



A glimpse on East Africa Geodynamics

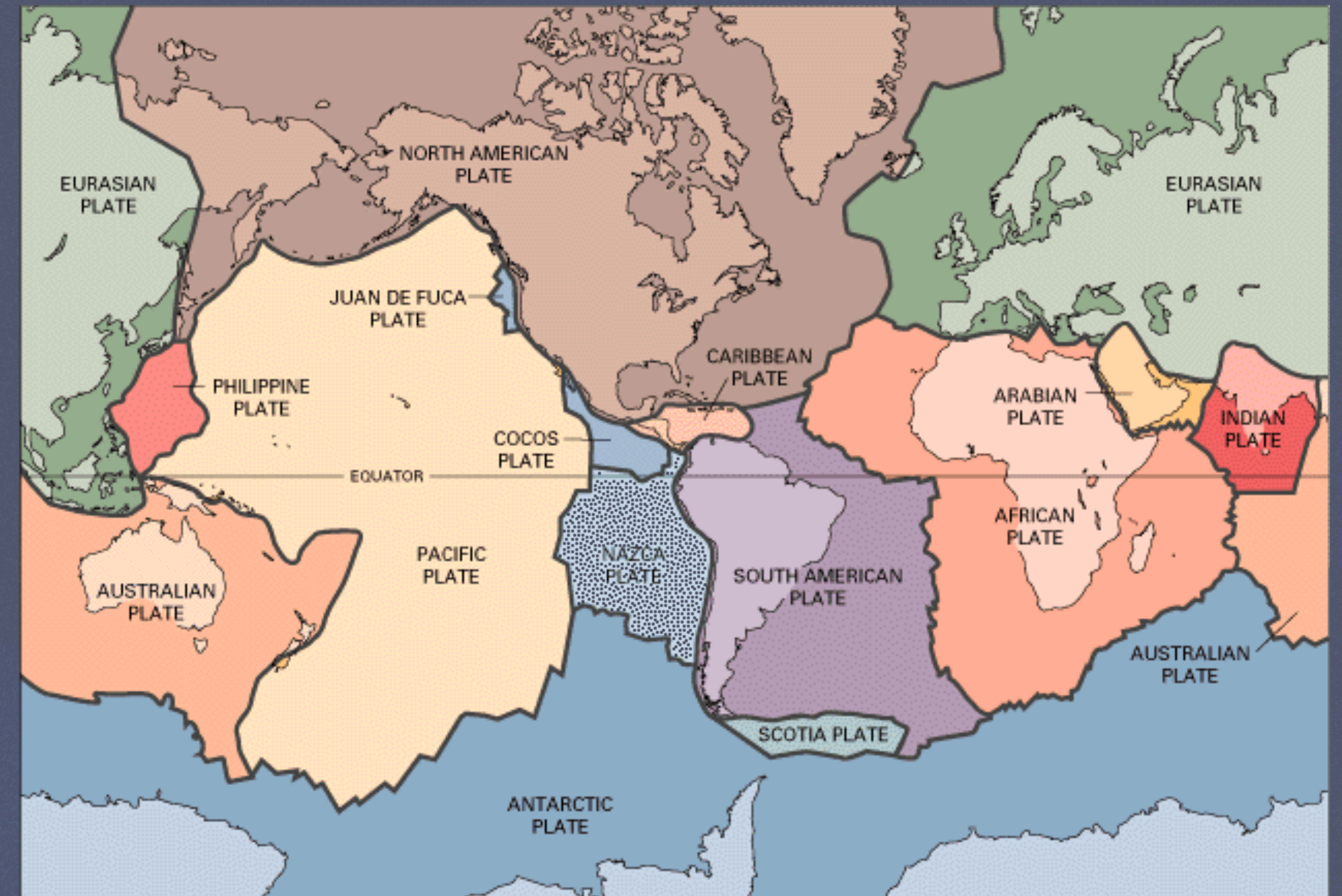
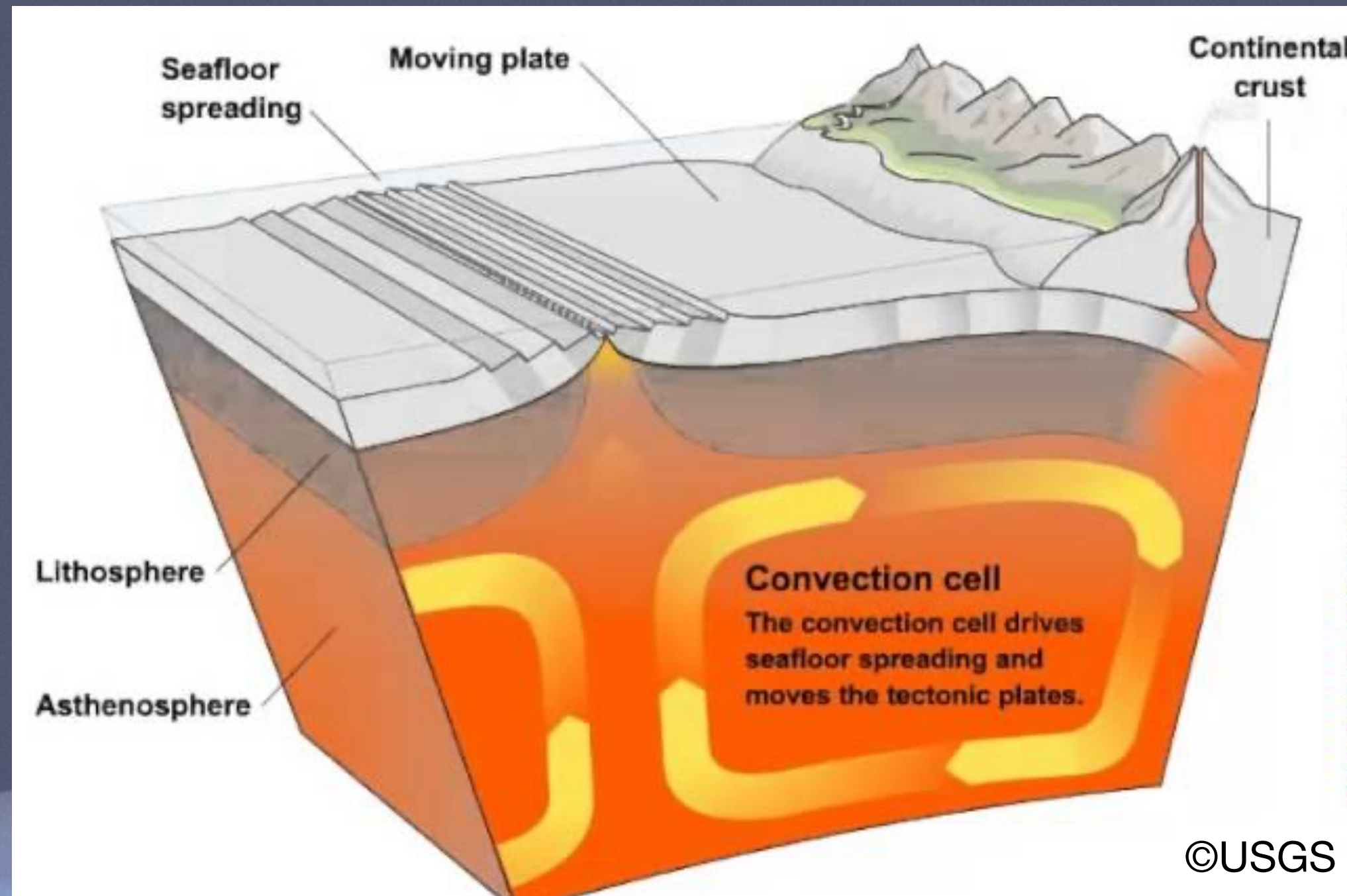
ICTP-EAIFR-IUGG Workshop

Christel Tiberi - Geosciences Montpellier - GDR Rift



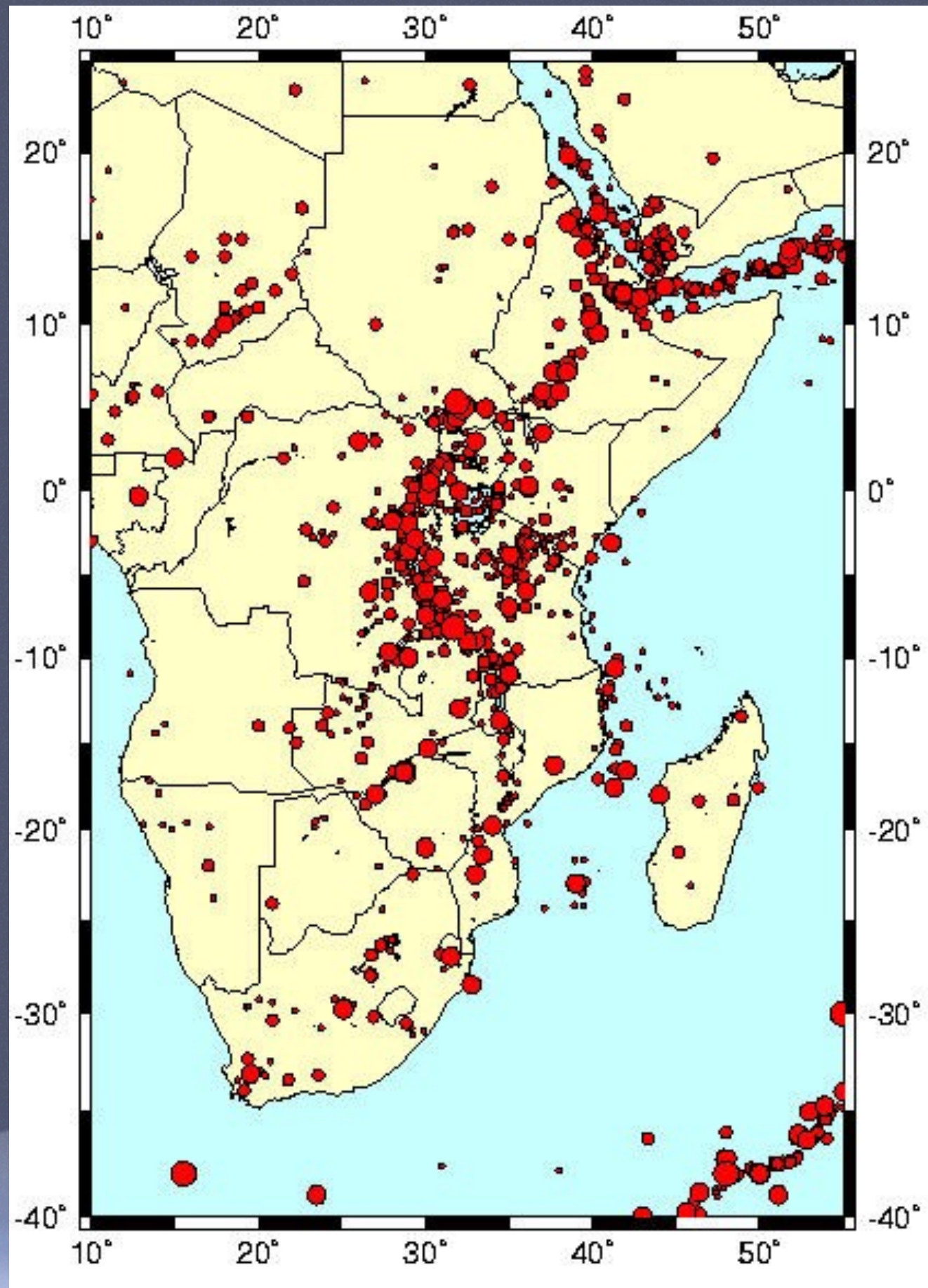
Plate tectonics

Driven by mantle convection
~15 plates



Rigid lithosphere -> no deformation inside the plate

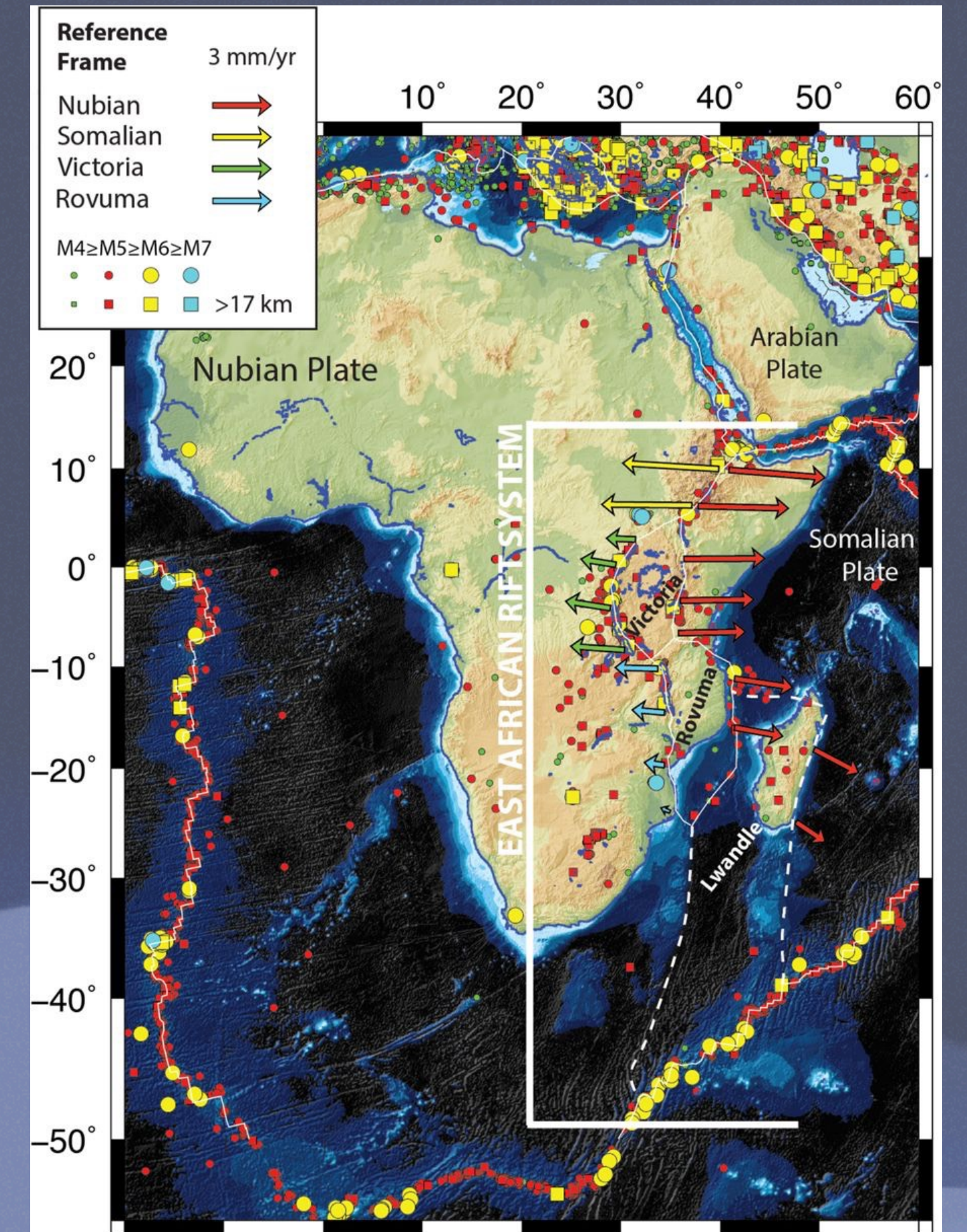
What happens in Africa?



