Seismic constraints on the thermal structure of a stagnant slab

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Recent images derived from migrated receiver functions [Kawakatsu, 2005] yield high-resolution constraints on the lateral depth variations of the 660-km seismic discontinuity beneath Japan, along an apparently stagnant slab. Assuming that this topography represents equilibrium deflection of the perovskite-forming transition in ringwoodite, we have converted these depth variations to local thermal anomalies via a Clapeyron slope. The observed topography suggests a narrow but large cold anomaly where the slab first intersects the lower mantle and a broader but small cold anomaly downstream of this intersection. To explore the possible origins of such a thermal structure, we have constructed kinematic thermal models of both stagnant and penetrative subducting slabs. Curiously, while the deep but narrow depression in the intersection region is more characteristic of penetrative subduction, the shallow but broad depression downstream is more characteristic of a slab stagnating near the top of the upper mantle. The composite picture suggests a more complex scenario than simple bending to the horizontal. The apparent extension of the low-temperature core of the slab into the top of the lower mantle is reminiscent of structures associated with the megalith model [Ringwood and Irifune, 1988] or with slab deformation attending a large Clapeyron slope and slow trench roll-back [Christensen, 2001].

References:

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