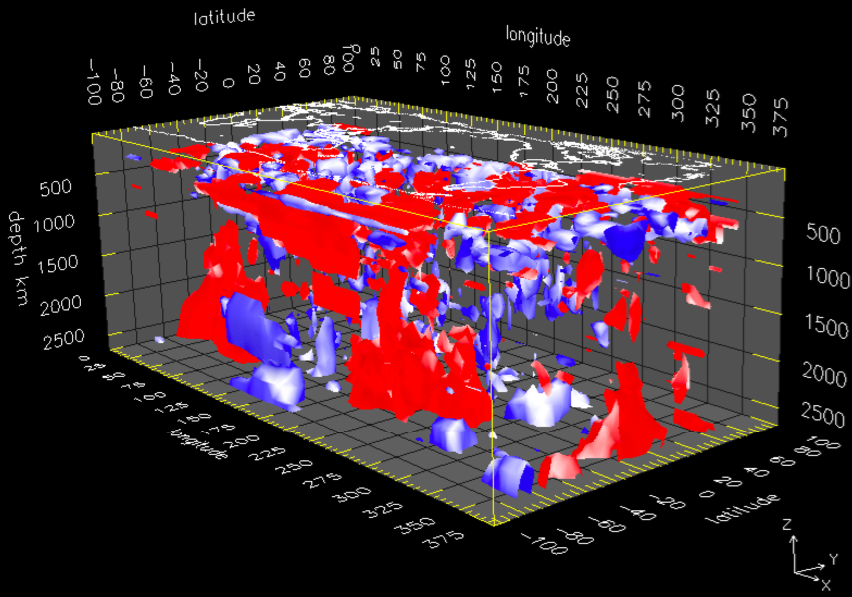
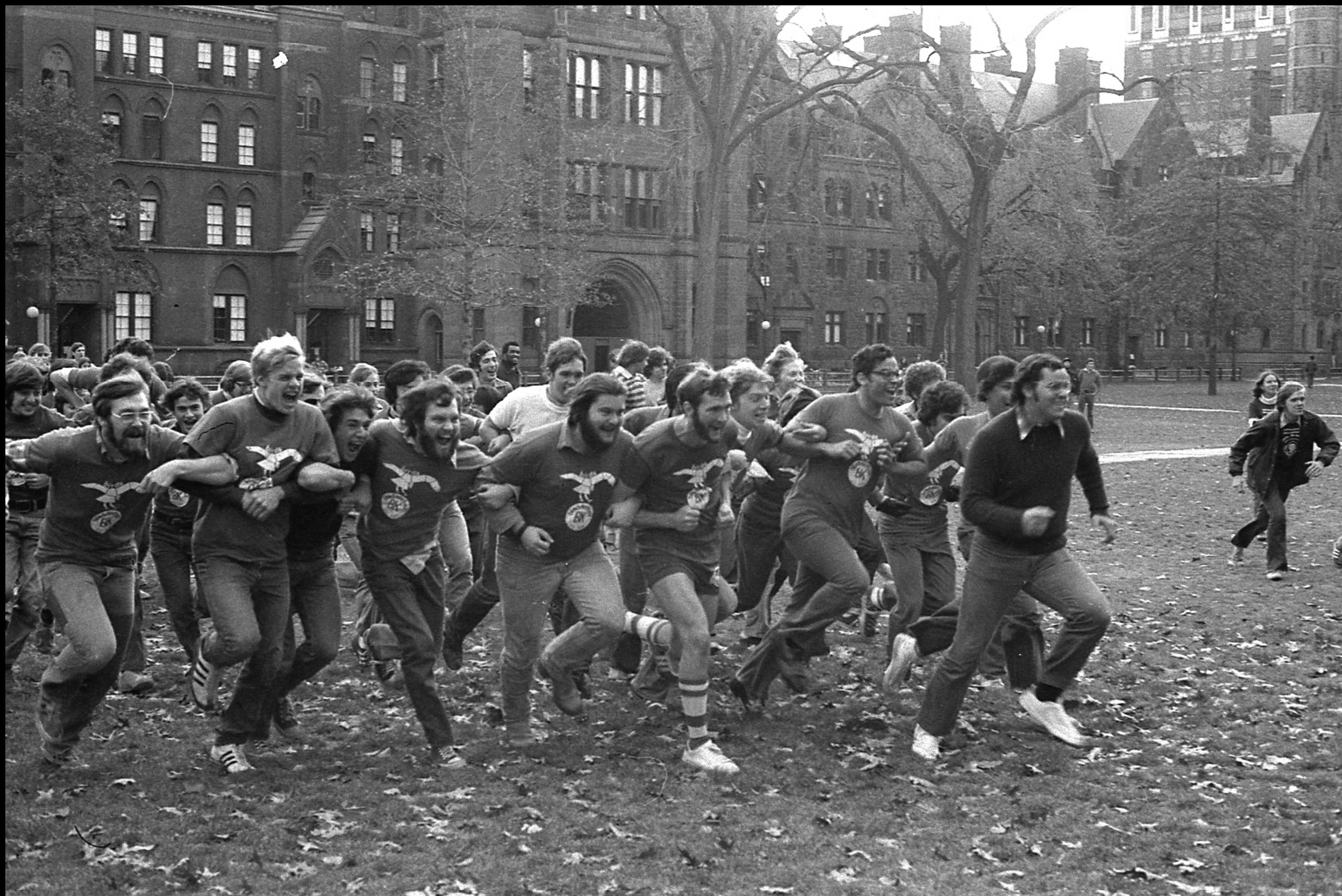
Part 1: Memories

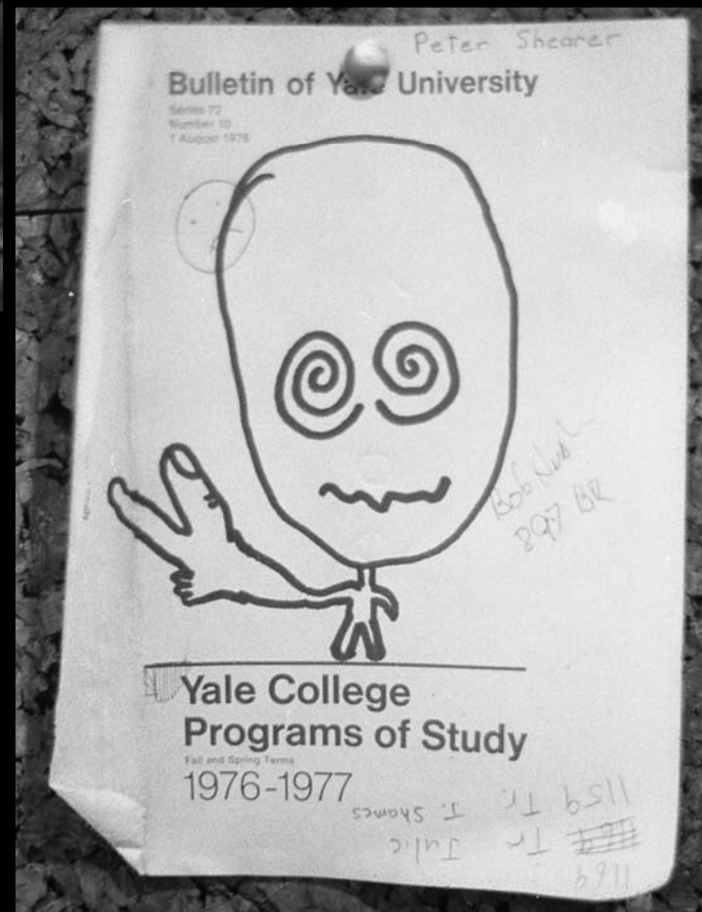


Part 2: Science

Yale Geology and Geophysics (1978)




