

Seismic structure of the Aleutian island arc near Adak: Finally, a Subduction Factory that actually makes continental crust?

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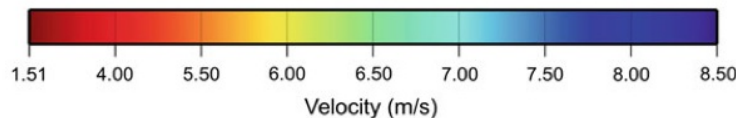
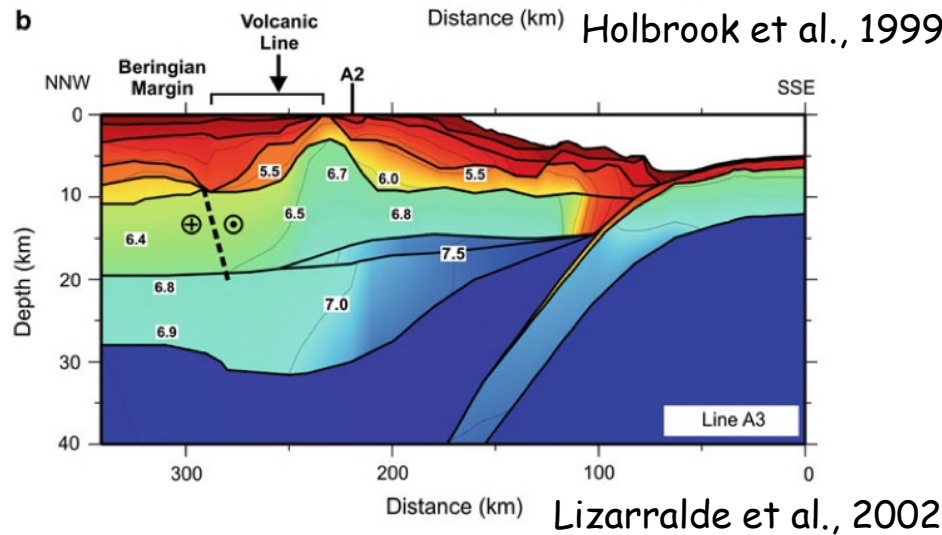
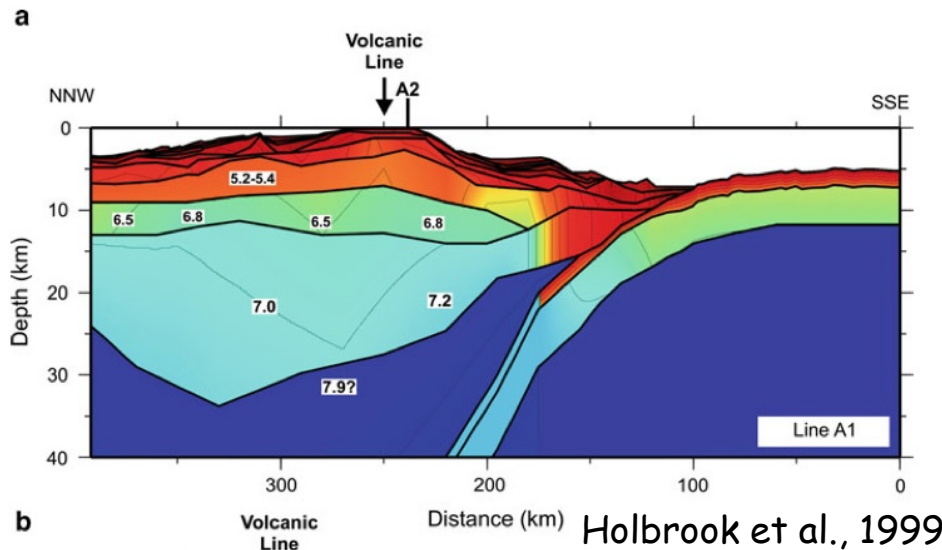


The Andesite Paradox

"The origin and composition of continental crust — particularly the lower crust — remain enigmatic. The principal conundrum to be resolved is how an andesitic to dacitic continental crust has formed when most mantle-derived magmas are basaltic."

