

Geotektonik – Global Tectonics

CHAPTER 5

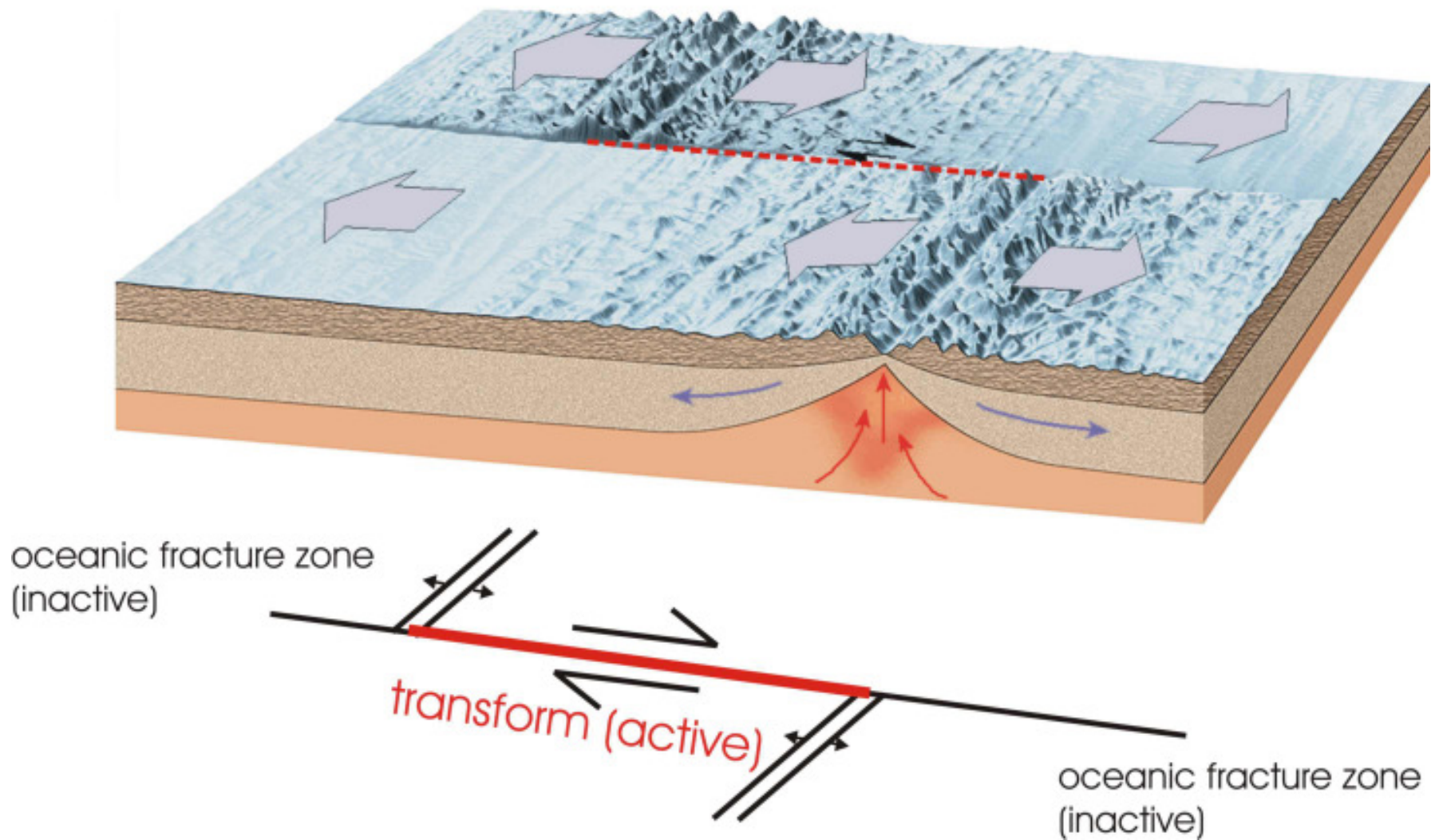
oceanic transform faults
and
oceanic fracture zones

CHAPTER 5

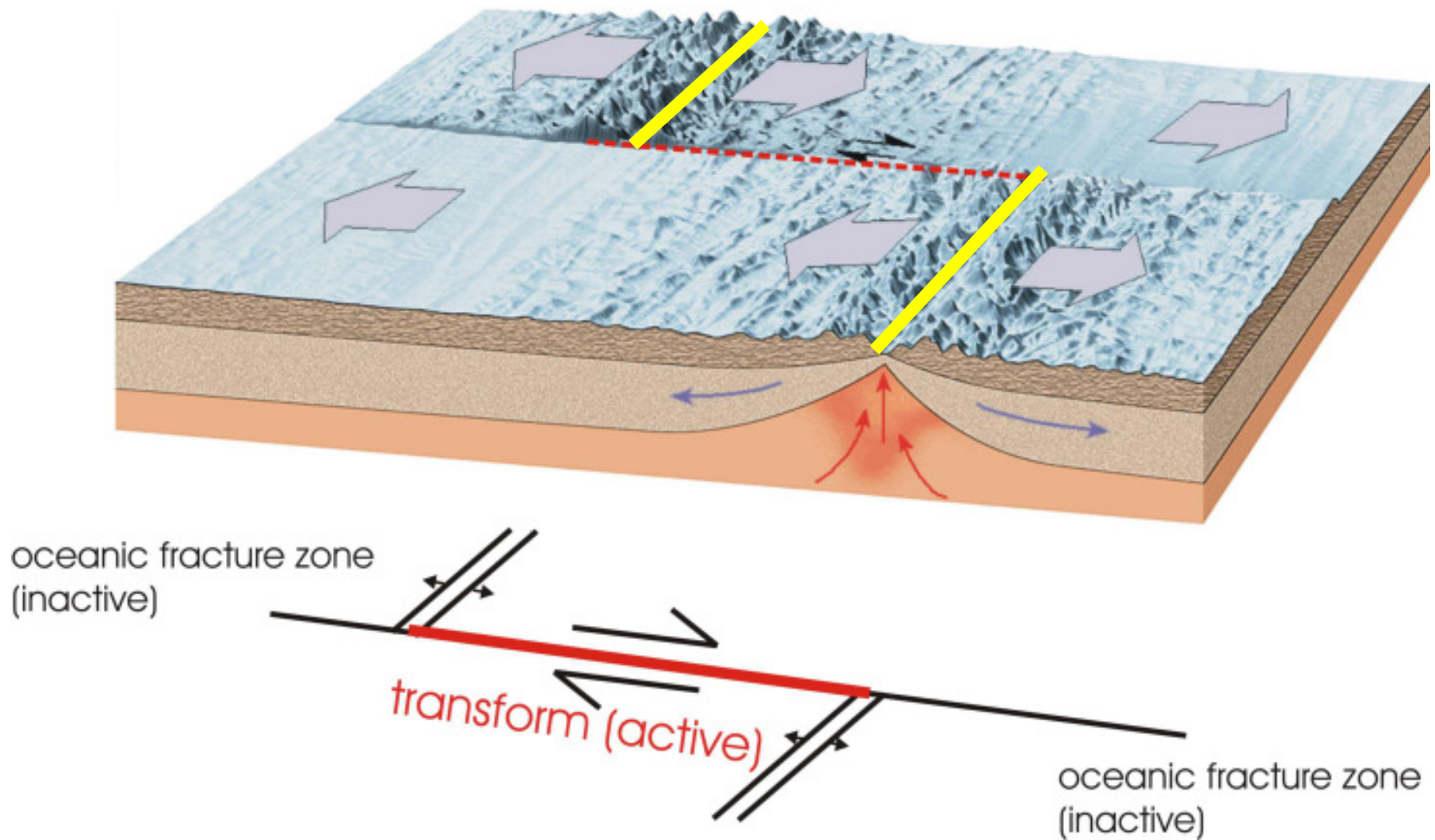
oceanic transform faults

- first order discontinuities in MOR -
- conservative plate boundaries in oceanic lithosphere -
- develop into oceanic fracture zones OFZ within plates -