BENJAMIN
SILLIMAN'S


Peter Shearer
Bulletin of
University
Yale College
Programs of Study
1976-1977

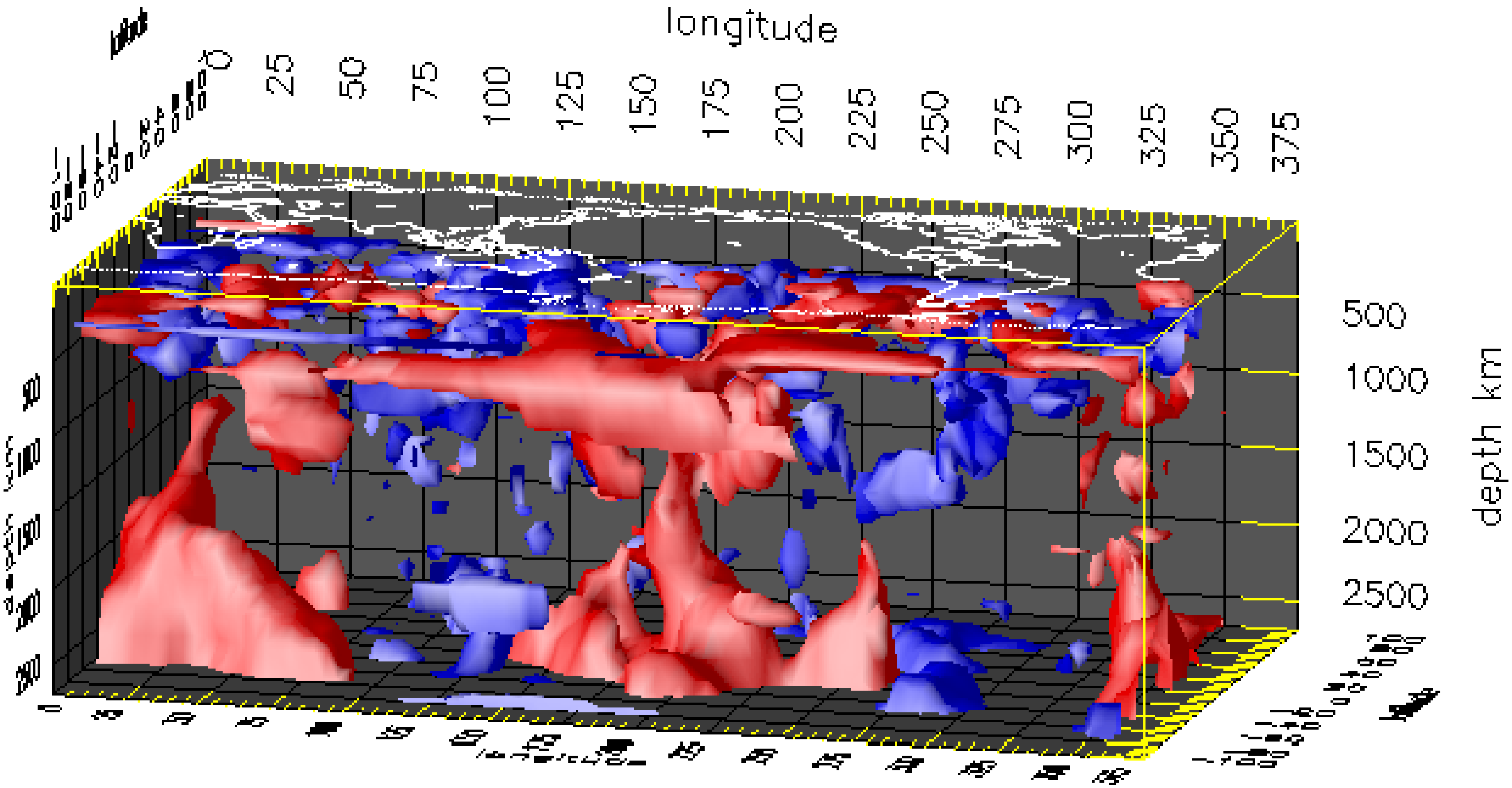
Brian Skinner

"Introduction to Geology (?)"

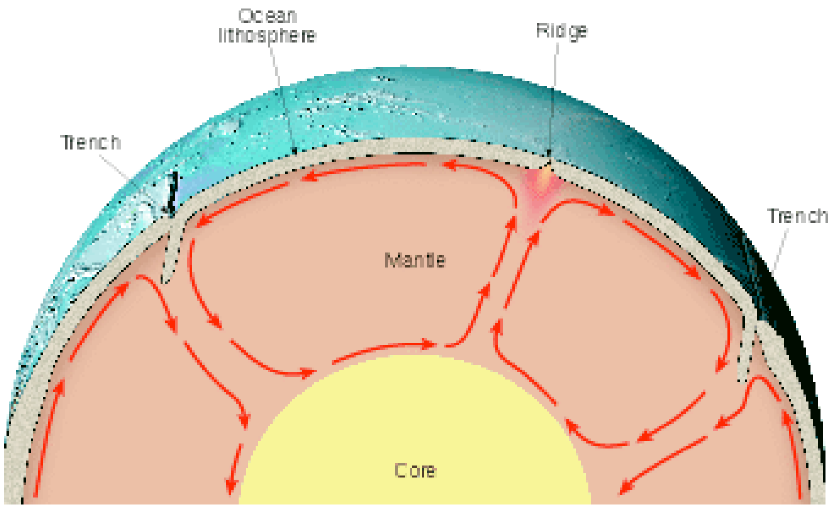
William Bennett

"The Computer as a Research Tool"

Seismology and the Mantle

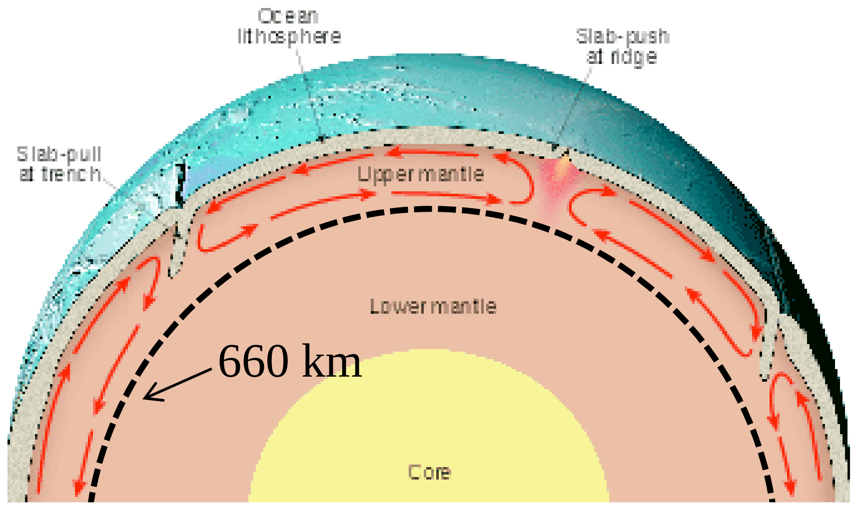


Whole or layered mantle convection?



