Geophysical Research Abstracts
Vol. 14, EGU2012-4700, 2012
EGU General Assembly 2012

Using high-resolution mantle circulation models to understand the origin of fast seismic anomalies in the Tethyan mantle.

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Study of the closure of the Tethys oceans throughout the Mesozoic era has revealed a complex tectonic history involving the closure of two major oceans, accretion of terranes and formation of arcs and back-arcs. As a result subduction history in the region is complex. Recent interpretations of high-resolution tomography studies begin to see evidence of this complexity in the mid-mantle. Seismically fast anomalies between 700 and 2000 km depth are though to be cold and dense material associated with Tethyan subduction in the Indian region. Interpretations of tomography suggest there are three mid-mantle anomalies and a fourth shallower anomaly arising from the subduction of Tethys ocean crust.

Here we model global mantle convection with assimilated plate motions. The tectonic reconstructions assimilated contain 300 million years of geological information as the surface velocity boundary condition. We focus on the Tethys regions where the reconstructions contain a wealth of detail, including Palaeotethys and Neotethys subduction at the Eurasian margin, and a second, intra-ocean Neotethys subduction behind a series of back-arc oceans.

Such a history generates mantle circulation models that accurately reproduce robust features observed across a variety of seismic tomography models including both P and S wave data. To understand which mid-mantle anomalies arise from which subduction zone we use plate tracking marker particles. This method shows that deeper (1200-1500 km) anomalies beneath India arise from intra-ocean subduction in the Neotethys, whilst shallower (700-950 km) anomalies are mostly from subduction at the Eurasian margin. Between 950 and 1200 km depth material from both subduction zones exist, with northern anomalies arising from subduction at the Eurasian margin, and the more southern anomalies from subduction at the intra-ocean subduction zone. Suggesting that both subduction zones are active at the same time.

Slight mismatches between slab like features imaged by tomography and the cold mantle regions modelled in this study can provide a feedback to the tectonic reconstructions. Although the geological evidence for an intra-ocean Neotethys subduction zone is strong, it is geographically challenging to locate. In the assimilated plate motion history this subduction zone migrates southward, which leaves a thin shallowly dipping temperature anomaly in the modelled field. To more accurately recreate the tomographically imaged anomaly we suggest a more stationary subduction zone in the south of the region.