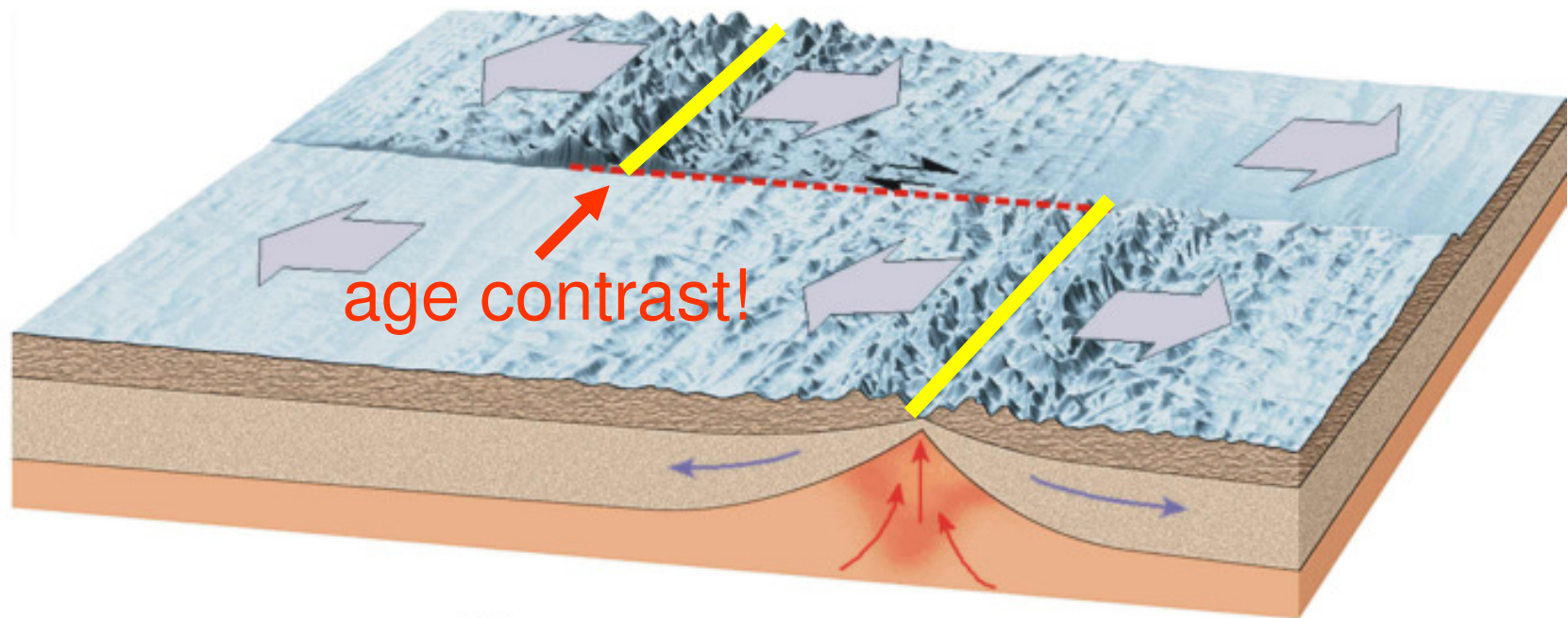
oceanic transform fault (conservative plate boundary)



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oceanic transform fault (conservative plate boundary)

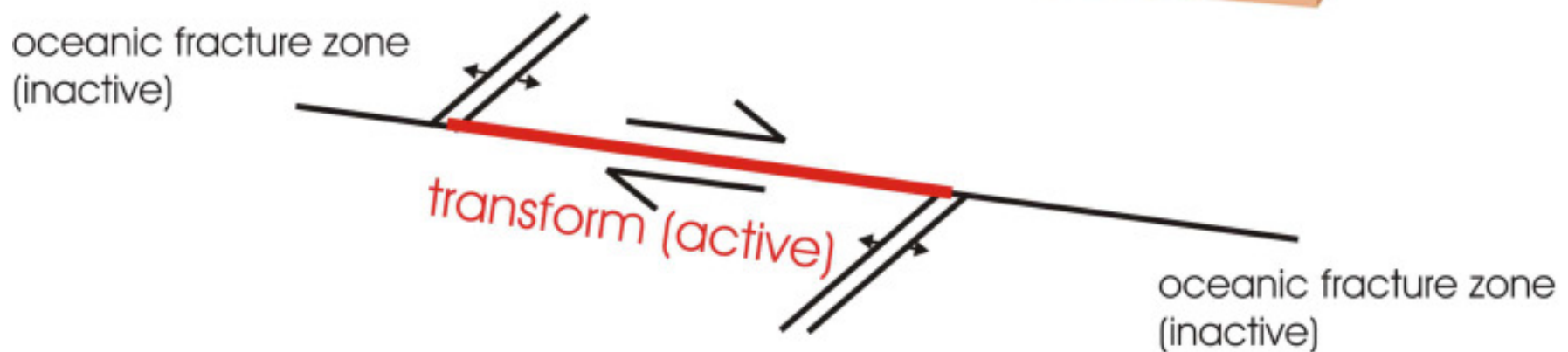
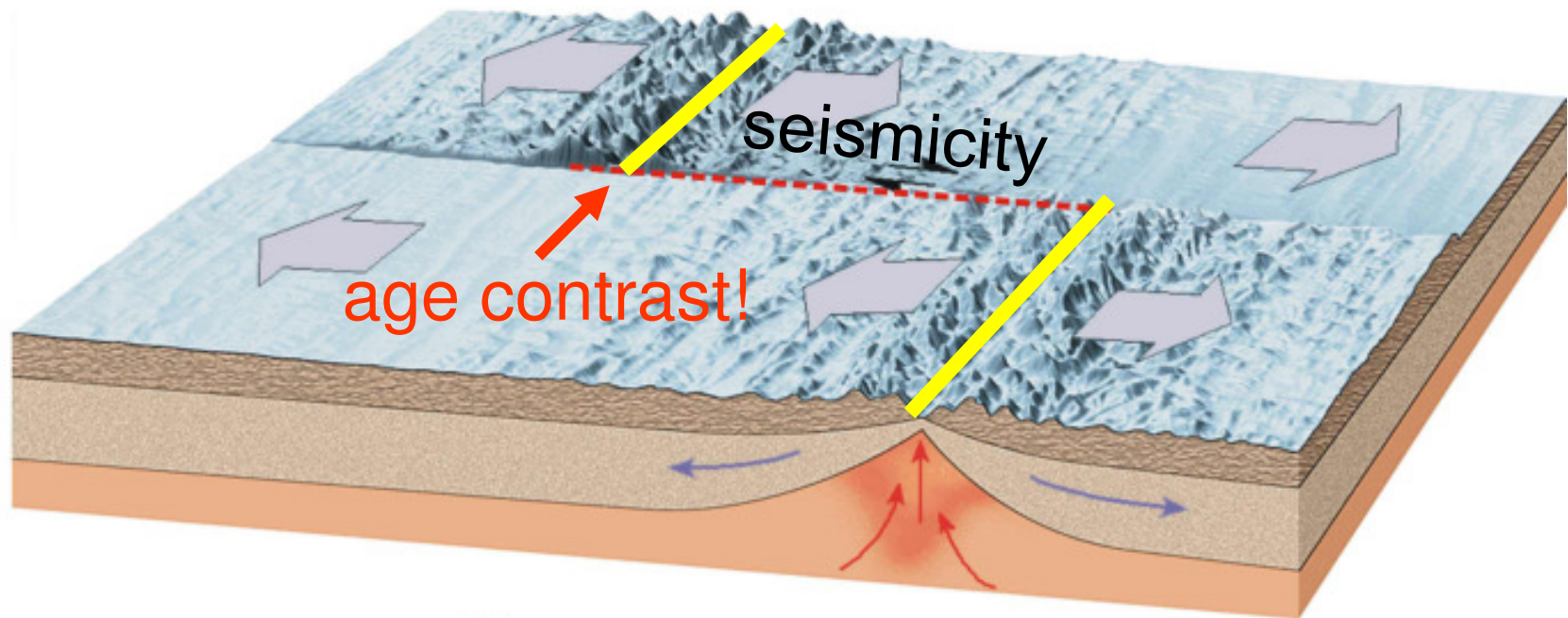


oceanic fracture zone
(inactive)

