LIP Reading: Understanding the Kerguelen Plateau and Broken Ridge

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From Early Cretaceous time (million years ago (Ma)) until separated by seafloor spreading at ≈ Ma the Kerguelen Plateau and Broken Ridge formed a contiguous plateau with an area of nearly two million square kilometers or roughly one third the size of Australia Scientists had long debated whether these huge predominantly undersea features are formed mainly of continental or oceanic type crust Drilling of igneous basement by the ODP and subsequent petrological geochemical and geochronological analyses of core samples demonstrated convincingly that the Kerguelen Plateau and Broken Ridge comprise a hybrid of oceanic and continental rocks Gneiss a continental rock was found as clasts within a conglomerate at one drill site in and is the first unequivocal evidence of continental crust from the plateau Fragments of East Gondwanan (Indian Antarctic and Australian) continental lithosphere became isolated within the nascent Indian Ocean perhaps related to surfacing of the Kerguelen mantle plume (see Figure) and in addition to the gneiss geochemical traces of these fragments have been found in multiple locations on the Kerguelen Plateau and Broken Ridge Nevertheless the uppermost crust of both features is dominated by basaltic rock although more silica rich magmas were erupted explosively during the final stages of plateau formation Subsidence of the Kerguelen Plateau since formation resembles that of normal oceanic lithosphere and is attributed to contractional cooling implying that continental components in the lithosphere are not volumetrically significant

Radiometric (Ar/ Ar) age determinations of Kerguelen hotspot basalts and crustal volume estimates have been used to infer temporal variations in hotspot magma output (see Figure) Most models for the origin of continental flood basalts and oceanic plateaus predict initially voluminous ("plume head" or the rising bulbous head of a plume) magmatism over a relatively short period of million years followed by steady state ("plume tail" or the trailing straw like appendage below the plume head) magma output at much lower rates Furthermore massive magma output from hotspots is commonly but not always associated in space and time with continental breakup Our results require a more complex scenario to explain the prolonged duration the spatial extent and the timing of magmatism (see Figure) Initial magmatism associated with the Kerguelen hotspot(s) post dates continental breakup between India and Antarctica and between India and Australia although that magmatism affected both continental and expanding Indian Ocean lithosphere

We suggest that either multiple plume "drops" emanated from the source region at the boundary between the Earth's mantle and core or that vigorous mantle circulation caused strong mantle shear during Early Cretaceous time that may have split the initial plume into several "drops" of varying sizes buoyancies and mantle ascent rates In either scenario different drops could account for the small volumes of dispersed continental basalts on India Australia and Antarctica and the relatively large volumes of basalts of the Southern Kerguelen Plateau Elan Bank the Central Kerguelen Plateau and Broken Ridge that formed over an interval of million years Subsequently the plume conduit became continuous and formed the Ninetyeast Ridge

Figure (Page)
Plate tectonic reconstructions of the southern Indian Ocean (left) using a hotspot reference frame and Kerguelen hotspot output (right) from ≈ million years ago to present The Kerguelen hotspot has produced ≈ x km of mafic crust since ≈ Ma Magma output has varied significantly through time beginning with low volumes contemporaneous with or postdating continental breakup extending through at least one and possibly two peaks from ≈ to ≈ Ma and then decreasing to relatively steady state output ever since Output rates between ≈ and ≈ Ma exceed those of most other hotspot traces; subsequently output rates have been at levels typical of many hotspots including Hawaii Reconstructed positions of the Kerguelen hotspot assuming that either the Kerguelen Isles (K) or Heard Island (H) is the current location of the hotspot are indicated by red stars Volcanic rock associated with the Kerguelen hotspot is indicated in black and lamprophyres (L) as diamonds as they have appeared through geologic time Continental margins appear in dark gray and continents in light gray Dashed line indicates a possible northern boundary for Greater India IND: India; ANT: Antarctica; AUS: Australia; EB: Elan Bank; NP: Naturaliste Plateau; BB: Bunbury Basalts; RAJ: Rajmahal Basalts; SKP: Southern Kerguelen Plateau; CKP: Central Kerguelen Plateau; BR: Broken Ridge; WP: Wallaby Plateau; SB: Skiff Bank; NER: Ninetyeast Ridge; NKP: Northern Kerguelen Plateau

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