# The Mantle Through the Transition Zone

1. What is the buoyancy and rheology structure of the upper mantle and how does it mediate flow and drive convection at all scales?

2. What is the chemistry and mineralogy of the upper mantle and what is the relative importance of compositional and thermal heterogeneity?

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- Seismic anisotropy is key observable.
  - Joint inversions of different seismic data (surface waves, shear-wave splitting, Pn, etc.) will help resolve its 3D structure and relation to likely mantle flow fields.
  - Need to move beyond simple anisotropy models (radial, etc.) to consider more general forms (e.g., tilted symmetry axes, higher order symmetries) and to use better theoretical sampling kernels. (Figure of USArray splitting?)
  - Comparisons to convection models

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- What is the nature of the lithosphere-asthenosphere boundary (LAB)?
  - New converted-phase observations are providing important constraints on its sharpness and depth (figure from Karen's talk?) and suggest that it's not purely thermal in origin.
  - Is the LAB a global feature? What role does asthenospheric flow play in the motion of plates? Why does the LAB appear locally sharp?

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- What are the scales of mantle convection and how do they interact?
  - Recent seismic images show complex structure in the upper mantle (USArray tomography figure?).
  - How do small scale convection and lithospheric delamination interact with large-scale whole mantle flow? How do these flows affect surface tectonics?

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- How does the transition zone affect mantle flow?
  - How much flux is there across the 660-km discontinuity?
  - Recent seismic observations do not show clear evidence of plumes arising from the deepest mantle to the surface, yet deep large-scale structure in mantle does seem correlated with surface intraplate magmatism.

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- Improved tomographic images of *P* and *S* velocities and attenuation are critical. This will require better numerical techniques to model wave propagation as well as better methods for combining classically separated types of seismic observations (body-wave travel times, surface-wave dispersion measurements, receiver functions).
  - Adjoint waveform inversions (figure?).
  - Use more of seismogram, full bandwidth, all phases
  - Seismic inversions with mineral physics constraints.
  - Joint inversions of separate data sets
  - Improved uncertainties to facilitate intelligent use of models

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- Transition zone and upper-mantle discontinuities are key constraint on mantle composition. They lie at the intersection of seismology and mineral physics.
  - New migration techniques combined with unaliased data sets (more stations!) will improve the seismic results.
  - Does short-wavelength discontinuity topography require compositional variations?

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- What role is water playing in seismic observations as well as mantle dynamics?
  - Do recent observations of LVZ above the 410 require a water-rich layer?
  - How ubiquitous is this layer?
  - How important is water for mantle rheology?
  - How does water affect discontinuity topography and amplitude?

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- Length scales of chemical heterogeneity are important for understanding geochemical observations and mixing in convection calculations, as well as understanding buoyancy sources.
  - New theory and observations to understand scattered (coda) waves to constrain scale lengths, amplitude, and depth variation of smaller scale heterogeneities.