Whole mantle convection

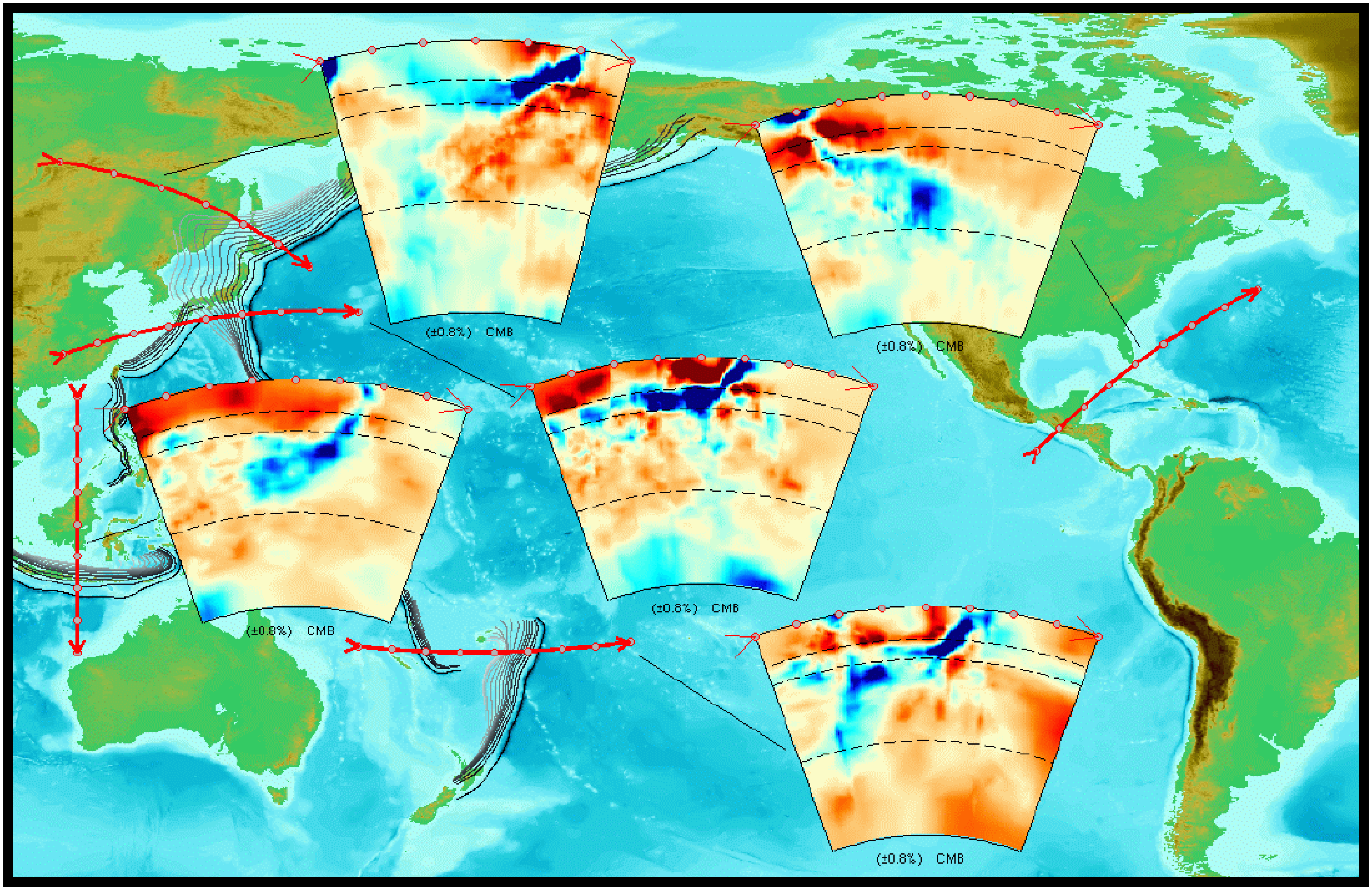
Favored by geodynamicists



Layered mantle convection

Favored by geochemists

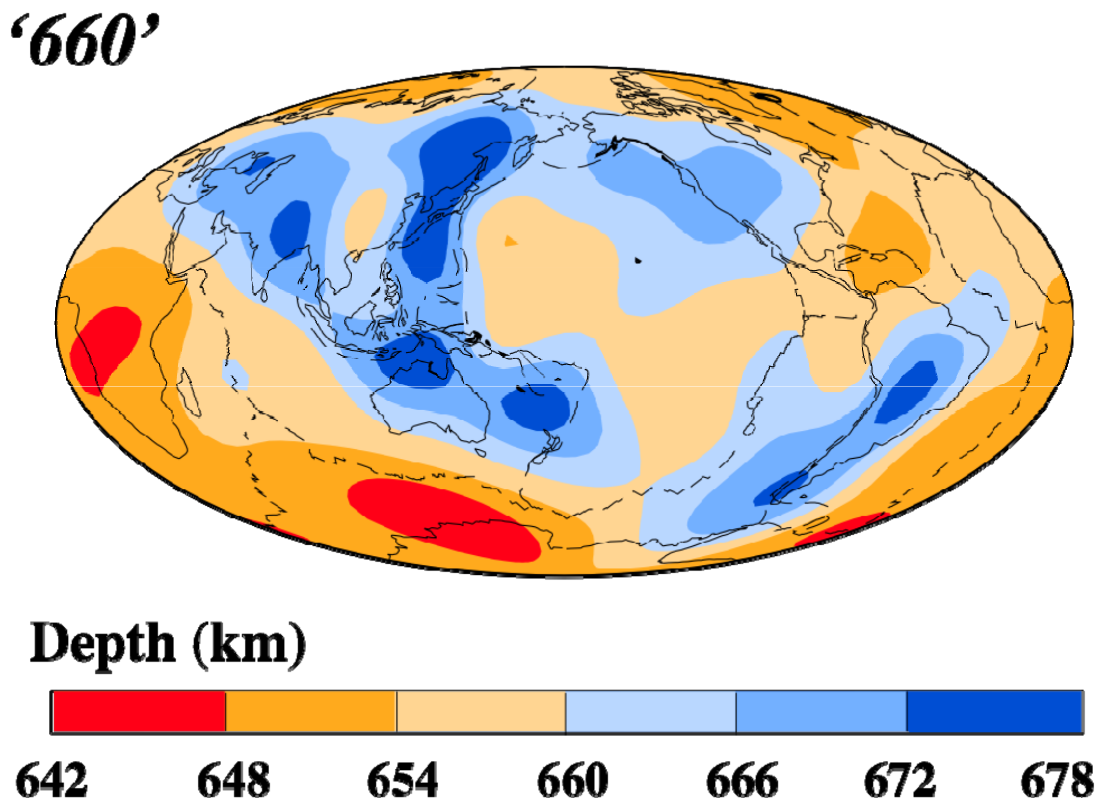
Mantle tomography cross-sections



(Karason & Van der Hilst, 2000)

