Geodynamical Predictions for the Thermochemical Pile Hypothesis

Over the past decade, seismic observations have increasingly hinted at the presence of regional compositional heterogeneity in Earth's lower mantle. However, the manner in which this heterogeneity affects mantle convection remains poorly understood, and several competing hypotheses of large-scale, thermochemical mantle convection currently exist. Each conceptual model has significantly different consequences for our understanding of thermal and mass transport, therefore, it is critical that we determine which, if any of these, are representative of the actual Earth. One conceptual model postulates the presence of large, primordial thermochemical piles beneath Africa and the Pacific in Earth's lower mantle. We have performed geodynamical modeling to determine predictions (i.e., hypothesis tests) for the primordial thermochemical pile hypothesis. We have investigated 2 potential avenues of future observation: core-mantle boundary (CMB) topography and ultra-low velocity zones (ULVZs). We predict that primordial thermochemical piles are expected to produce a unique signature of CMB topography, in which CMB topography beneath piles is positive (above the mean) and relatively flat. Furthermore, a narrow ridge of elevated CMB topography is predicted to exist along the perimeter of piles. We also predict that ULVZs should preferentially accumulate along the margins of piles. Moreover, ULVZs are predicted to have an asymmetrical shape to them, much thinner on the side that faces a pile interior. We propose that these testable predictions provide valuable targets for future seismic studies.