Seismicity



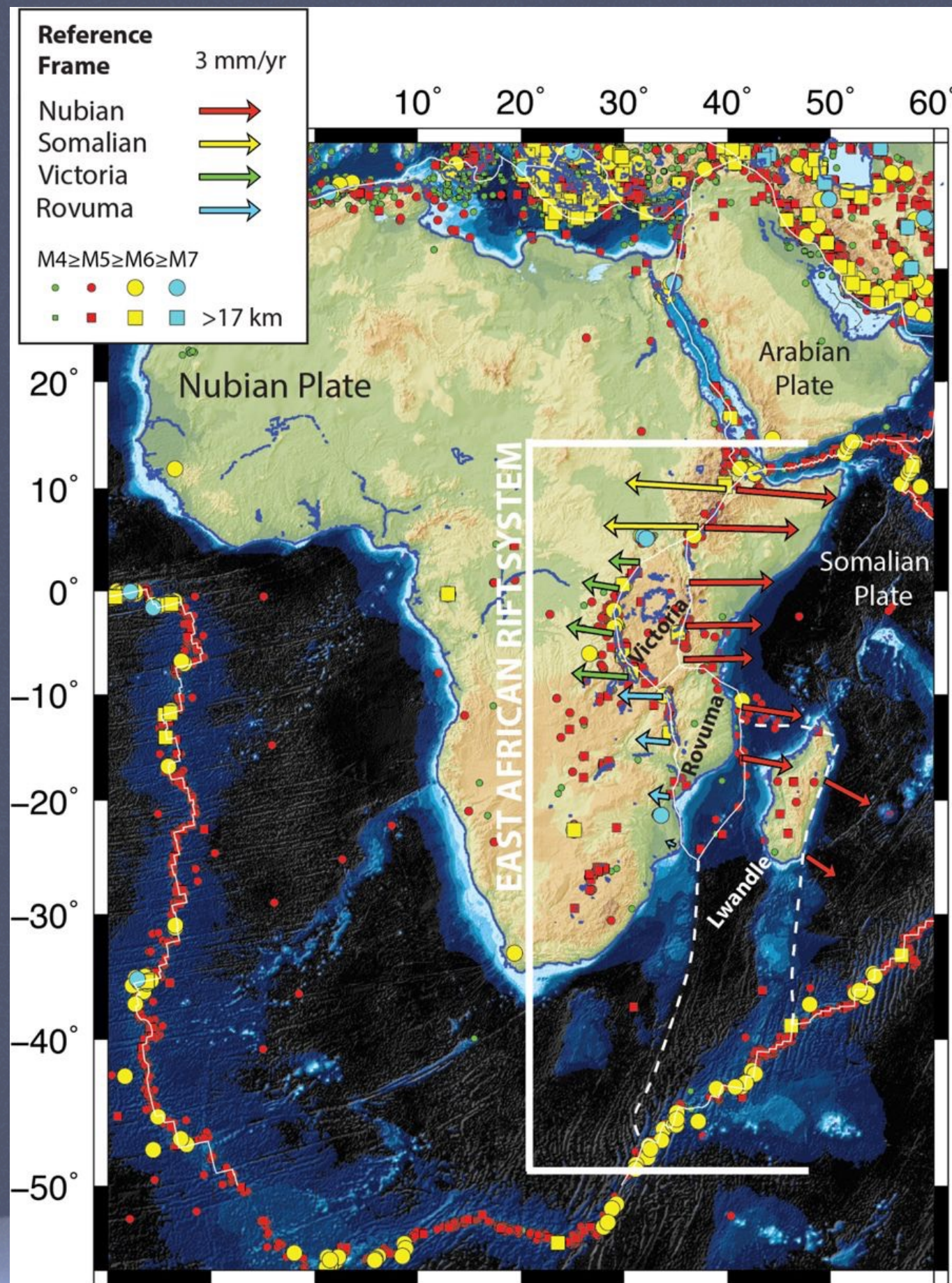
Volcanoes



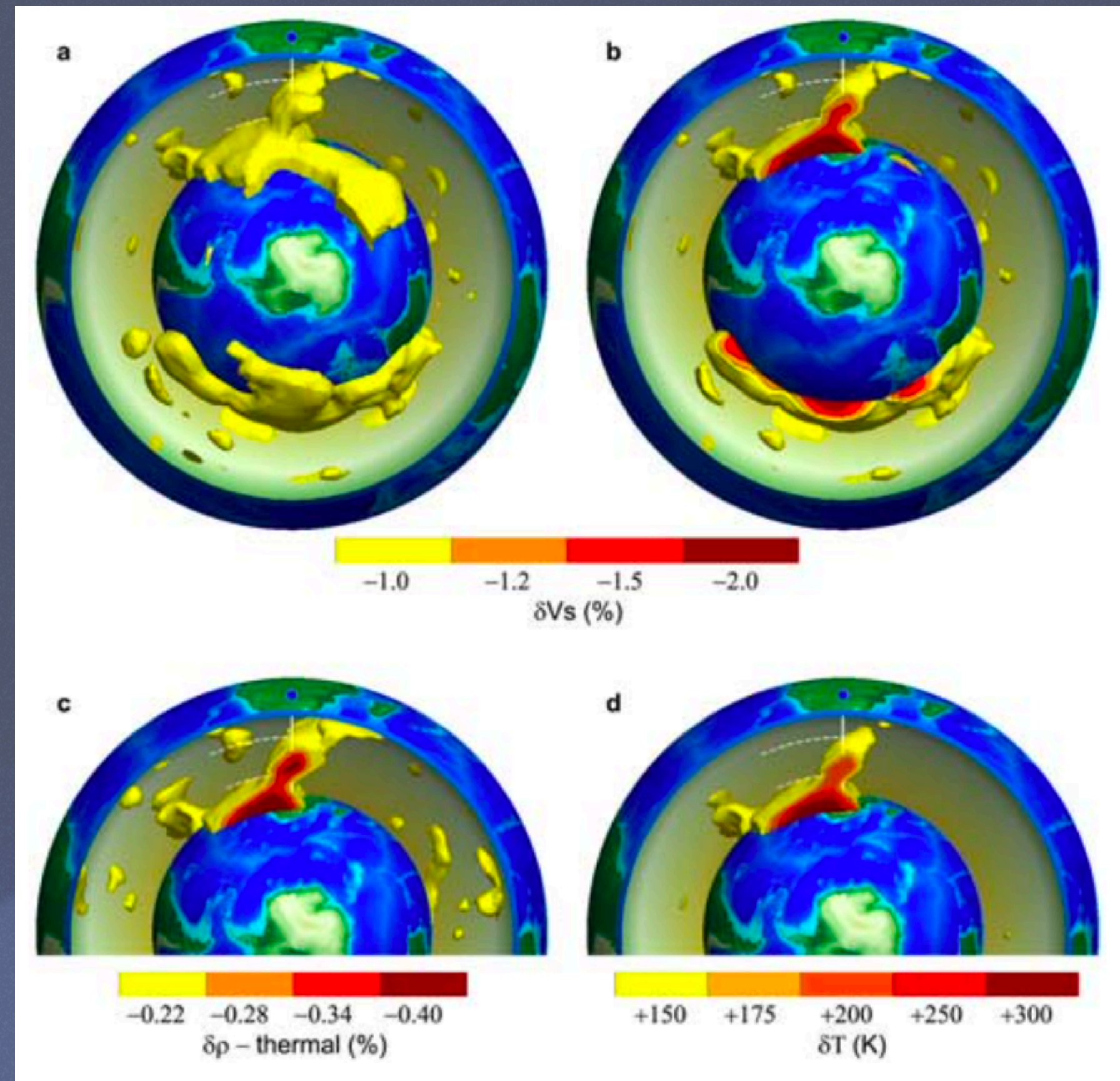
Stamps et al. 2018

Observations show a divergent movement running from Afar region to Mozambique Golfe
Why ?

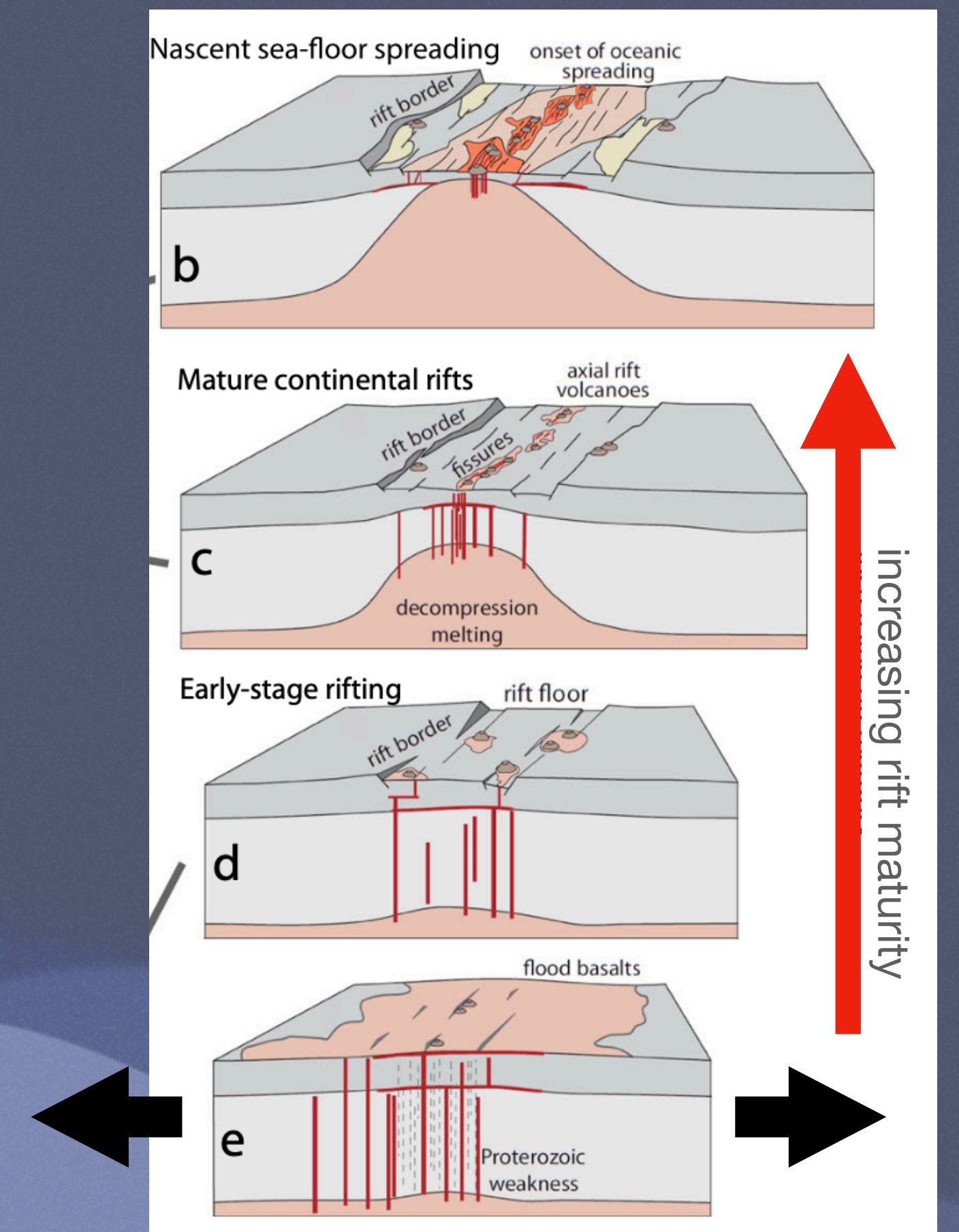
What happens in Africa?



Stamps et al. 2018



Simmons et al. 2007



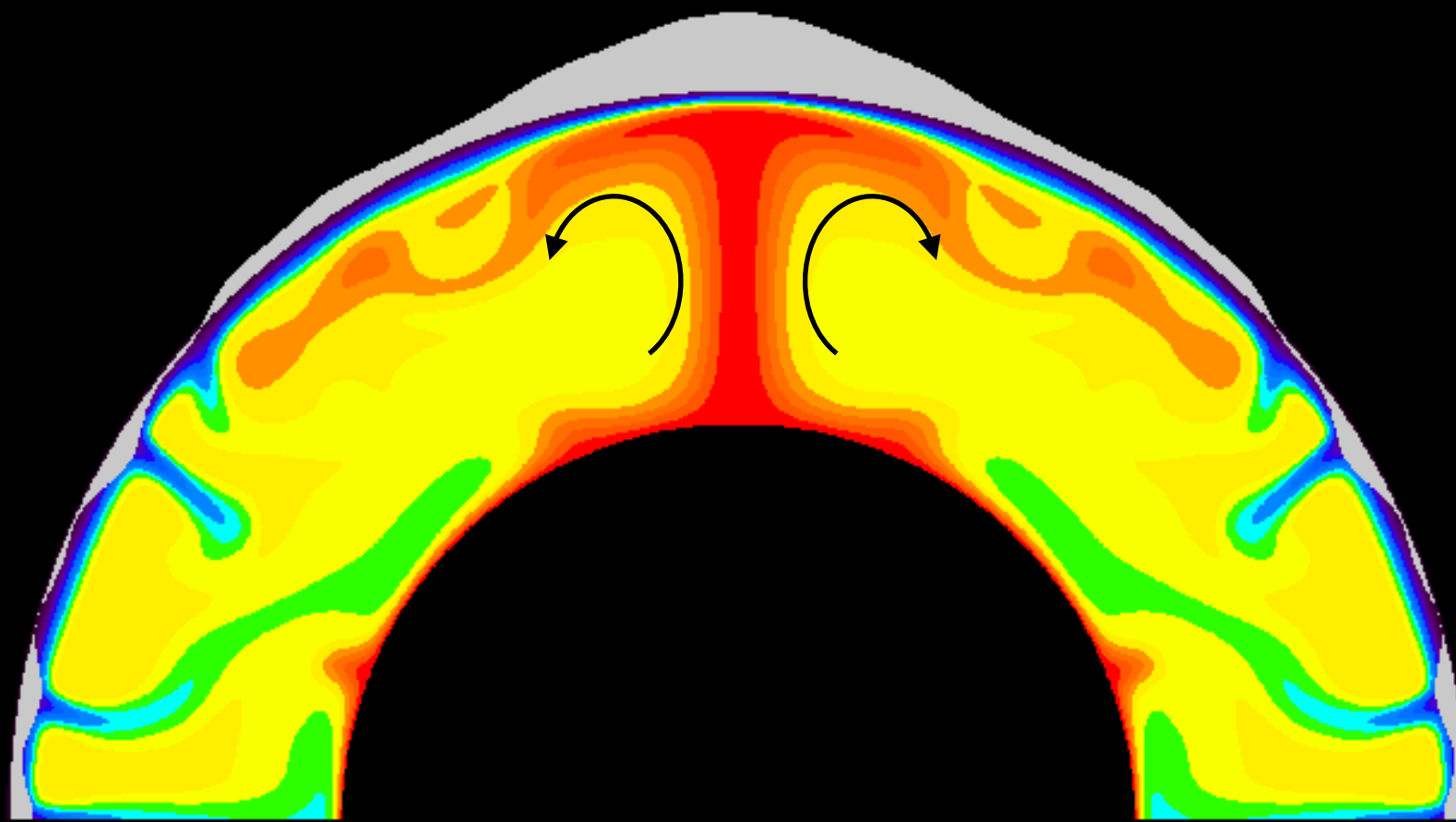
Biggs et al. 2021

Indirect geophysical methods
 Hot and buoyant material
 Plume ascent=new convection cell

