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Applying marine geophysics to the East Africa Rift System: a possible strategy for investigating the Western Rift?

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Applying marine geophysics to the East Africa Rift System: a possible strategy for investigating the Western Rift?

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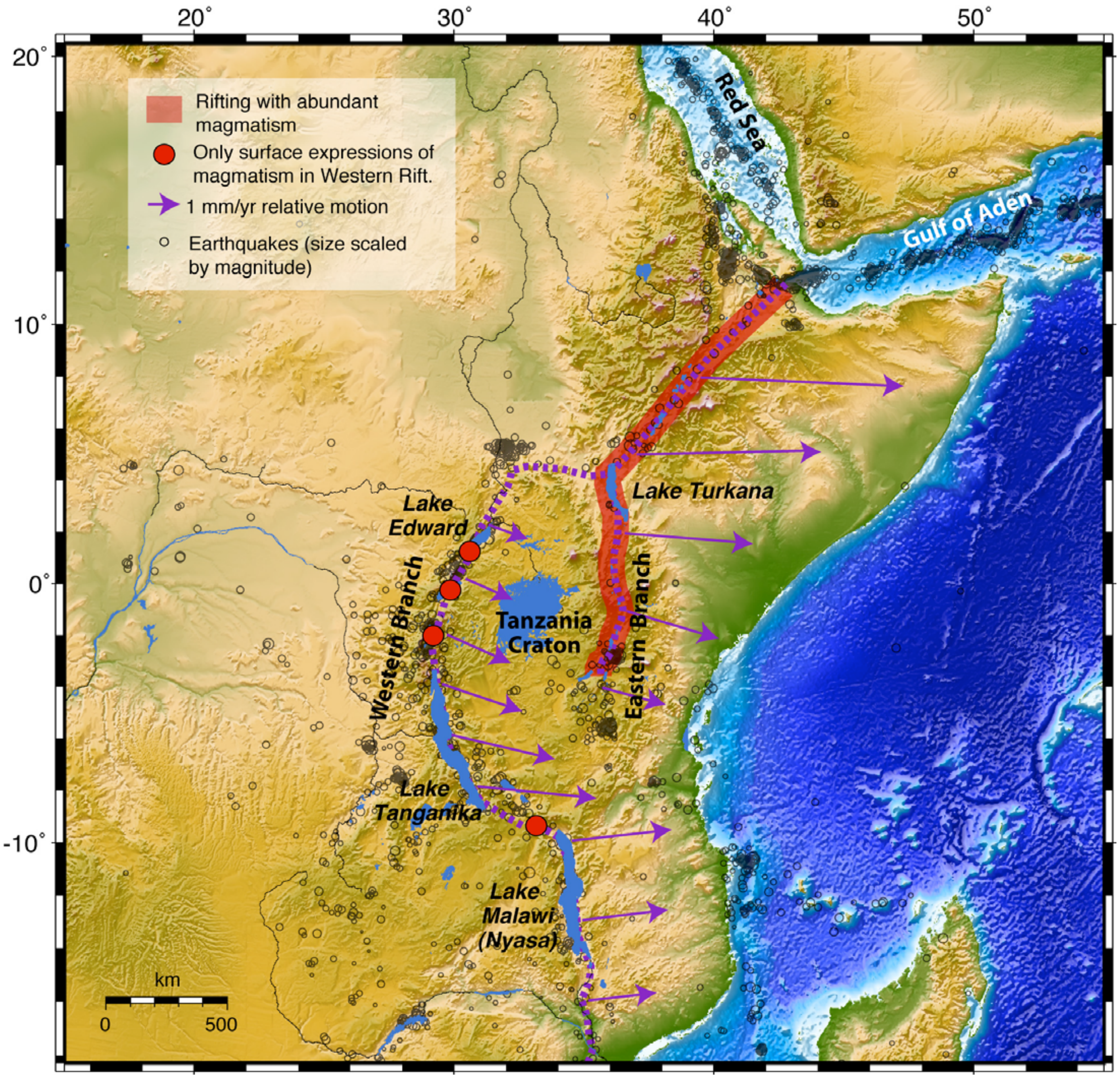
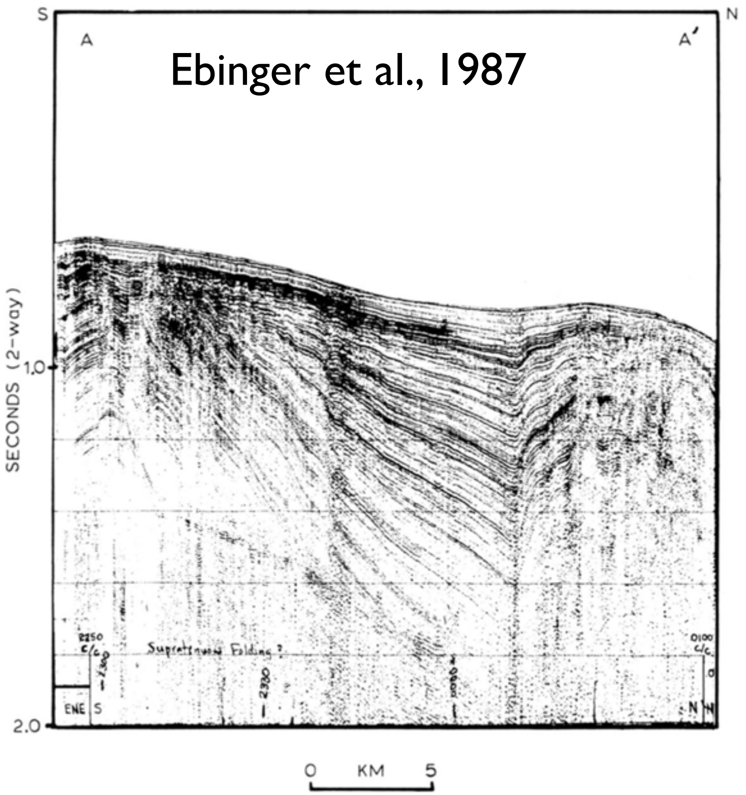
James B. Gaherty, Scott L. Nooner, Cynthia J. Ebinger, Andrew A. Nyblade, Christopher A. Scholz, Cornelia Class, Matthew E. Pritchard



Furman, 2007

Stamps et al., 2008

Pioneering work acquiring seismic reflection data in the lake during the PROBE project



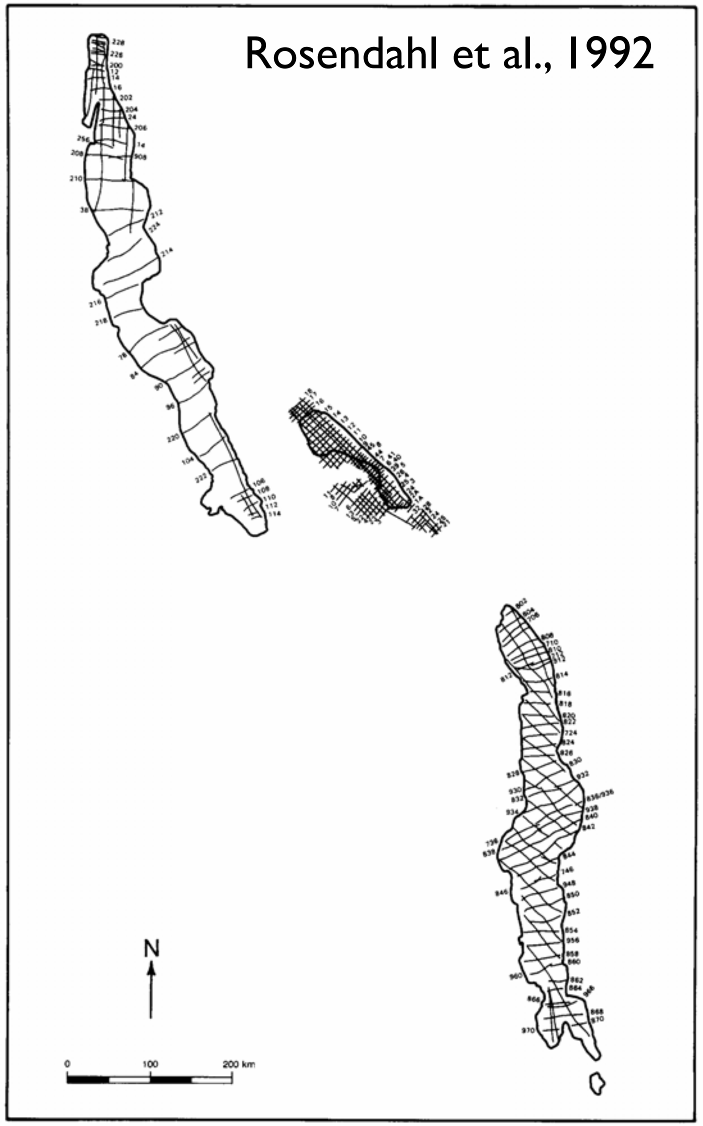
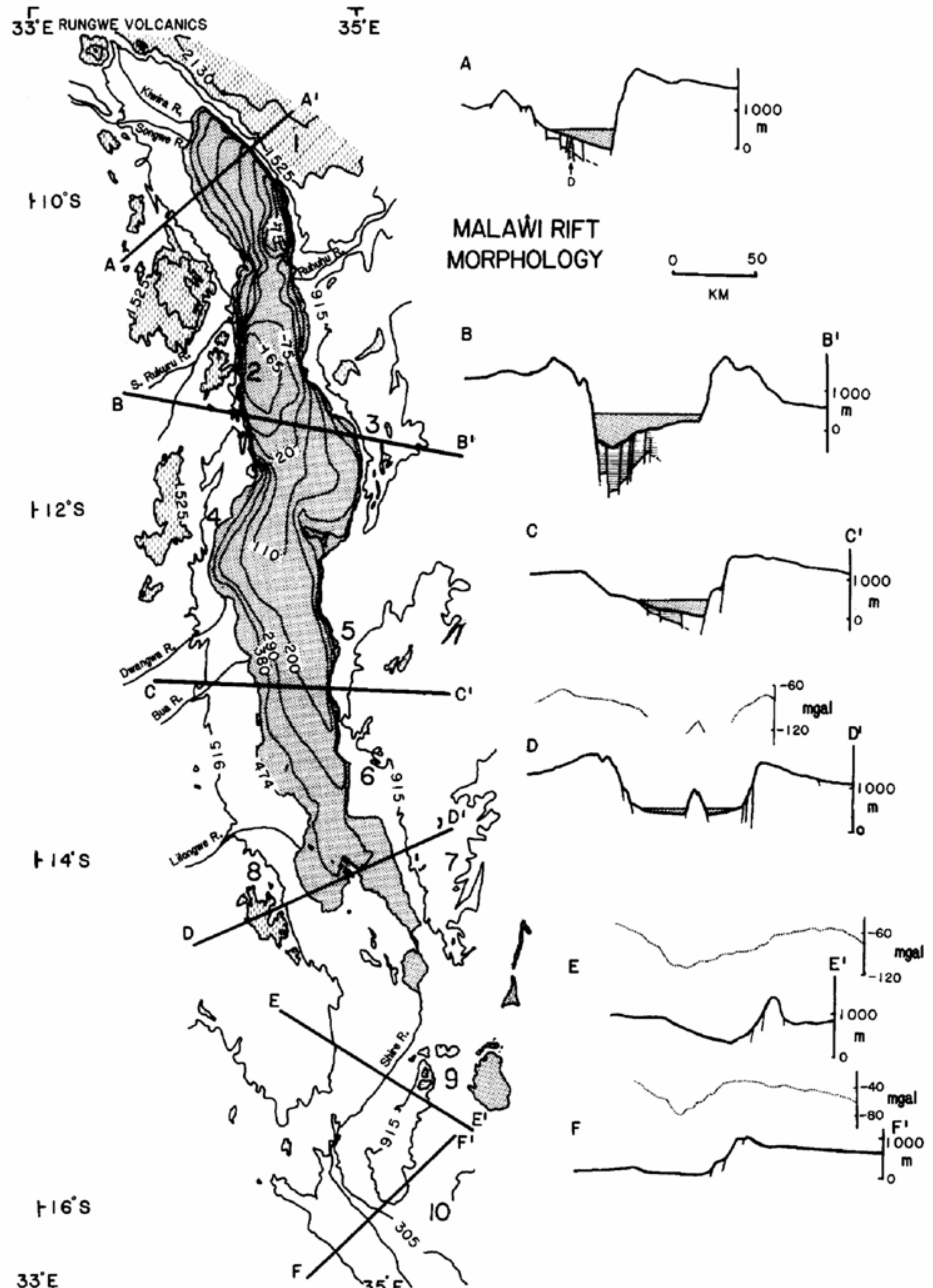
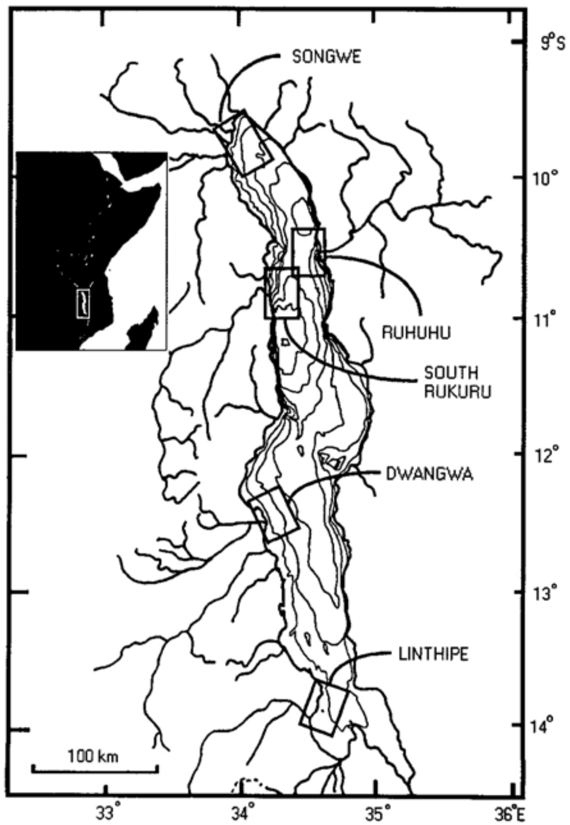