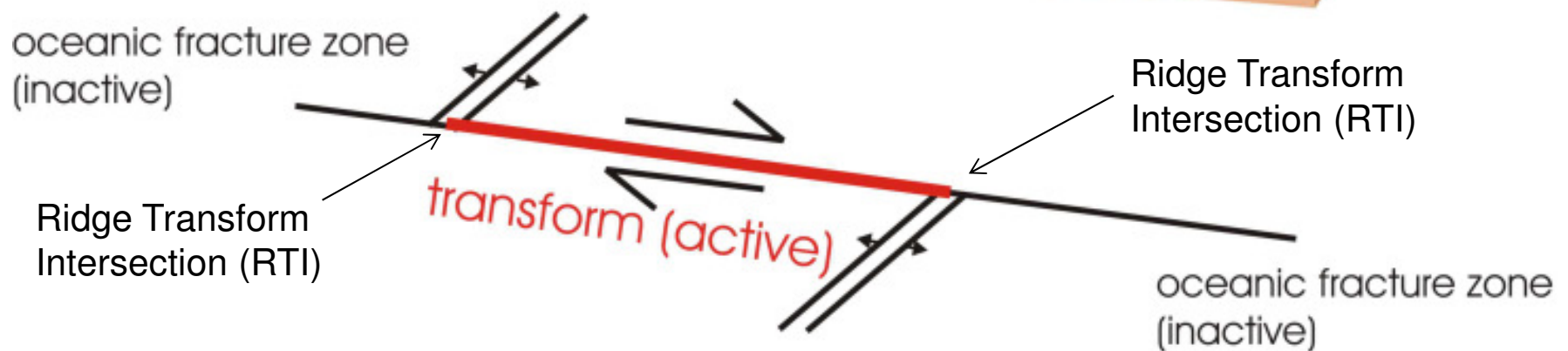
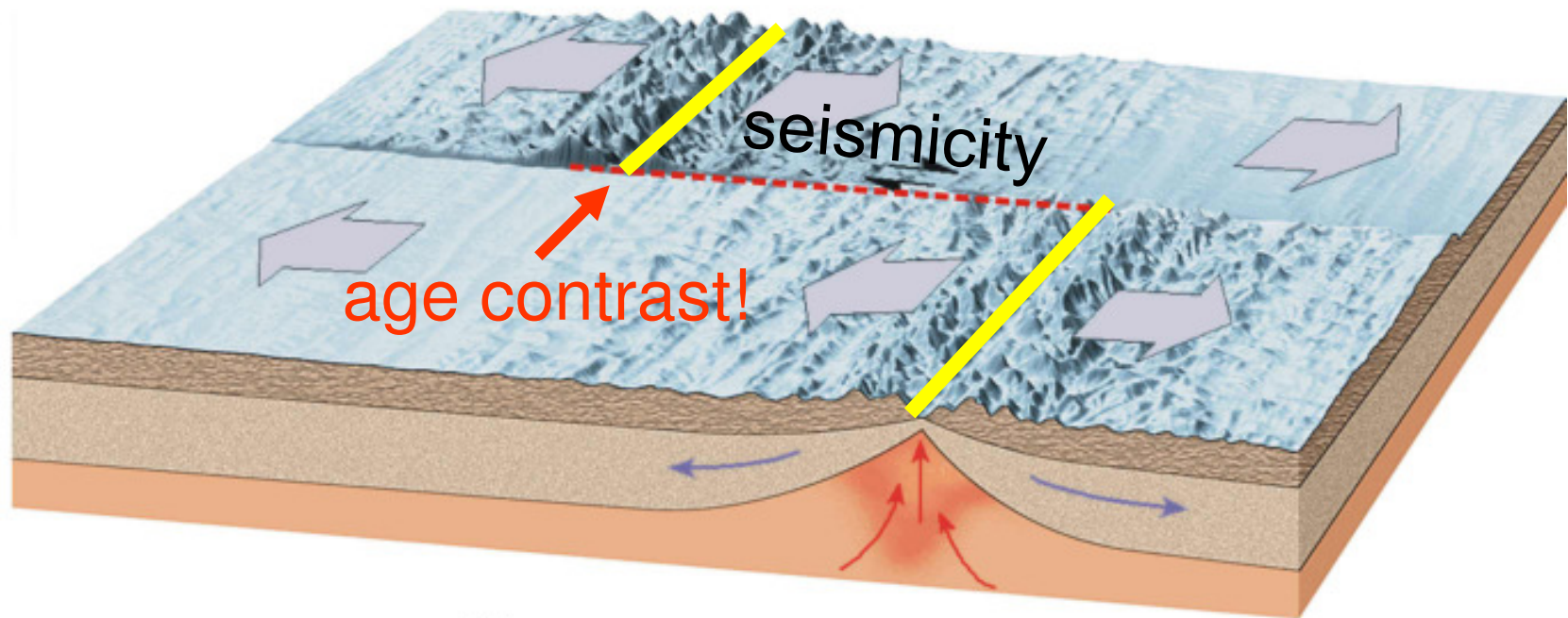
transform (active)