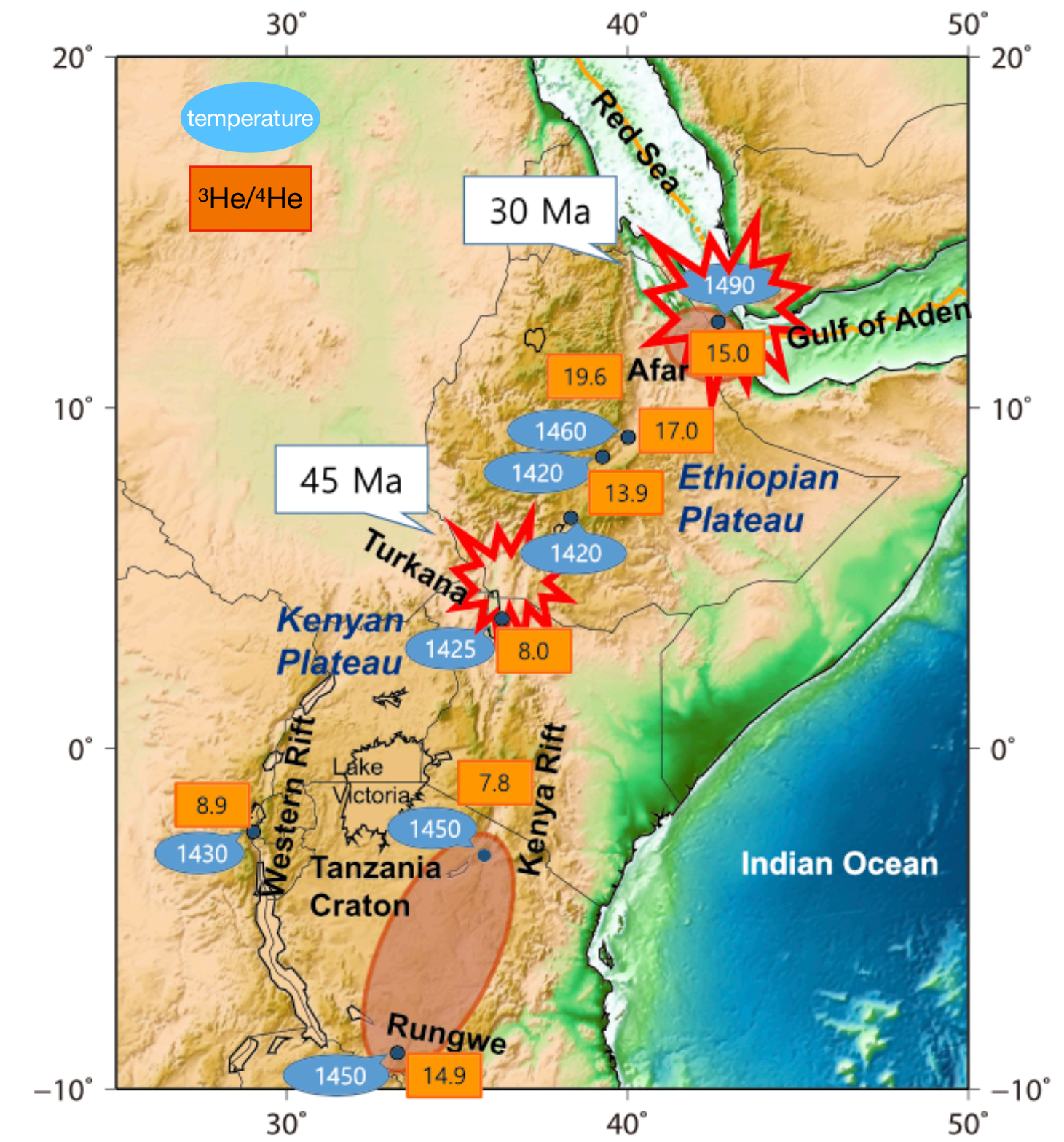
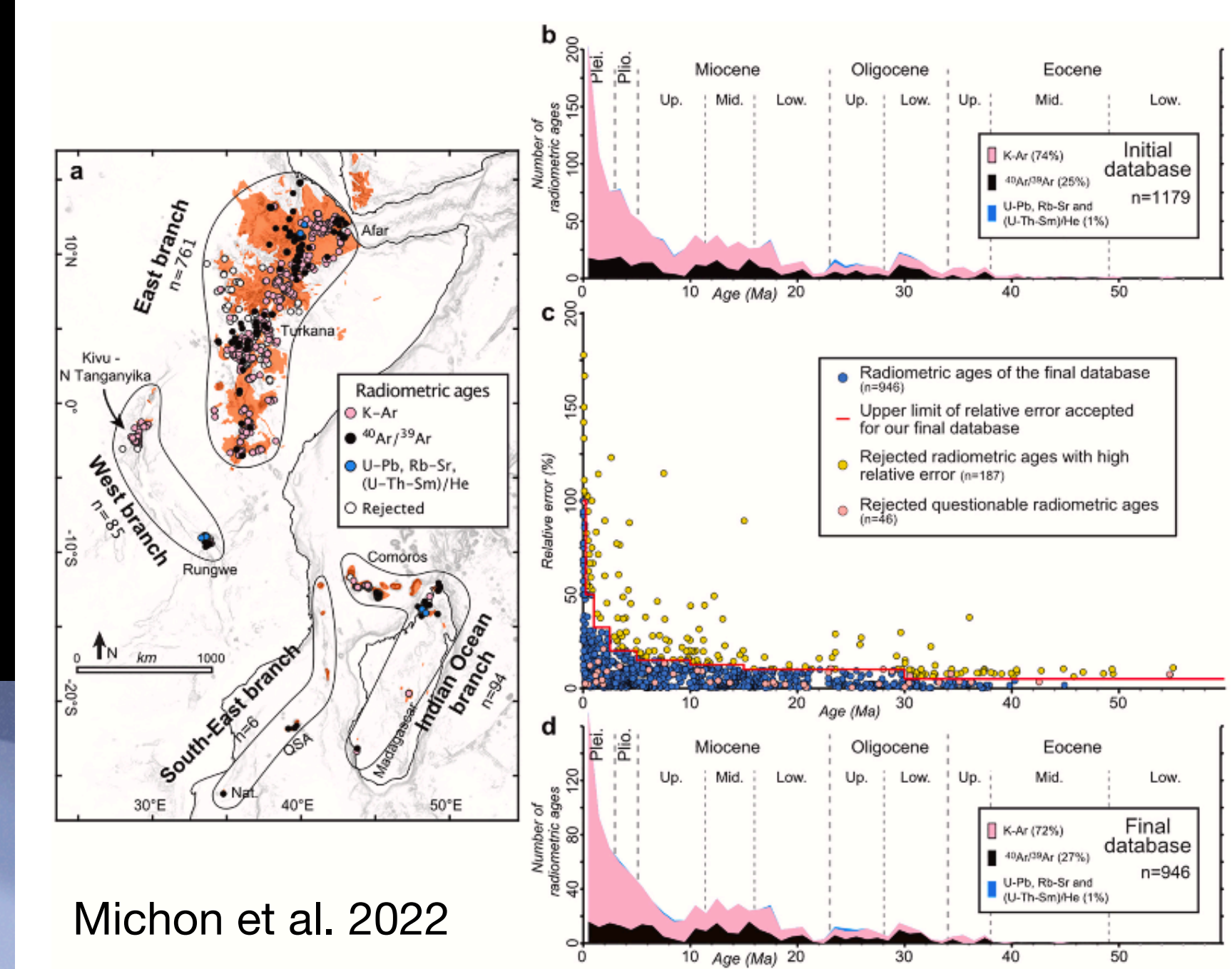
What processes are at work?

A plume since ~40My
Geochemical evidences

Mantle Convection Simulation by
Walter Kiefer (LPI) and Louise Kellogg (Univ. California)



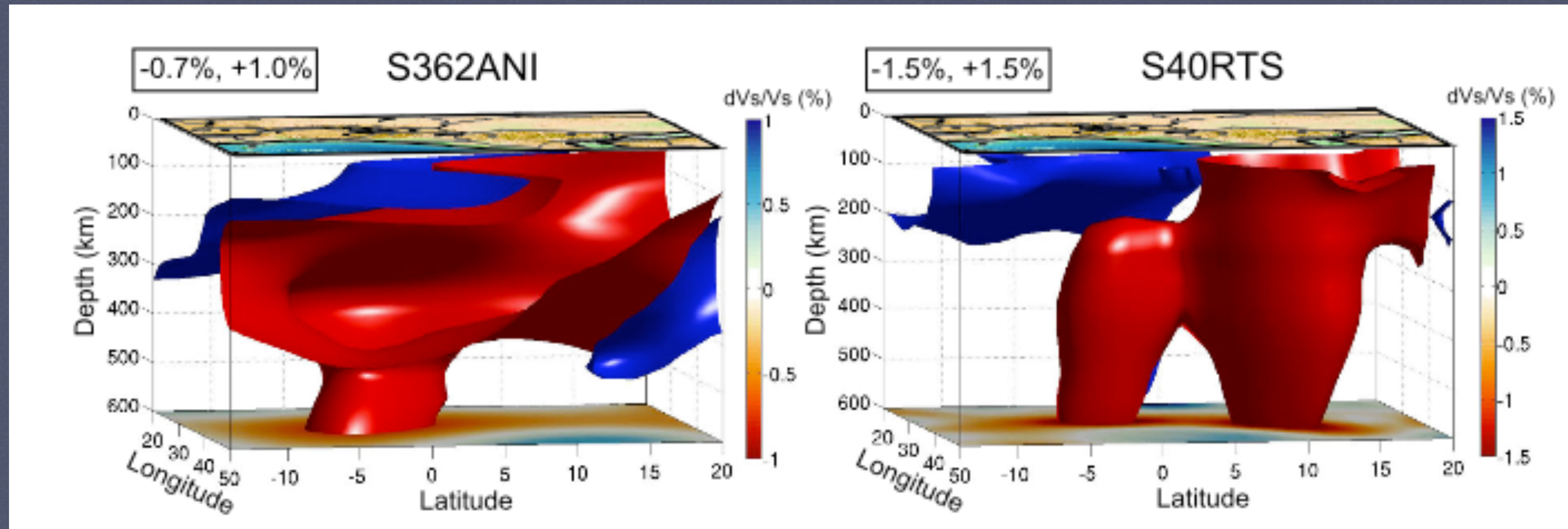
©1997 W. Kiefer



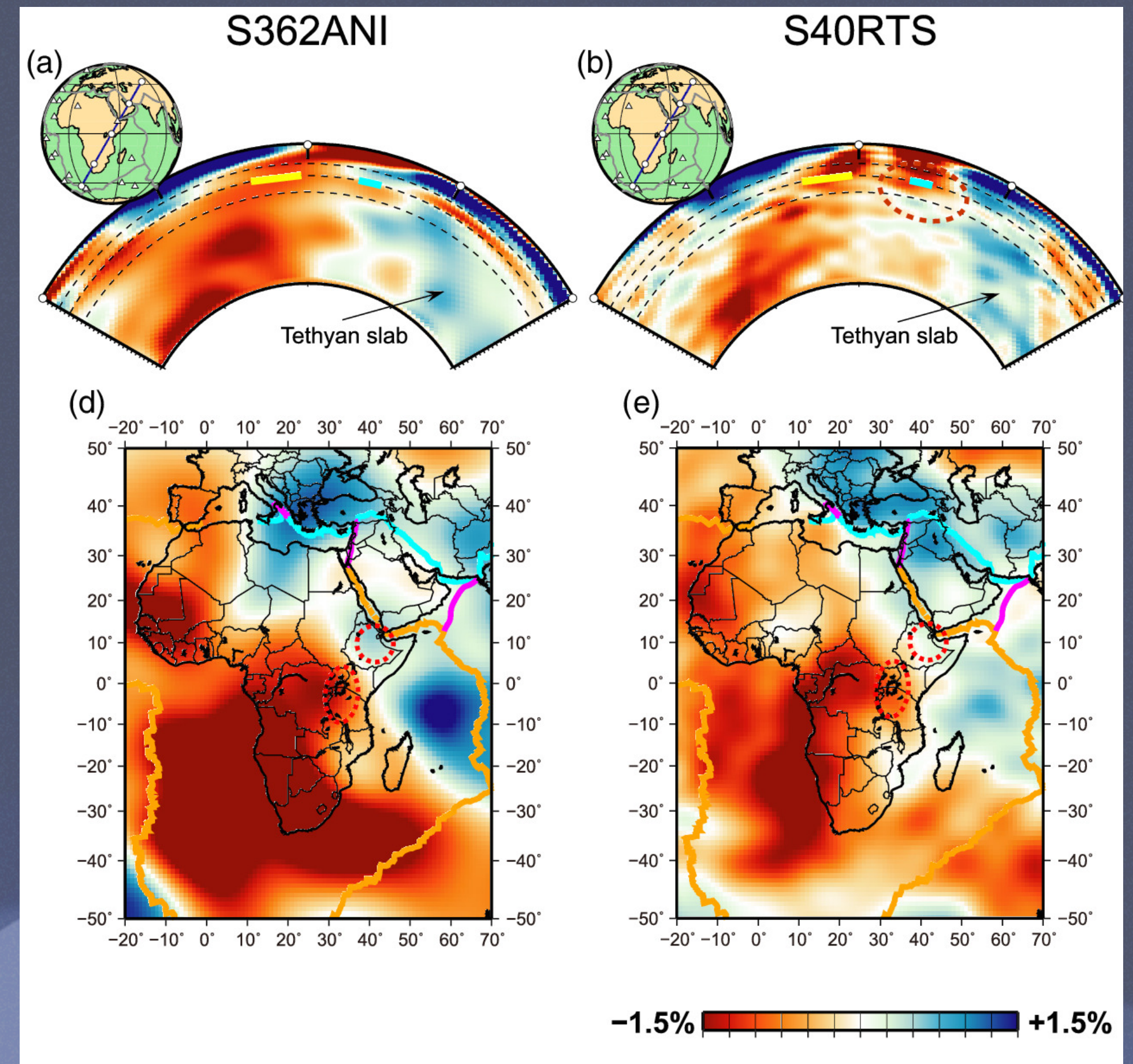
Chang et al. 2020

What processes are at work?

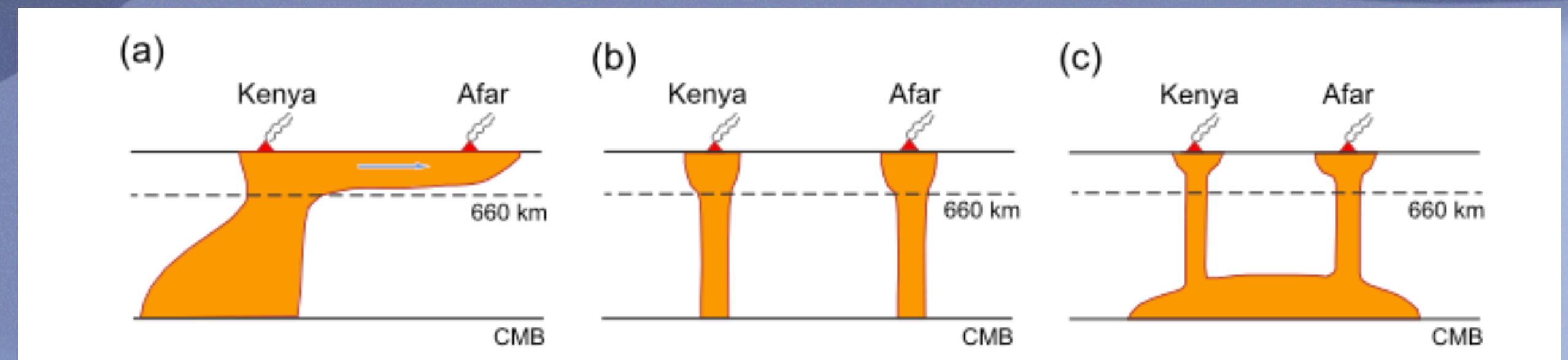
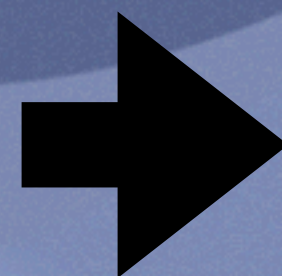
A plume since ~40My
Geophysical evidences
but...



Chang et al. 2020



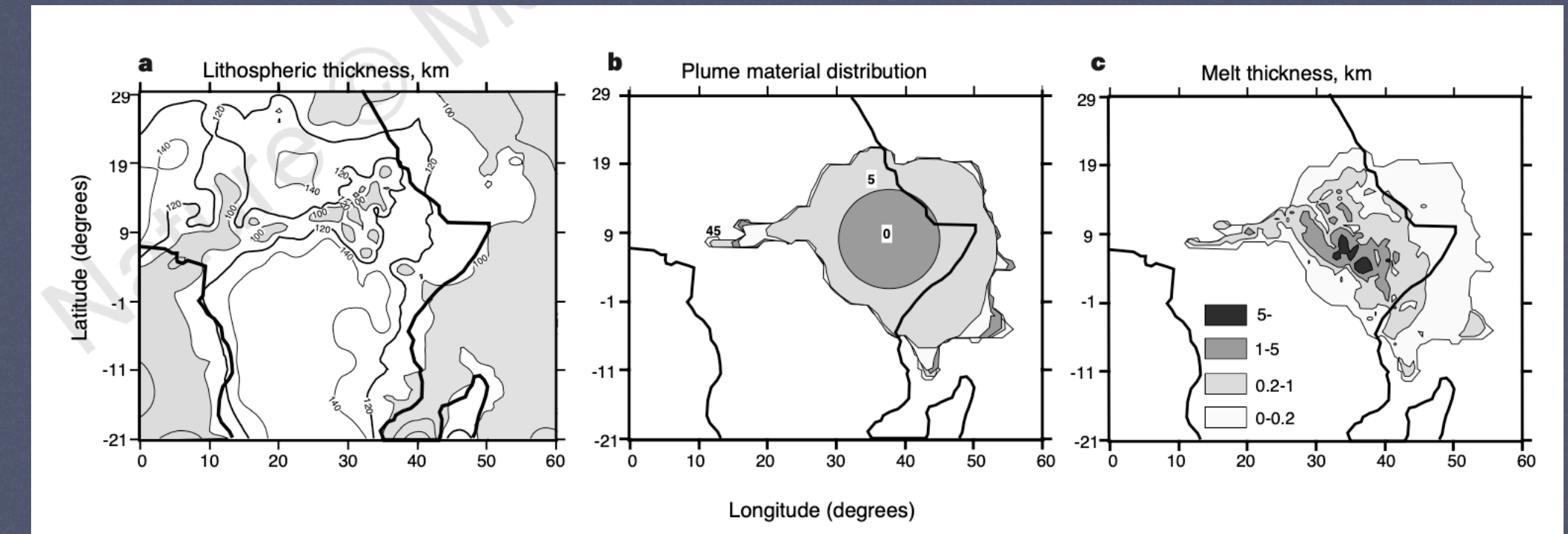
Different scenarios/propositions



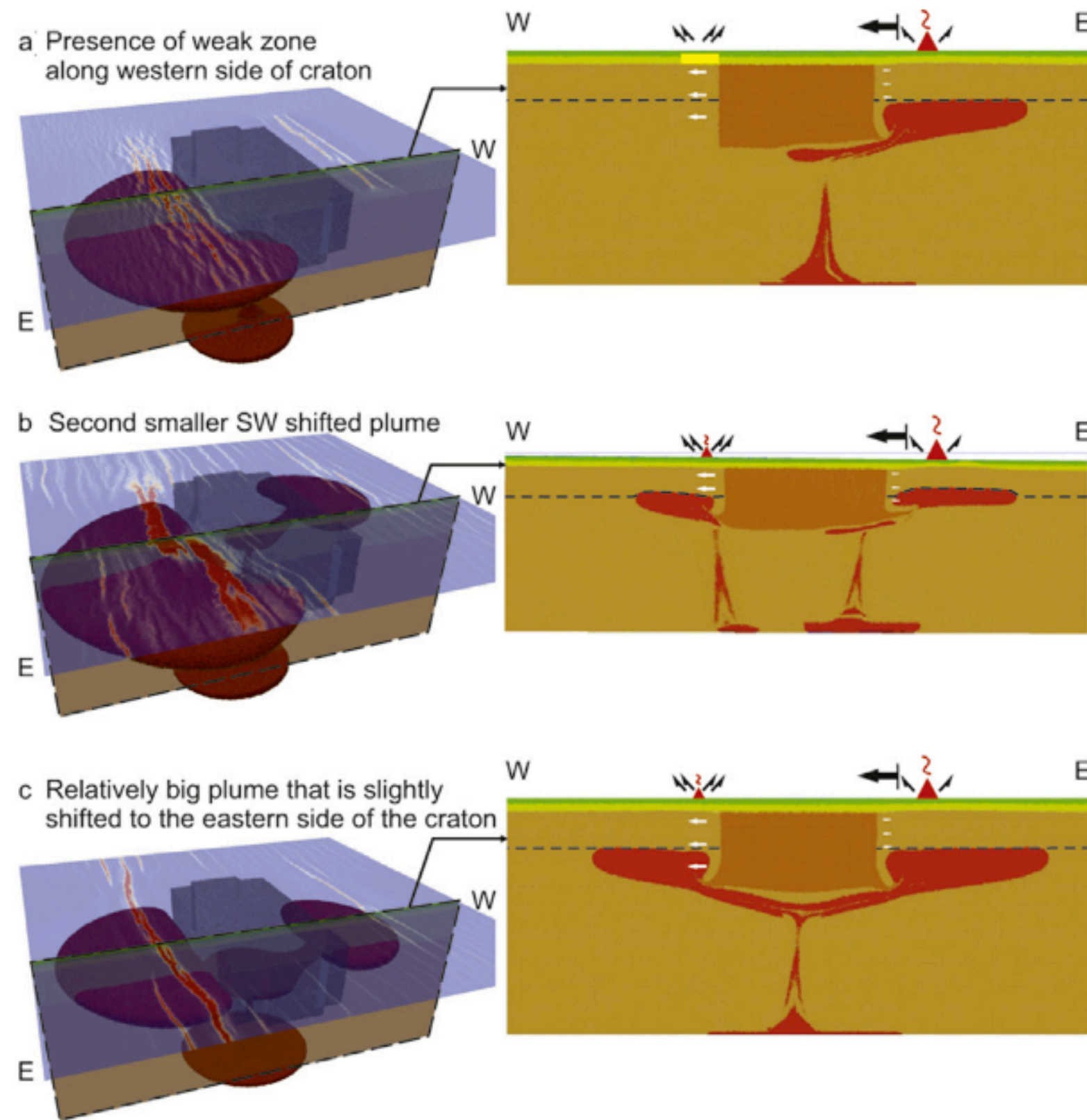
What processes are at work?

