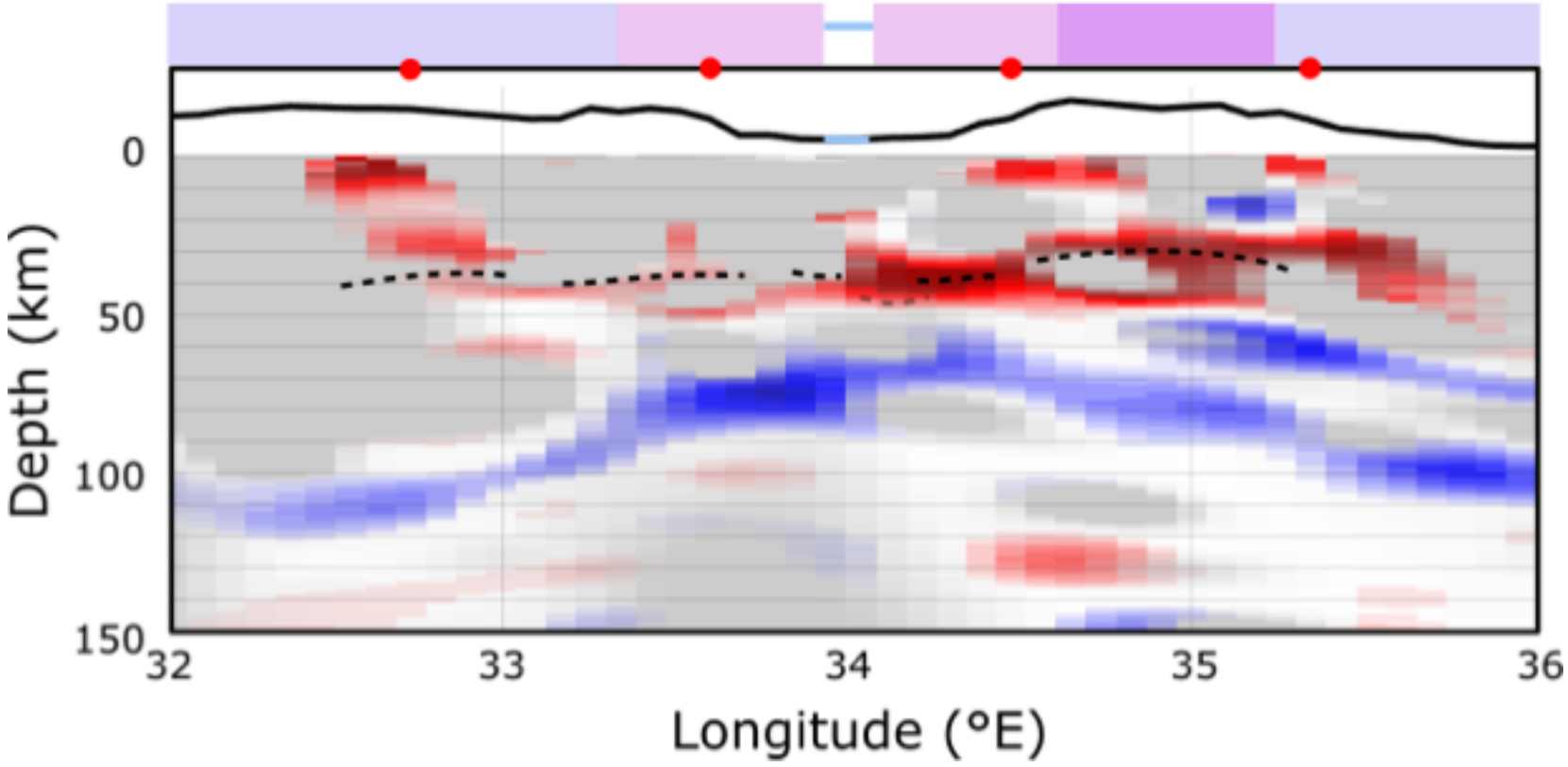
Lithospheric structure of an incipient continental rift:

Converted wave imaging of the Malawi Rift, southern East African Rift System



Emily Hopper, Jim Gaherty, Donna Shillington

Lamont-Doherty Earth Observatory

Cindy Ebinger, Andy Nyblade, Patrick Chindindali, Richard Ferdinand, Gabby Mbgoni, Godson Kamihanda

EAST AFRICAN RIFT SYSTEM, LAKE MALAWI

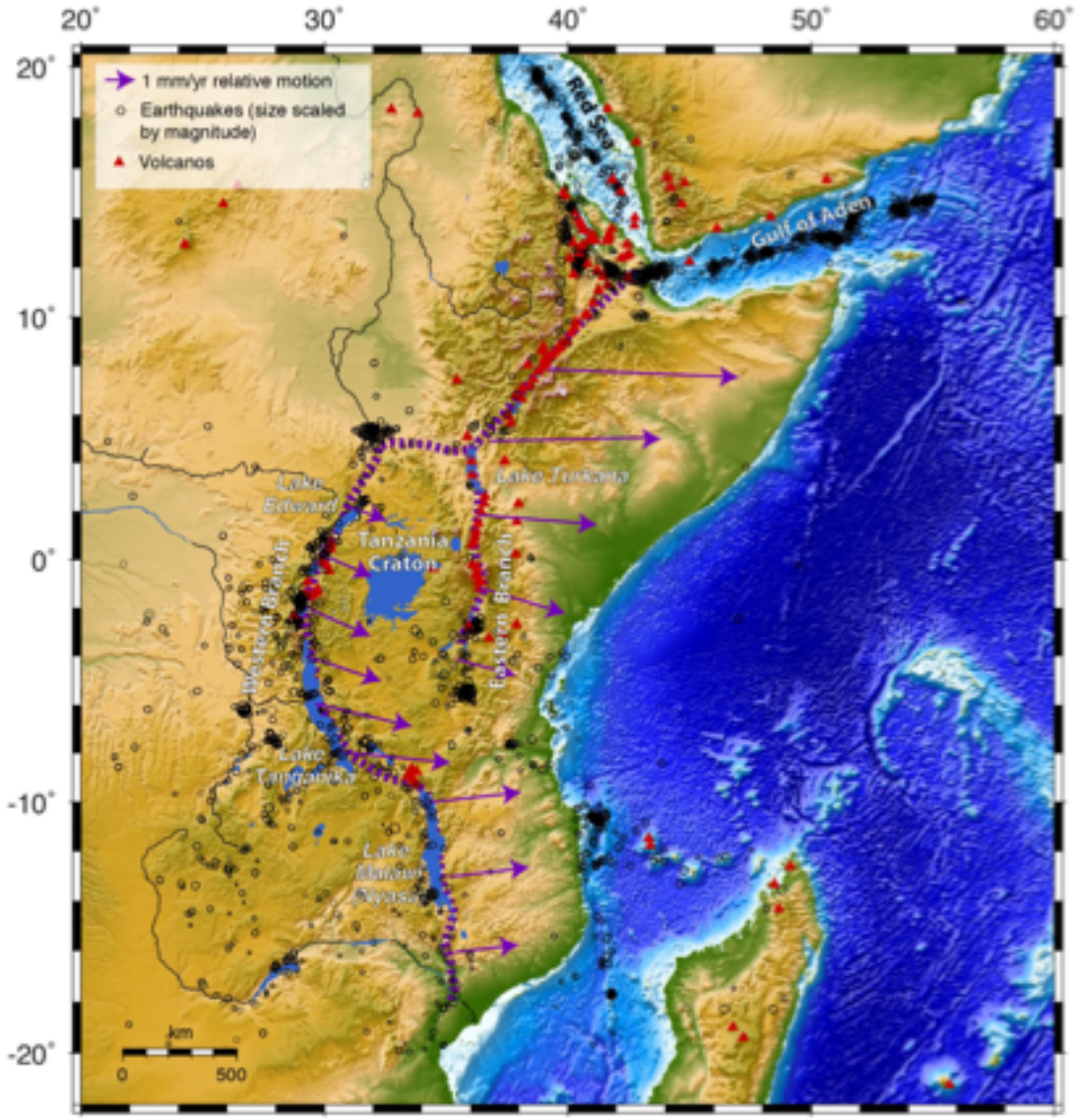
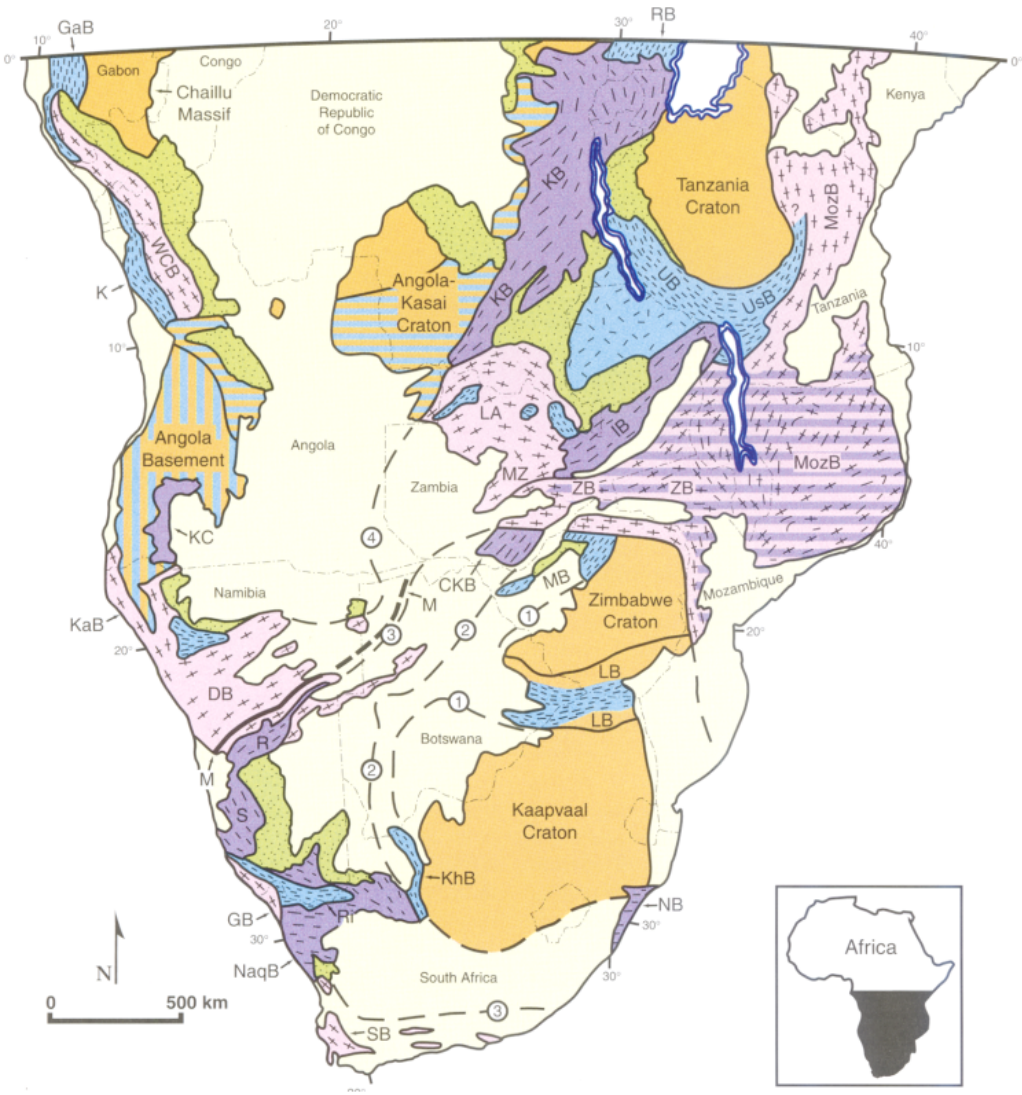


