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Plume Flow and Melting Beneath a Moving Heterogeneous Lithosphere

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Large Igneous Provinces (LIPs) are considered to be formed by rapid eruption of huge volumes of basalts in a geologically short time span of less than 5 million years as a result of decompression melting of an ascending mantle plume head beneath the lithosphere. In these provinces, the average eruption rate exceeds 1 km^3/yr during the initial phase of volcanism and subsequently decreases by an order of magnitude. Deccan Volcanic Province also fall under the same category and, together with Chagos-Laccadive Ridge and Reunion hotspot, is considered as one of the best examples globally of mantle plume activity. There are alternate views also for the genesis of LIPs. Attempts have been made to reproduce eruption characteristics of LIPs through fluid dynamical modeling approach in order to decipher the properties and processes of the Earth's deep interior. Initially, simple models of steady state thermal convection were developed to explain the volcanism at the Hawaiian hotspot as a result of decompression melting of an ascending mantle plume. Subsequently, more complicated models involving time-dependent and compositional convection were developed to explain the genesis of LIPs. These models, however, only partially explain the melting characteristics. Present work incorporates heterogeneous lithospheric architecture and horizontal shear due to plate motion in three-dimensional numerical models and analyses their effect on the volume and rate of plume melting. In these models the viscosity is highly temperature- and depth-dependent and the lithosphere is defined as mechanically strong high viscosity lid. The model reproduces the characteristics of melting rates estimated for LIPs without invoking an excessively high plume thermal anomaly. These results also support juxtaposition of late-stage and main phase of volcanism in a flood basalt province.