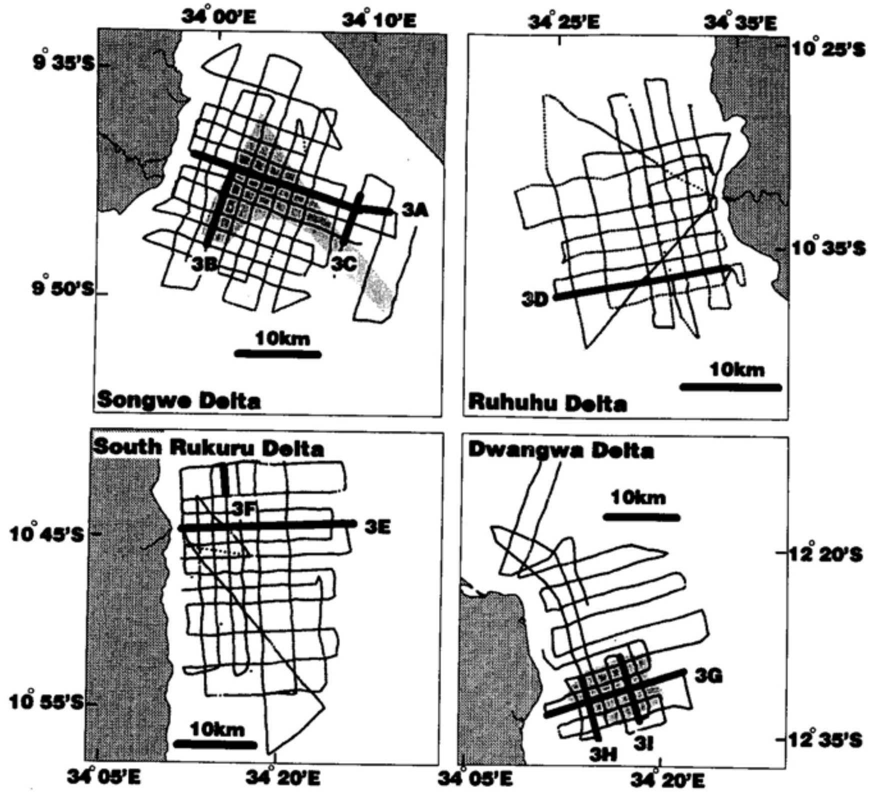
Fig. 2. Map portfolio of the Tanganyika, Rukwa and Malawi Rift Zones. (A) Multifold seismic reflection coverage used in analysis. Lines with numbers refer to line drawings shown in Fig. 3. (B) Permo-Triassic, Cretaceous and Cenozoic sedimentary cover associated with known rift basins. (C) Structure map on acoustic basement. Compiled from Rosendahl (1987), Sholz and Rosendahl (1988), Versfelt and Rosendahl (1989) and Scott et al. (in press). (D) Possible pull-apart geometry linking Kalemie, Rukwa and Livingstone Basins.



