Significance of seismic tomography within the wider geoscience community

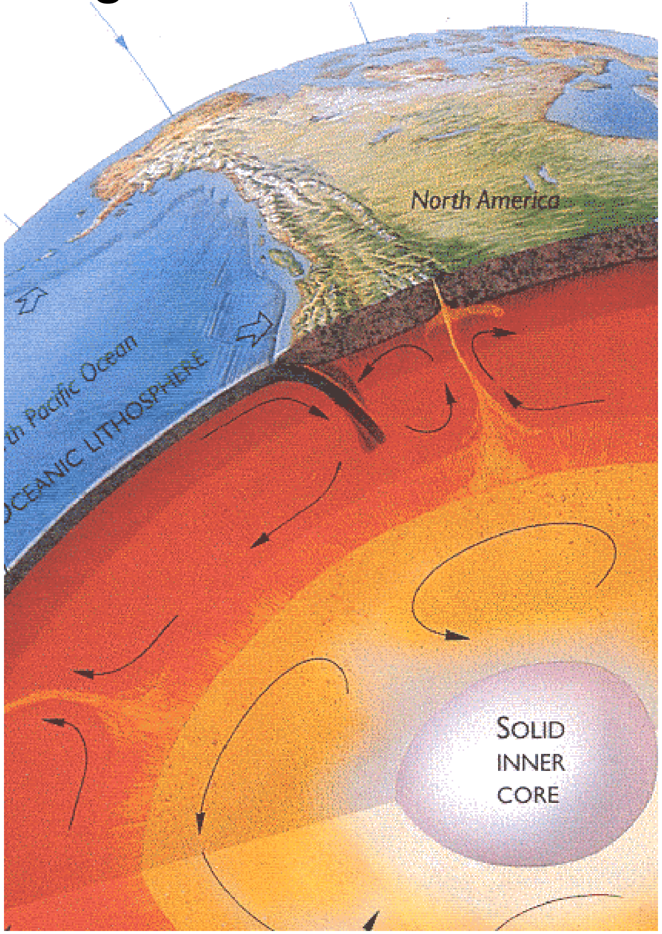
- Computational seismology works on improving imaging methods. Other geoscientists care mainly about the images themselves.

- Hopefully, tomography results make sense in light of surface studies (geology, tectonics) and mantle convection simulations (geodynamics).

- Solutions are non-unique -- but how bad is it? And how do I **convey** that to a non-specialist?

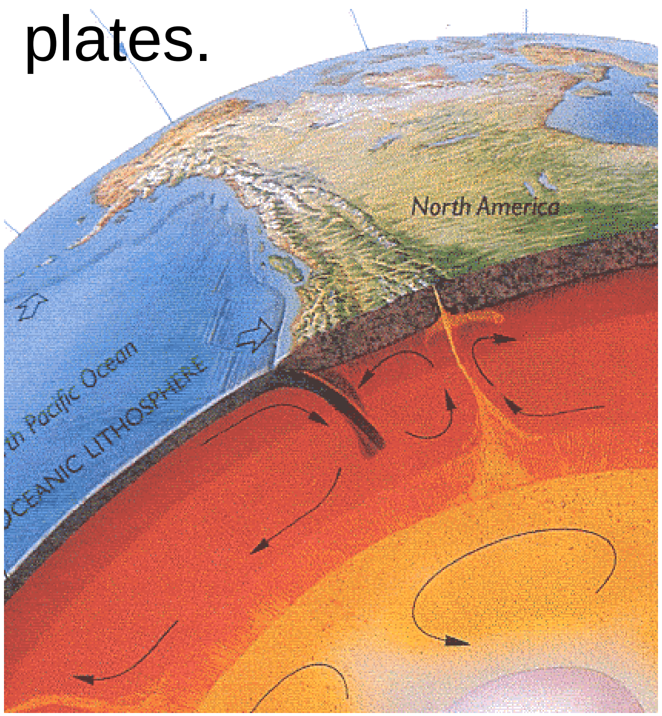
Example study: the mantle under North America -- window into a distant past