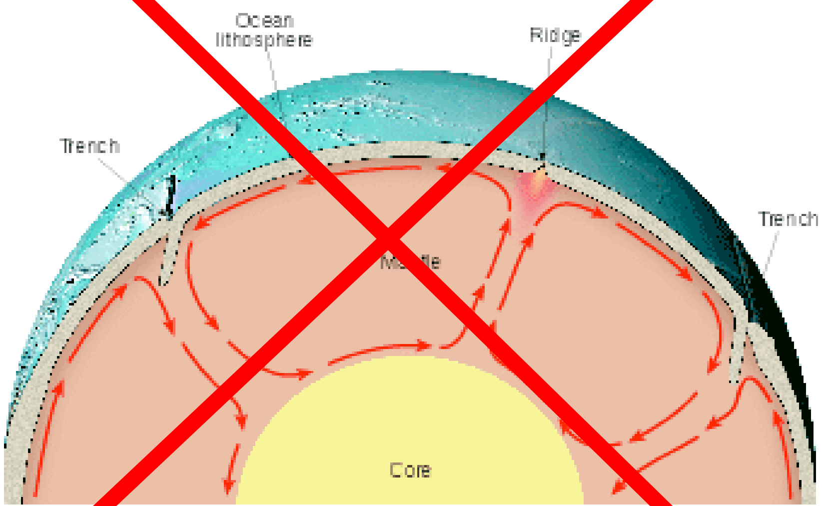
Some slabs go through the '660', some are deflected

'660' topography is depressed where cold slab material pools in the transition zone

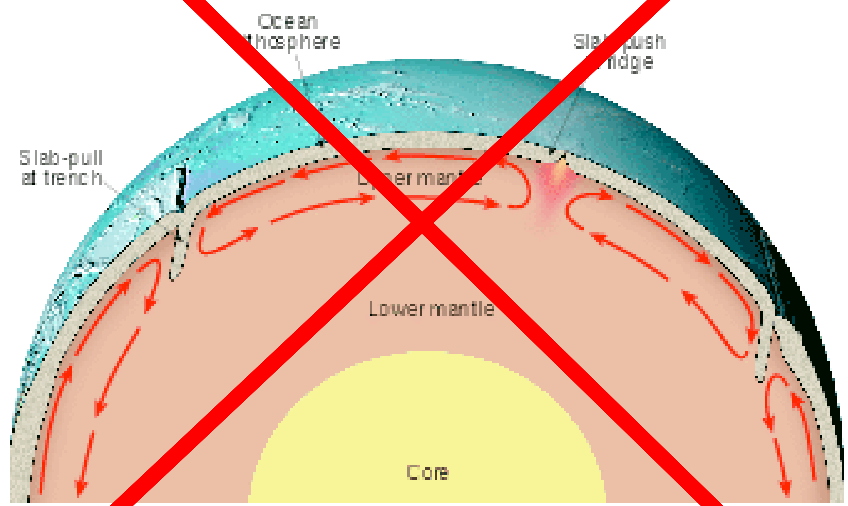


from Flanagan and Shearer (2008)

Whole mantle convection



Layered convection



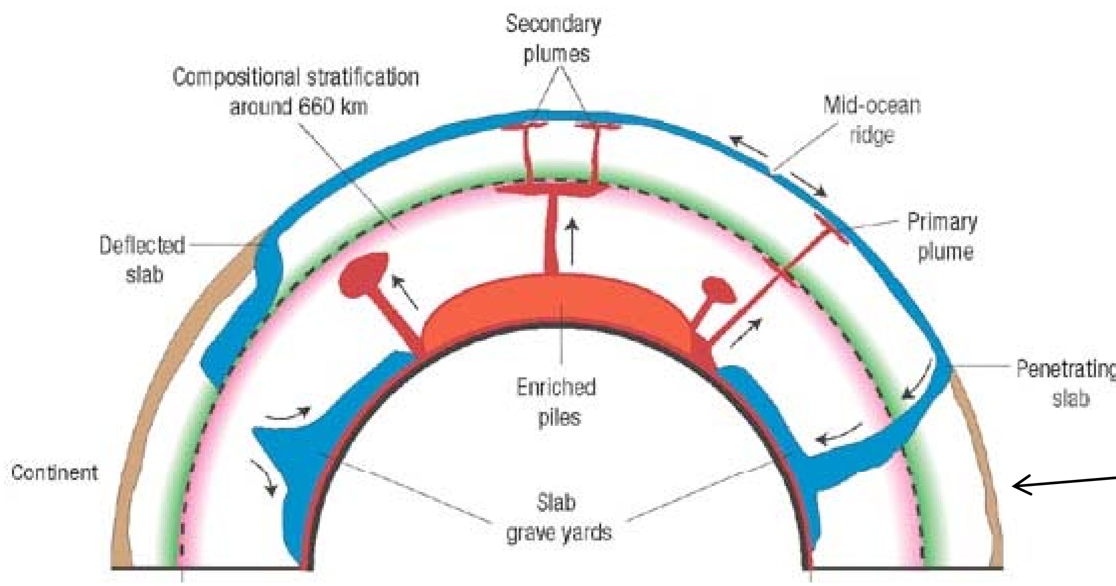
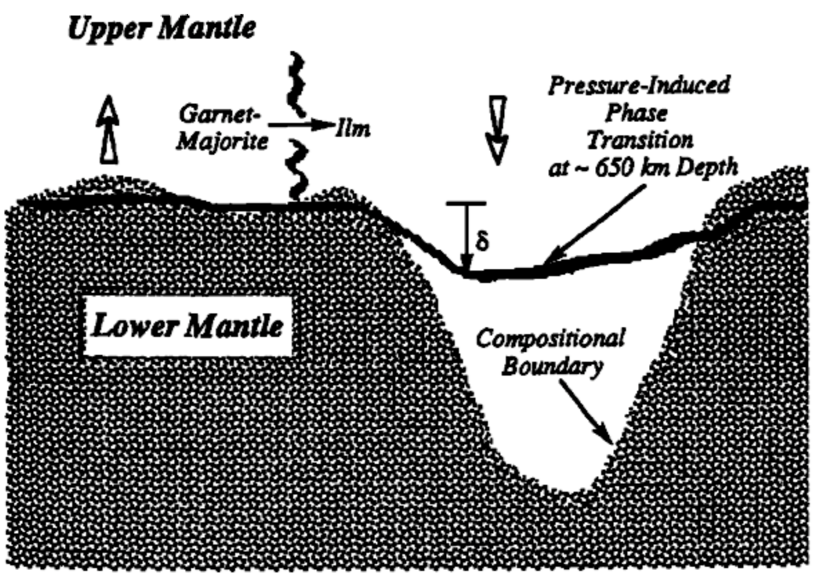


Figure from Tackley (2008)

