

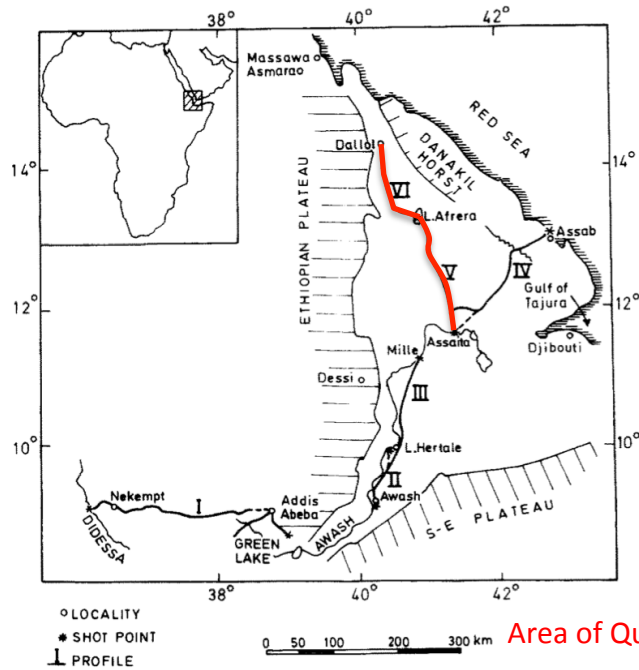
The crustal structure of Afar: what does it tell us about rift evolution?

Graham Stuart, James Hammond, Mike Kendall,
Mariangela Guidarelli, Anna Stork, Derek Keir, Atalay Ayele,
David Thompson, Manahloh Belachew, Cynthia Ebinger

Universities of Leeds, Bristol, Rochester and Addis Ababa

Previous Work

Berkhemer et al 1975

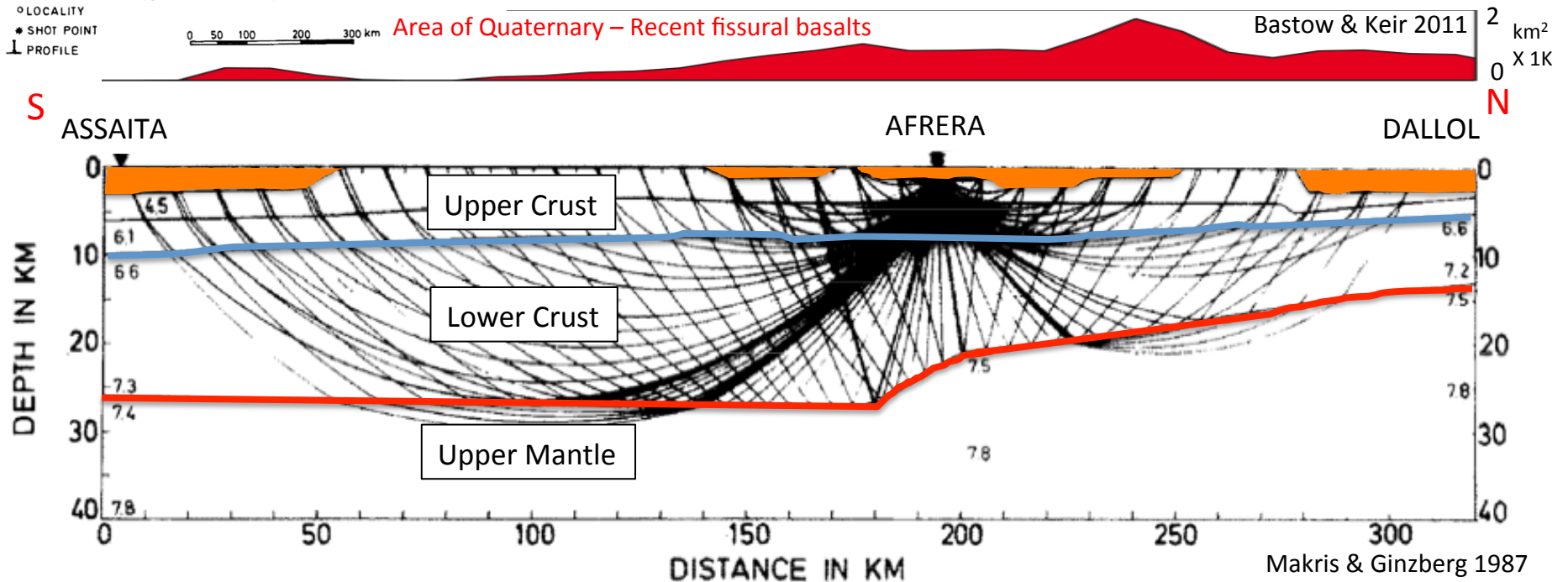


Evidence (seismic refraction)

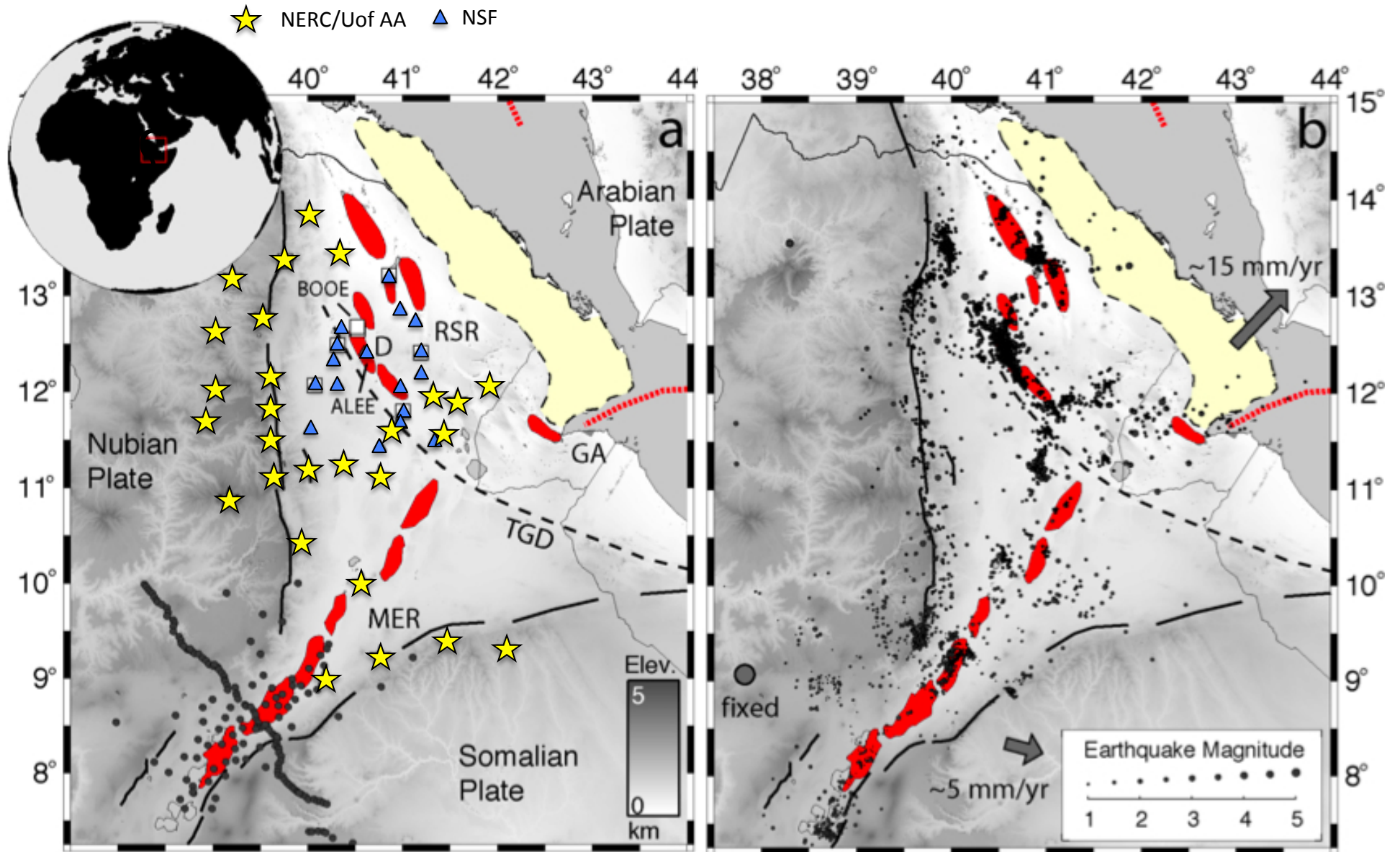
- Thin crust relative to normal continental crust (26 – 14 km)
- Thinned upper crust (6.1 km/s) everywhere
- High velocity intruded lower crust (> 7 km/s)
- Low velocity upper mantle (7.4 - 7.5 km/s)

