Thermo-chemical Internal Dynamics & Volatile Distribution

Most relevant "Grand Challenges":

#5. Where are water & hydrocarbons beneath the surface?

#6. How do magmas ascend and erupt?

#7. What is the lithosphere-asthenosphere boundary?

#9. How do temperature & composition control mantle convection?

#10. How are Earth's internal boundaries affected by dynamics?

Thermo-chemical Internal Dynamics & Volatile Distribution

Scientific Themes

- Structure of the Lithosphere and Asthenosphere
- Lithosphere-Asthenosphere Interactions
- Distinguishing Melt, Volatiles, Composition, & Temperature

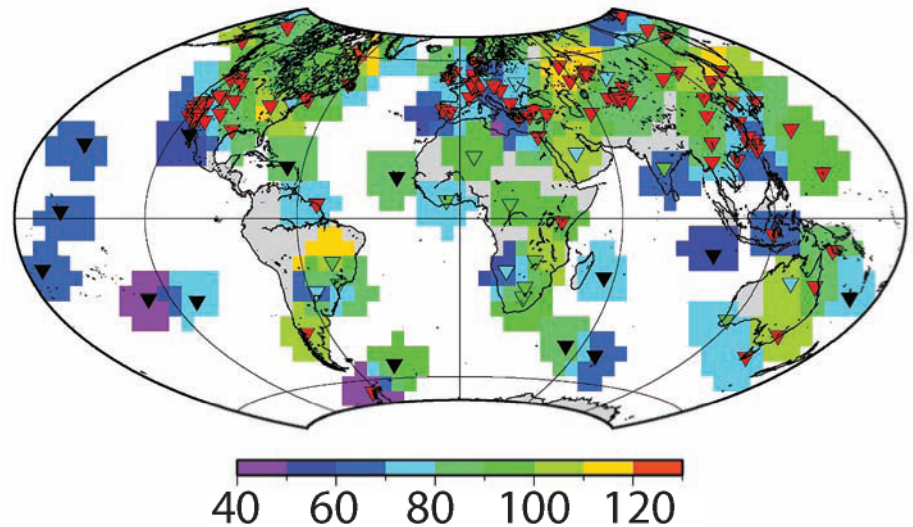
Future Directions

- Improving seismic images
  --new analysis of existing data [utilizing more of the waveform; integrating different measurement types; HPC]
  --collection and analysis of new data

- Improving interpretations of seismic images
  --collection of experimental data
  --utilizing data sets from other disciplines

