique Ocean. The major suture zones bounding the belt are strike-slip zones due to southward-directed escape tectonics (3). These were re-occupied during Gondwana rifting, and now bound the Marion Swell as the Andrew Bain and Gallieni Fracture Zones. Thus, the Marion Rise is likely the product of delamination of old arc-related lithosphere along with the Marion, Crozet, and Reunion Hotspots.

This leaves the fate of old Mozambique Ocean crust as an interesting paradox, as its lithosphere would not have the required signature of hydrous melting associated with the accretion of old arc terrains in the Pan African - East Antarctic Orogenic belt. Models for continent – ocean crust subduction, however, suggest that where the lithospheric slab is old and cold, it can penetrate the mantle transition zone, whereas young ocean crust, as forms in back-arc basins, or buoyant sub-arc mantle would not penetrate the transition zone, and thus would be trapped when East and West Gondwana collided. With the coincidence of the breakup of Gondwana with the eruption of the Karoo and associated lavas, it is reasonable to suppose that these are sourced from melting of the old Mozambique Ocean lithosphere in the lower mantle, possibly above the anomaly at D''.

References:

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