Testing the Mantle Plume Theory

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The physics of low Reynolds number plumes is well understood, and this allows a number of testable predictions to be made about mantle plumes. Mantle plumes are predicted to originate from the core-mantle boundary and to consist of a large head, ~1000 km in diameter followed by a narrower tail. When the head reaches the top of its ascent it flattens to form a disk with a diameter of 2000 to 2500 km. The prediction that plumes originate from the core-mantle boundary has recently been confirmed by seismic studies, using a new finite frequency technique, which have successfully traced plumes to the core-mantle boundary. The prediction that plume heads should form flatten disks 2,000 to 2,400 km across is confirmed by the length of thickened oceanic crust that developed during the early stages of the opening of the North Atlantic above the Iceland plume head. This resulted in hot mantle from the plume head being drawn into the spreading centre to produce the predicted 2400 km of thickened oceanic on both sides of the Atlantic. Initial eruption from a plume head should be preceded by ~1000m of domal uplift. Uplift prior to volcanism has documented for a number of flood basalt provinces, the best example being Emeishan in China where the shape and magnitude of the observed uplifted dome agrees closely with that predicted from laboratory and numerical modeling. High-temperature picrites are expected to dominate the first eruptive products of a new plume and should be concentrated near the centre of the volcanic province. This distribution of picrites is observed in the Karoo and Emeishan. Picrites are also found in the Iceland-North Atlantic, Reunion-Deccan, Parana-Etendeka-Tristan da Cunha, Siberian Traps (Meymechites), Galapagos-Caribbean and Hawaii large igneous provinces. The excellent agreement between the predictions of the mantle plume theory and observations from large igneous provinces provides strong support for the veracity of the theory. Confirmation that plume heads have a diameter of 1,000 km in the upper mantle requires plumes to originate from the core-mantle boundary. As a consequence, the high-temperature melting products of plumes can be used to document the nature of the material in the boundary layer above the core and to show how it has varied with time.