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The Stability of Tibetan Continental Mantle Lithosphere

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The Tibetan Plateau is underlain by thickened crust [e.g., 1,2] and thickened mantle lithosphere [3,4]. The Lithosphere-Asthenosphere boundary (LAB) has been interpreted on a number of sections across the plateau at depths of > 200 km beneath the southern half of the plateau, with a step-like decrease to ~150 km beneath the northern part of the plateau [5,6]. Whether the seismically imaged LAB is explained by a change in mineral phase, fabric, or water content has remained uncertain. Surface wave analyses have also been interpreted [7] as showing that the Tibetan mantle lithosphere has been thickened by crustal shortening and more-or-less has been transported with the Tibetan crust as it moved northward with respect to the Eurasian continent. On the other hand the geological history of Tibet shows a complex diachronous history of volcanism [8] which manifests today in the volcanism of the Songpan Ganzi and west Qiangtang terrains of Northern Tibet, active since the mid-Miocene [9].

The volcanic activity of the northern Plateau is at odds with the simple structural interpretation based on seismic data. The question of how mantle-derived melts could penetrate a relatively cold, mechanically coherent, thickened mantle lithosphere requires an explanation. One possible explanation involves the mechanical overturn of the mantle lithosphere. If the mantle lithosphere is intrinsically less dense than the asthenosphere beneath, as suggested for example by [10], it could overturn rapidly by means of a convective instability that operates on a length scale comparable to its thickness, causing localized melting at the base of the crust, above the bulk of the unstable layer that is trapped, or at least partially trapped, by its density profile and the surrounding tectonic boundary conditions.

In this presentation I will describe some fluid dynamical calculations in which I attempt to illustrate how this mechanism works. Establishing that this type of process actually has happened beneath Tibet is of course much more difficult, but such a model could provide a thermal / physical context for an explanation of the recent volcanic history of the Tibetan Plateau.

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