Steven Plescia
12/9/16

Hildebrand Analysis: Topic 1

North America was subducted to the west under Rubia

Is there evidence from seismic tomography for west-dipping subduction?

Hildebrand's model for assembling North America invokes a two-stage subduction that involves North America subducting west under Rubia. More traditional North American assembly theories have only considered east-dipping subduction of a varying number of stages.

The basis for a potential west-dipping slab comes from tomography of the east coast of North America. Grand (1997) imaged a steep dipping slab off the east coast of North America. At the time, Grand interpreted this slab to most likely be the Farallon plate subducting under North America [Figure 1]. The important feature to note is that though the overall trend appears to be steeply dipping towards the east, a section of the anomaly in the 800-1800 km range appears to be vertical (Hildebrand 2014). This is particularly true when looking at the s-wave tomography instead of the p-wave tomography.

Sigloch (2008) examined the entire U.S. using multiple-frequency p-wave tomography and discovered two east-dipping slabs [Figure 2]. The survey, despite imaging the east coast, did not show evidence of a steep dipping slab where Grand had imaged his. Instead, Sigloch imaged two bodies over the western and central United States and interpreted her eastern most body to be the Farallon Slab. This would mean that the body imaged by Grand could not be the Farallon slab and would have to be attributed to a different process.

Sigloch and Mihalynuk (2013) took a similar approach as Sigloch (2008), but this time had access to more TA stations and did image a body off the east coast of the United States [Figure 4]. This body was interpreted to be near vertical, which creates a geodynamic issue for east-dipping subduction. Sigloch and Mihalynuk proposed a process [Figure 5] by which a thick, vertical slab could be created by west-dipping subduction. They argue that east-dipping subduction could not build up a thick, vertical slab column due to the constant westward migration of the trench.

My interpretation of these tomographic images differs from the authors'. I believe these bodies are dipping eastward, albeit steeply. This would not create the same geodynamic issue that Sigloch and Mihalynuk (2013) call upon and therefore would not necessitate west-dipping subuduction. In fact, I believe these tomographic images go so far as to strongly support east-dipping subduction as the preferred North American assembly model.

