What makes the lithosphere strong and the asthenosphere weak?

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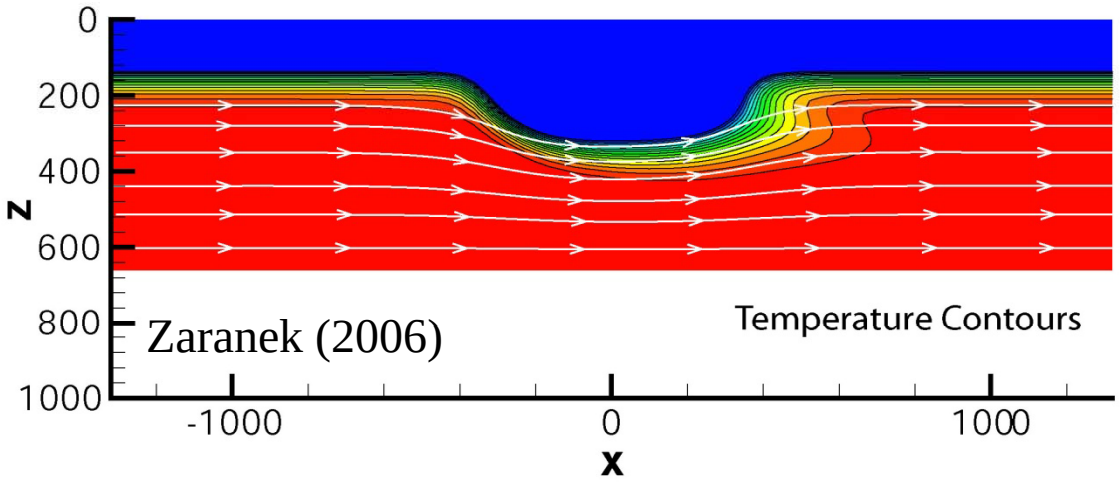
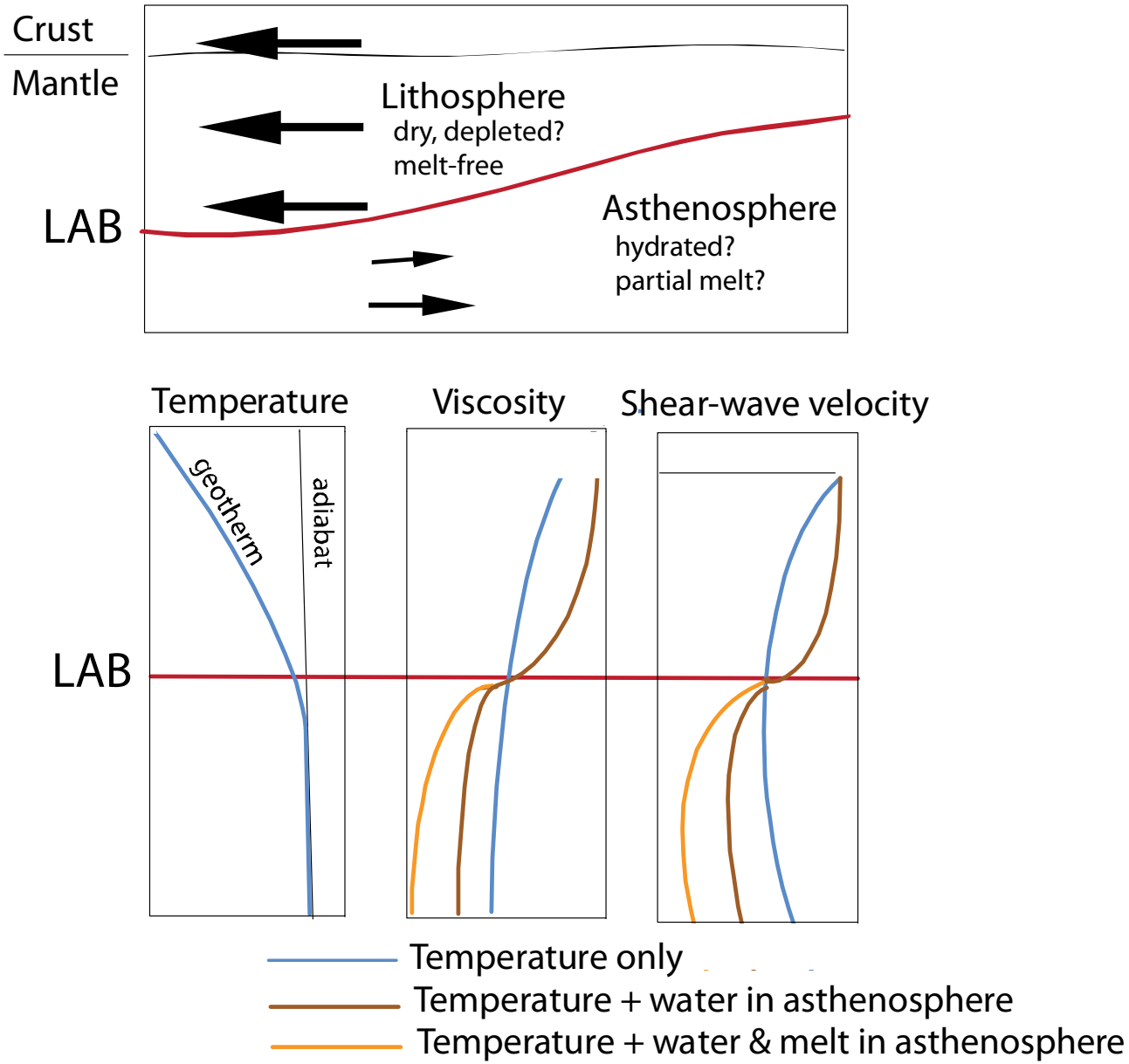
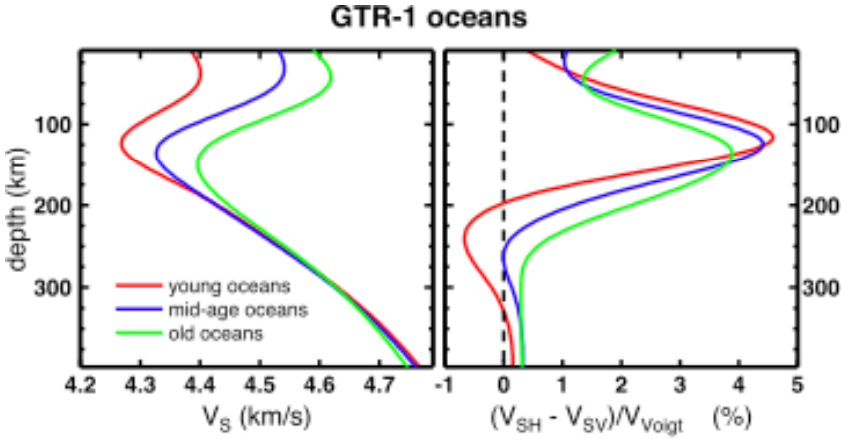
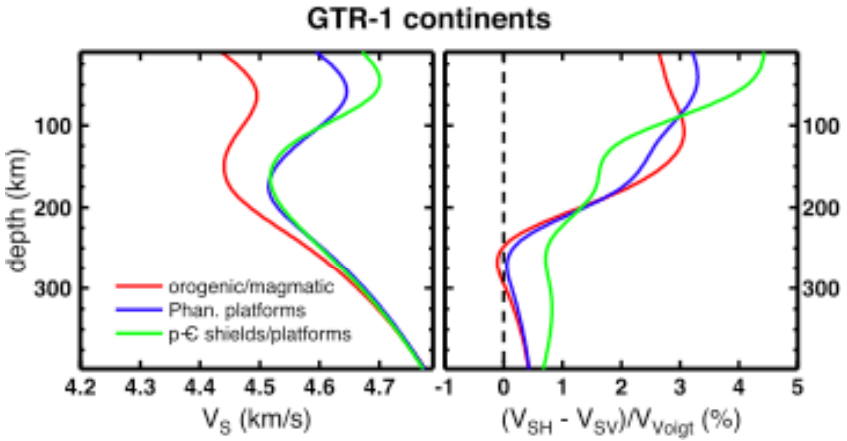
Thanks to: David Abt, Heather Ford, Scott French, Kate Rychert, Stéphane Rondenay