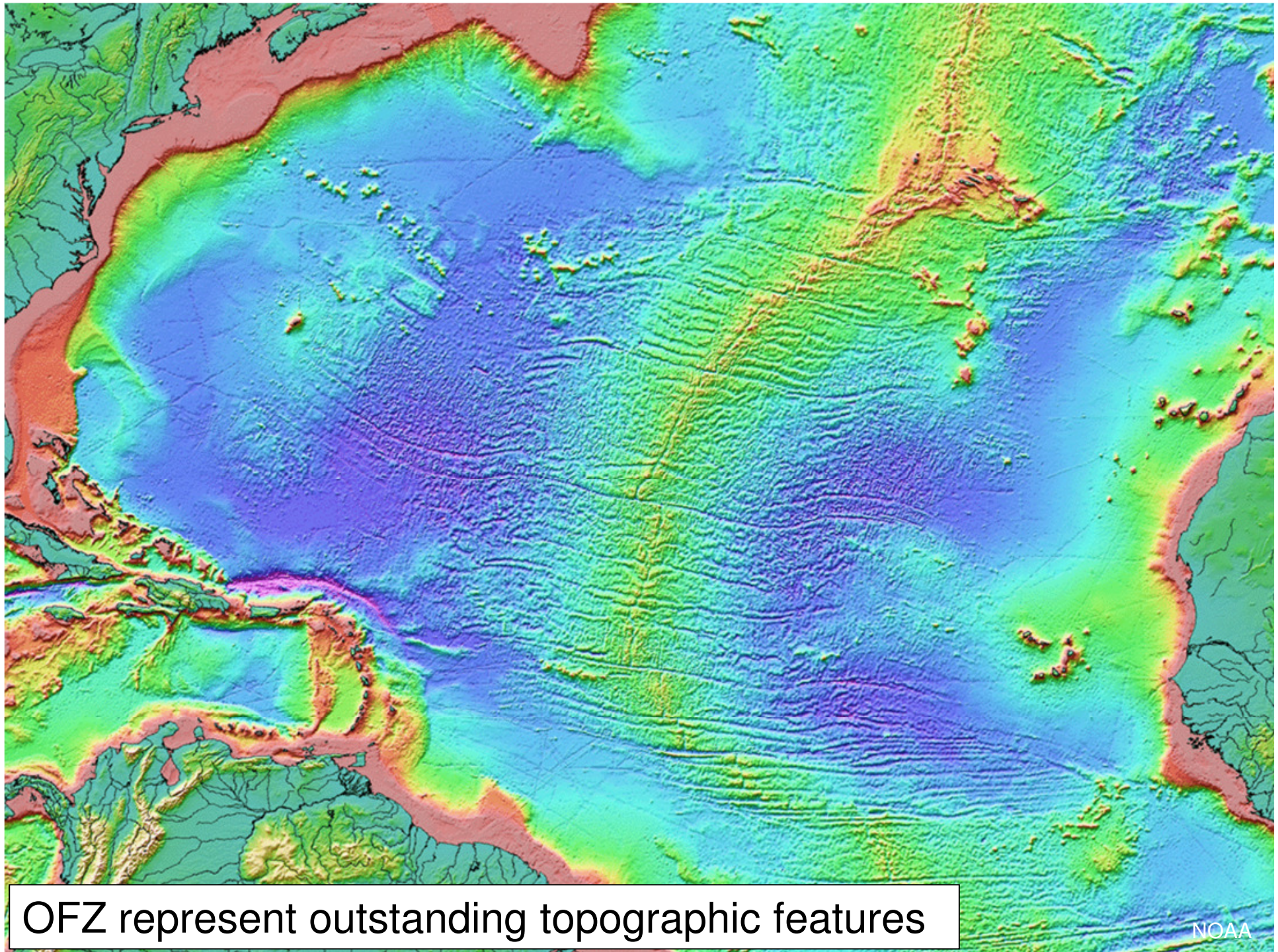
oceanic fracture zone
(inactive)

oceanic transform fault (conservative plate boundary)

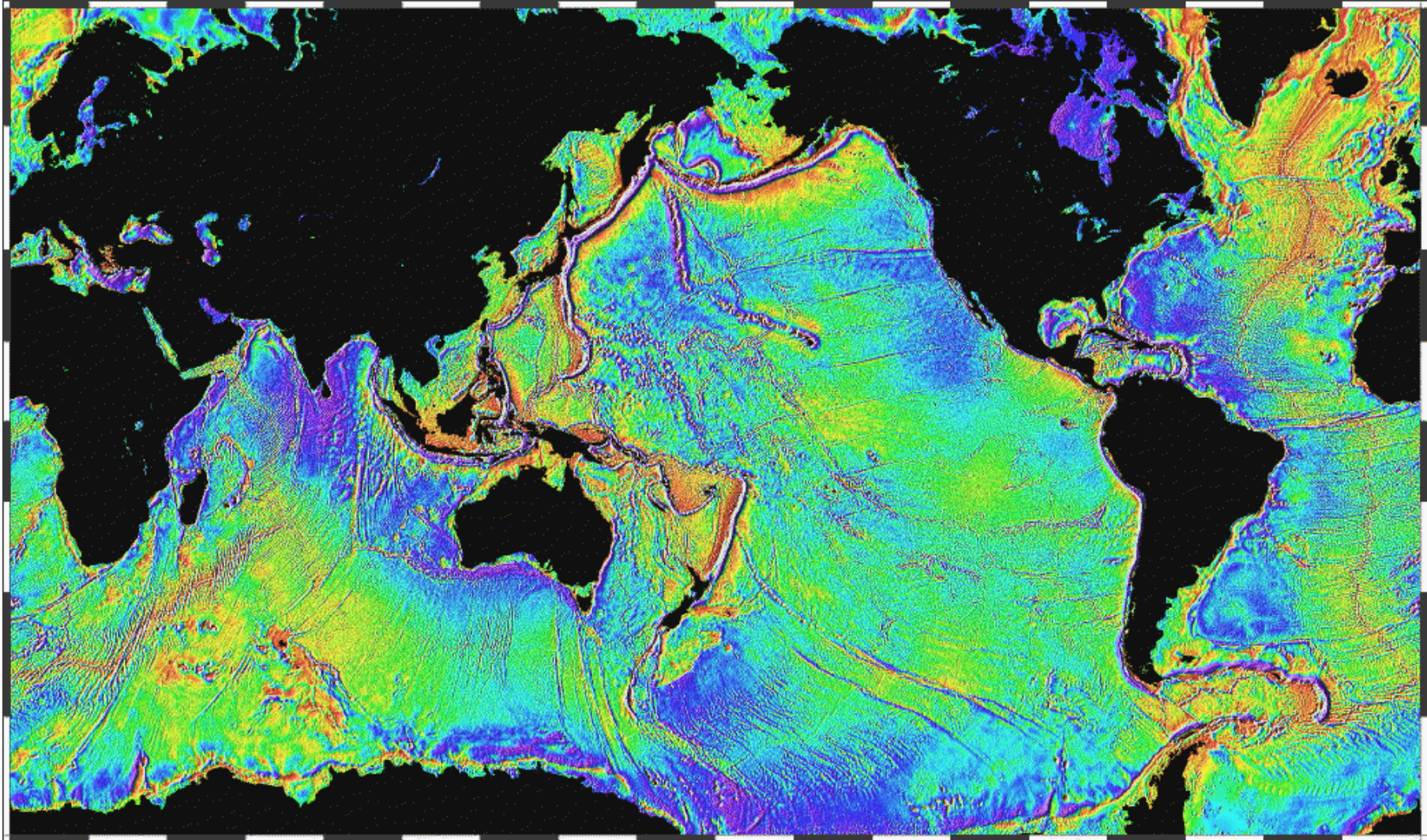


oceanic transform fault (conservative plate boundary)