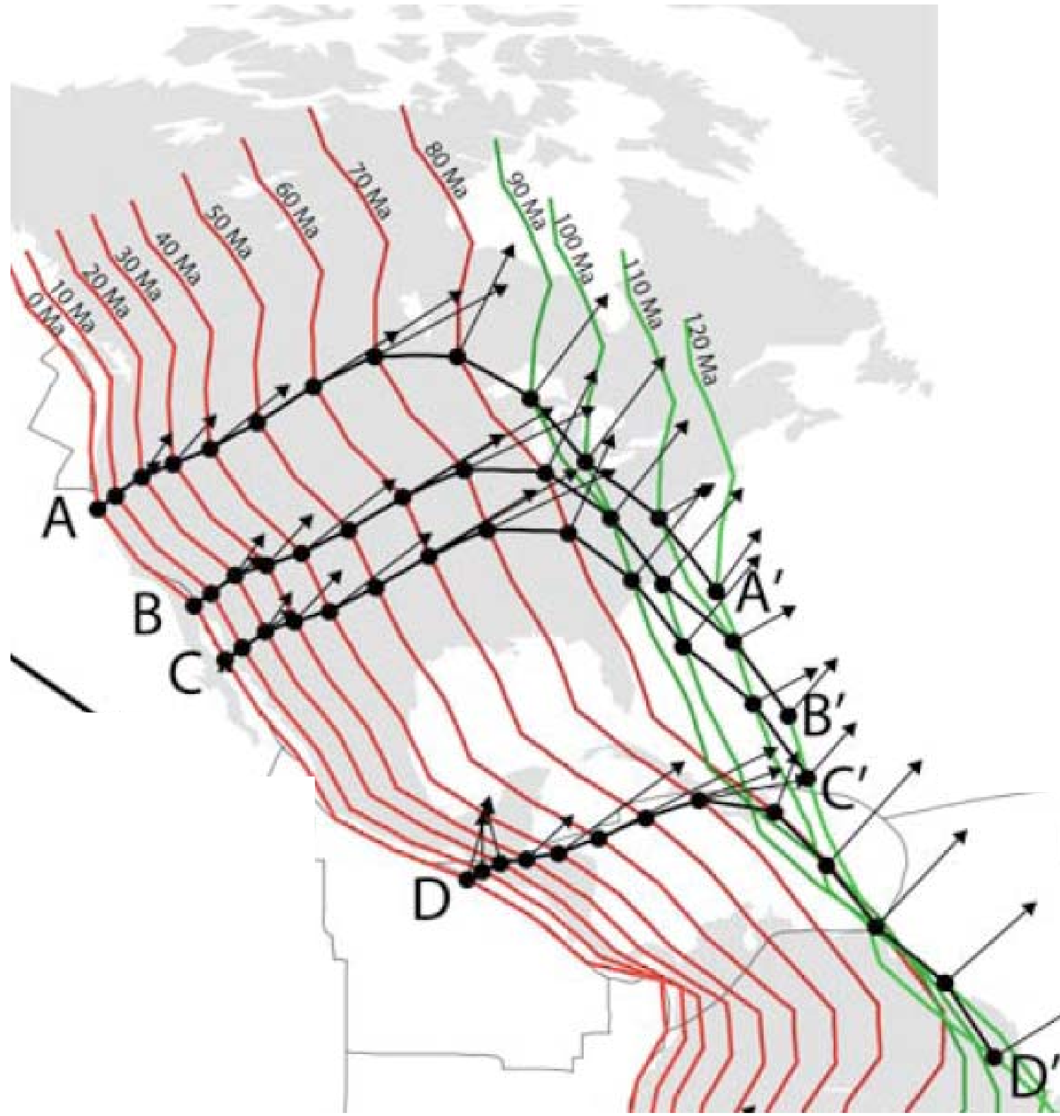
Subduction on the west coast: an oceanic plate gets submerged beneath the continent



A simple tectonic history(?)

- A single large plate has been subducting beneath the west coast for 180 million years. No significant interference from other plates.