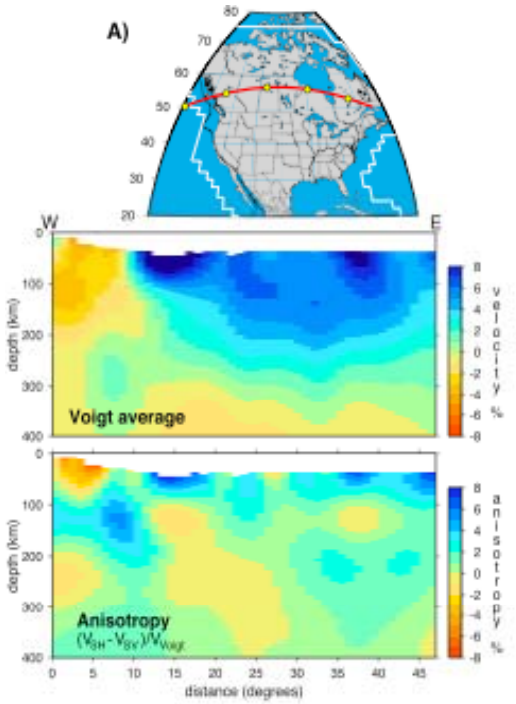
BROWN

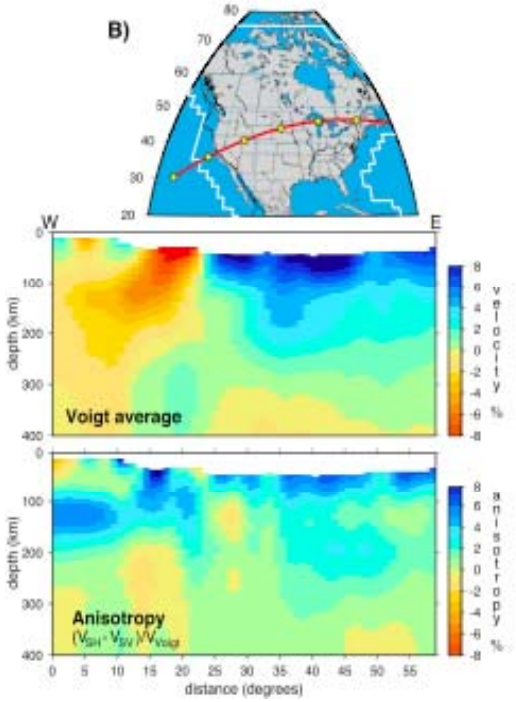



Crust
Mantle
Lithosphere
dry, depleted?
melt-free
LAB
Asthenosphere
hydrated?
partial melt?
Temperature
Viscosity
Shear-wave velocity
geotherm
adiabat
LAB
Temperature only
Temperature + water in asthenosphere
Temperature + water & melt in asthenosphere