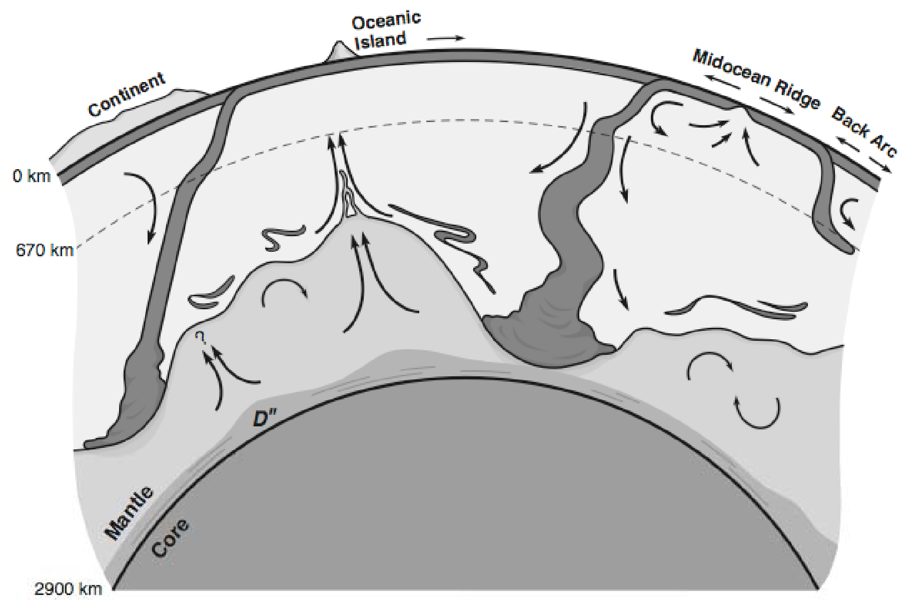
Intermittent or *partially layered* convection

Proposed "Stealth" discontinuities

- Compositional density interfaces with large dynamic topography
- Hypothesized to have small velocity jumps, making them hard to detect seismically



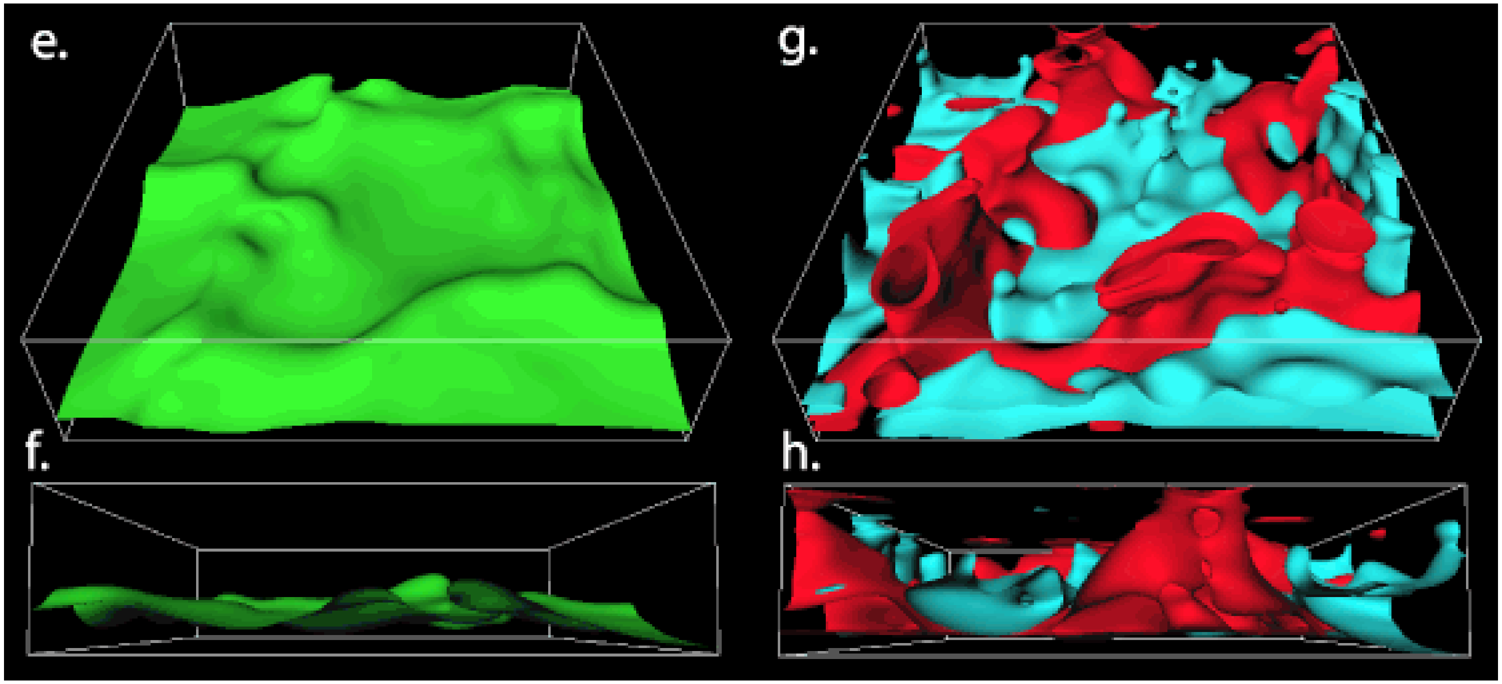
Jeanloz (1991)



Kellogg et al. (1999)

Tackley (2002) test of *Kellogg et al*. hypothesized layer

- 3-D numerical simulation of mantle convection
- Filtered to match seismic modeling
- Simulations predict peak in heterogeneity near interface depth
- Not seen in real tomography models or in direct searches in seismic data – argues against hypothesis



Interface position Temperature perturbation

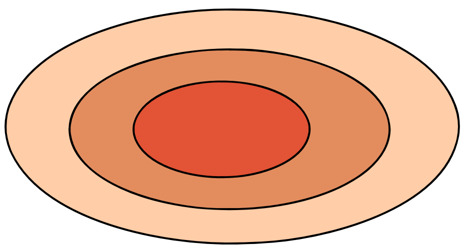
Tomography according to Guy:

- Success depends on using all different data types: body waves, surface waves, modes.
- Data coverage is most important, theoretical and inversion considerations can play a role but are less important.
- You have to do it right! Worry about source locations, crust corrections, etc.

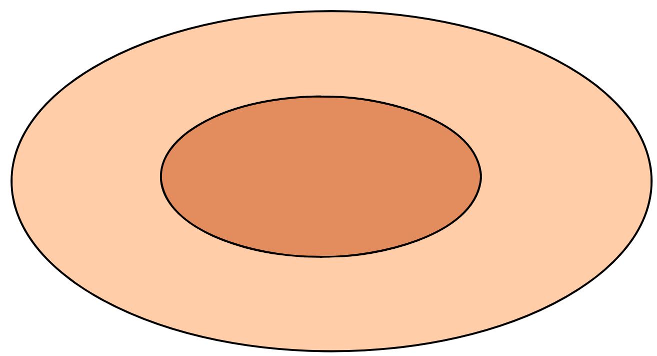
Guy Masters

Keep in mind when using tomography models…

- Relative weighting among different data sets and inversion regularization (smoothing) have a strong effect on the final model, in particular in the amplitude of the anomalies.
- This can account for many of the differences in the appearance of the models, even those based on similar data sets.