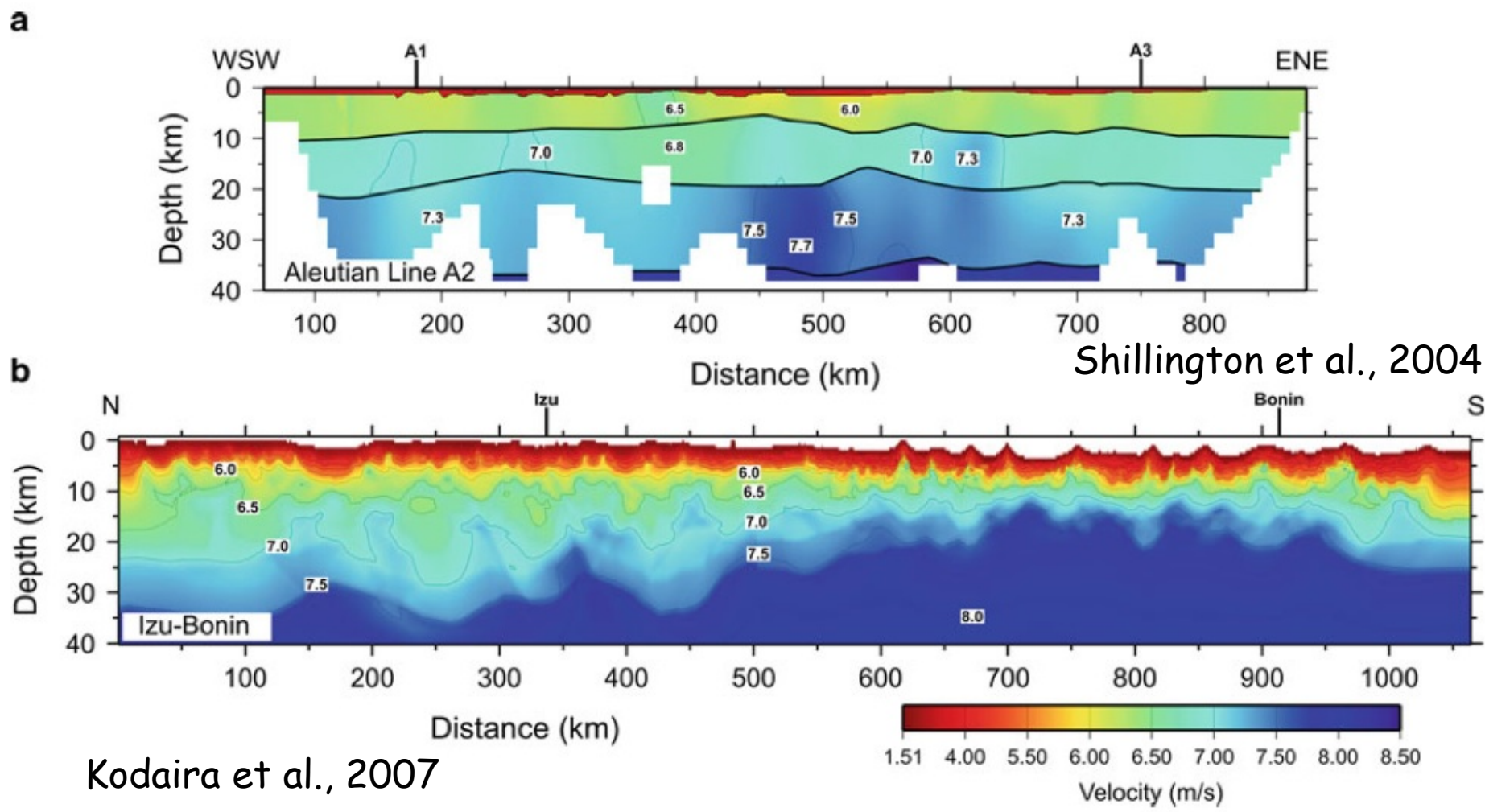
- Hacker et al., 2011

Crustal Structure of Island Arcs



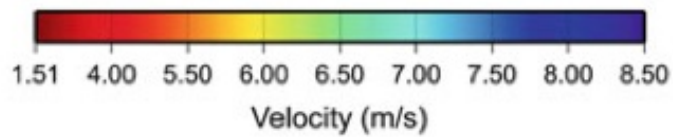
- Crustal thickness ~25-30 km beneath the Aleutian arc.
- Note the paucity of material with a velocity of 6.0-6.2 km/s.

Crustal Structure of Island Arcs

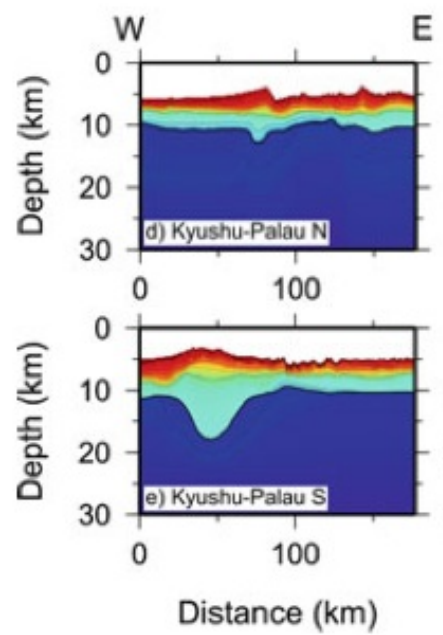


Kodaira et al., 2007

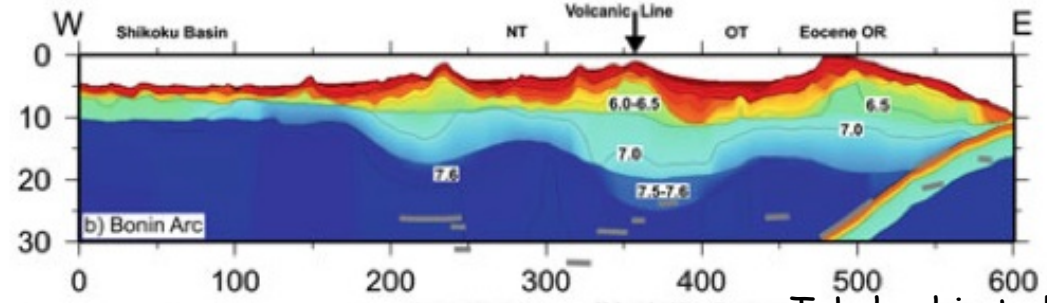
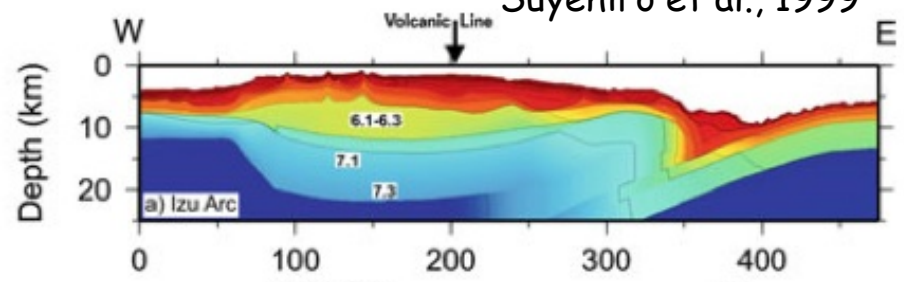
Crustal Structure of Island Arcs