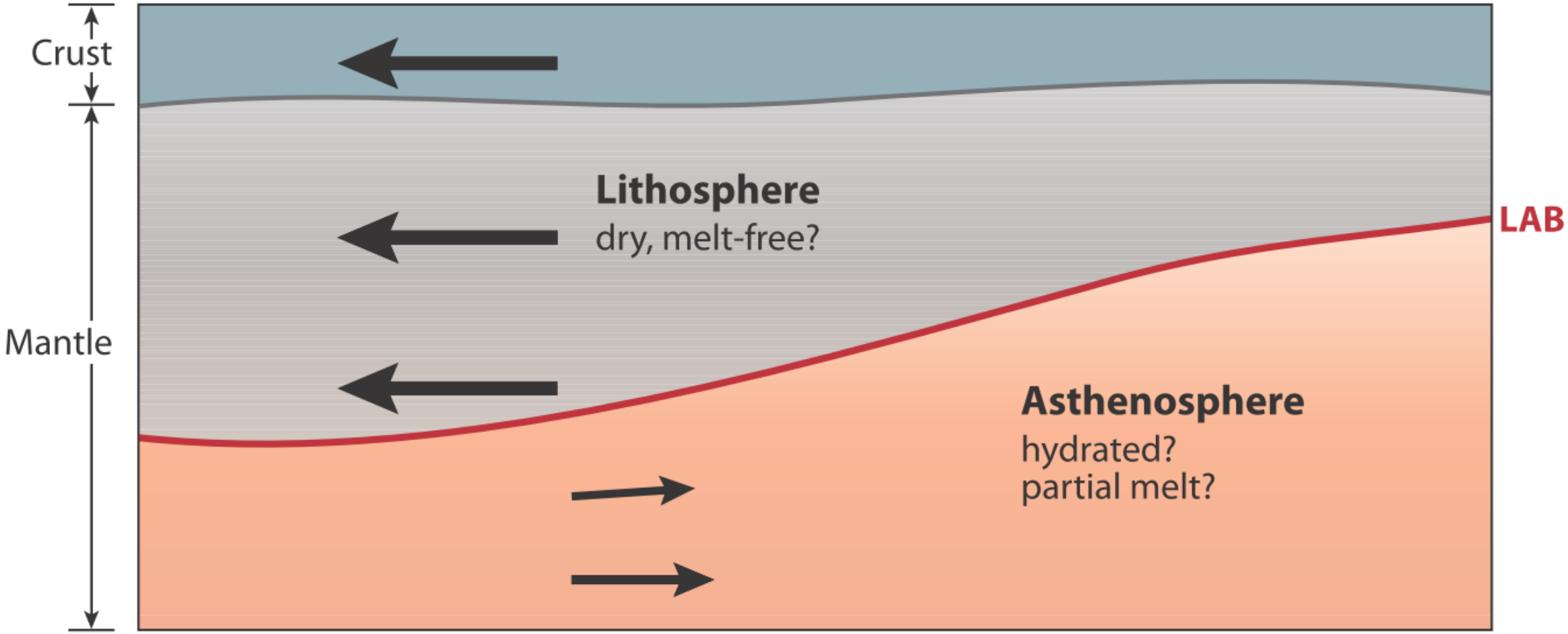
Plate Motions: Stamps et al., 2010

Volcanoes: Smithsonian Global Volcanism Project



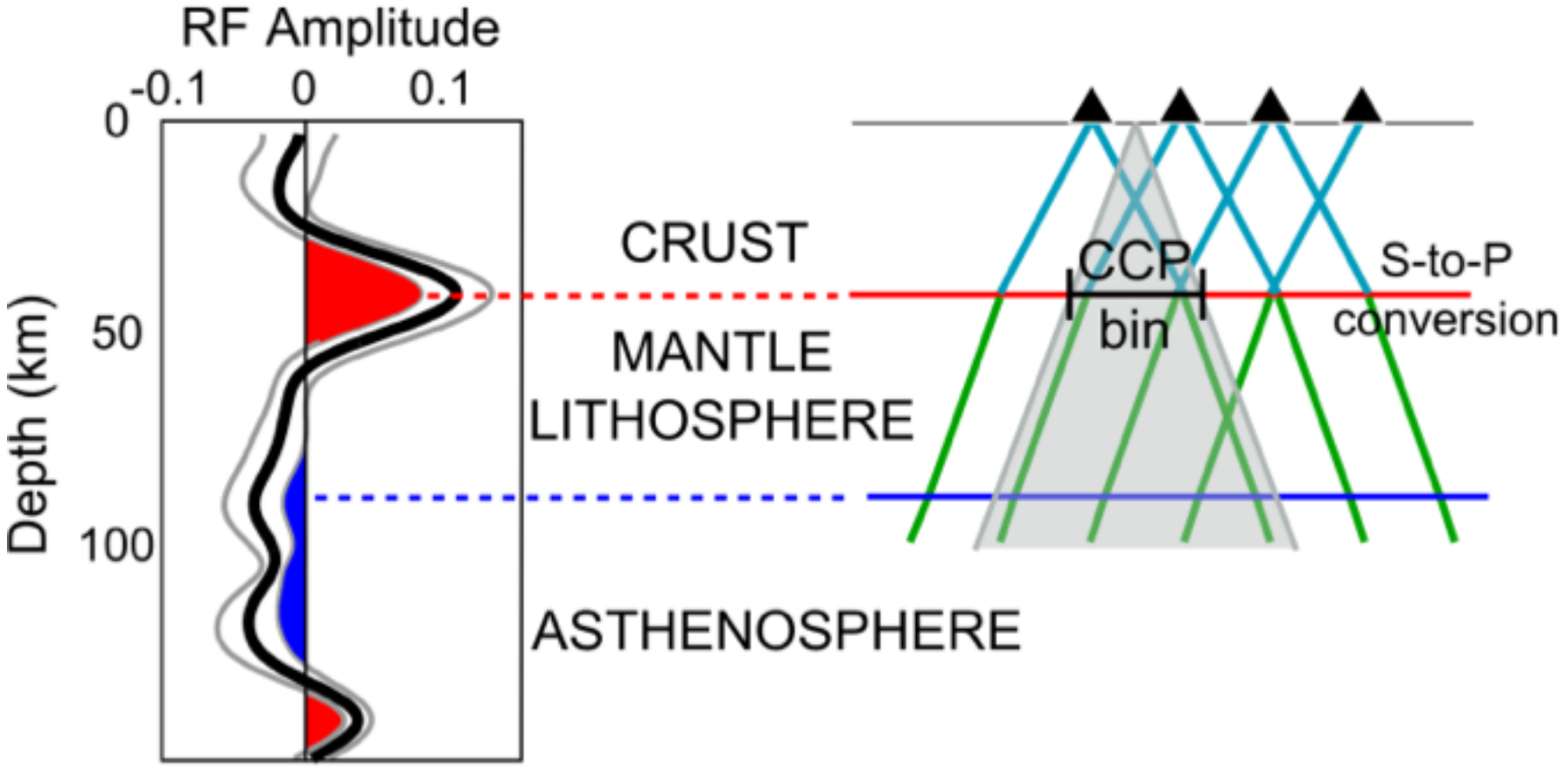
Hanson, 2003

THE LITHOSPHERE-ASTHENOSPHERE SYSTEM

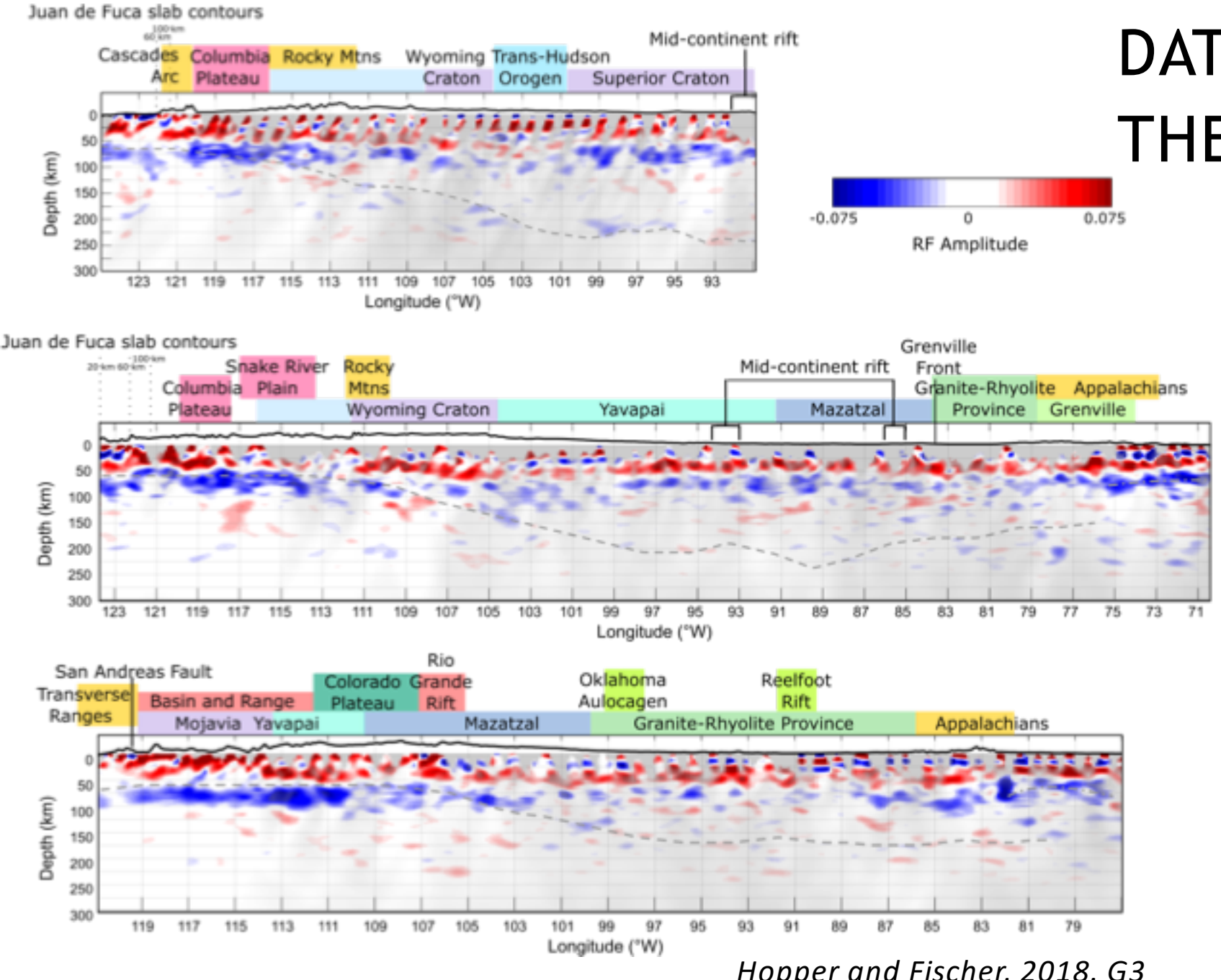


Fischer et al., 2010

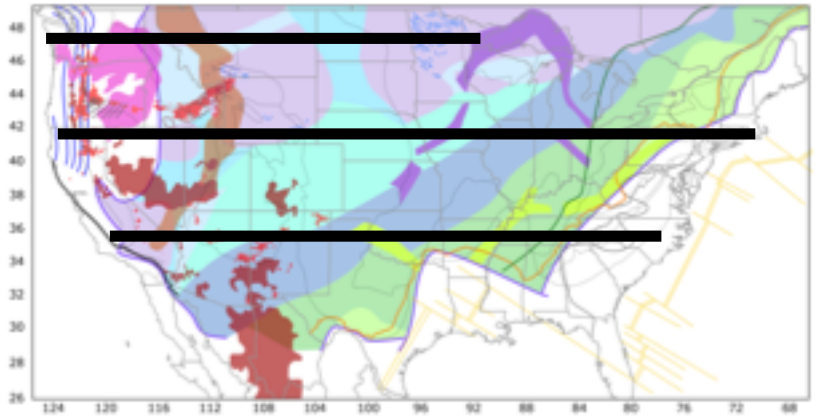
COMMON CONVERSION POINT (CCP) STACK
S-to-P scattered waves (and similarly, P-to-S)



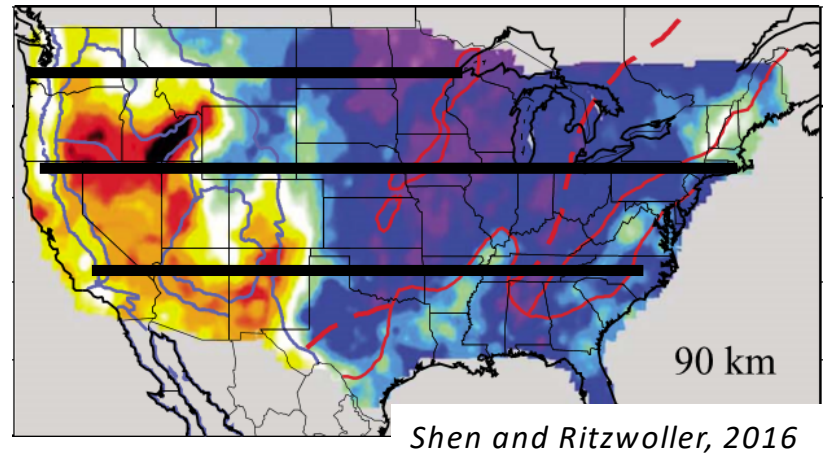
DATA-RICH IMAGING IN THE CONTIGUOUS U.S.