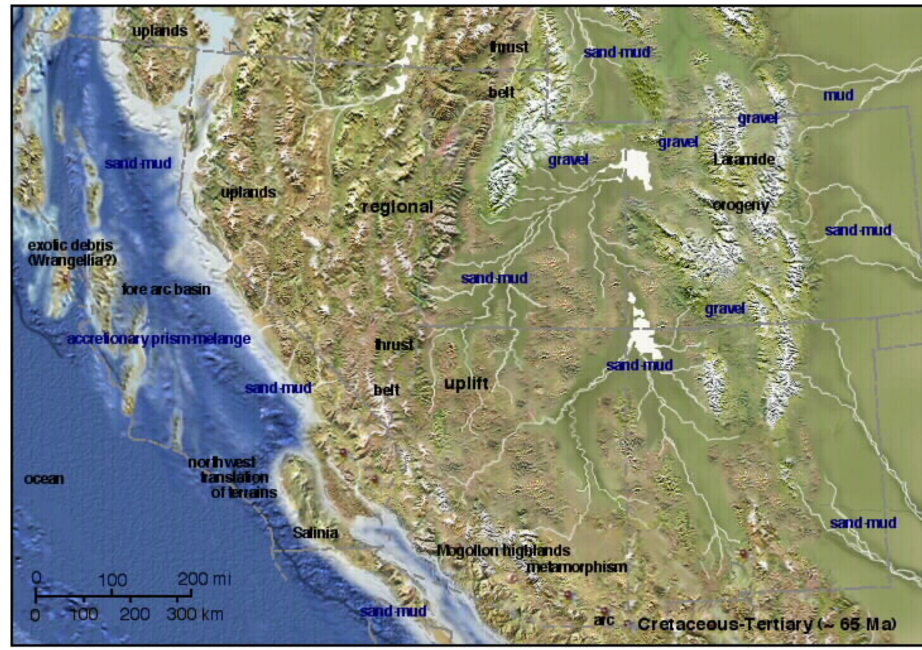


Geologists puzzle about episodes of rapid change in the past

Western U.S., 75 Myr ago

75 million years ago: A shallow inland sea covers the Rocky Mountain area

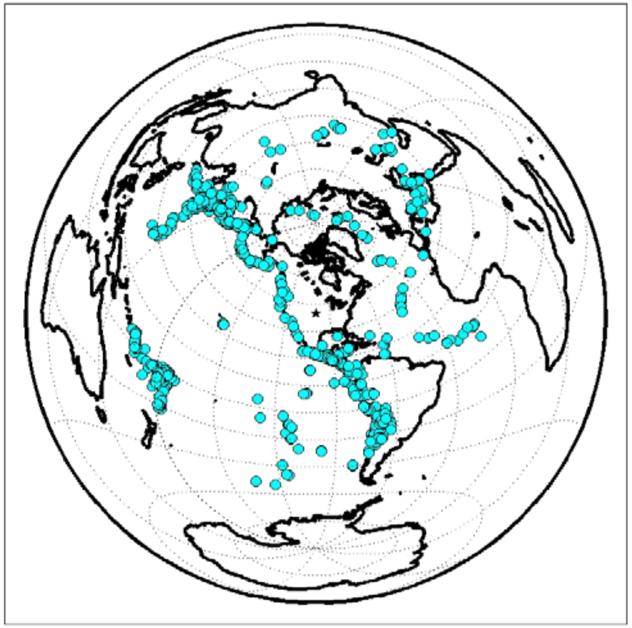
65 Myr ago