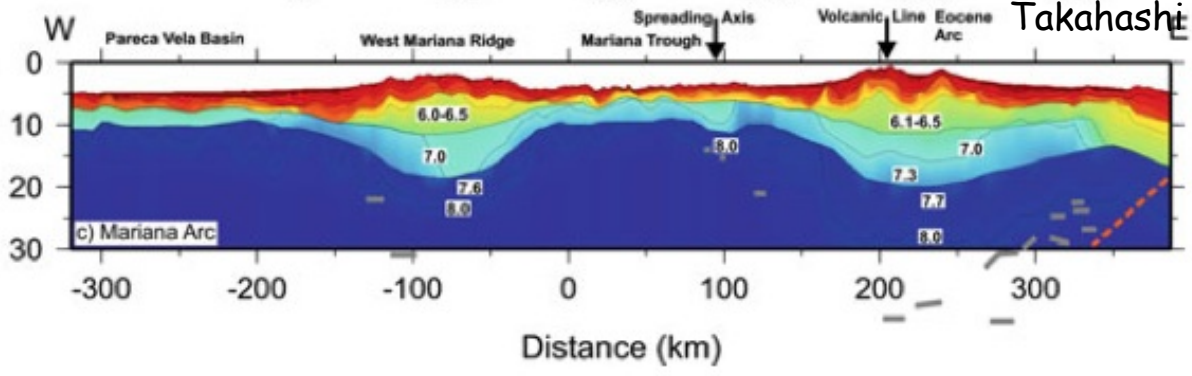
Nishizawa et al., 2007



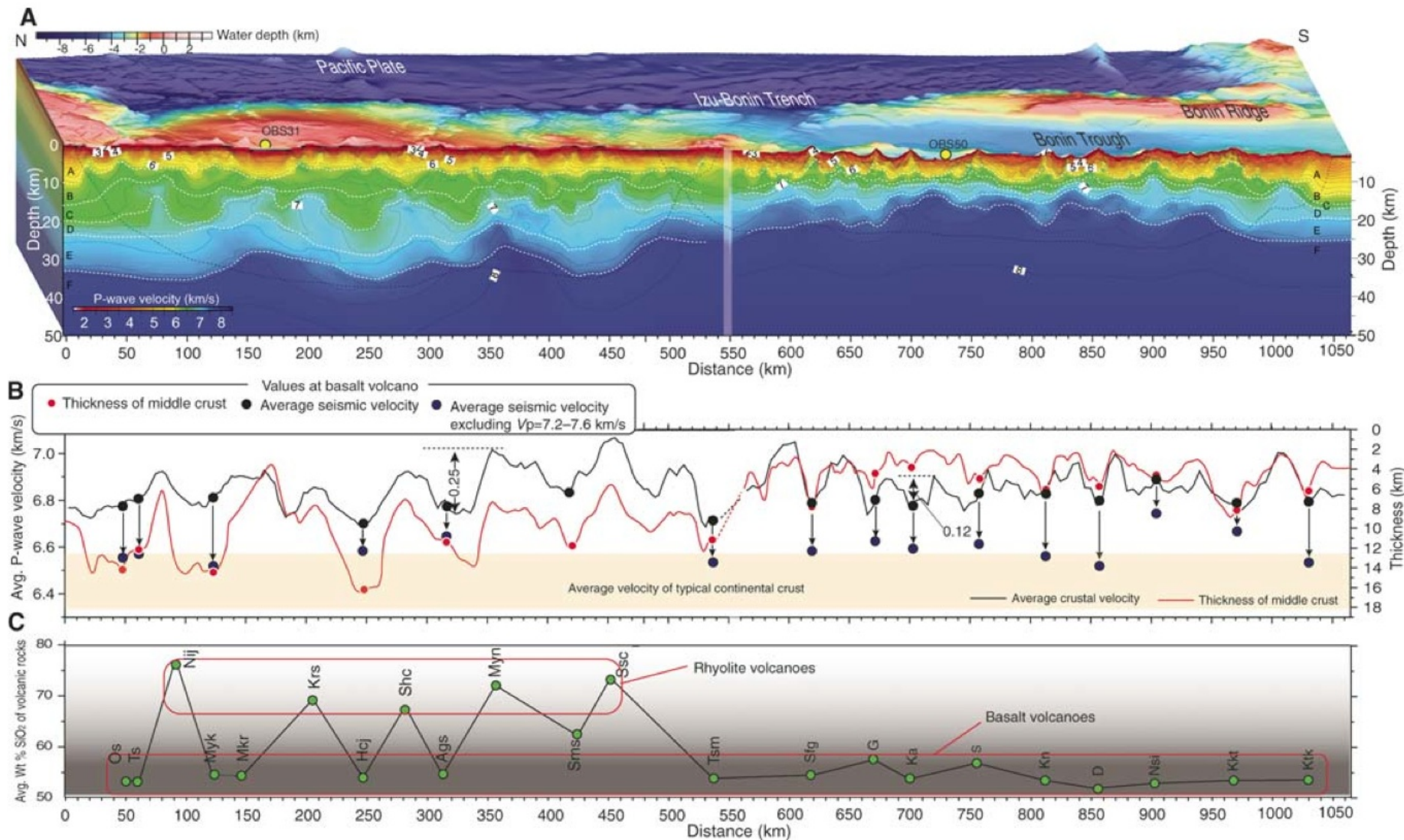
Suyehiro et al., 1999



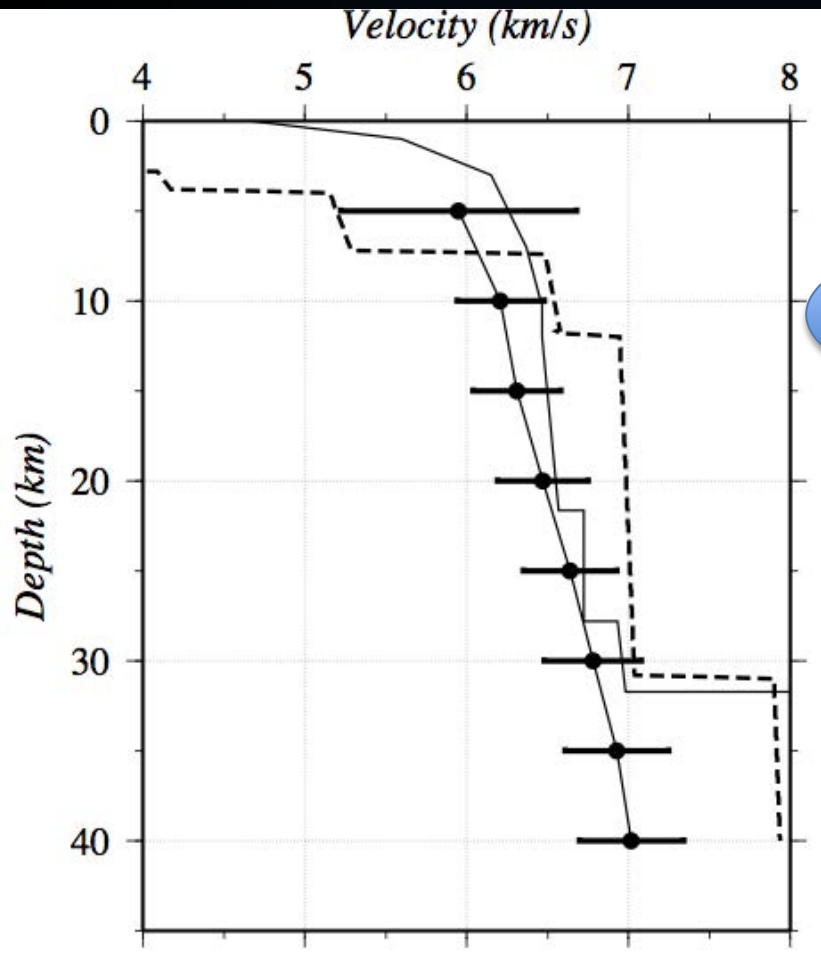
Takahashi et al., 2009



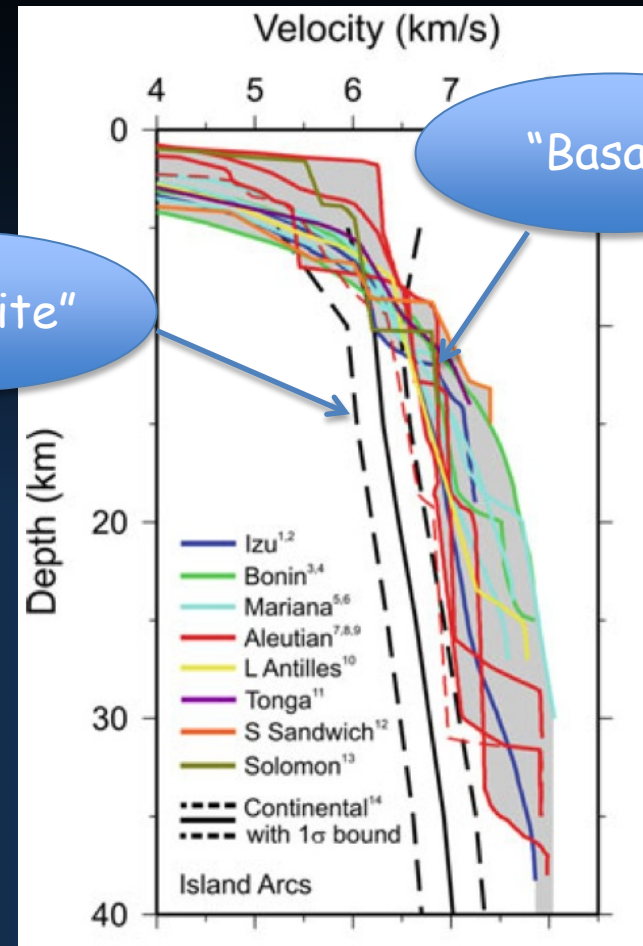
Crustal Structure of Island Arcs



Velocity Structures of Island Arcs



Holbrook et al., 1999



Calvert, 2011

Solutions to the Andesite Paradox

1. Delamination. A mafic/ultramafic, perhaps eclogitized, lower crust becomes gravitationally unstable (in the arc or upon continental accretion) and sinks into the mantle.
1. Temporal/Spatial Variability. At some times and places, arcs do produce crust that resembles (chemically and geophysically) bulk continental crust.
1. Arcs aren't really basaltic. Relamination (Hacker et al., 2011) produces a felsic lower crust that has seismic P-velocities similar to gabbro.
1. Arcs are unimportant. The vast majority of continental crust was produced by processes other than arc magmatism.