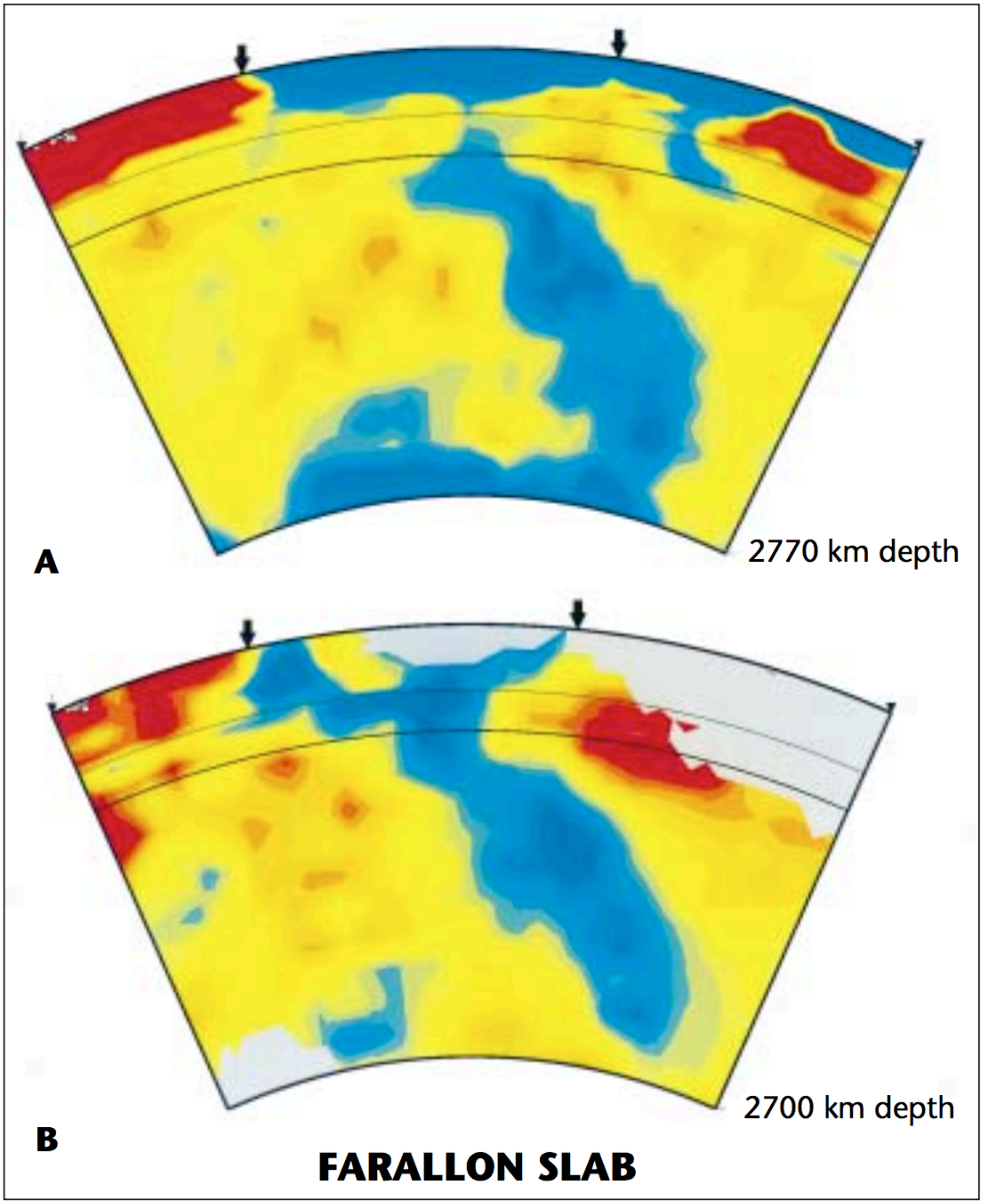

Figure 1: Cross sections of mantle P-wave (A) and S-wave (B) velocity variations along a section through the southern United States. The endpoints of the section are 30.1°N, 117.1°W and 30.2°N, 56.4°W. The images show variations in seismic velocity relative to the global mean at depths from the surface to the core-mantle boundary. Blues indicate faster than average and reds slower than average seismic velocity. The large tabular blue anomaly that crosses the entire lower mantle is probably the descending Farallon plate that subducted over the past ~100 m.y.

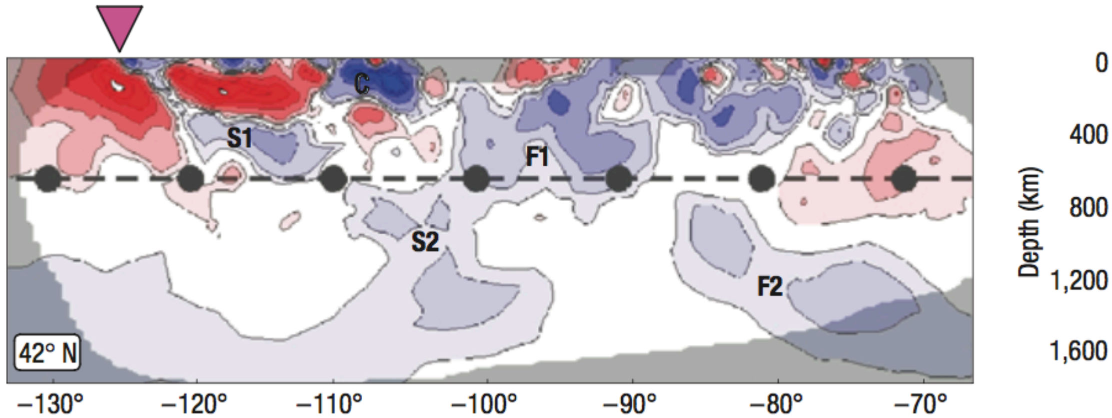

Figure 2: P-wave velocity anomalies in the North American mantle down to 1,800 km depth. The profile of this cross-section is the long east-west line in Figure 3.