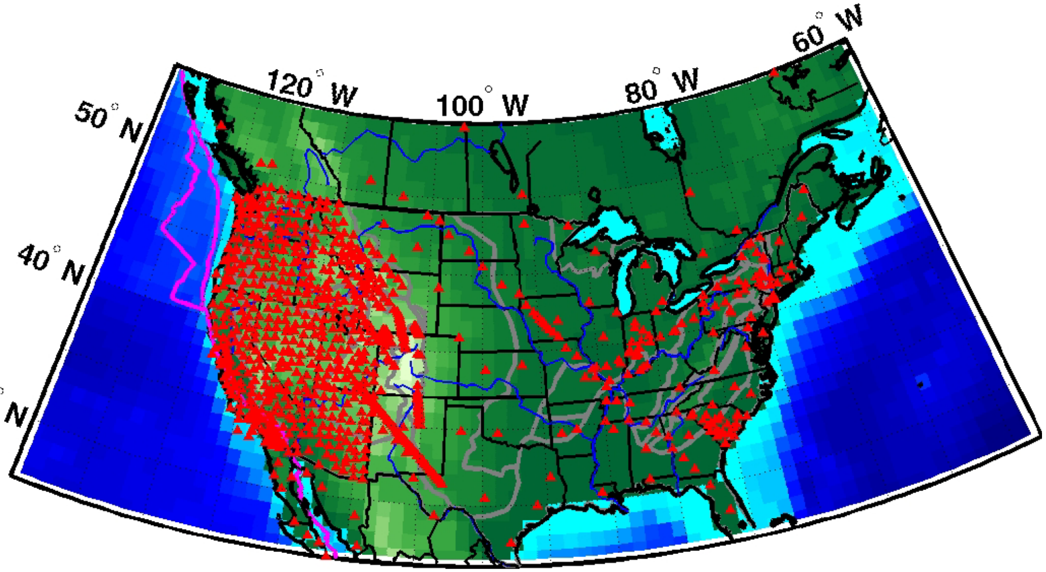
5-10 million years later: the sea is gone; 4-km-high mountains have risen.

Geometry of the body-wave tomography experiment

637 earthquake sources

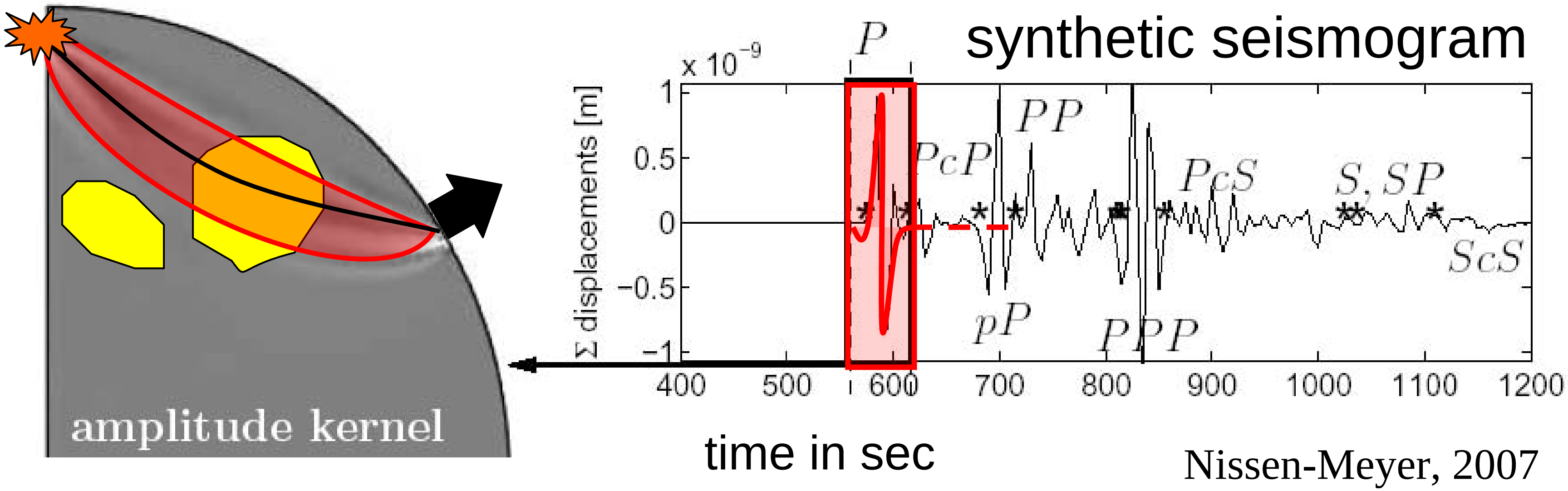


1125 broadband receivers (seismometers)