Scientific Questions

- Can island arcs, *anywhere*, create crust that looks *geophysically* like bulk continental crust?

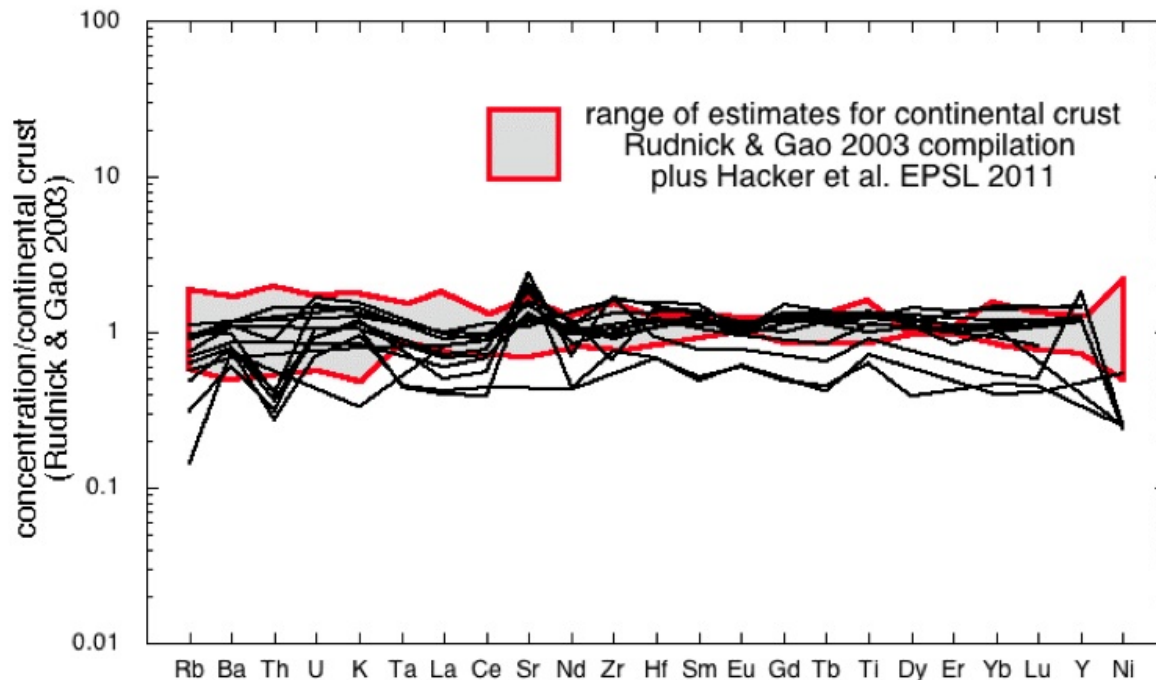
→ Hypothesis: The Aleutian arc, near and west of Adak, has a seismic velocity structure consistent with average continental crust.

- What magmatic processes (differentiation, focusing) control crustal composition and the distribution of volcanoes?

→ Hypothesis: Crustal thickness and crustal velocity structure correlate with the geochemistry of lavas and/or plutons along the arc.

Crustal-Scale Seismics: Why the Aleutians?

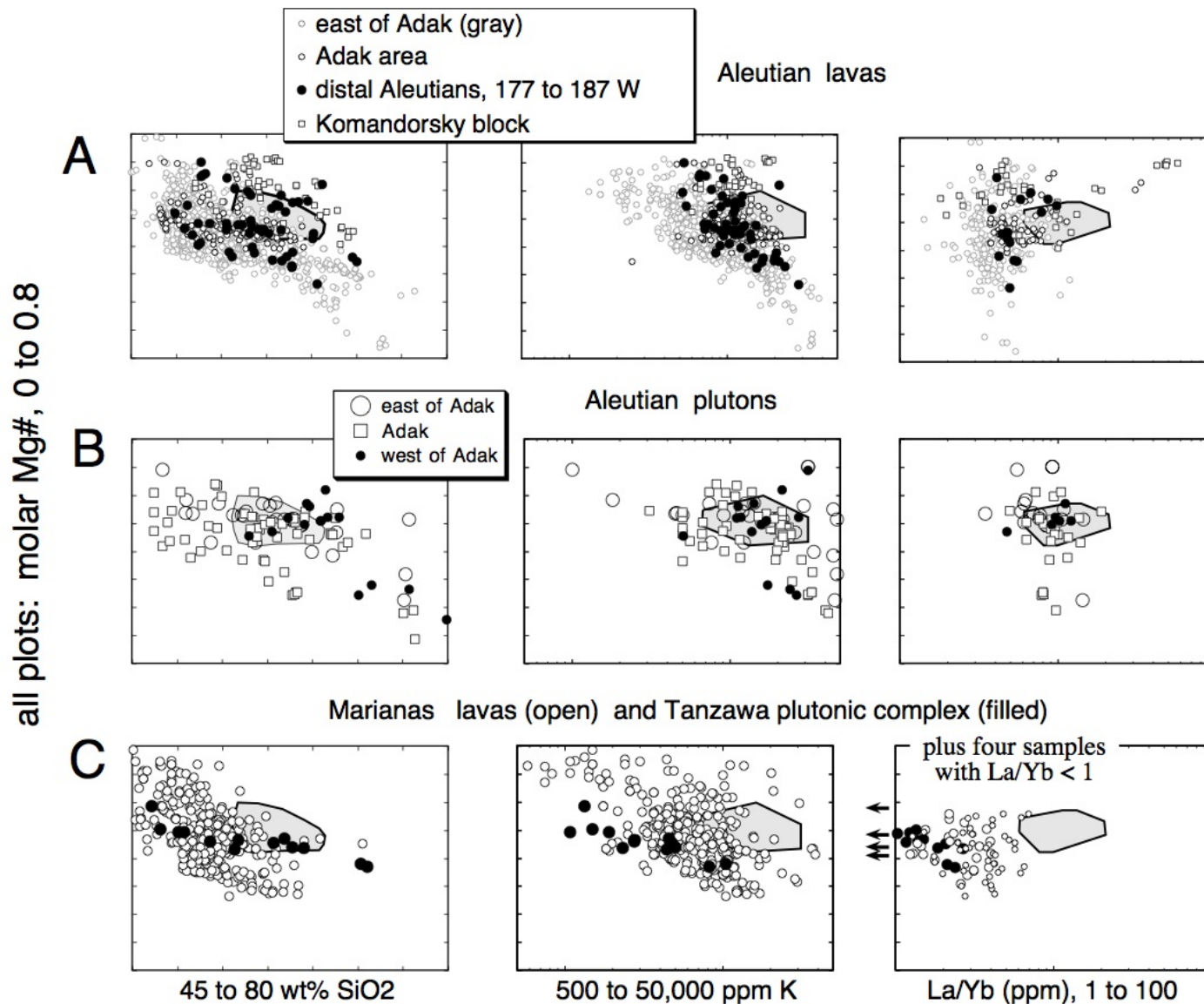
- *Intact* intraoceanic arc
- Plutonic compositions most similar to continental crust of all island arcs.
- Along-strike changes in forcing functions.