Models to test the hypotheses

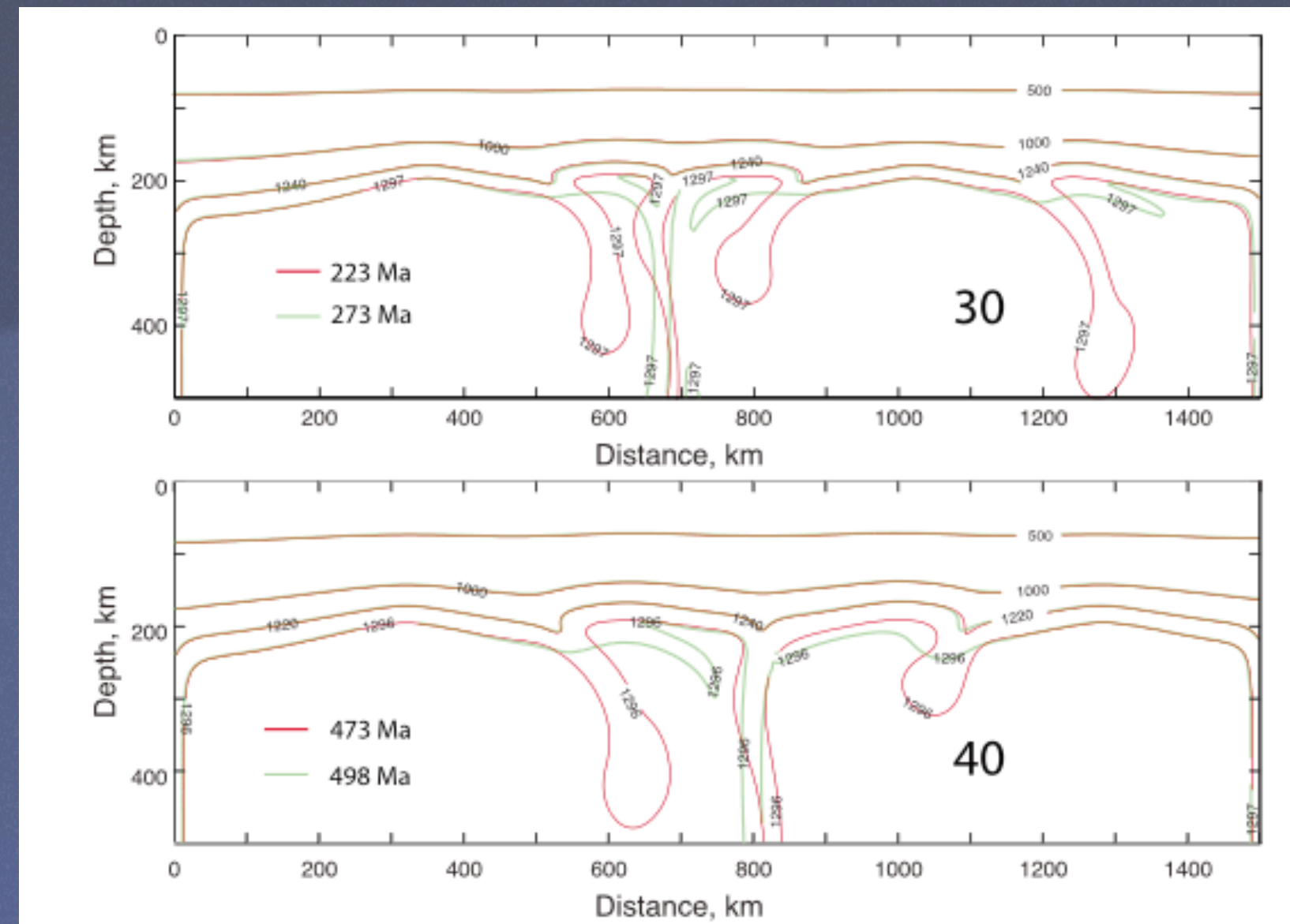
- the deep origin and evolution of the plume(s)
- their interactions with the lithosphere
- focusing of strain



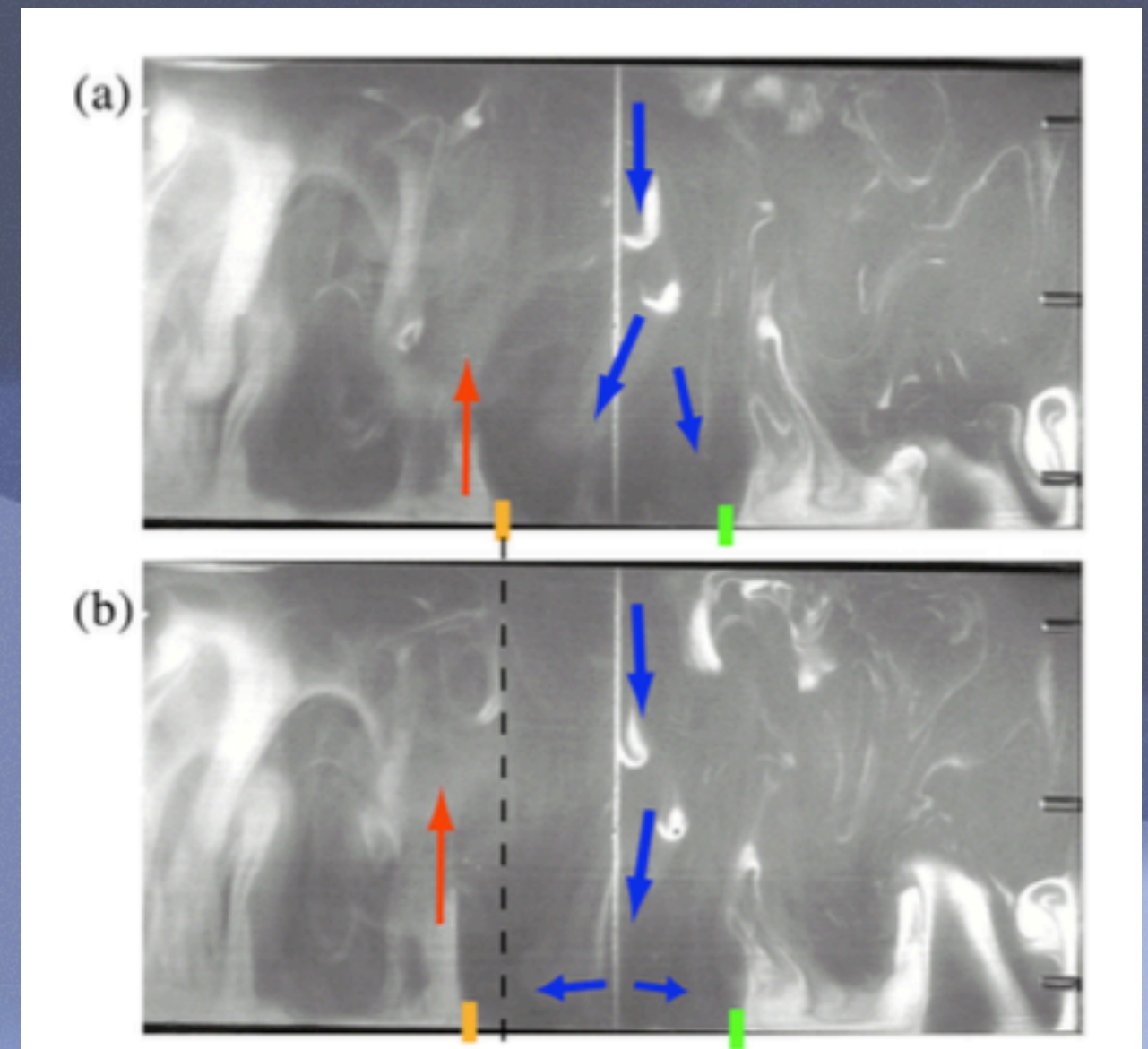
Ebinger & Sleep, 1998



Koptev et al., 2016



Sleep, 2011



Chang et al. 2020

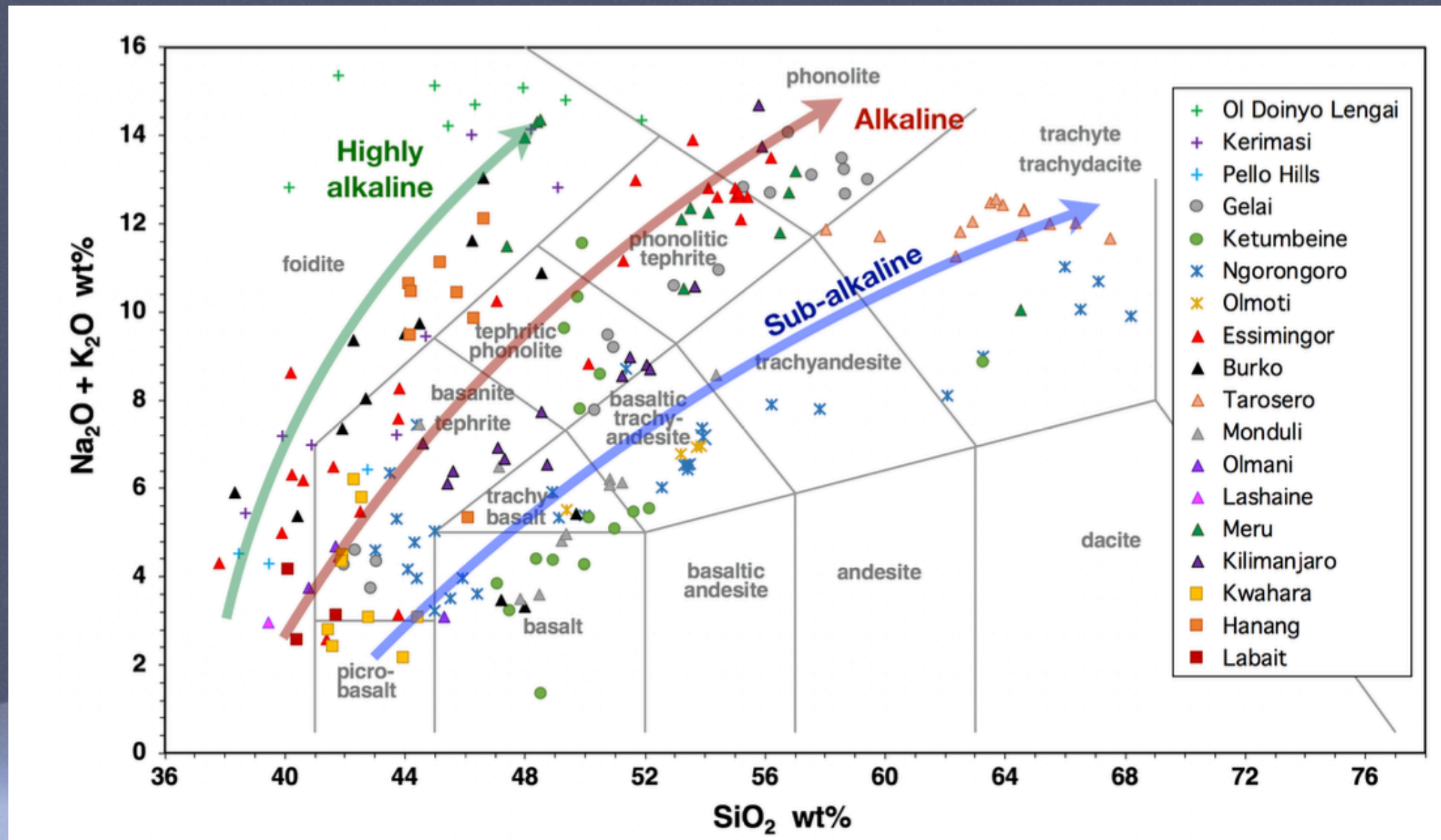
Magmatism weakens the lithosphere!

How do you relate deep processes and surface deformation?

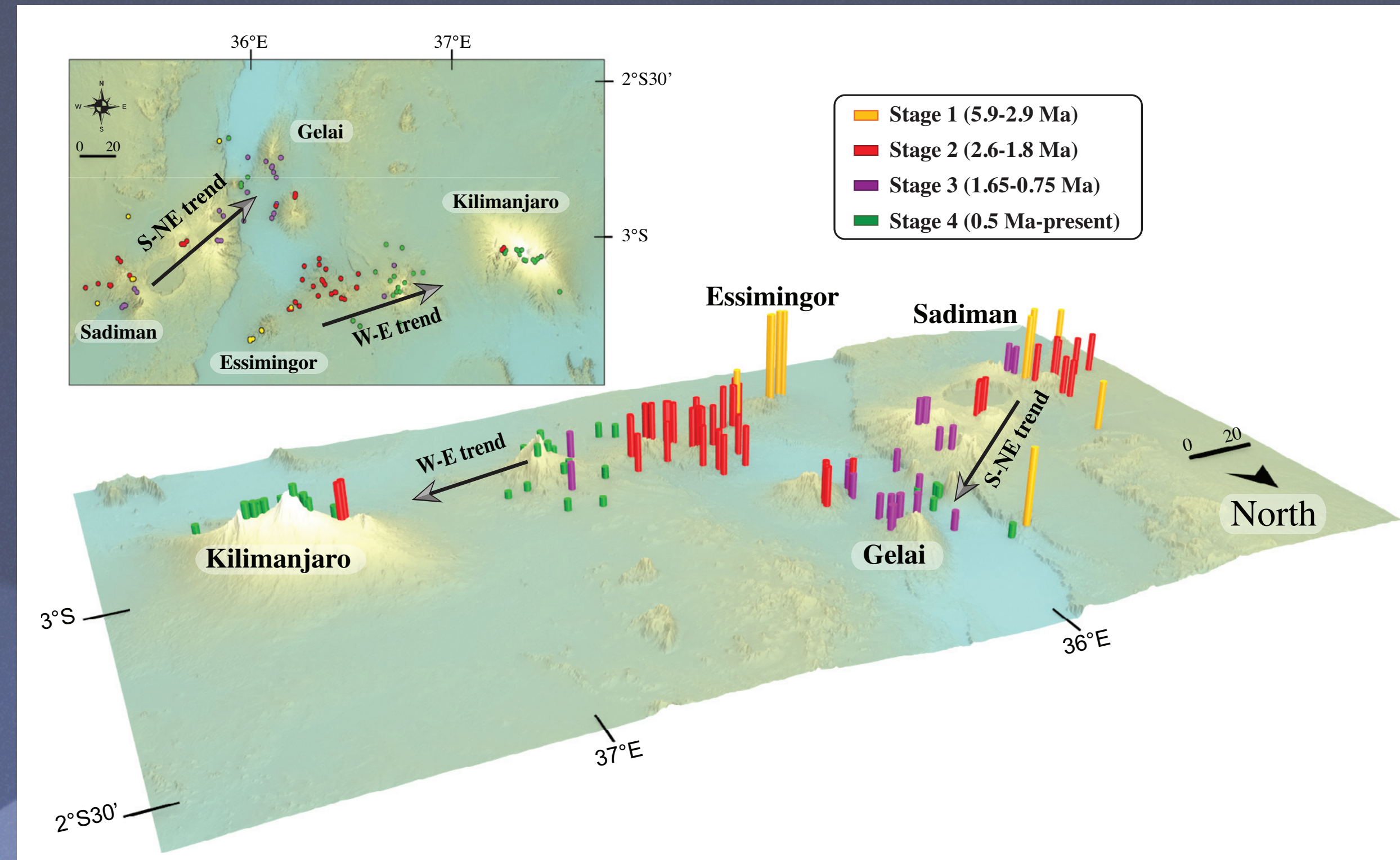
Magmatism = efficient to weaken the lithosphere !