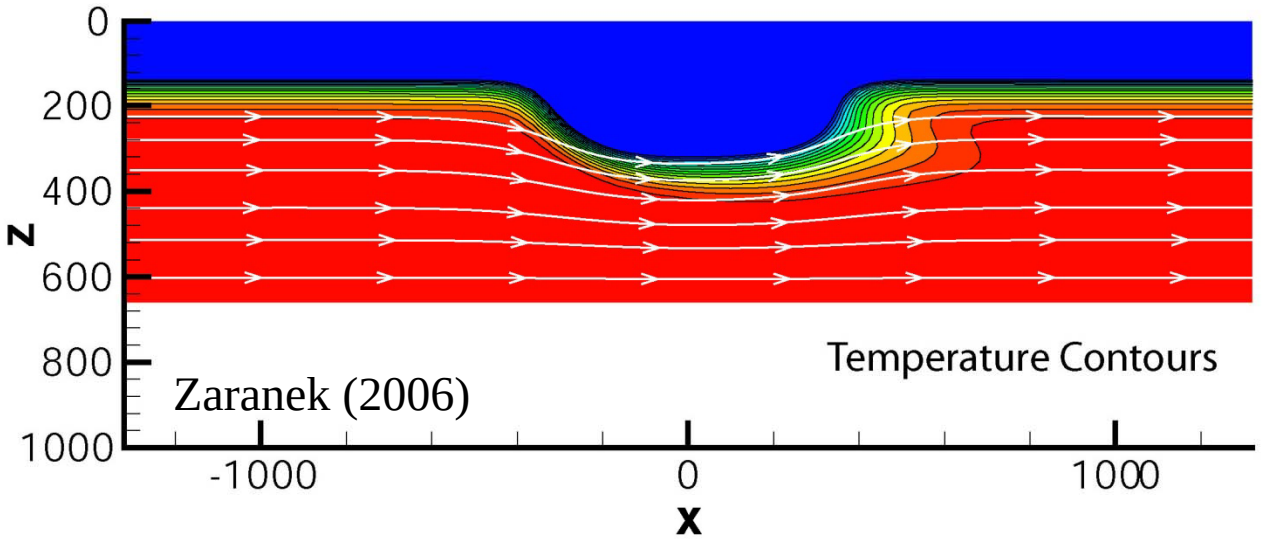
Nettles and Dziewonski (2008)

What can we learn from scattered/converted waves?

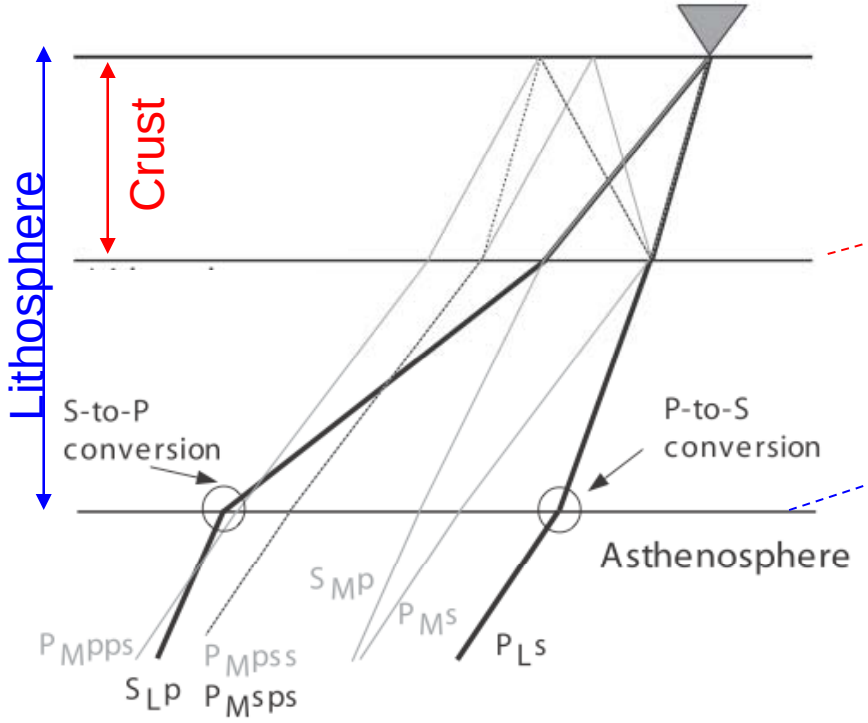
What is the depth of the lithosphere-asthenosphere boundary beneath continents?

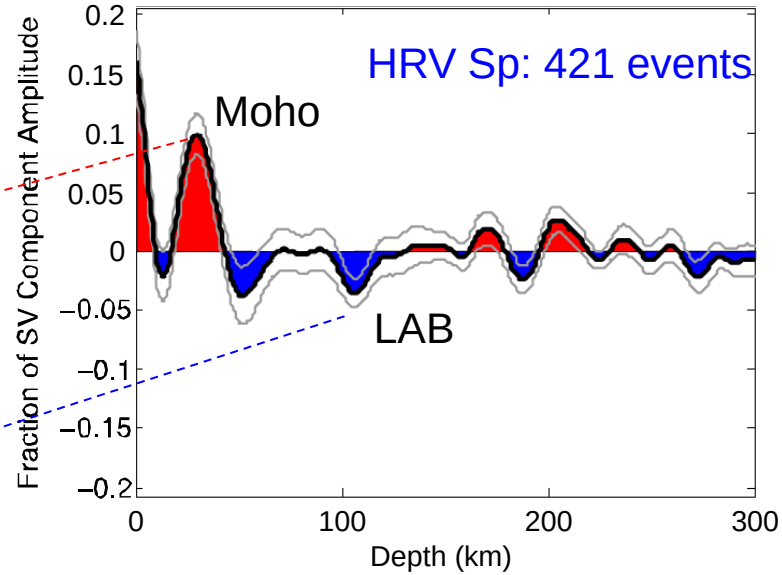
How sharp is the lithosphere-asthenosphere velocity gradient?

Why is the asthenosphere weak - temperature, water, melt?