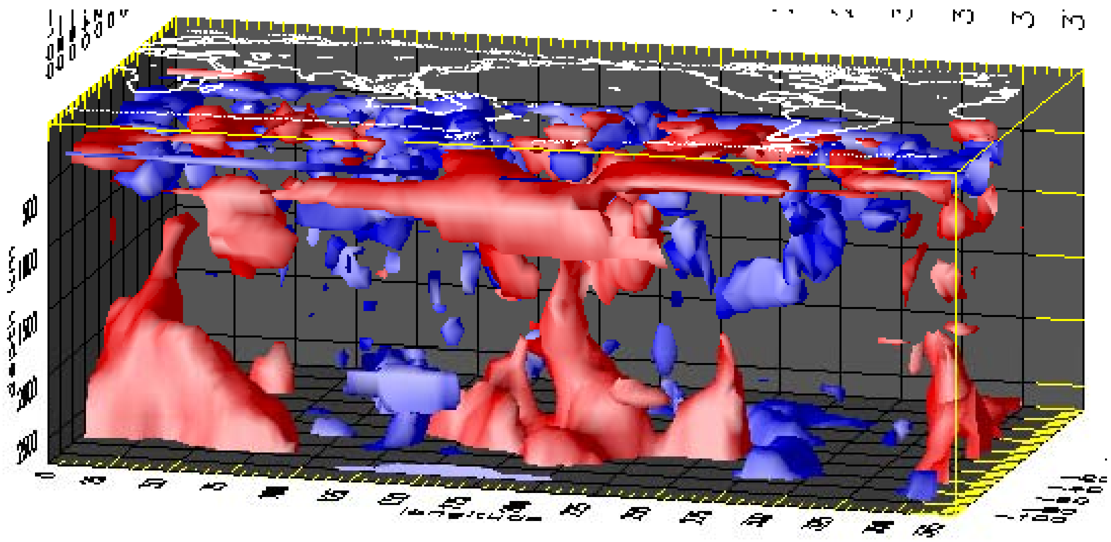
Lightly smoothed



Heavily smoothed

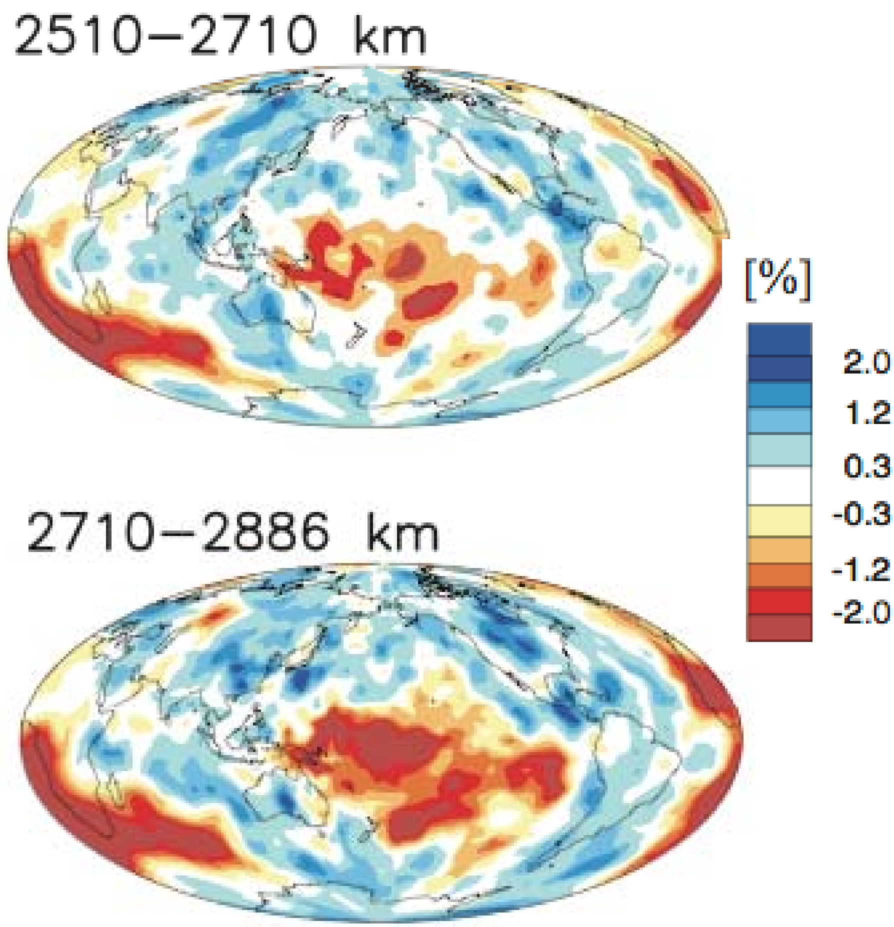
Mantle tomography

- Heterogeneity is strongest at the top and bottom
- Some slabs go through *660*, but pond or buckle at interface (must thicken or would be invisible in lower mantle in global models, would not cause broad depressions in *660* topography)
- Imaging plumes below *660* is near the limit of seismic resolution
- *Vp*/*Vs* ratios consistent with temperature variations in upper mantle, but require compositional heterogeneity in lowermost mantle