Why all branches aren't magmatic?

Why some part of the rift are narrower?



Clutier, 2021



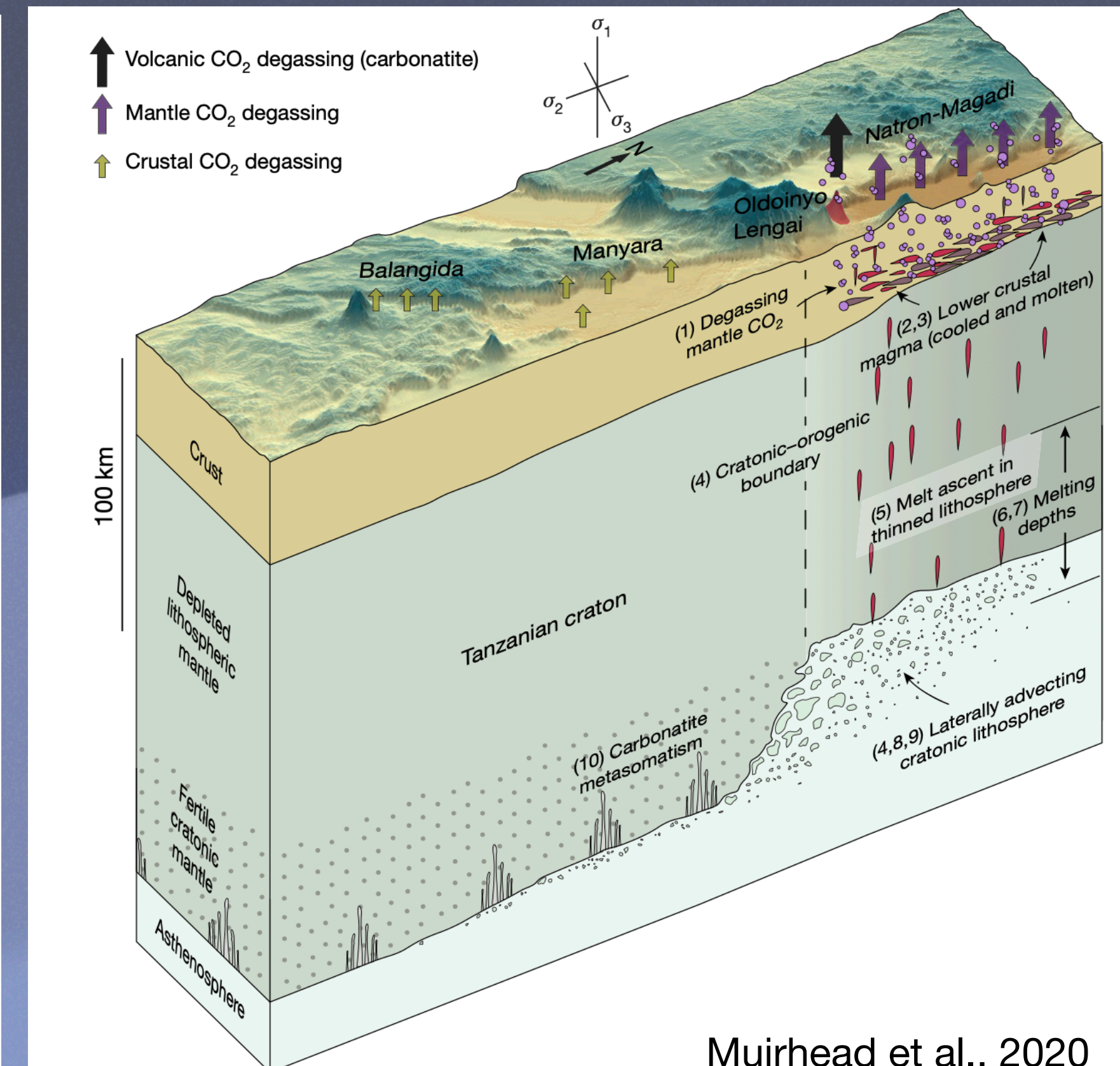
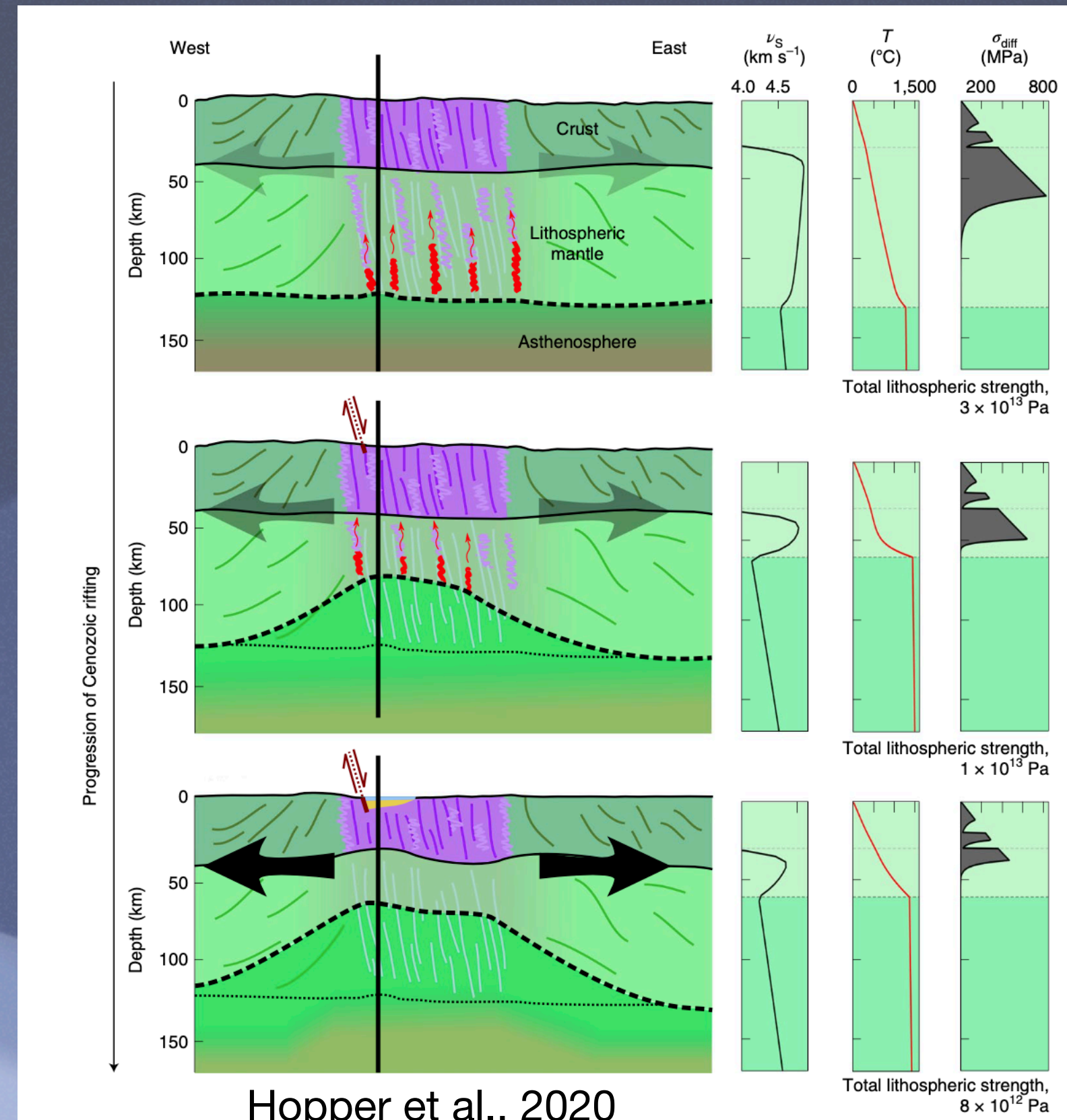
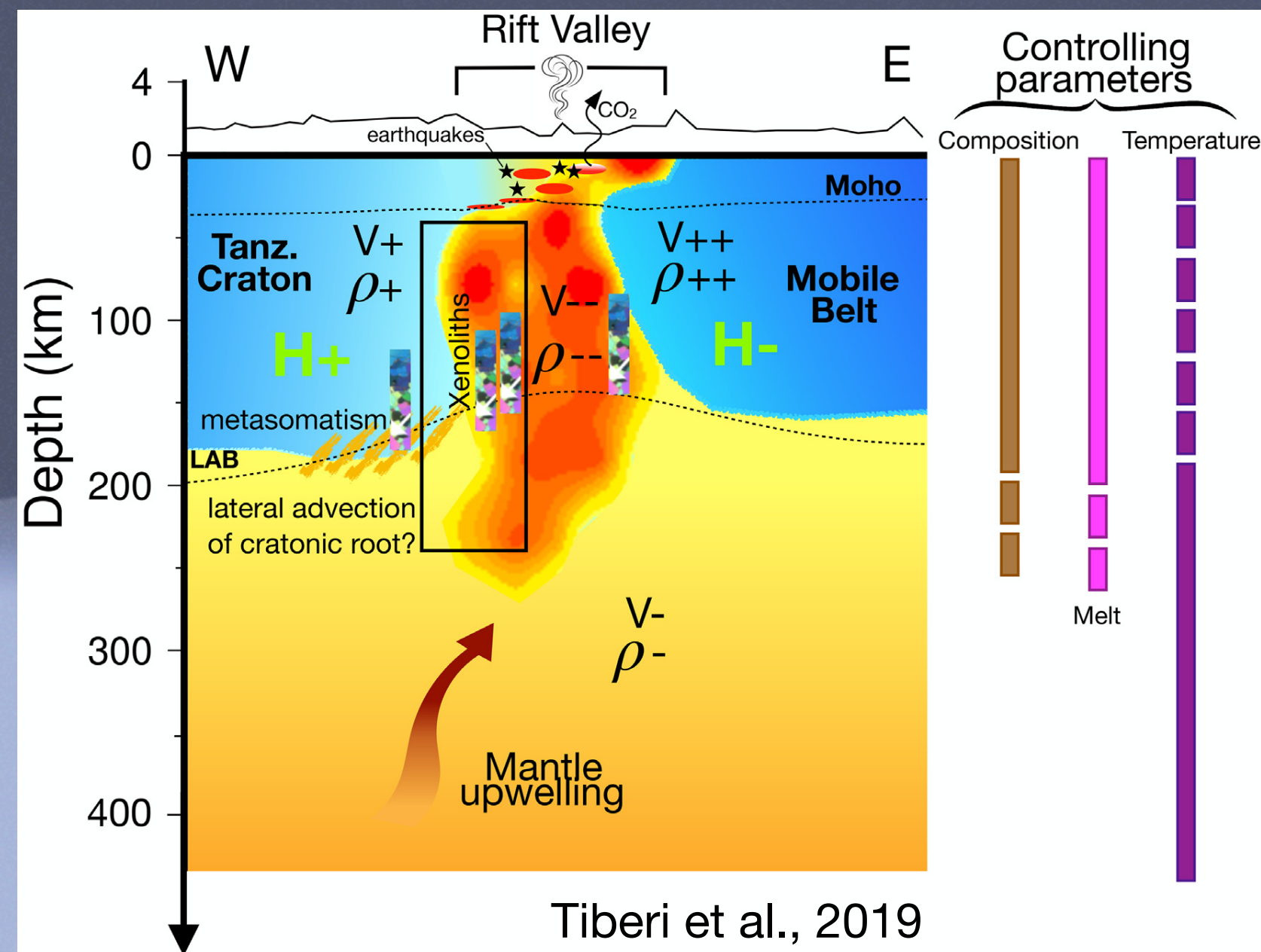
Mana et al., 2015

How do we explain the diversity of volcanic styles?
Are magmatism and tectonics linked? (How?)

