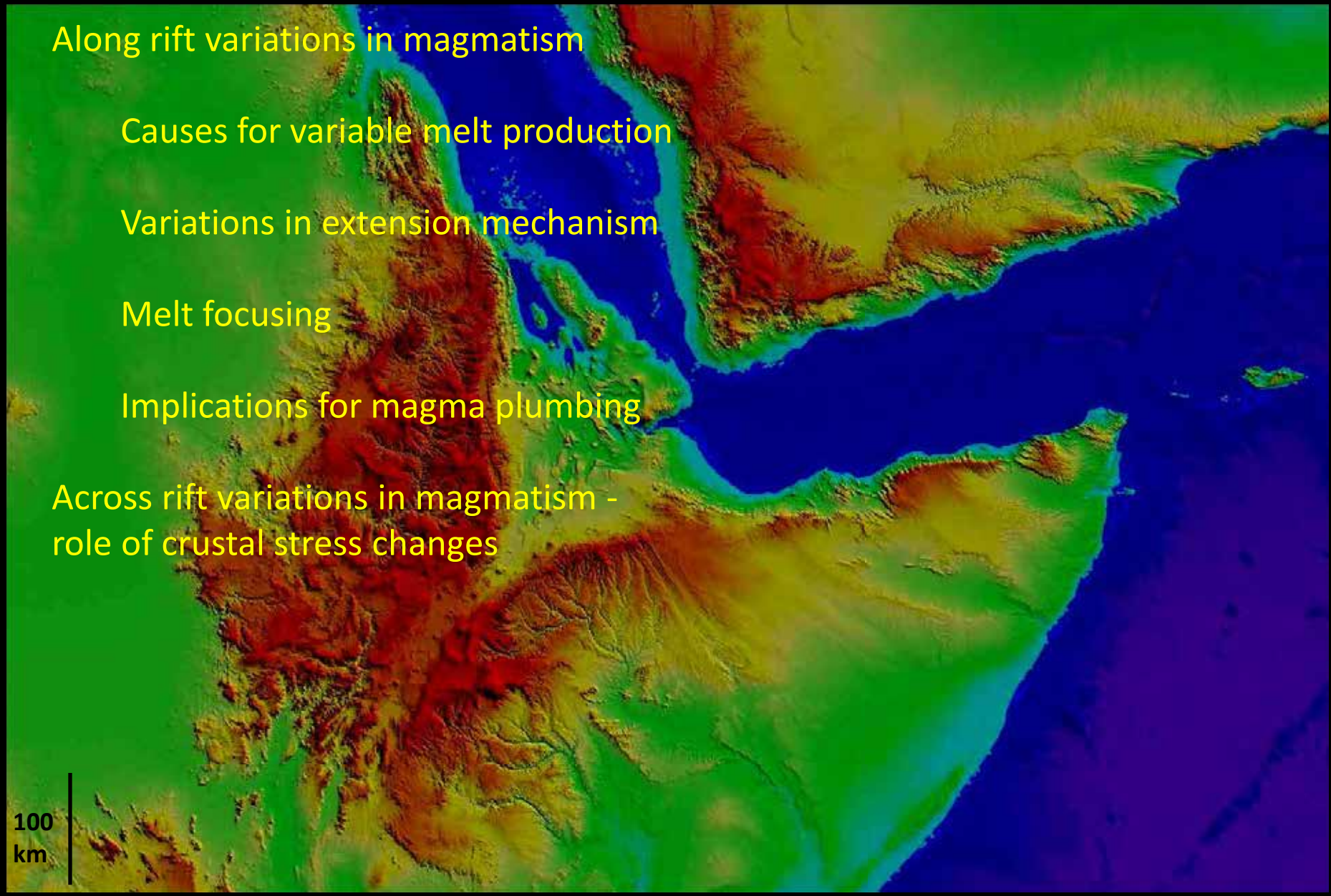
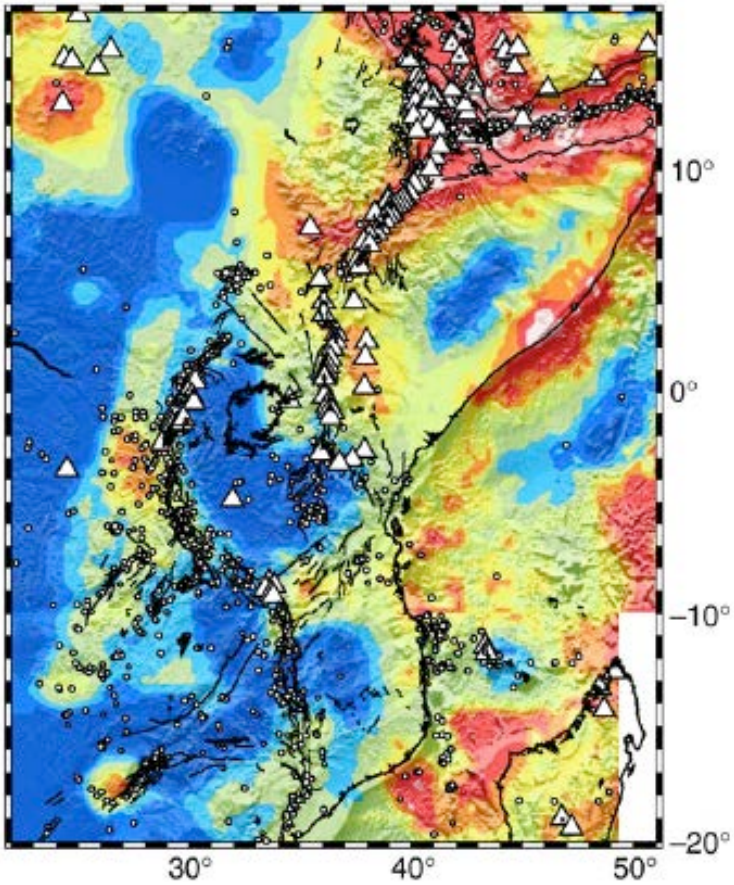
Rifting and oceanic spreading - the focusing of melt delivery in space and time

Derek Keir University of Southampton

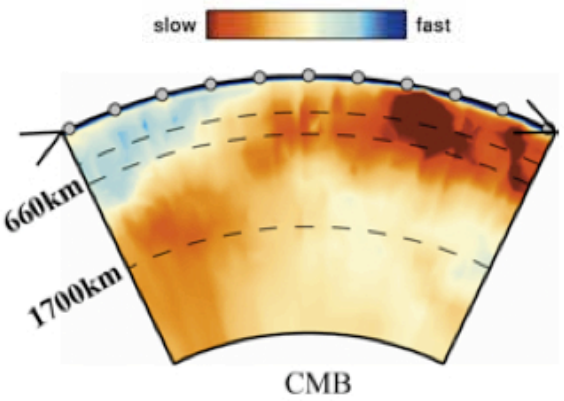
Outline

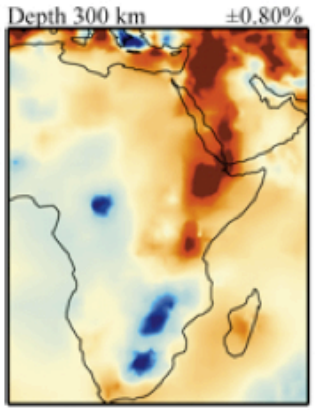

Along rift variations in magmatism
Causes for variable melt production
Variations in extension mechanism
Melt focusing
Implications for magma plumbing
Across rift variations in magmatism -
role of crustal stress changes
100
km

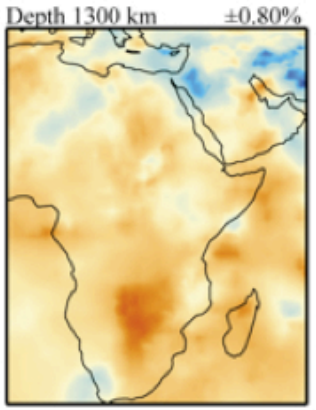
Along-rift variations in magmatism over large length scales

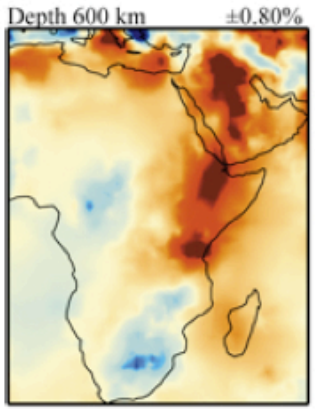


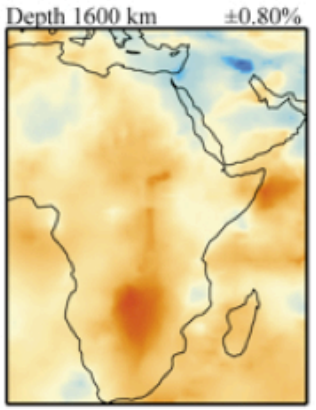
Perez-Gussinye et al., 2009







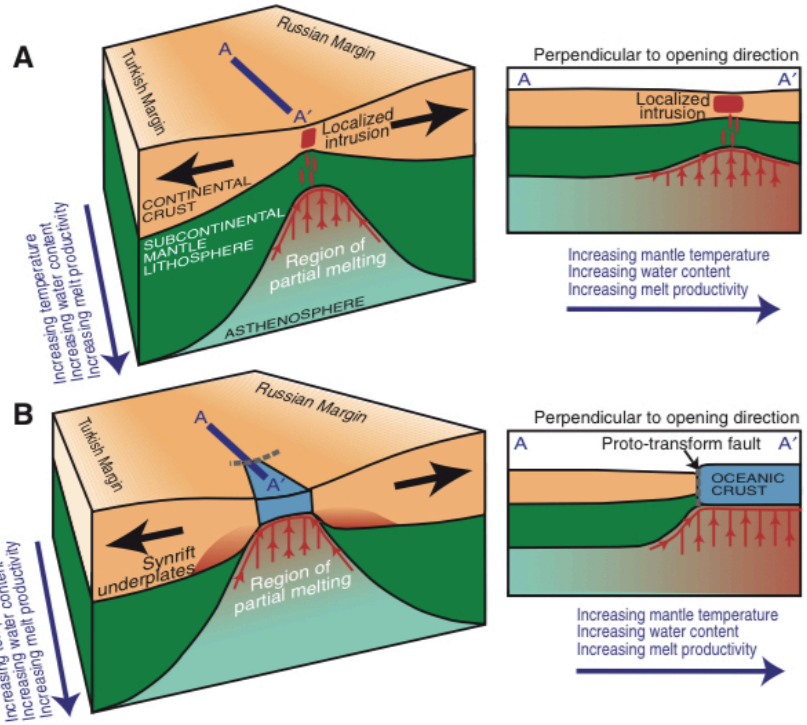


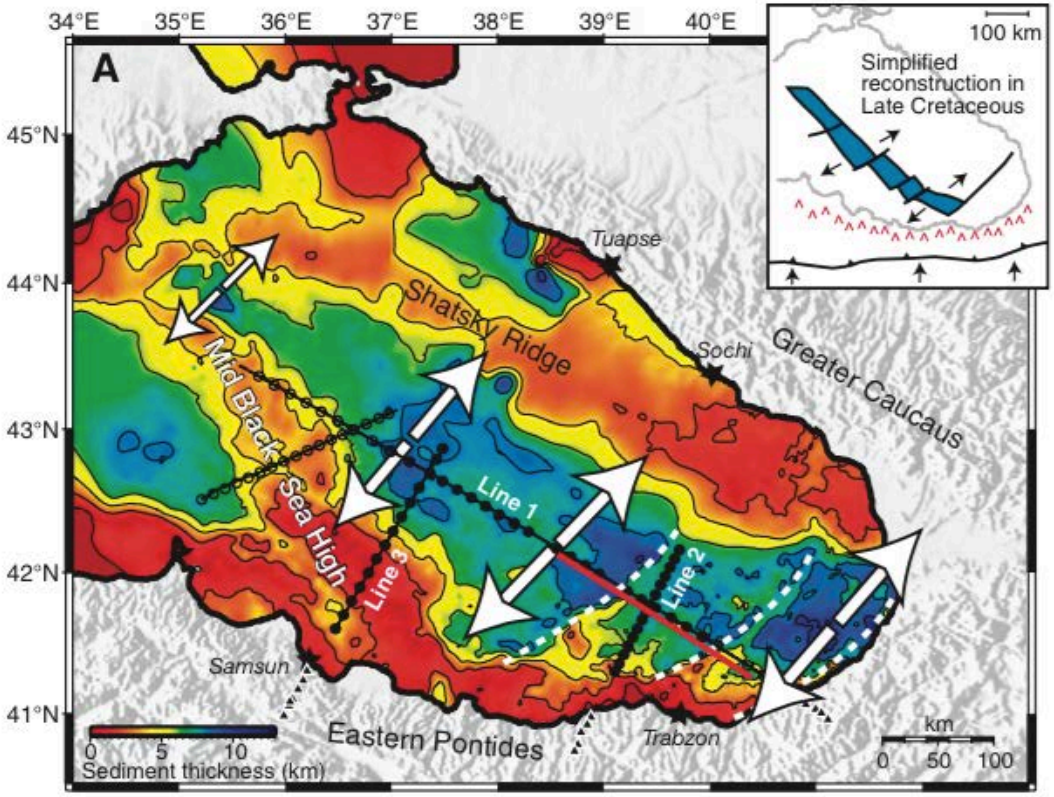


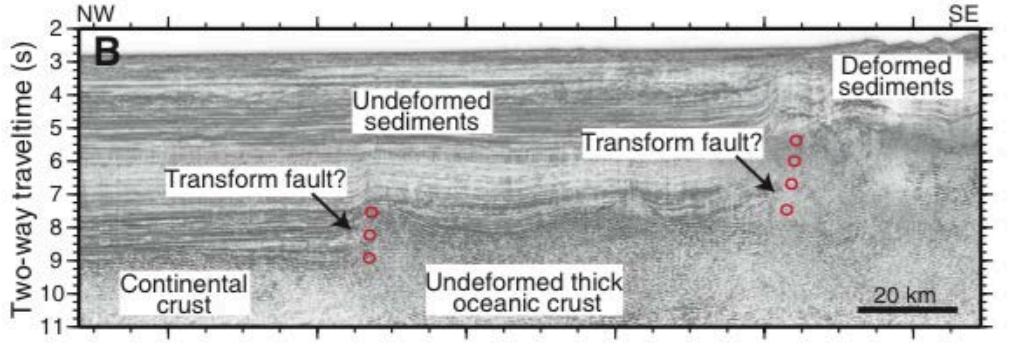
Li et al., 2008

Eastern Black Sea

- Abrupt transition between magma starved and magma rich extension
- Melt focusing caused by along rift variations in extension and resultant thickness of lithosphere