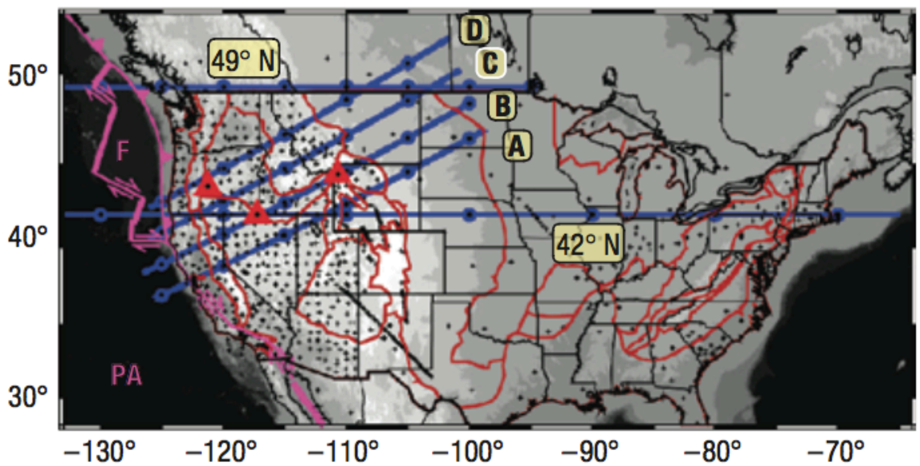

Figure 3: Map showing the tomographic cross-sections of all the profiles in Sigloch 2008. The long, horizontal profile cutting across the United States from west to east is the profile for Figure 2.

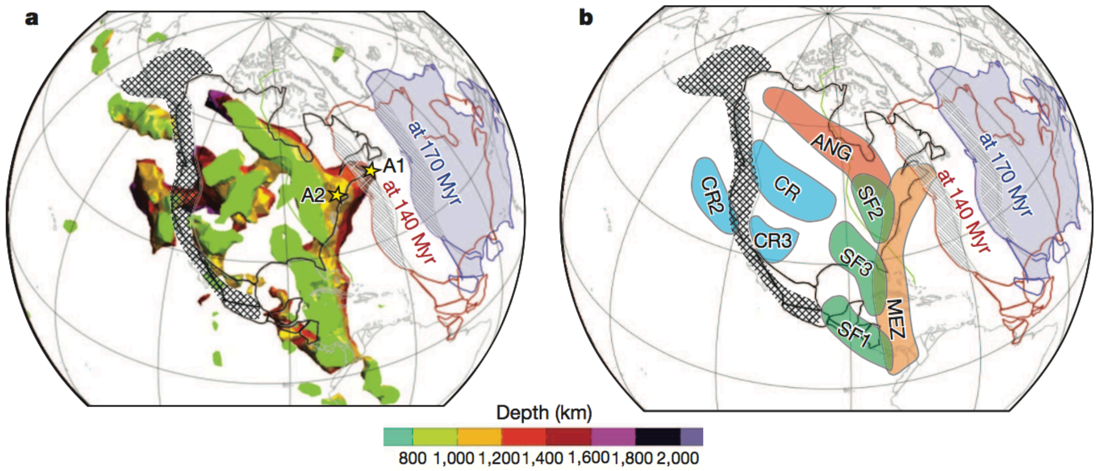

Figure 4: Slabs under North America and continental motion over time. **a)** Subducted slabs at and below 900 km depth. P-wave tomography model[13] rendered as three-dimensional (3D) isosurface contours, which enclose faster- than-average structure (threshold dvP/vP 5 0.25%, where vP is the P-wave velocity). Colour signifies depth and changes every 200 km; the scene is illuminated to convey 3D perspective. **b)** Interpretative legend.

