Towards geodynamic interpretation of seismic mantle structure

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Seismology has probably yielded the most tantalizing images of the Earth's interior, yet their geodynamic interpretation is not straightforward, due to limits on seismic resolution and uncertainties in how seismic velocities depend on temperature, pressure and composition. Furthermore, available data do not fully constrain the mantle's seismic structure. So, although published seismic models represent optimum data fits (in some sense), other models may also be acceptable, leaving room for alternative interpretations. The first direct interpretations of 1-D seismic models provided some very strong geodynamic constraints on the approximate composition of the mantle, the existence and nature of the transition zone, and on the relative homogeneity of the lower mantle. Since then tomographic images on scales ranging from global (1000's km) to local (few kms) have provided various insights in the dynamic deviations from this spherical background structure. Most prominent in these is the expression of subducted material in upper and lower mantle, continental roots, and two large slow regions in the deepest lower mantle. The detailed interpretation and composition of each of these remains a topic of debate, although in recent years it has become increasingly clear that not only thermal structure, but also compositional variations play a significant role in mantle dynamics. Other topics of controversy are the existence, structure, and role of mantle upwellings, whether the base of the transition zone corresponds to a boundary layer in any sense (i.e., possibly temporally and spatially discontinuous), and what the exact contributions of chemical differentiation and thermal structure are to the boundary layers on the mantle's top, the lithosphere, and its base, encompassing the seismic D". Because of the non-uniqueness of seismic models, the most promising way to improve our understanding seems to step away from direct interpretation and instead turn towards the testing of geodynamically plausible hypotheses against the data, increasing them in complexity if justified by significant data misfits. I will discuss some examples for the mantle's spherical background structure (what is its physical meaning?), for the structure of the lithosphere and asthenosphere (can we distinguish the signature of composition and melt from temperature?), for subducting plates (how much material is located where and when was it subducted?), and for possible active mantle upwellings (what should they look like and is this imagable?). I will cover aspects of seismic sensitivity, methods and uncertainties for converting thermo-chemical structure into seismic velocities, and show results from dynamic hypothesis tests of our and other groups.