Conclusion

Stretched continental crust overlying a mantle up-welling



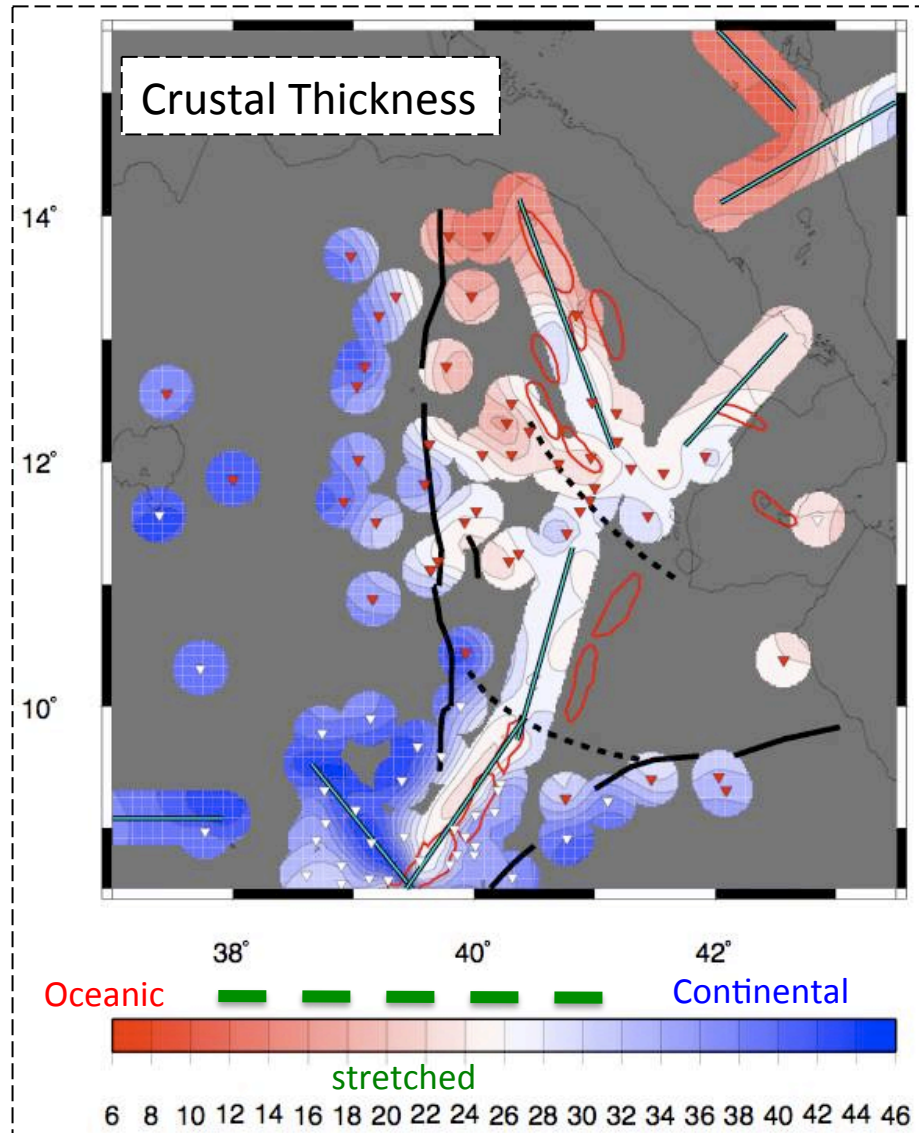
Data sets



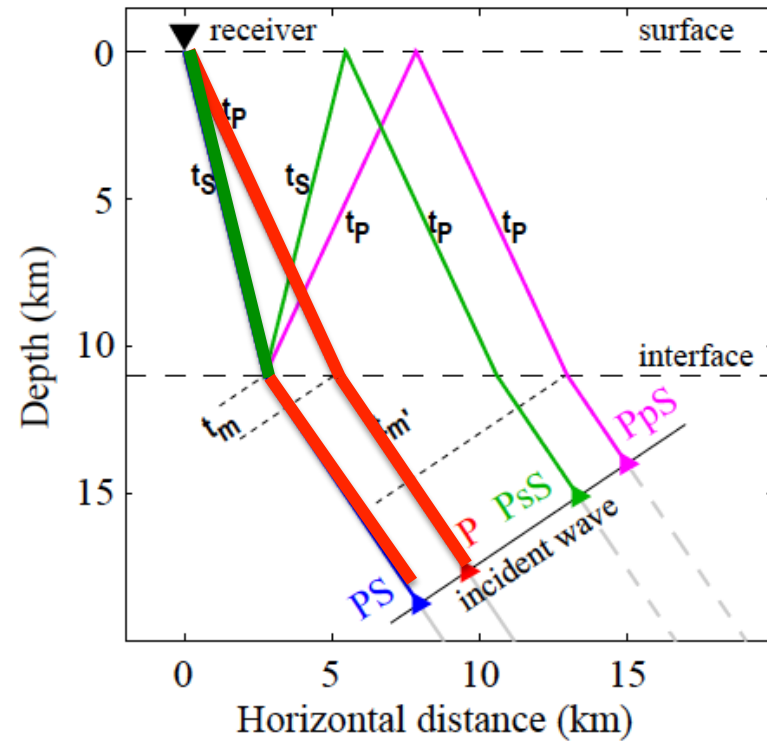
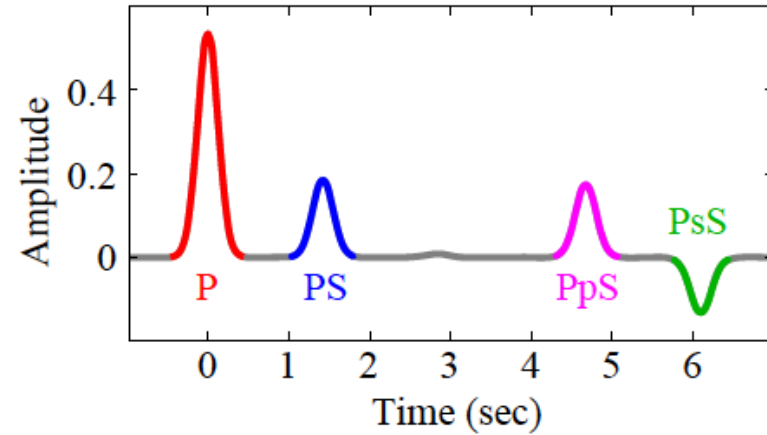
Keir et al 2011

Belachew et al 2011

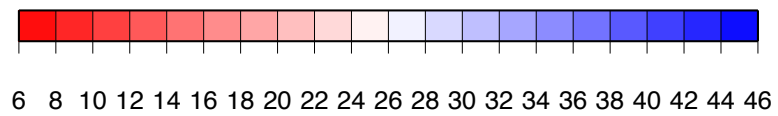
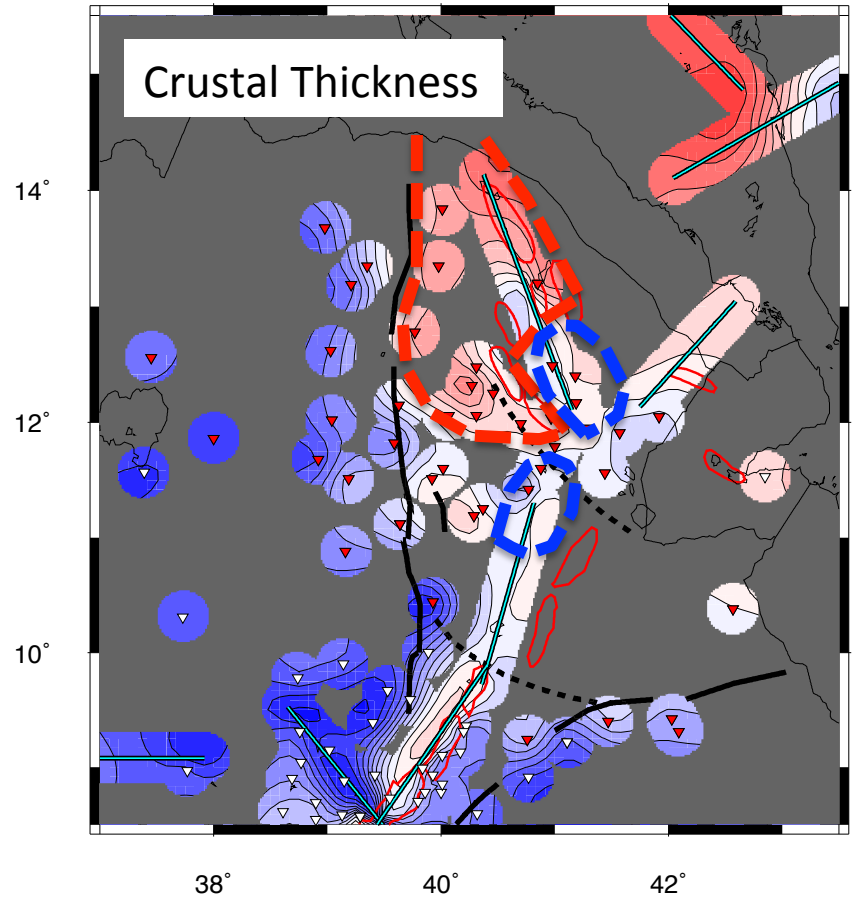
Receiver Functions