Hopper and Fischer, 2018. G3

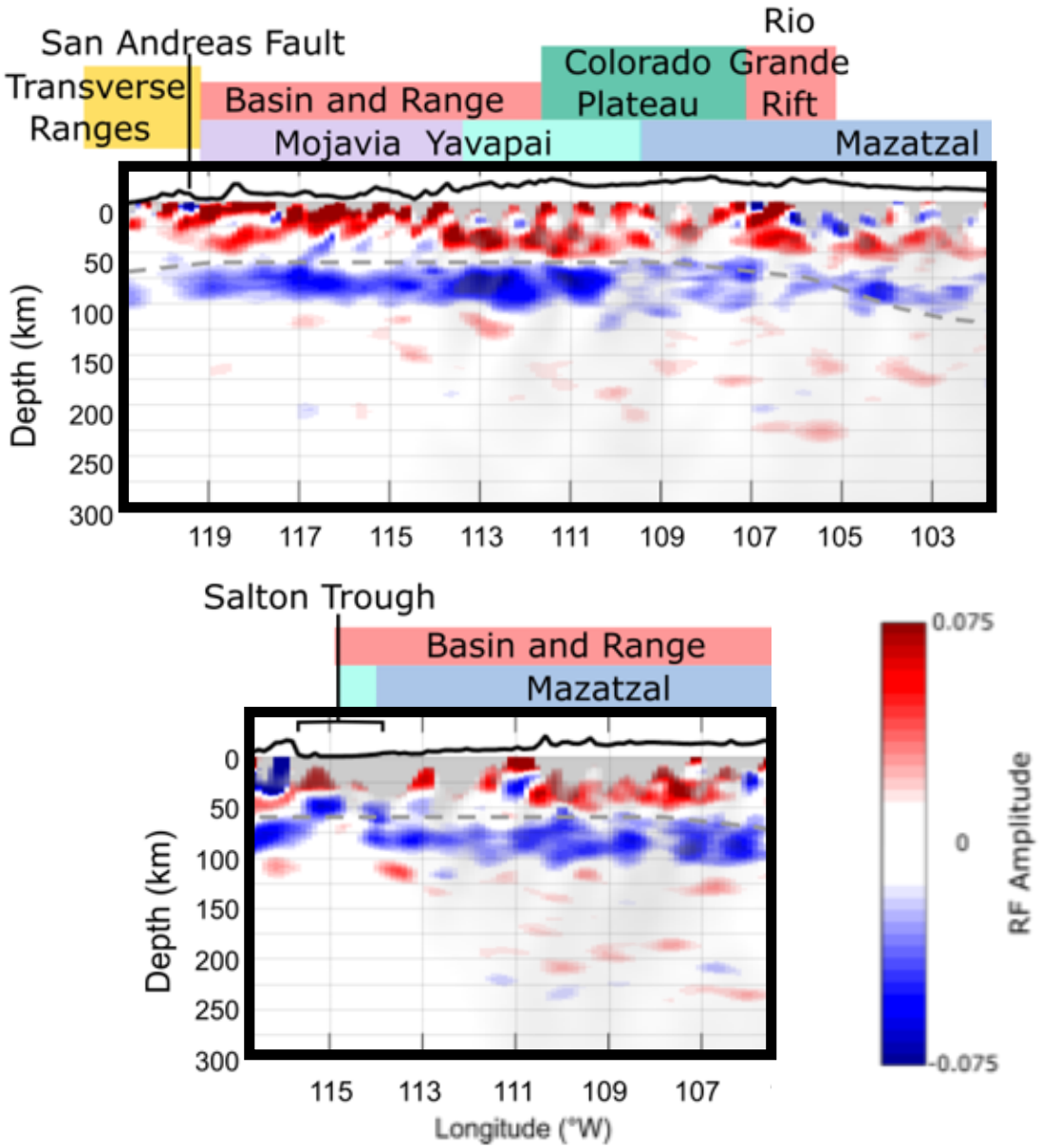


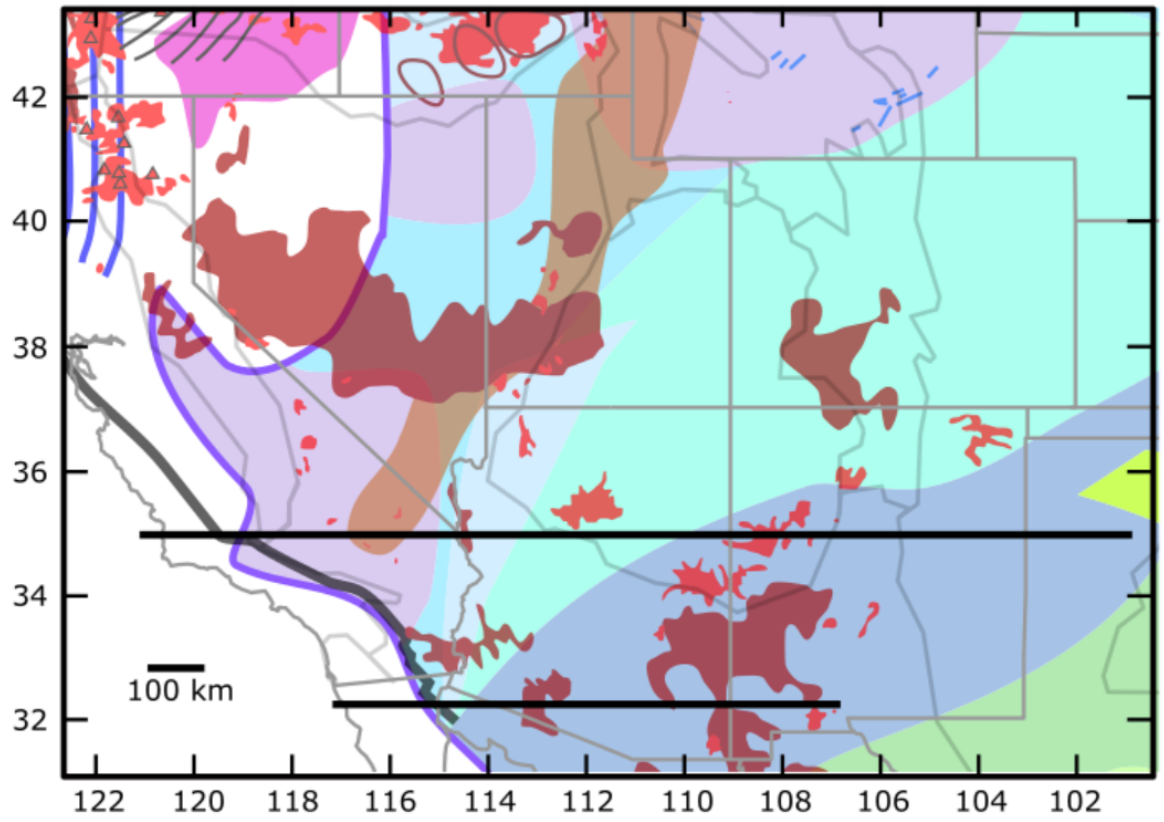
After Whitmeyer & Karlstrom, 2007



Shen and Ritzwoller, 2016

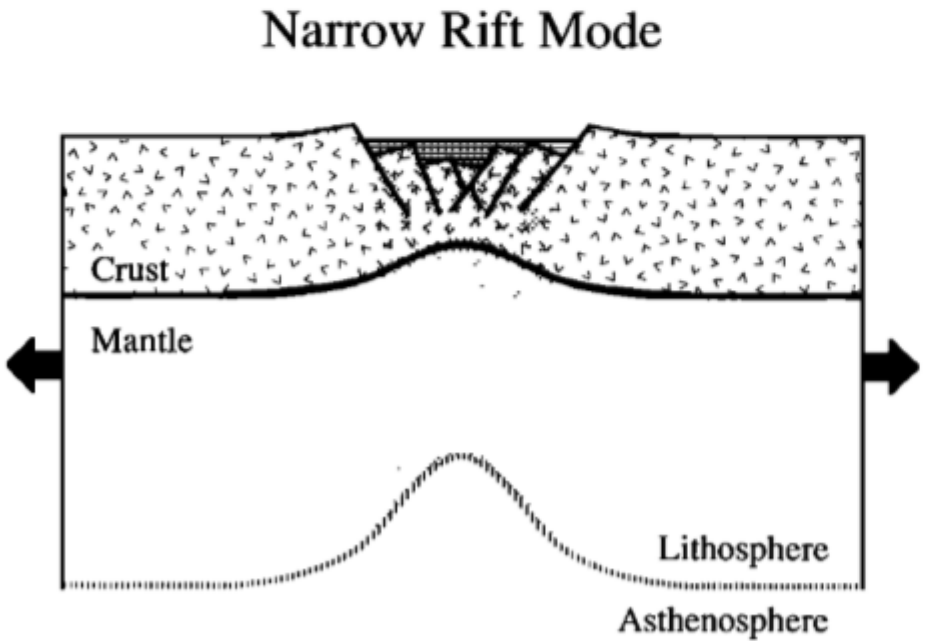
RIFT ARCHITECTURE IN THE WESTERN U.S.

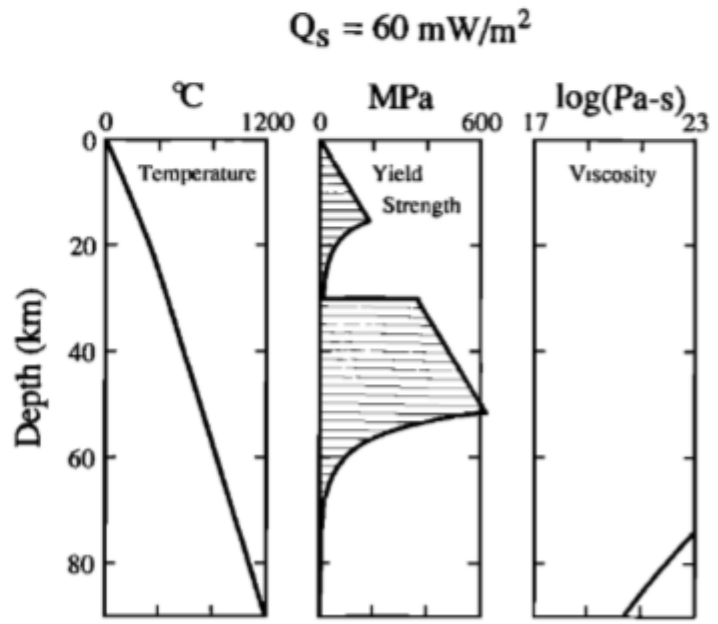


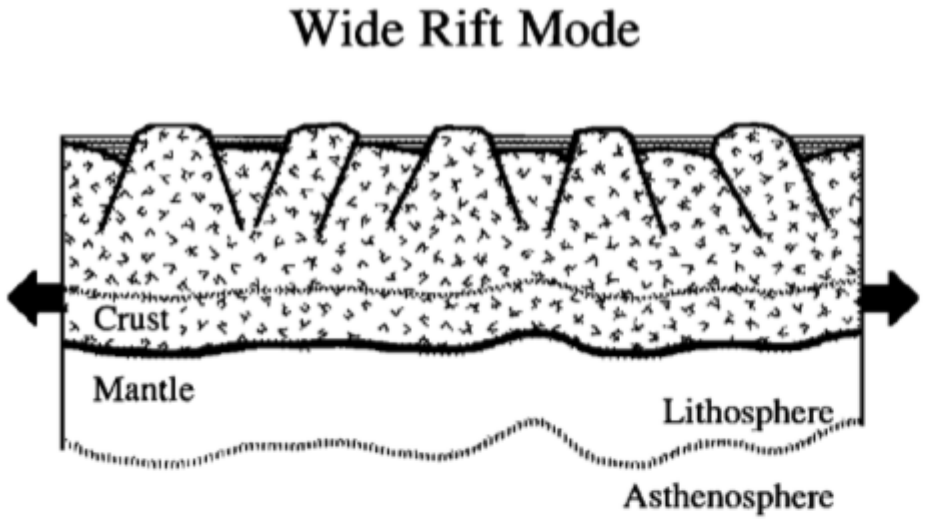


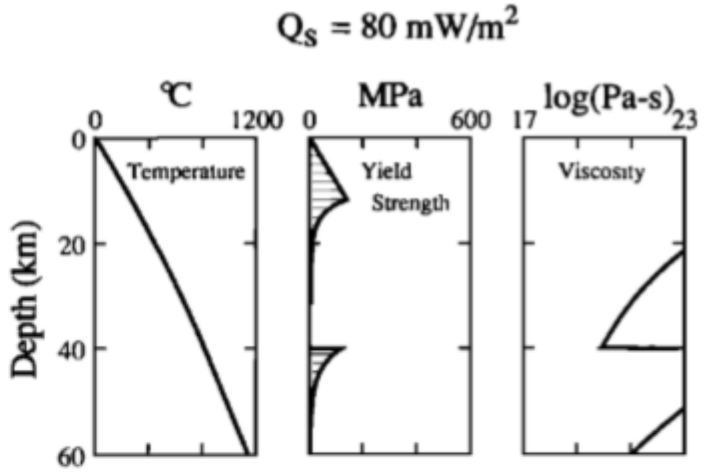
Hopper and Fischer, 2018. G3

MODES OF RIFTING





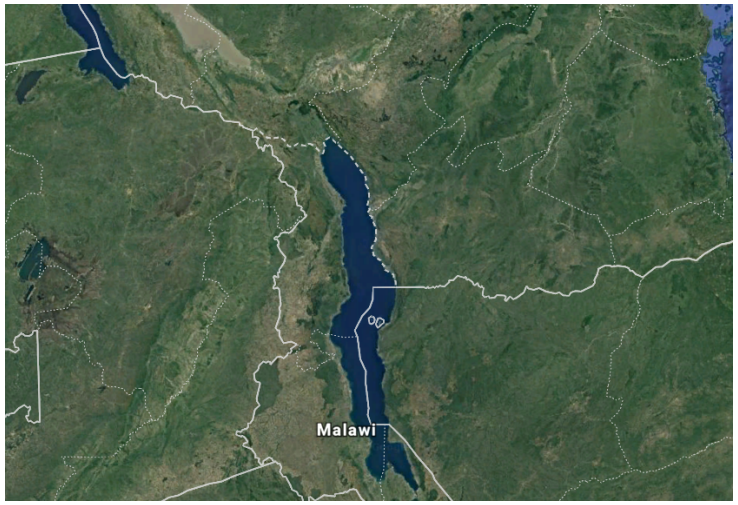




Buck, 1991

MODES OF RIFTING

Narrow Rift Mode



150 km

Malawi Rift:

- ~2 mm/year extension
- 9 Ma to present
- <15% cumulative extension
- Limited volcanism