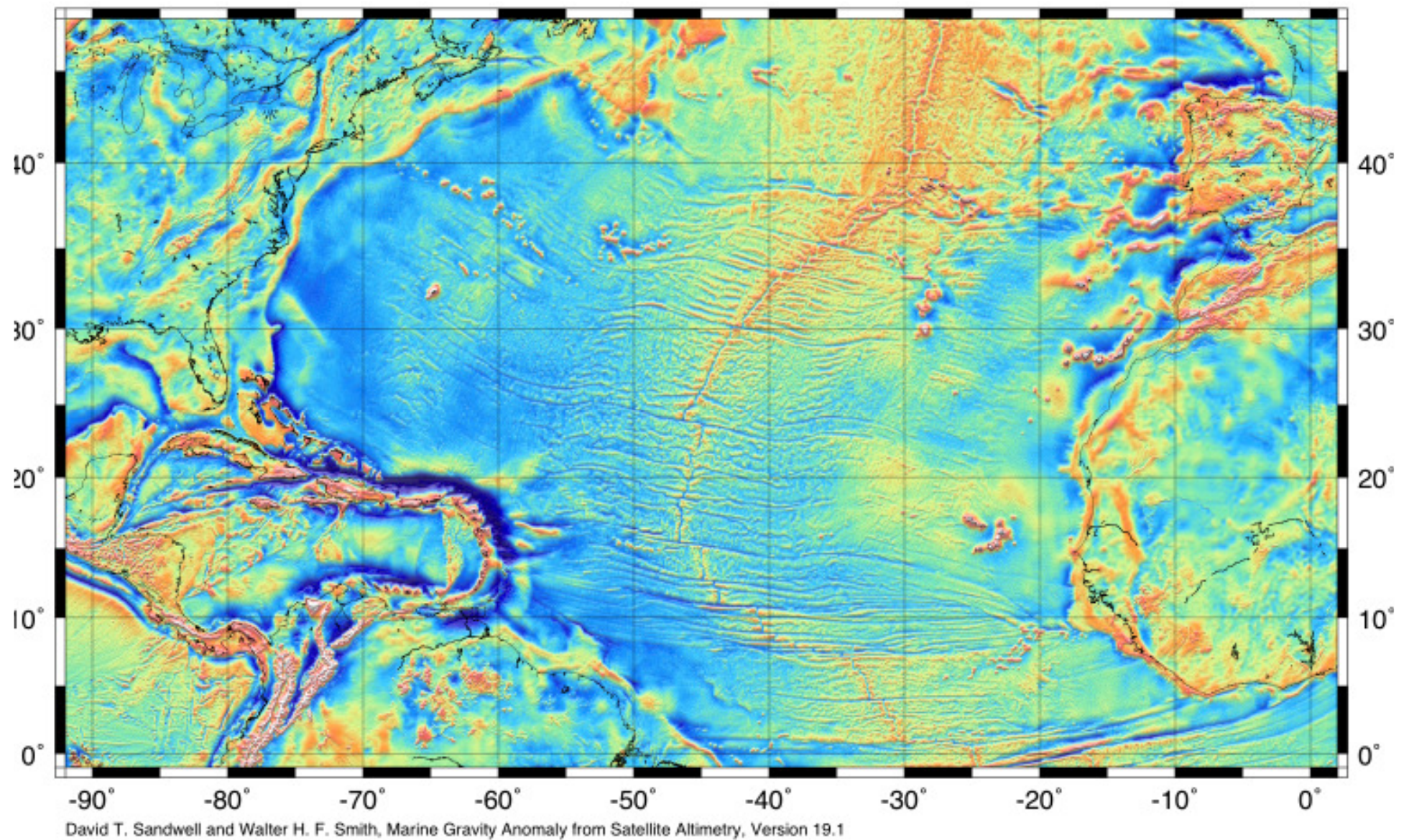


OFZ represent outstanding topographic features



Sandwell & Smith (2009) J. Geophys. Res. 114

OFZ are obvious on SEASAT world gravity map