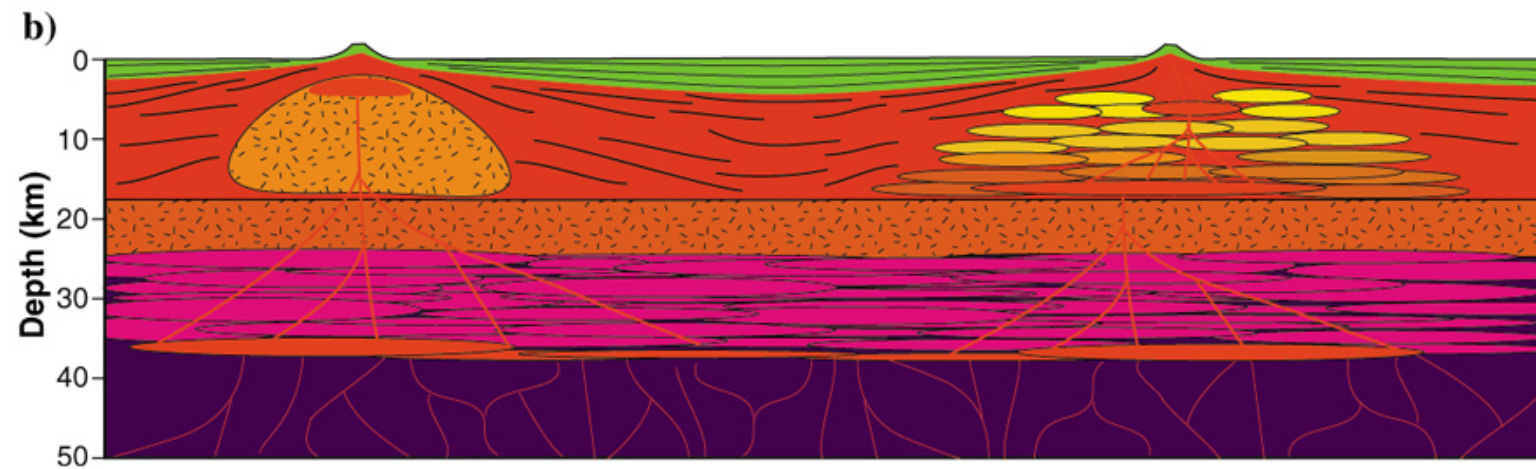
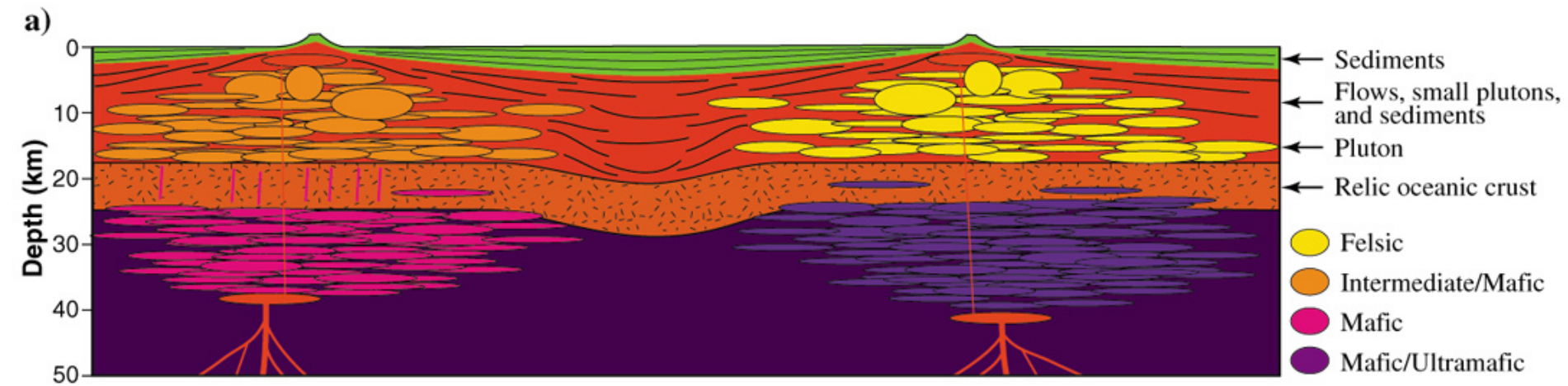
Aleutian plutons
 $56 < \text{wt\% SiO}_2 < 65$
 $0.4 < \text{molar Mg\#} < 0.6$

Figure 1: All Aleutian plutons with major elements similar to continental crust that have INAA trace element data, normalized to continental crustal estimate of Rudnick & Gao Treatise on Geochem 2003.