Ebinger, 1989; Ebinger et al., 1993; Saria et al., 2014

Wide Rift Mode

150 km

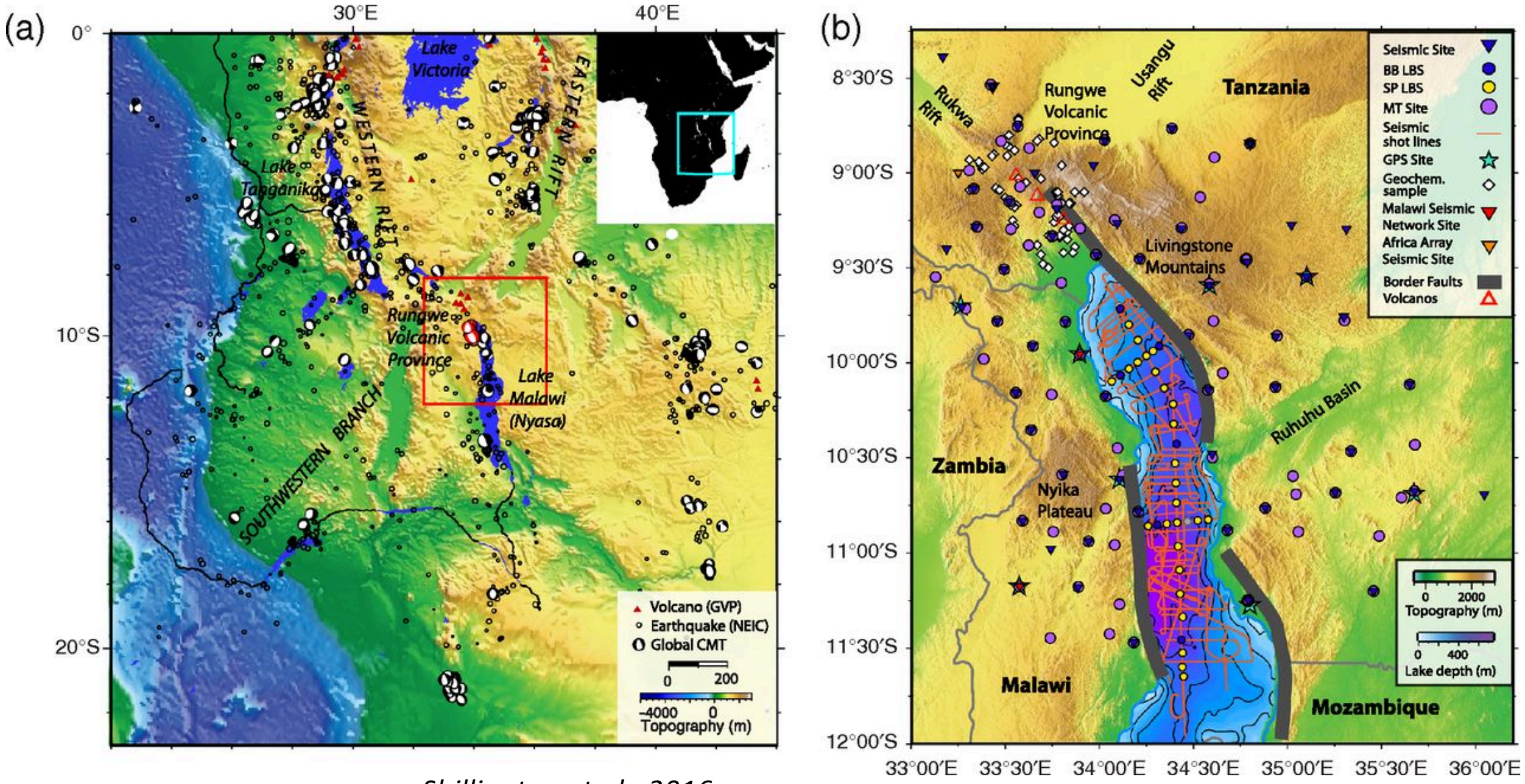
Google Earth

Basin and Range:

- ~10 mm/year extension
- 36 Ma to present
- 50-200% cumulative extension
- Widespread volcanism

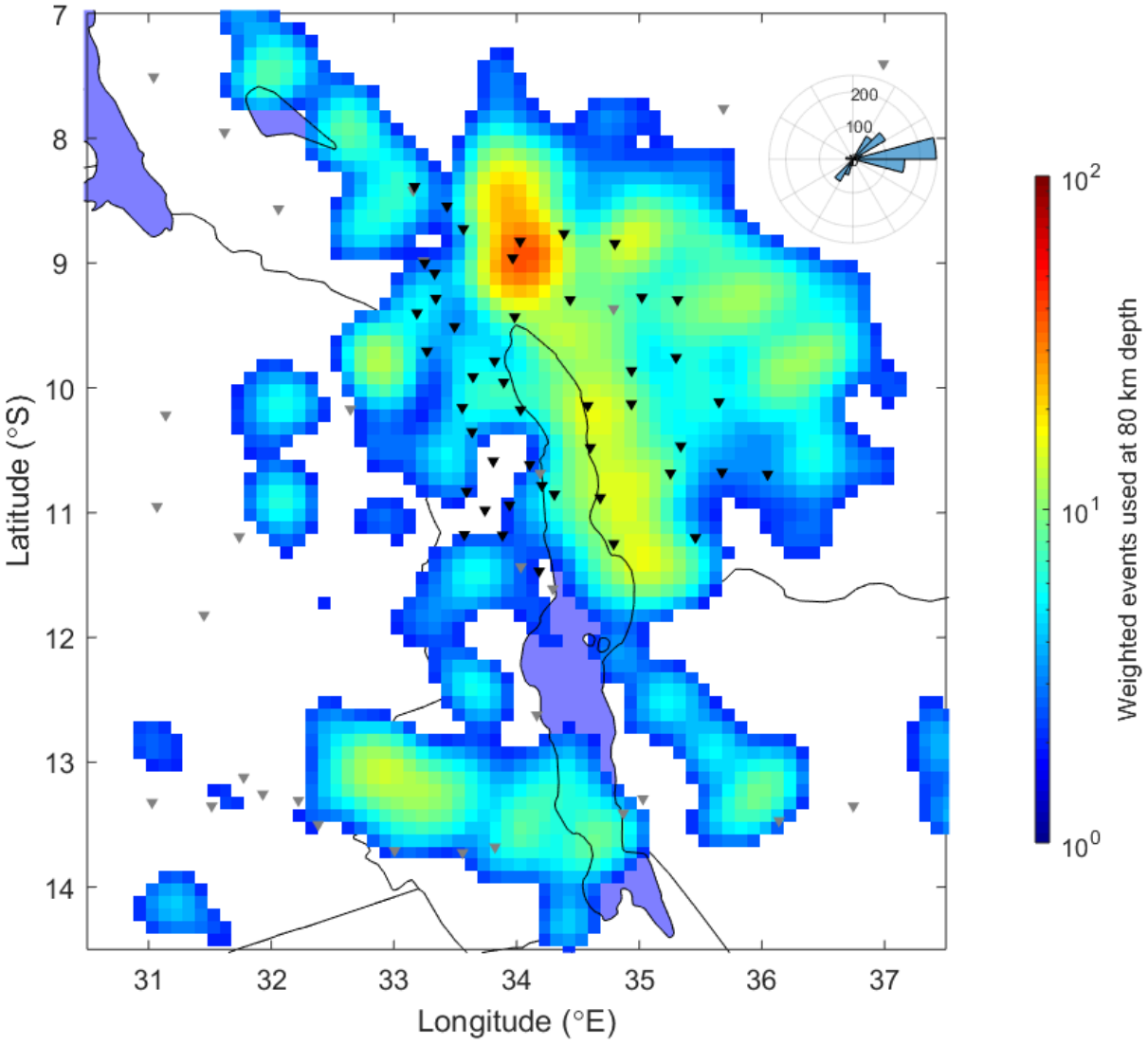
McQuarrie and Wernicke, 2005

THE SEGMeNT EXPERIMENT

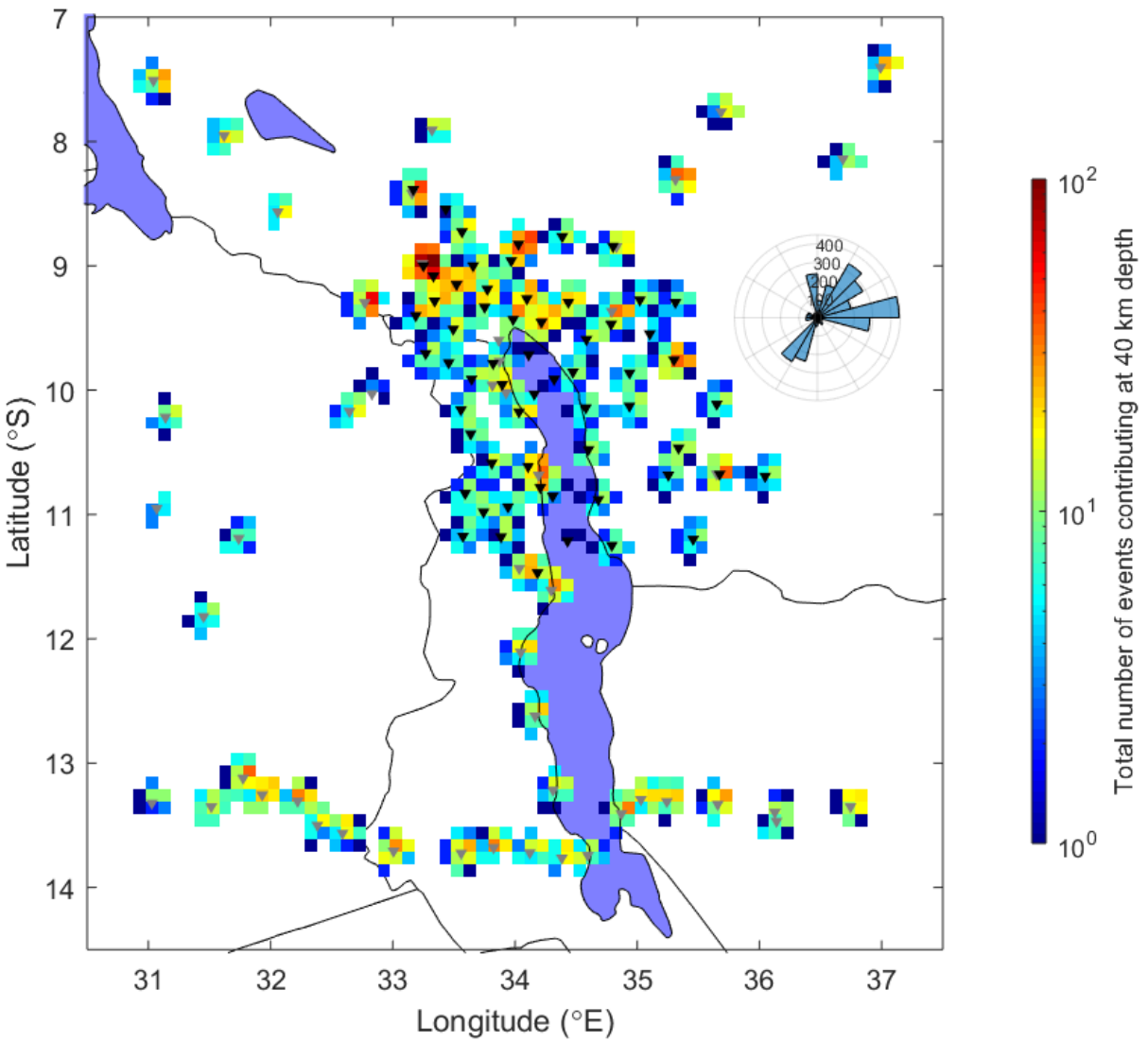


Shillington et al., 2016

DATA: SEGMeNT + other available broadband

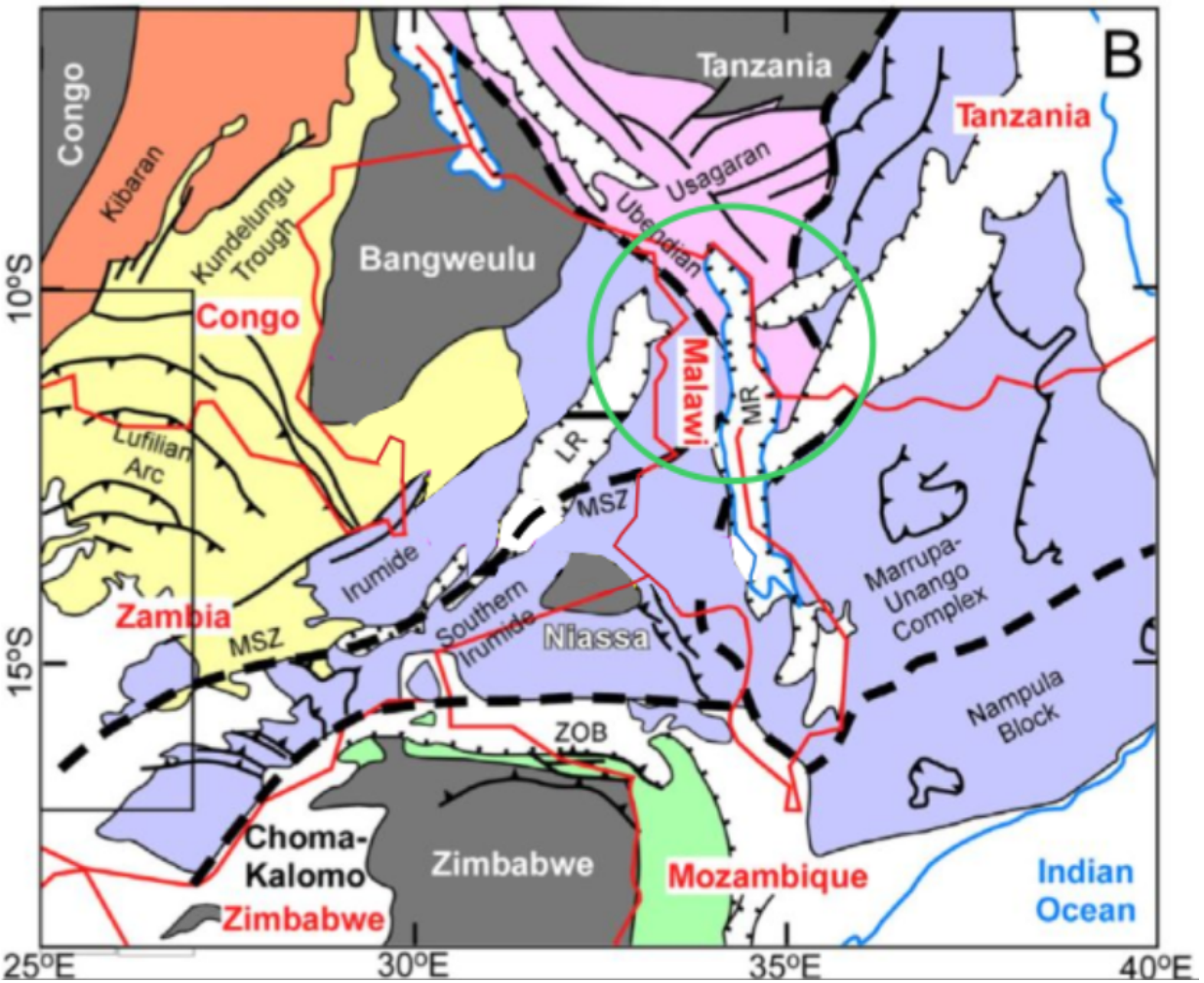


Data coverage at 80 km for Sp stack (total 802 RFs)