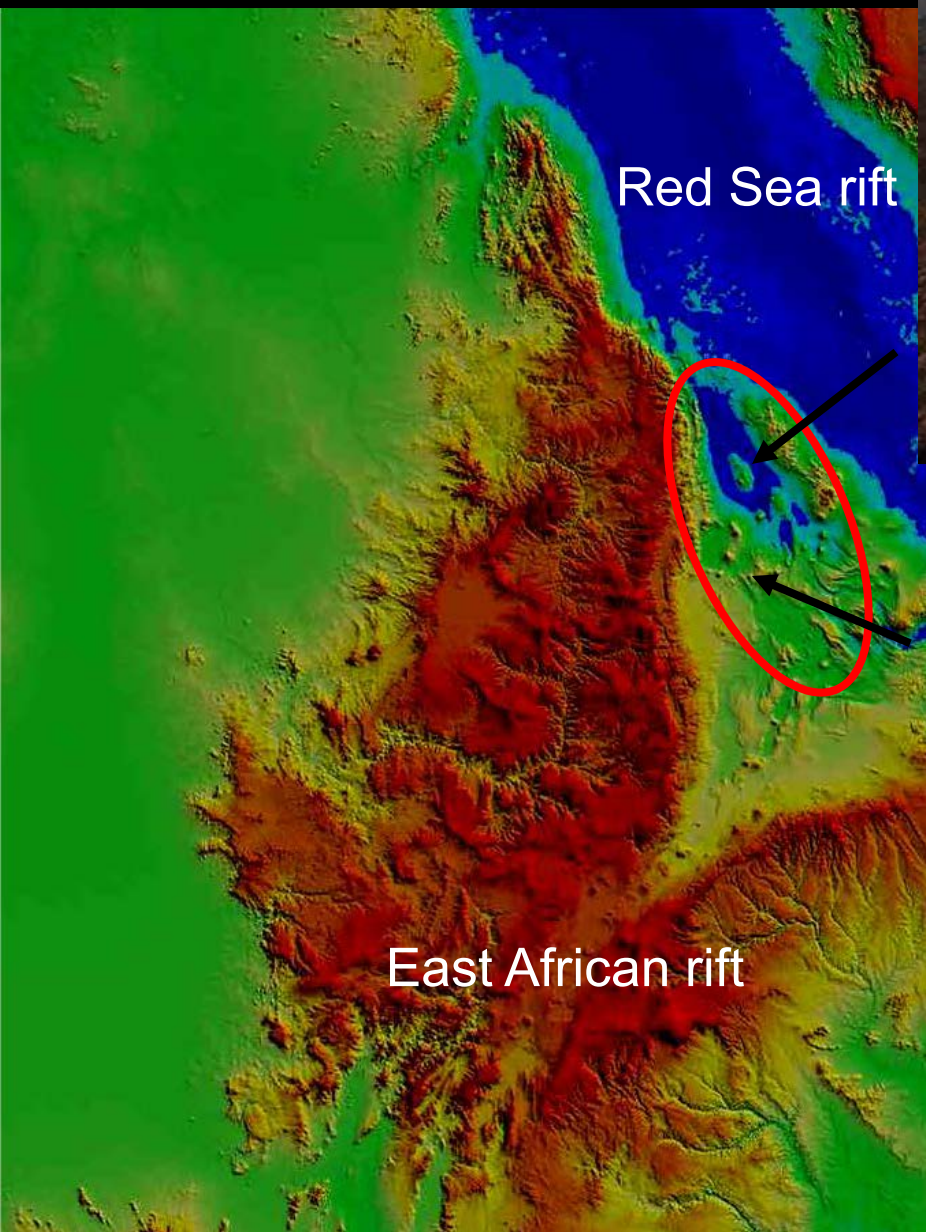






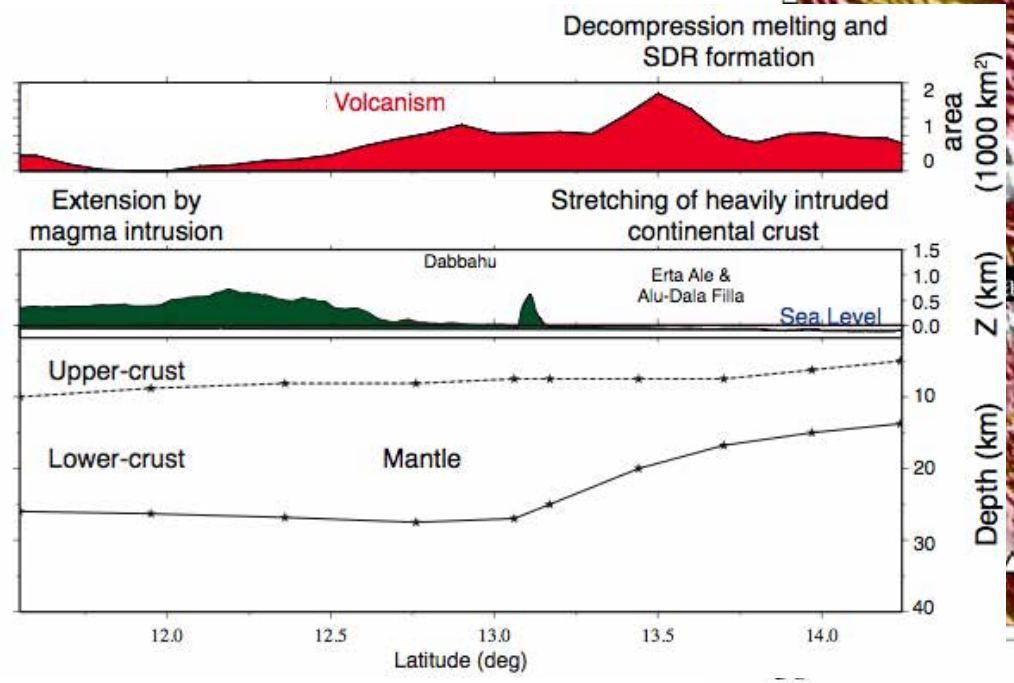
Shillington et al., 2008, Geology

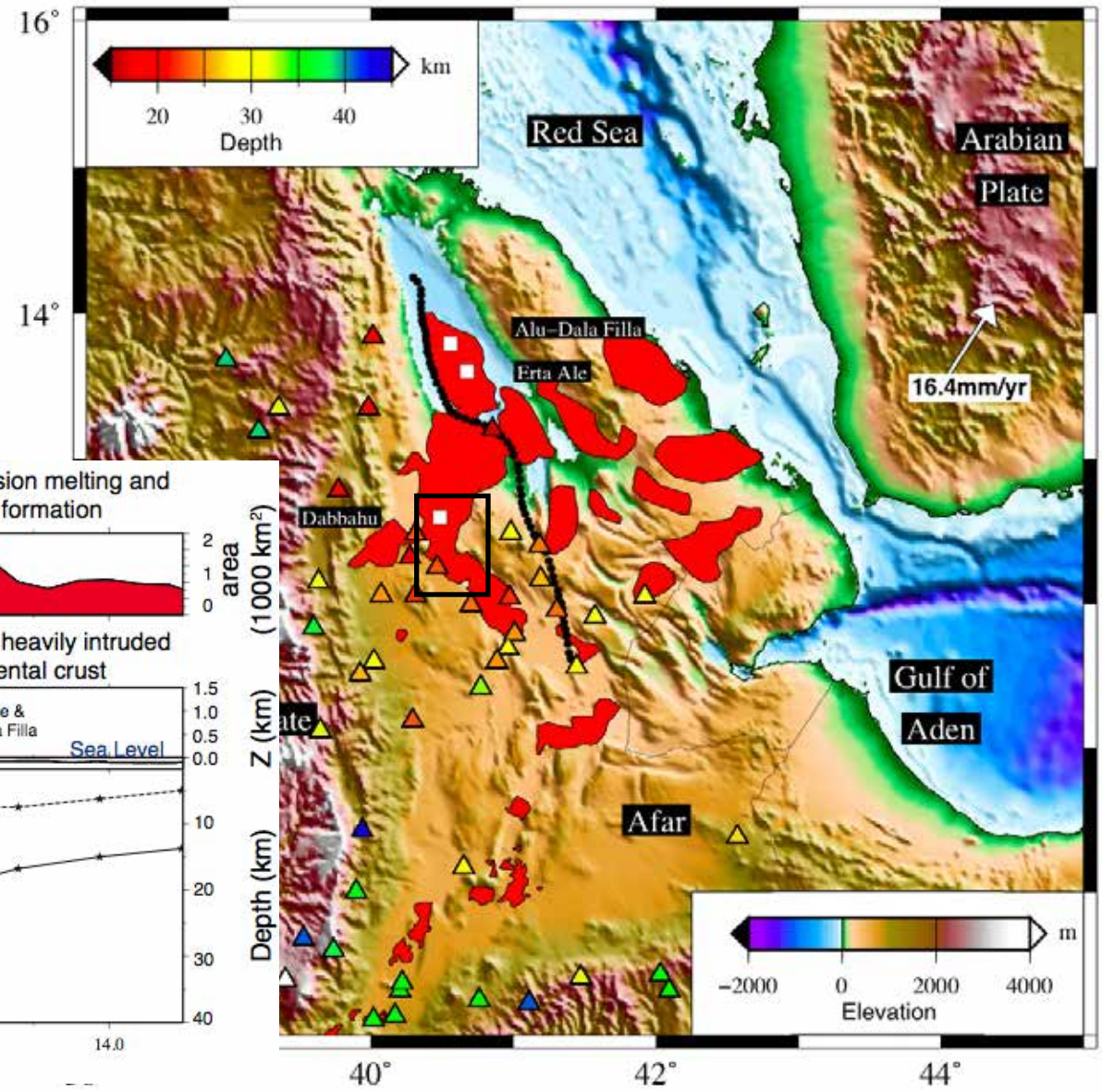
Along-rift variations at the Red



Along-rift variations in style of deformation at the Red Sea rift in Afar

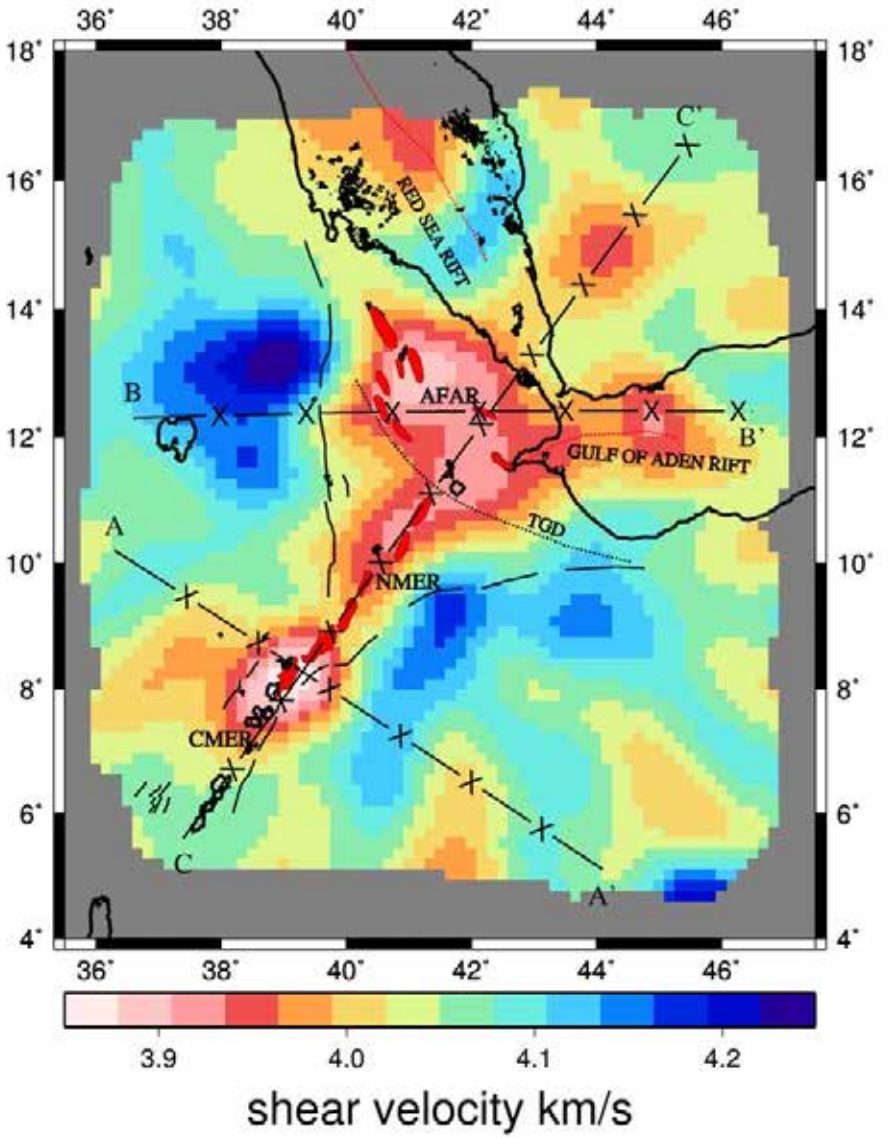
Bastow and Keir, 2011, Nature Geoscience





