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Seismic Structure of Inner Core Boundary Region Correlated with Predicted Outer Core Flow

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Seismic observations of the inner core reveal a pattern of lateral variation in elastic velocities, attenuation, scattering, and anisotropy having a strong but incompletely understood correlation with outer core flow predicted from dynamo simulations controlled by heat flow across the core-mantle boundary. Currently resolvable large spatial scales exhibit at least a tripartite latitudinal rather than hemispherical pattern in attenuation, elastic velocities, and anisotropy[1]. These large and smaller scale lateral variations are most densely sampled by seismic body waves traversing the equatorial region of the inner core, where cyclonic cylinders of outer core convection are tangent to its boundary. Correlations of inner core structure with predicted outer core flow include (a) a thin (10-40 km thick) zone of low P velocity and possibly near zero S velocity beneath the equatorial eastern Indian Ocean[2], which is coincident with a predicted region of strong down-welling flow and inner core growth[3]; (b) a broad region beneath the central and eastern equatorial Pacific that more strongly attenuates PKIKP[1], containing small-scale (1-10km) volumetric heterogeneities inferred from the coda of reflected PKiKP waves[4], which is coincident with a predicted region of inner core melting[5]; and (c) a narrow region of fast P velocity 150 km beneath the eastern equatorial Atlantic[6], which is coincident with a predicted secondary, weaker, longitudinal zone of down-welling[5]. To explain observed decadal time variations on the order of 0.1's of sec for the travel times of PKIKP, the mantle control suggested by these correlations requires either an small upper bound ($<<$ 0.2 deg/year) to differential rotation of the inner core or small oscillations about a position locked to the mantle by lateral density anomalies. To confirm which regions of the inner core are freezing and which are melting, theoretical and experimental work is needed to link observations of scattering, attenuation, and anisotropy to estimates of heterogeneity scale lengths and grain sizes.

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