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A Seismological View of Geochemical Reservoirs in the Mantle?

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Recent progress in imaging structure in the lower mantle shows unequivocal evidence for slab penetration into the lower mantle in many, if not most, deep subduction zones. Sometimes these fast seismic anomalies extend all the way to the core mantle boundary, sometimes they appear to stop, but rarely do they appear as simple tabular structures. At the very least, these images show that the simple idea of essentially separate upper-and lower-mantle reservoirs is untenable. This has led to some new hypotheses concerning the topology of mantle reservoirs that might reconcile the new seismological data with geochemical constraints.

For example, some images of lower mantle structure have been used to argue for a change in nature in 3D structure at a depth of roughly 2000 km in the mantle and this has been used as evidence for chemical layering but now with a much deeper interface (and one that is convoluted to escape detection by the usual seismological techniques). Another hypothesis invokes the presence of hot viscous "blobs" distributed throughout the mantle but which can remain unsampled at the surface.

In this review, we consider several modern seismic tomography models of both P and S velocity and attempt to determine which features are robust. Our basic conclusion is that evidence for a change in the nature of structure within the lower mantle is weak at best. We also review evidence for anti-correlation of density perturbations with S velocity (which has been used to support a geochemically distinct lowermost mantle layer) that comes from the analysis of free oscillations. This anti-correlation is only weakly supported by the data but an anti-correlation of bulk sound speed with S velocity does seem to be robust. This latter observation is possibly consistent with iron enrichment but, at the very least, indicates the presence of strong chemical heterogeneities in the bottom 500 km or so of the mantle.