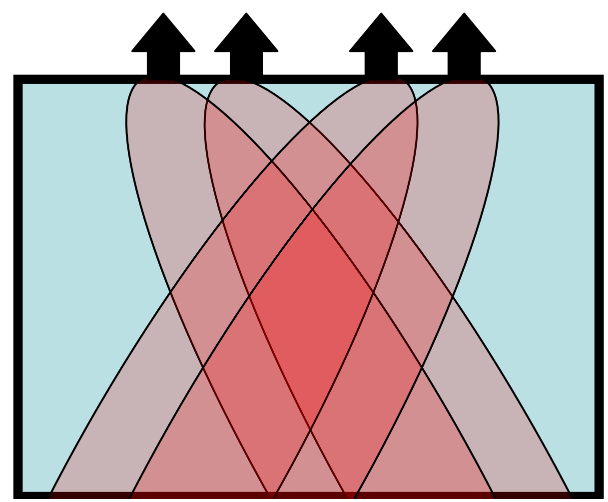
•Signal sources are P-waves generated by large but distant earthquakes

How body waves sample the earth

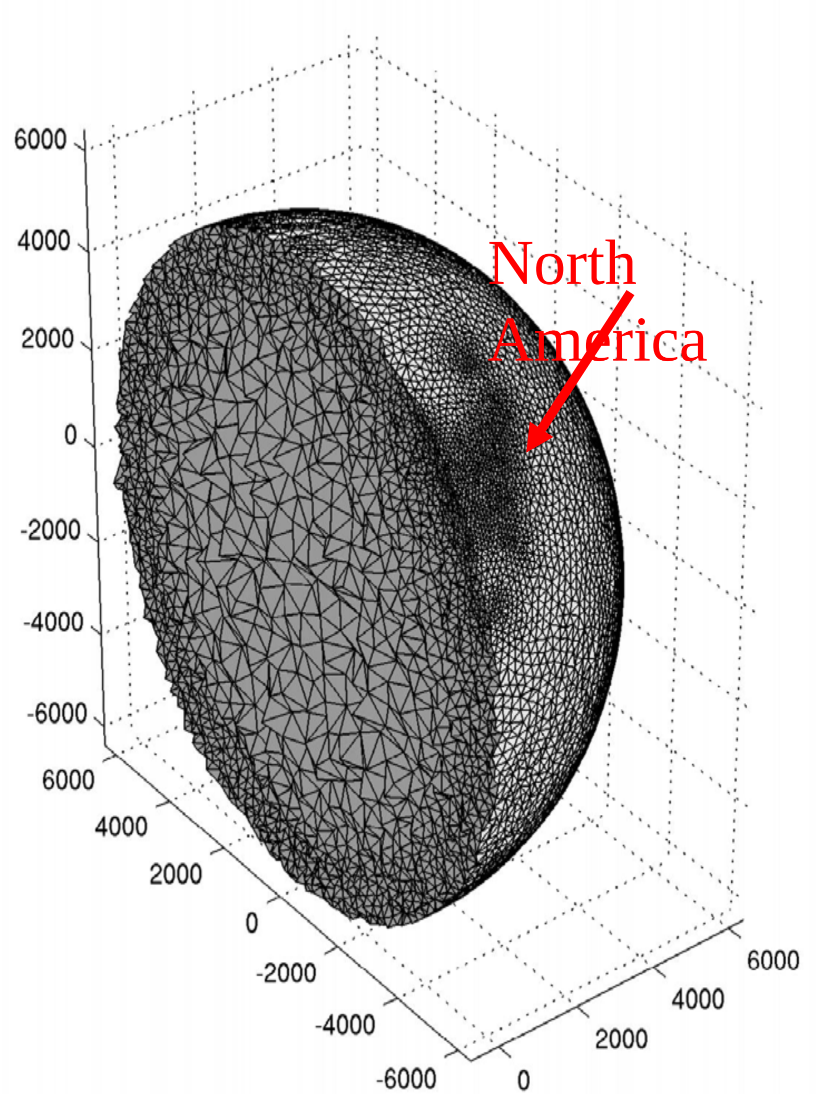


Nissen-Meyer, 2007

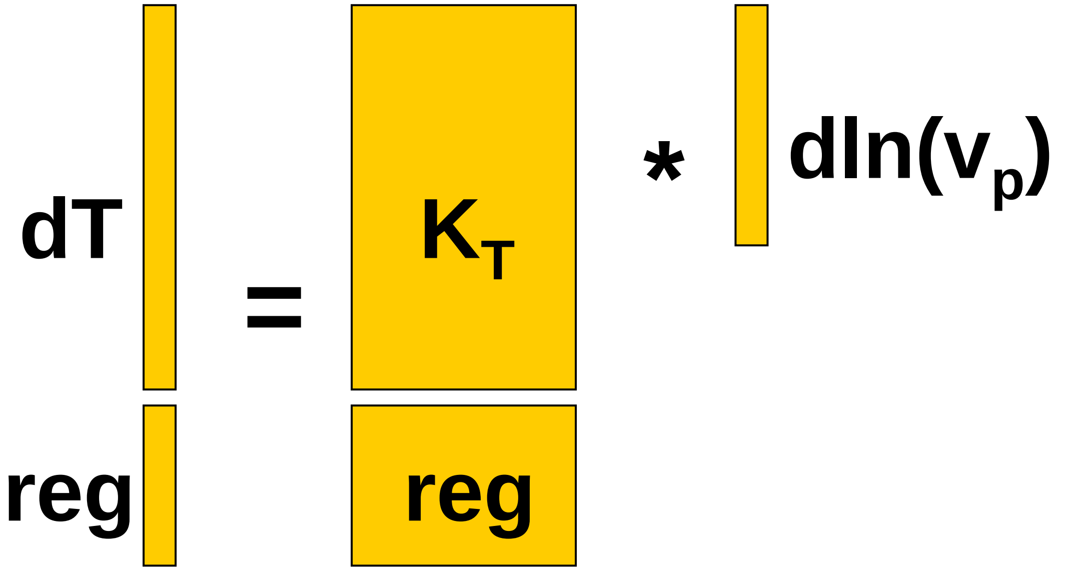
Sensitivity kernels (shaded red) map the areas sampled by the body waves used.



To solve the inverse problem, expand the sensitivity kernels on a global grid



Inverse problem (linear)