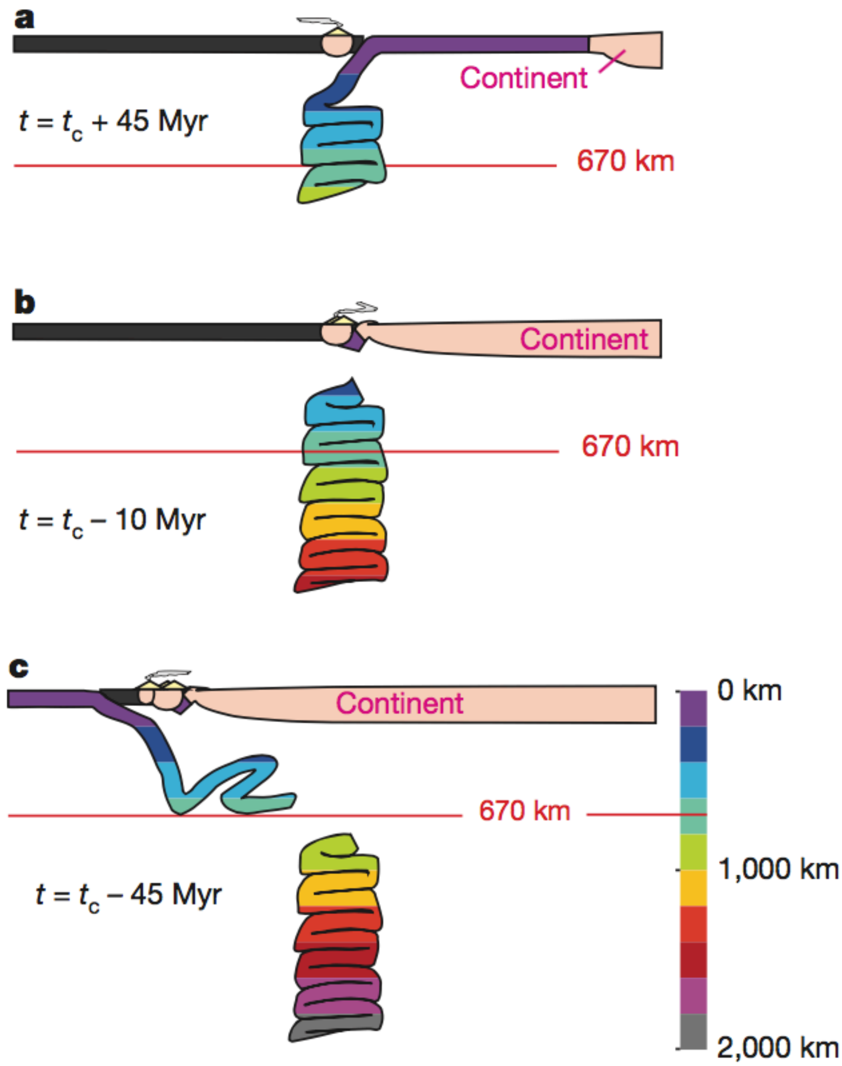

Figure 5: Schematic cross-section and evolution of a terrane station. t_C denotes the time of arc-continent collision. Motions are shown in a lower- mantle reference frame. **a)** Well before the collision, both trench and arc are active. Slab buckling is due to the viscosity contrast around 670 km, but the backlog reaches into the upper mantle. **b)** Around t_C and up to about 10 Myr later, the continent overrides the trench and accretes its arc terranes, while the slab breaks. **c)** Well after the collision, the slab wall continues to sink. Seaward, a new Andean-style subduction has developed. Anchored in the lower mantle, the slab wall is sinking vertically at a steady-state rate of approximately 10 mm yr^{-1} in all three panels.

References:

- Grand, Stephen P., van der Hilst, Rob D., and Widiyantoro, Sri., Global Seismic Tomography: A Snapshot of Convection in the Earth, *GSA Today*, 1997, 7 (4), p. 1-7.
- Hildebrand, Robert S., Did Westward Subduction Cause Cretaceous–Tertiary Orogeny in the North American Cordillera? *Geological Society of America Special Papers,* 2009, 457, p. 1-71, doi:10.1130/2009.2457
- Hildebrand, Robert S., Mesozoic Assembly of the North American Cordillera. *Geological Society of America Special Paper,* 2013, 495, p 1-169.
- Hildebrand, Robert S., Geology, mantle tomography, and inclination corrected paleogeographic trajectories support westward subduction during Cretaceous orogenesis in the North American Cordillera, *Geoscience Canada*, 2014, v.41, p. 207–224, http://dx.doi.org/10.12789/geocanj.2014.41.032.
- Sigloch, Karen, and Mihalynuk, Mitchell G., Intra-oceanic subduction shaped the assembly of Cordilleran North America, *Nature*, 2013, v. 496, p. 50–56, http://dx.doi.org/10.1038/nature1201
- Sigloch, Karen, McQuarrie, Nadine, and Nolet, Guust, Two-stage subduction history under North America inferred from multiple-frequency tomography, *Nature Geoscience*, 2008, v. 1, p. 458–462, http://dx.doi.org/10.1038/ngeo231.