Sandwell & Smith (2009) J. Geophys. Res. 114

OFZ are obvious on SEASAT world gravity map

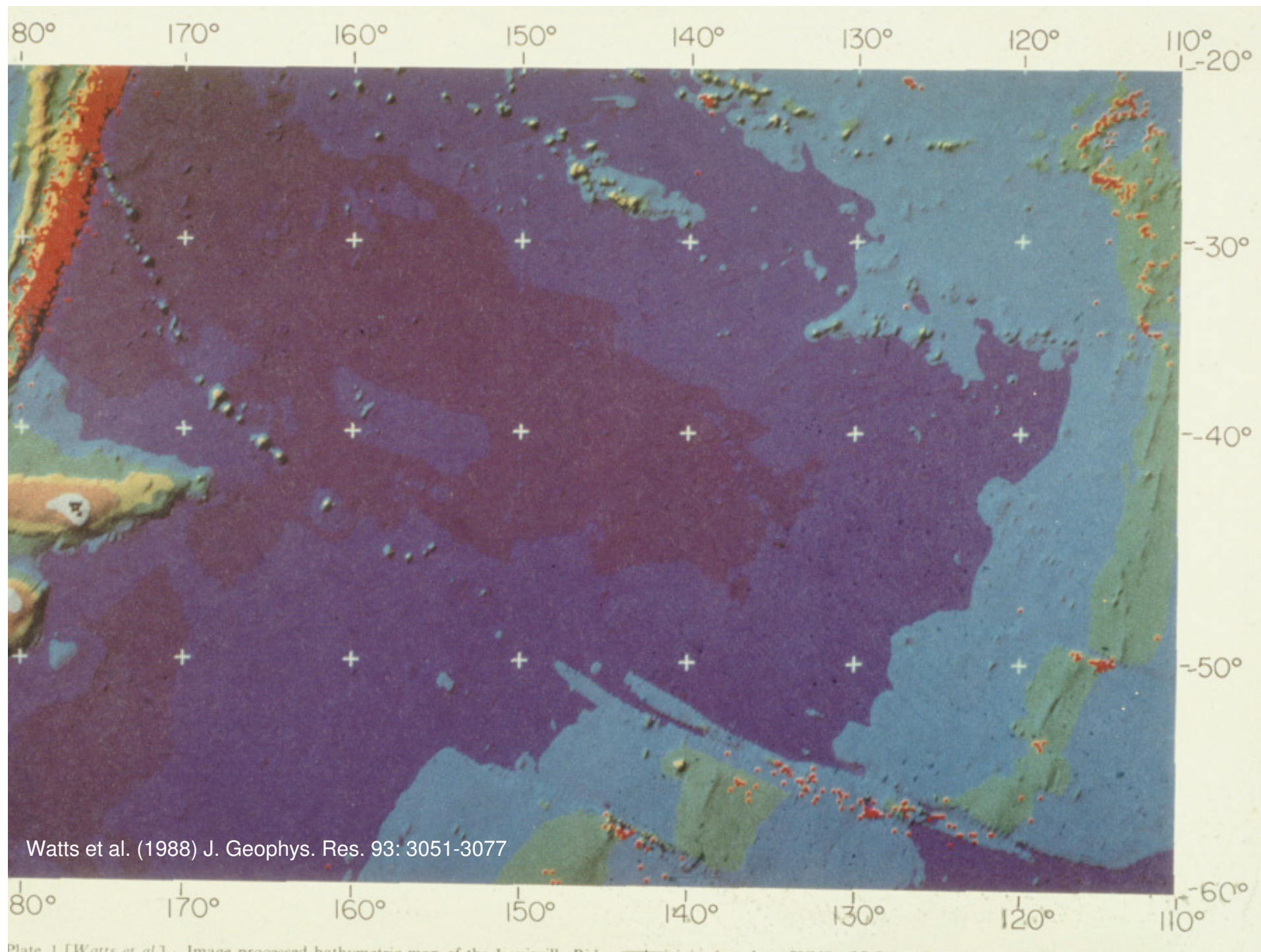
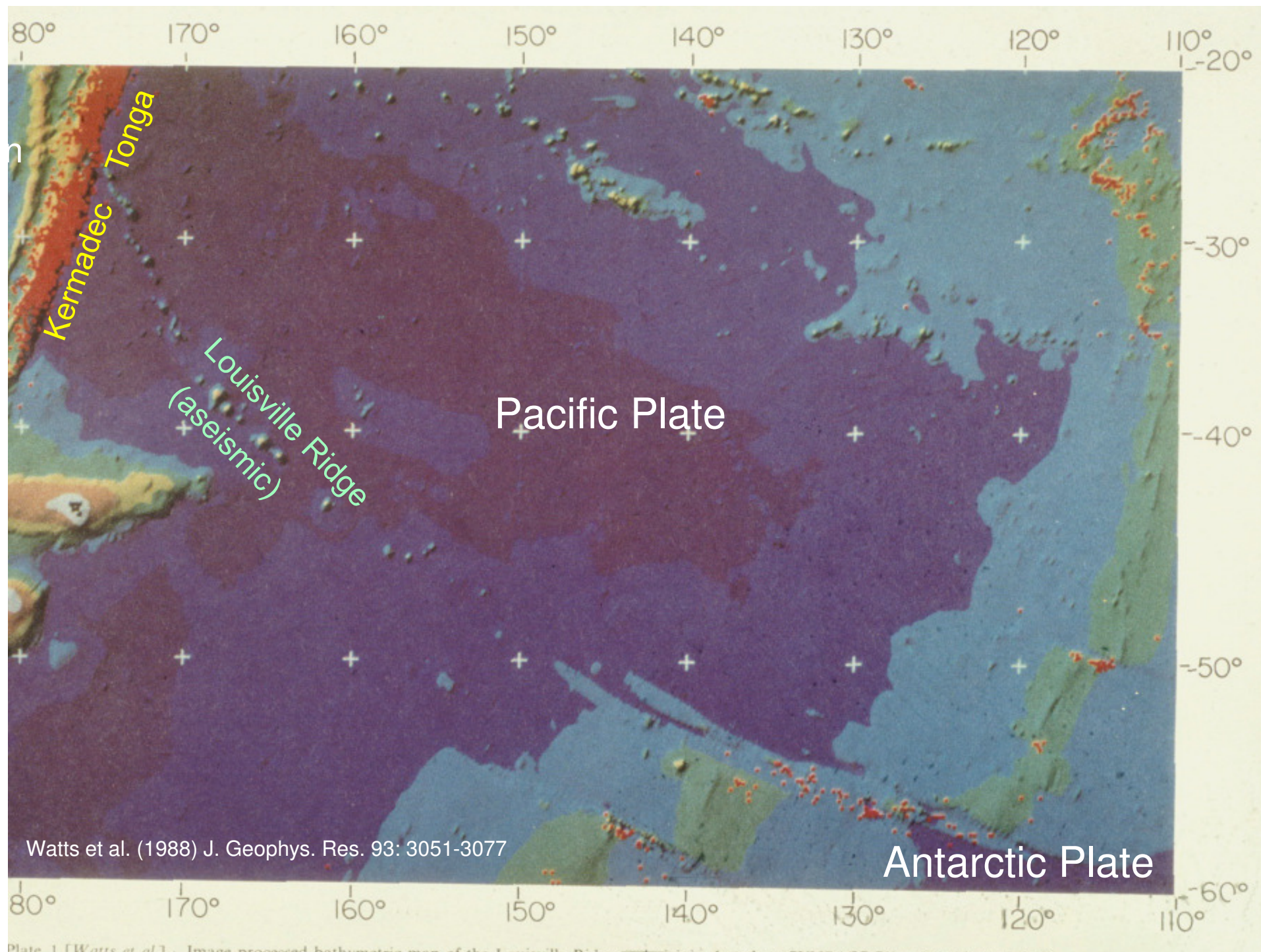
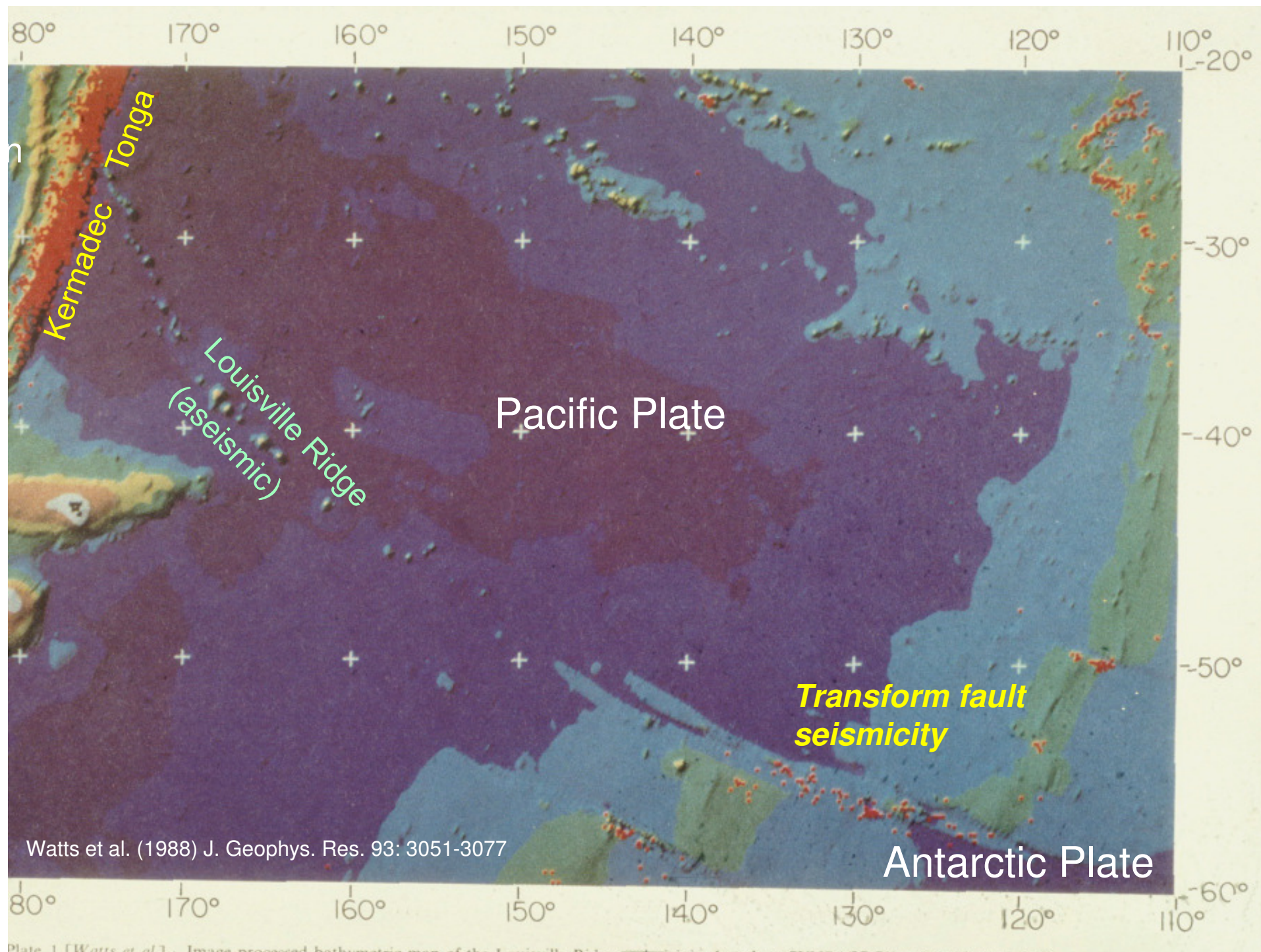