3-D depth averaged slice

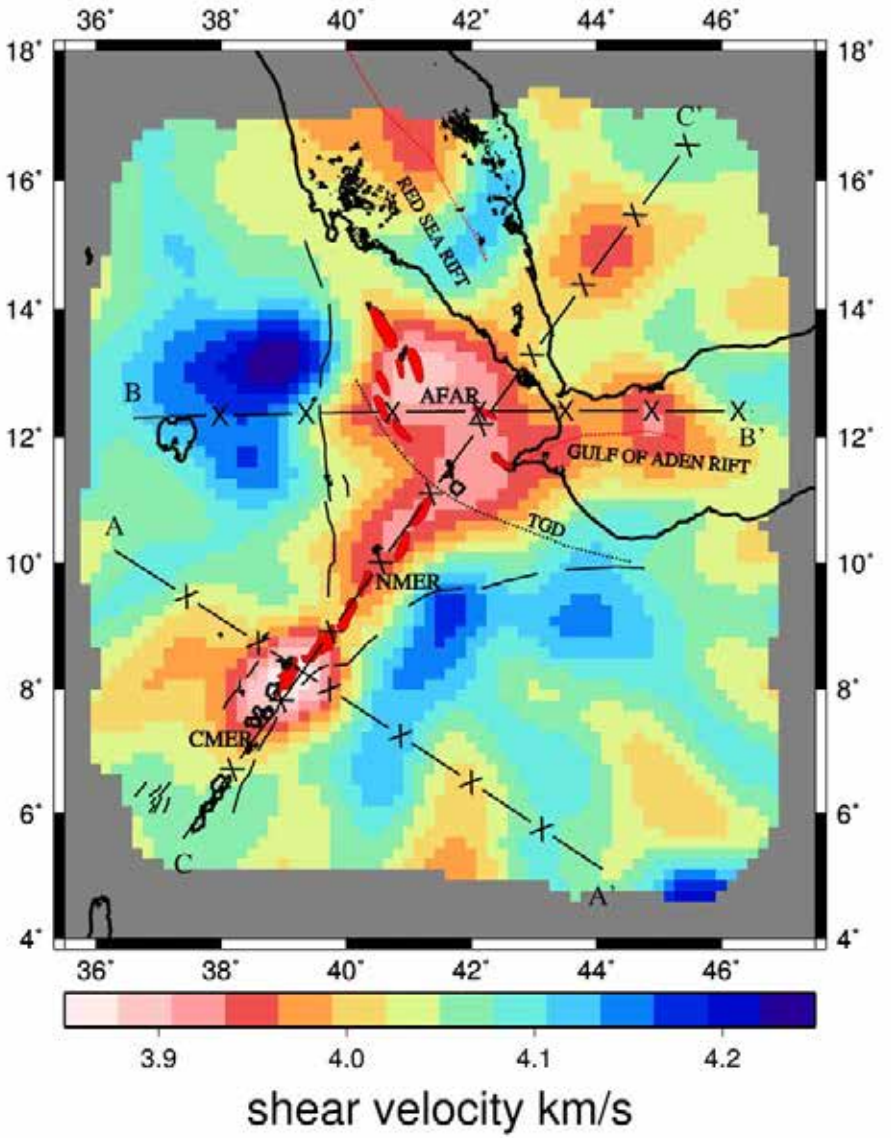
- The mantle beneath the border faults and rift flanks is characterised by higher velocity mantle (>4.1 km/s)
- Shear wave velocities of less than 4.00 km/s underlie the rift
- Low velocities focused in the CMER, NMER, Afar, Red Sea, and Gulf of Aden
- Particularly slow in the CMER and northern Afar



Gallacher et al., in review

Ethiopia mantle melt production

- Velocities beneath the flanks consistent with warm mantle of 100K above normal mantle
- Afar anomaly 3.5% slower than the surrounding mantle
- Velocities in the rift are slow and would require mantle temperatures of >250 K
- Afar requires ~0.35% melt



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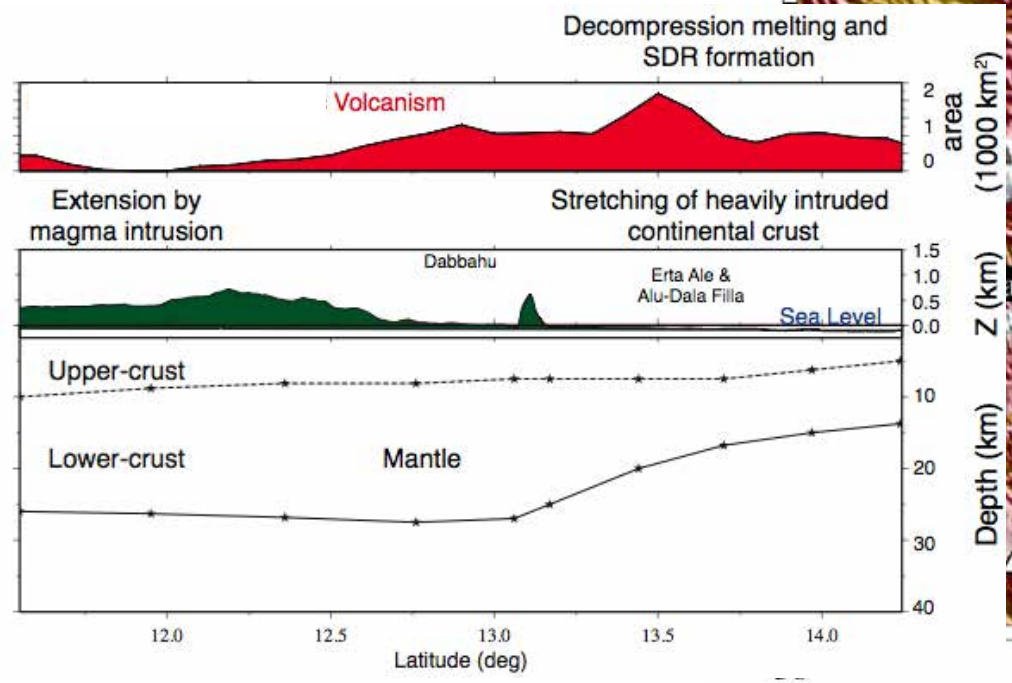