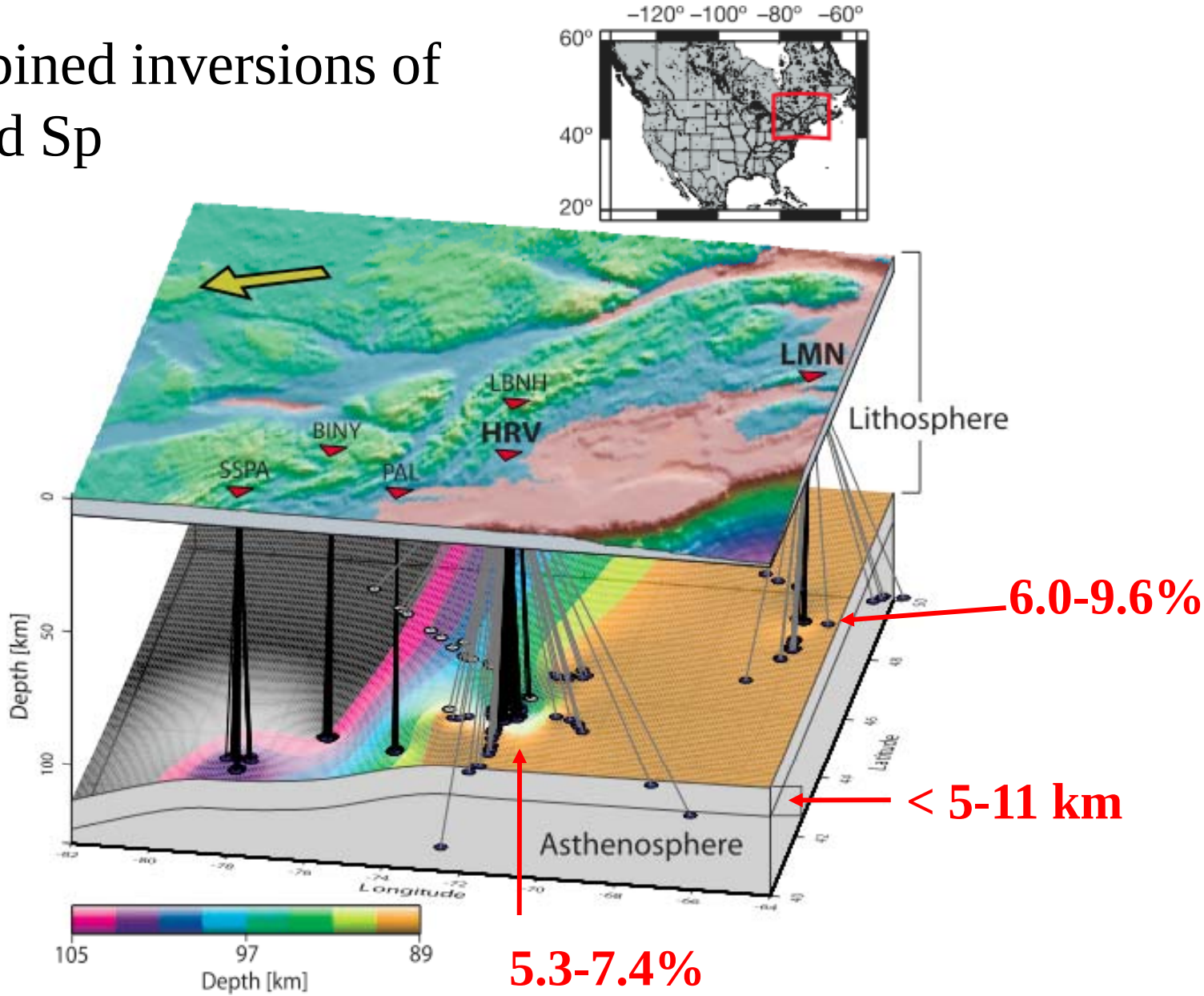


Sp or Ps “receiver functions”