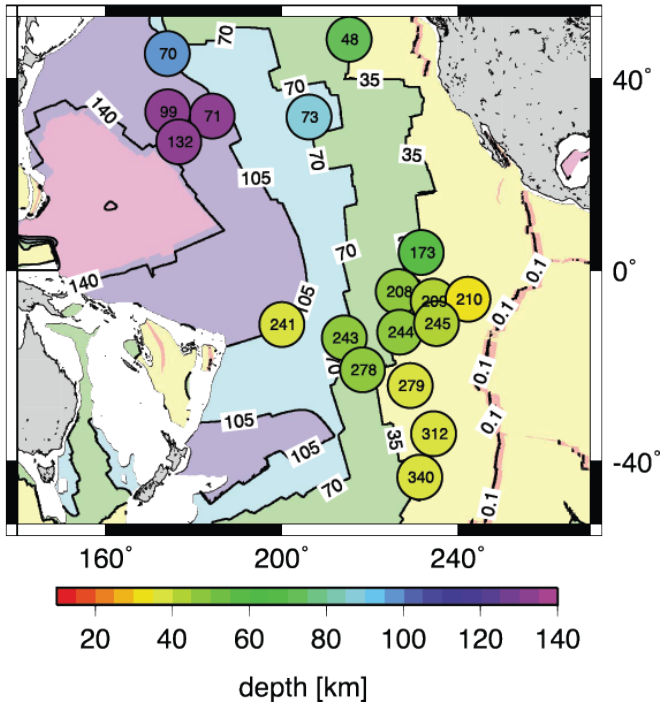
- Improving coverage in the oceans

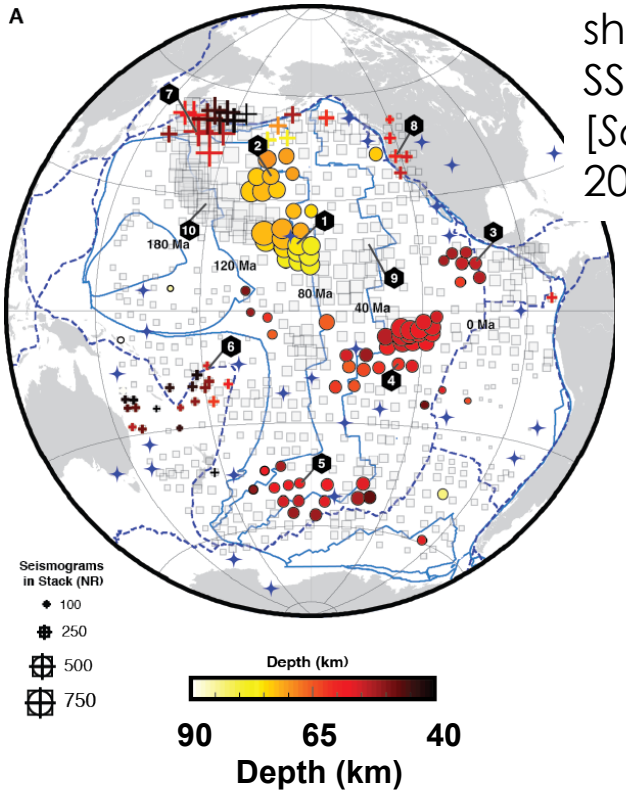
Structure of the Lithosphere and Asthenosphere