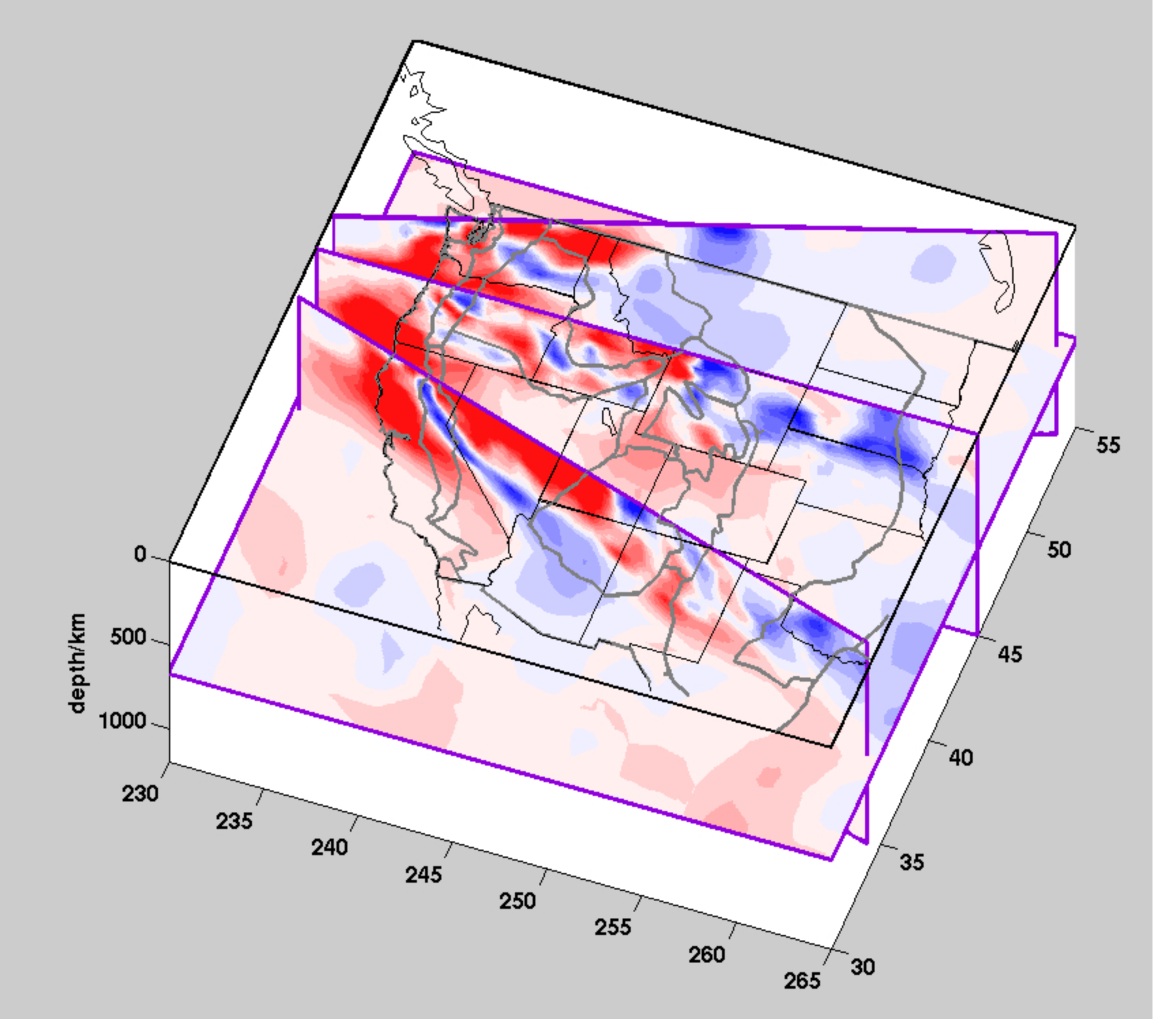


data

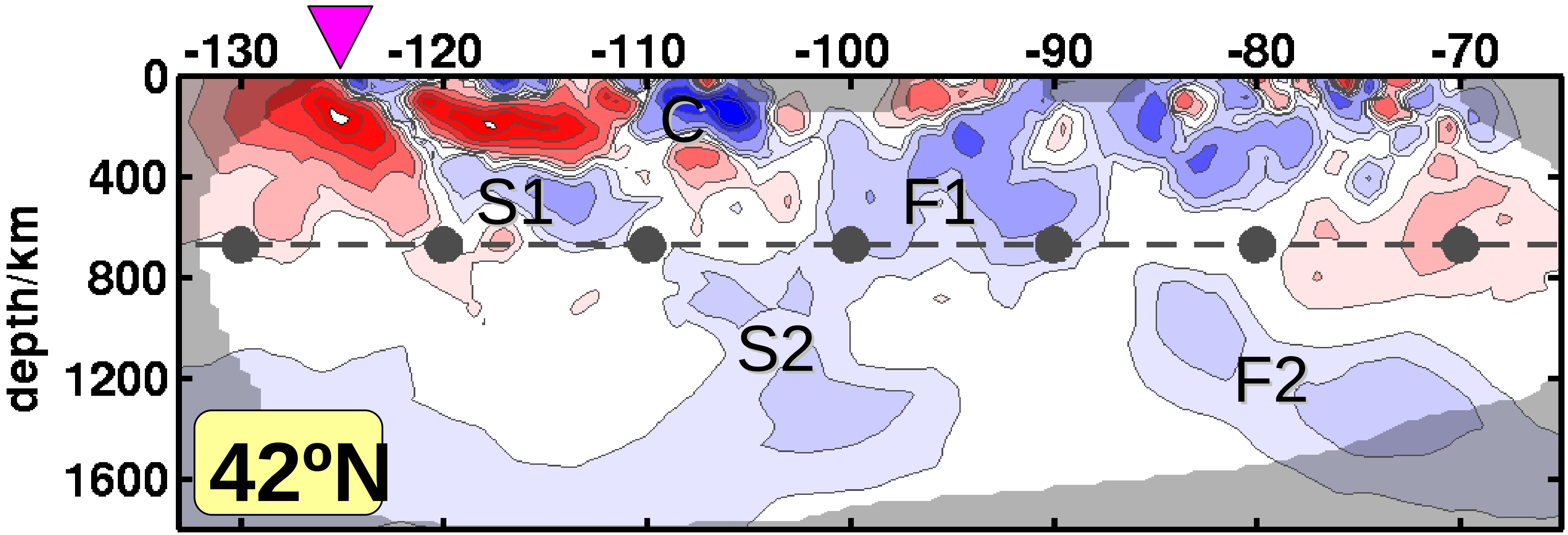
physical model
(rows = kernels)

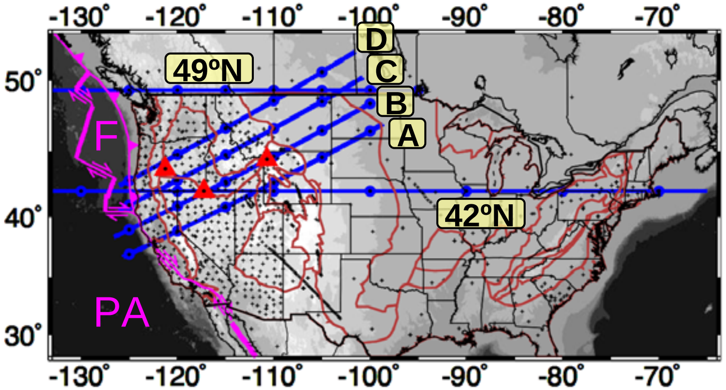
3-D earth structure
(unknowns)