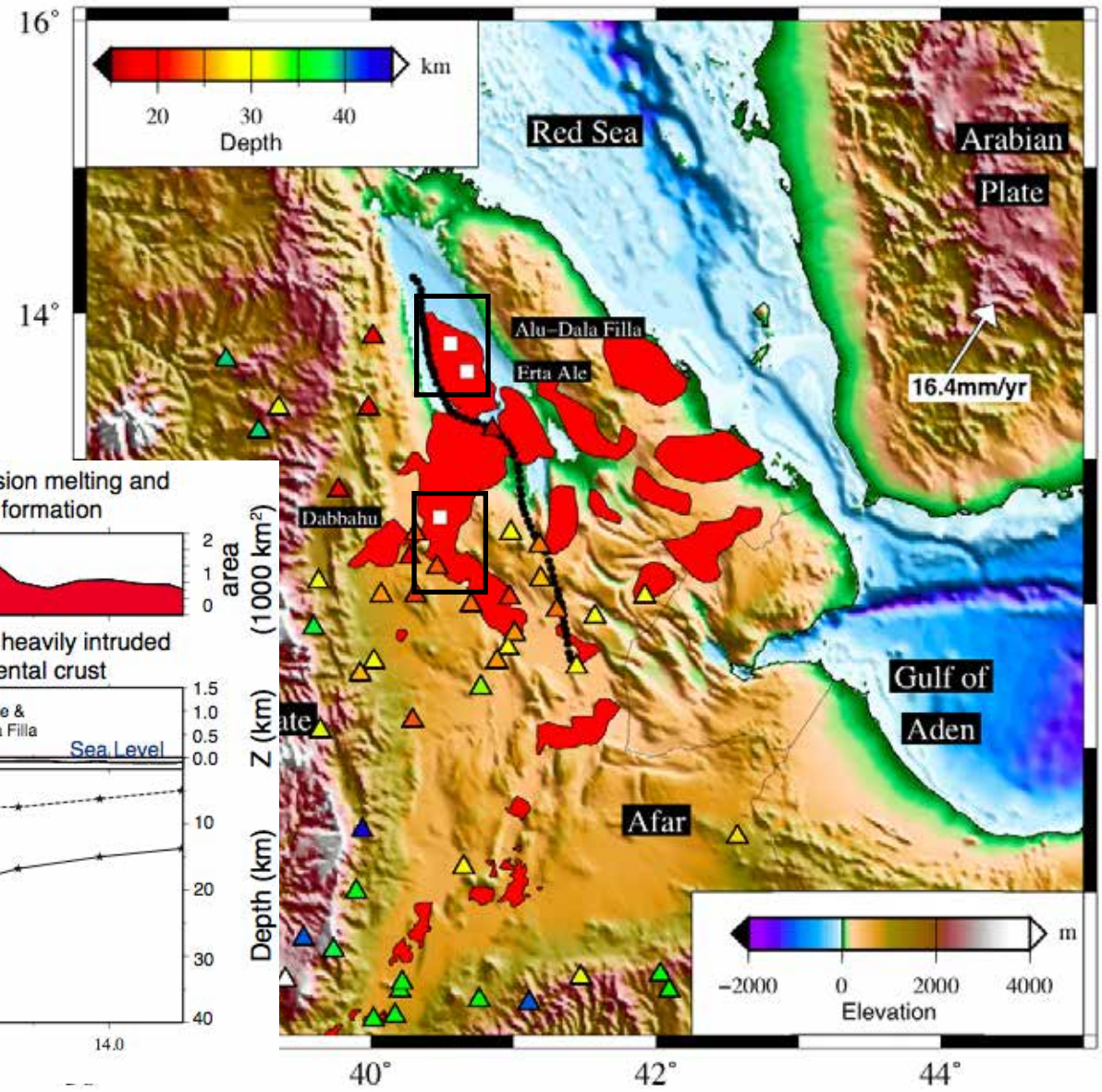

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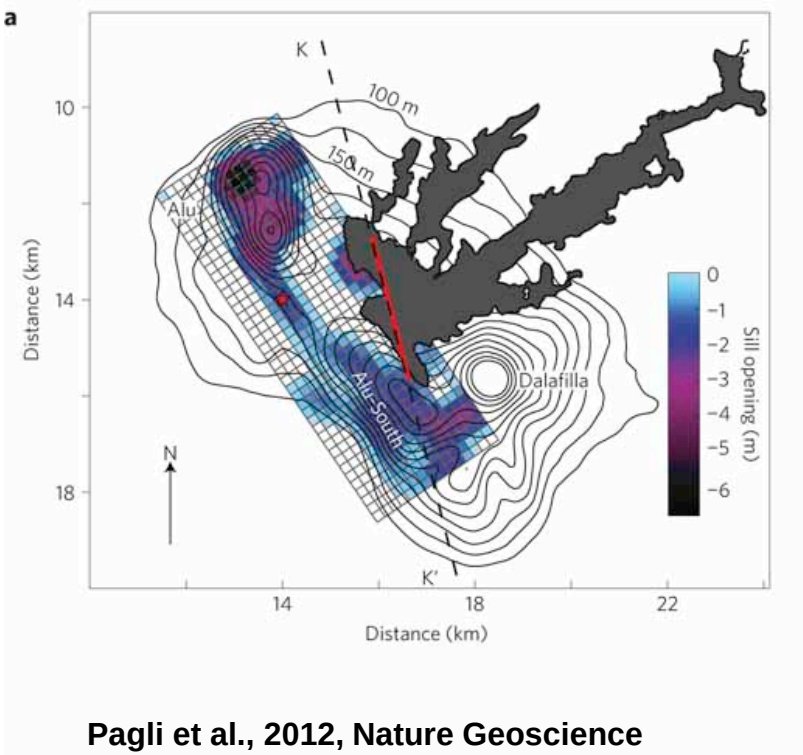
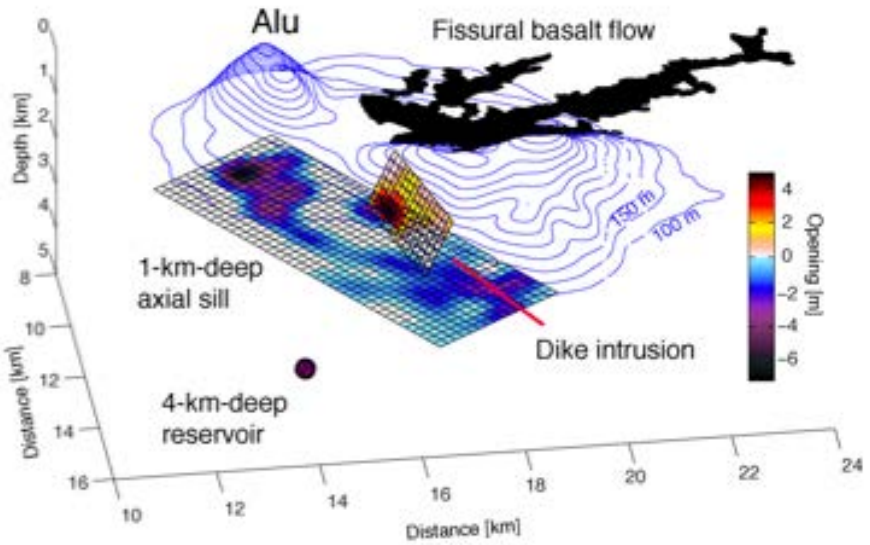
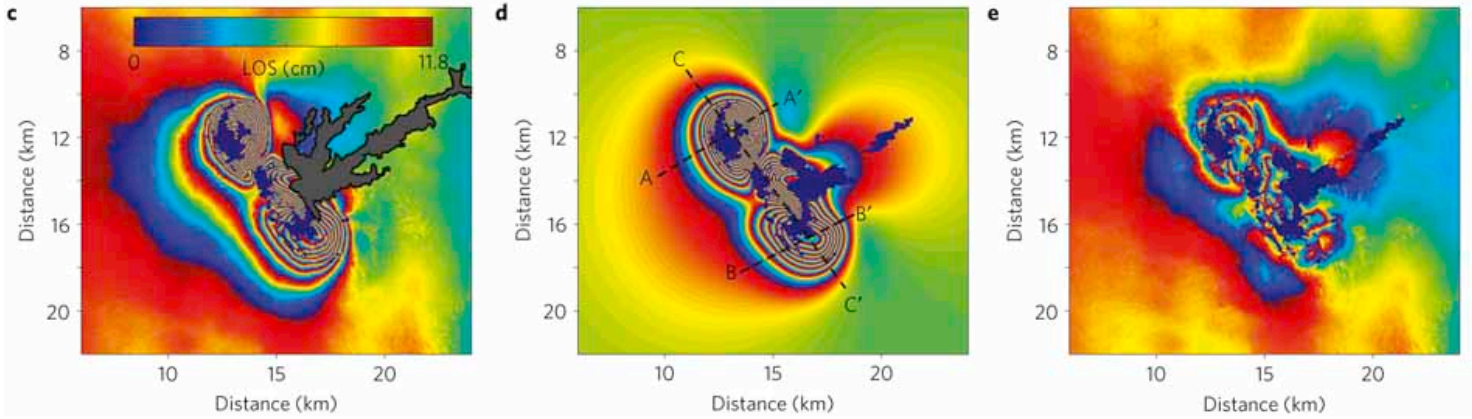
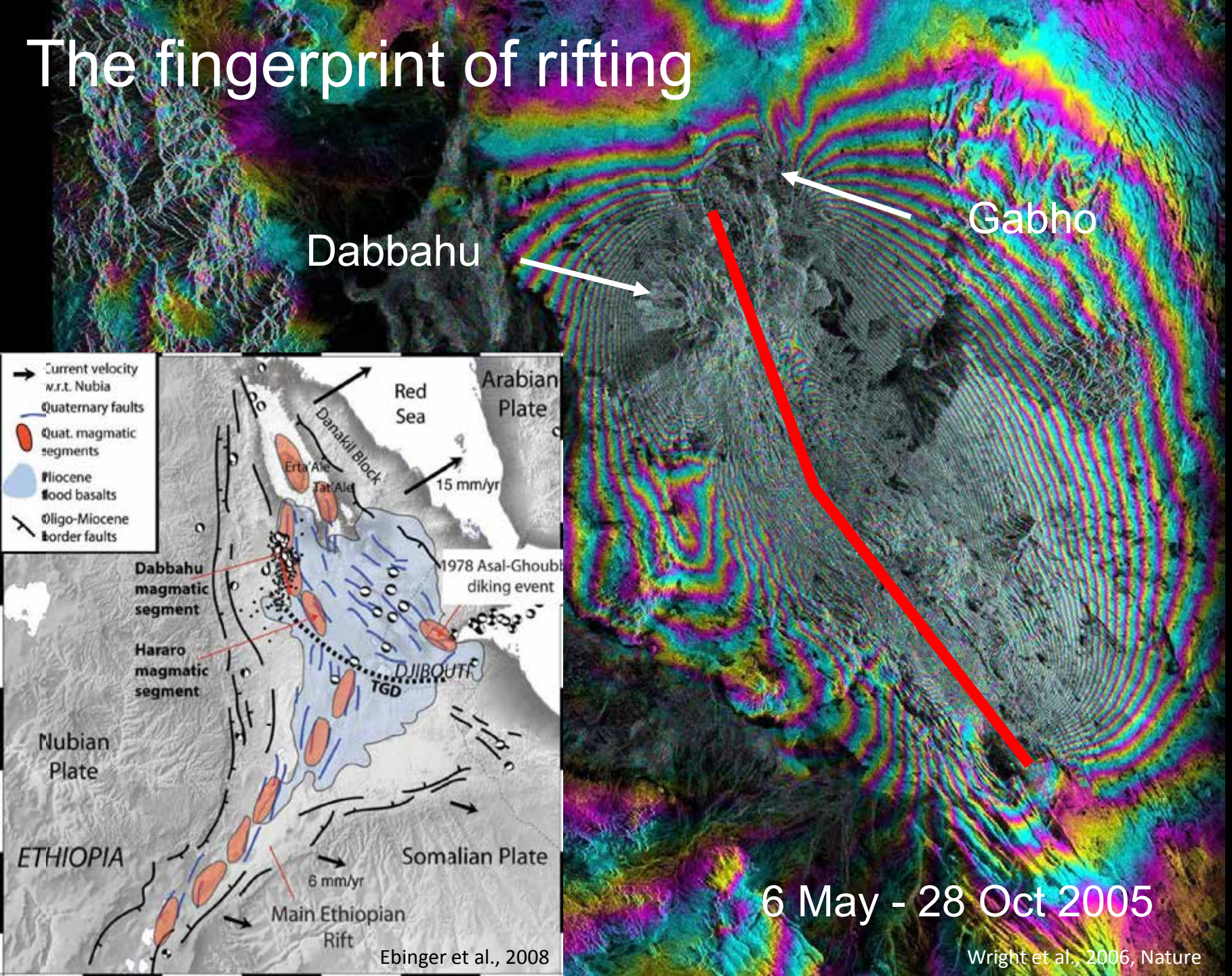