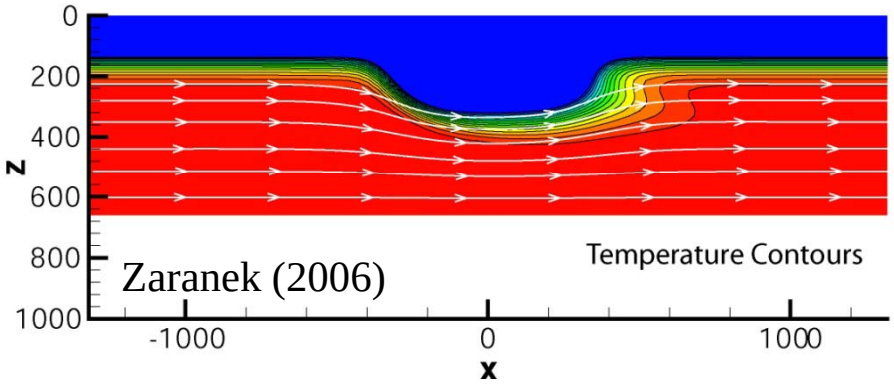


Combined inversions of Ps and Sp

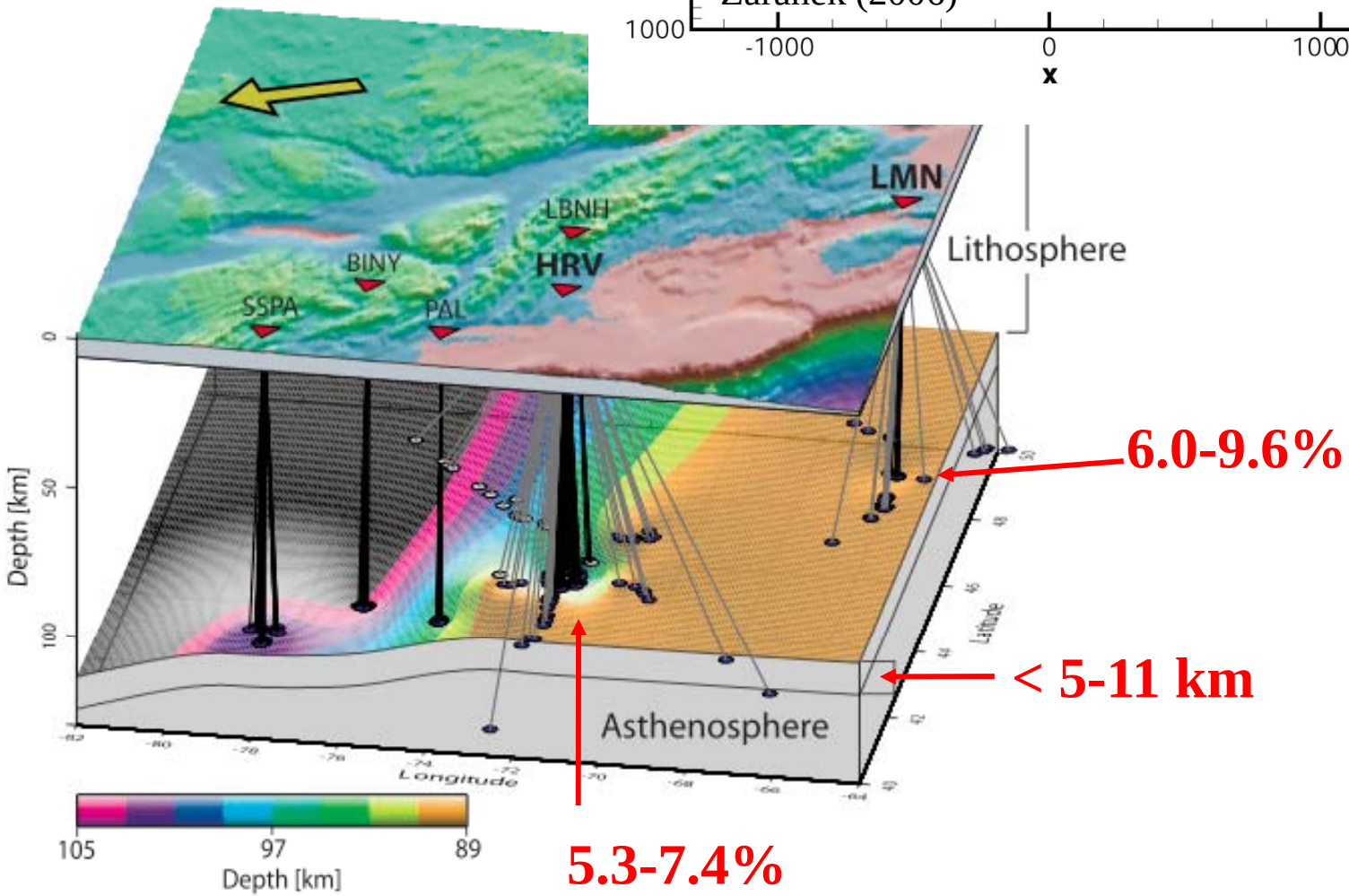


Rychert et al. (2005 & 2007)

Combined inversions of Ps and Sp



Zaranek (2006)