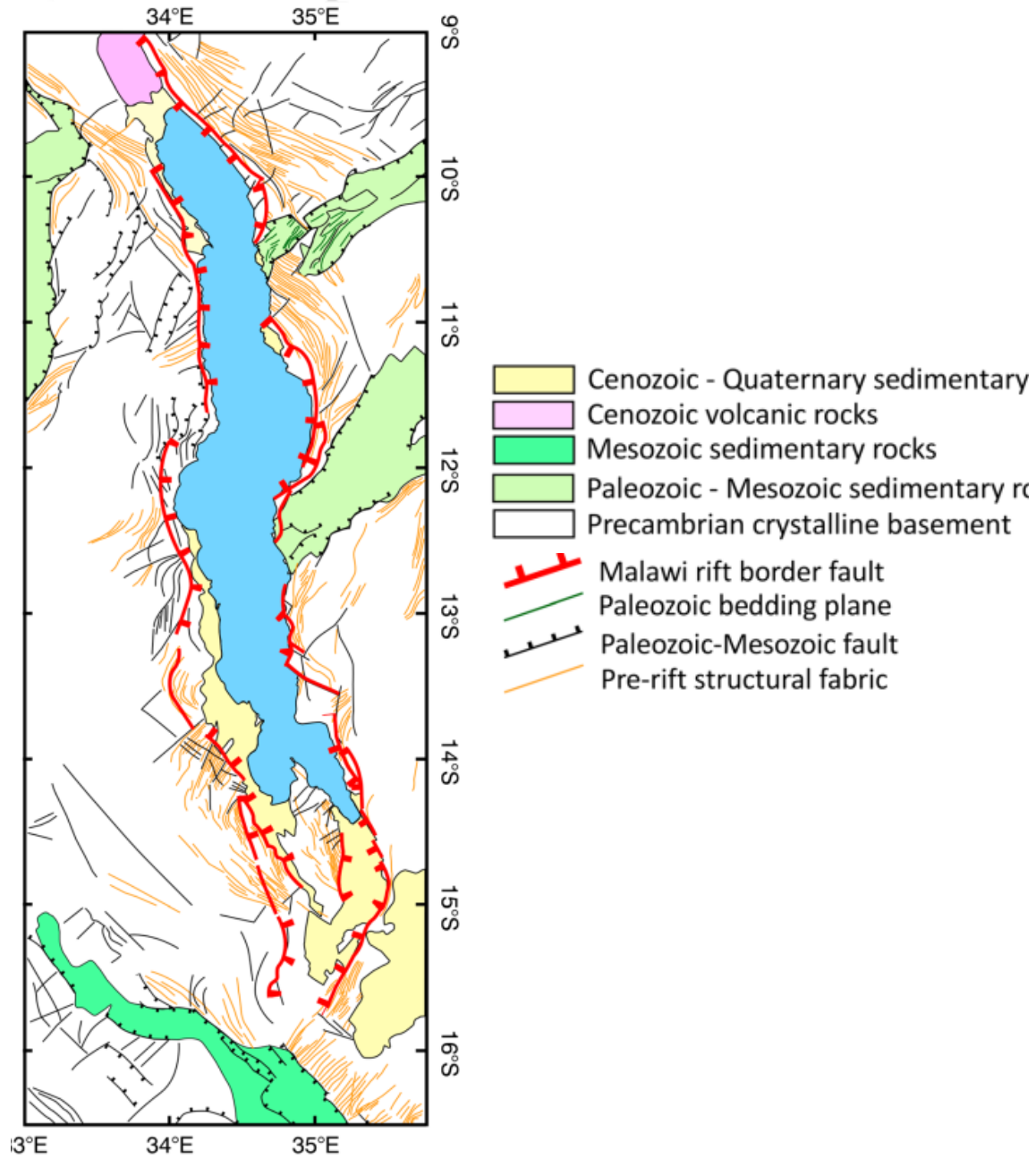


Data coverage at 40 km for Ps stack (total 3001 RFs)