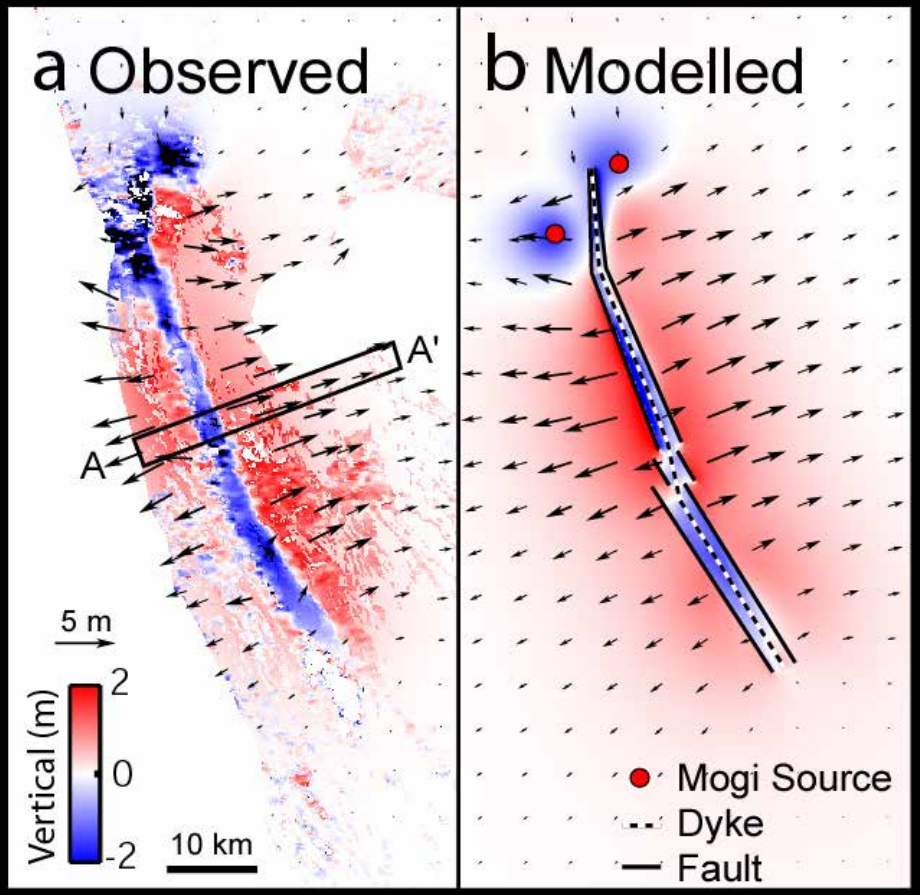


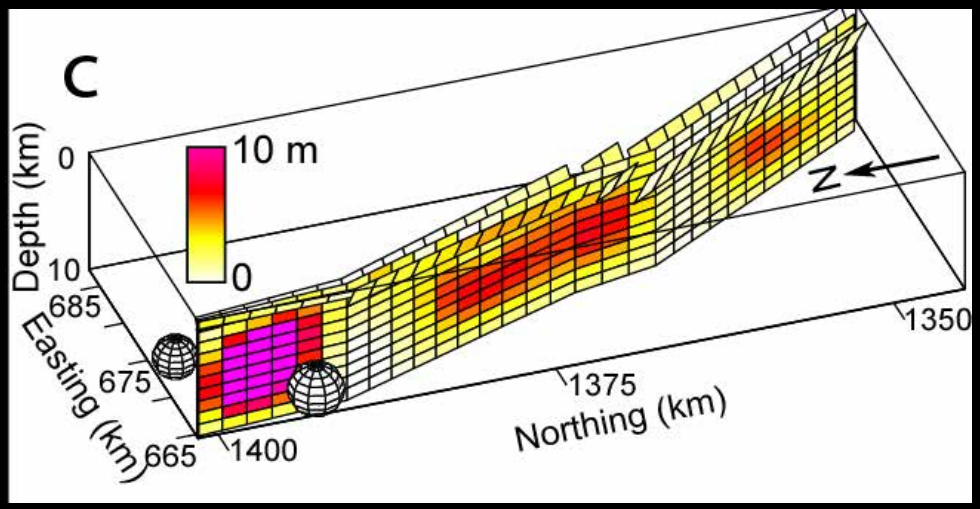
Pagli et al., 2012, Nature Geoscience



The fingerprint of rifting



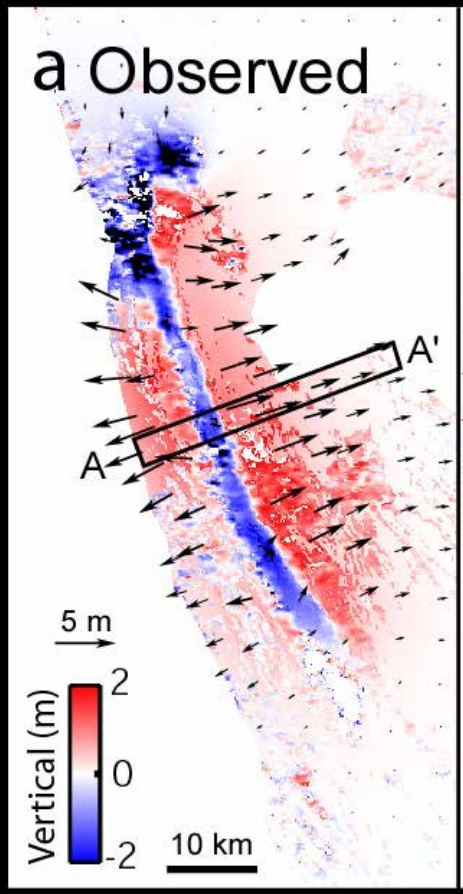


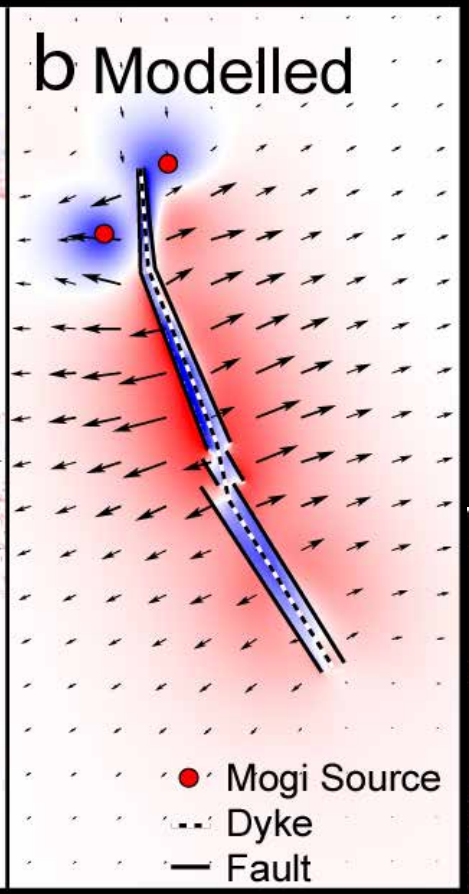


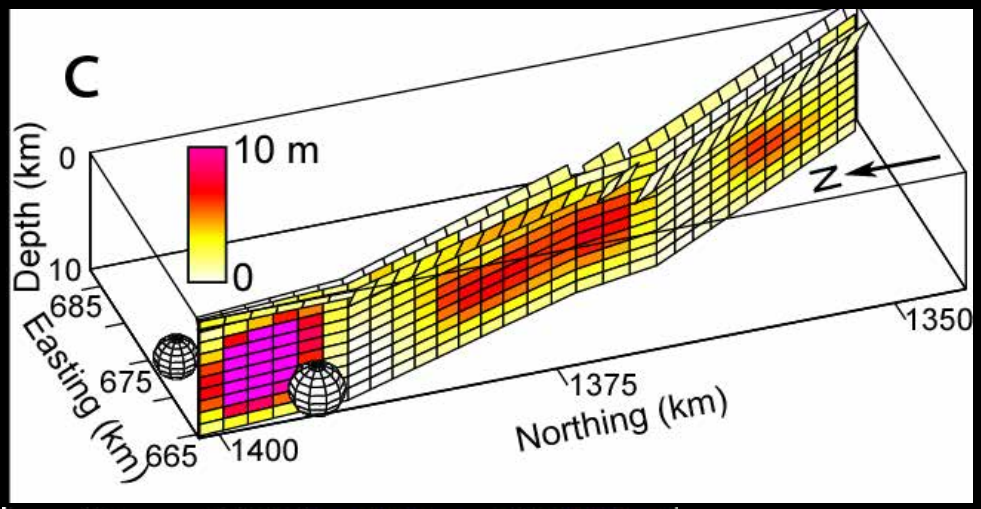
2.5 km^3 magma intruded along dyke

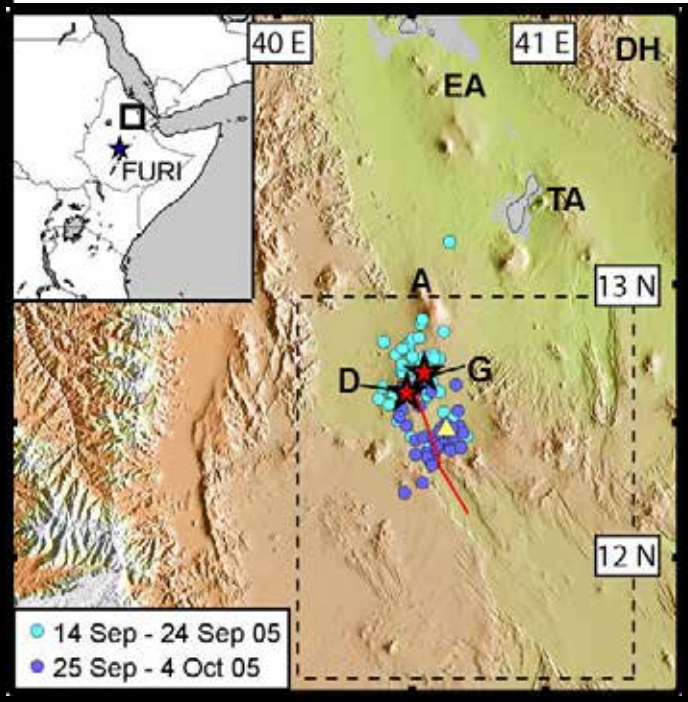
~0.5 km^3 from Dabbahu and Gabho

Wright et al., 2006, Nature









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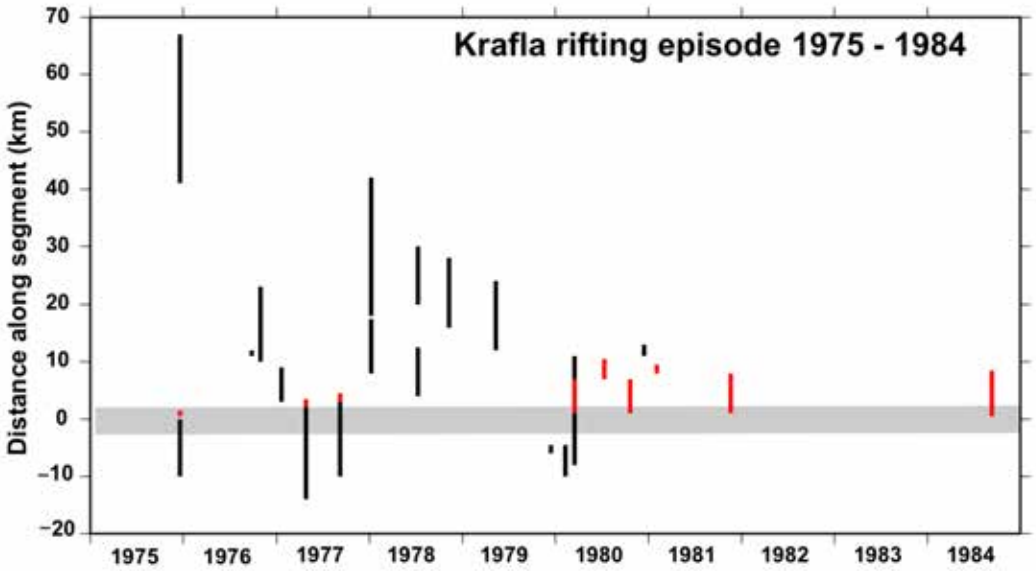
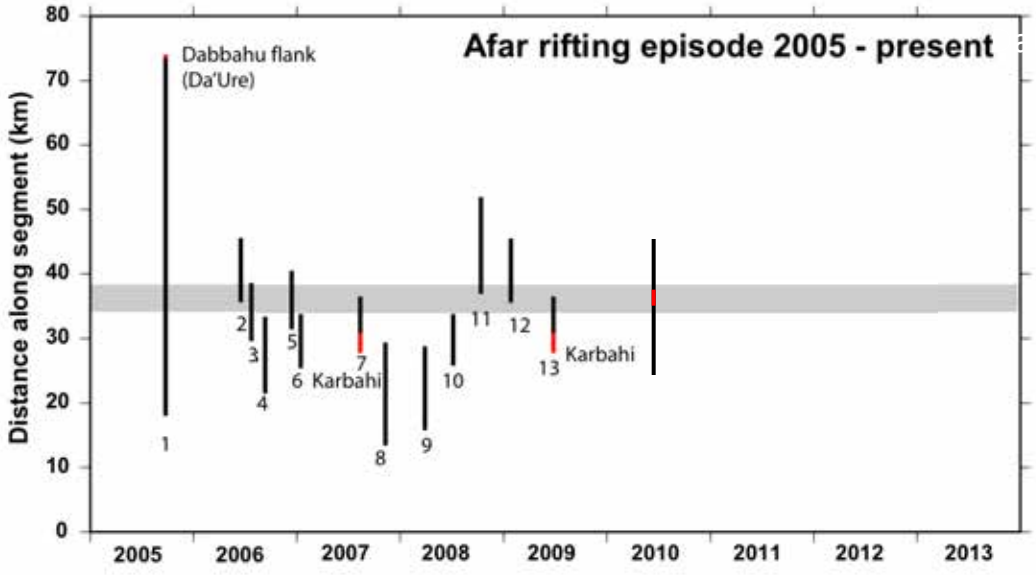
Earthquakes responsible for < 7 % of moment release

Temporally focused axial intrusion a single episode

Wright et al., 2006, Nature

Melt focusing in time





Hamling et al., 2009, GJI

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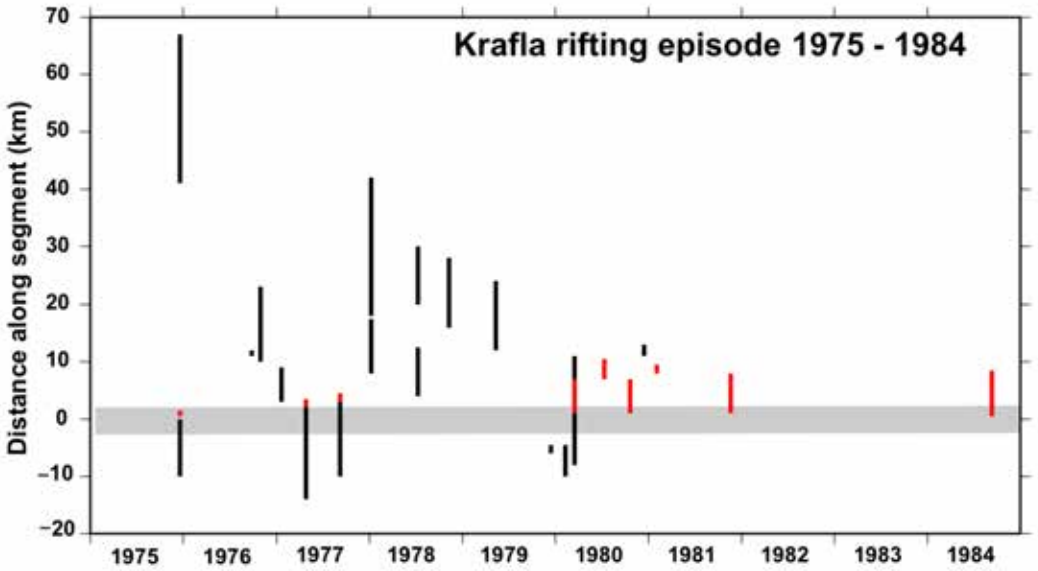
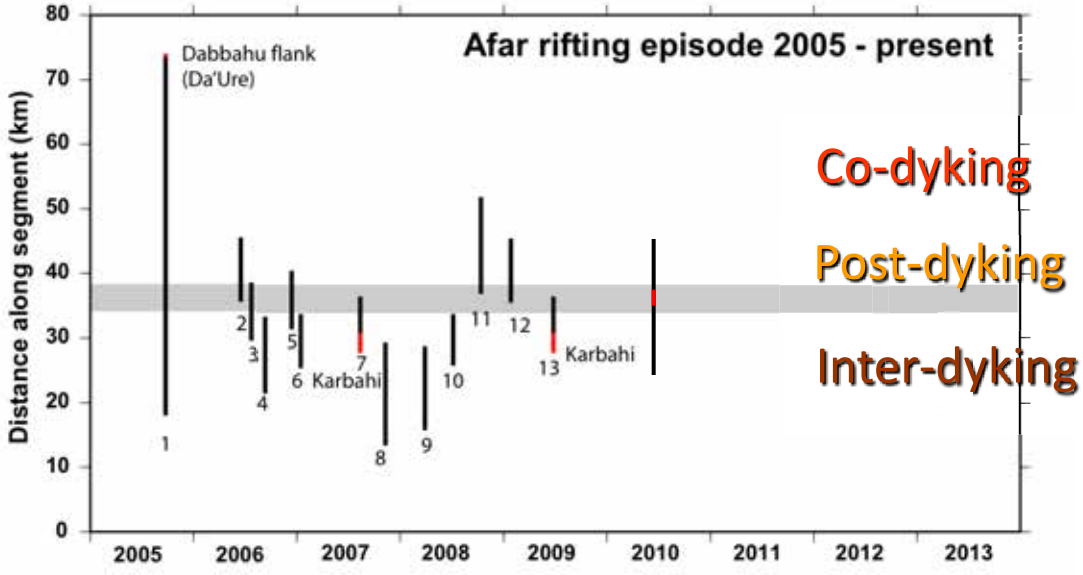
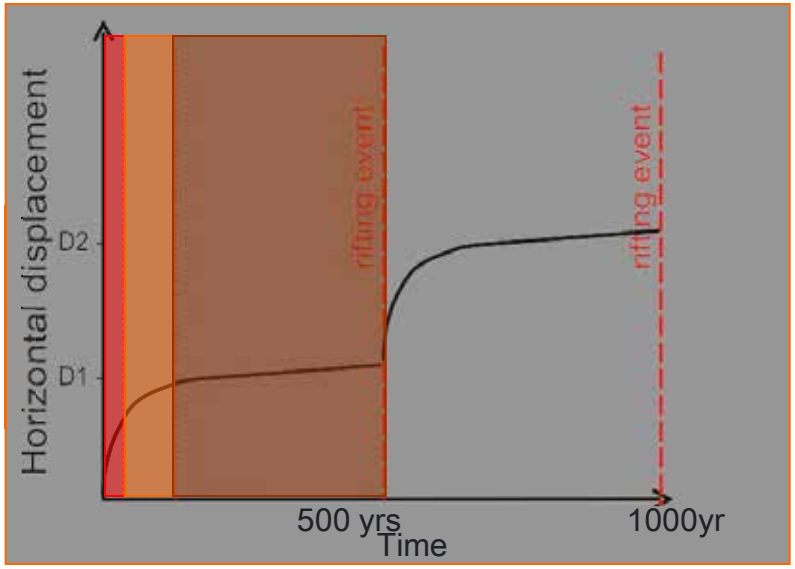