depth (km) to negative discontinuity in Ps phase *[Rychert & Shearer, 2009]*

long-period SS modeling *[Rychert & Shearer, 2011]*



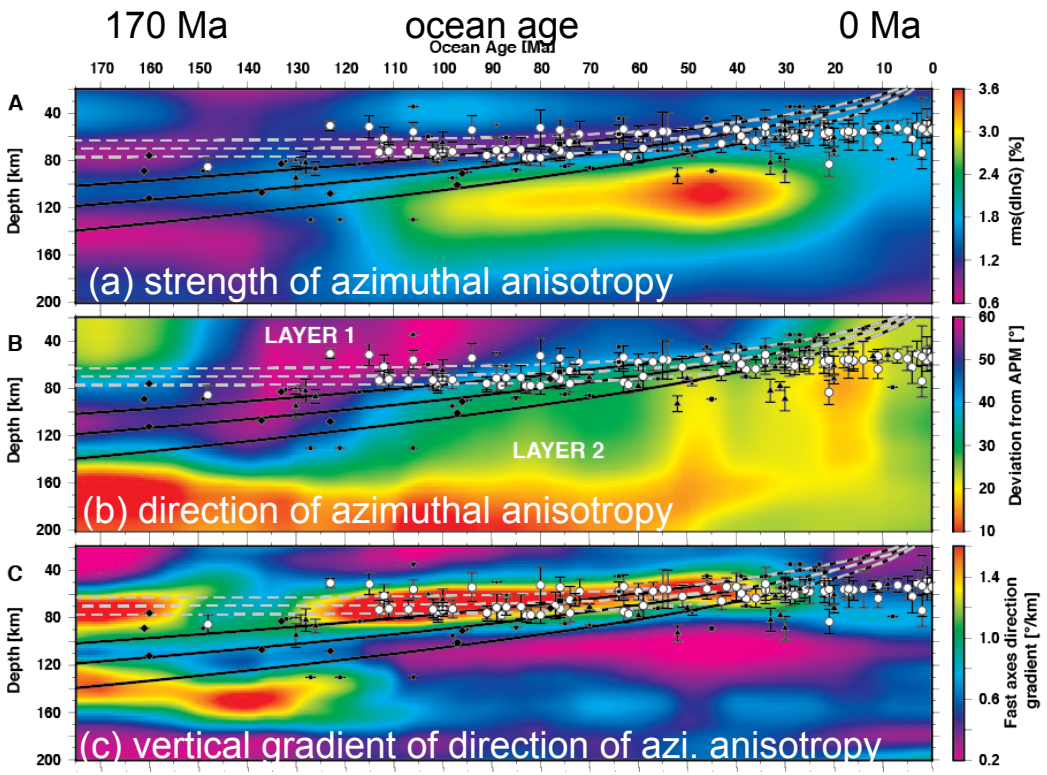


short-period SS precursors *[Schmerr, 2012]*

Structure of the Lithosphere and Asthenosphere

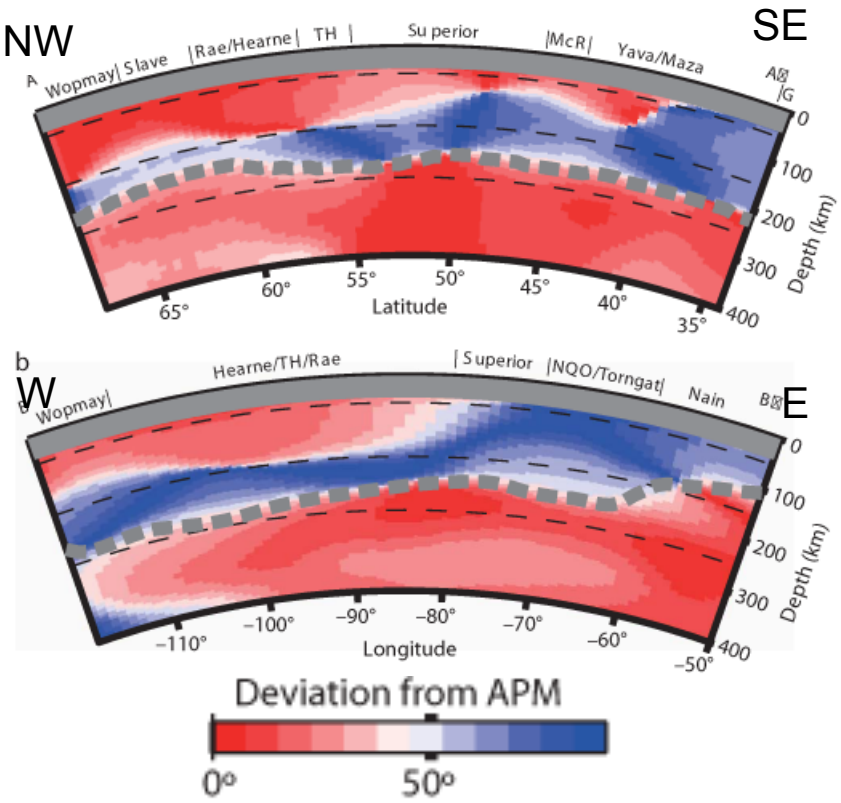
- Relationship between azimuthal anisotropy (direction & magnitude) and seismic discontinuities

