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The Australian-Antarctic Discordance: a convergence of tectonic and geodynamic forces

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Oceanic crust lying between Australia and Antarctica exhibits a number of unusual crustal, morphological and geochemical signatures. The Australian-Antarctic Discordance (AAD) is a section of oceanic crust straddling the Southeast Indian Ridge (SEIR) associated with 'chaotic' basement morphologies. The AAD coincides with a much larger region of unusually deep oceanic crust, the Australian-Antarctic Depth Anomaly (AADA). The depth anomaly extends from the SEIR to the Australian and Antarctic continental margins where the depth anomalies deepen and widen proximal. A number of other unusual geological characteristics exist in the AAD/AADA region. Wide-angle seismic investigations reveal that ridge-proximal crust is $\sim$3km thinner than normal. Also a sharp boundary between Pacific MORB-source mantle and Indian MORB-source mantle is located at the eastern boundary of the AAD/AADA

The spatial coincidence of the AAD and the AADA means that deciphering how the many unusual geological phenomena and patterns were formed, and whether they are related, is problematic. Many models have been proposed, including: a stable cold-spot suspended in the mantle that migrated with the SEIR; cool down-welling material or reduced upwelling beneath the SEIR; passive along-axis flow in response to cooler temperatures at the AAD segment of the ridge; an ancient subducted slab at depth and related cool mantle-wedge material in the upper mantle; inhibited replenishment of the upper mantle by the separating continental roots of Australian and Antarctica.

To date none of these models adequately explain all the signatures present in the AAD/AADA region. We propose that the combination of unusual geological signatures can only be explained through a combination of processes, including the presence of a body of cold/depleted upper mantle beneath the SEIR, the incursion of Pacific-type mantle into the Indian-type mantle domain, negative dynamic topography related to an ancient subducted slab, and ultra-slow spreading rates. In order to separate the influence of each mechanism we constrain the spatial extent of both anomalously rough and anomalously deep oceanic basement by computing residual roughness and residual depth anomaly grids using new sediment thickness constraints from Australian and Antarctic margin seismic data. A key finding is that only where the AAD and AADA coincide is the ocean crust both anomalously rough and deep. Elsewhere the oceanic basement is only anomalously deep.

We propose that the presence of an ancient subducted slab at depth has led to broad-scale negative dynamic topography in a N-S striking band across the Australian Southern Ocean and possibly onto the adjacent continents. Encroaching Pacific-type mantle has formed the V-shape eastern boundary. Ultra-slow spreading rates are likely responsible for the extremely anomalous depths close to the continental margins, and the presence of cold/depleted upper mantle beneath the SEIR has most likely led to the formation of the anomalously rough and extremely deep AAD.