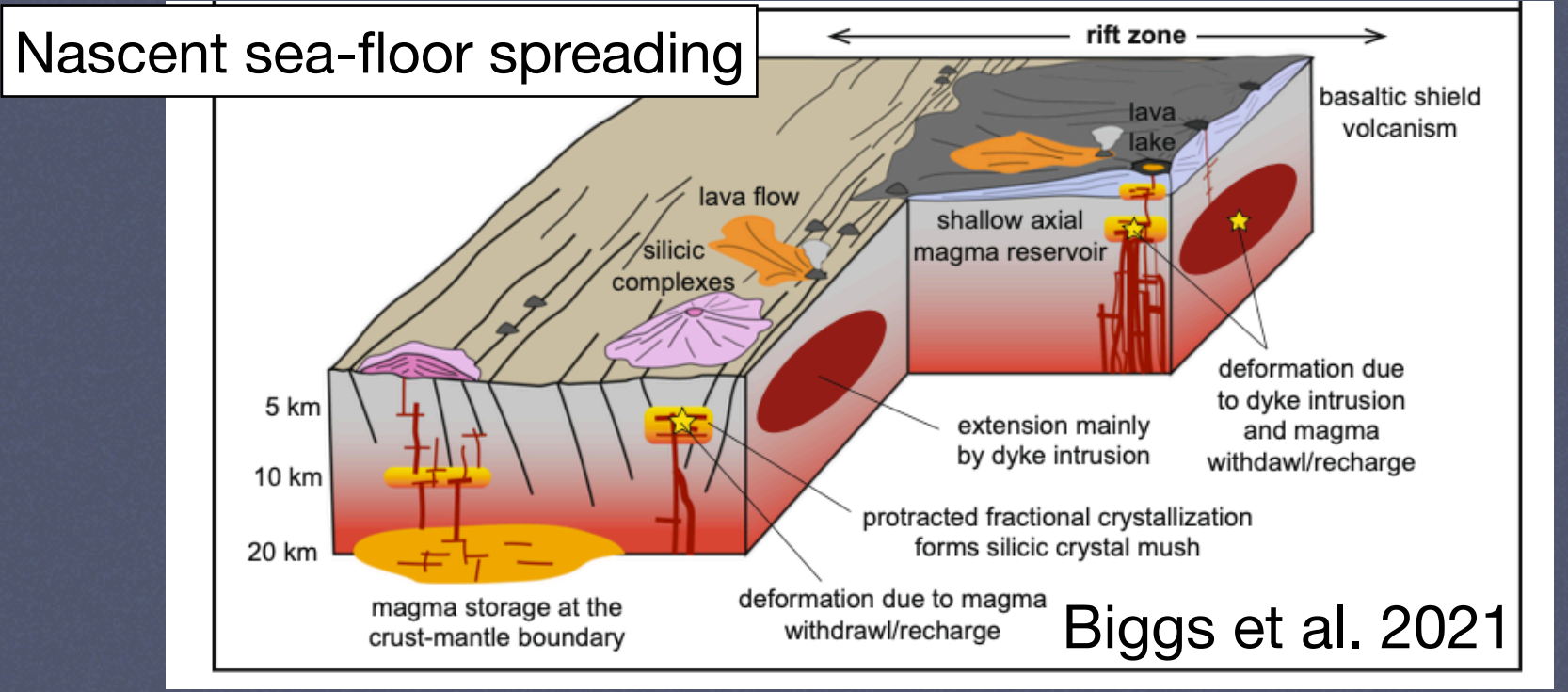
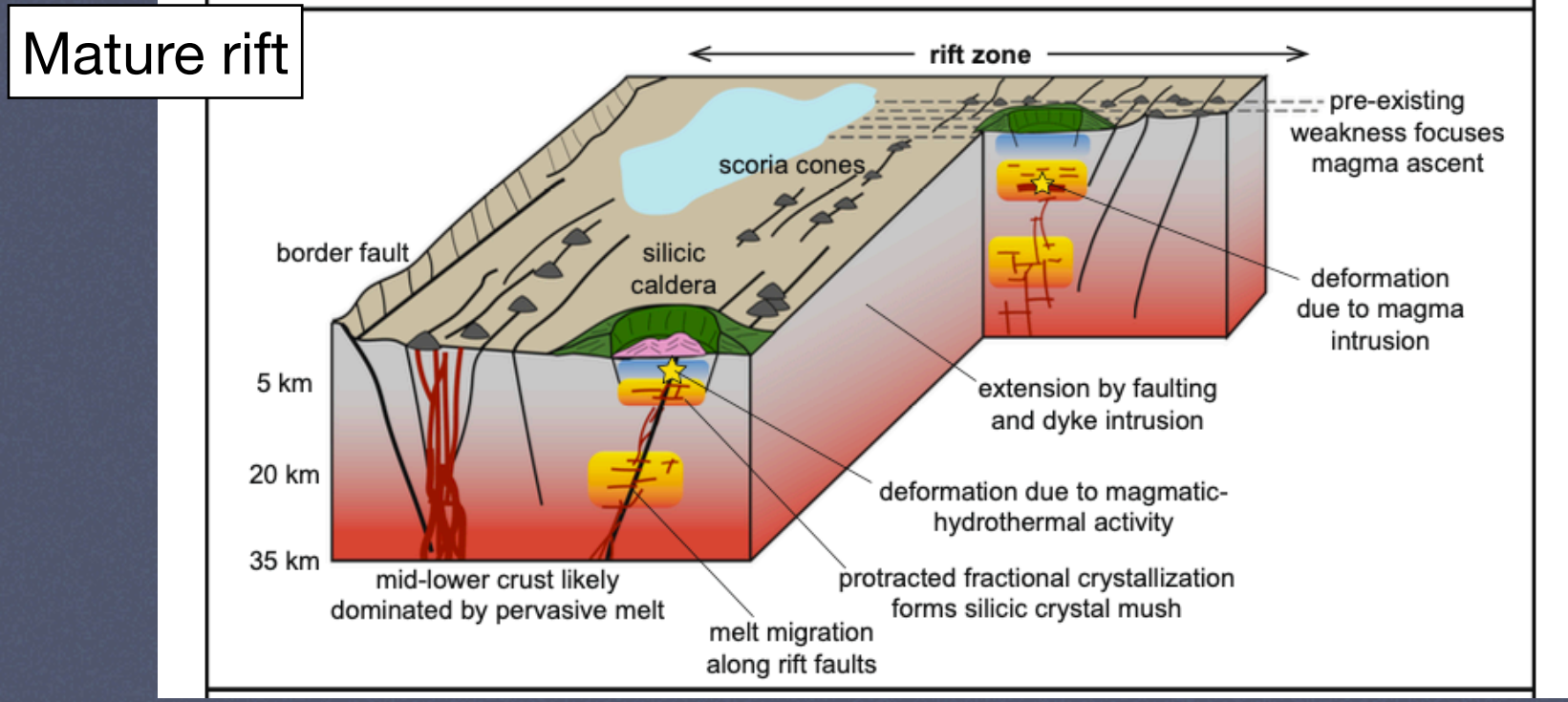
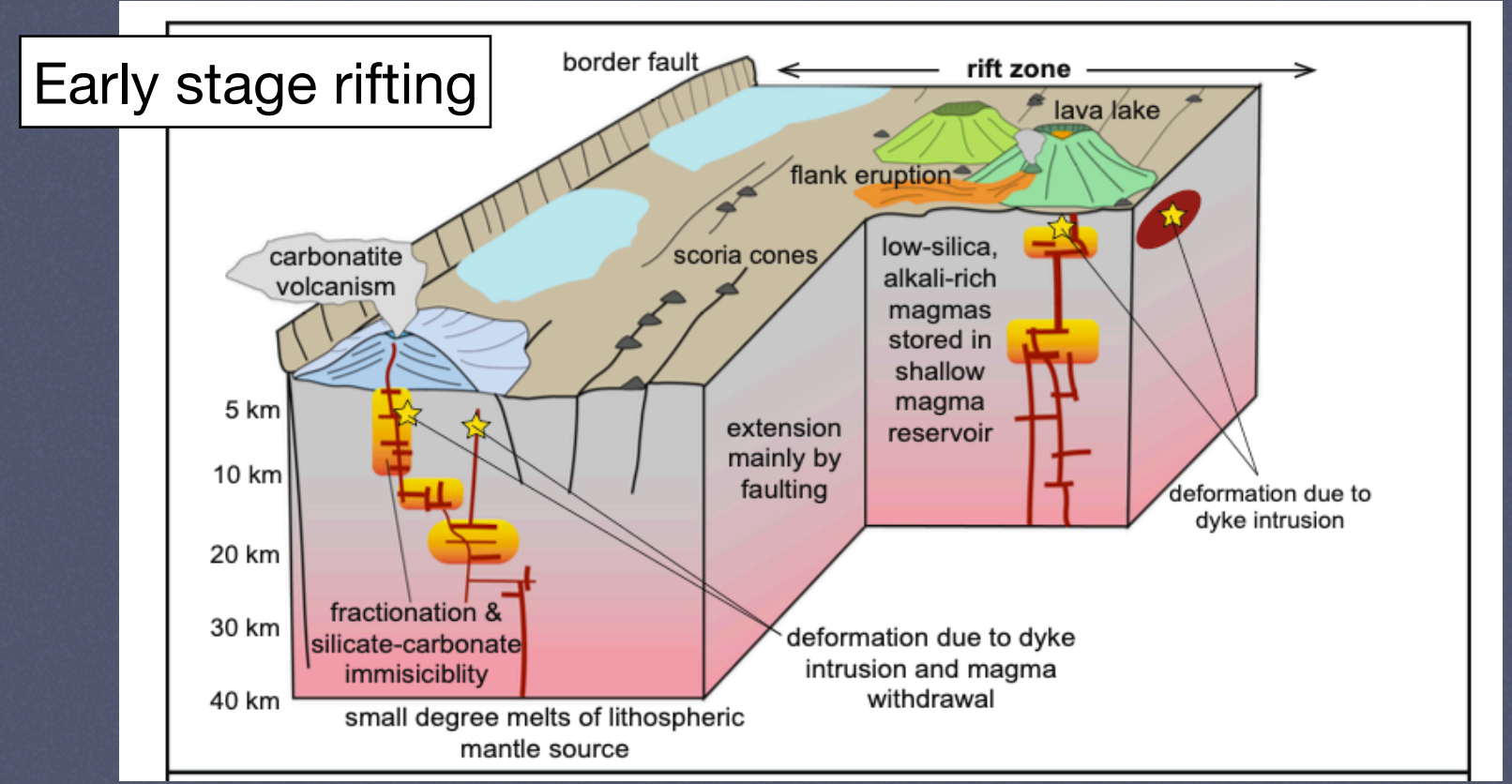
How do you relate deep processes and surface deformation?

Depends on

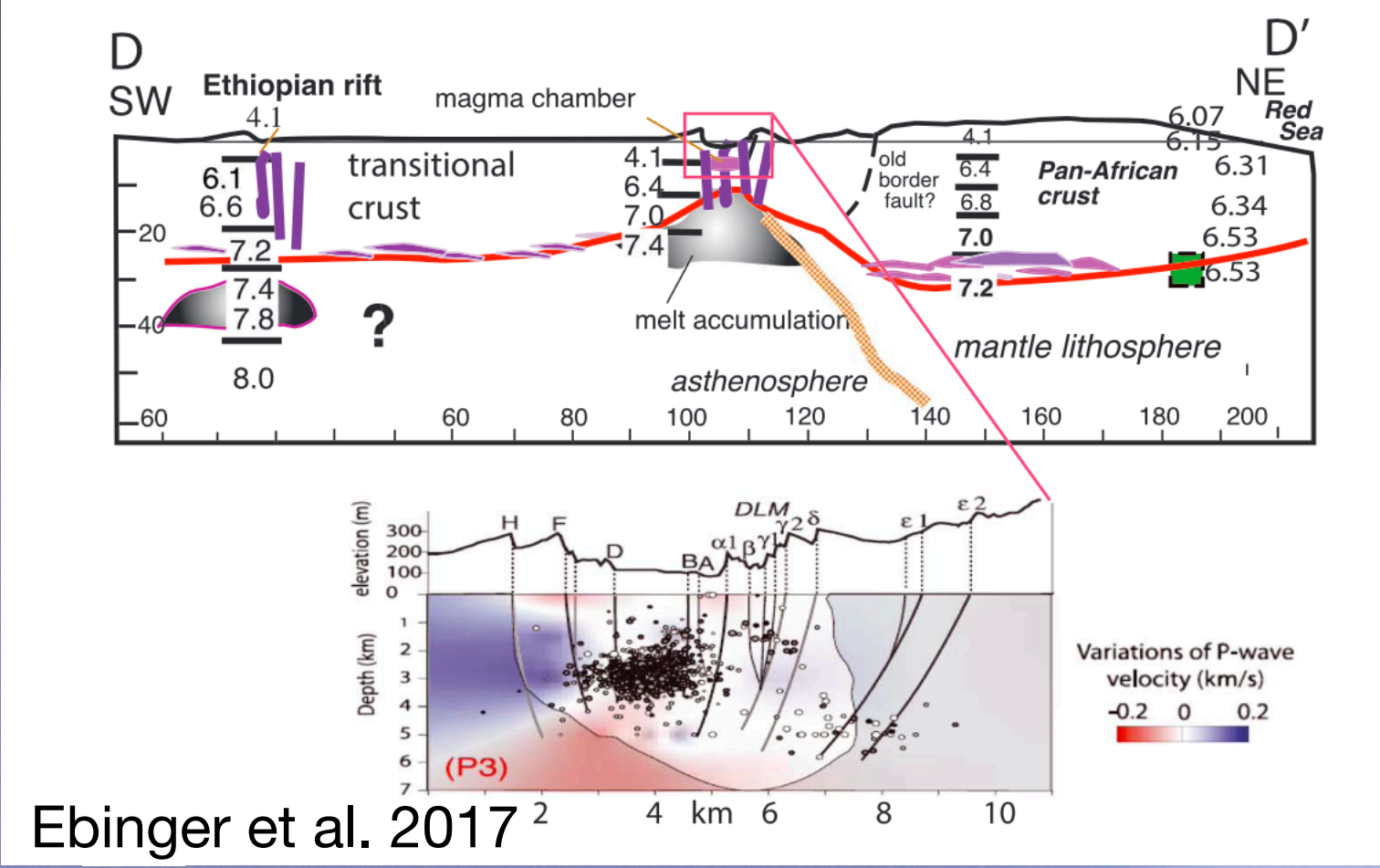
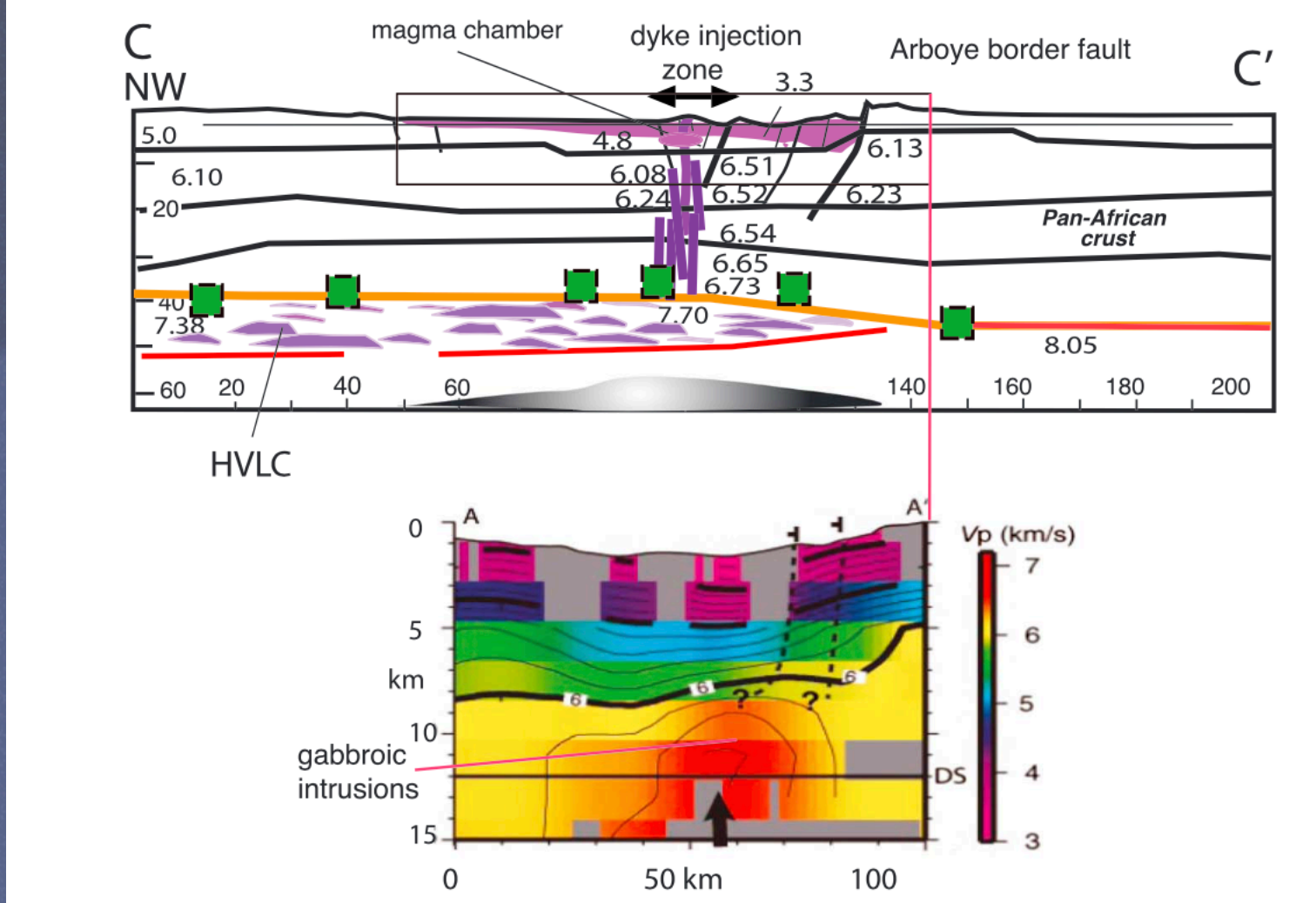
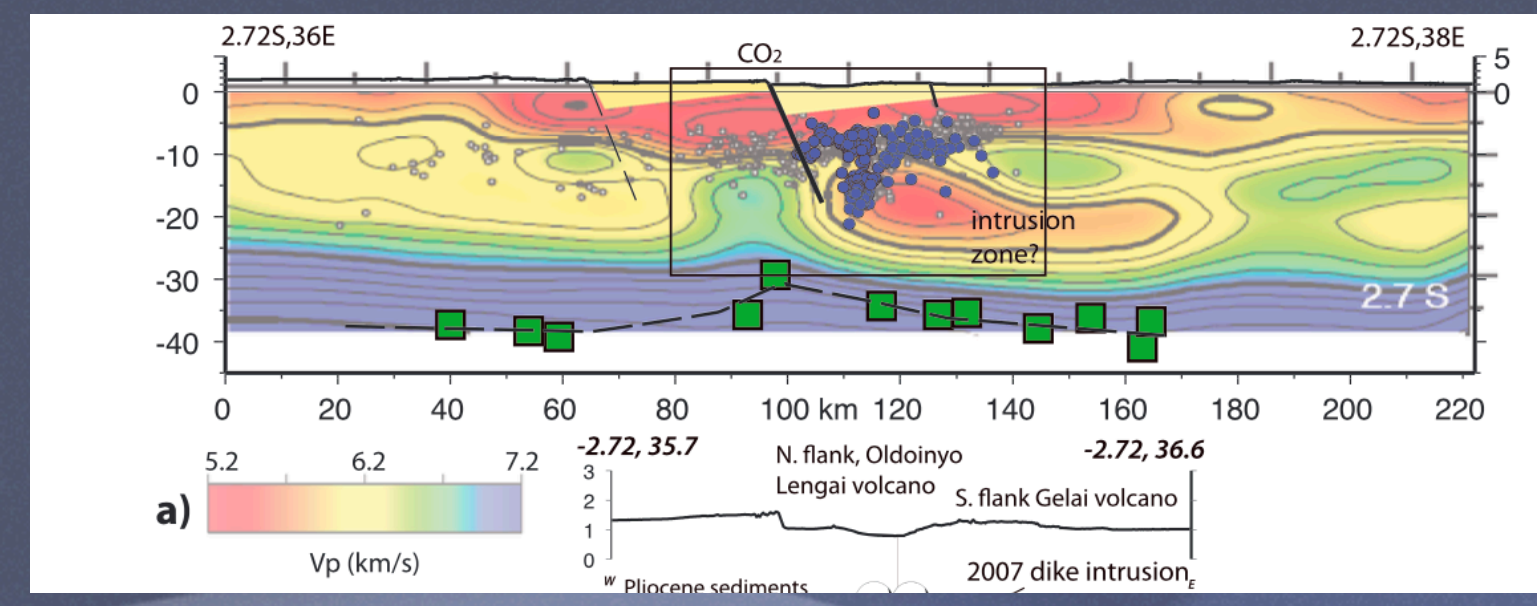
- the inherited structures
- the state of the lithosphere (age, temperature, hydration)
- presence of melt
- discontinuities



How do you relate deep processes and surface deformation?