LOCAL TECTONICS

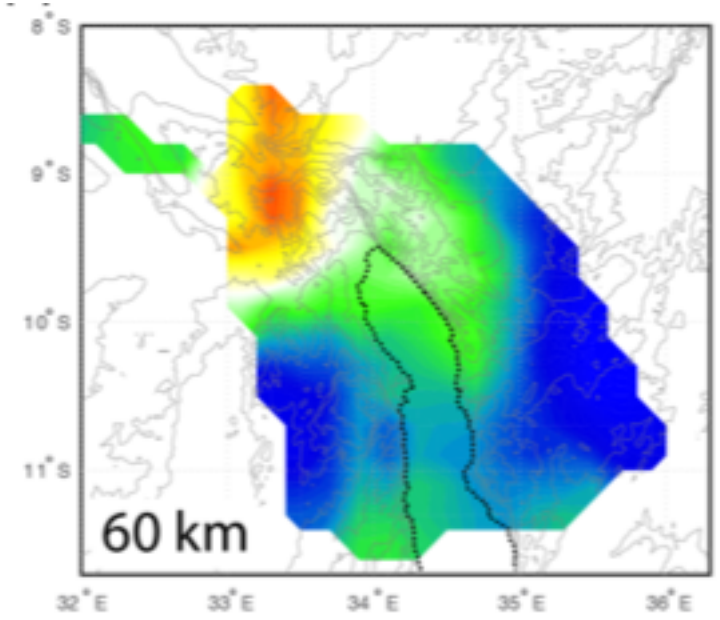


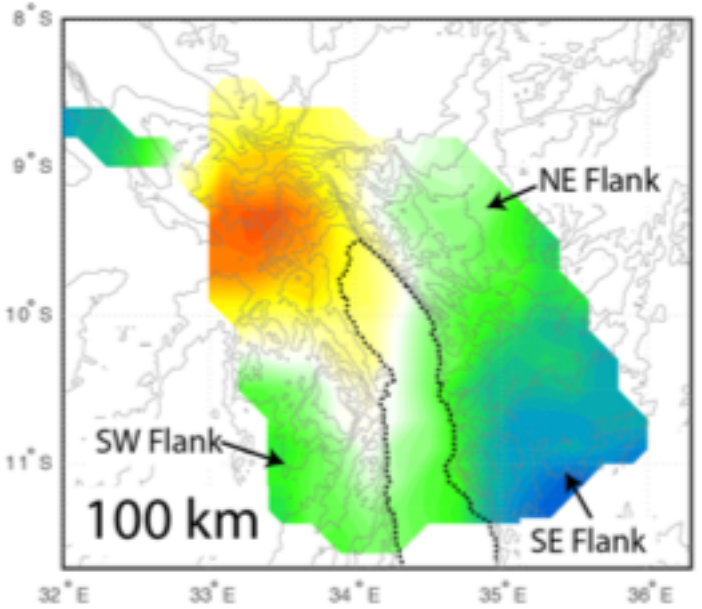
Sarafian et al., 2017

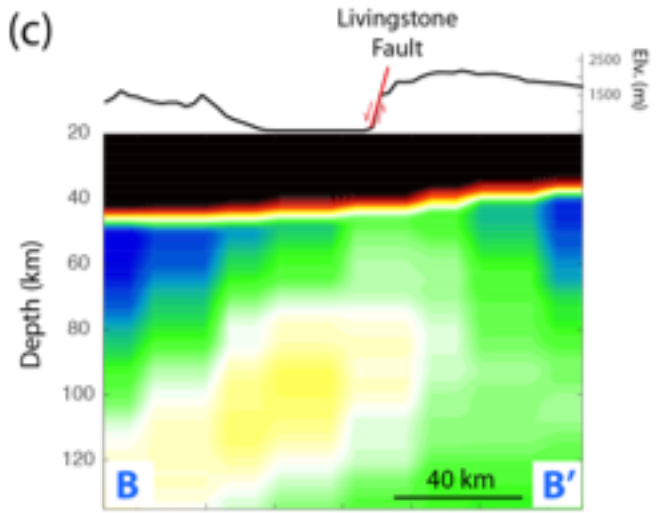


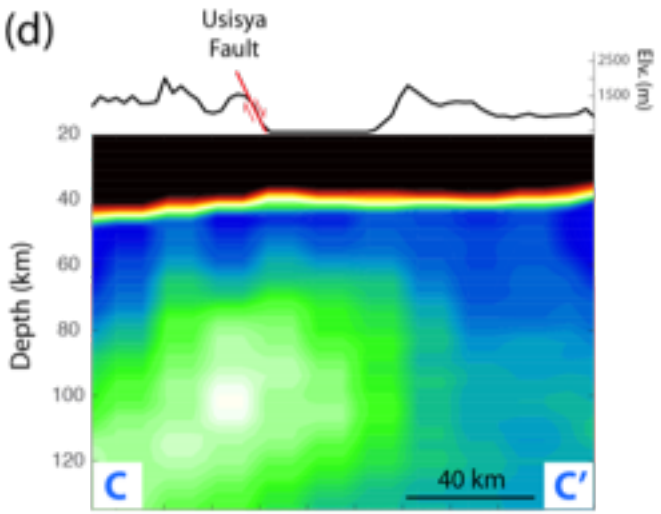
Lao-Davila et al., 2015

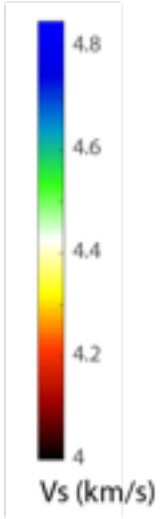
SURFACE WAVE TOMOGRAPHY, LAKE MALAWI

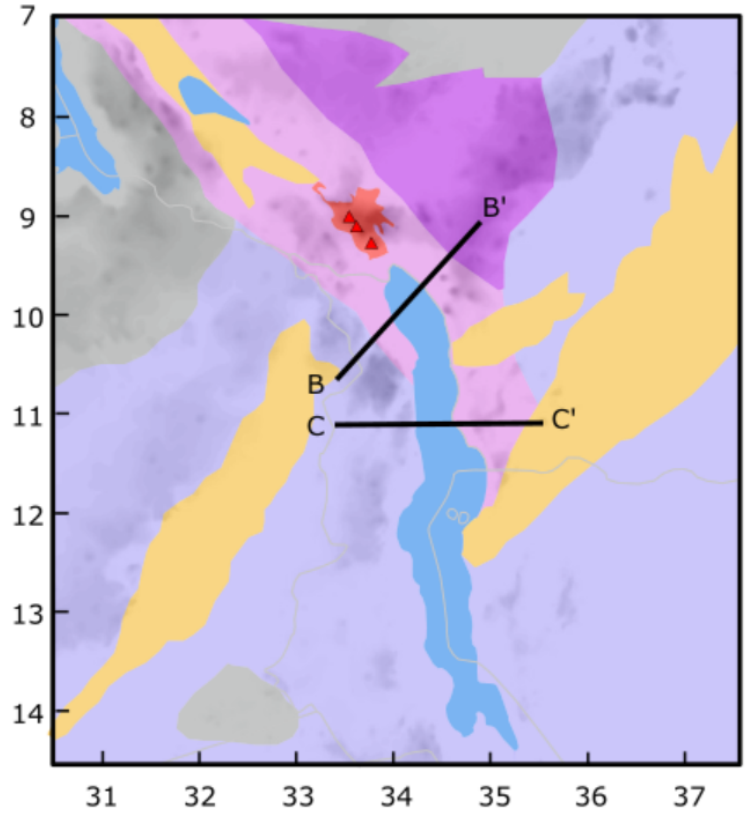




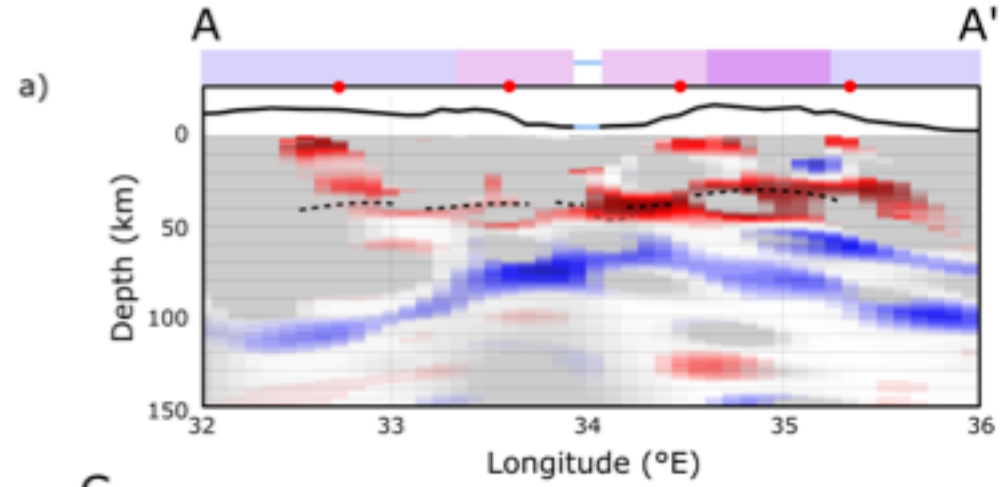


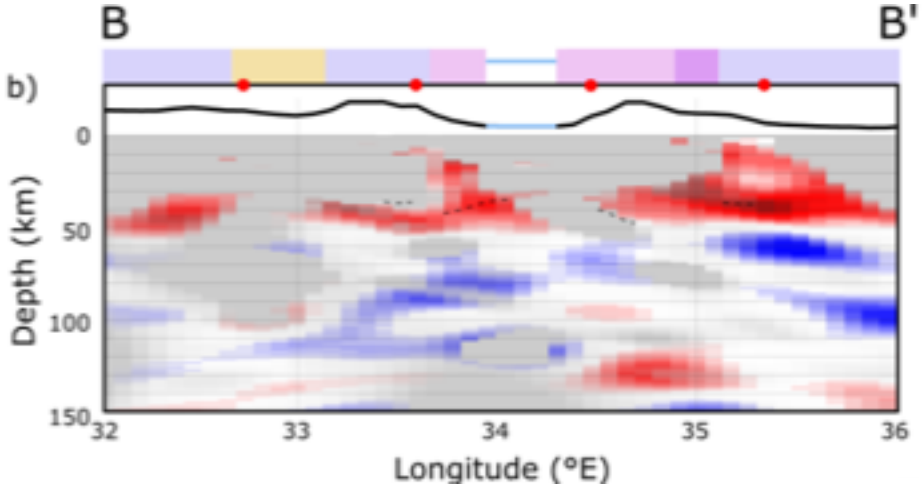


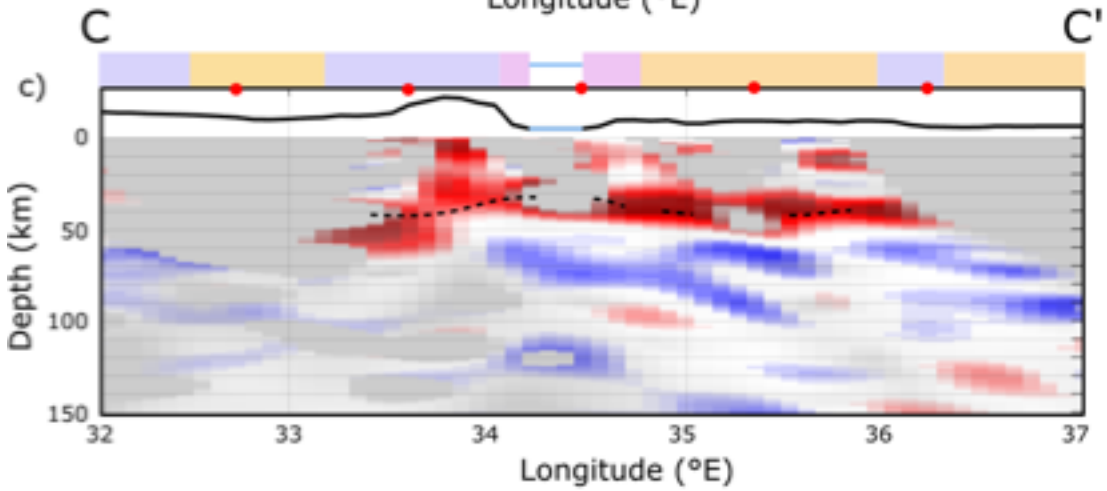


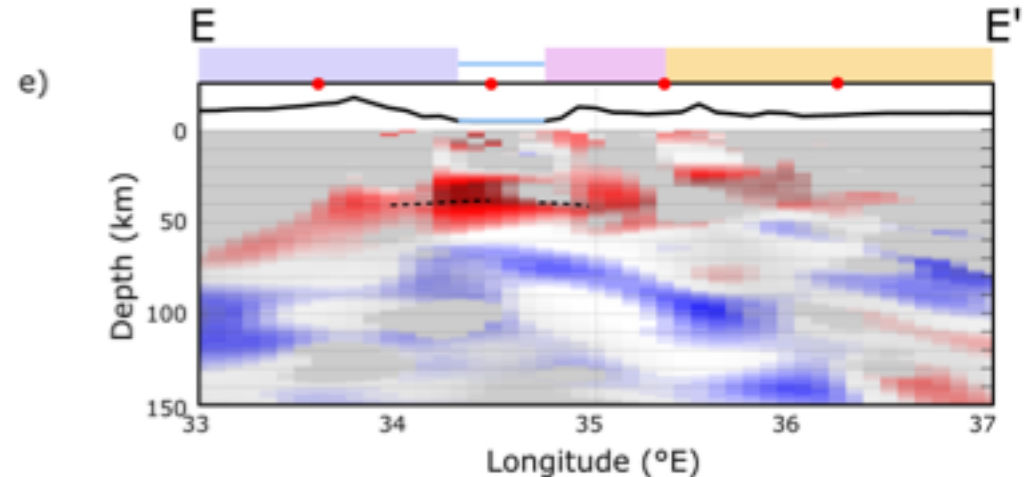