Pacific



after Beghein et al. 2014

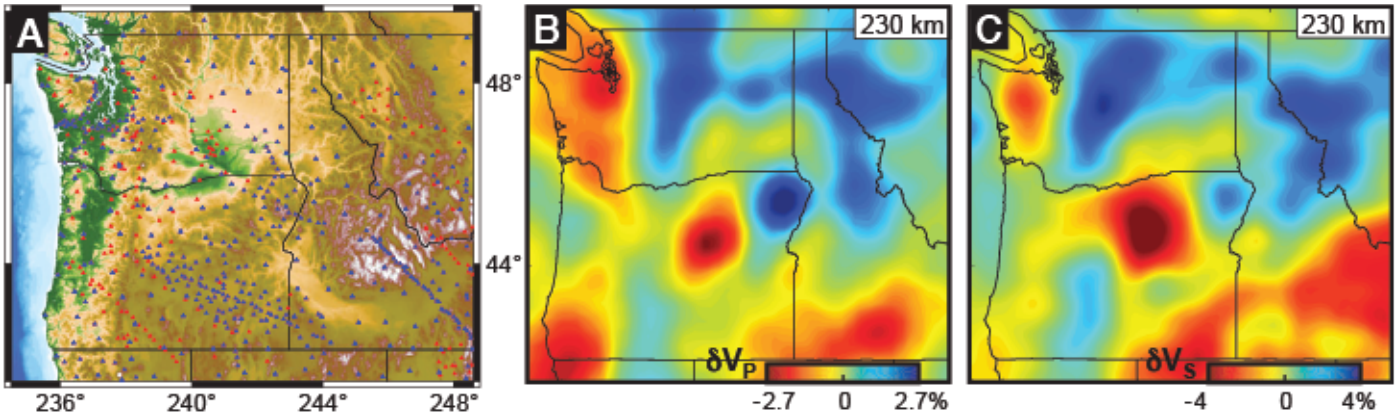
North America



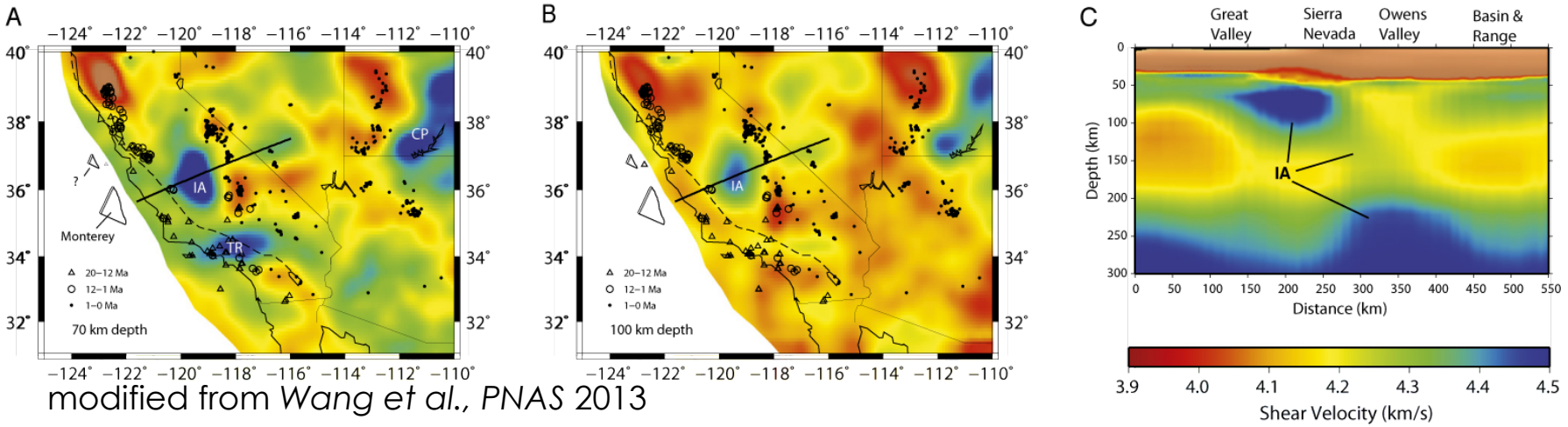
Yuan & Romanowicz 2010

Lithosphere-Asthenosphere Interactions

High V_S & V_P beneath western U.S.:
slab fragments? delaminating lithosphere?