Result: a 3-D model of seismic P-wave velocities under North America



The subducted slab (blue=fast=cold) in the mantle down to 1800 km depth





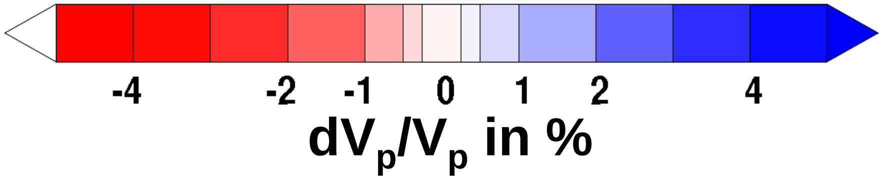
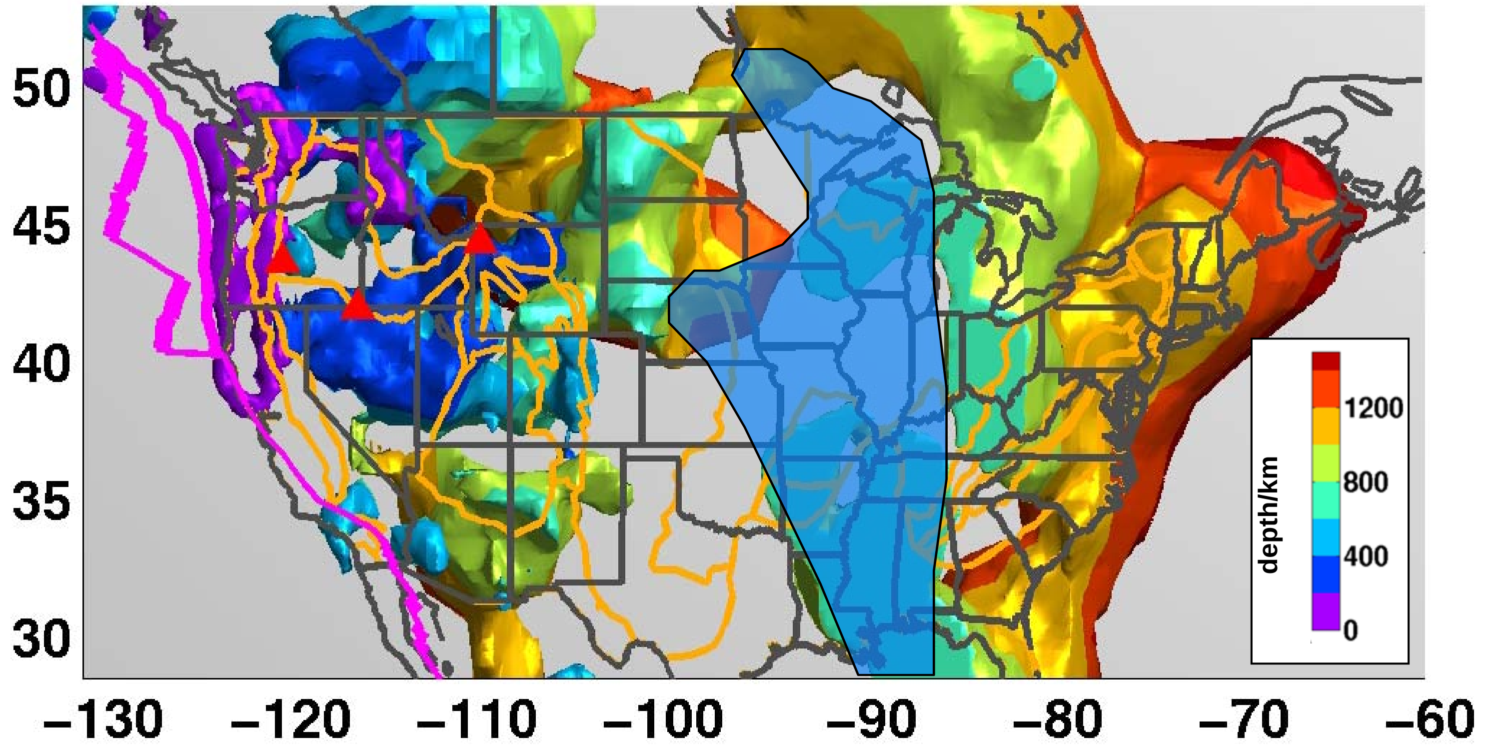