Biggs et al. 2021



Ebinger et al. 2017

- Melt + volatiles (CO₂ H₂O) migration
- Crustal alteration and weakening (sills)

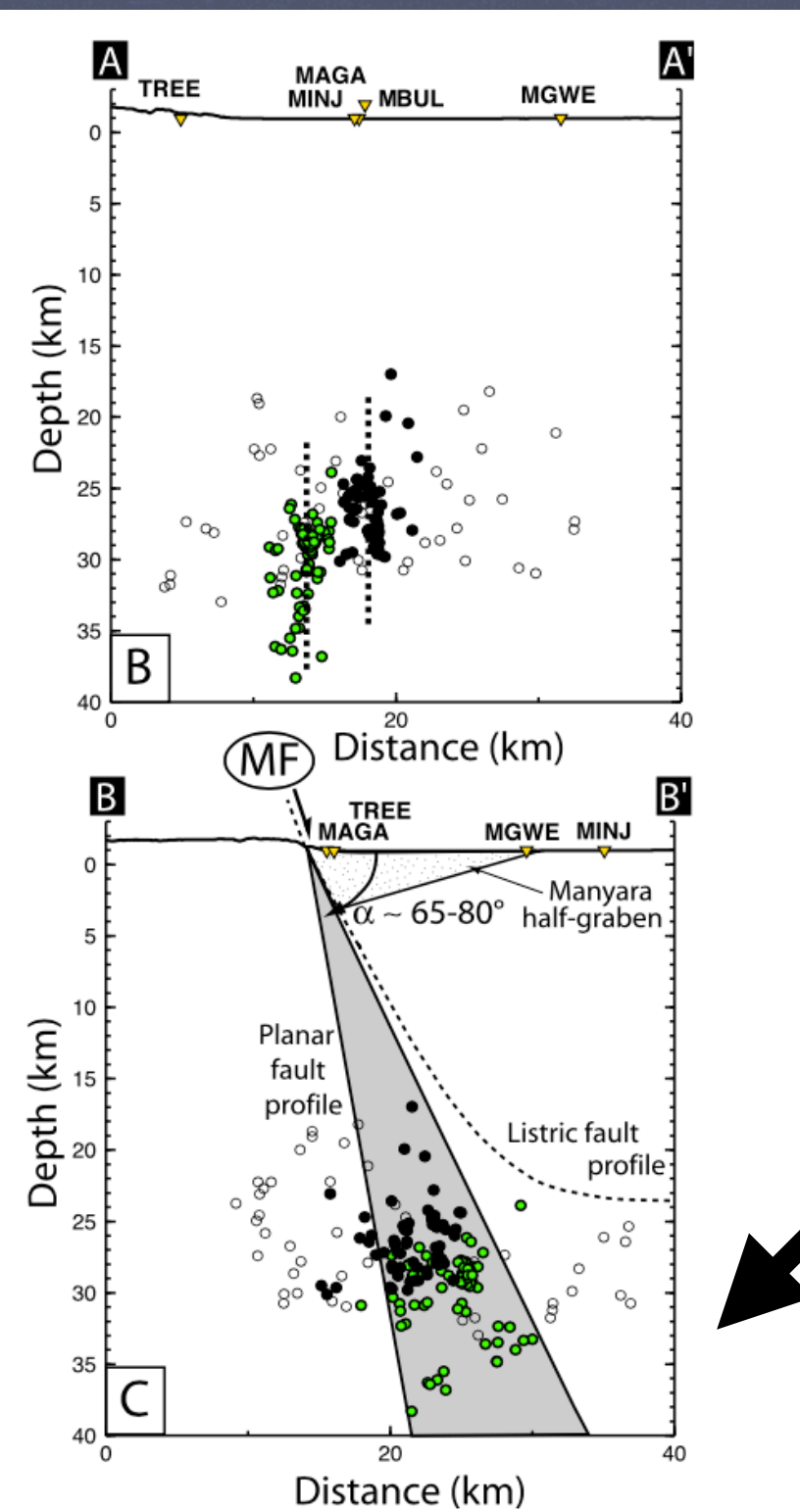
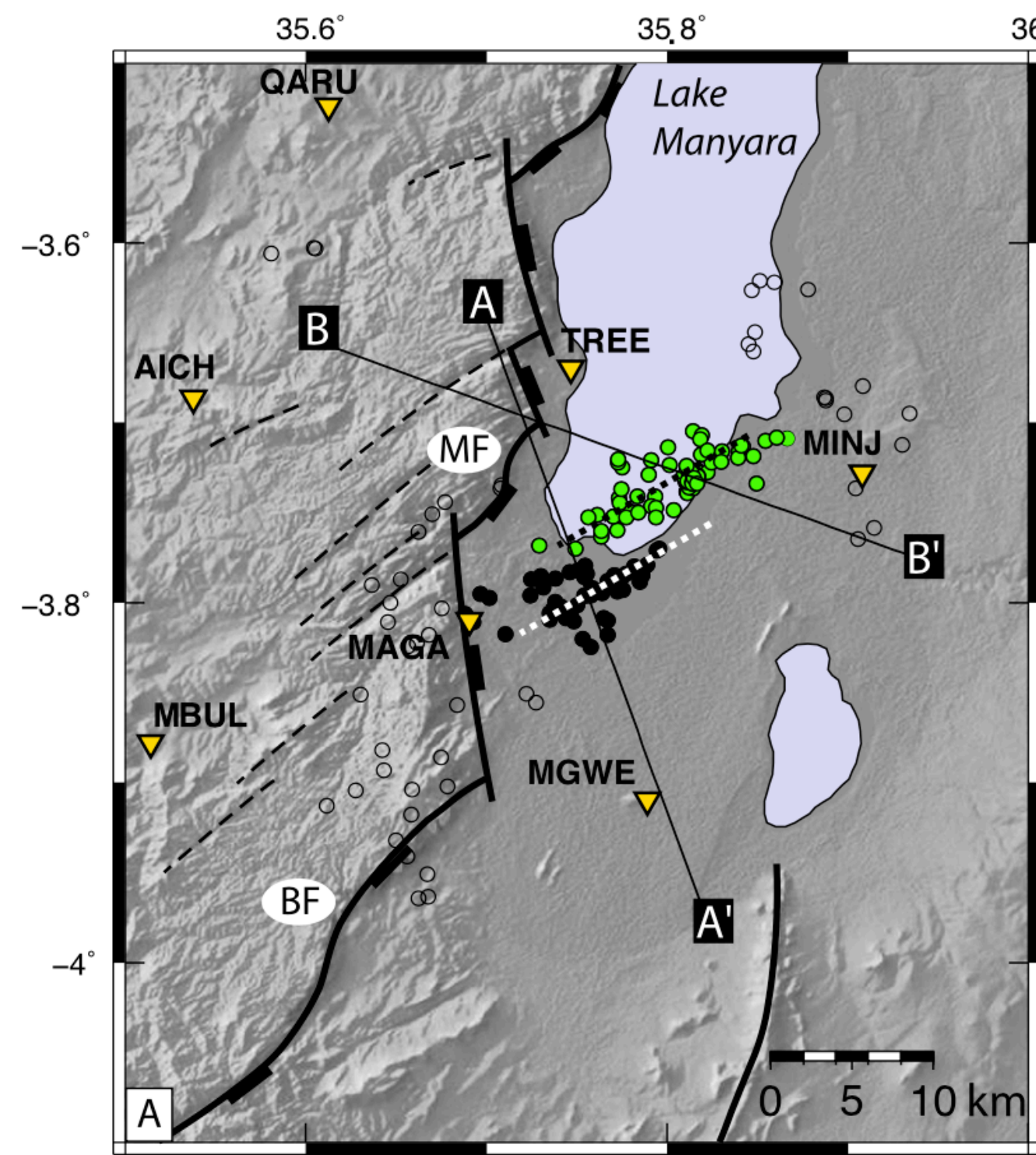
- Enhanced fault/melt interaction
- Faulting systems development

- New mafic crust (dykes)
- Crustal reservoirs / segments
- Extension through intrusion

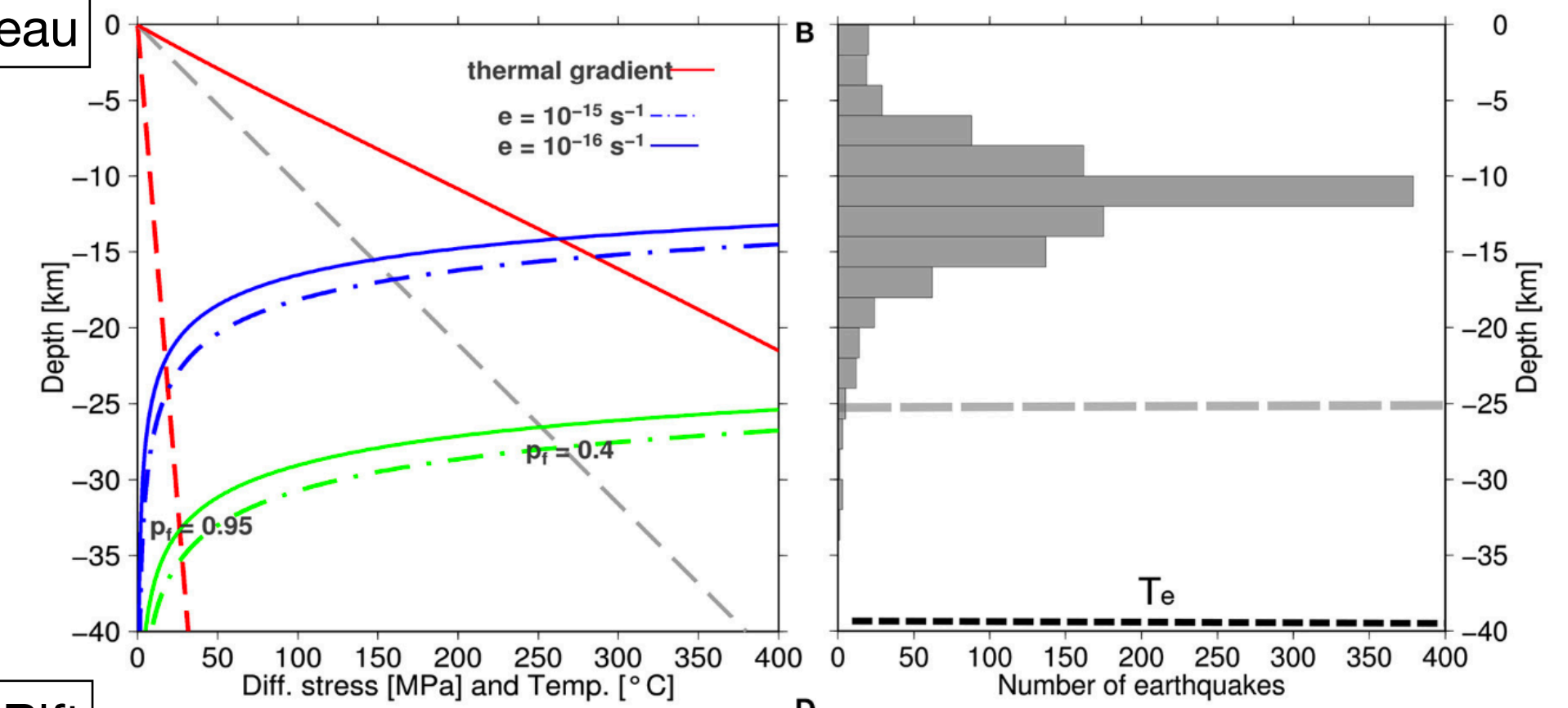
How do you relate deep processes and surface deformation?

Rheology of the lithosphere influence the distribution of earthquakes in depth

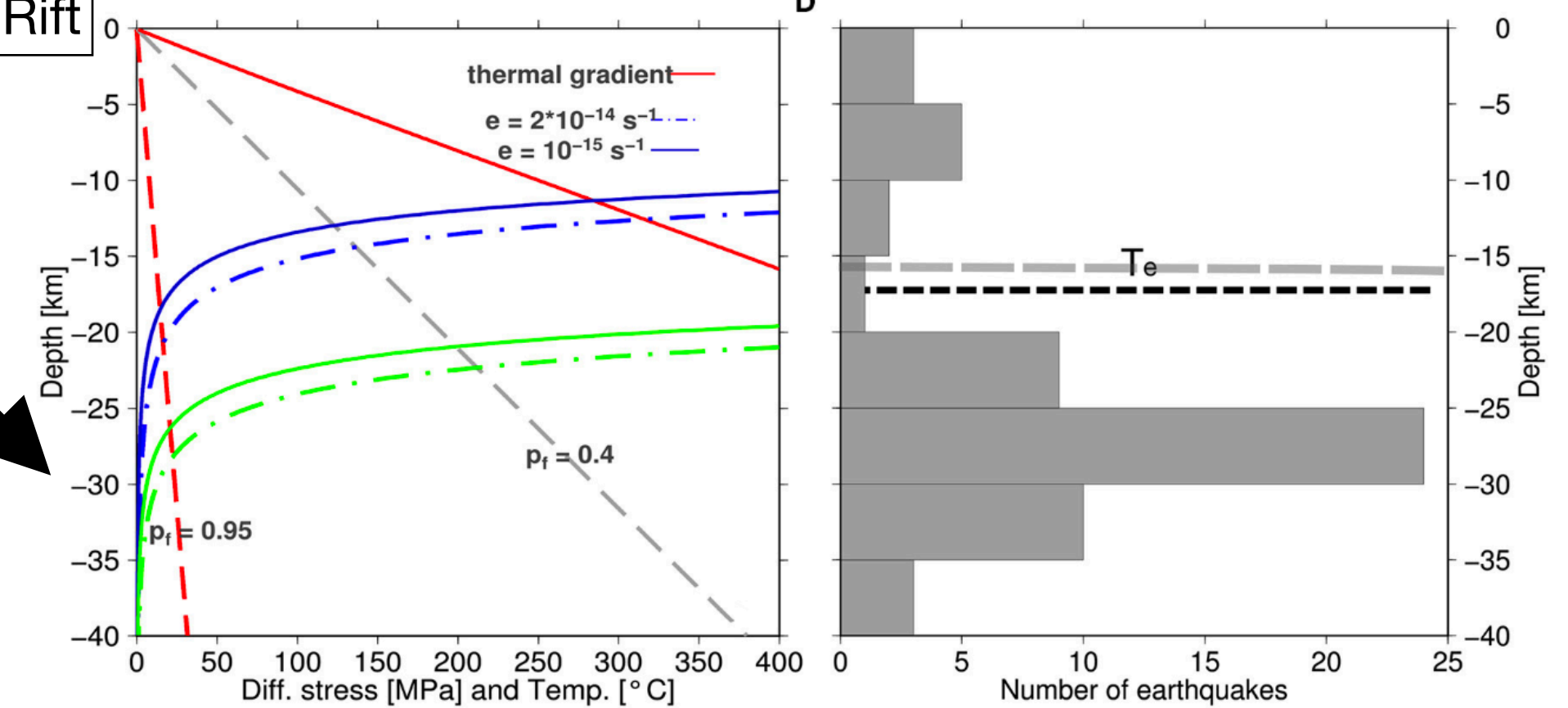
Eastern Branch



NW Ethiopian Plateau



Main Ethiopian Rift



Fluids?
High strain rate?
mafic crust?
low geothermal?

How do you relate deep processes and surface deformation?

a lot of inter-acting factors
CO₂, rheology, melt, hydration, inherited structures...