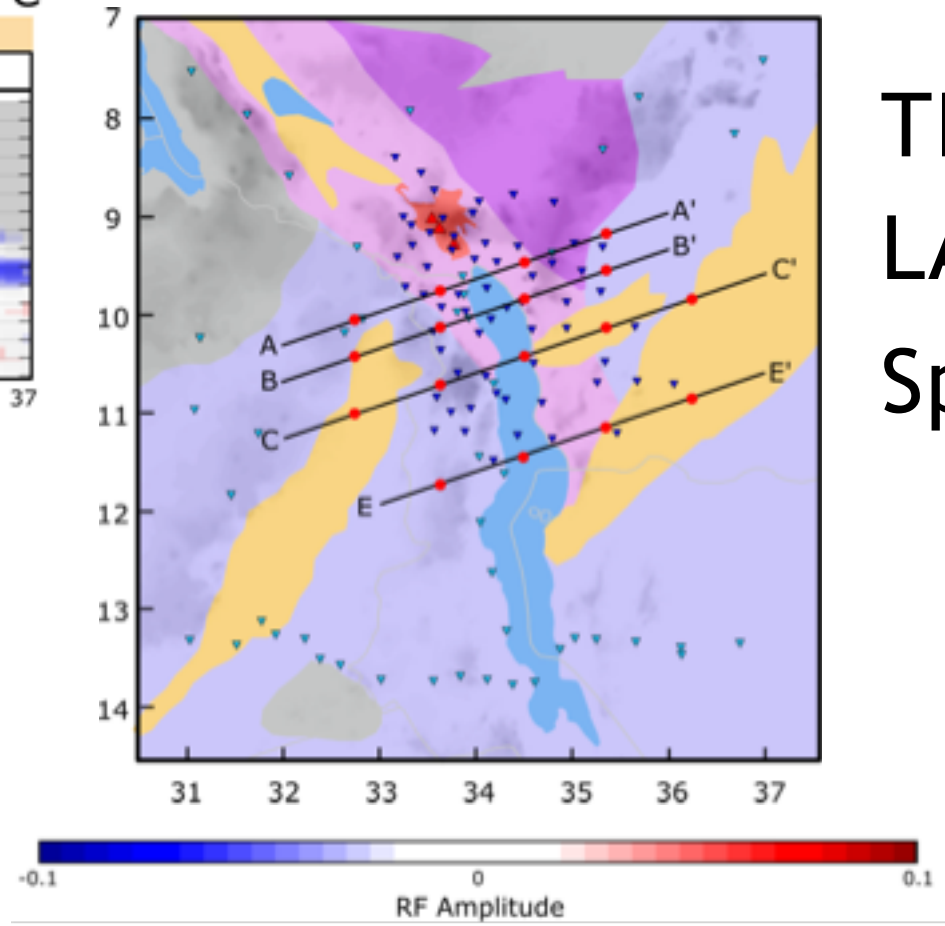
Accardo, 2018



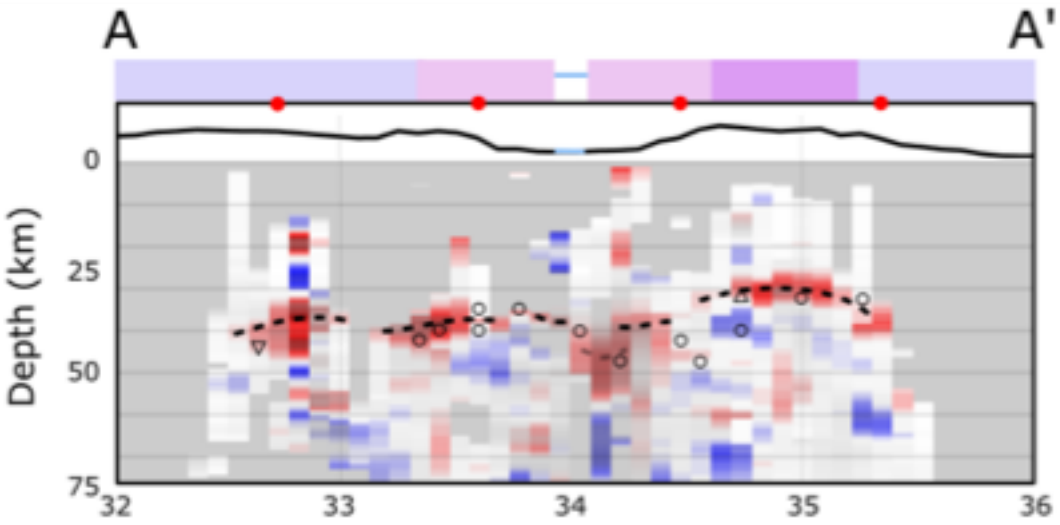


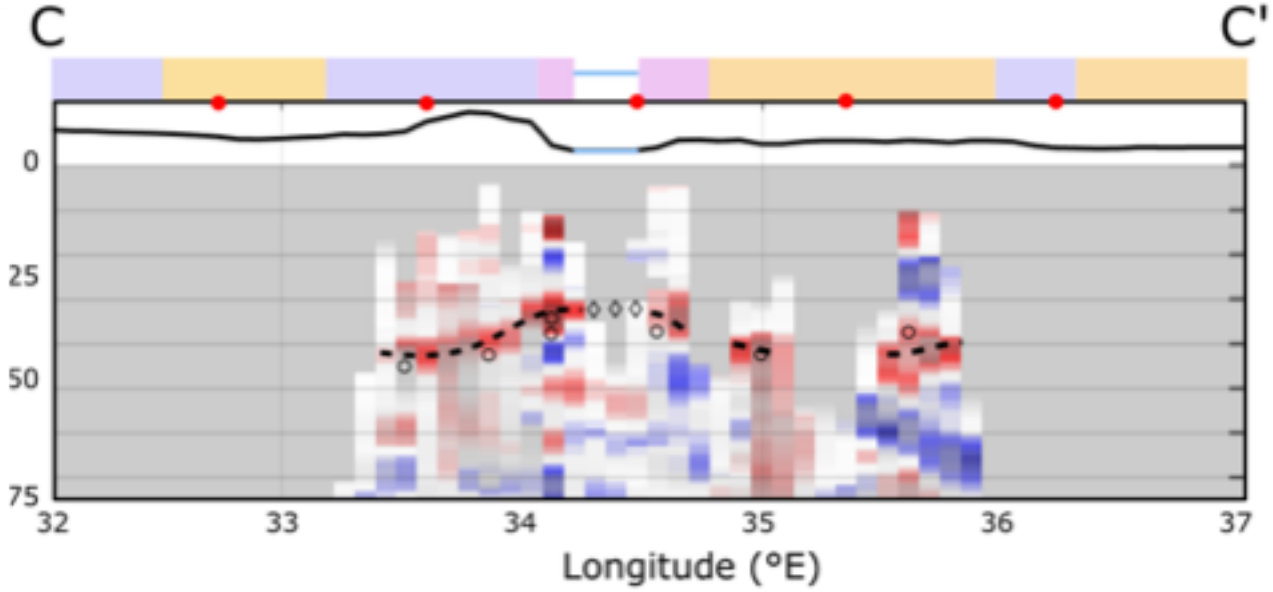


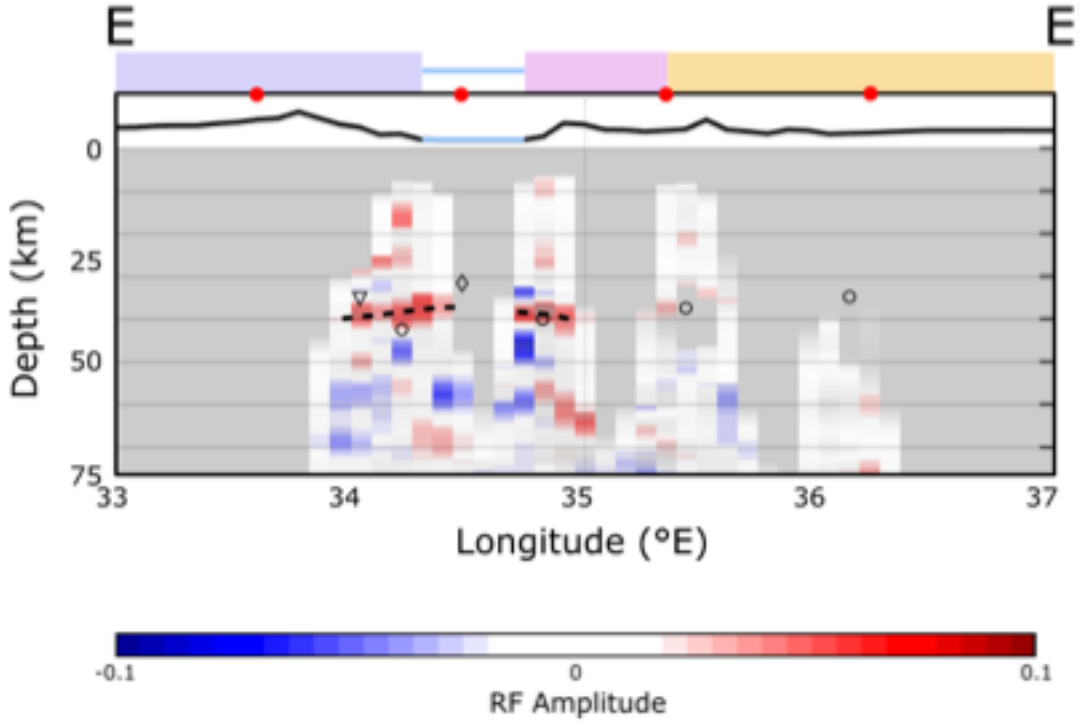


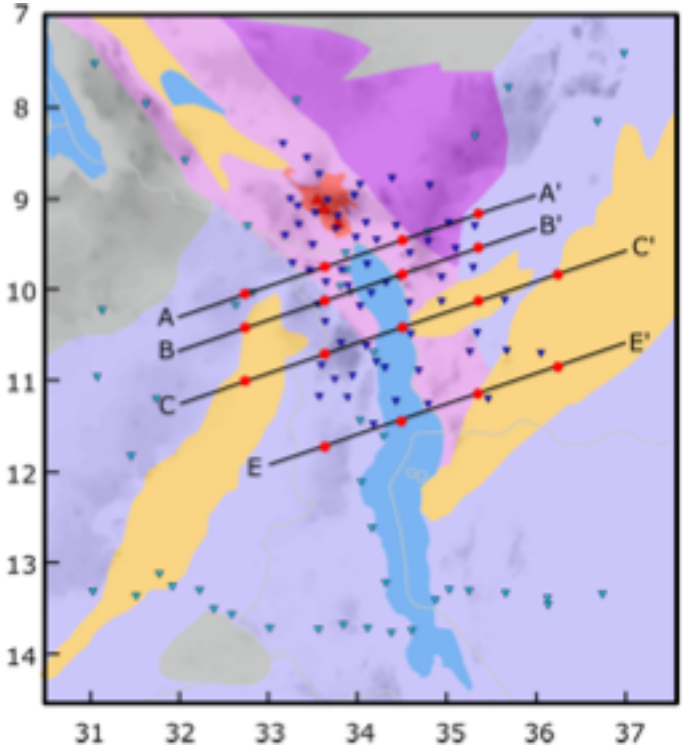


TRAVERSING LAKE MALAWI: Sp imaging





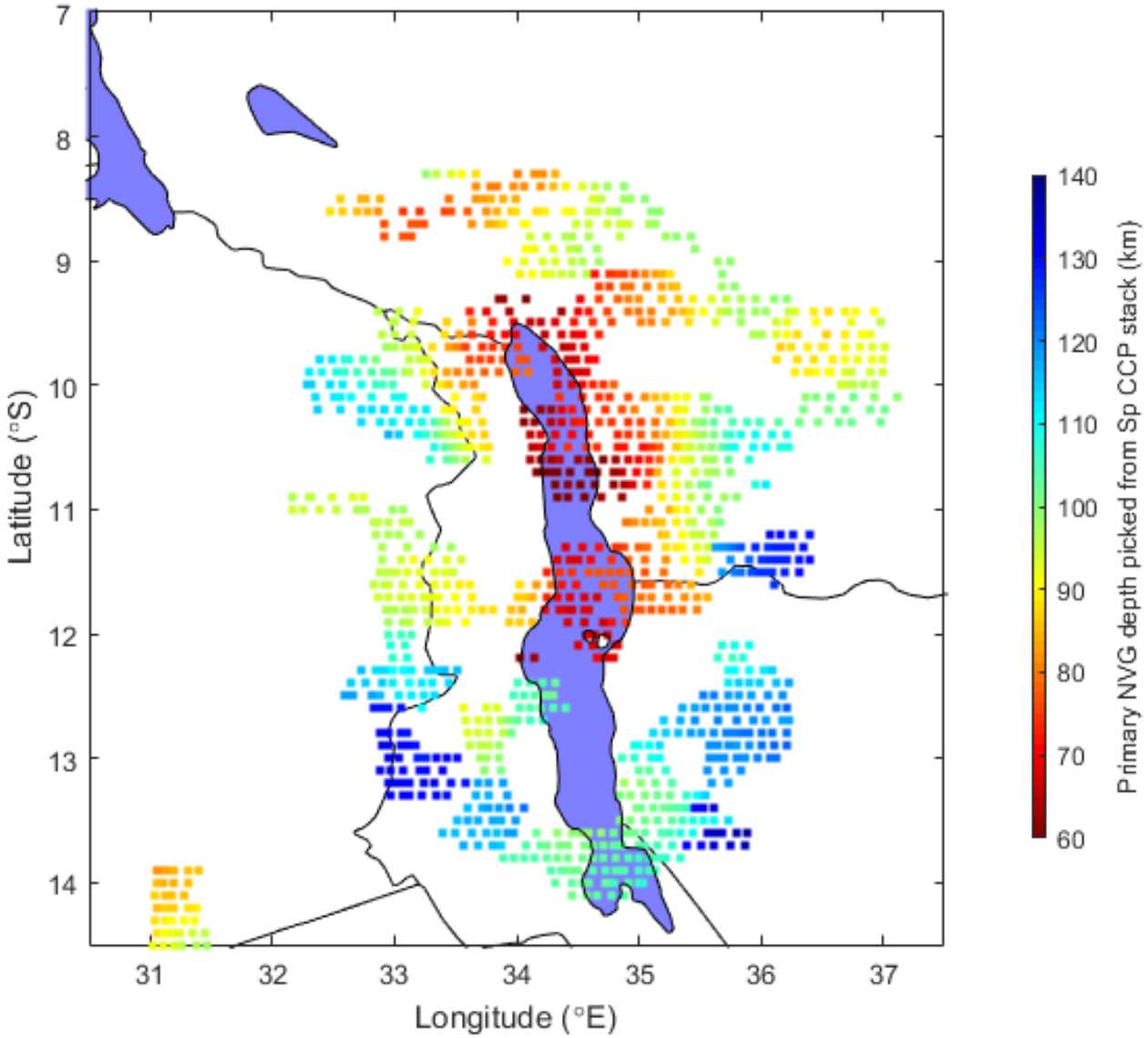


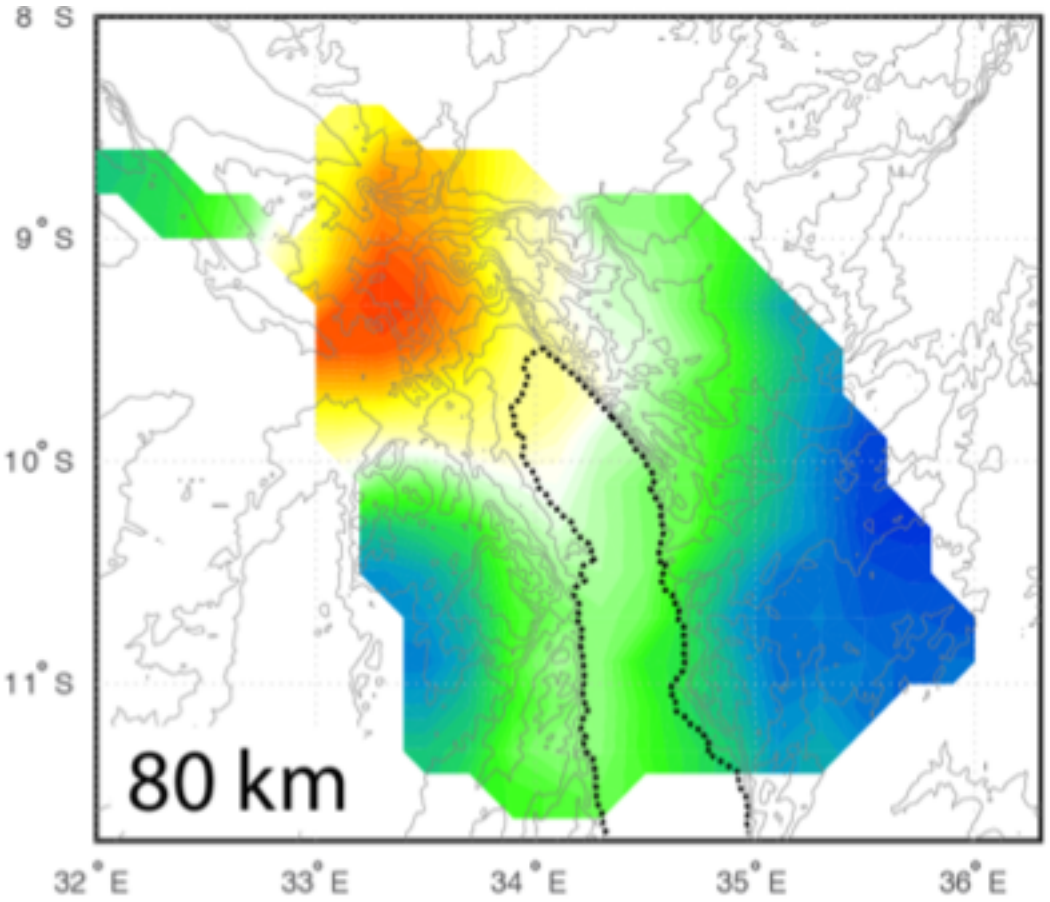


TRAVERSING LAKE MALAWI: Ps imaging

- Borrego et al., in review
- Shillington et al., in prep
- Kachingwe et al., 2015
- Tugume et al., 2012
- Last et al., 1997