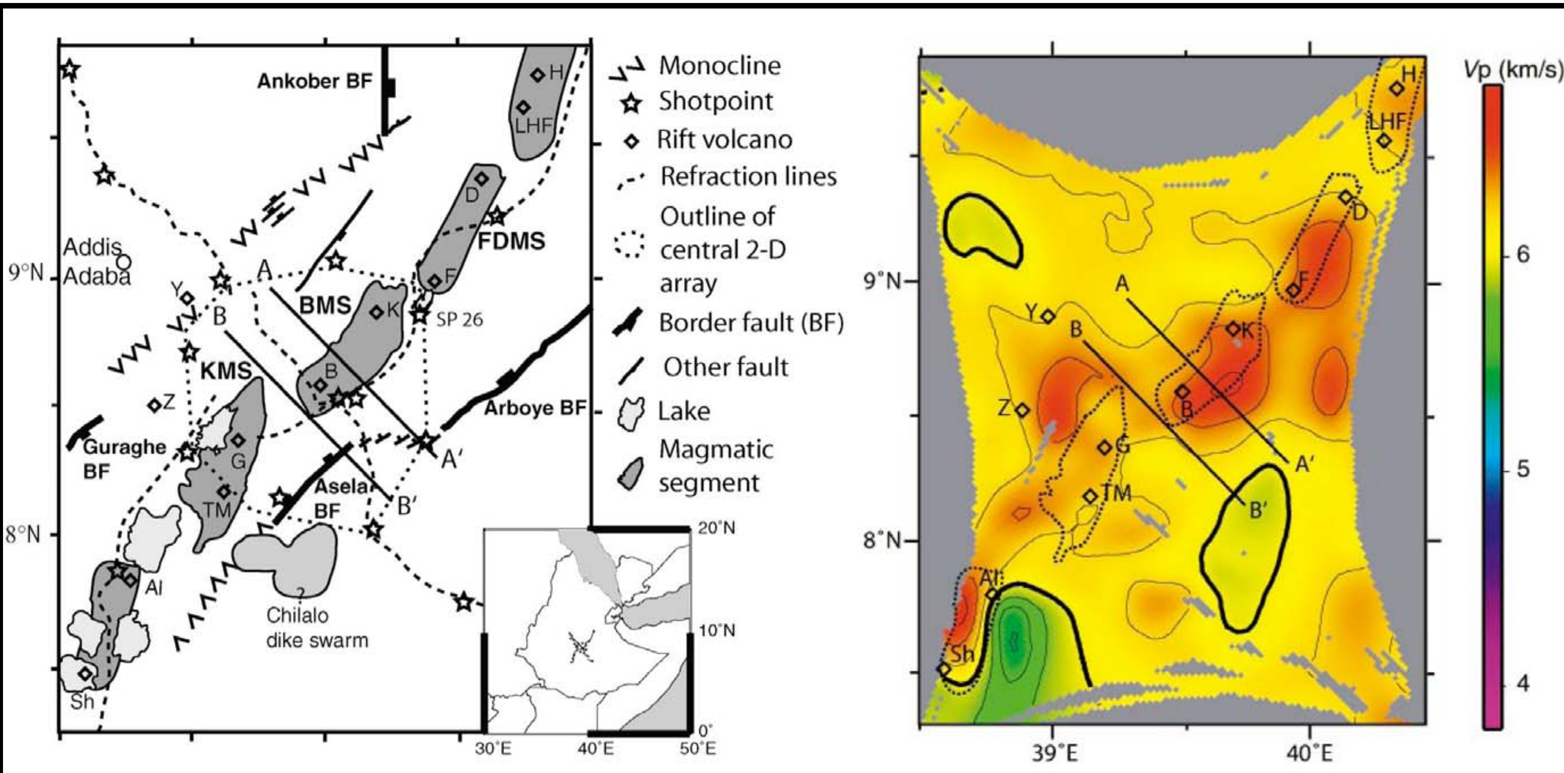
Ebinger et al., 1987

High-resolution seismic reflection data acquired in selected regions

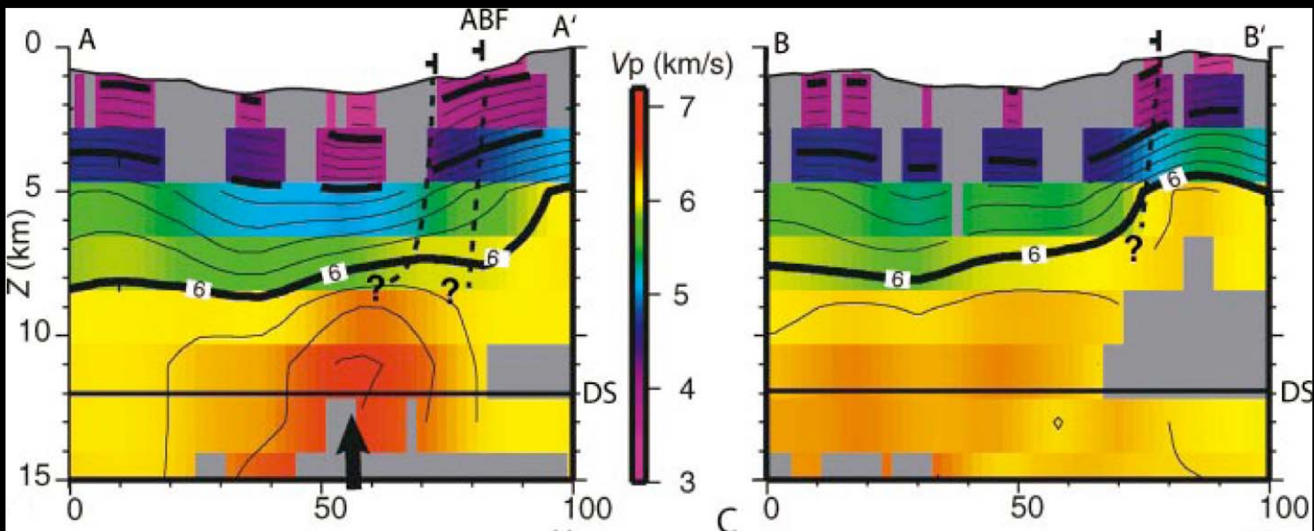




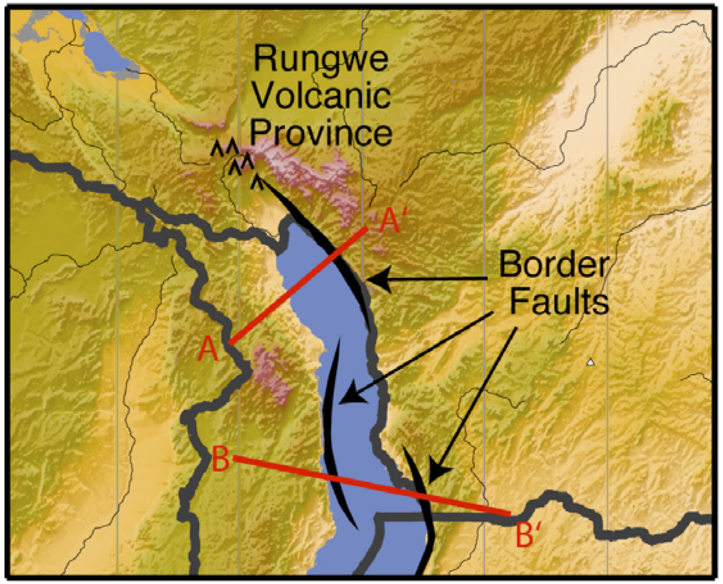
Scholz et al., 1993

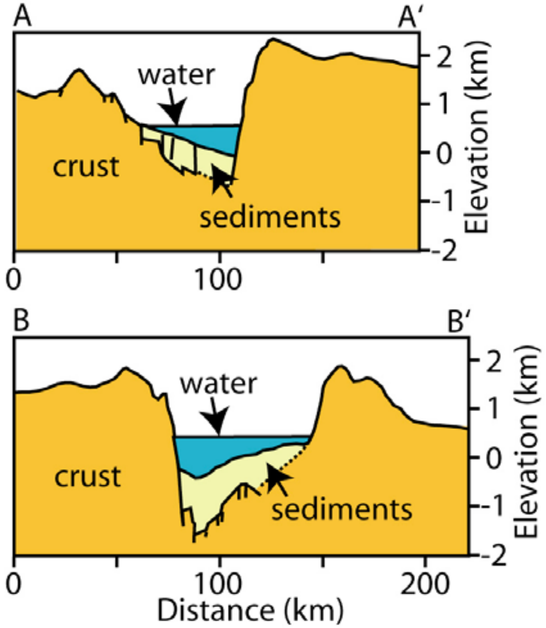


Keranen et al., *Geology*, 2004



Some questions about Western Rift …





Modifed from Ebinger et al., 1987

- What is the subsurface distribution of magma in the mantle lithosphere, crust and sediments?
- How does magmatism relate to tectonic segmentation?
- What is the deep geometry of border faults and how do they relate to deep earthquakes?
- What is the nature of the lower crust and how is it related to deep earthquakes?
- Which faults are active and is there venting in the lake?

What can marine geophysics tell us about rifting and associated geohazards?

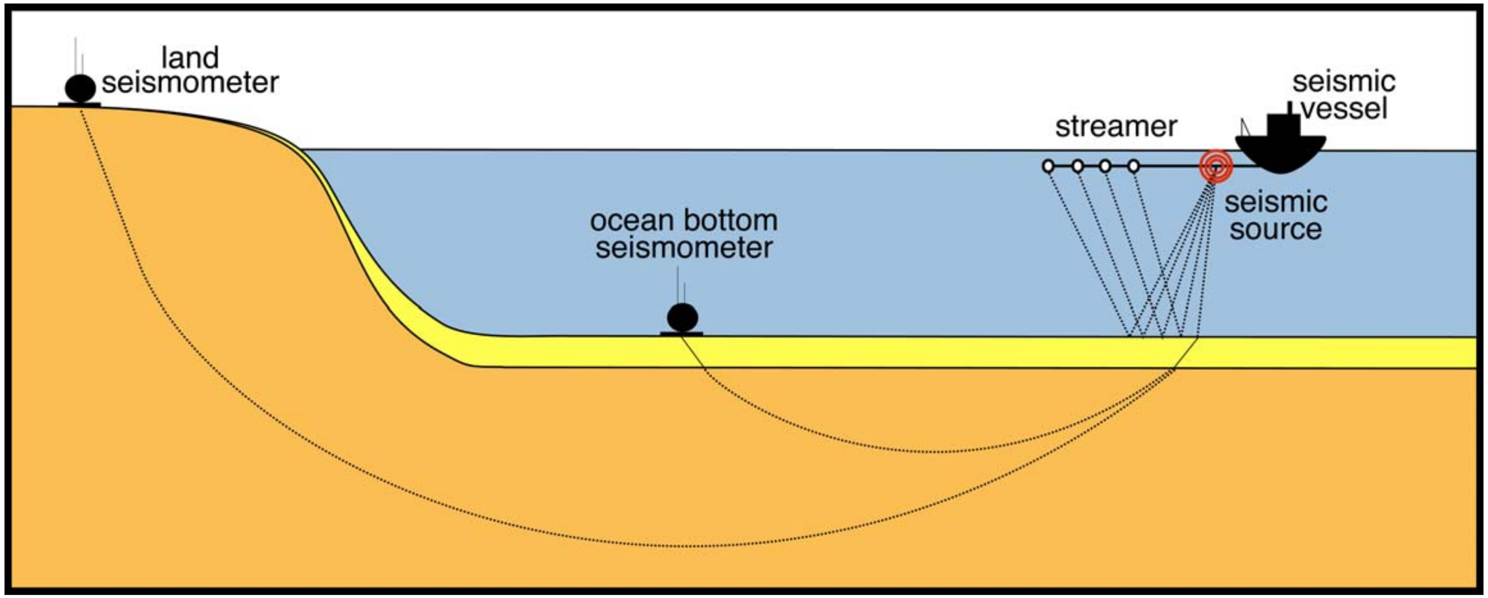
- Onshore-offshore seismic refraction data: crustal thinning, constraints on lower crust, and magmatic intrusion (example: Black Sea)
- Deep-penetration multi-channel seismic reflection data: fault geometry, sediment thickness, and sills/dikes (example: Newfoundland margin)
- Swath bathymetry data: active faulting, 3D linkages of faults, venting (example: Hess Deep)

Marine multichannel seismic reflection and onshore/offshore seismic refraction

Some advantages…

Easier to obtain a dense dataset (shots and receivers)

Don’t have to use explosives



Acquisition: sources and receivers

Land

- Sources are normally explosives or vibroseis trucks
- Receivers may be geophones or 3-component seismometers