Rift maturing

Pre-existing structures influence

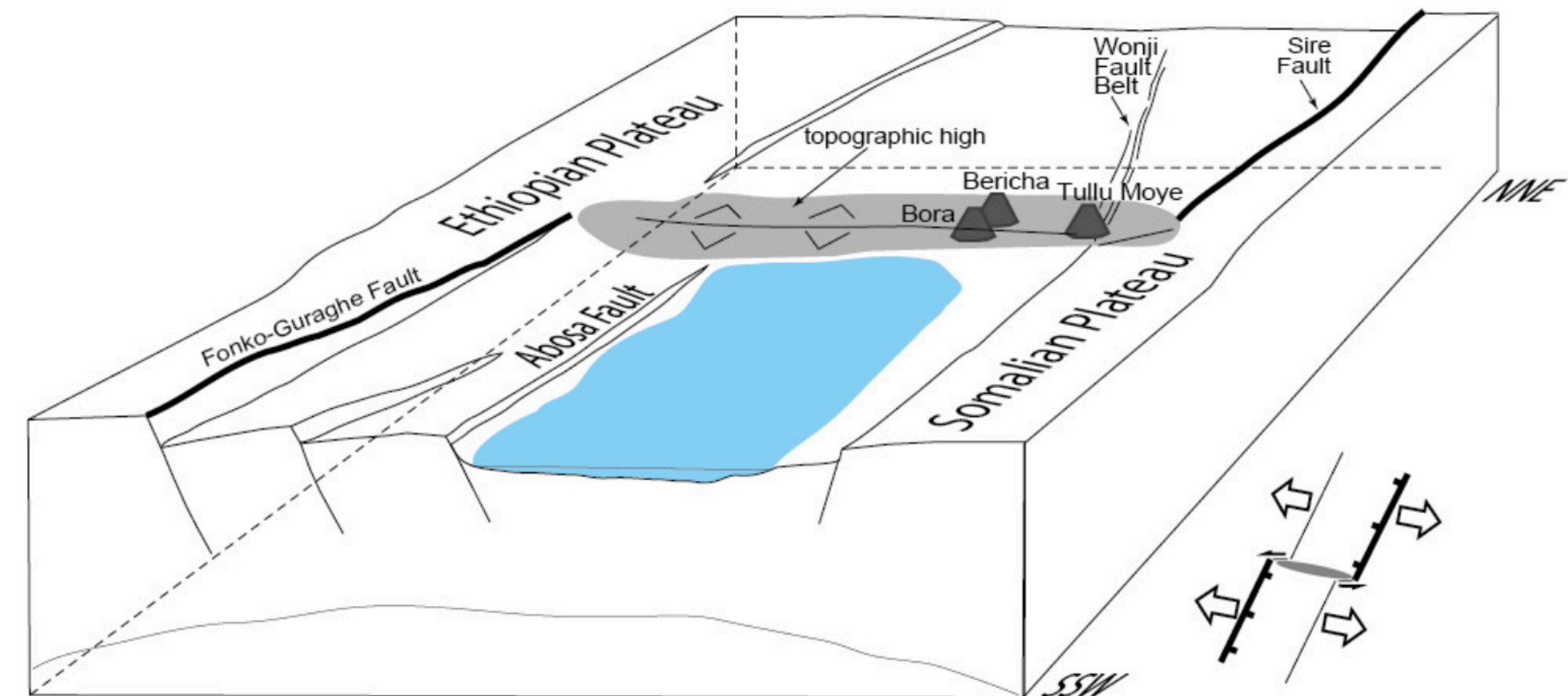
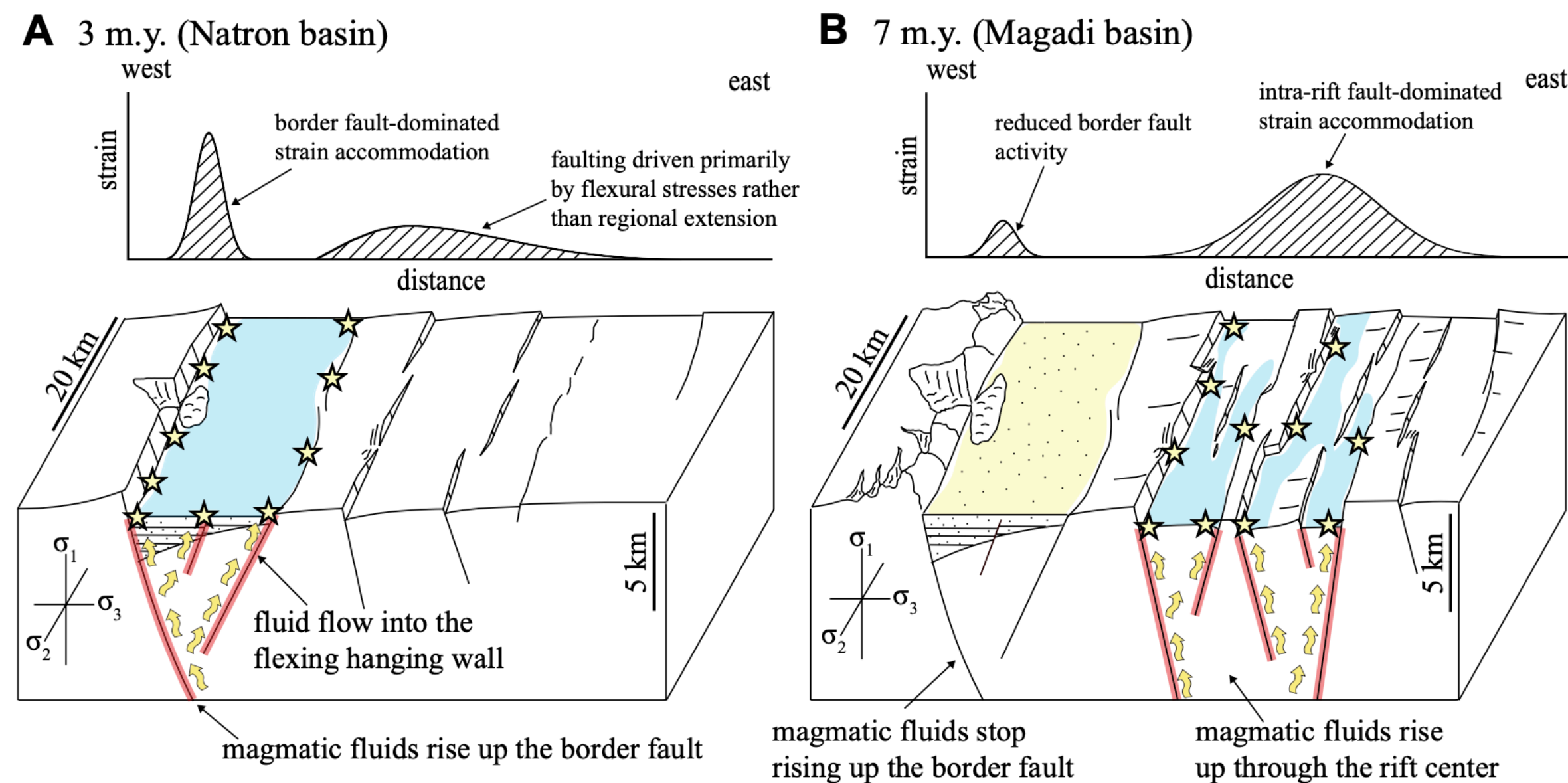
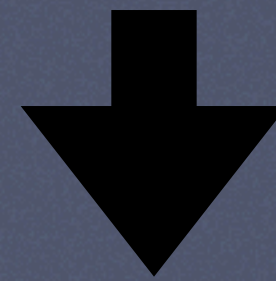


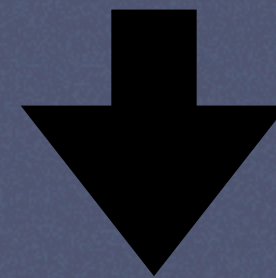
Fig. 7 - 3D block diagram of the studied central MER sector illustrating the possible relationships among the rift-related structures and the suggested transverse structure along which are located the major Bora and Bericha volcanoes, whereas at the intersection of these structures is located the still active Tullu Moye volcano. With light blue the megalake is also reported whose northern part is delimited by the inferred transverse structure. In the small inset a sketch of rift valley with major and minor faults and the inferred transfer zone.

How do you relate deep processes and surface deformation?

a lot of inter-acting factors
CO₂, rheology, melt, hydration, inherited structures...



Rift morphology, evolution



distribution of resources, human, animals, vegetation
risk understanding, sustainable energy, management...

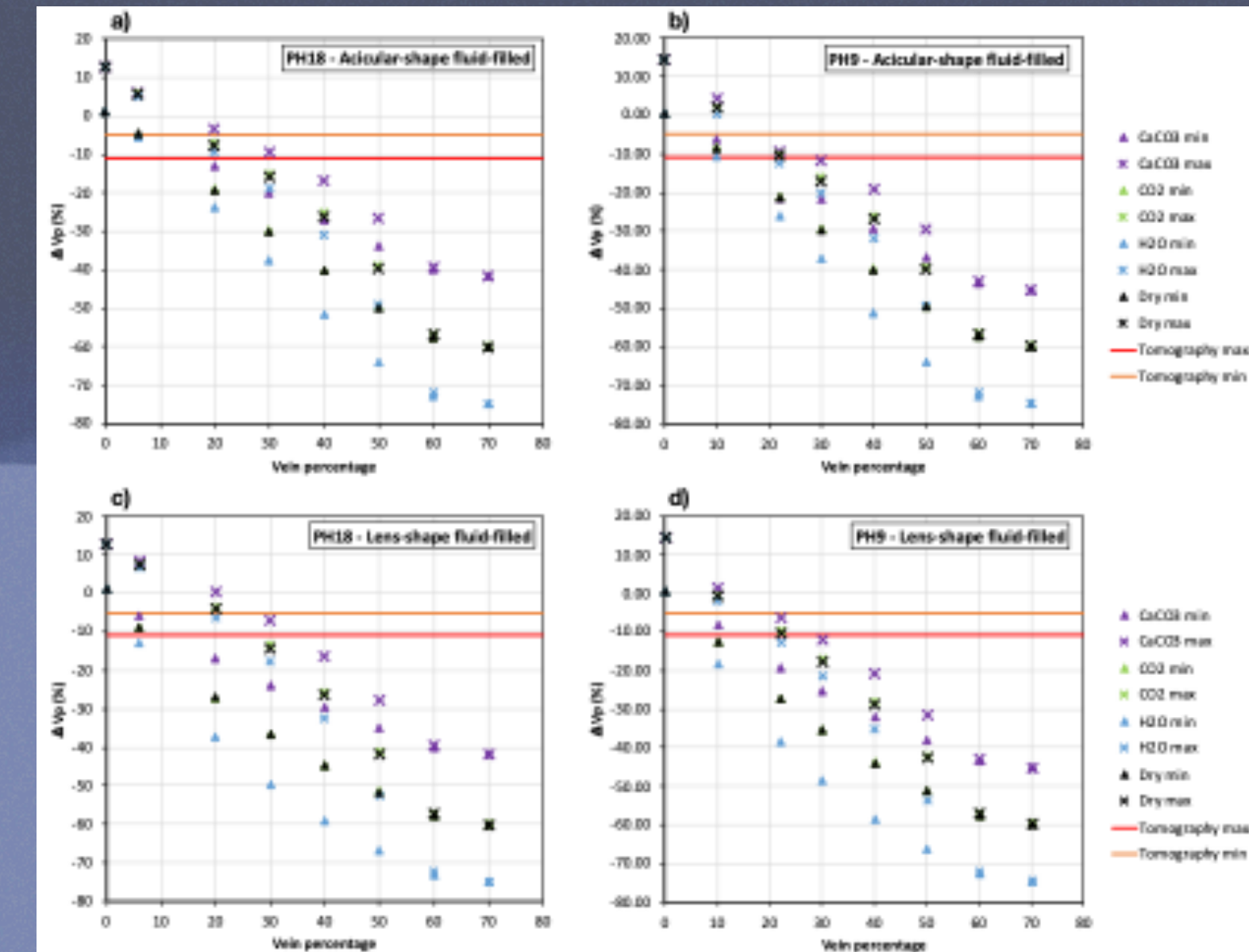
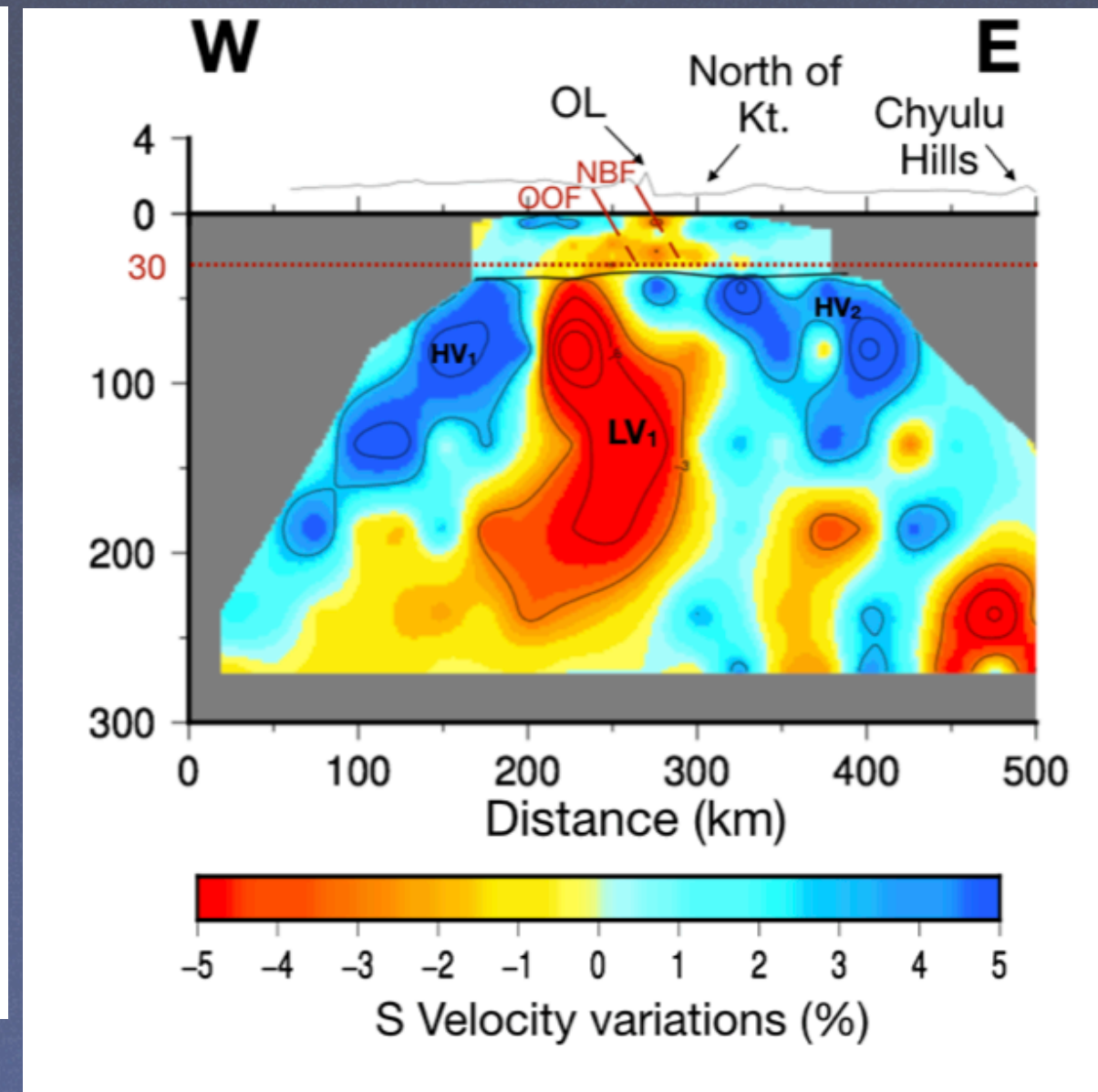
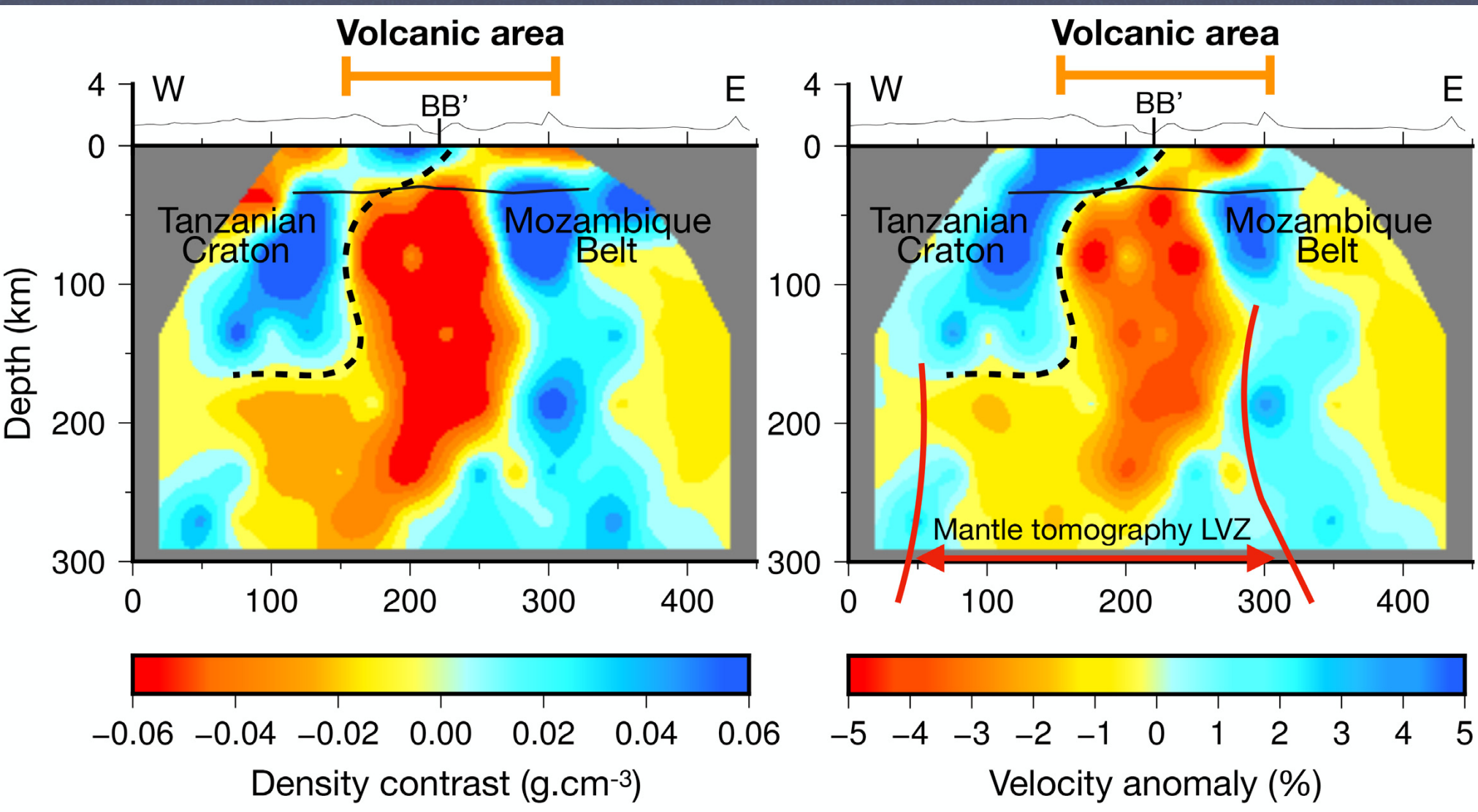
What's next?

- Inter-disciplinary improve
- multi scaling approaches
 - parameter identification / isolation
 - exploration of solutions

Density

P-waves

S-waves



Tiberi et al., 2019

Clutier et al., sub.