Schmandt & Humphreys 2011

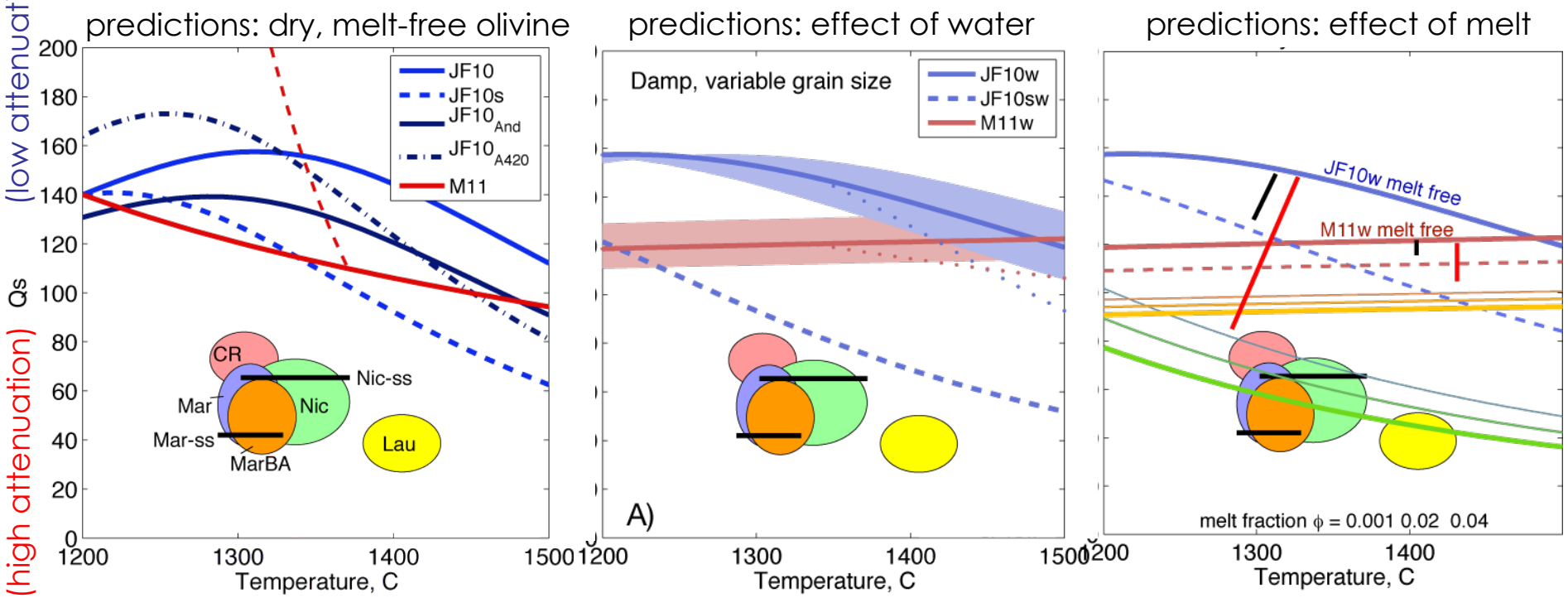


modified from *Wang et al., PNAS* 2013

Distinguishing Melt, Volatiles, Composition, Temperature

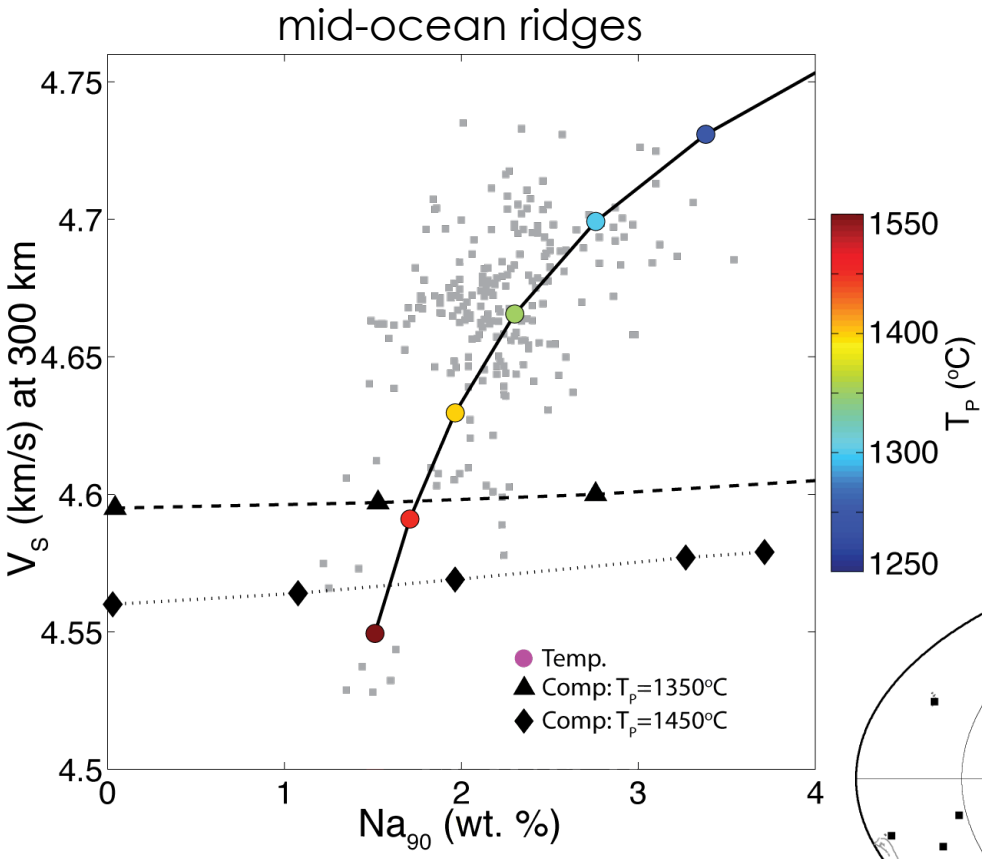
Subduction zones: High attenuation in the mantle wedge due to melt