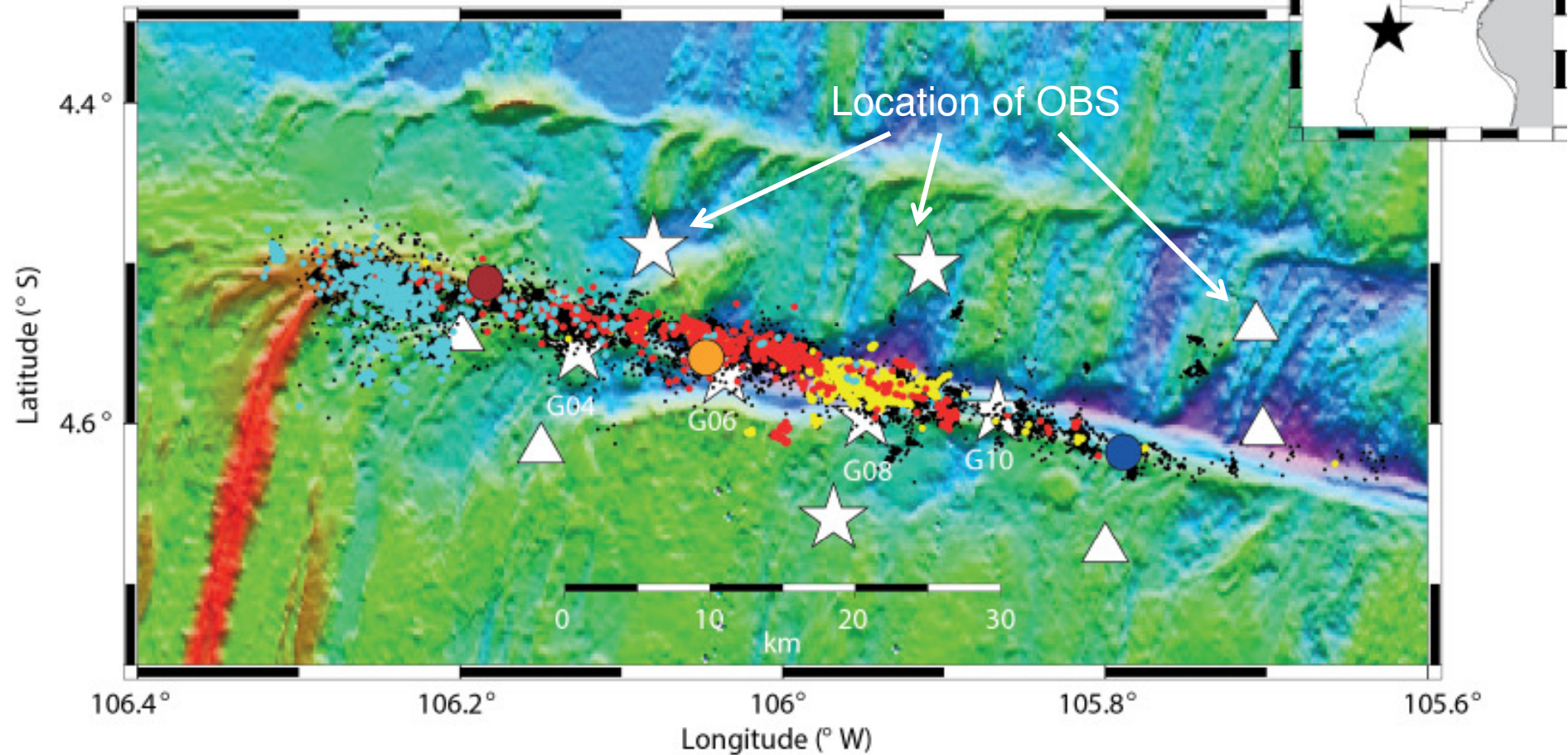
Plate 1 [Watts et al.]: Image processed bathymetric map of the Louisville Ridge and vicinity based on GEOSAR data from 1985-1986.





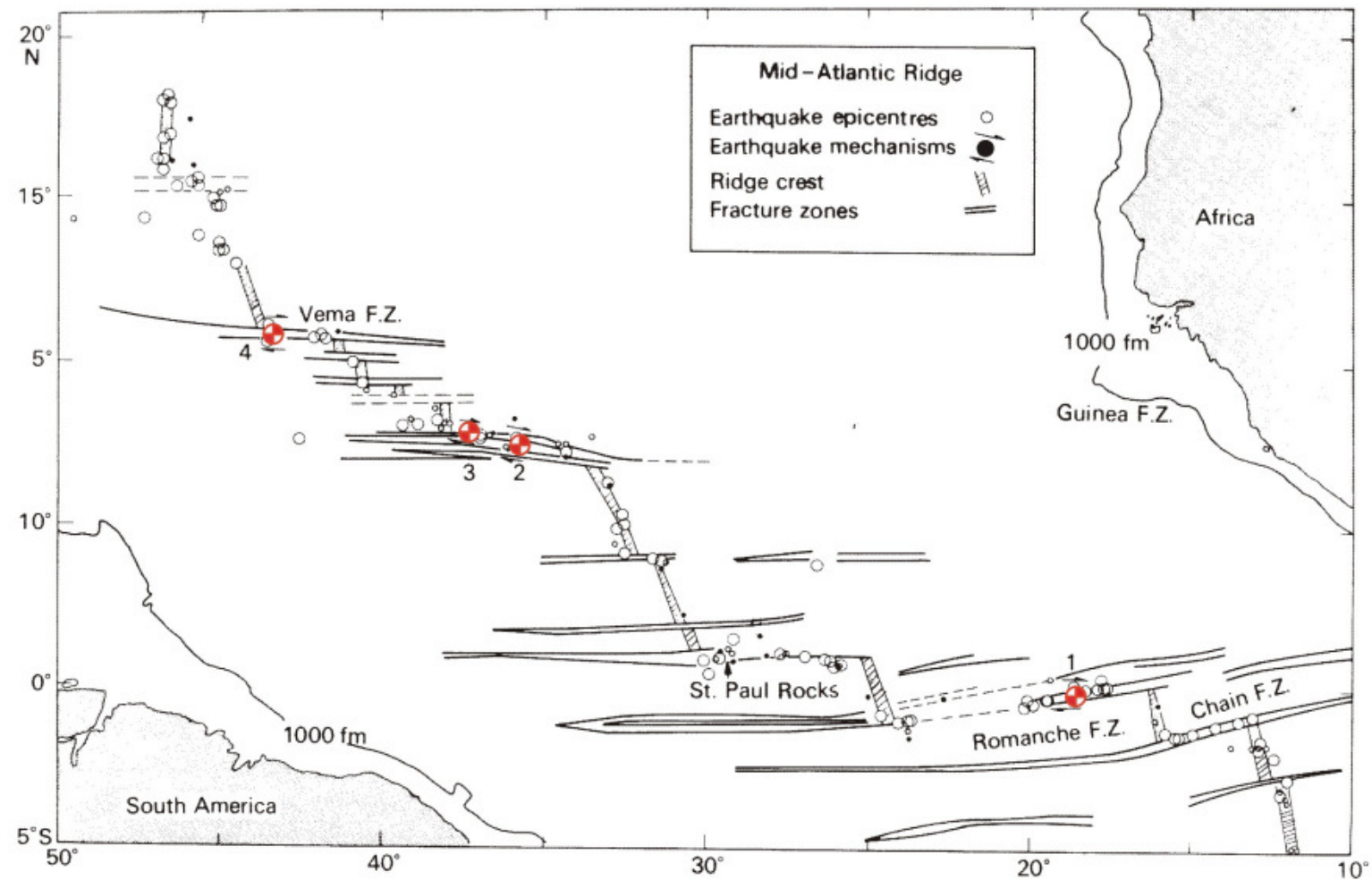
Seismicity along Gofar Transform (East Pacific Rise)

[example of transform seismicity recorded by local network]