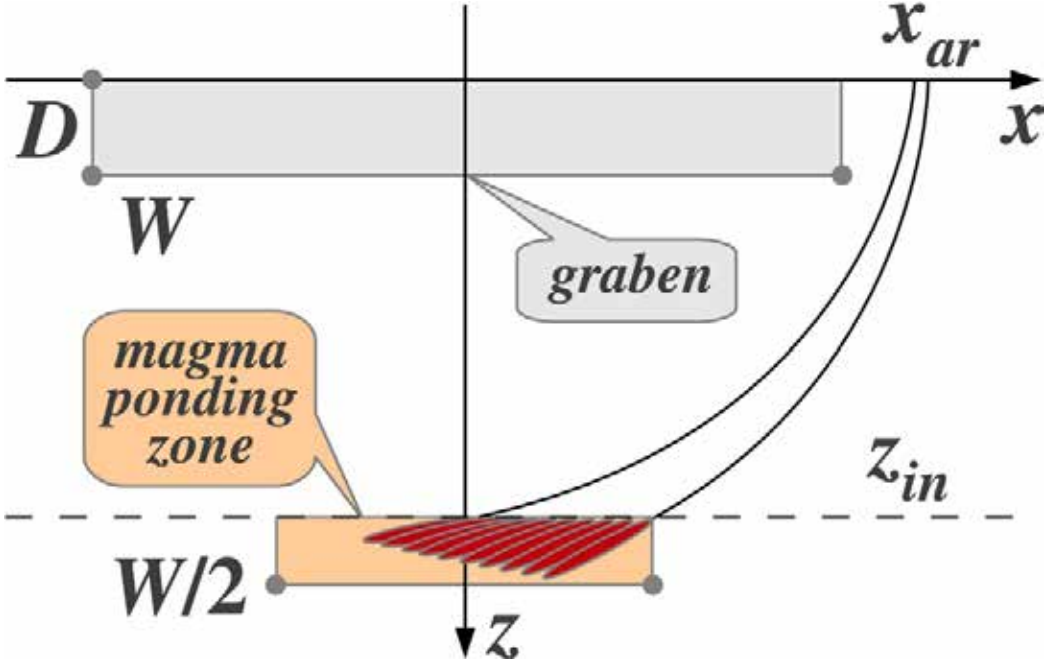




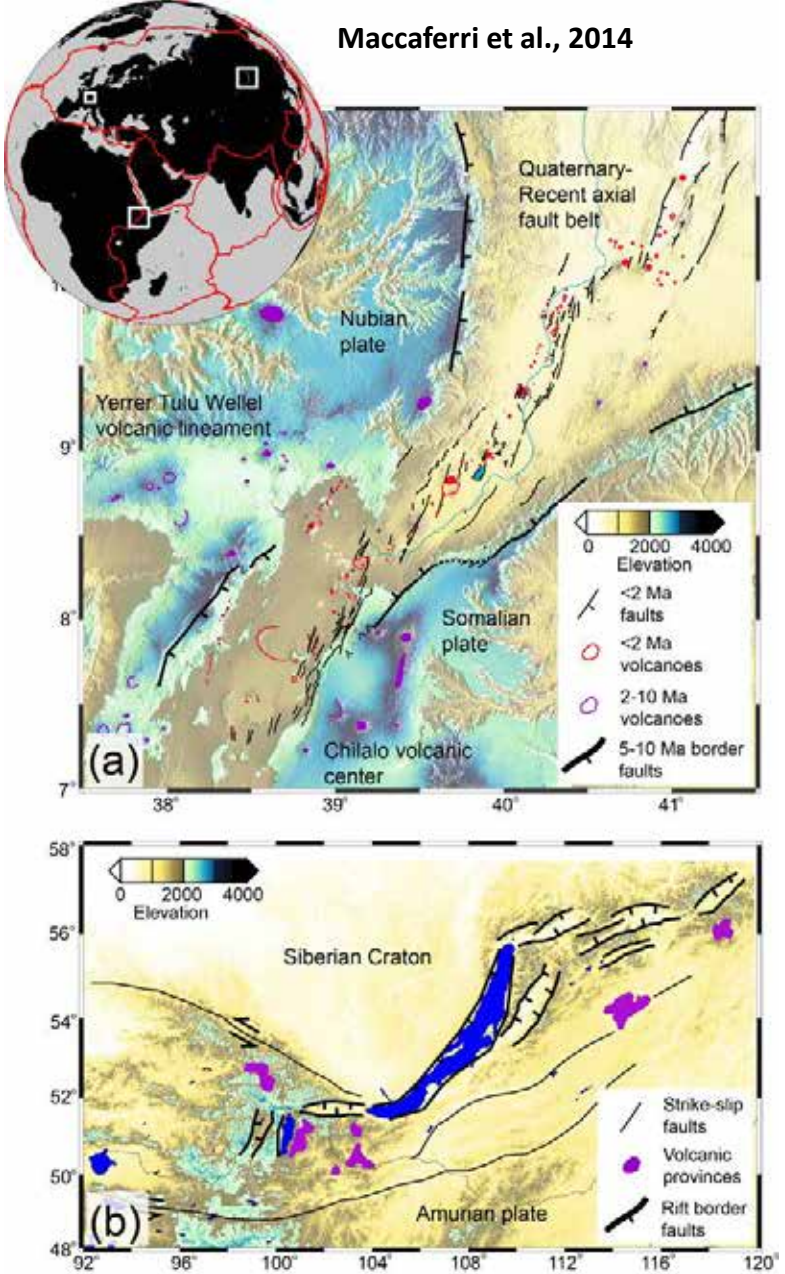
Hamling et al., 2009, GJI

Pagli et al., 2015, Geosphere

Rift flank volcanism



Maccaferri et al., 2014



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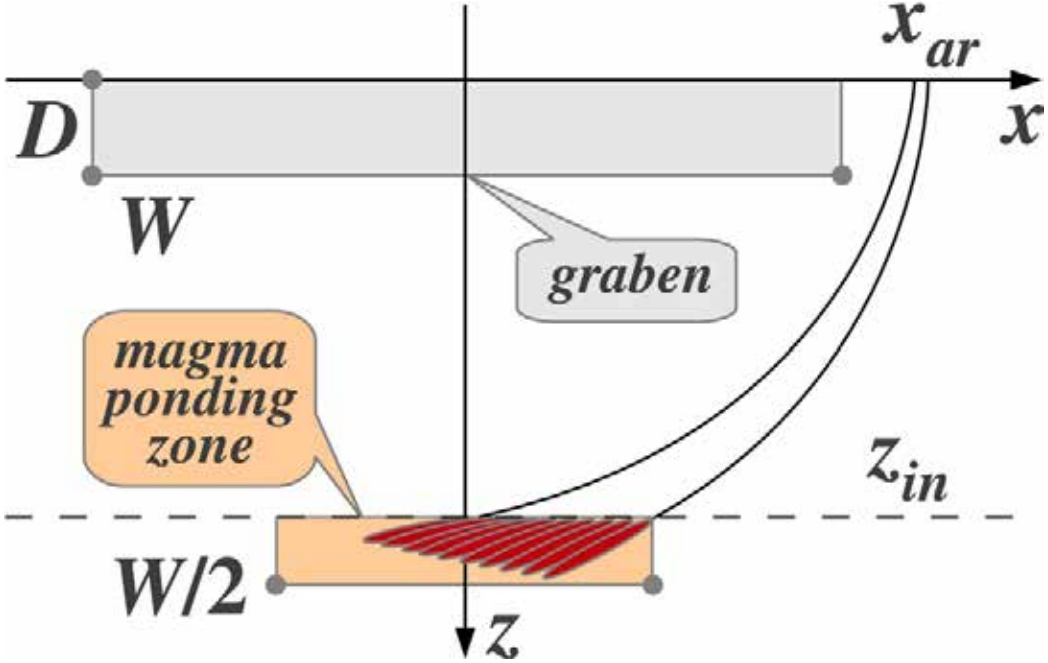
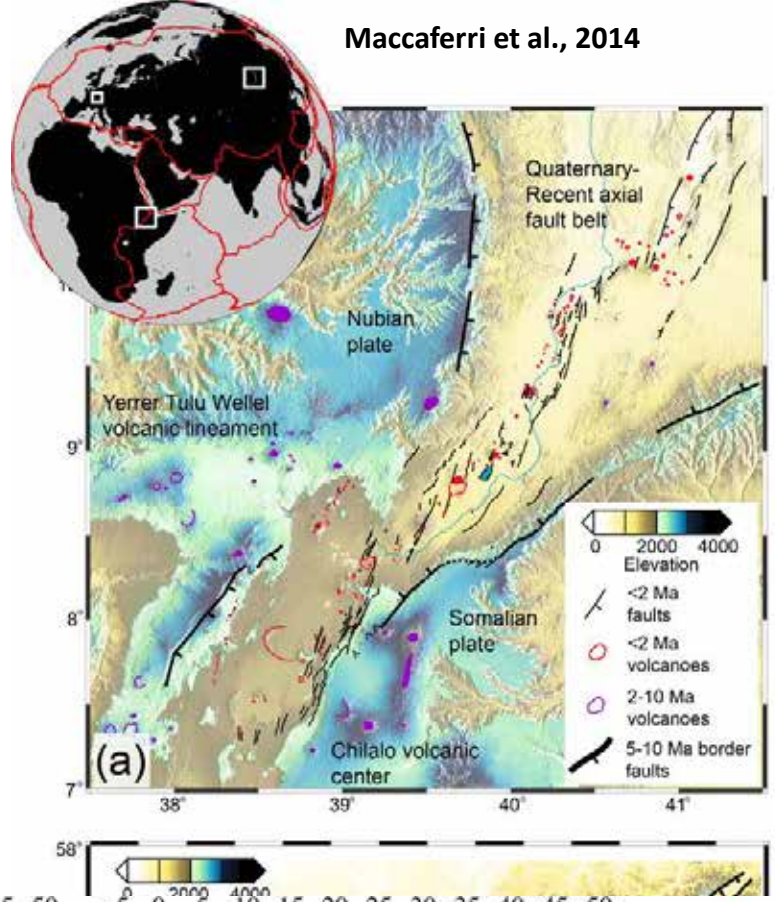
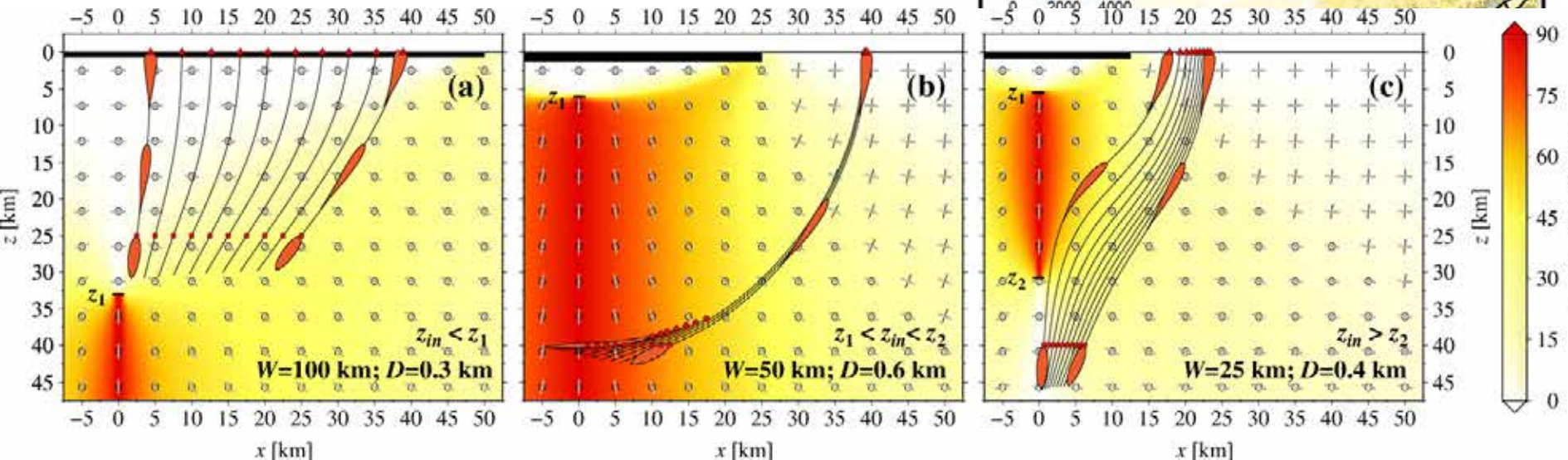
Maccaferri et al., 2014







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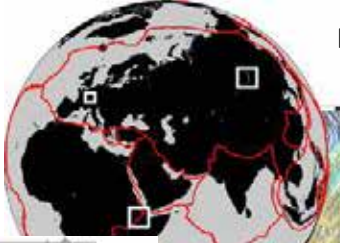