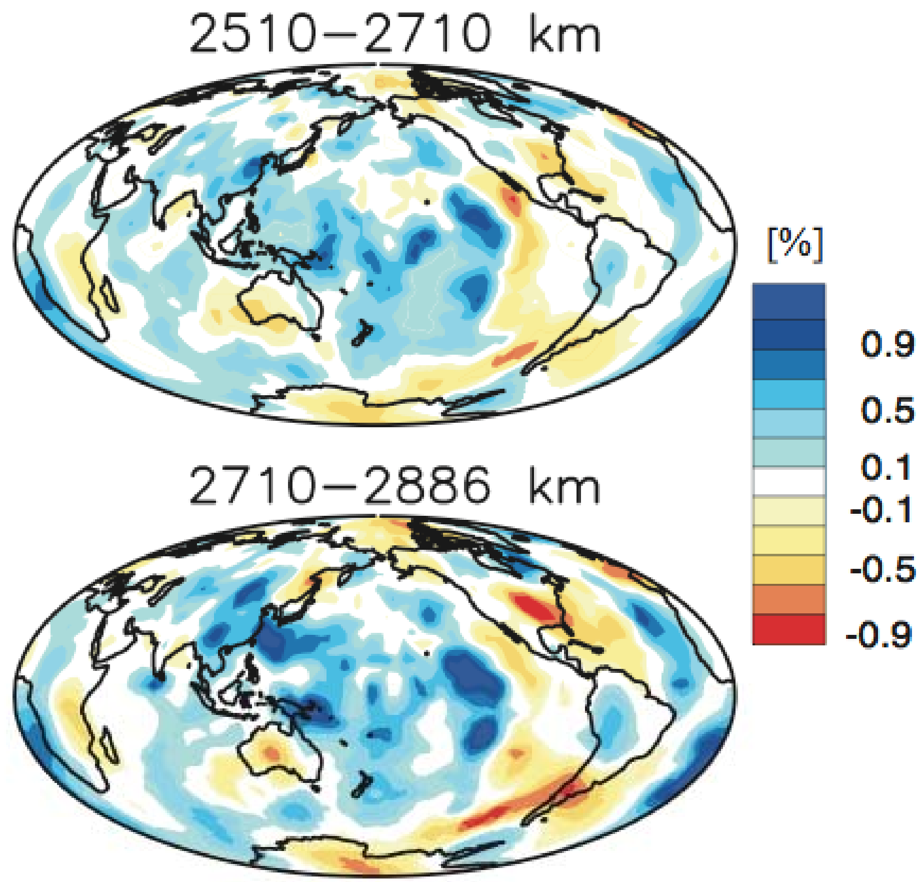


Lowermost mantle anomalies

Shear velocity perturbations



Bulk sound speed perturbations



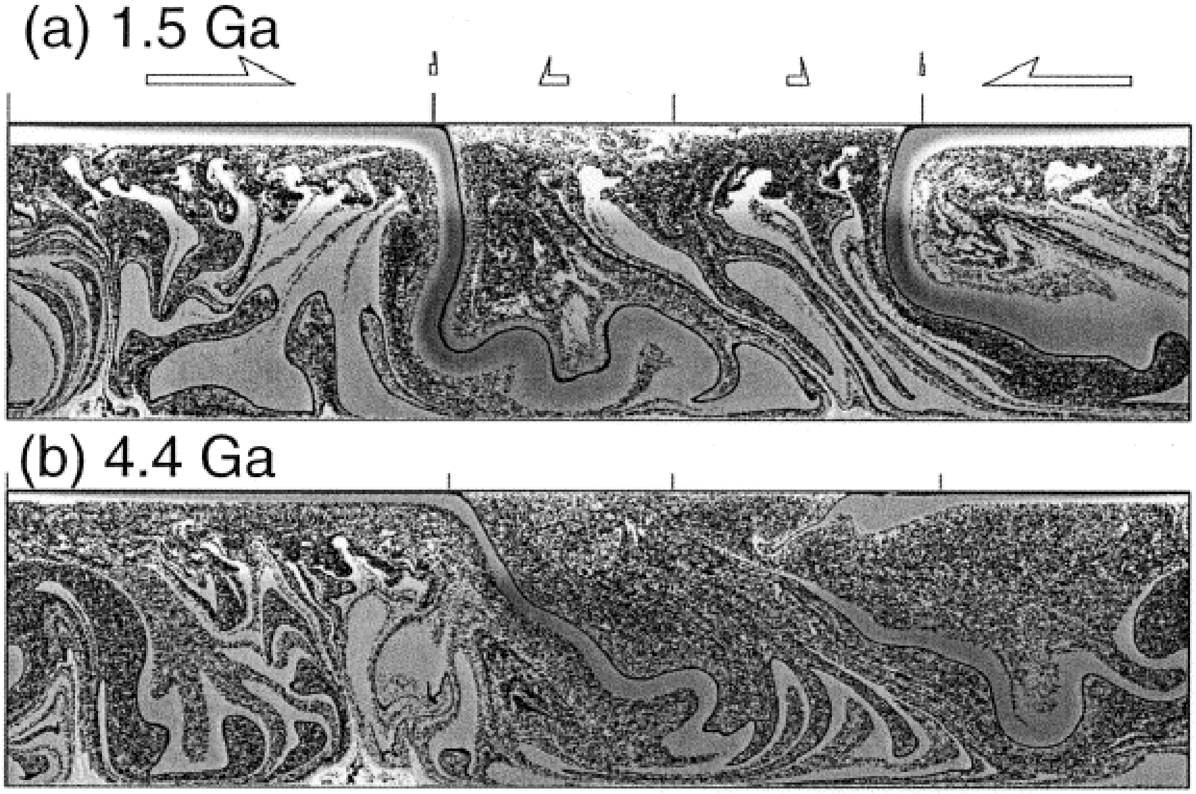
Anti-correlation indicates compositional variations

Survival of geochemical mantle heterogeneities

Francis Albarede

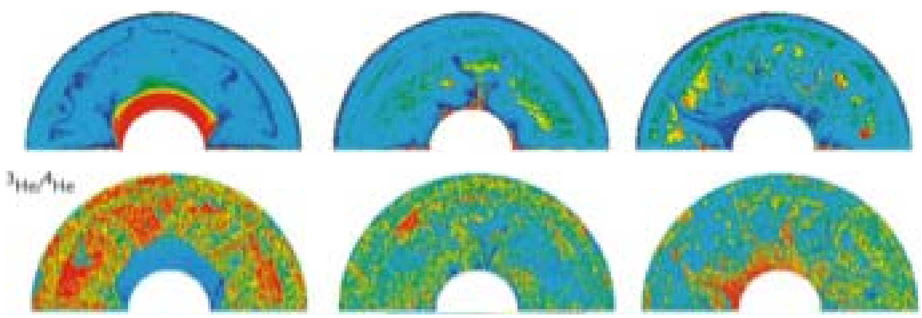
"Up to 50 percent primordial material may be present in the mantle, but scattered throughout as small (<~10 km) domains, strongly sheared and refolded, and interlayered with younger recycled material." (2004 AGU talk)

Mantle mixing calculations



Heterogeneity is likely at all scales

Davies (2002)



Xie & Tackley (2004)

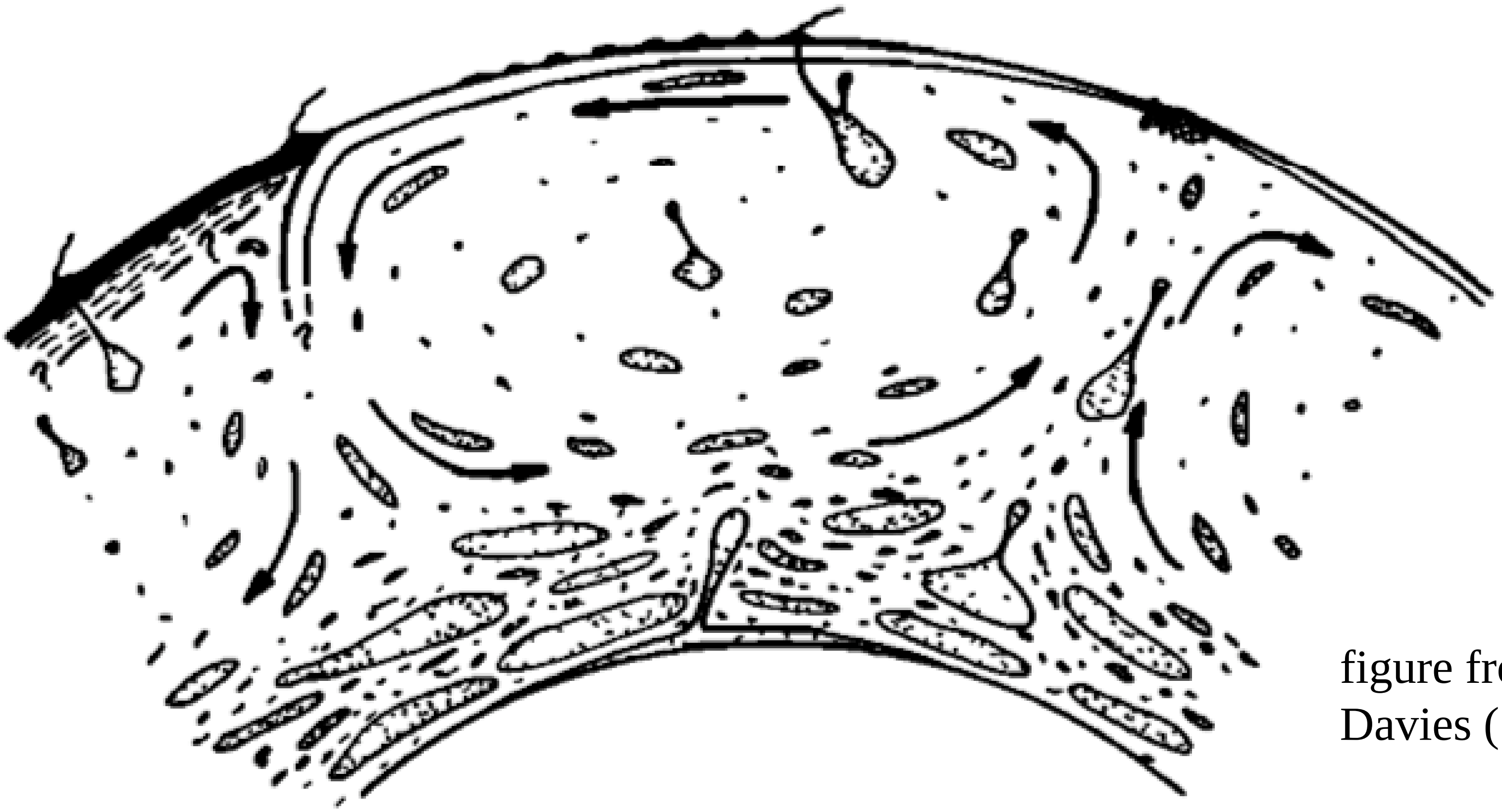


figure from
Davies (1984)