Hammond et al 2011

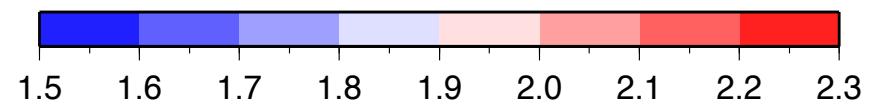
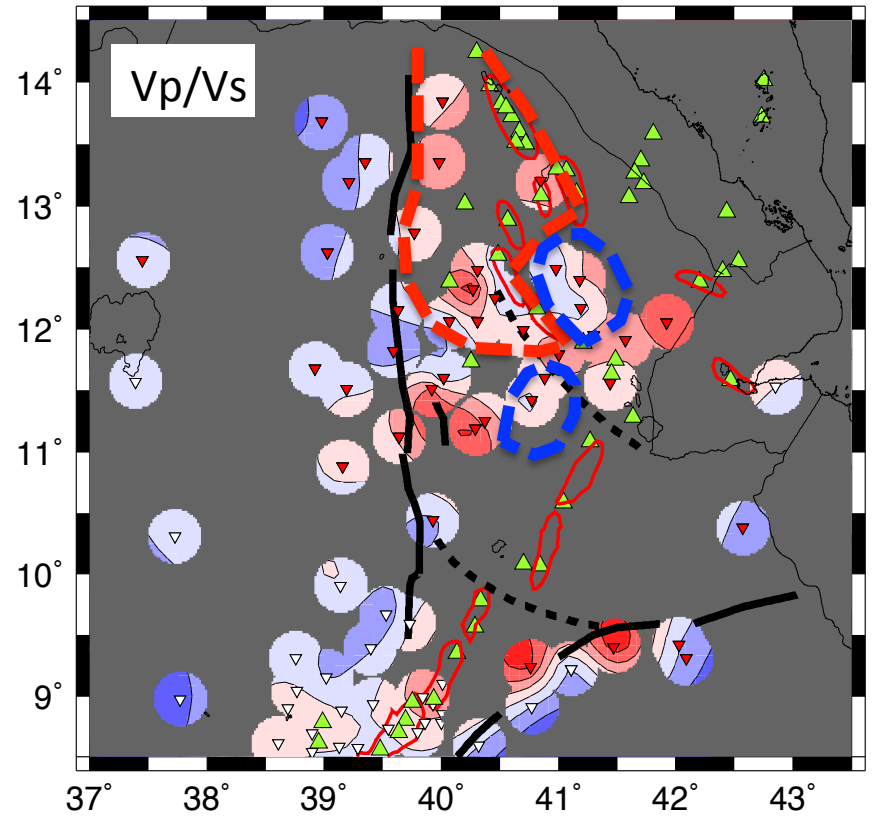


Receiver Functions



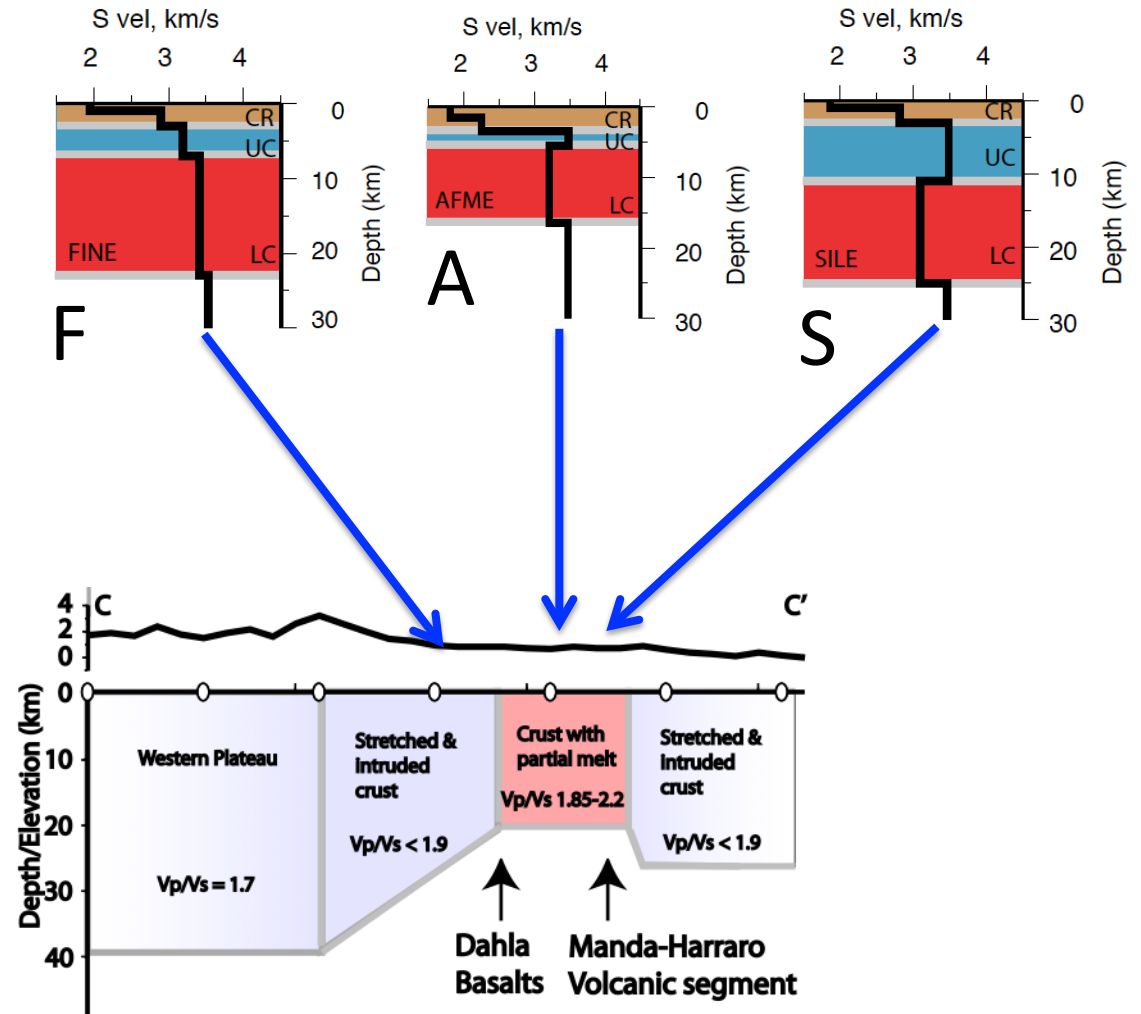
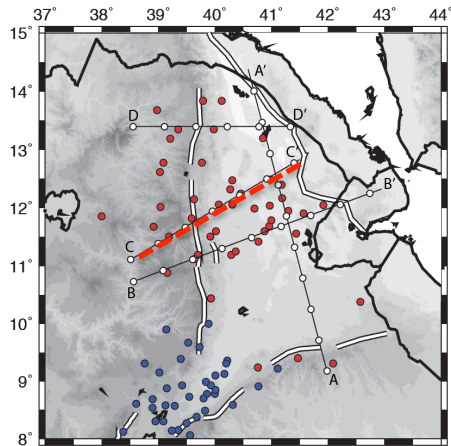
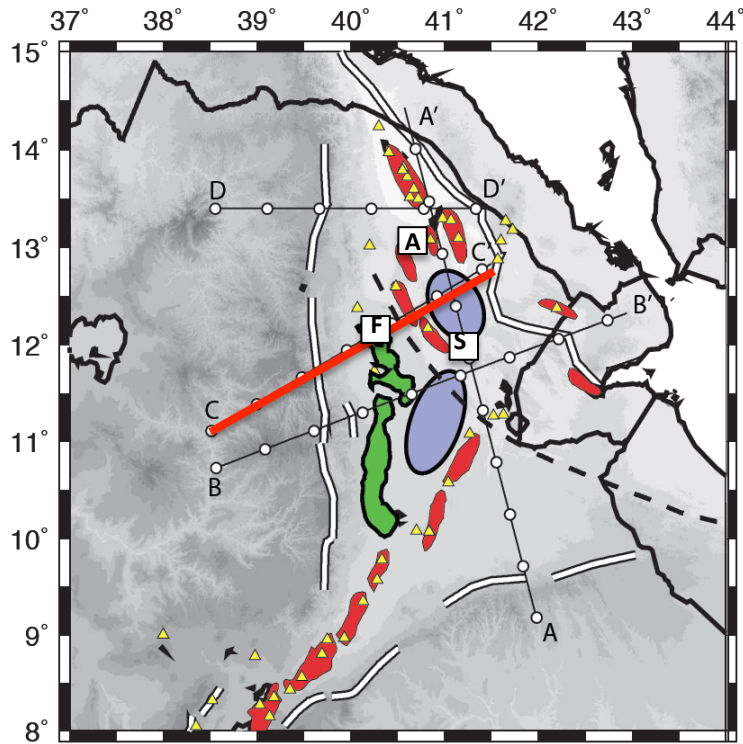
Moho depth(km)

