Potential constraints on the nature of lower mantle seismic heterogeneities

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Lowermost mantle seismic tomography have imaged large scale structures, the most striking features being two large low-shear wave velocity provinces (LLSVPs). The nature of these heterogeneities is still debated. On the basis of available seismic observation, a thermo-chemical origin appears more likely, but a purely or thermally dominated origin is still advocated. Furthermore, the detailed nature of chemical heterogeneities, primordial or recycled, is also debated. Discriminating between these hypothesis may require additional constraints independent of seismic velocity data.

Geochemical signatures of ocean island basalt (OIB) indicate that OIB plumes sample several reservoirs, one of which should be undegassed. Numerical experiments of thermo-chemical convection showed that the entrainment of primitive material by plumes originating from reservoirs of primordial material quantitatively agrees with OIB data [1]. Recent experiments further indicate that these plumes also re-entrain small fractions of recycled oceanic crust, thus qualitatively explaining the chemical diversity of OIB plumes [2].

Because it increases with temperature and strongly varies with iron content, electrical conductivity may help mapping thermo-chemical distributions at depth. Using appropriate mineral physics data, synthetic 3D maps of lower mantle electrical conductivity can be deduced from the thermo-chemical structure predicted by probabilistic tomography. Following this approach, a belt of high conductivity should be present in the lowermost mantle, with maximum values around 12 S/m located in the LLSVPs [3]. If present, such a belt may trigger electrical currents and induce magnetic field variations with period of one year or more.

Finally, provided it can be mapped by seismology, core-mantle boundary dynamic topography may bring key constraints. Numerical models of convection indicate that thermo-chemical reservoirs would induce a slight depression of typically 1 or 2 km surrounded by a ridge of positive topography. Instead, aggregates of purely thermal plumes would induce positive topography with similar amplitude.

[1] Deschamps, Kaminski & Tackley, *Nature Geoscience* **4**, 879-882.n[2] Li, McNamara & Garnero, *Nature Geoscience* **7**, 366-370. [3] Deschamps, *Terr. Atmos. Ocean. Sci.* **26**, 27-40.