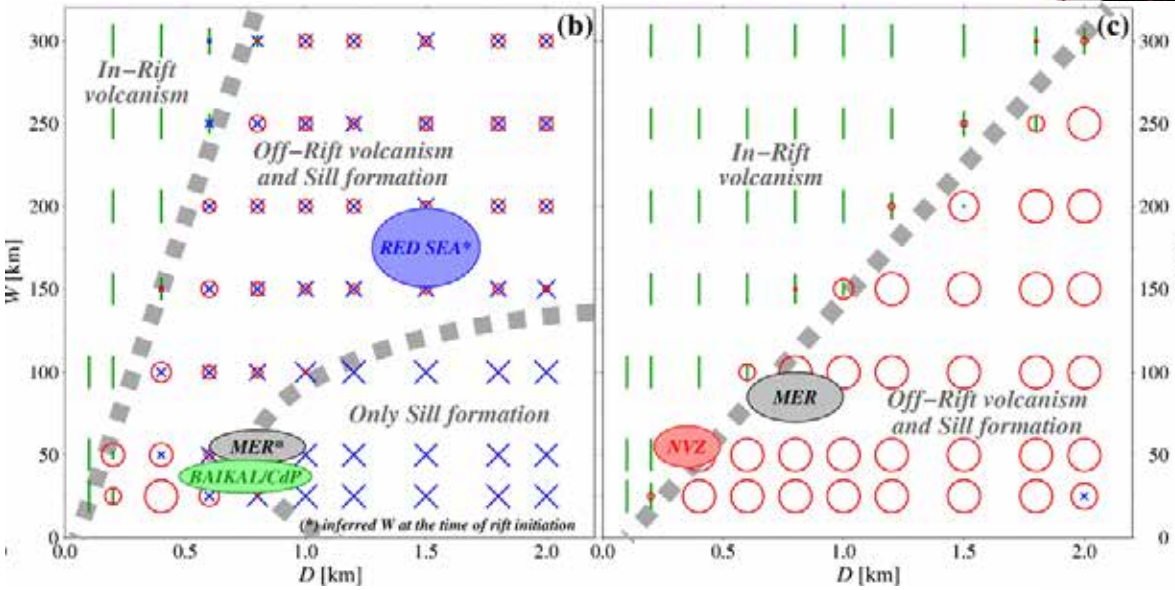

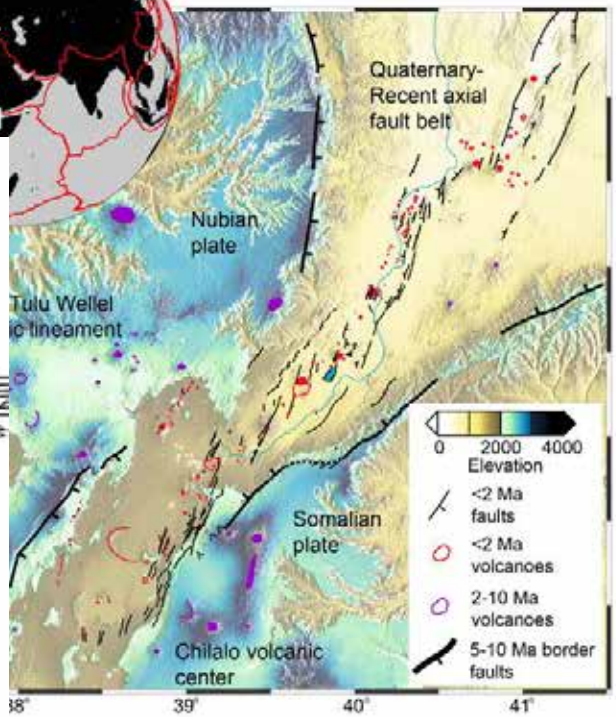

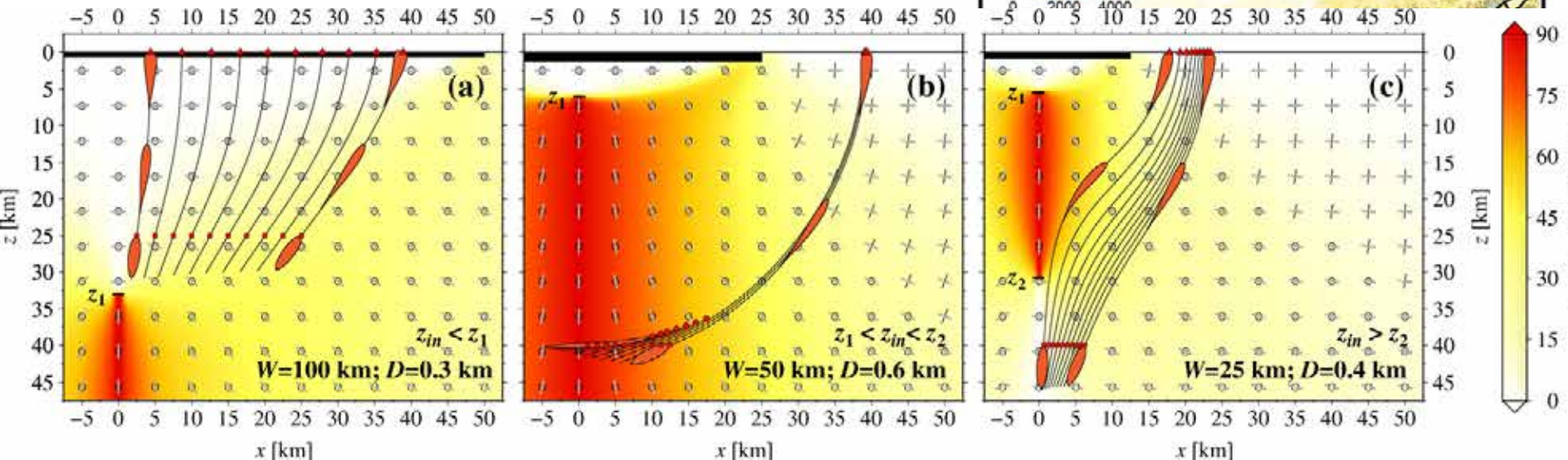

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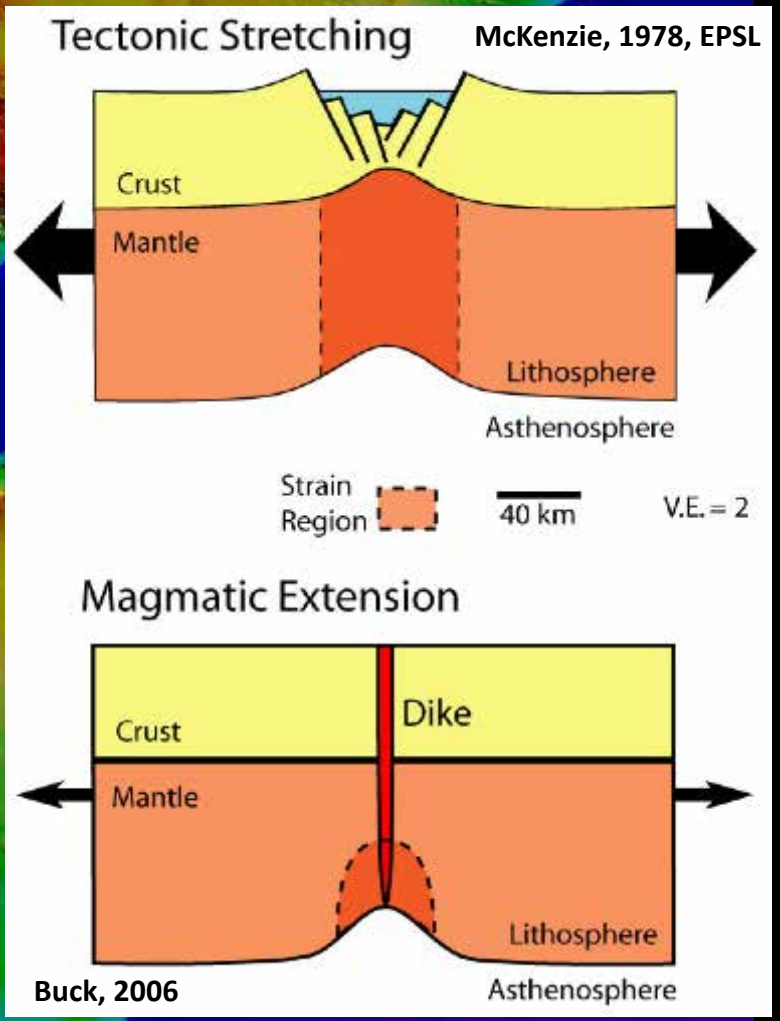
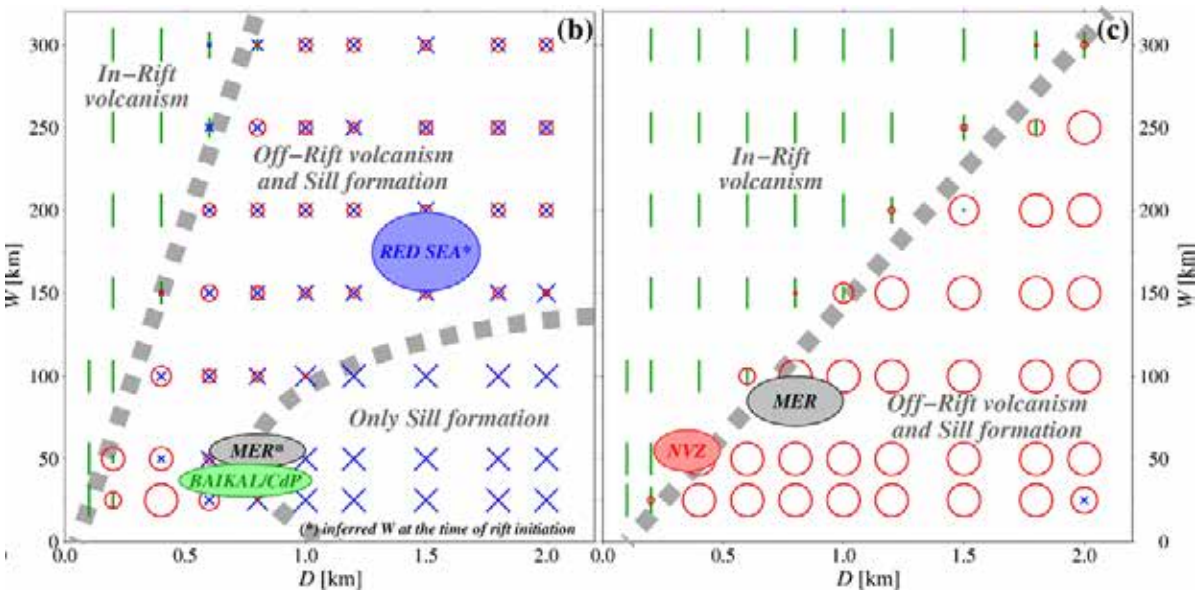