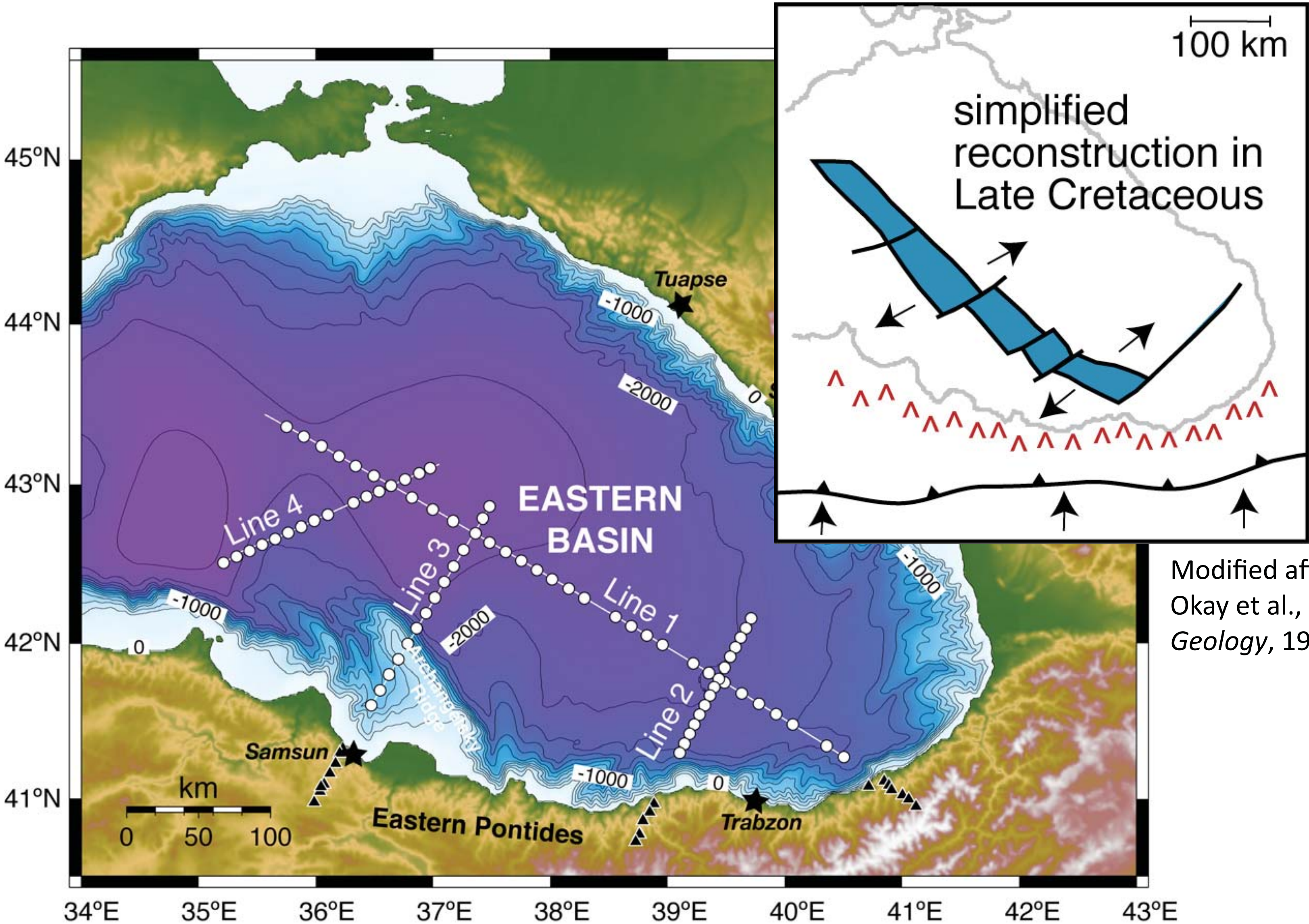
Marine

- Sources are usually airgun arrays
- Receivers are ocean bottom hydrophones or seismometers (OBH/OBS), or towed hydrophone streamers

Hybrid onshore/offshore experiments also possible

I

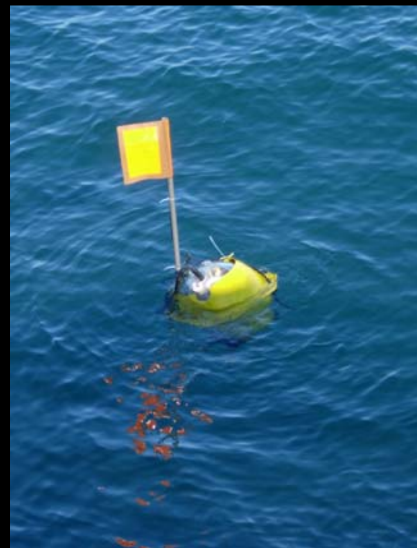
Onshore-offshore wide-angle reflection/refraction studies: an example from the Black Sea

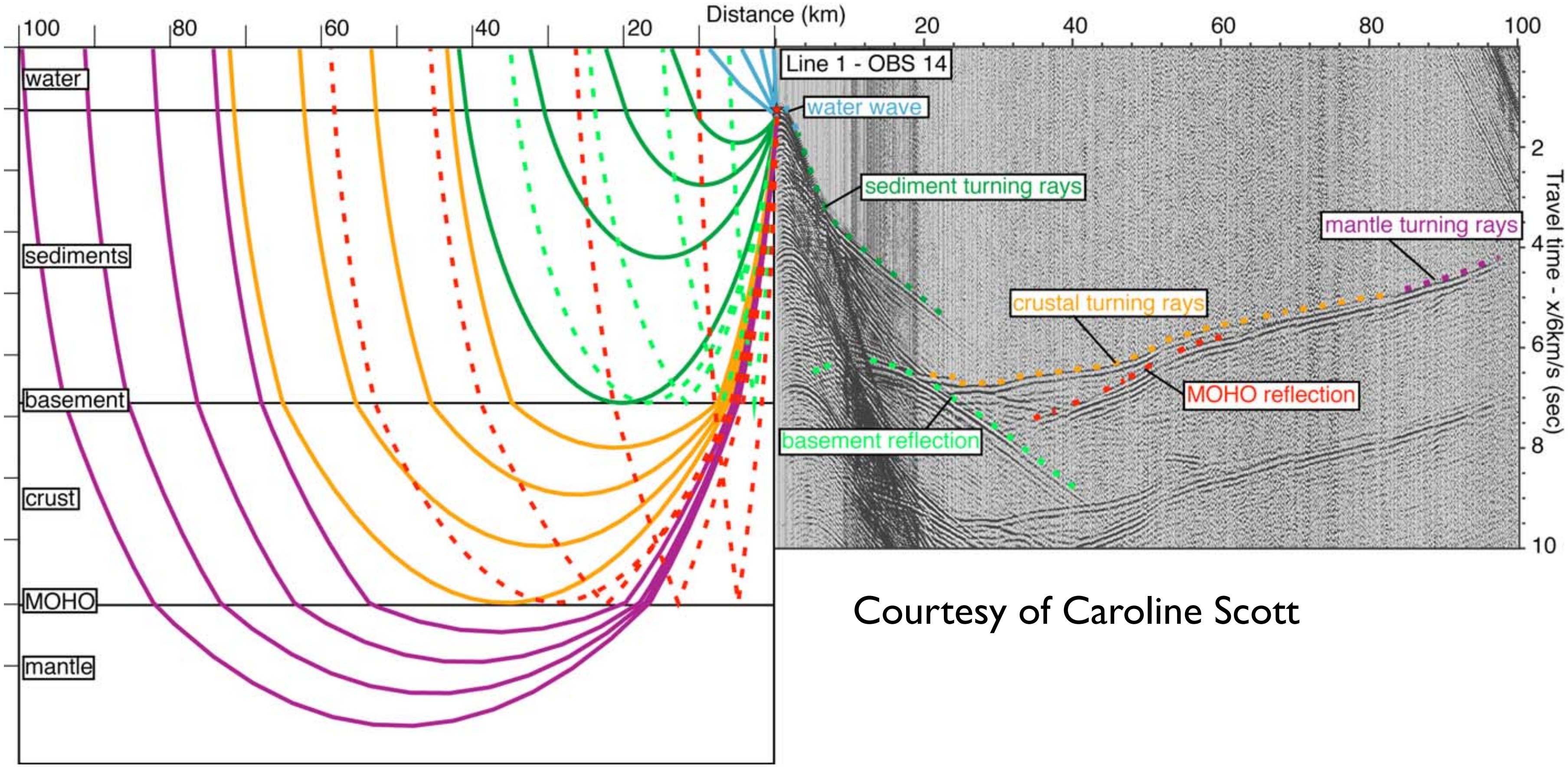


Modified after Okay et al., *Geology*, 1994

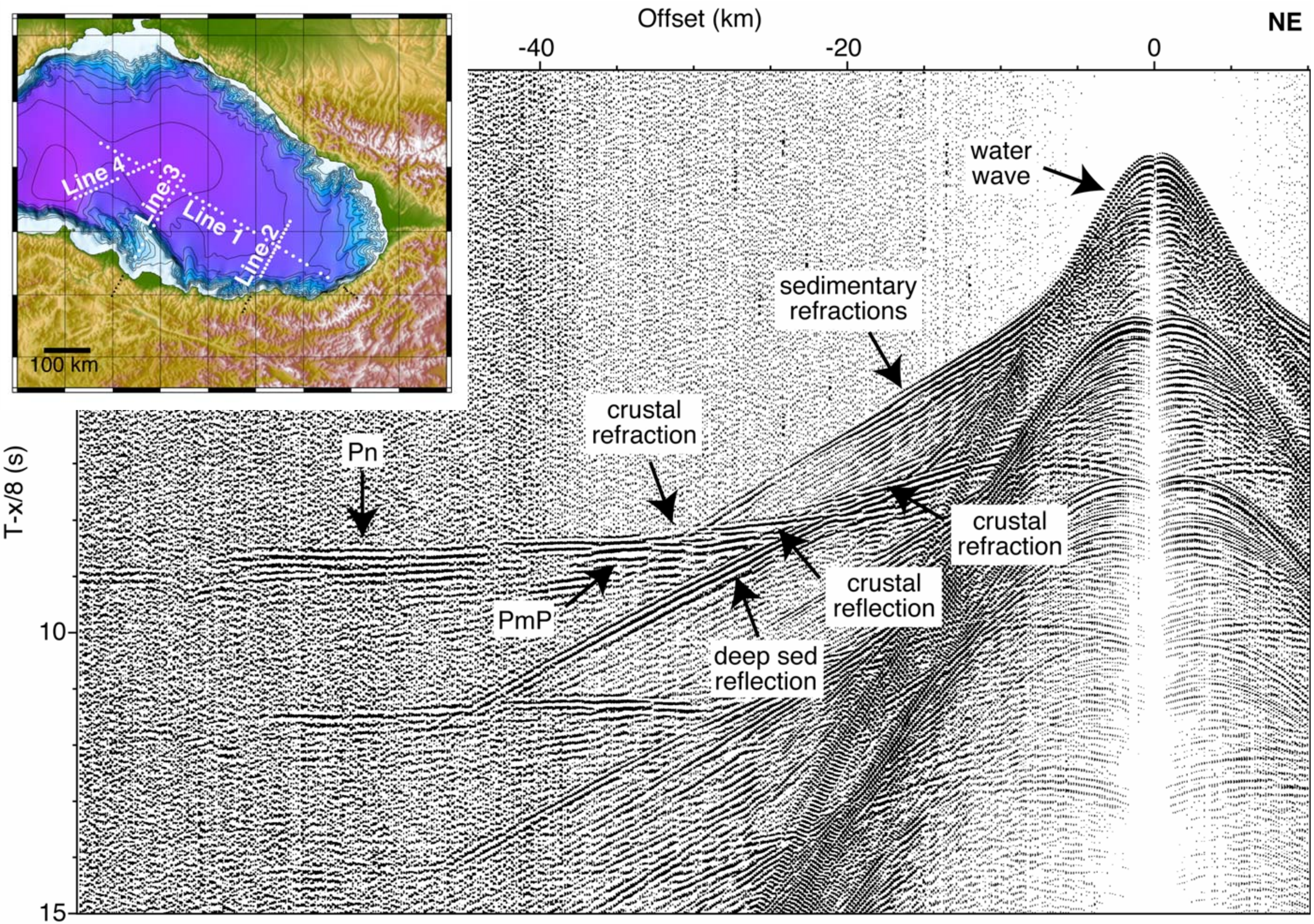
Onshore/offshore wide-angle seismic experiment: Feb-March 2005

- 9-gun, 3140 cu. in. source fired every 60-90 s
- 34 4-channel OBS deployed along 4 lines at 8-15 km spacing, recording with 4 ms sampling rate
- 12 3-channel Guralp 6TD seismometers deployed along 3 lines at 4-8 km spacing, recording with 5 ms sampling rate