- high temperature, water not enough

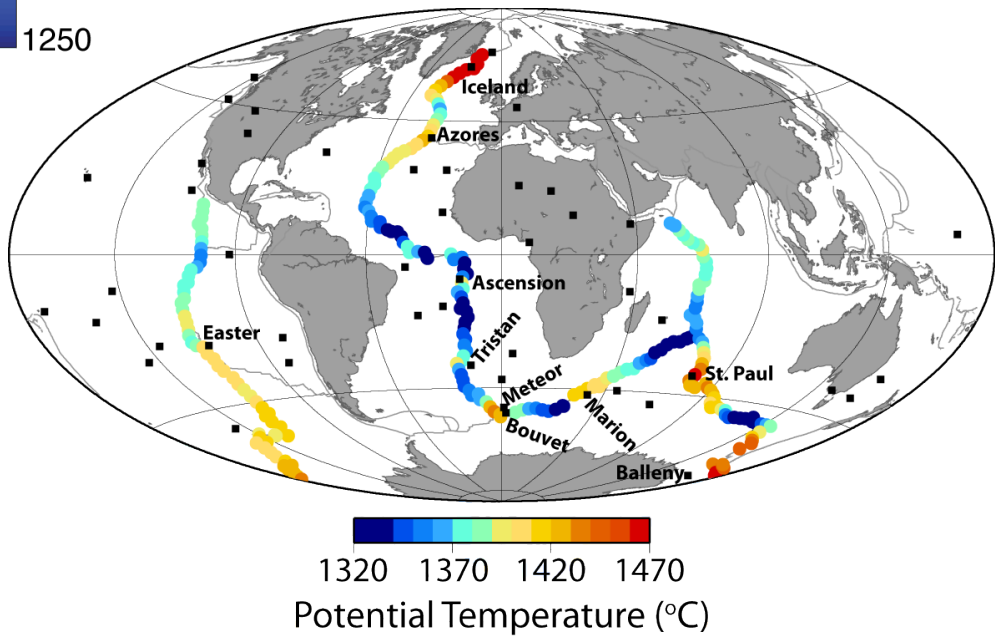


Abers, Fischer, Hirth, Wiens, Plank, Holtzman, McCarthy, & Gazel, submitted 2014

Distinguishing Melt, Volatiles, Composition, Temperature



Dalton et al., Science, 2014



Improving Coverage in the Oceans

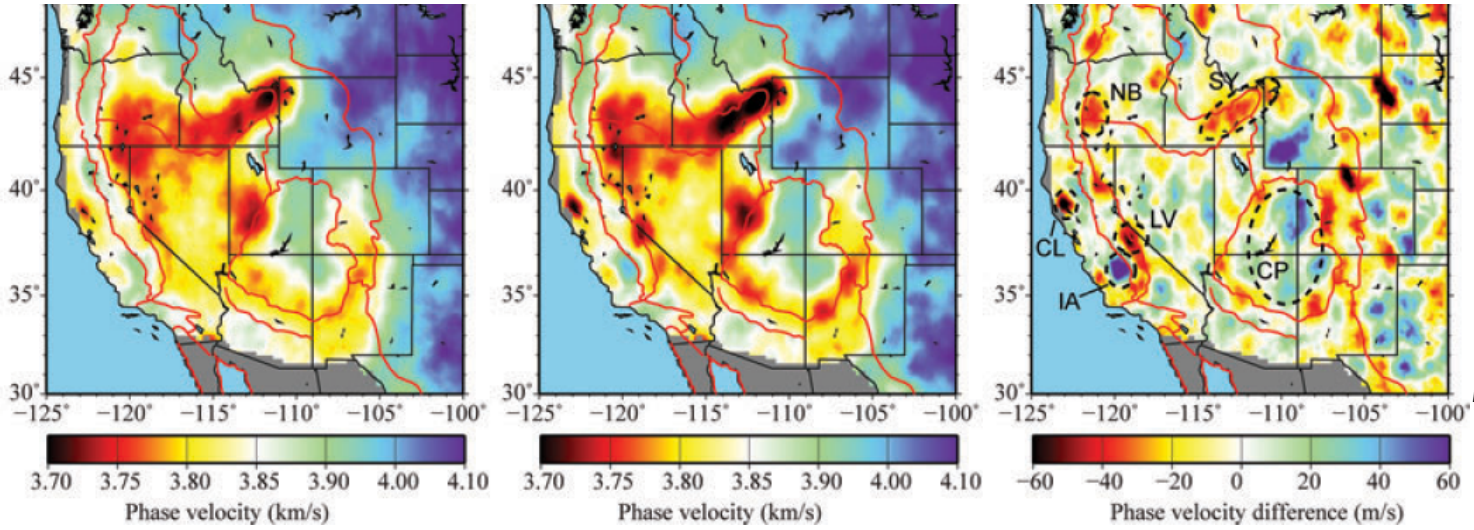
Results from USArray have challenged previously-held assumptions about continents. What currently-held assumptions about oceans would be challenged?