Image of the subducted Farallon slab in the mantle

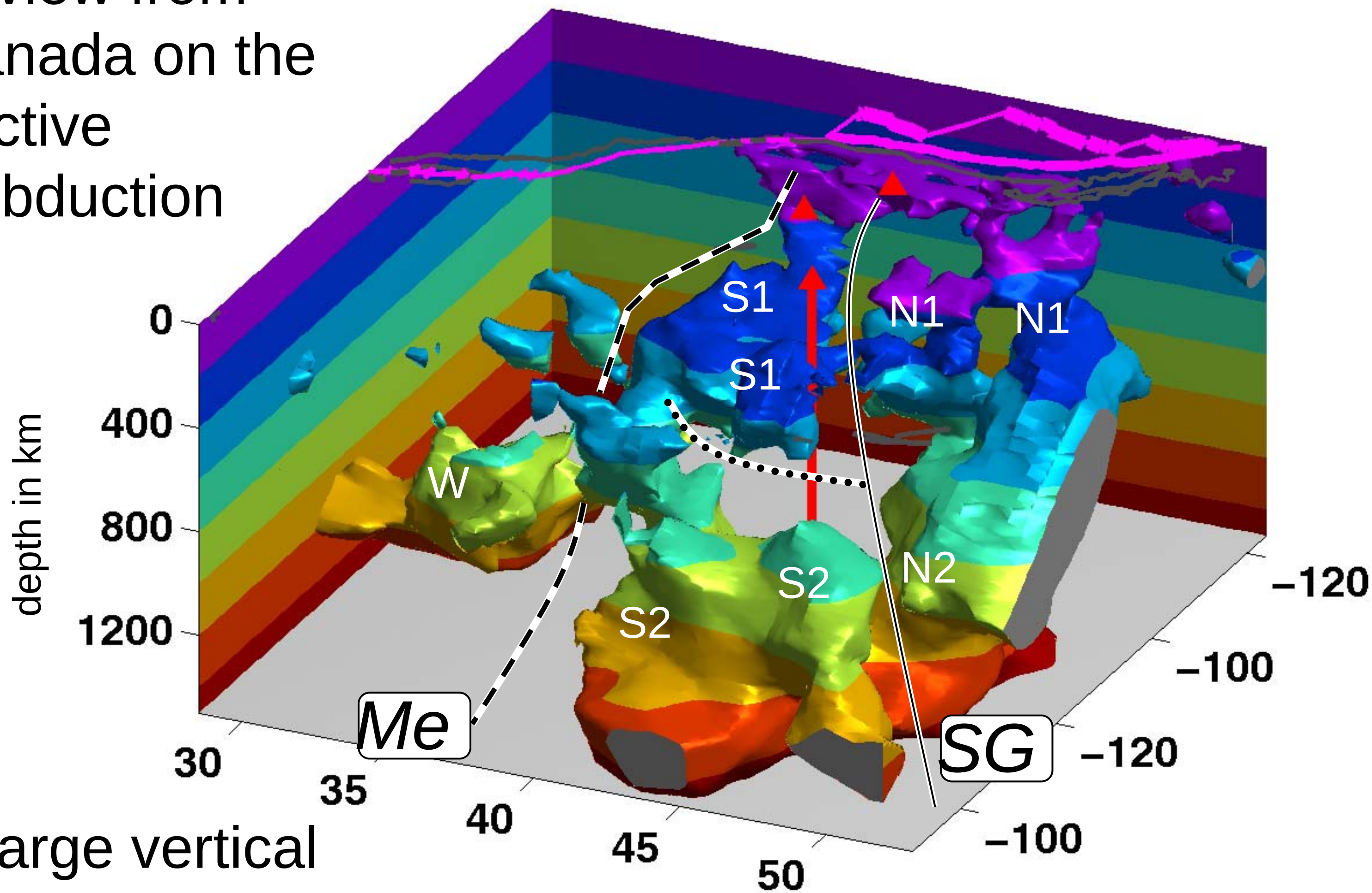


Sigloch, McQuarrie, Nolet 2008, Nature Geo

- Seismically fast material is contoured (fast means cold).
- Color signifies depth. We can confidently image ~1500 km deep.
- Crust and lithosphere not rendered.

The “current” subduction system

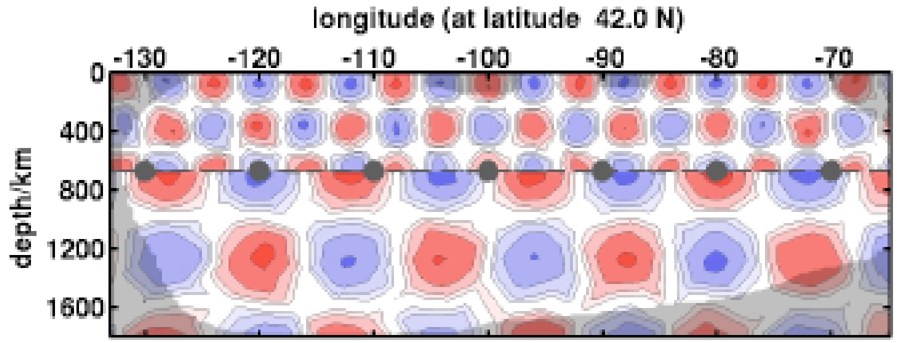
Bird’s-eye view from eastern Canada on the currently active western subduction system.



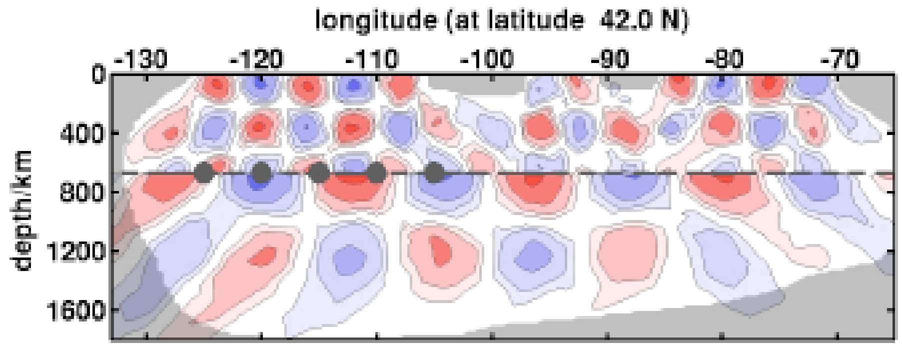
Notice the large vertical offsets of some adjacent fragments.

Resolution tests

INPUT



RECOVERED



- Assume some hypothetical earth structure
- Compute synthetic data from it
- Invert the data. Is the input structure recovered?

Questions

- New model is surprising but plausible (because it explains more geological observations that earlier models).
- How different can other plausible models be that also fit the data? Possible to generate such models a priori?
- Alternatively, at what level of confidence can we say that certain **interesting** features are real? (Example: tears in the plate, which are geodynamically important.)

Inverse problem