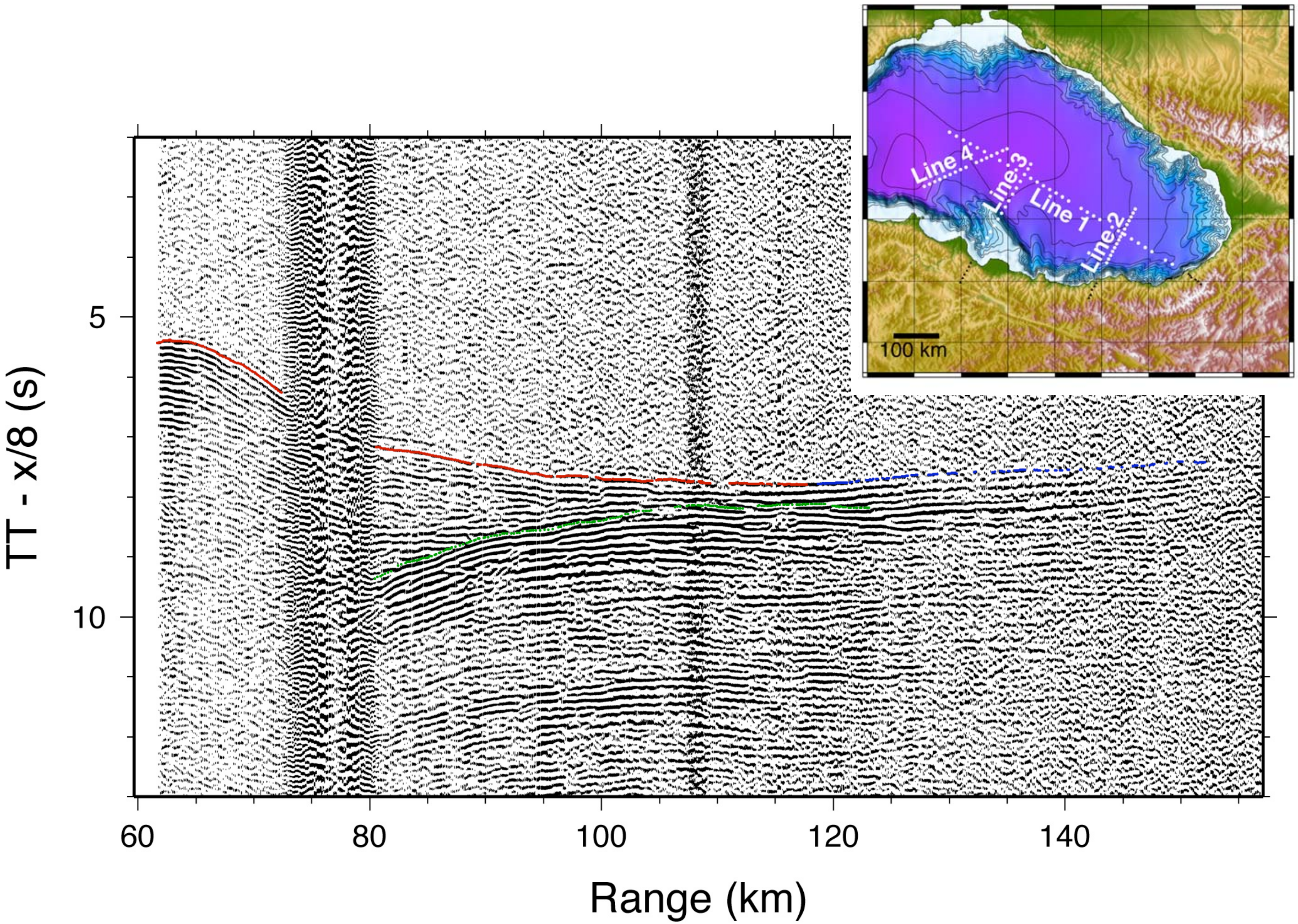


Courtesy of Caroline Scott



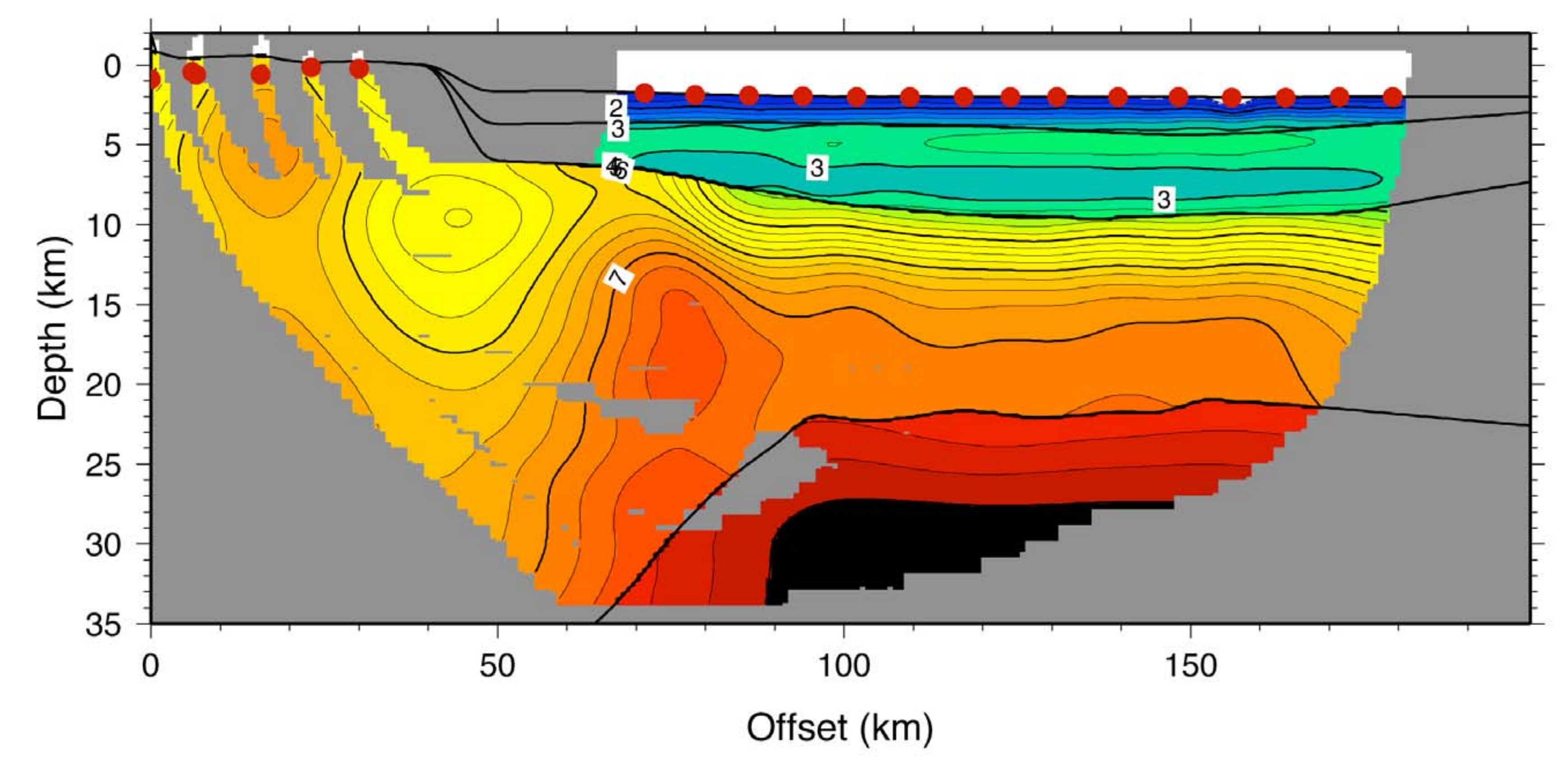
Line 4
Line 3
Line 1
Line 2
100 km
Offset (km)
NE
-40
-20
0
water wave
sedimentary refractions
crustal refraction
Pn
crustal refraction
crustal reflection
PmP
deep sed reflection
T-x/8 (s)
10
15

Line 3, OBS 2



TT - x/8 (s)
5
10
60
80
100
120
140
Range (km)
Line 4
Line 3
Line 1
Line 2
100 km