Hammond et al 2011



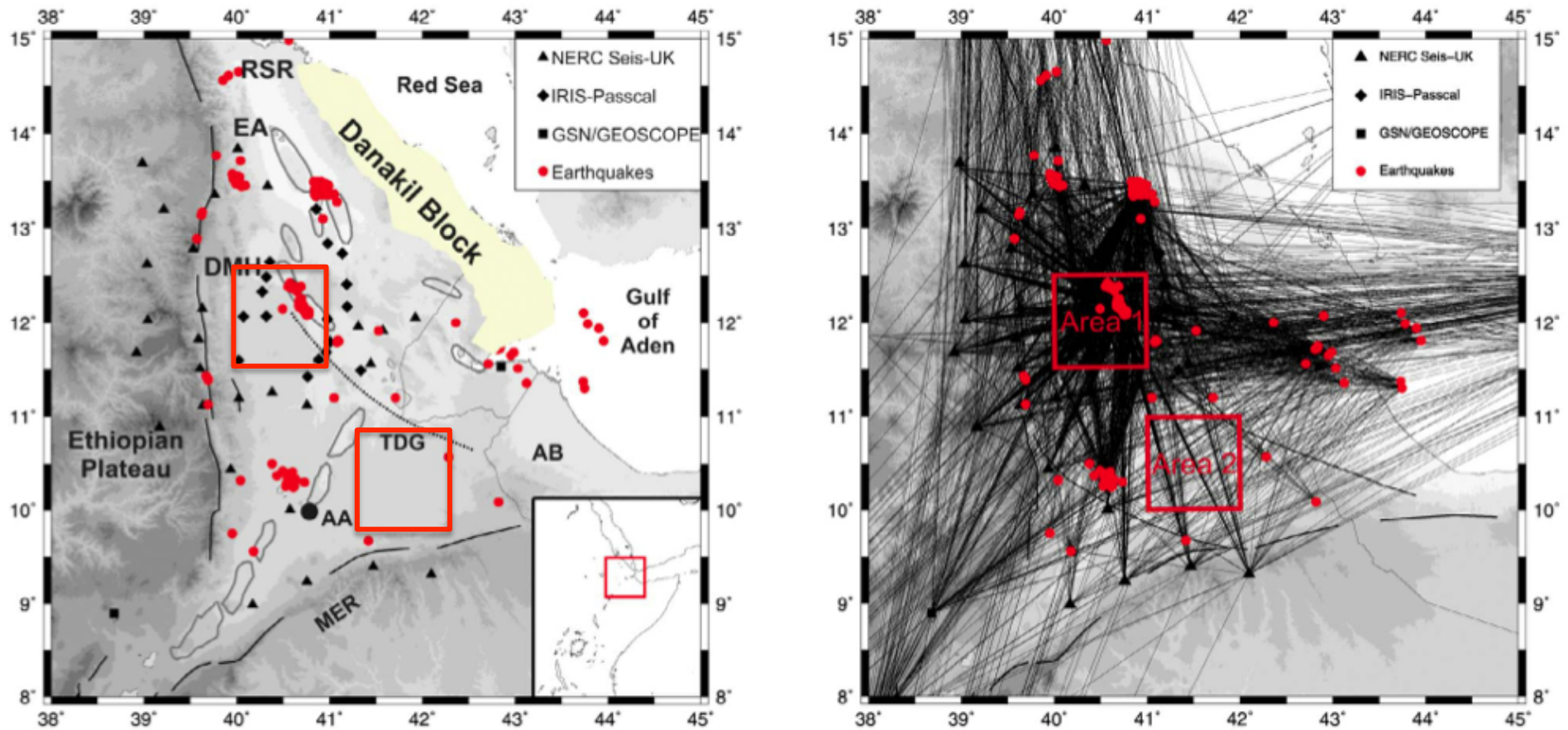
Vp/Vs

Modeling the Receiver Functions



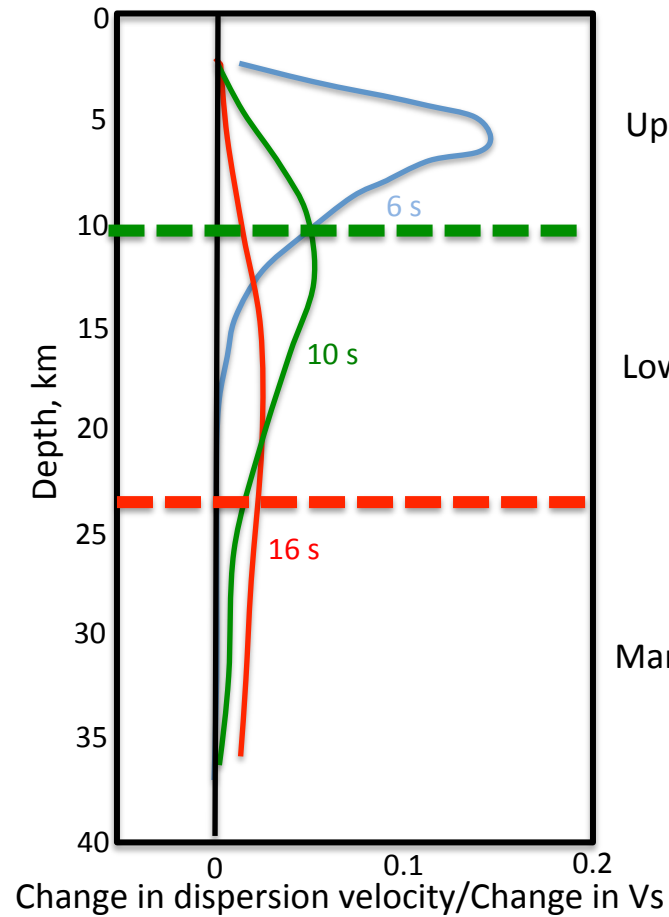
Hammond et al 2011

Surface Waves



Guidarelli et al 2011

Surface Waves

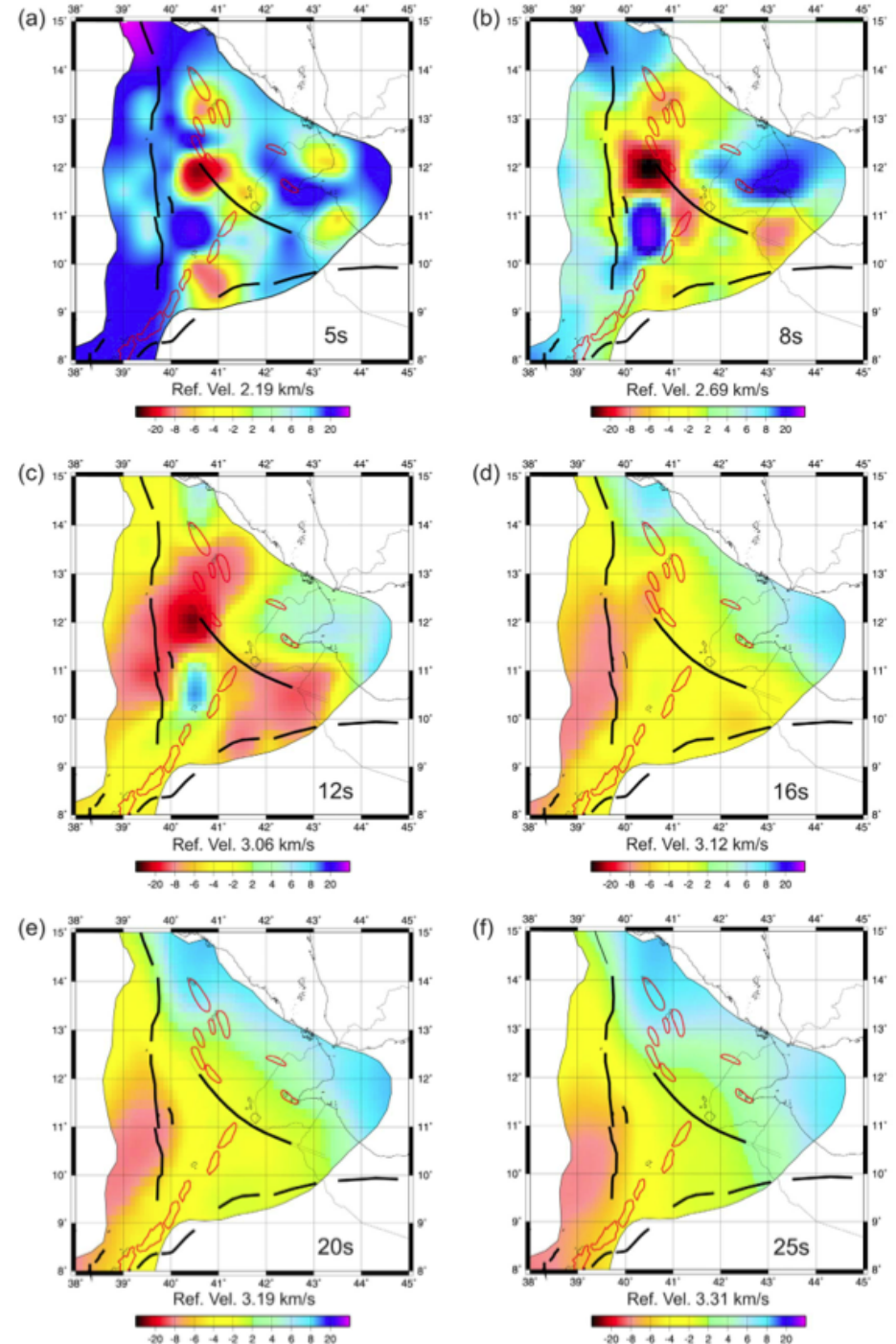


Upper Crust

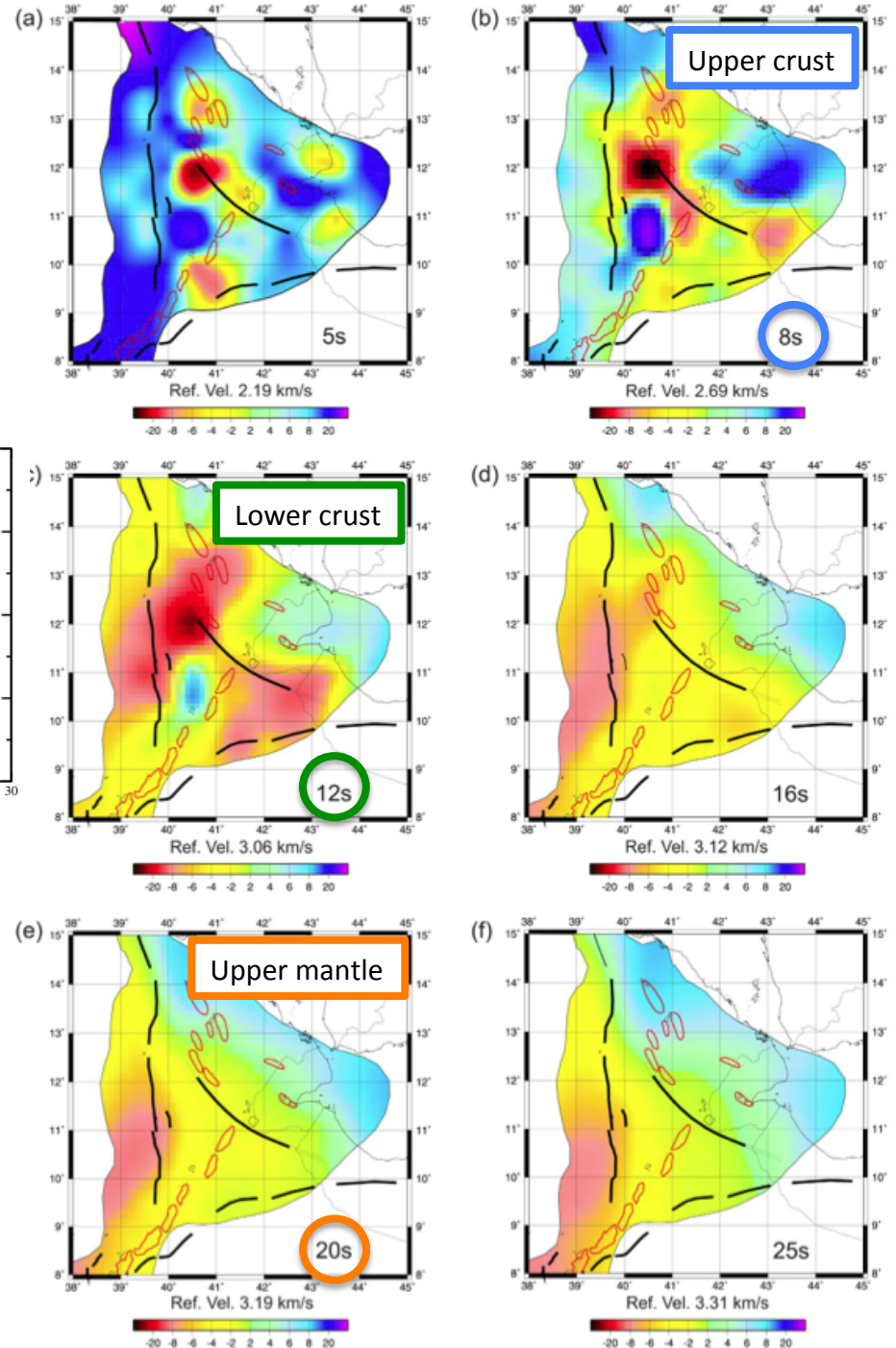
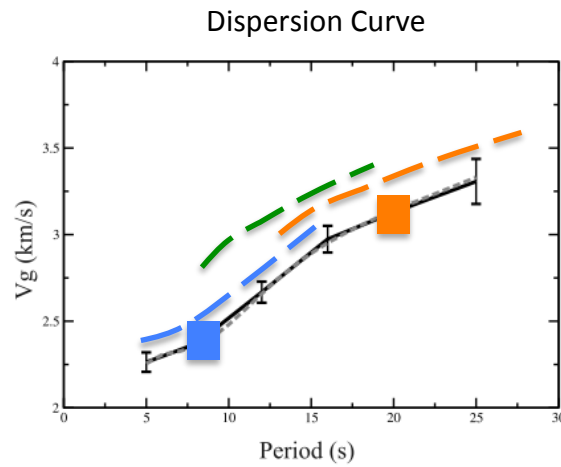
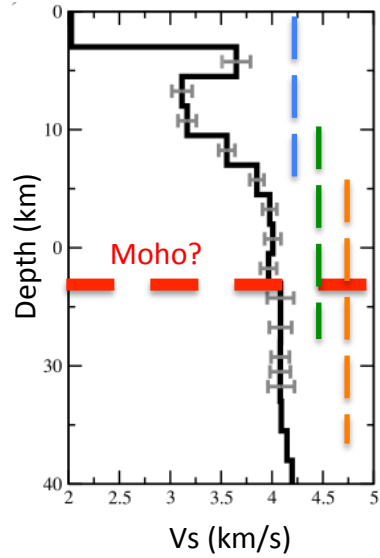
Lower Crust