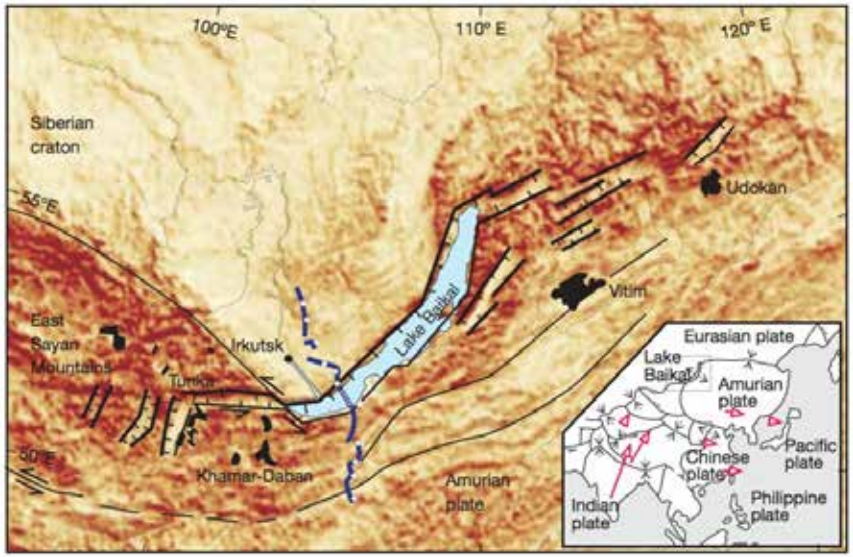
100 km

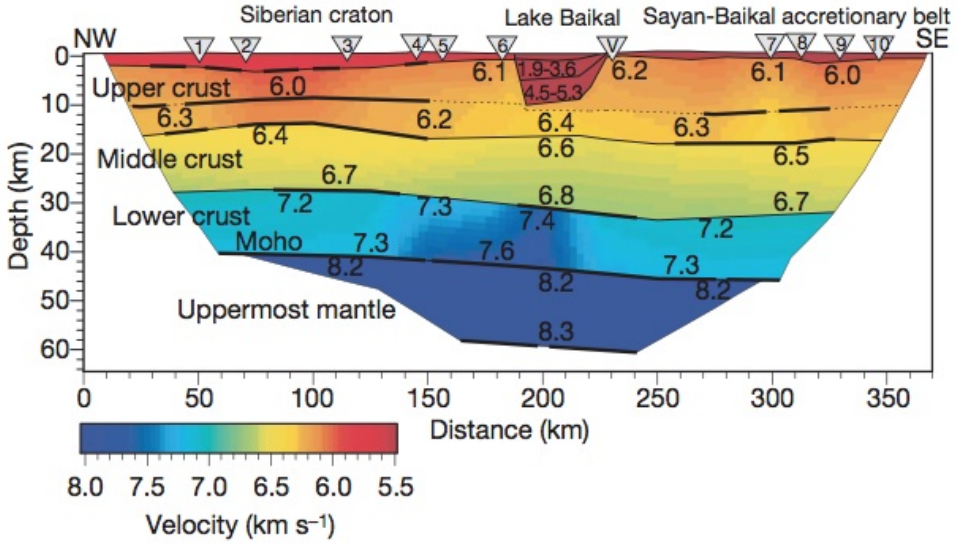
Rift flank volcanism & intrusion



Thybo and Nielsson, 2009, Nature

Maccaferri et al., 2014, Nature Geoscience





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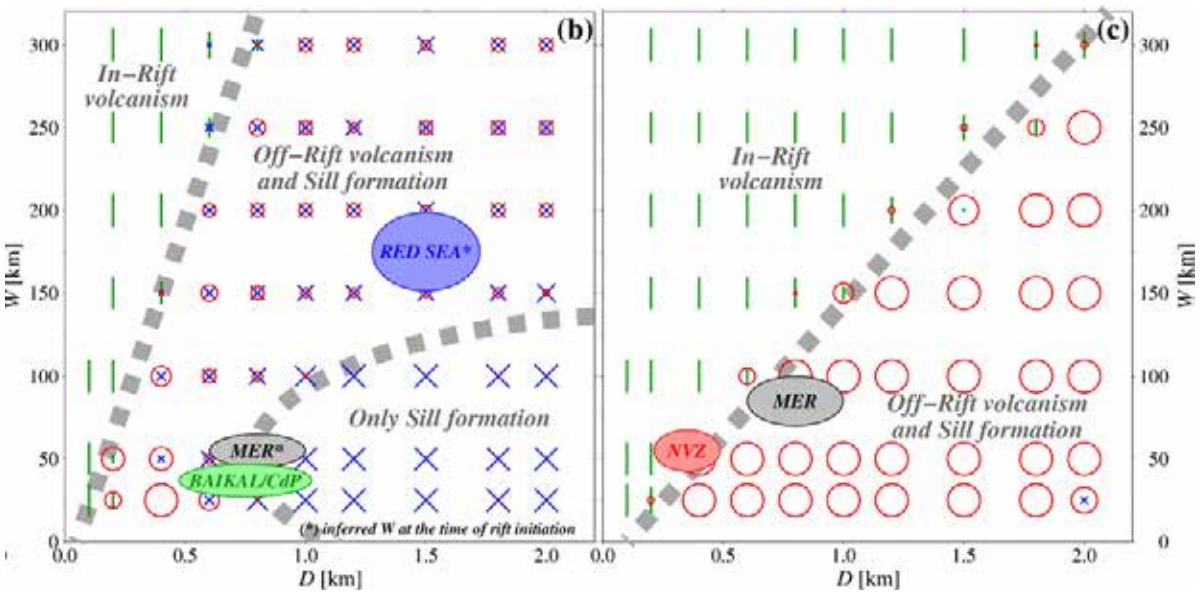
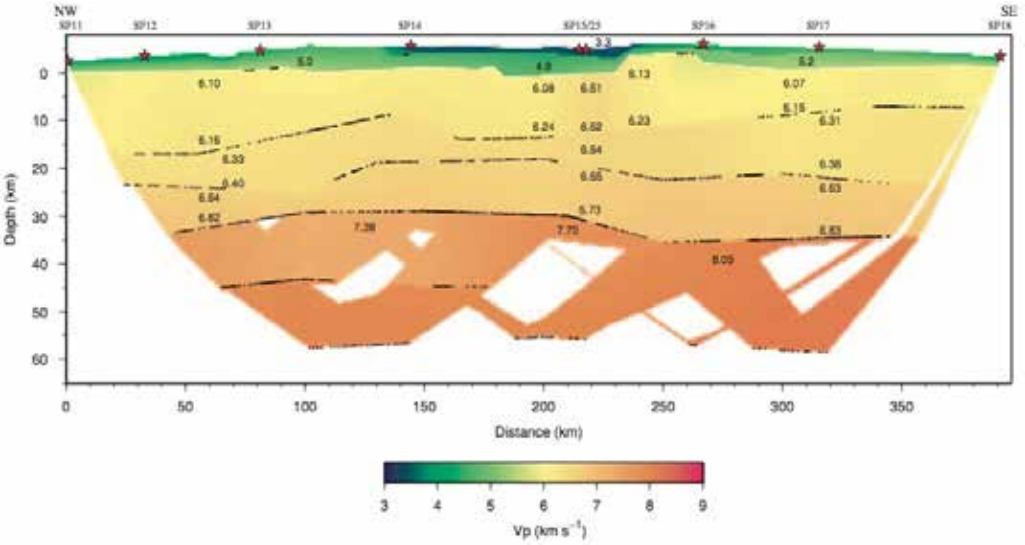
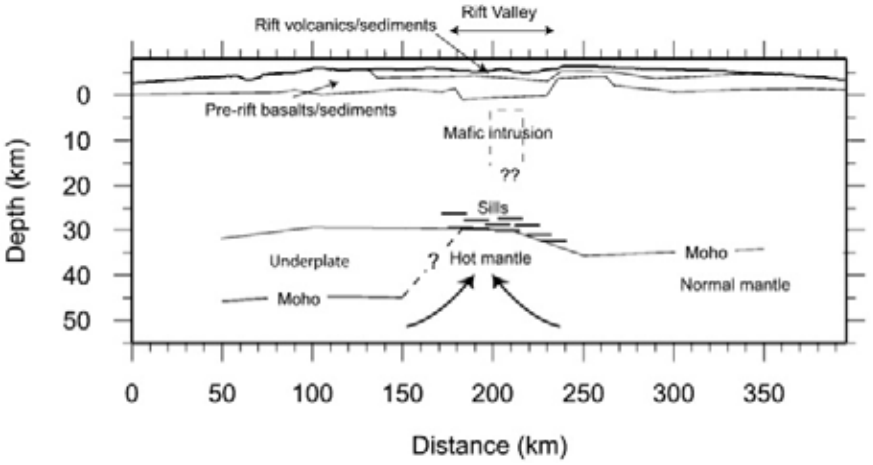


Mackenzie et al., 2005, GJI

Maccaferri et al., 2014, Nature Geoscience





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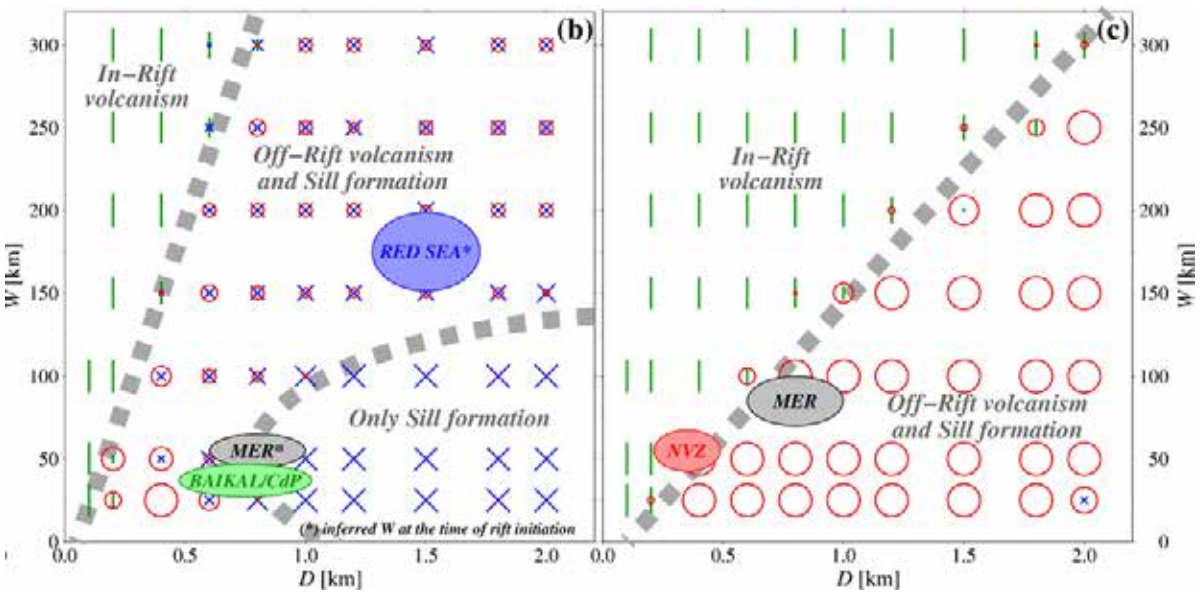
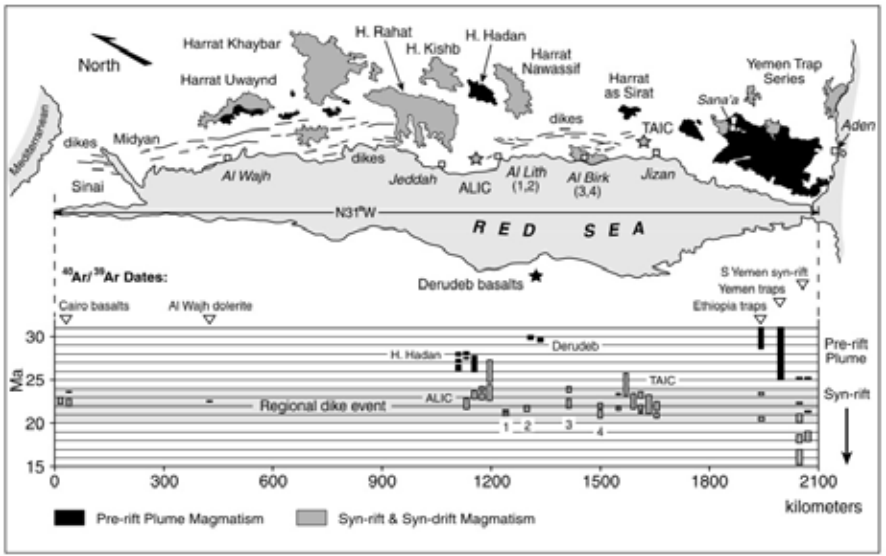


Bosworth et al., 2006, J. Afr. Earth Sci.

Maccaferri et al., 2014, Nature Geoscience



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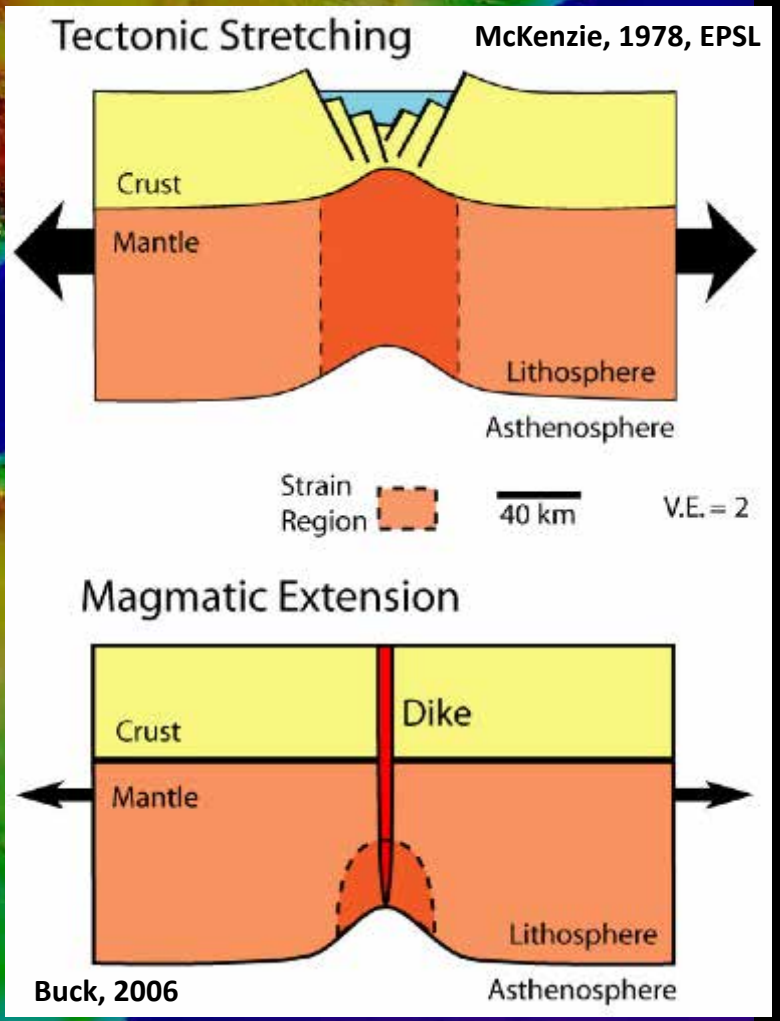

100 km

Shear driven melt segregation near the LAB

Holtzman and Kendall, 2011, G-Cubed

Kendall et al., 2005, Nature