Line 2

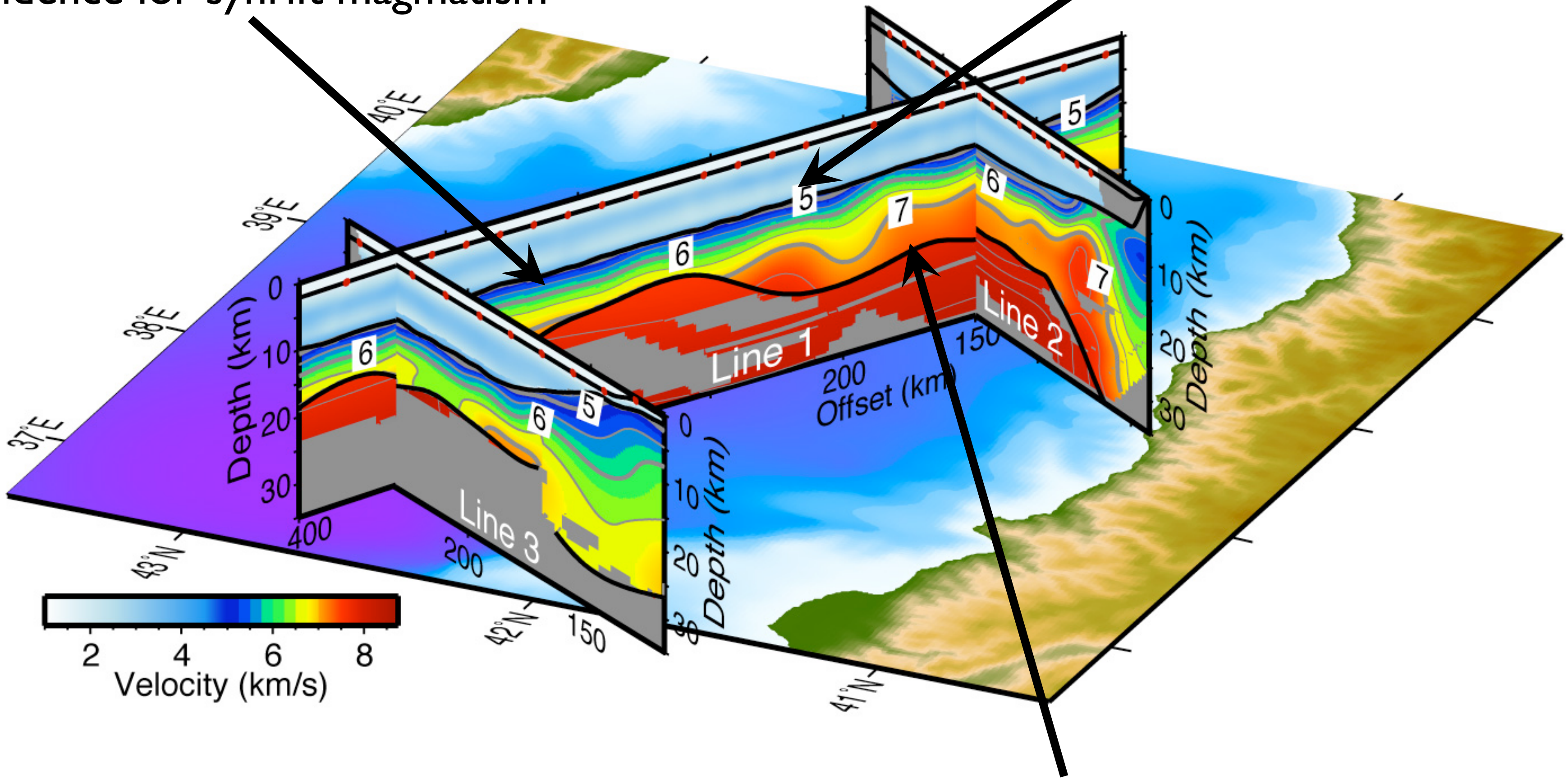


Peter Brown, MRes thesis (NOCS), 2007

Shillington et al., 2009

Thinned continental crust without evidence for synrift magmatism

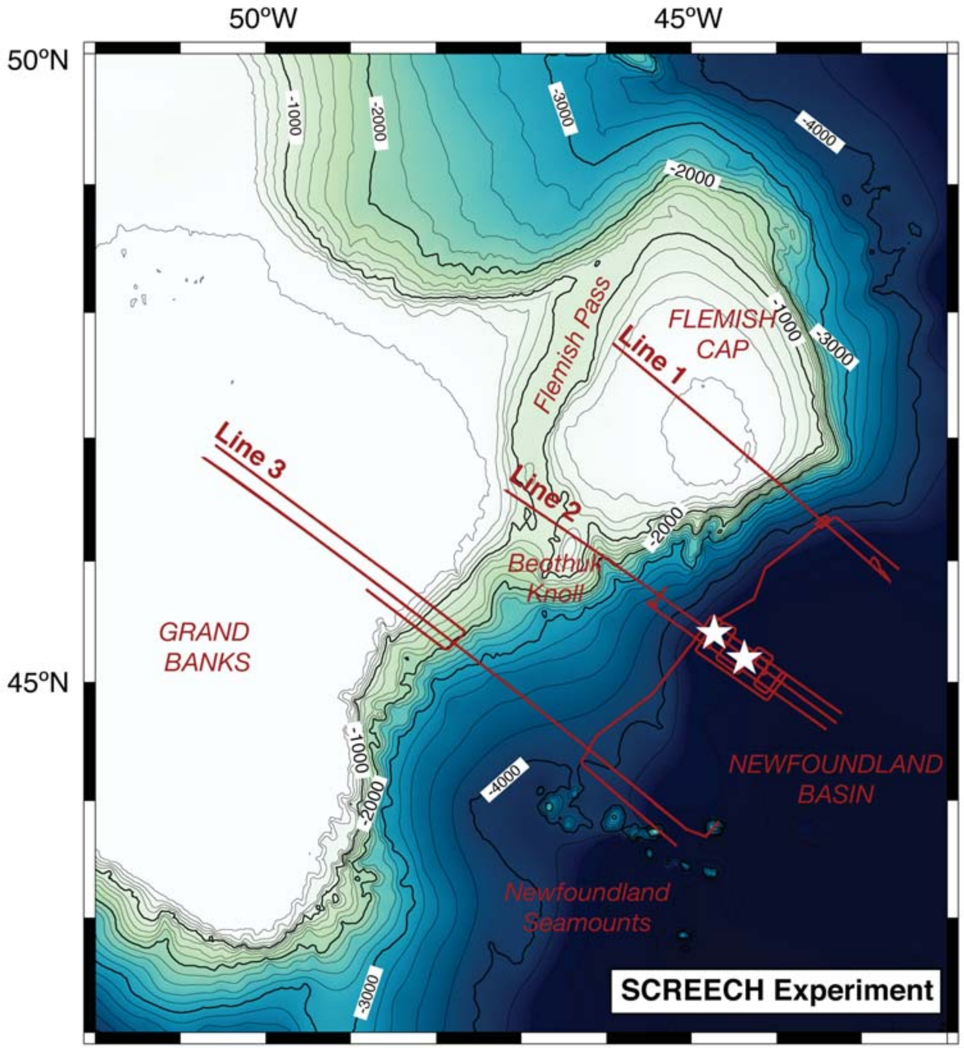
Transition between these two domains coincides with Ordu fault.

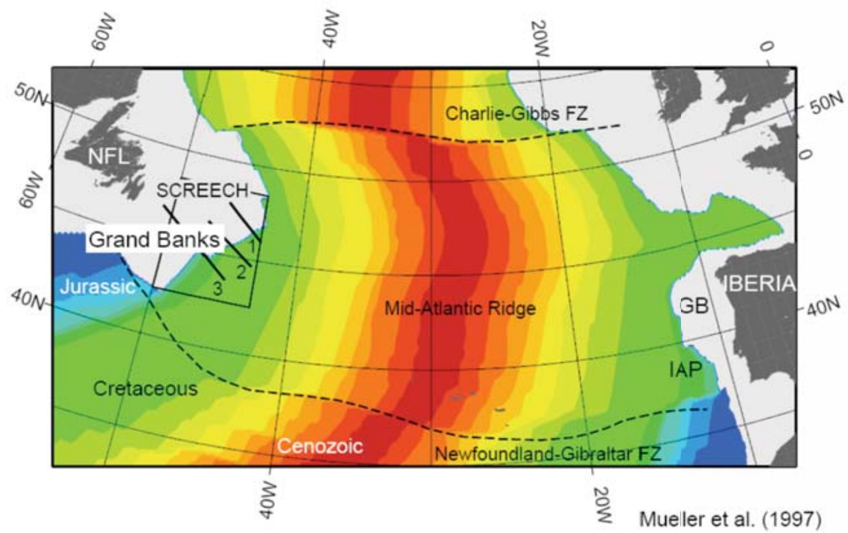


Thick oceanic crust, which indicates magmatically robust spreading.

Shillington et al., *Geology*, 2009

2 Deep penetration multi-channel seismic reflection studies: an example from the Newfoundland margin

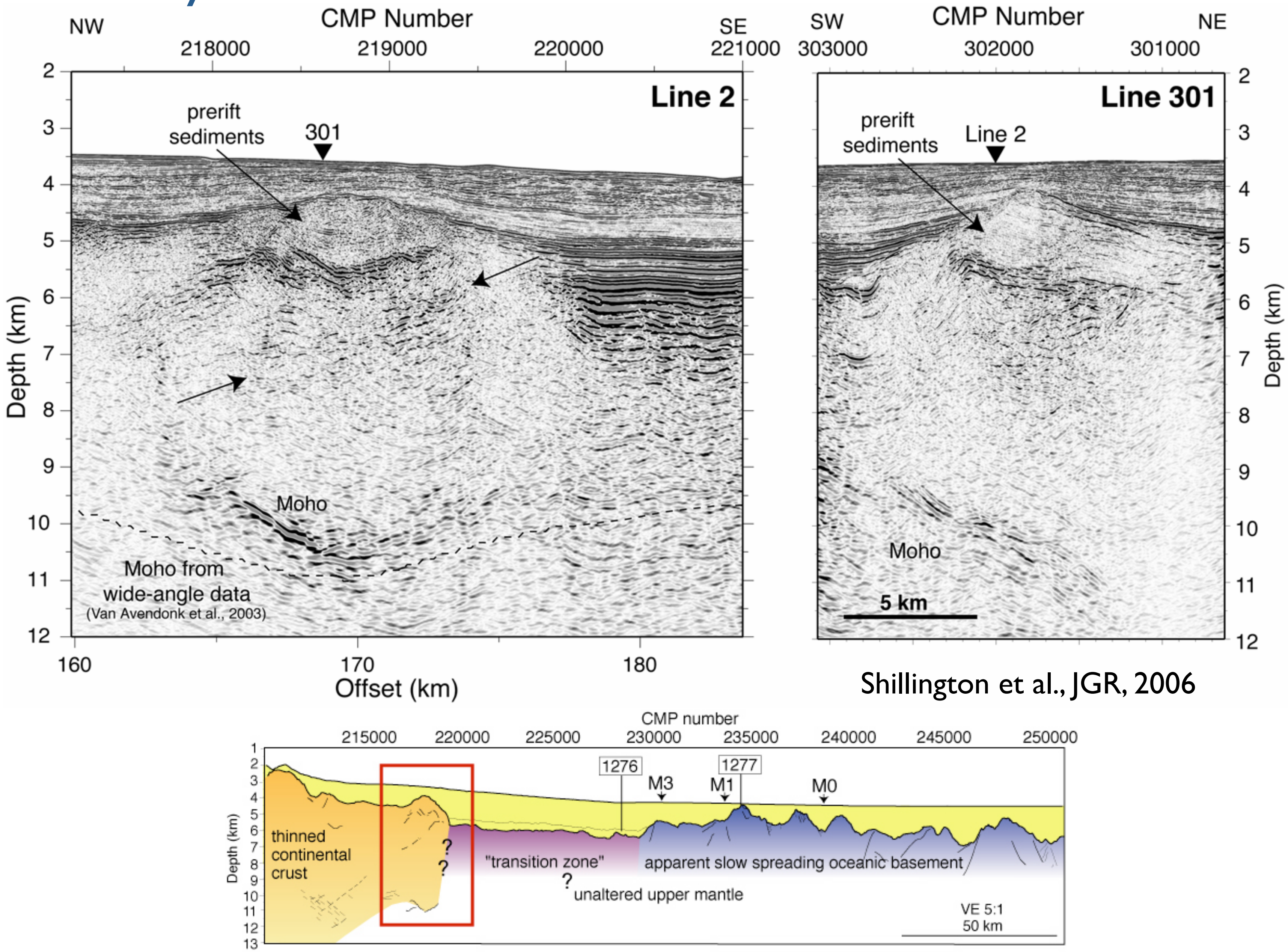




Mueller et al. (1997)