Mantle

Guidarelli et al 2011

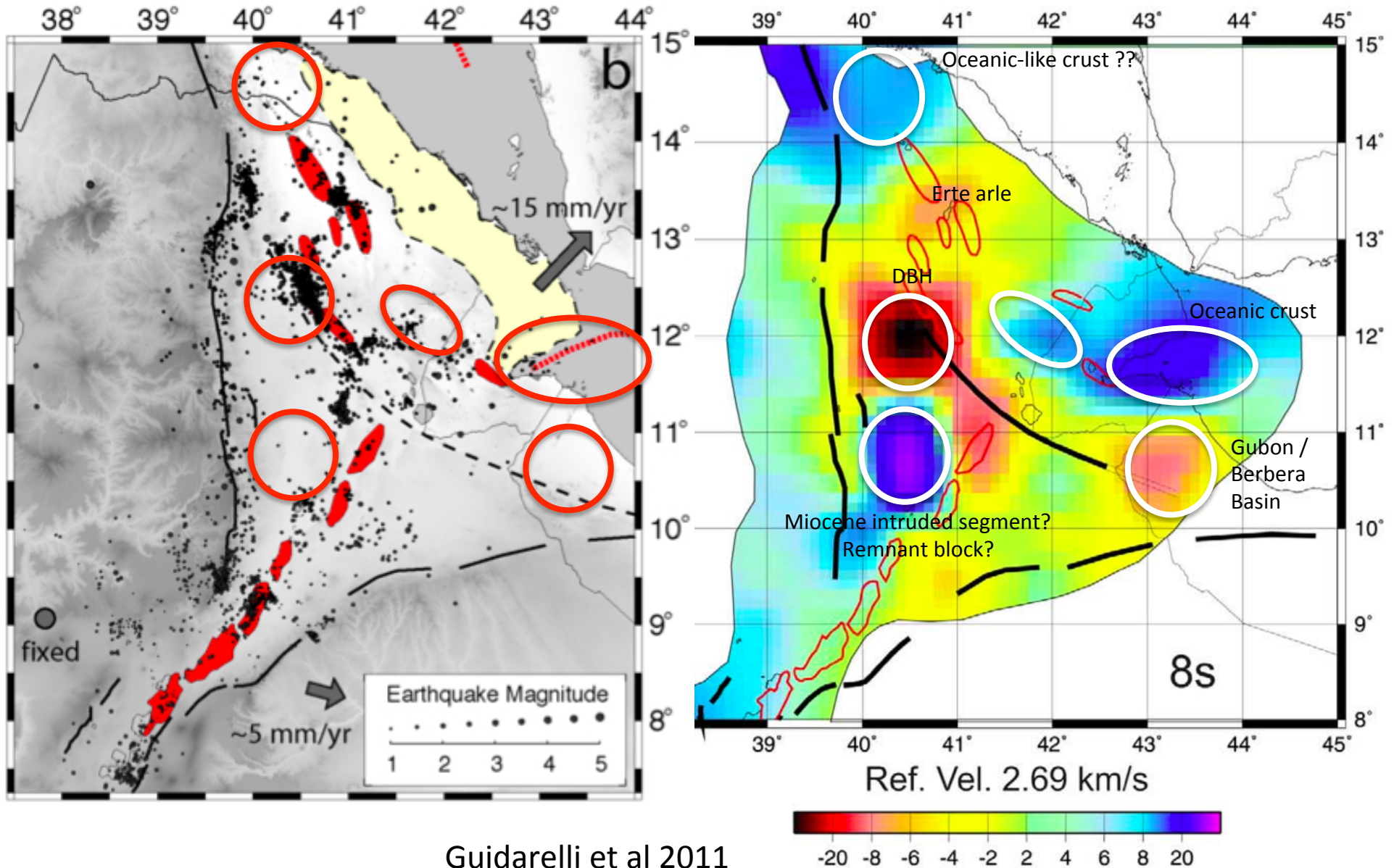


Surface Waves



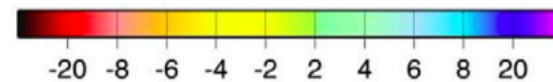
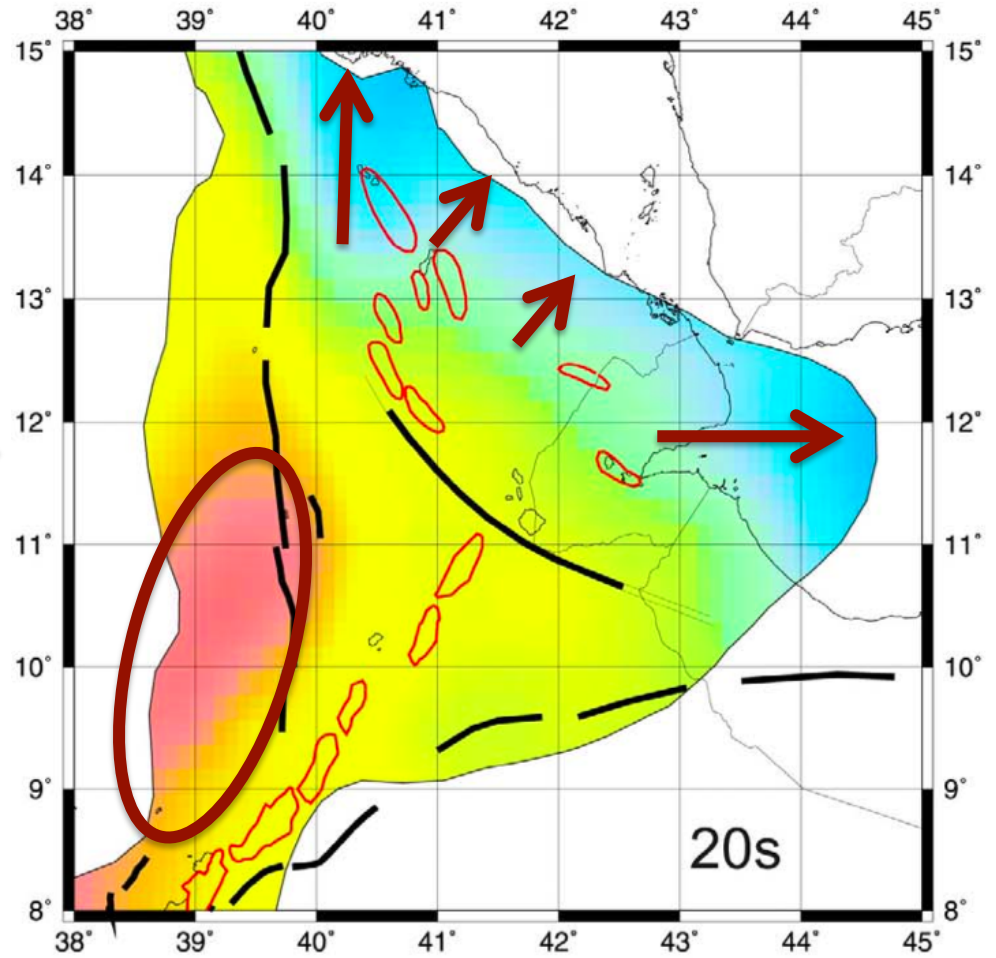
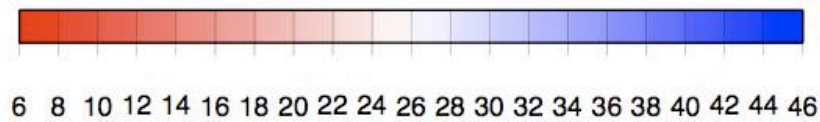
