Tales of Two LIPs: Kerguelen/Broken Ridge (Indian Ocean) and Ontong Java (Pacific Ocean)

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The Kerguelen Plateau and Broken Ridge (KPBR), and Ontong Java Plateau (OJP), are among the largest igneous provinces (LIPs) on Earth, with crustal volumes of 25 and 57 million cubic km, respectively. They represent episodic and massive mafic magmatism not clearly associated with plate tectonic processes. LIPs are significant in the Earth system both for underlying mantle processes and effects on the global environment. Investigations of the two features have revealed significant differences. The Kerguelen hotspot has produced mafic magmas since at least 120 Ma, perhaps the longest continuous hotspot record on Earth. KPBR contain microcontinental fragments. Upper crust of KPBR is structurally complex, and includes sag basins, rift zones, pull-apart basins, faulted flanks, and volcanic centers. Although dominantly tholeiitic basalt, the upper crust contains a wide range of basaltic to rhyolitic volcanic products. Nearly all of the drilled upper crust formed subaerially, and subsequently subsided beneath sea level at rates comparable to those of typical oceanic crust. In contrast to KPBR, OJP is entirely oceanic, includes no continental material, and cannot be unequivocally linked to any hotspot track or currently active hotspot. It appears to have formed instantaneously, in a geological sense, at approximately 120 Ma, together with flood basalts in the older neighboring Nauru, East Mariana, and Pigafetta Basins, and simultaneously with the Manihiki and Hikurangi plateaus. The upper crust of OJP is structurally relatively simple, although its flanks are faulted in places, and is homogeneously tholeiitic. To date, all igneous basement rocks drilled on the plateau and sampled from obducted OJP sections in the Solomon Islands formed in a submarine environment, and subsequent lithospheric subsidence was either minimal or erratic. OJP is characterized by a low velocity mantle root extending several hundred kilometers into the asthenosphere that is interpreted as chemically, not thermally, anomalous. This root appears to deflect normal Pacific Ocean asthenosphere around it, and thus seems to be rigidly coupled to OJP crust. Classic plume theory explains neither KPBR nor OJP. Plume models predict massive flood volcanism roughly coeval with continental breakup, yet the onset of voluminous KPBR magmatism post-dated separation of India and Antarctica by at least 10 million years. Plume theory also predicts short-lived (approximately 1 Myr) plume head volcanism followed by long-lived (10 to 100 Myr) plume tail volcanism, yet peak magma output of the Kerguelen hotspot lasted approximately 25 Myr. Plume models predict major lithospheric uplift approximately coeval with voluminous magmatism, and subsequent plateau subsidence at rates similar to normal oceanic lithosphere, but the main OJP was never above sea level and has experienced only slight or erratic ensuing subsidence. Alternatives to existing plume models are needed to explain both KPBR and OJP.