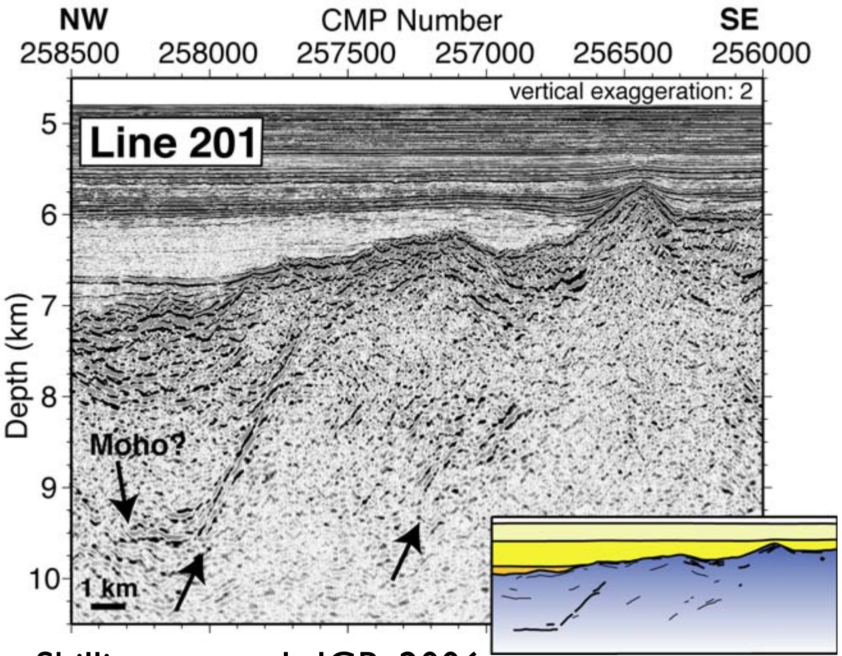
- Jurassic-Cretaceous rifting. Earliest seafloor spreading at ~130 Ma – 125 Ma
- From south to north
- Magma poor, sediment starved

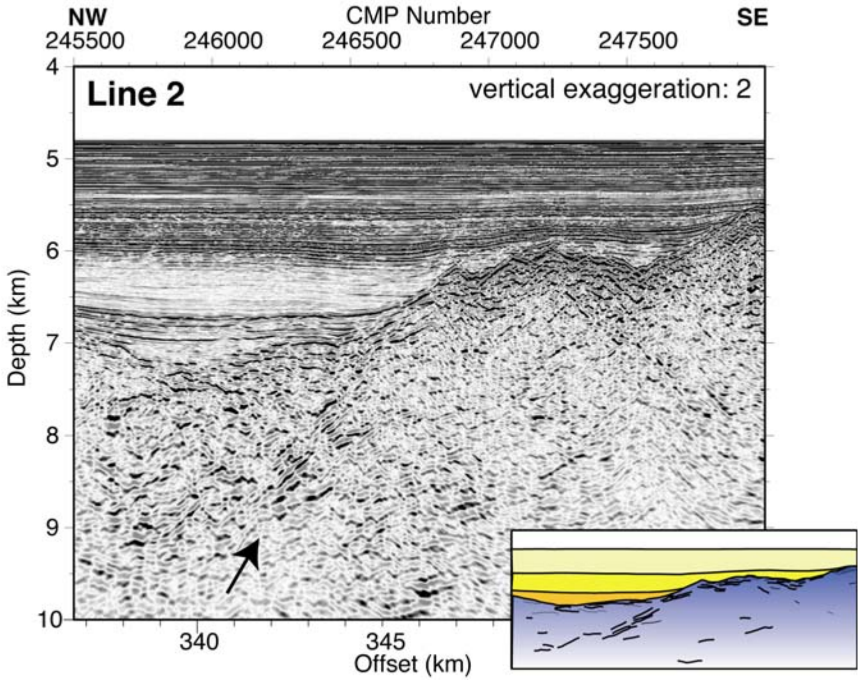
Boundary between continental and "transitional" basement