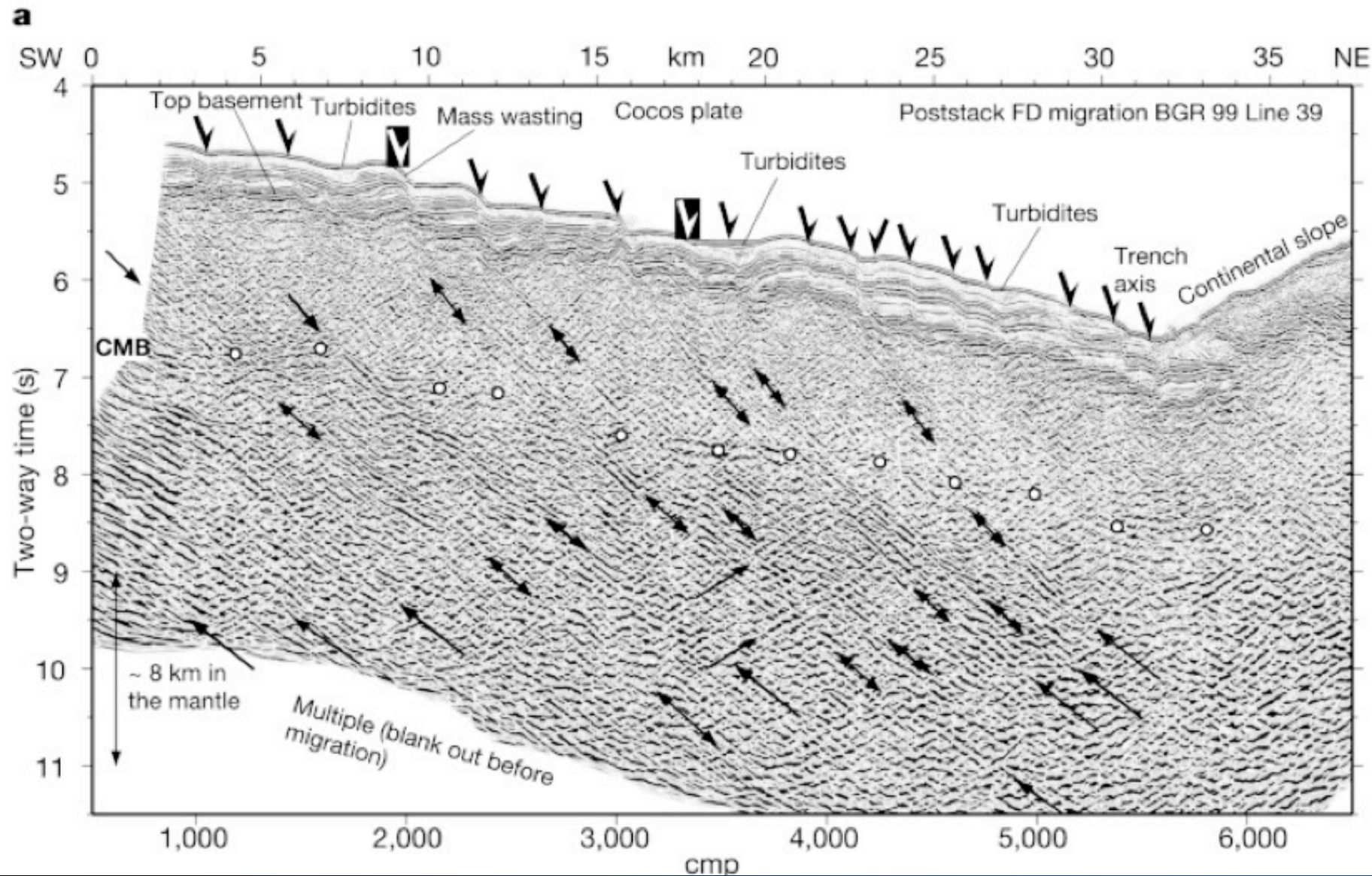
Crustal-Scale Seismics: Why the Aleutians?