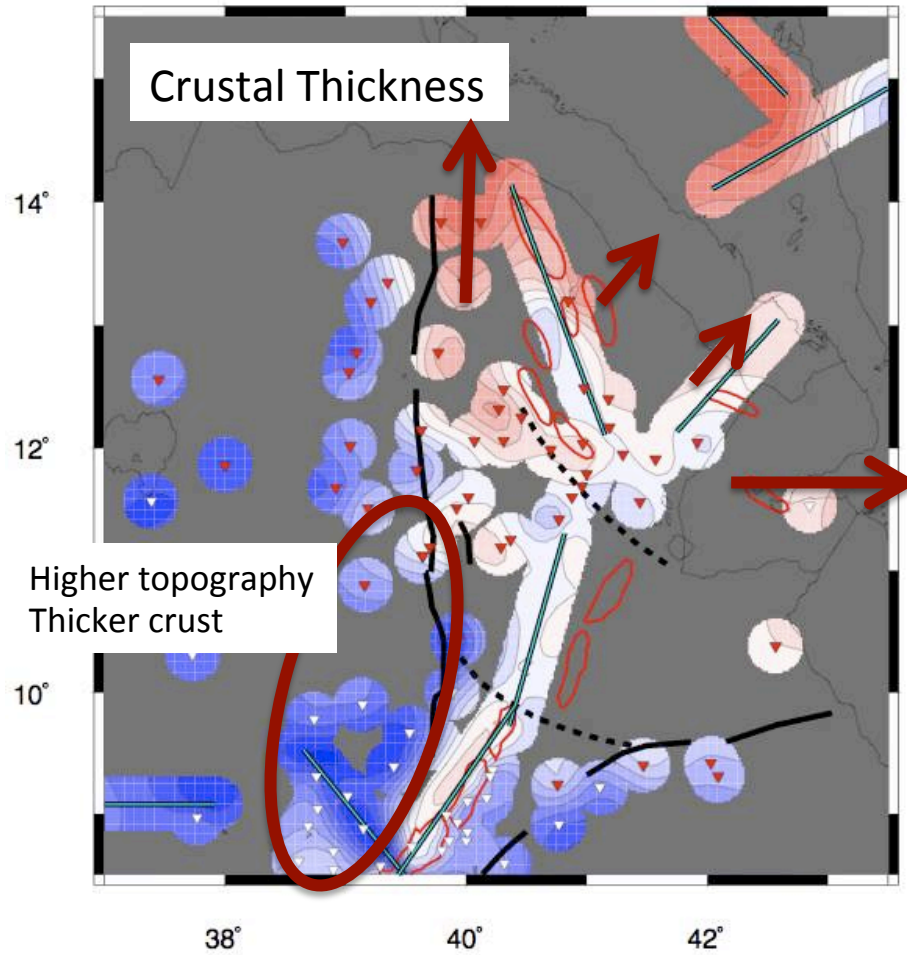
Guidarelli et al 2011

Upper Crust



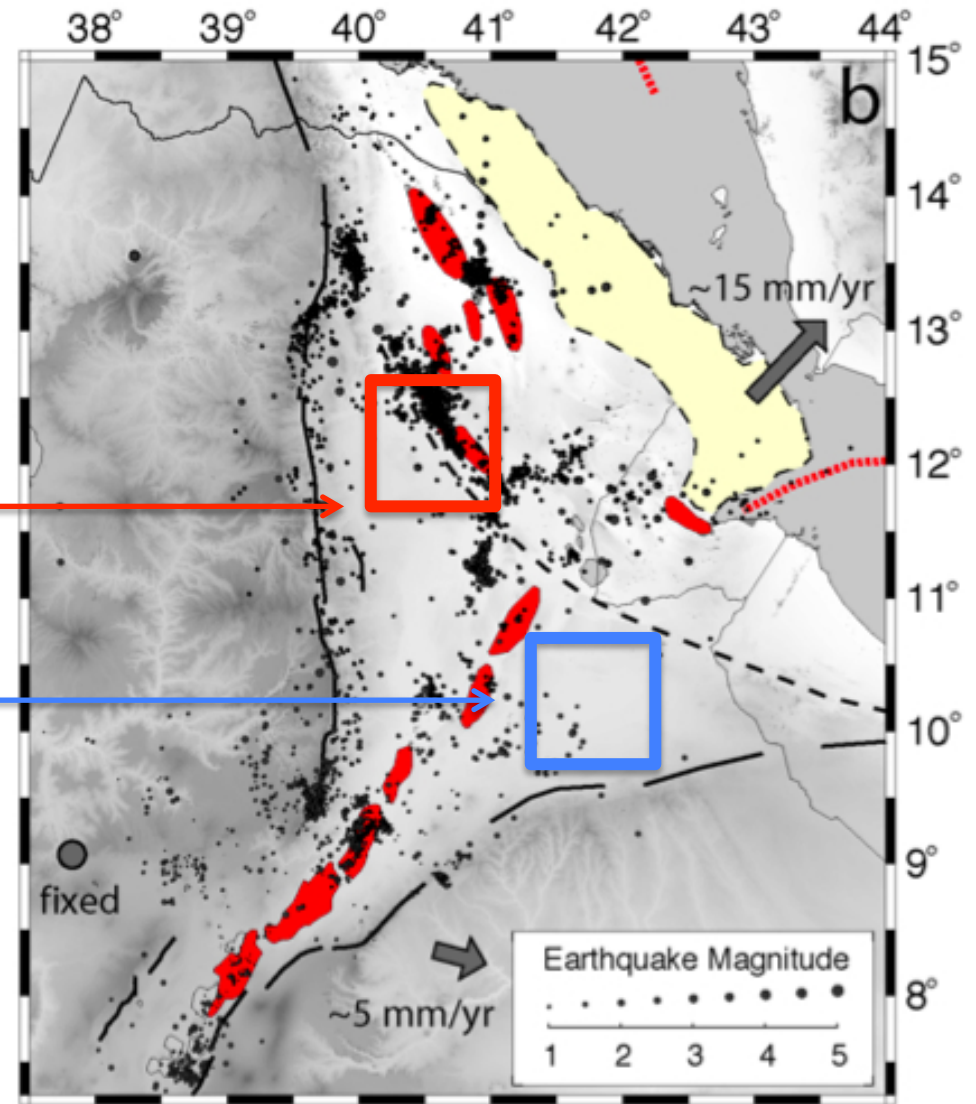
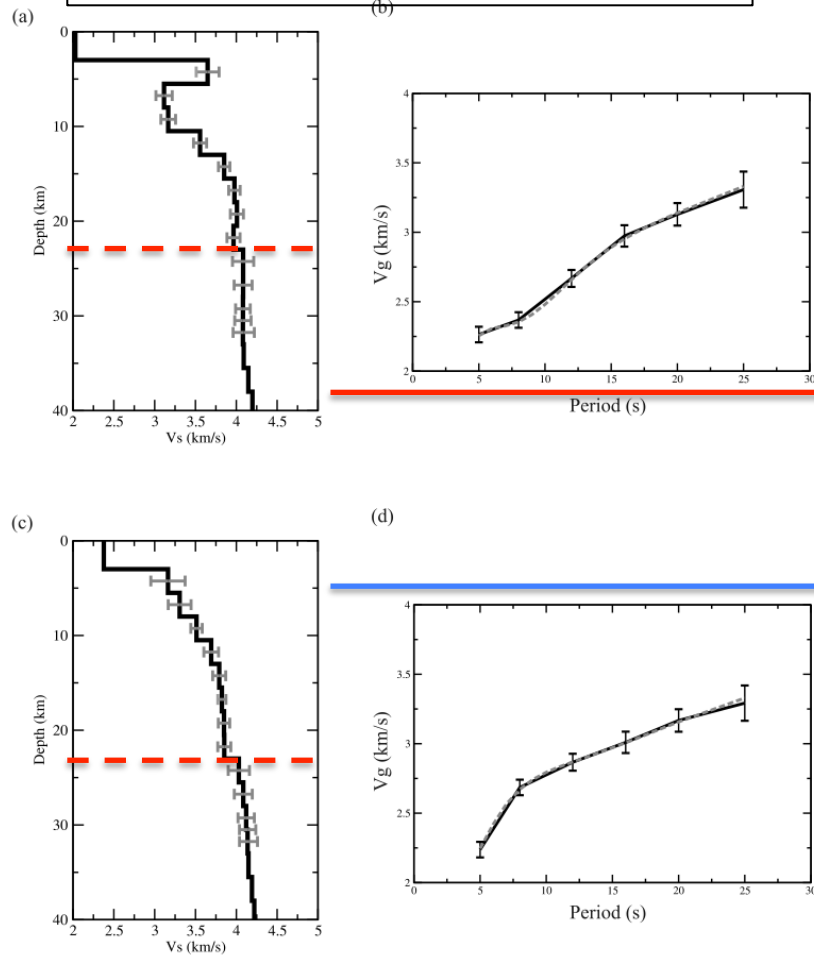
Guidarelli et al 2011