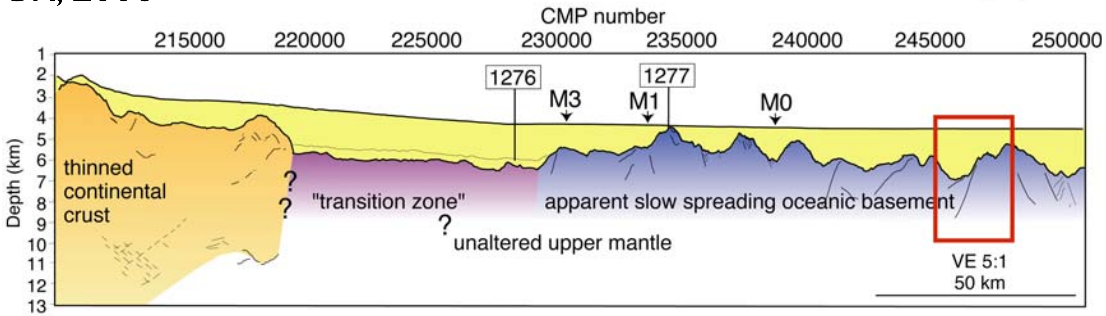
Shillington et al., JGR, 2006

Faults in embryonic oceanic basement

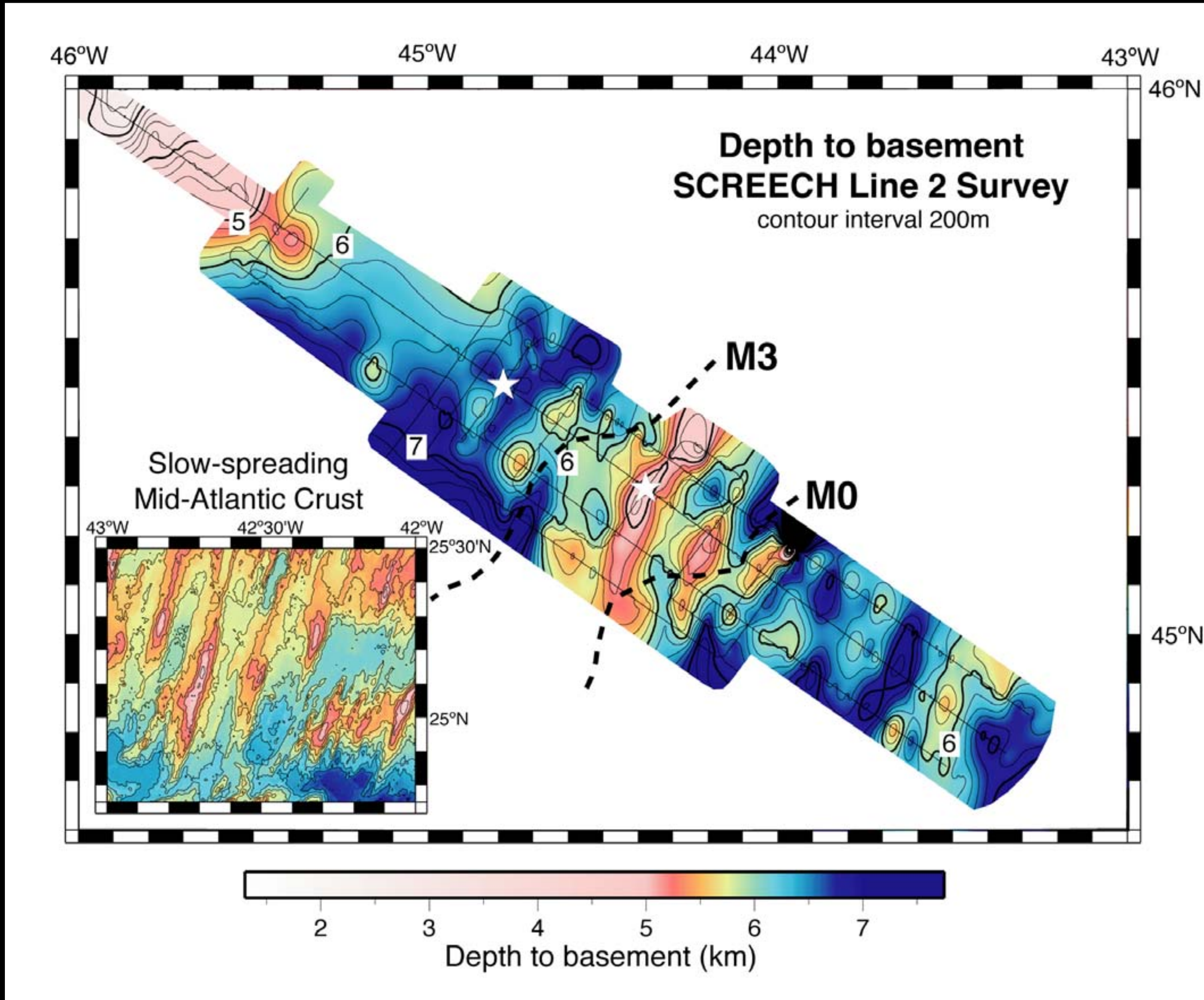




Shillington et al., JGR, 2006

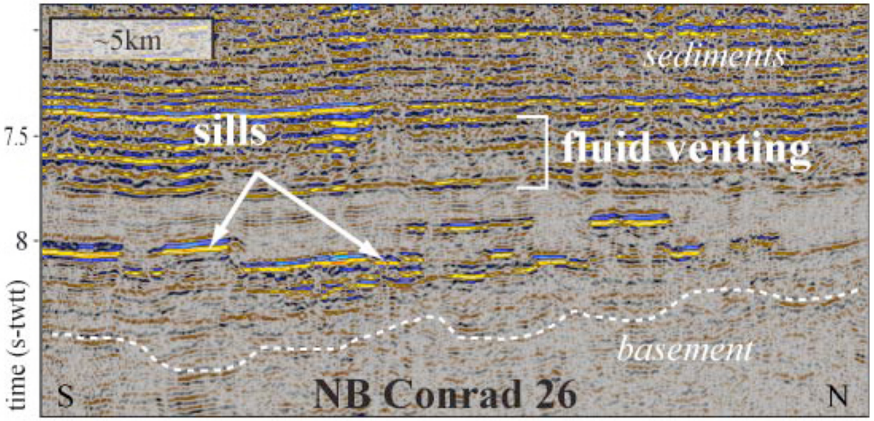


Basement topography and other characteristics



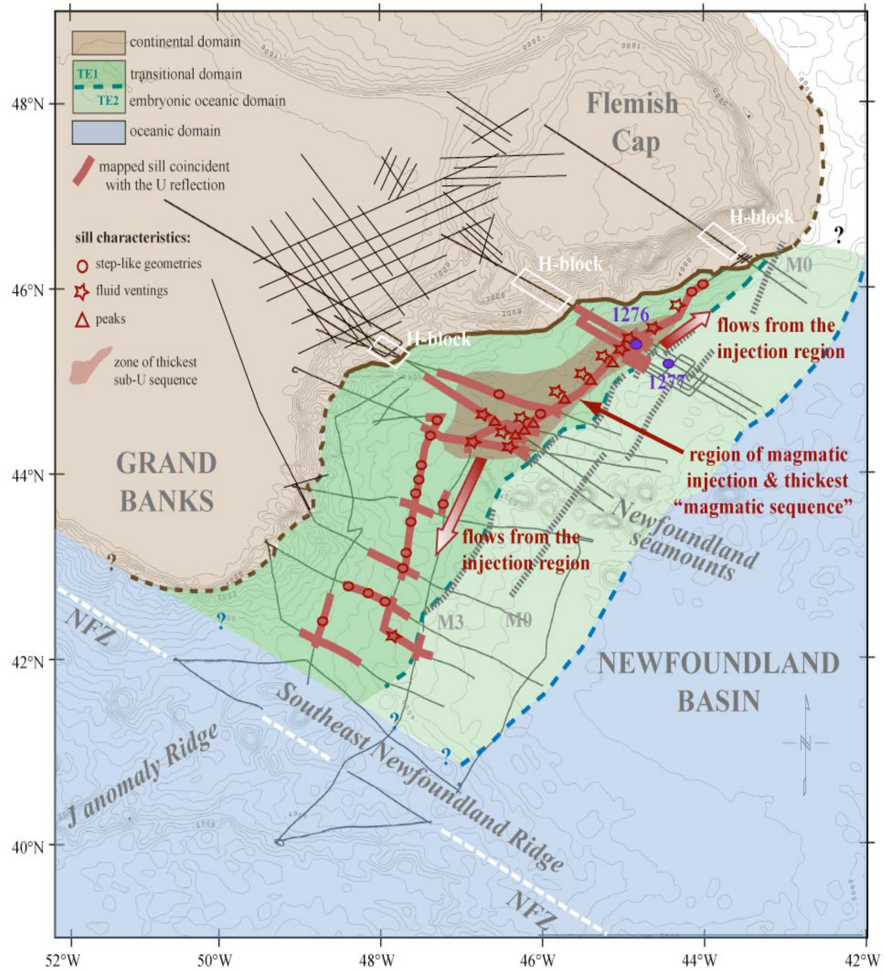
Shillington et al., 2006

Identify sills injected into the sediments



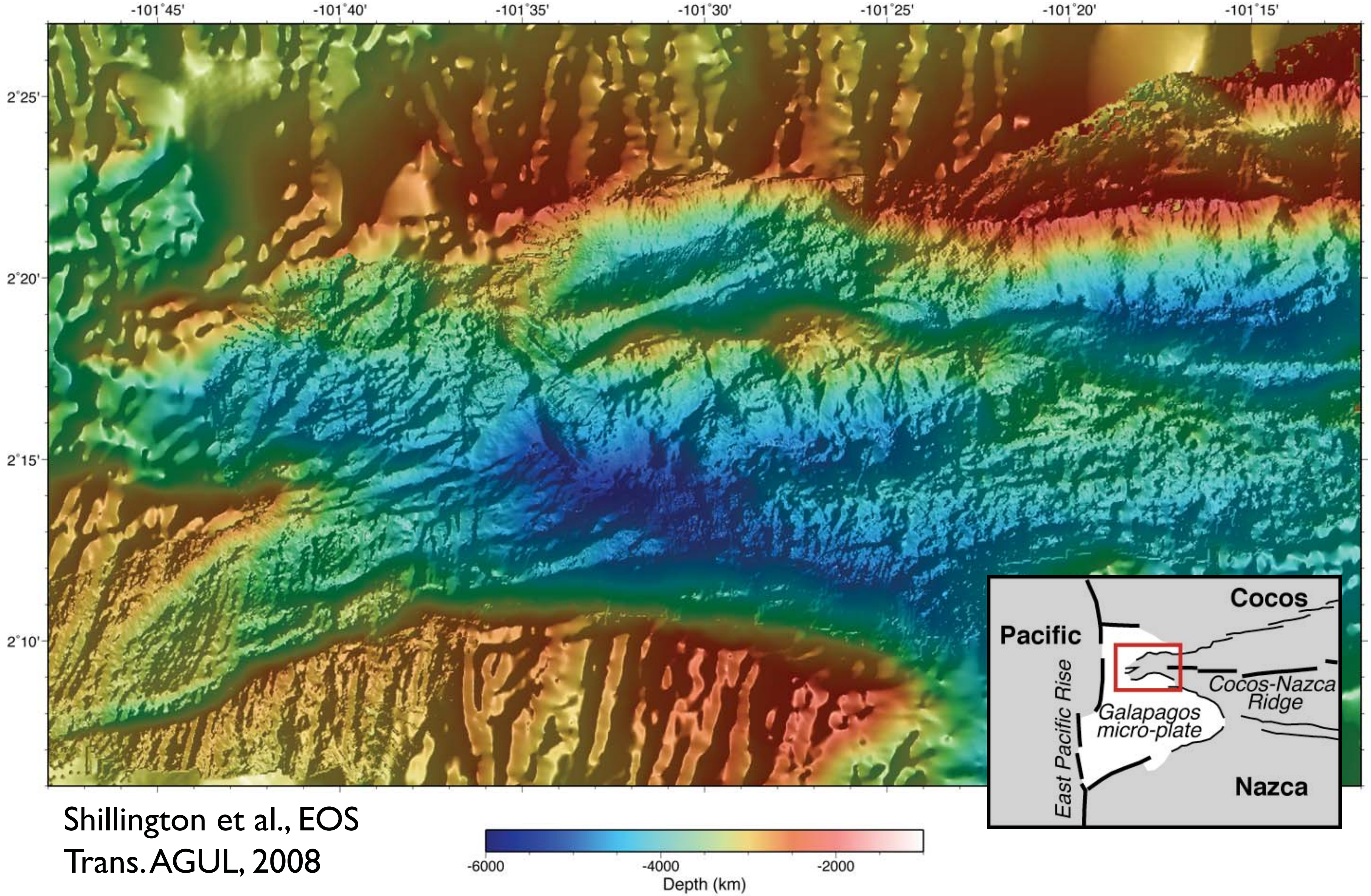
Sills have distinct seismic reflection characteristics (high amplitudes, often discontinuous, etc)

Seismic reflection data can be used to map lateral extent of sills and make first-order estimates on volume of magmas intruded in sediments.

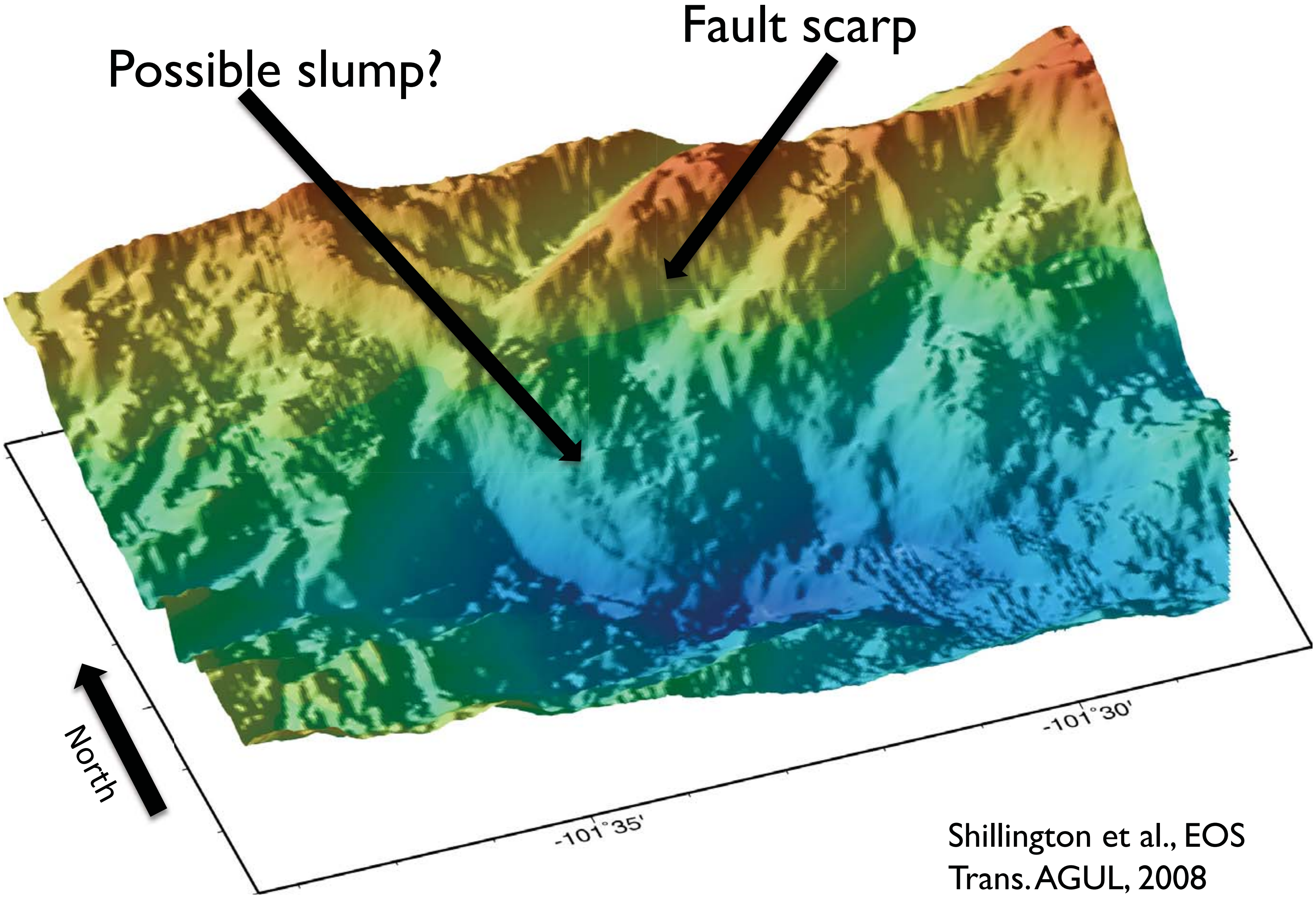


Péron-Pinvidic, Shillington & Tucholke, in review

3 Multibeam bathymetric mapping: an example from Hess Deep



Shillington et al., EOS Trans. AGUL, 2008



Shillington et al., EOS
Trans. AGUL, 2008

Take-home message

- 'Marine' geophysics could be a very useful tool for investigating tectonics and associated volcanic/seismic hazards in the Western Rift.

- Such data can provide new information on fault geometry, distribution of magma in the mantle lithosphere, crust and sediments, etc.

- Having this type of information in the Western Rift would make for excellent comparisons with similar datasets to the north in Ethiopia and Gregory Rift

- This approach would strongly complement onshore activities, including seismic/geodetic networks, geology, geochemistry, etc.