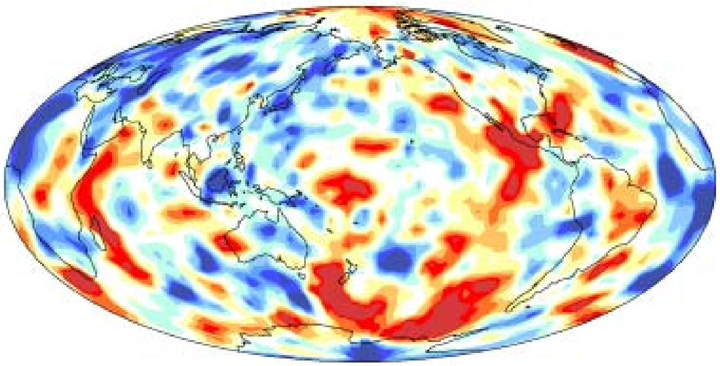
"Plum Pudding" hypothesis for mantle composition

Chemical heterogeneity at all scale lengths due to incomplete mixing of subducted lithosphere

Could placate geochemists who want separate reservoirs, while permitting whole mantle mixing

Seismic resolution gap at intermediate scales

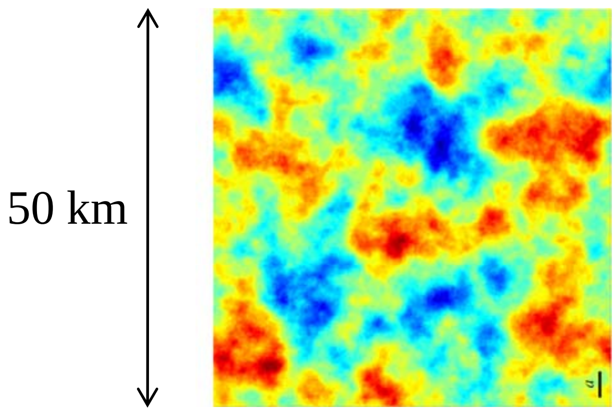
LARGE scale



Mantle tomography resolves heterogeneity of >1000 km scale length (0.5 to 3%, deterministic model)

Few constraints at intermediate scale lengths (50 to 500 km)

SMALL scale

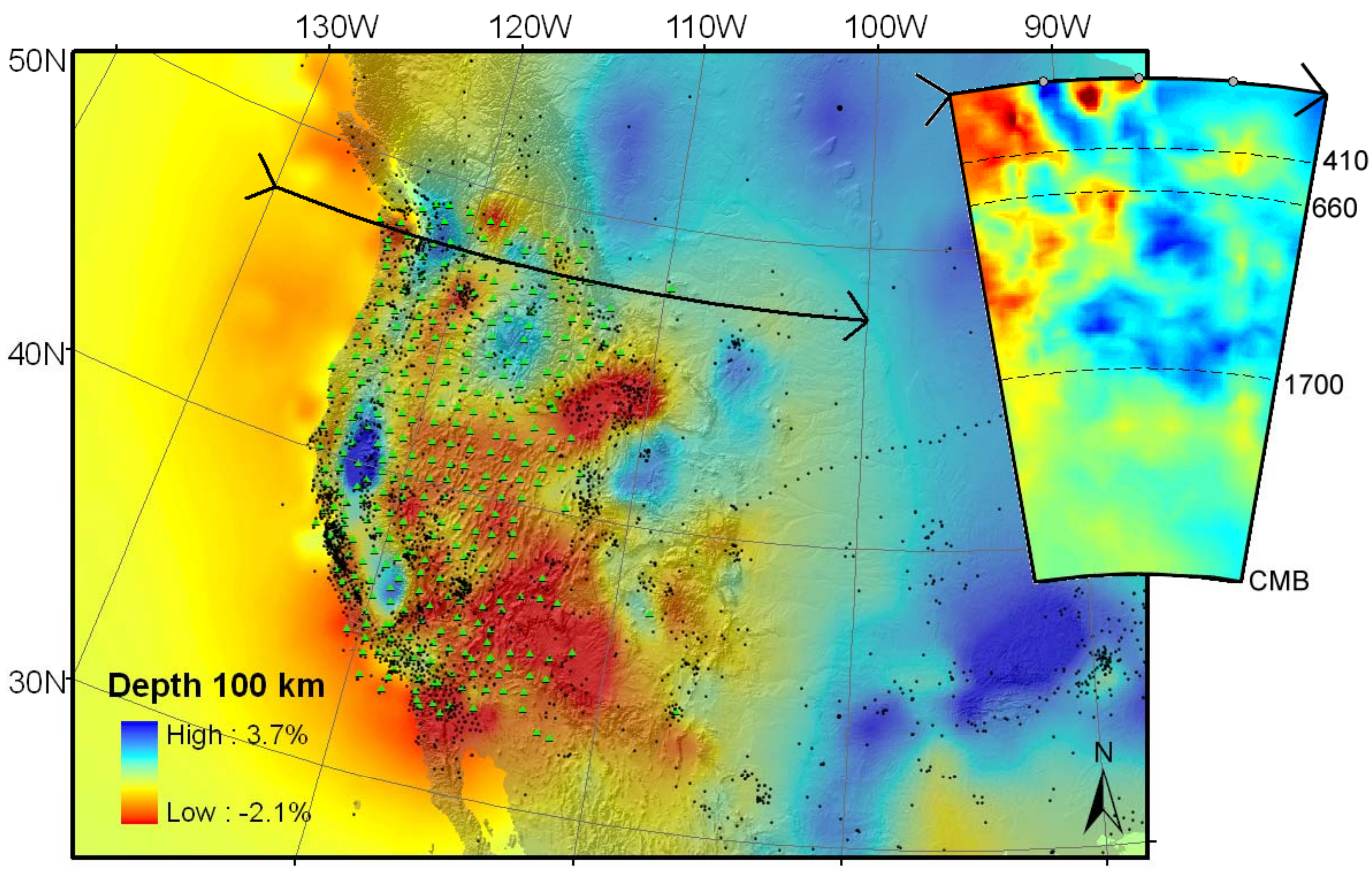


Observations of high-frequency scattered waves require small-scale heterogeneity at 5–10 km scale length (0.5% RMS, statistical model)

Filling the resolution gap:

Push tomography to higher resolution

Requires much denser station coverage (e.g., USArray)



Courtesy: Scott Burdick (MIT, May 2007)

Filling the resolution gap:

- Push scattering observations and modeling to longer periods/scales
- Will constrain heterogeneity power spectrum over wide range
- Will facilitate quantitative comparisons to geochemical mixing models