Crustal Thickness

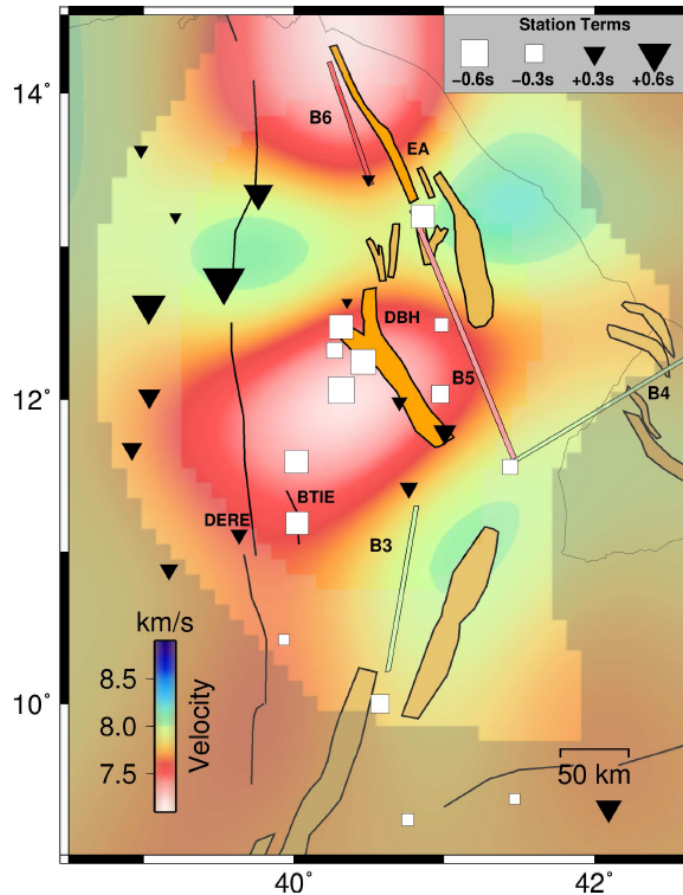


Modeling Surface Waves

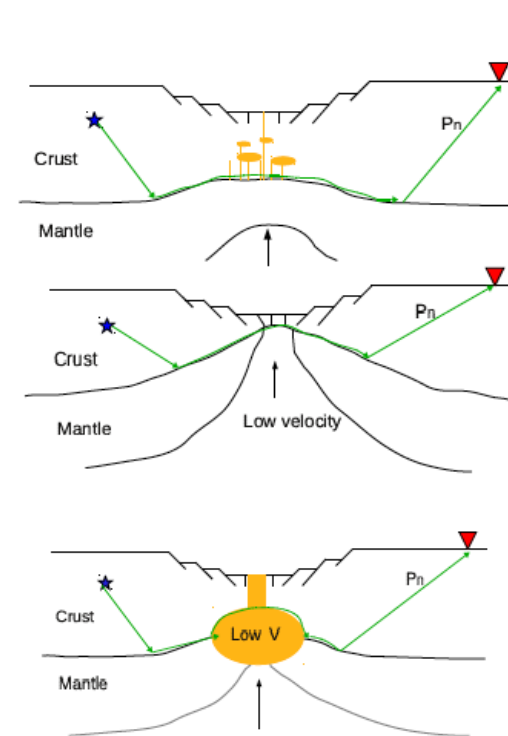
Low V_s velocity upper crust
around recently active segments



Uppermost mantle velocity study (Pn)

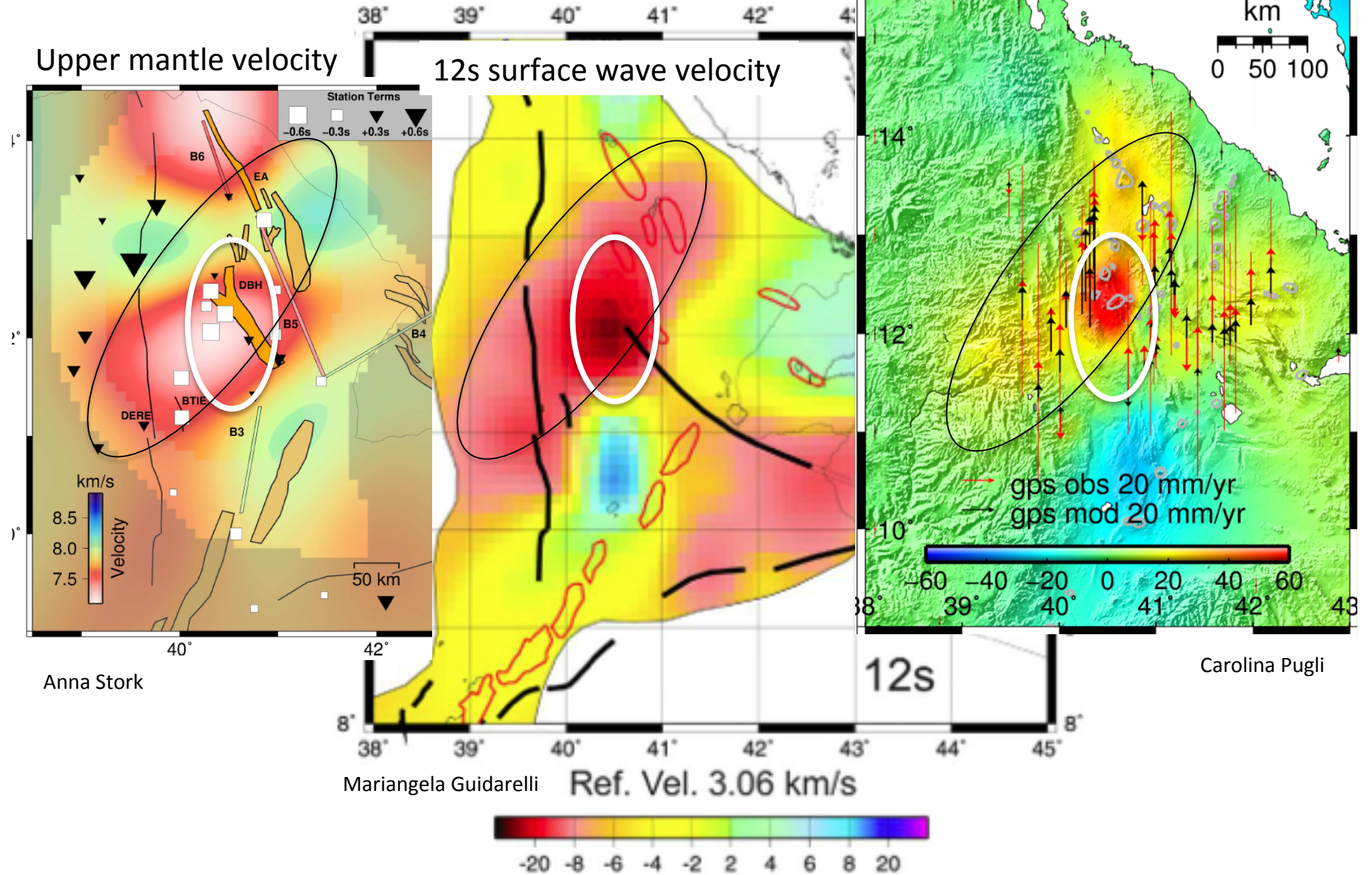


P_n velocity model of the uppermost mantle for the Afar region. No shading: $\sigma < \pm 0.4$ km/s, light grey shading: $\sigma = \pm 0.4 - 0.5$ km/s, dark grey shading: $\sigma > 0.5$ km/s.