6.0-9.6%

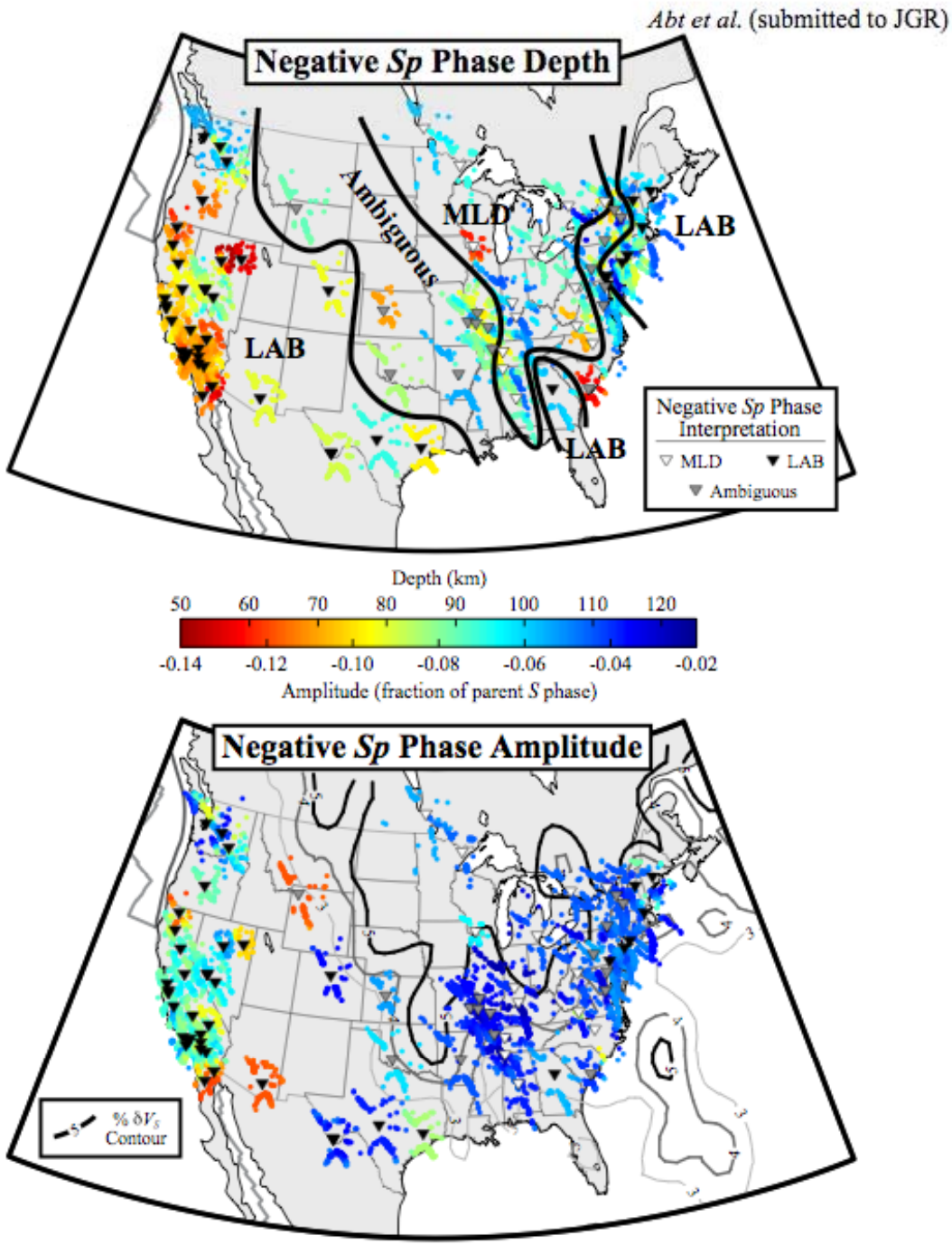
< 5-11 km

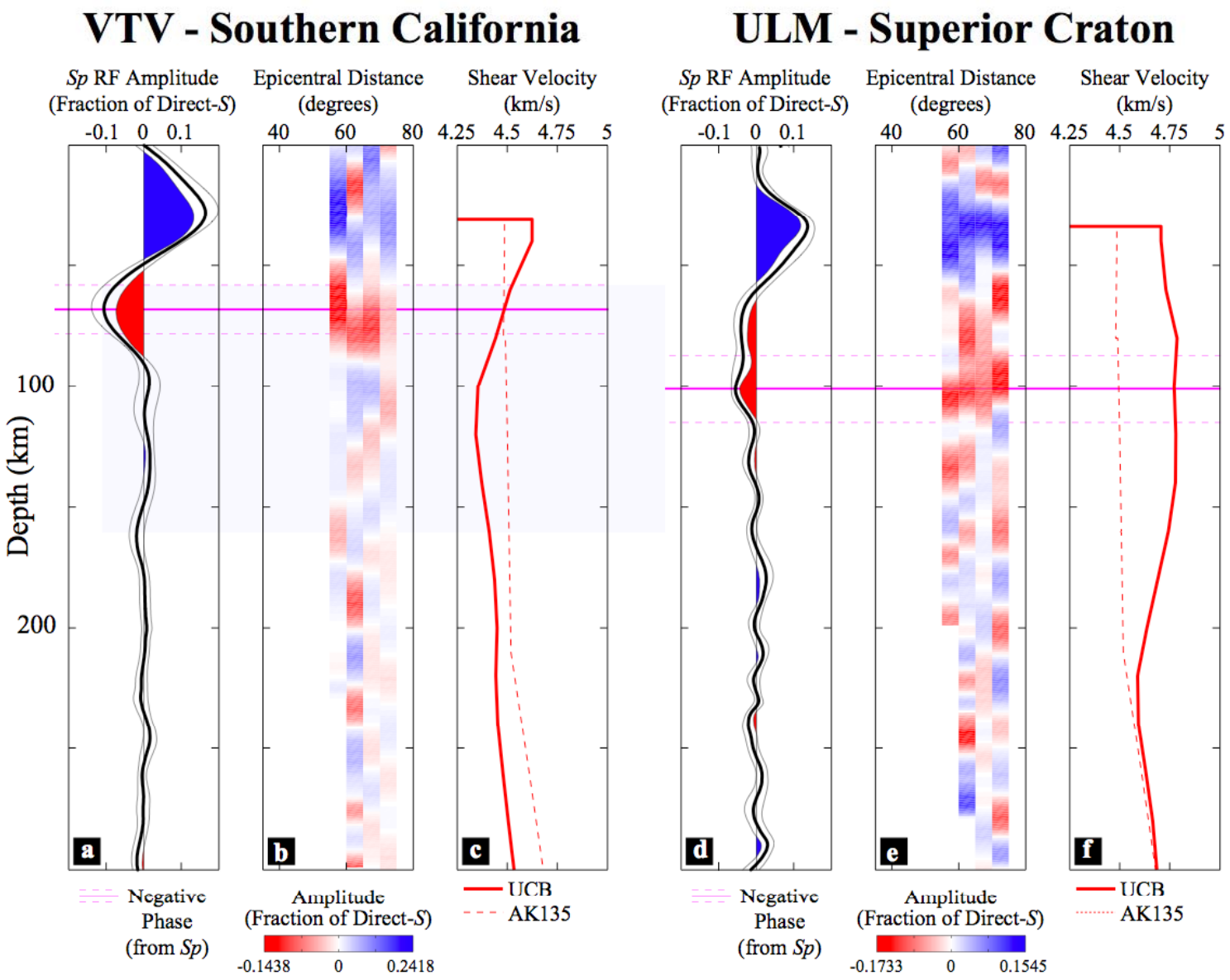
5.3-7.4%

Rychert et al. (2005 & 2007)

North America: Sp
Abt et al. (2009)

- Strong LAB phase beneath western U.S. and portions of Appalachians
- No LAB phase beneath cratons
- Discontinuity within cratonic lithosphere