MAPPING THE DEPTH OF THE LAB

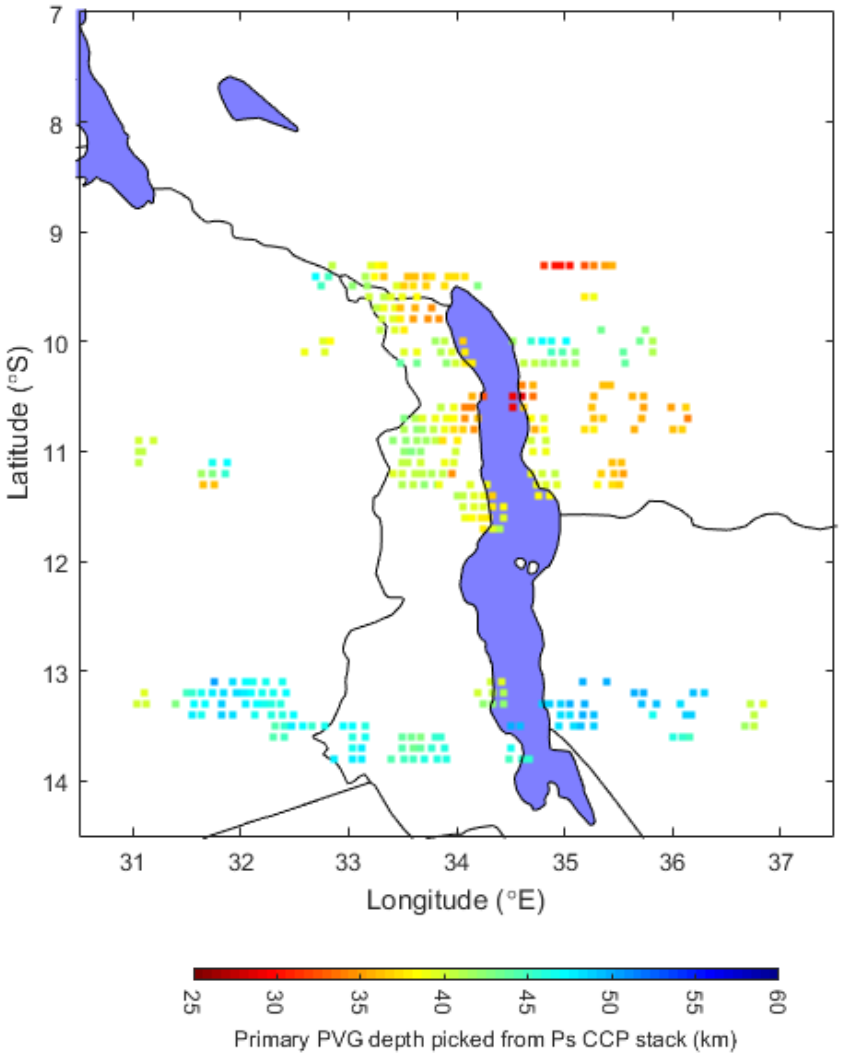


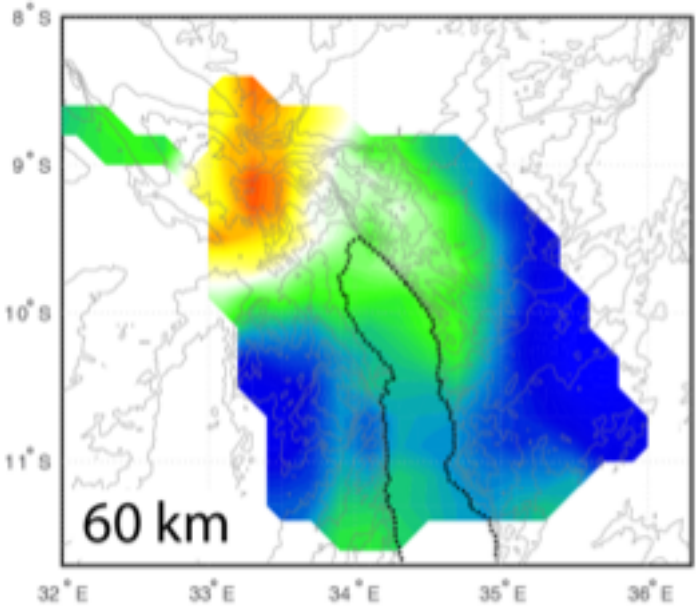


Accardo, 2018

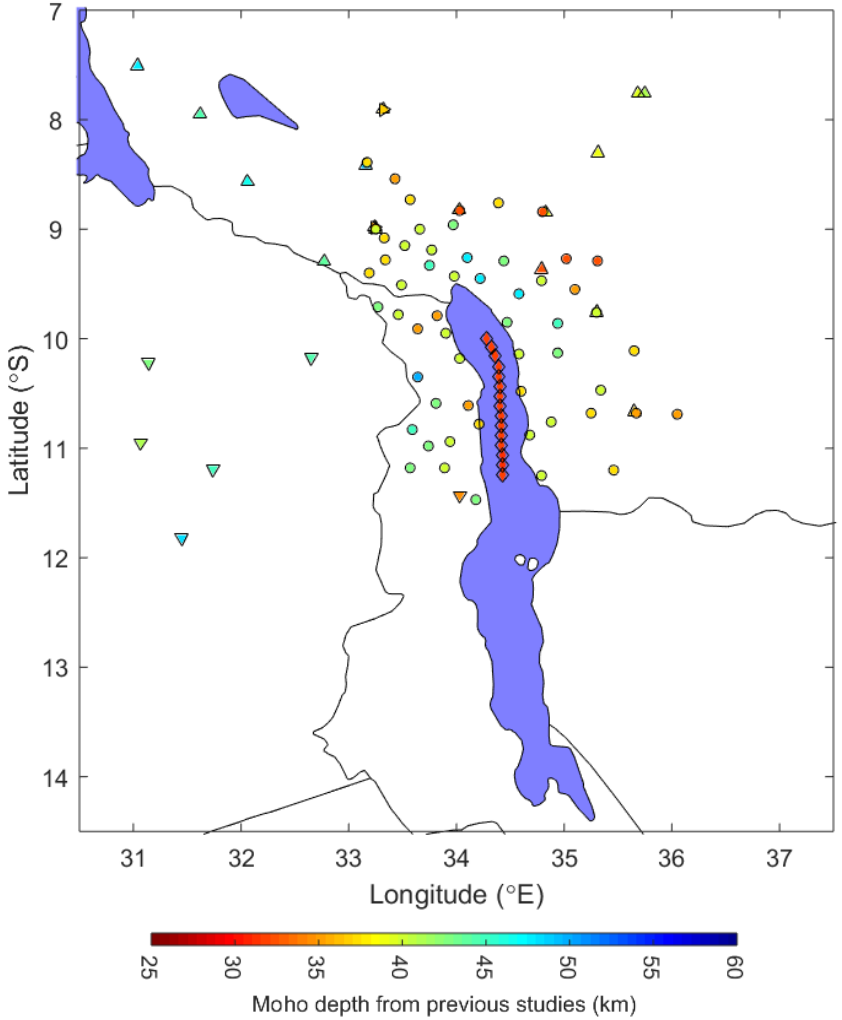
Primary NVG depth from Sp CCP stack

MAPPING THE BASE OF THE CRUST





Accardo, 2018

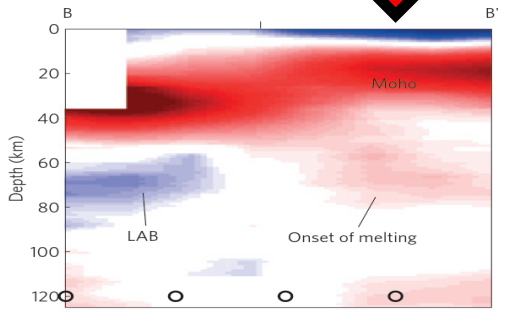


Crustal thickness from Ps CCP stack

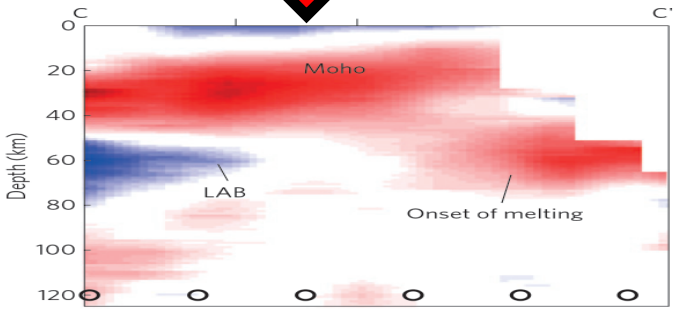
Borrego et al., in review
Shillington et al., 2017
Kachingwe et al., 2015
Tugume et al., 2012
Last et al., 1997

A NARROW RIFT THROUGHOUT THE LITHOSPHERE

Main Ethiopian Rift

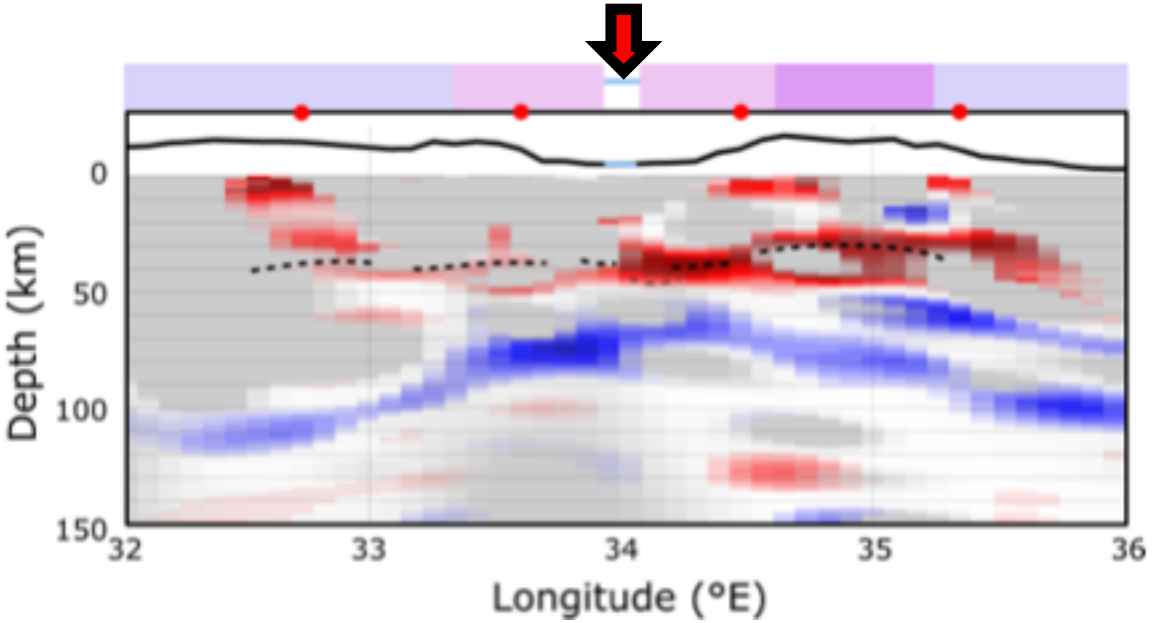


Main Ethiopian Rift



Rychert et al., 2012 (v.e. 2x)

Malawi Rift



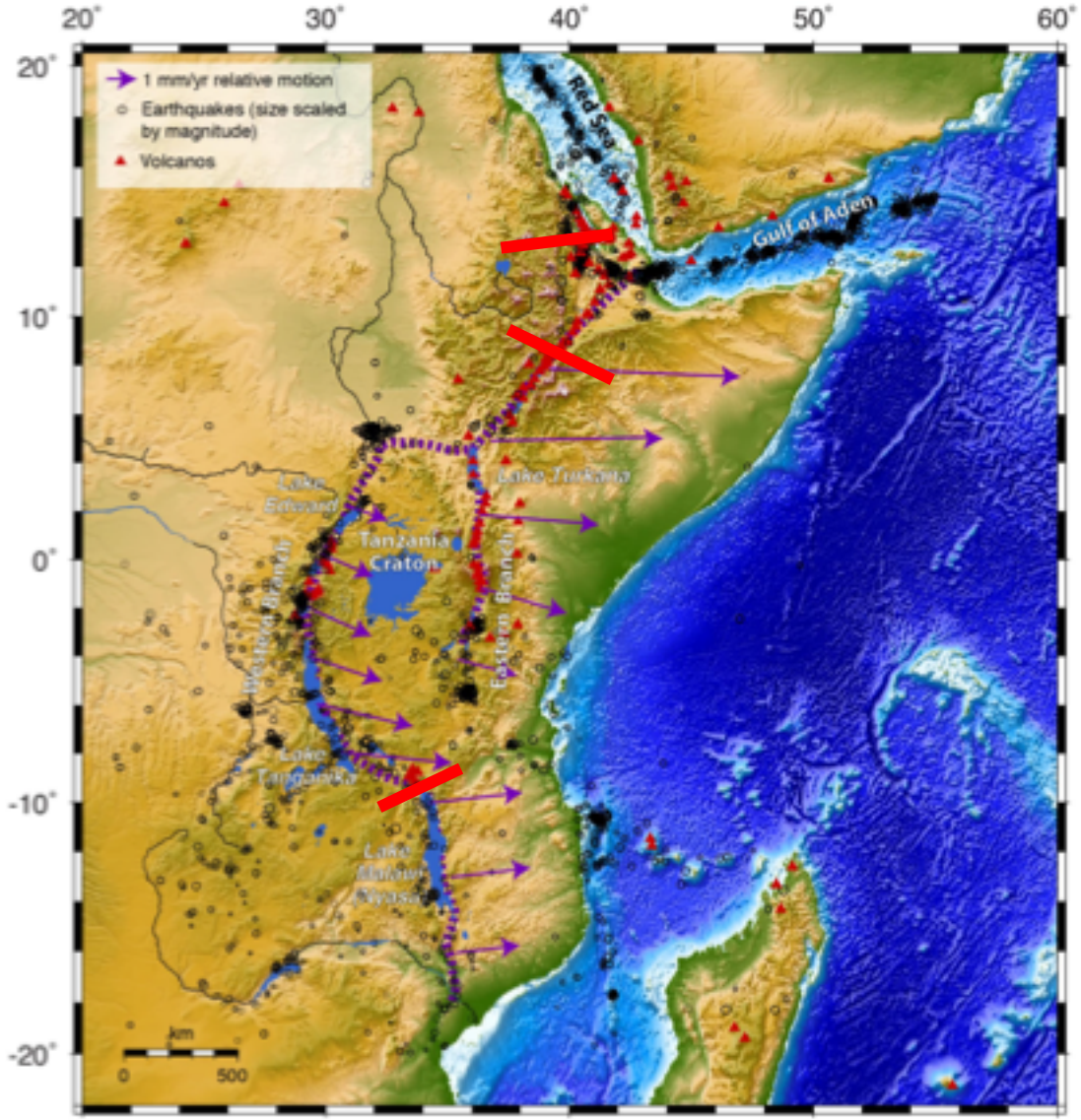


Plate Motions: Stamps et al., 2010

Volcanoes: Smithsonian Global Volcanism Project

CONCLUSIONS

- Crustal thinning localised beneath Lake Malawi
  - ~ 50 km wide
  - $\beta \leq 1.75$
- Lithospheric thinning also localised (c.f. Main Ethiopian Rift), with much greater thinning of the lithospheric mantle
  - ~ 70 km wide
  - $\beta \leq 4.1$
    - Need more than just mechanical stretching!
- Spatial patterns of lithospheric thinning suggest some asymmetry
- Rift localization controlled by pre-existing structure (e.g. sutures, weak Ubendian Belt) or is asymmetry from dynamic processes of rifting old, cold lithosphere?