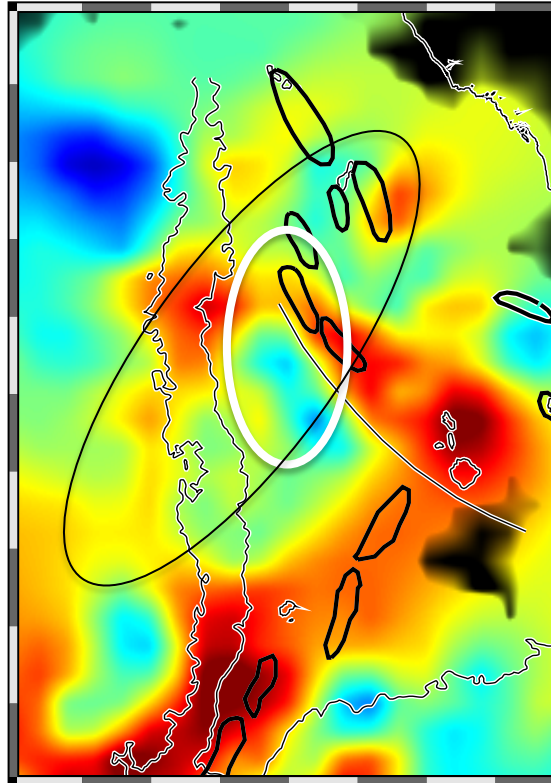


Stork et al 2012

Integration of results



75 km tomographic velocity

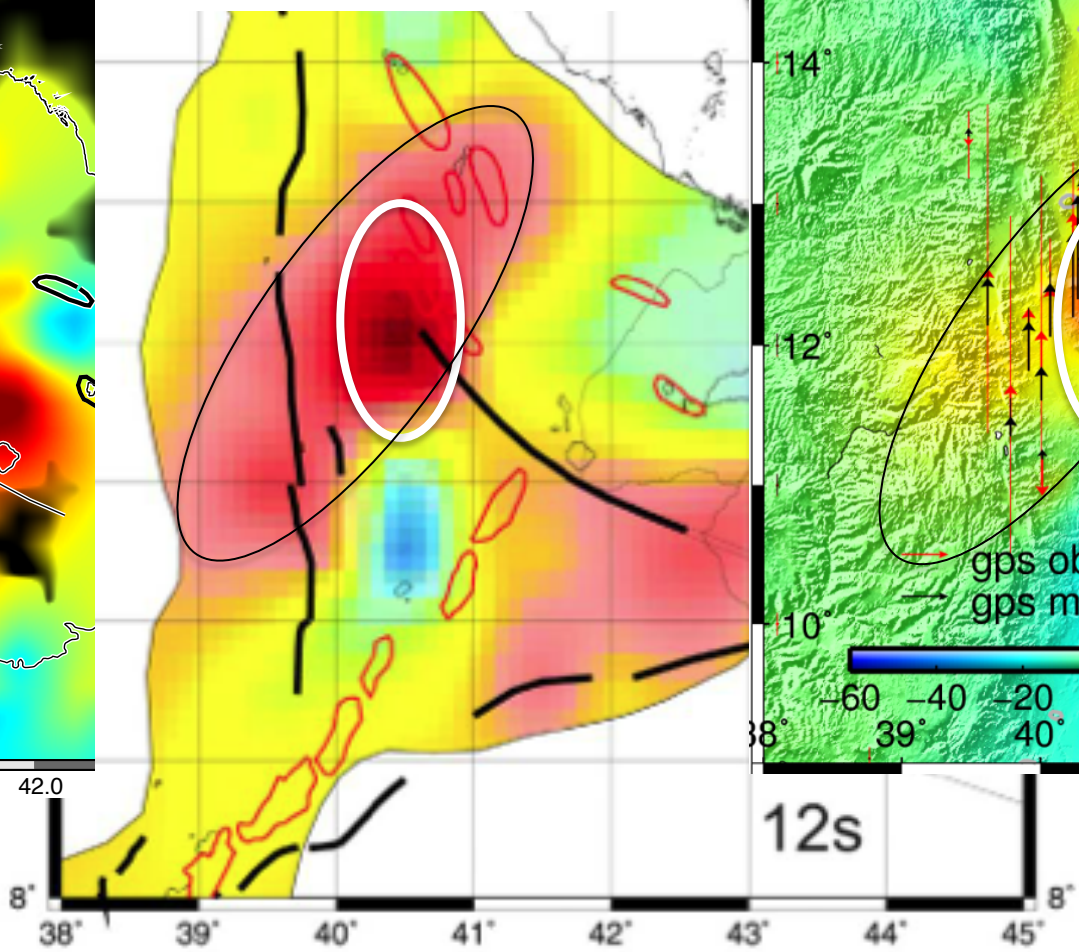


39.0 39.5 40.0 40.5 41.0 41.5 42.0

James Hammond

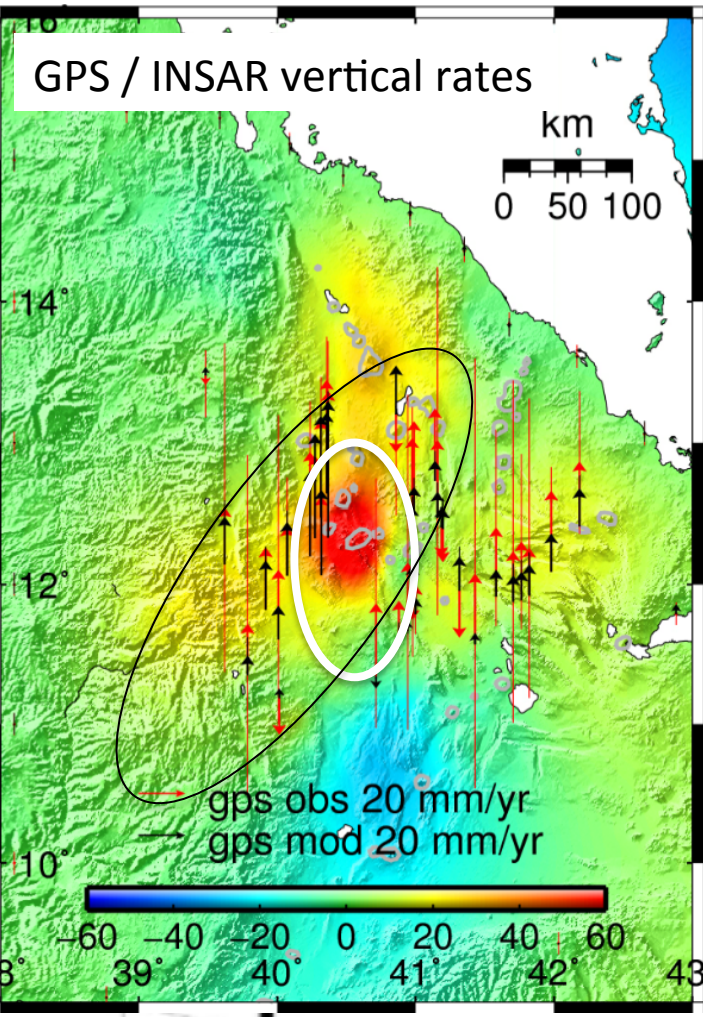
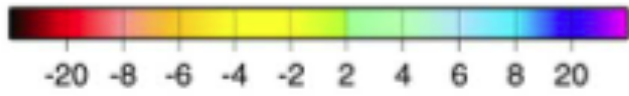
39° 40° 41° 42° 43°

12s surface wave velocity



8° 38° 39° 40° 41° 42° 43° 44° 45°

Mariangela Guidarelli Ref. Vel. 3.06 km/s



GPS / INSAR vertical rates

km
0 50 100

gps obs 20 mm/yr
gps mod 20 mm/yr

-60 -40 -20 0 20 40 60

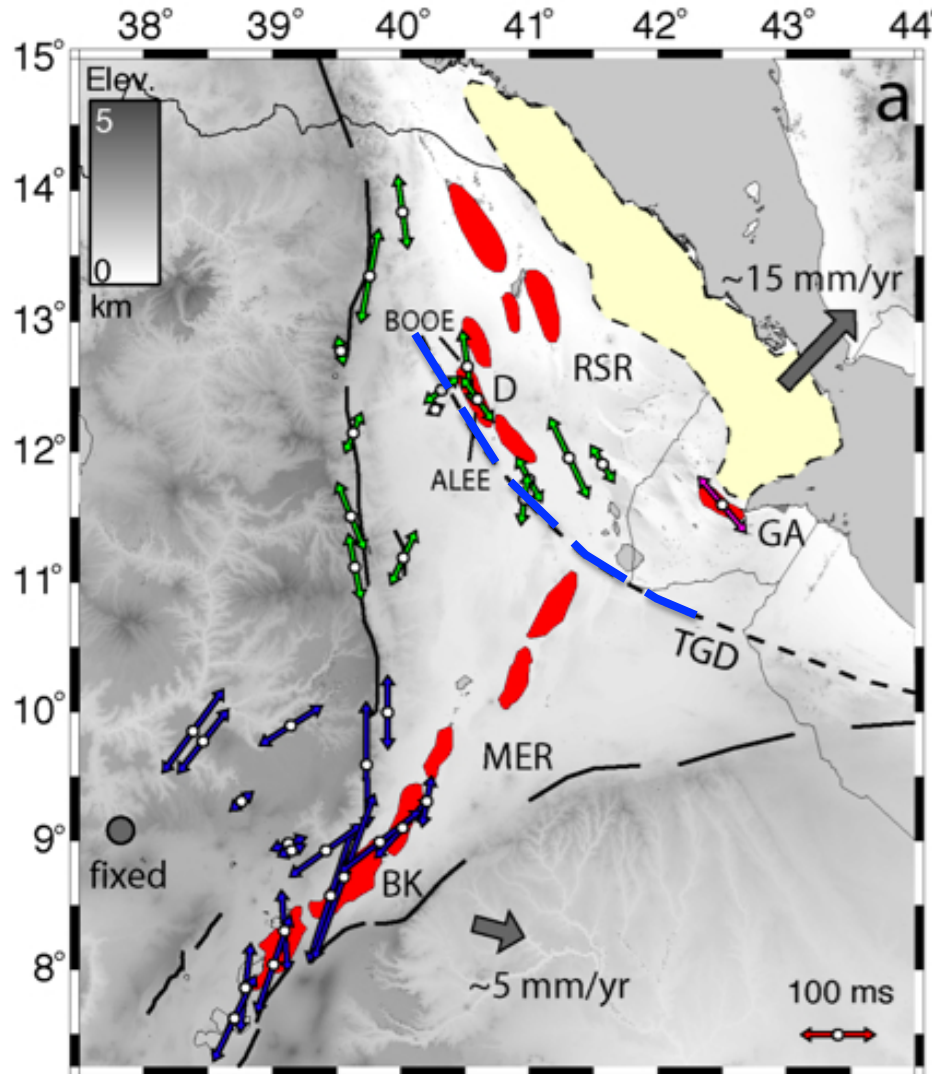
Carolina Pugli

12s

Conclusions

- Furthered our understanding of lateral variation of crustal structure in Afar
- Recently active regions show low Vs in the upper crust – evidence for partial melt
- There is asymmetry in rift structure due to migration of the rift axis eastward
- Rifting process leaves behind remnant blocks of less-stretched continental crust

Crustal shear wave splitting



- Magnitude of anisotropy increases into magmatic segments
- Fast polarization direction generally orthogonal to current extension

Keir et al 2011