Provides an opportunity to target fundamental concepts:
-- relationship between mantle flow and seismic anisotropy
-- relationship between plate motion and mantle flow
-- details of melt generation and ascension
-- small-scale convection beneath plate
-- image plate-boundary shear zones

Two Final Examples

1. Rayleigh wave phase velocity (60 s): Using amplitude in addition to phase provides new information

Phase only | Phase and amplitude | Difference

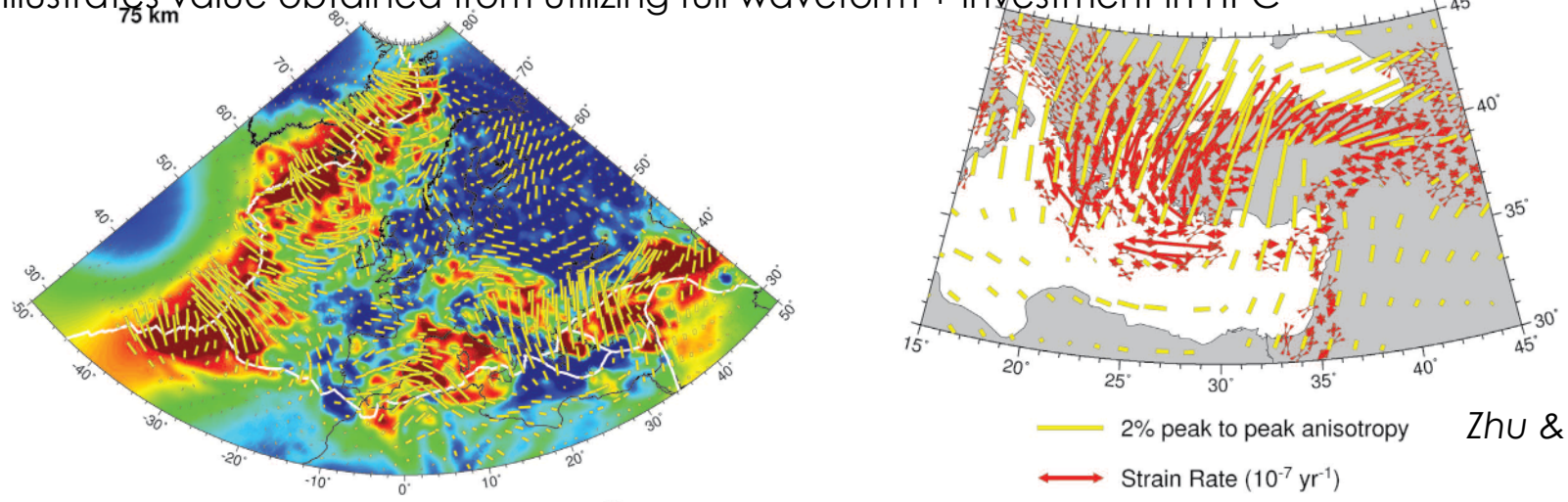


Lin & Ritzwoller 2011

2. V_S and azimuthal anistropy beneath Europe and Northern Atlantic from adjoint tomography

Resolution of small-scale features & agreement between anisotropy and geodetic strain-rate field

Illustrates value obtained from utilizing full waveform + investment in HPC



Zhu & Tromp 2013