EVIDENCE FOR VIGOROUS CRETACEOUS MANTLE DYNAMICS FROM LARGE IGNEOUS PROVINCES

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Conditions on Earth today are dramatically different from those that existed during the Cretaceous Period, which ended 65 million years ago. Widespread evidence indicates that during the Cretaceous, which preceded the Cenozoic Era we are now in, climate was considerably warmer, sea level was significantly higher, episodes of oceanic anoxia were more frequent, and mass extinctions were more common. In addition, seafloor spreading rates were higher, and Earth's magnetic field was uncharacteristically steady in that it did not switch from normal to reversed polarity for ~35 million years. The ODP has made critical contributions to this list of Cenozoic-Cretaceous contrasts. For example, ODP results have demonstrated that the Cretaceous was a time when huge volumes of magmatic material flowed to Earth's surface from the mantle, and not just from the typical seafloor spreading process. Instead, most of the magma was injected upwards through volcanic hotspots. These eruptions formed many features, including two giant oceanic plateaus and several large igneous provinces (LIPs). ^{40}Ar-^{39}Ar dating of basalts recovered by ODP from the two giant submarine igneous plateaus, Ontong Java and Kerguelen-Broken Ridge, show major peaks in magmatism at ~121/90 and ~115/85 Ma, respectively [*Bercovici & Mahoney,* 1995], and many other LIPs, including oceanic plateaus, volcanic passive margins, and continental flood basalts, were emplaced during the Cretaceous. Magmatic fluxes from hotspots at this time accounted for 50% or more of the integrated heat loss from Earth's interior, whereas during the Cenozoic, only 5% of Earth's heat has been lost in this manner. Simple calculations involving estimated volumes of the two giant plateaus and degrees of partial melting (see figure) suggest that the whole mantle convected, if not overturned, during part of the Cretaceous [*Coffin & Eldholm,* 1994]. Convection of the entire mantle may be linked to the higher seafloor spreading rates and unusual magnetic field behavior during the Cretaceous. Furthermore, LIP emplacement episodically altered the geometries of the ocean basins, continental margins, and the continents, as well as affected the chemistry and physics of the oceans and atmosphere, with enormous environmental impact. A major future challenge for ODP is to investigate causal links between Cretaceous mantle dynamics and environmental change.

References:
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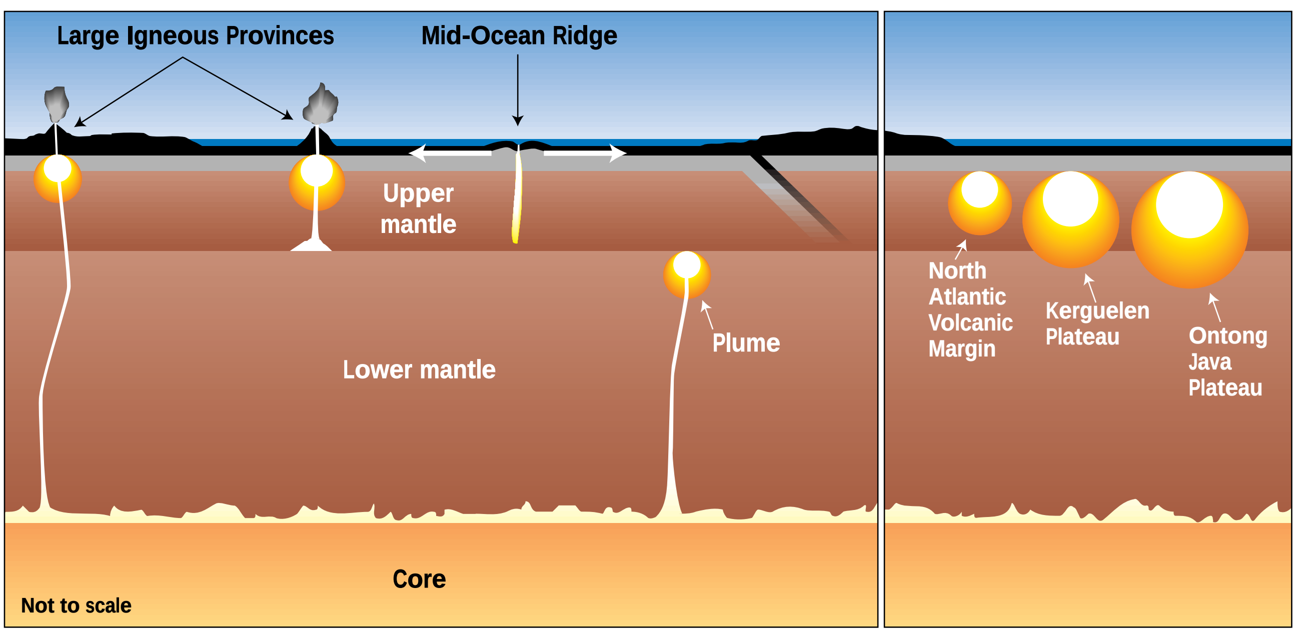

Rising plumes of hot material migrate through Earth's mantle; where the head of the plume reaches the surface, a large igneous province forms (left). Plumes probably originate at the boundary layers between the core and mantle at 2900 km below Earth's surface, and between the upper and lower mantle. The parent plumes of the most voluminous igneous provinces were so huge that they must have originated at least in part in the lower mantle, most likely at the core-mantle boundary. The spheres on the right depict the minimum (white) and maximum (orange) inferred diameters of the plumes associated with five large igneous provinces.