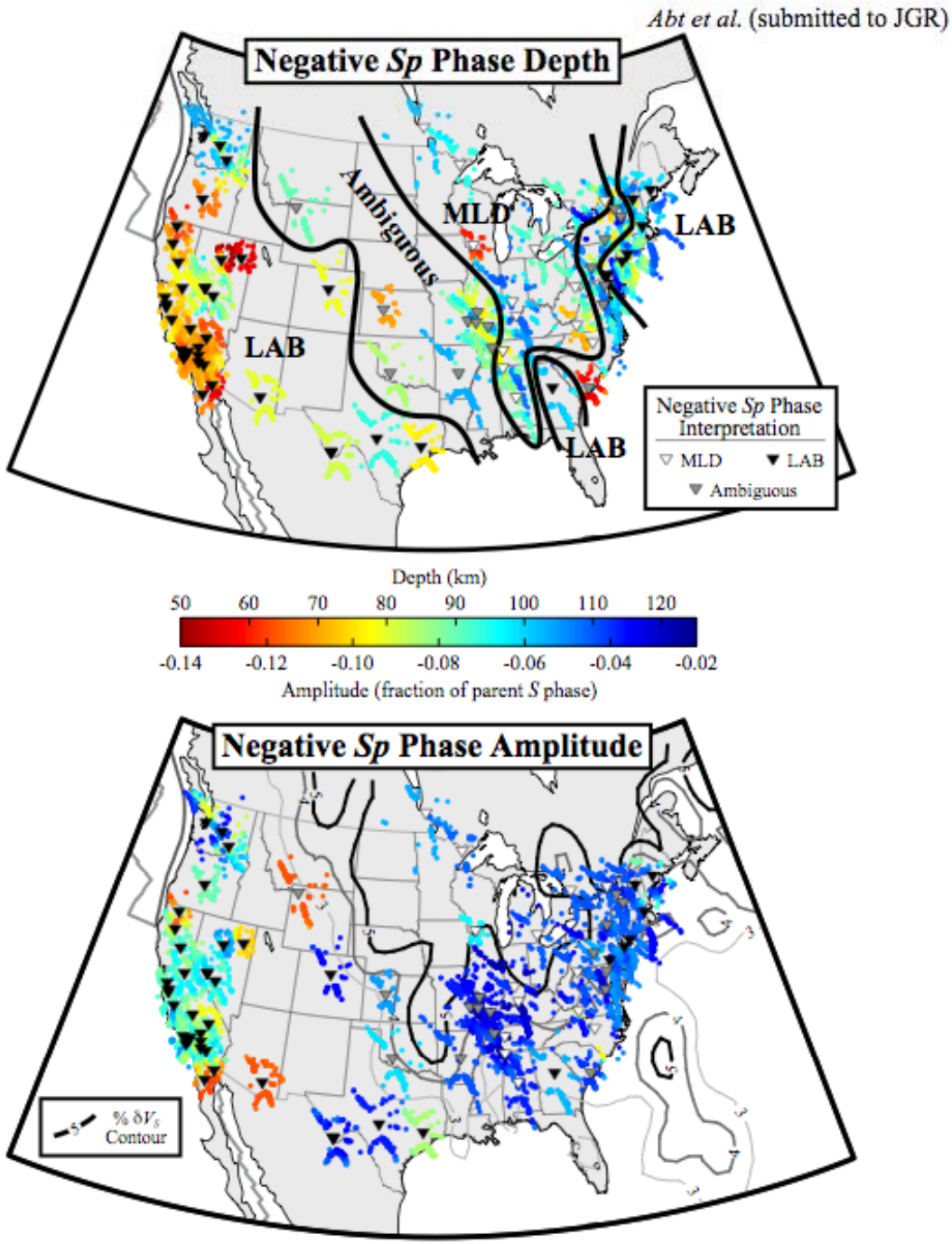



VTV - Southern California
ULM - Superior Craton
Sp RF Amplitude
(Fraction of Direct-S)
-0.1 0 0.1
Epicentral Distance
(degrees)
40 60 80
Shear Velocity
(km/s)
4.25 4.5 4.75 5
Depth (km)
100
200
a
b
c
d
e
f
Negative
Phase
(from Sp)
Amplitude
(Fraction of Direct-S)
-0.1438 0 0.2418
-0.1733 0 0.1545
UCB
AK135

