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Large Igneous Provinces of the Indian and Pacific Oceans: Insights into Mantle Dynamics and LIP Construction

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A rich mosaic of disparate crustal types characterizes the Earth beneath the sea, and although 'normal' oceanic crust approximately seven kilometers thick is by far the most prevalent, abnormally thick oceanic-type crust of large igneous provinces (LIPs) also forms a significant component of the marine realm. LIPs are massive and rapid crustal emplacements of predominantly Fe- and Mg-rich (mafic) rock that have not formed by seafloor spreading or subduction. LIPs may represent the dominant form of magmatism on other terrestrial planets and moons of the solar system. On Earth, LIP rocks are readily distinguishable from mid-ocean ridge and subduction-related arc rocks on the basis of petrology, geochemistry, geochronology, physical volcanology, and geophysical data. LIPs occur within both continents and oceans, and include continental flood basalts in the former, and volcanic passive margins, oceanic plateaus, submarine ridges, and ocean basin flood basalts in the latter. Transient LIPs and associated persistent, age-progressive volcanic chains, or hot spot tracks, are commonly attributed to decompression melting of hot, buoyant mantle ascending from the Earth's interior, and thus provide a window into mantle processes. Magmatism associated with LIPs currently represents approximately 10% of the mass and energy flux from the Earth's deep interior to its surface. This flux shows distinct episodicity over geological time, in contrast to the relatively steady-state mode of crustal accretion at seafloor spreading centers. LIP observations therefore suggest that dynamic, non-steady-state circulation within the Earth's mantle has been important for at least the last 250 million years and probably much longer. Research on Cretaceous Indian and Pacific oceanic plateaus—Kerguelen/Broken Ridge, Ontong Java, Manihiki, Hikurangi, Shatsky, Hess, Magellan—and ocean basin flood basalts—Nauru, East Mariana, Pigafetta—has stimulated many ideas about mantle dynamics and LIP construction.