

## 5.1.11

**The statistical upper mantle assemblage**A. MEIBOM<sup>1</sup> AND D.L. ANDERSON<sup>2</sup><sup>1</sup>Stanford University (meibom@pangea.stanford.edu)<sup>2</sup>California Institute of Technology (dla@gps.caltech.edu)**THEME 5:  
THE DEEPER EARTH****Session 5.1:****Reconciling mantle geochemistry and geophysics: Mantle reservoirs and other tales.**

CONVENED BY:

DAVID BERCOVICI (DAVID.BERCOVICI@YALE.EDU)

STEIN B. JACOBSEN  
(JACOBSEN@NEODYMIUM.HARVARD.EDU)

One of the long-standing paradoxes about the Earth's mantle is that isotopic evidence points to long-term separation of chemically distinct reservoirs while geophysical evidence suggests convection extending over its entire depth. Geochemical observations: isotopic variations of midocean ridge basalts and the continental crust, budgets and fluxes of noble gases, the Earth's heat production and flow, all suggest at least two large separate mantle reservoirs. One is depleted of incompatible elements (such as U and Th) compared to initial mantle composition; the other is enriched in incompatible elements and possibly, part of primordial mantle composition. However, recent seismic tomography images suggest that subducting slabs descend across the entire mantle, thus destroying layering or reservoirs. So how are isotopically distinct reservoirs preserved over Earth history? Geodynamic models also suggest that layering would induce a plume-dominated form of convection at odds with inferred hotspot plume fluxes. This session will explore ways to reconcile the disparate observations by re-assessing the key observations by drawing on research across disciplinary boundaries.

A fundamental challenge in modern mantle geochemistry is to link geochemical data with geological and geophysical observations. Many of the early geochemical models involved a layered mantle and the concept of geochemical reservoirs. Indeed, the two layer mantle model has been implicit in almost all geochemical literature and the provenance of OIB and MORB [1]. Large scale regions in the mantle, such as the "convective" (i.e. well-stirred, homogeneous) upper mantle, sub-continental lithosphere, and the lower mantle were treated as distinct and accessible geochemical reservoirs. Here we discuss evidence for a ubiquitous distribution of small-to-moderate scale (i.e.  $10^2$ - $10^5$  m) heterogeneity in the upper mantle, which we refer to as the **Statistical Upper Mantle Assemblage (SUMA)**. This heterogeneity forms as the result of long-term plate tectonic recycling of sedimentary and crustal components. The SUMA model does not require a convectively homogenized MORB mantle reservoir, which has become a frequently used concept in geochemistry. Recently, Kellogg *et al.* [2] modeled MORB and OIB Sr and Nd isotopic compositions as local mantle averages of random distributions of depleted residues and recycled continental crustal material. In this model, homogenisation of the MORB source region is achieved by convective stirring and mixing. In contrast, in the SUMA model, the isotopic compositions of MORB and OIB are the outcome of homogenisation during sampling, by partial melting and magma mixing (e.g. [3,4]), of a distribution of small-to-moderate-scale upper mantle heterogeneity, as predicted by the central limit theorem. Thus, the 'SUMA' acronym also captures what we consider the primary homogenisation process: **Sampling Upon Melting and Averaging**.

SUMA does not require the participation of distinct (e.g. lower mantle) reservoirs to explain OIB compositions. The complementary methods outlined in this work and in e.g. [2, 3] provide a strong link between geochemical data and potential geophysical observables, such as the degree of partial melting, size of the melting regime, the characteristic length scales of the chemical heterogeneity and bathymetry, seismic scattering and anisotropy. We support the view that statistical distributions of lithologic components and sampling theory should replace the concept of distinct, isolated geochemical reservoirs, and extensive convective stirring prior to sampling.

**References**

- [1] van Keken *et al.* (2002) *Ann. Rev. Earth Planet. Sci.* **30**, 493-525 (2002).
- [2] Kellogg *et al.* (2002) *EPSL* **204**, 183-202.
- [3] Helffrich and B.J. Wood (2001) *Nature* **412**, 501-507.
- [4] Kogiso *et al.* (2004) *GCA* **68**, 345-360.