Fractionation Processes and Magma Pathways

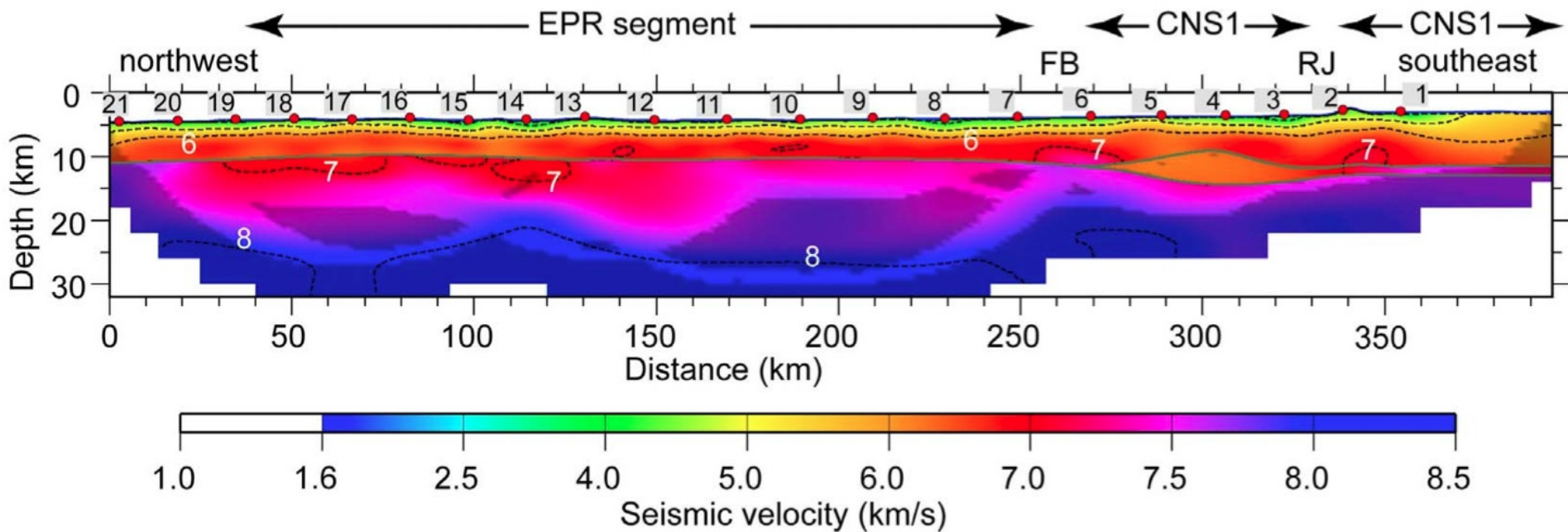


Volatiles and Fluids: Serpentinization

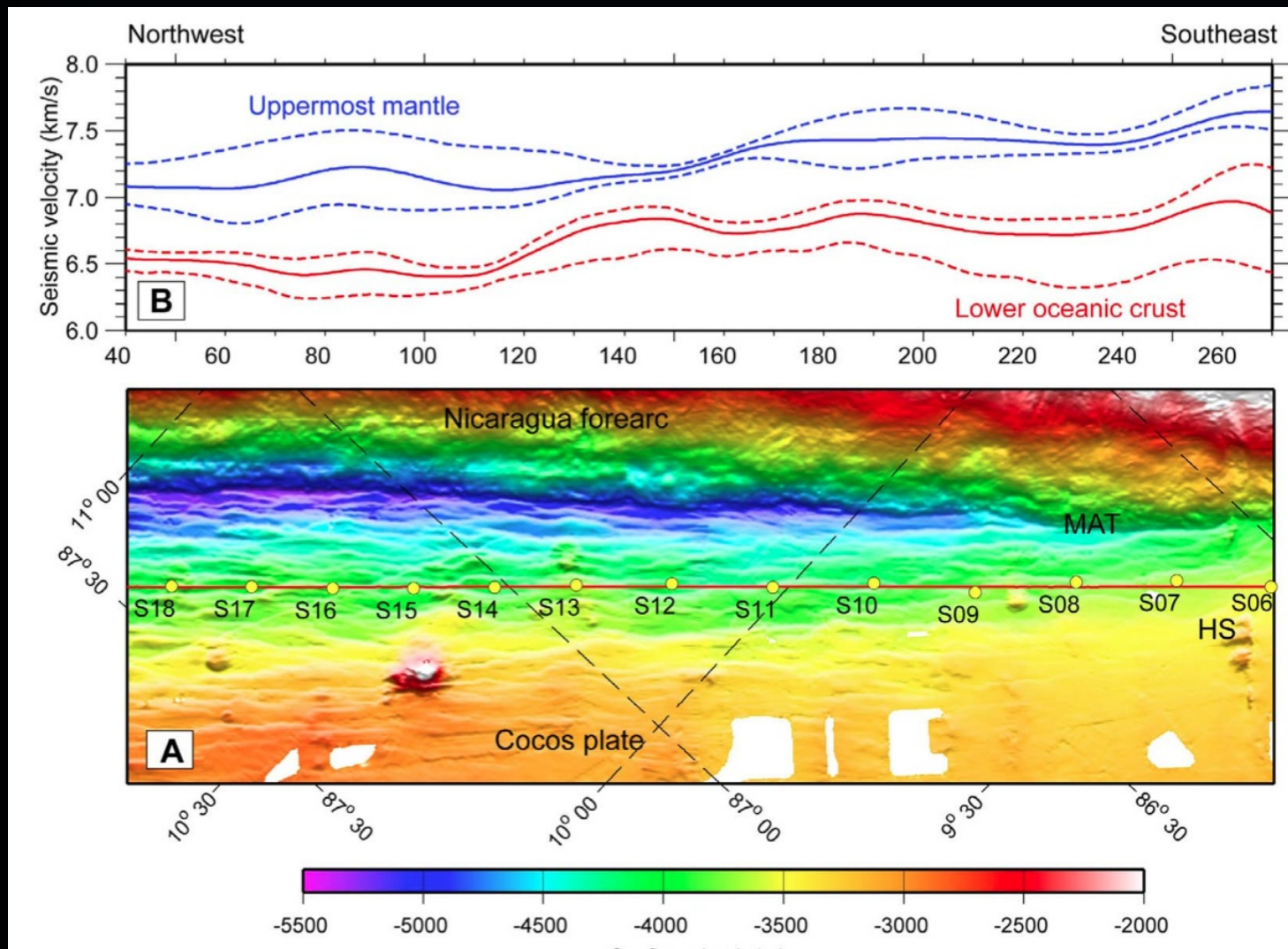


Ranero et al., 2003

Volatiles and Fluids: Serpentinization in the Downgoing Plate

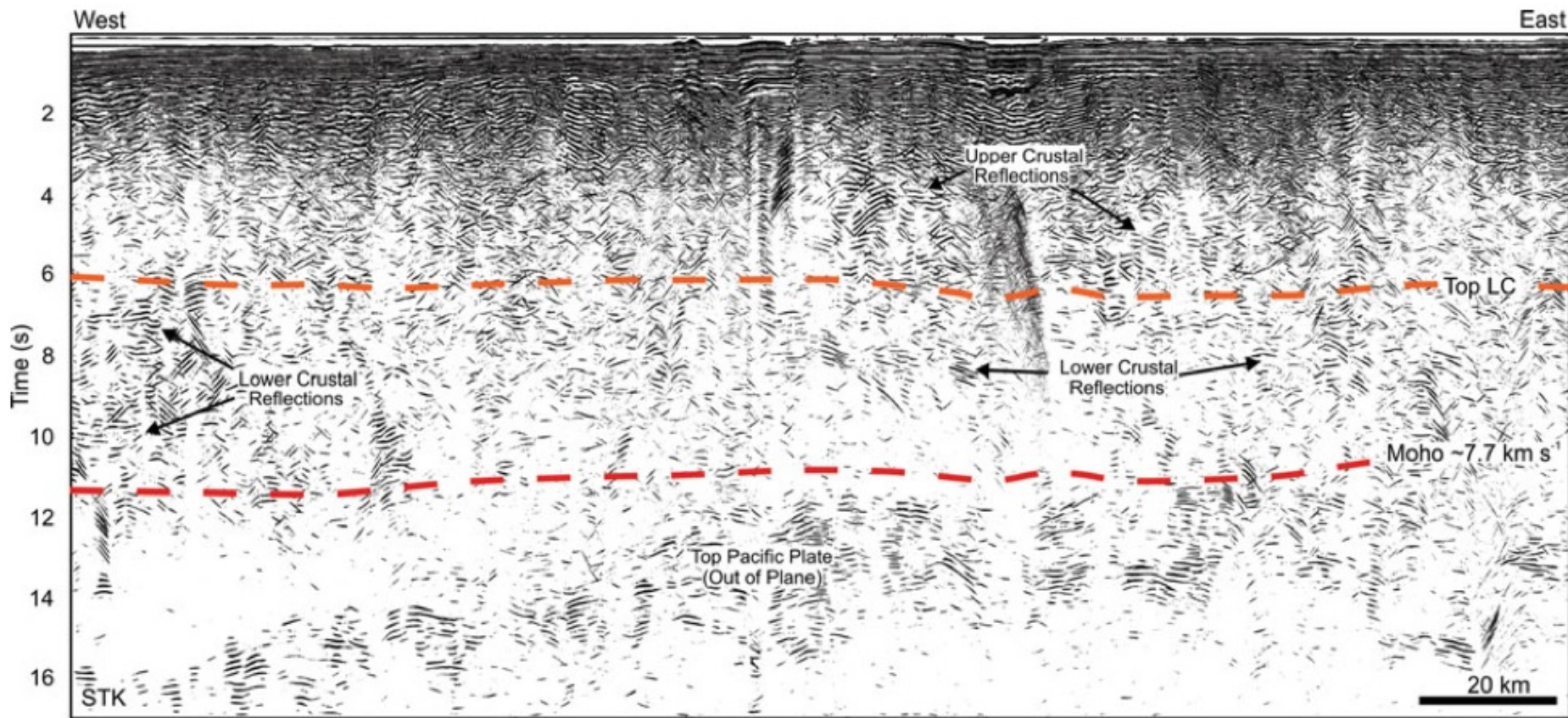


Volatiles and Fluids: Serpentinization in the Downgoing Plate

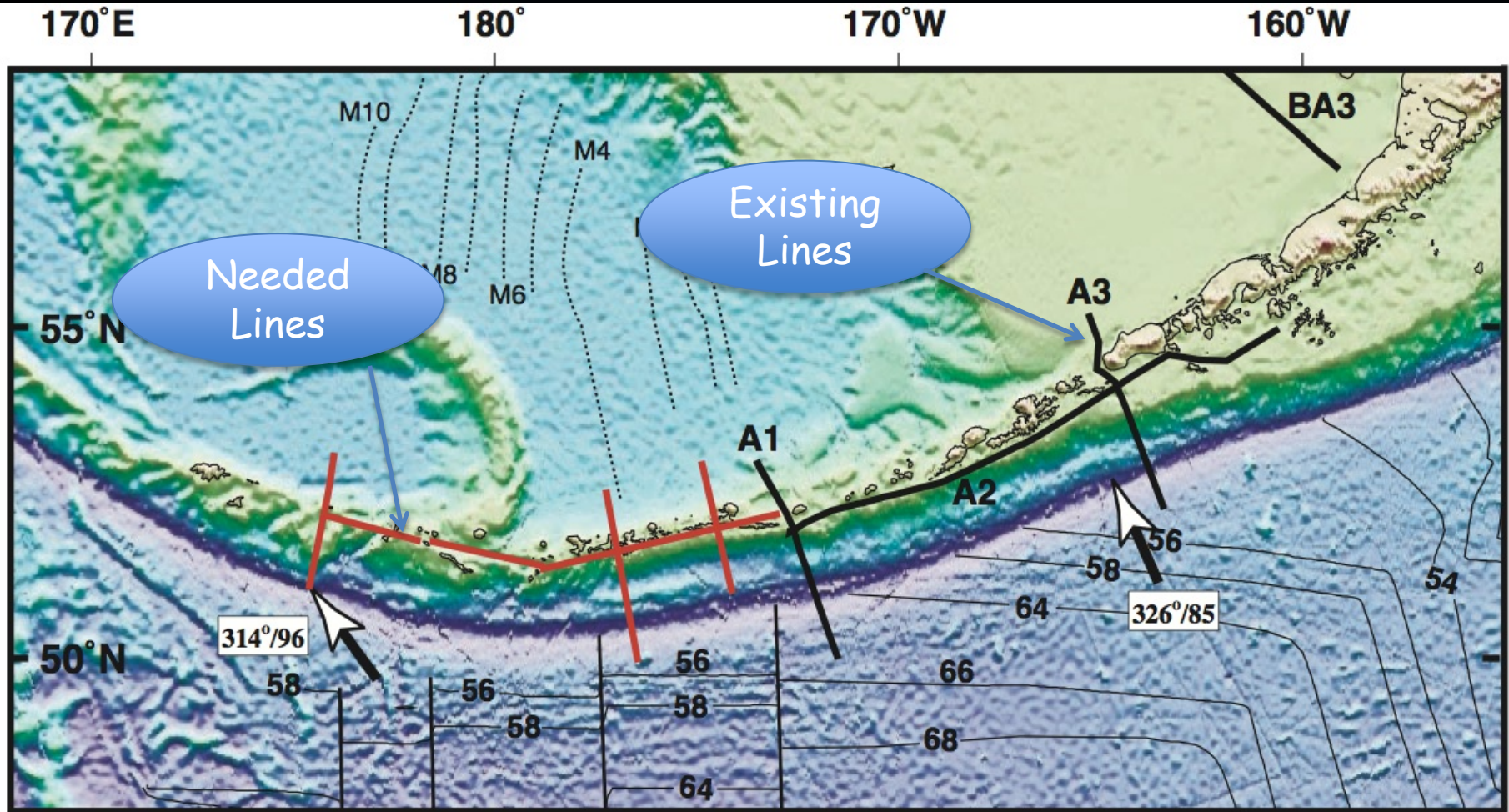


Van Avendonk et al., 2011

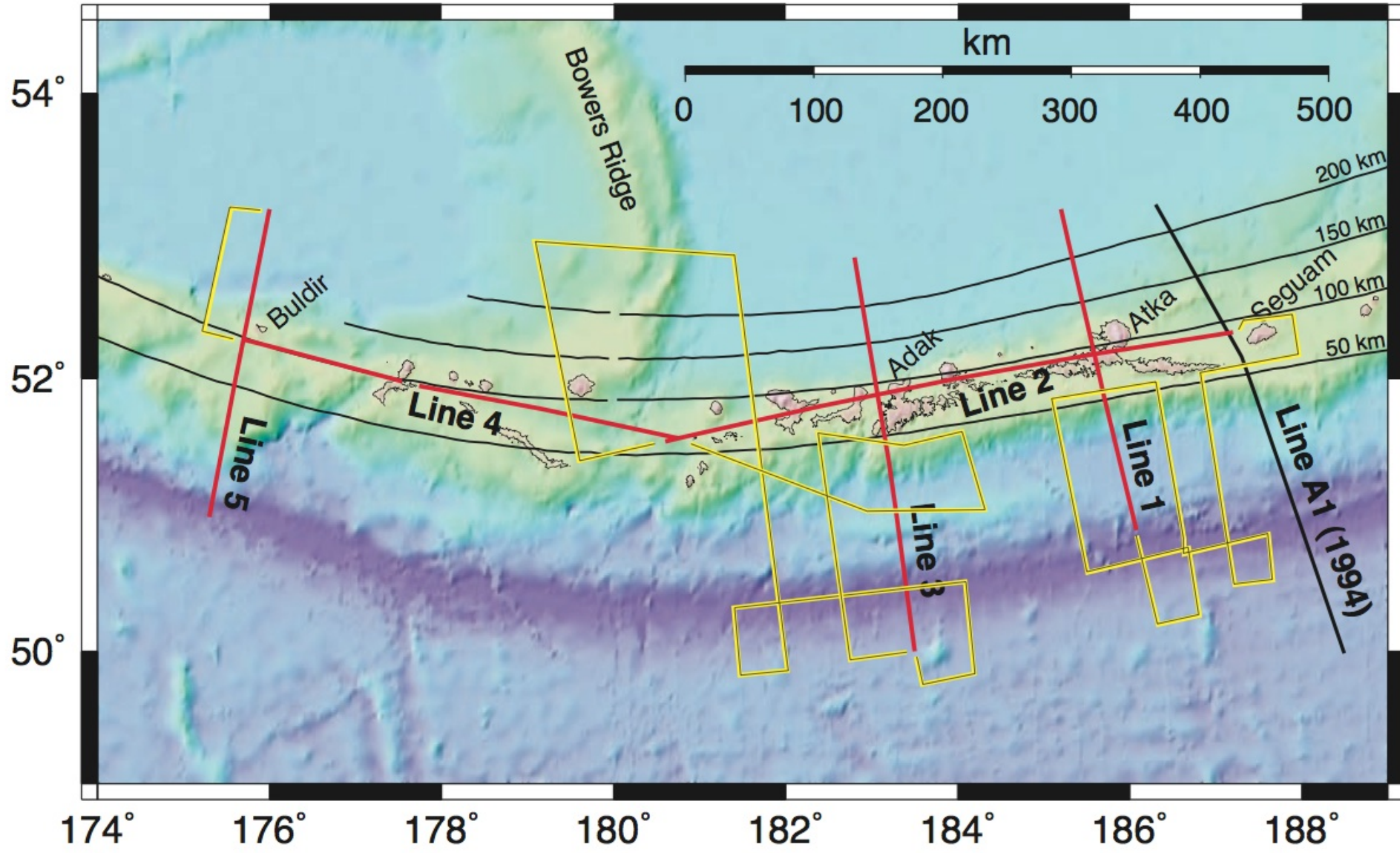
When do Continents Acquire Lower-Crustal Reflectivity?



A Notional Survey



A Notional Survey



Considerations

1. Coordination. Active-source seismic surveys should be spatially coordinated with other activities, including:
 - passive-source imaging
 - earthquake studies
 - Earthscope deployments
 - geochemical sampling
1. Shear Waves. Onshore seismometers should be deployed on islands to increase chances of recording converted S-waves. Ideally, the distribution of Poisson's ratio in the crust would be determined.