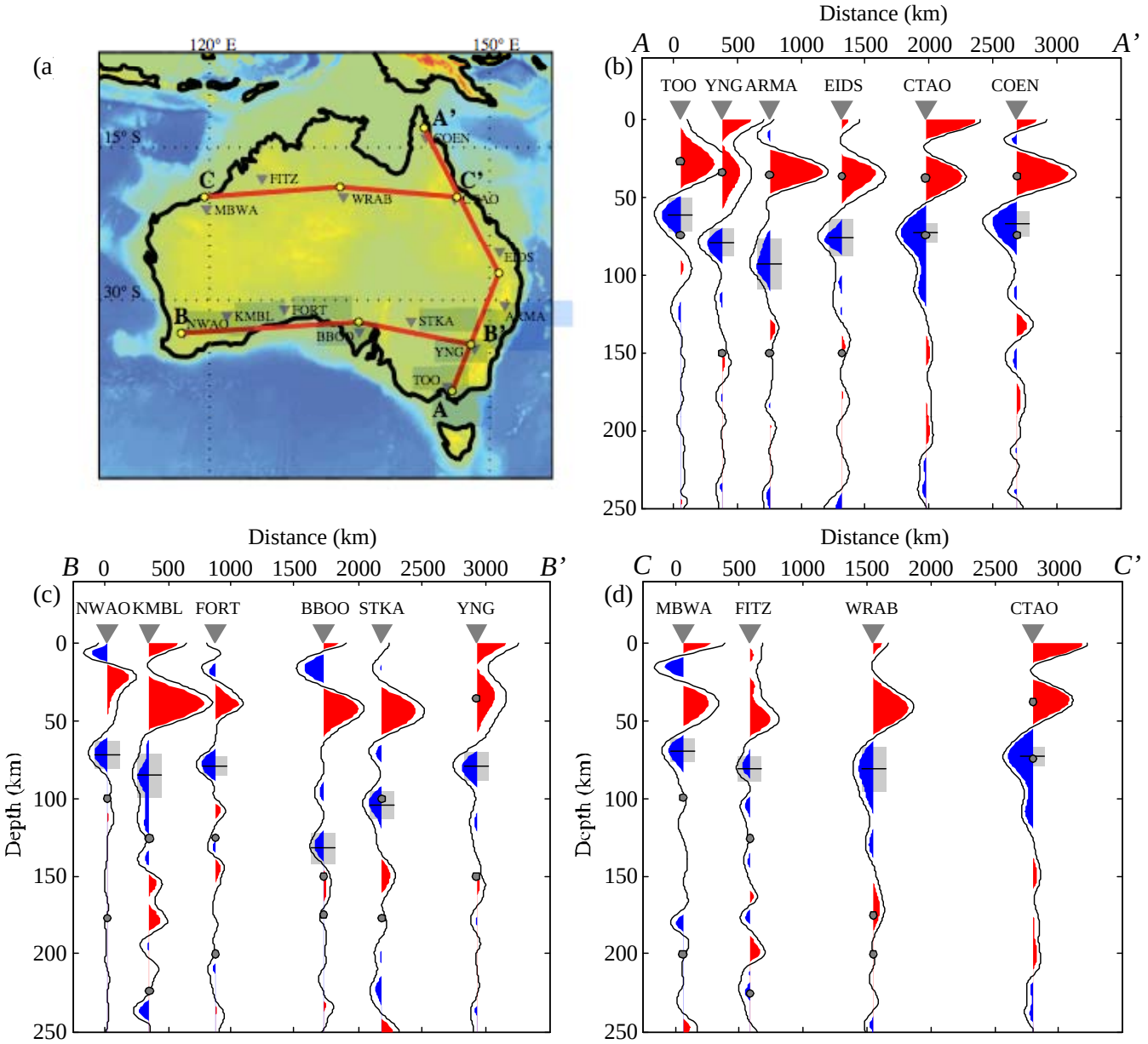
North America: Sp

Abt et al. (2009)

- Sharp LAB beneath younger continent - < 30 km - water/melt in asthenosphere
- Gradual/weak LAB beneath cratons - > 50 km - temperature alone



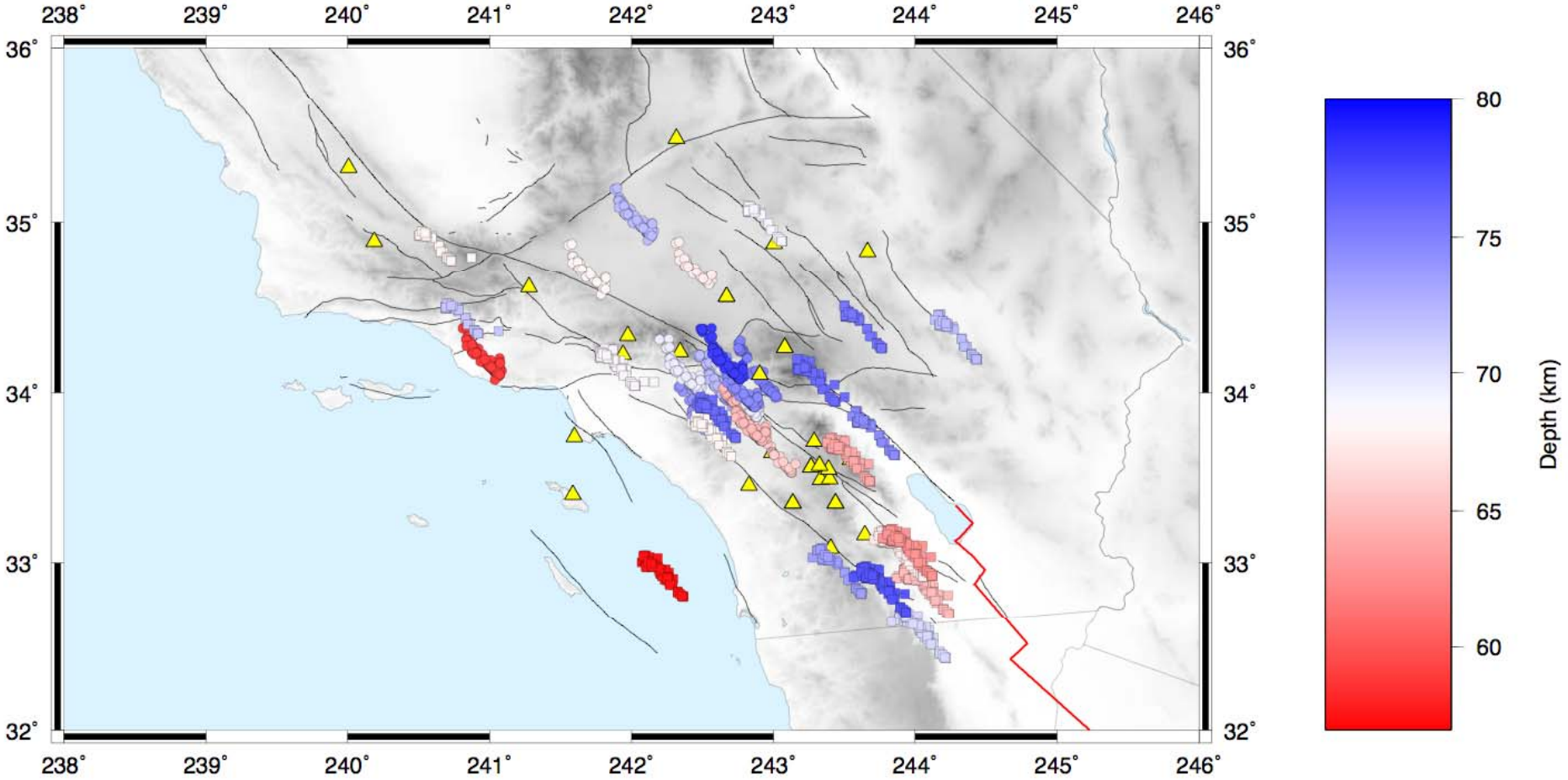
Australia: Sp (Ford et al., in prep)



- Sharp LAB beneath Phanerozoic E. Australia < 30 km - water/melt in asthenosphere
- Gradual/weak LAB beneath craton - > 50-90 km - temperature alone

Sp conversion point depths: LAB in Southern California

French et al.



Conclusions

Phanerozoic North America and Australia

- **LAB at 50 km to 110 km**
- **LAB velocity gradient sharp - water/melt in asthenosphere**

Craton

- **No “LAB” phase at depths comparable to base of fast lid**
- **LAB velocity gradient small or gradual - consistent with purely thermal boundary**
- **Velocity drop internal to lithosphere at 60 to 115 km**

Southern California

- **Lithosphere is:**
  - **< 60 km beneath southern CA Borderlands**
  - **locally thinned (10-15 km) beneath San Jacinto Fault**