OBS = **O**cean **B**ottom **S**eismometer

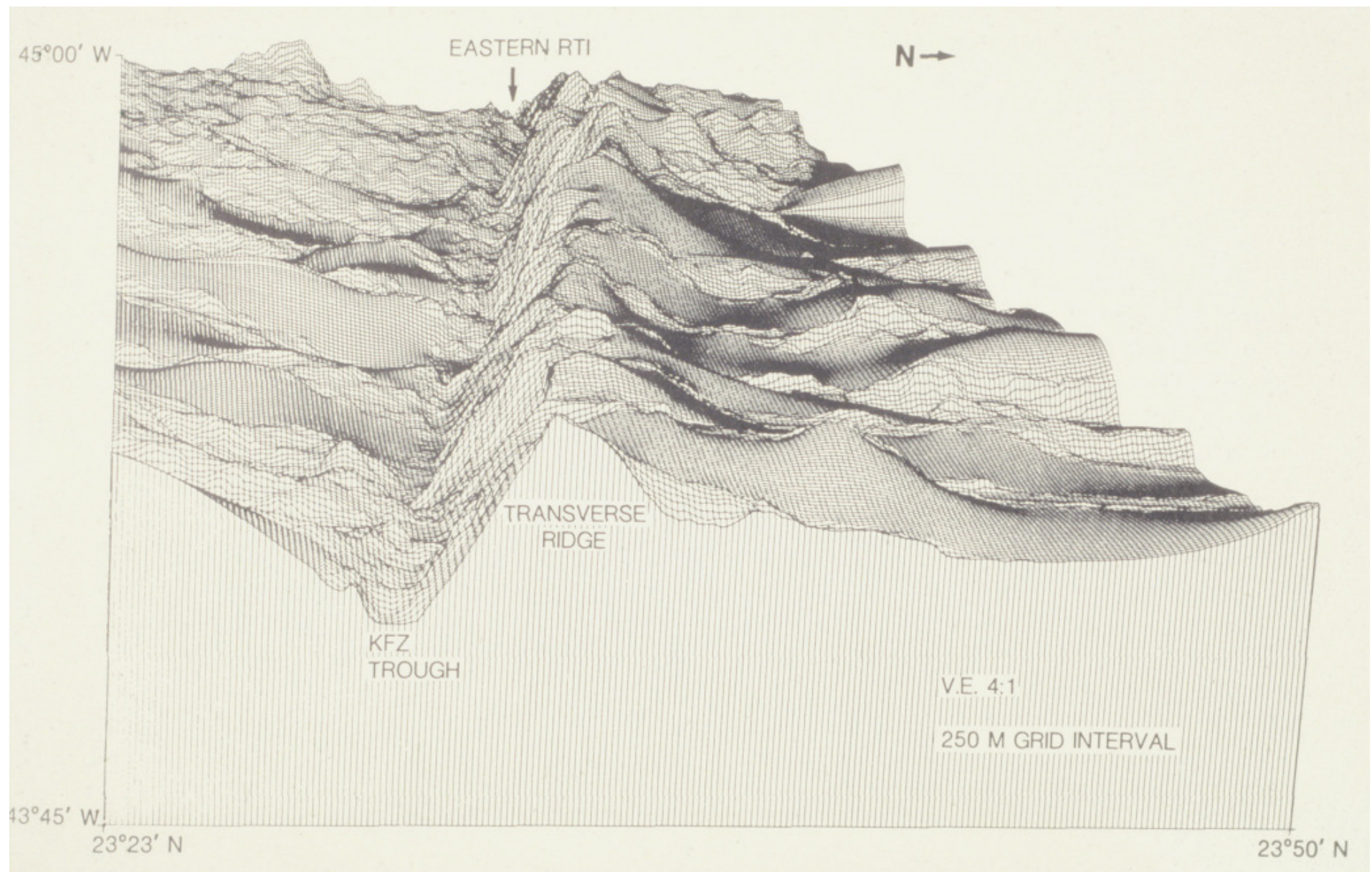
Oceanic fracture zones at the equatorial section of the MAR



focal mechanism solution

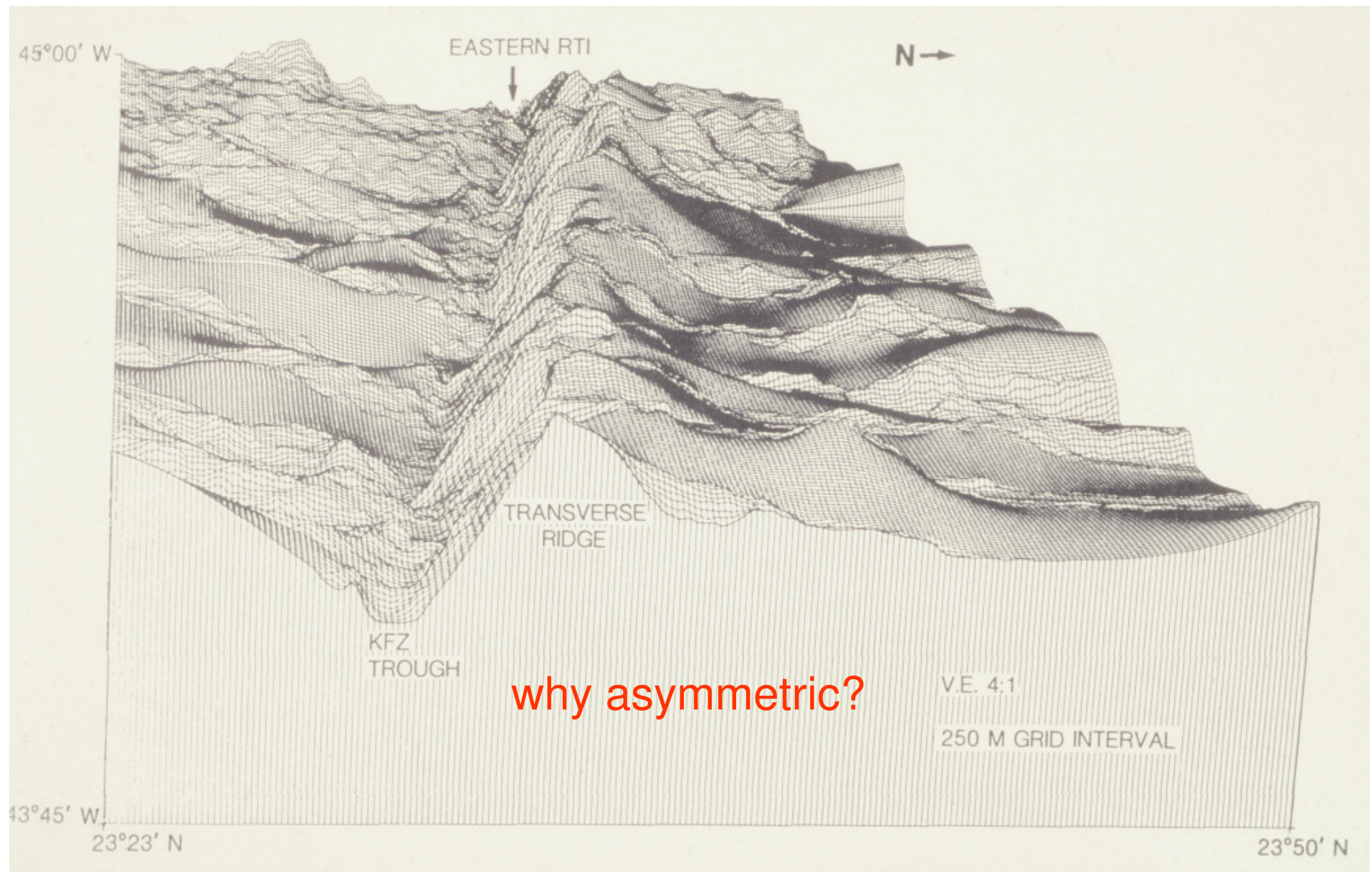
after: Sykes (1967) J. Geophys. Res. 72: 2137

from BOTT M.H.P. (1982) The interior of the Earth (2nd ed., Arnold)



Kane Fracture Zone

Pockalny et al. (1988) JGR 93: 3179-3193

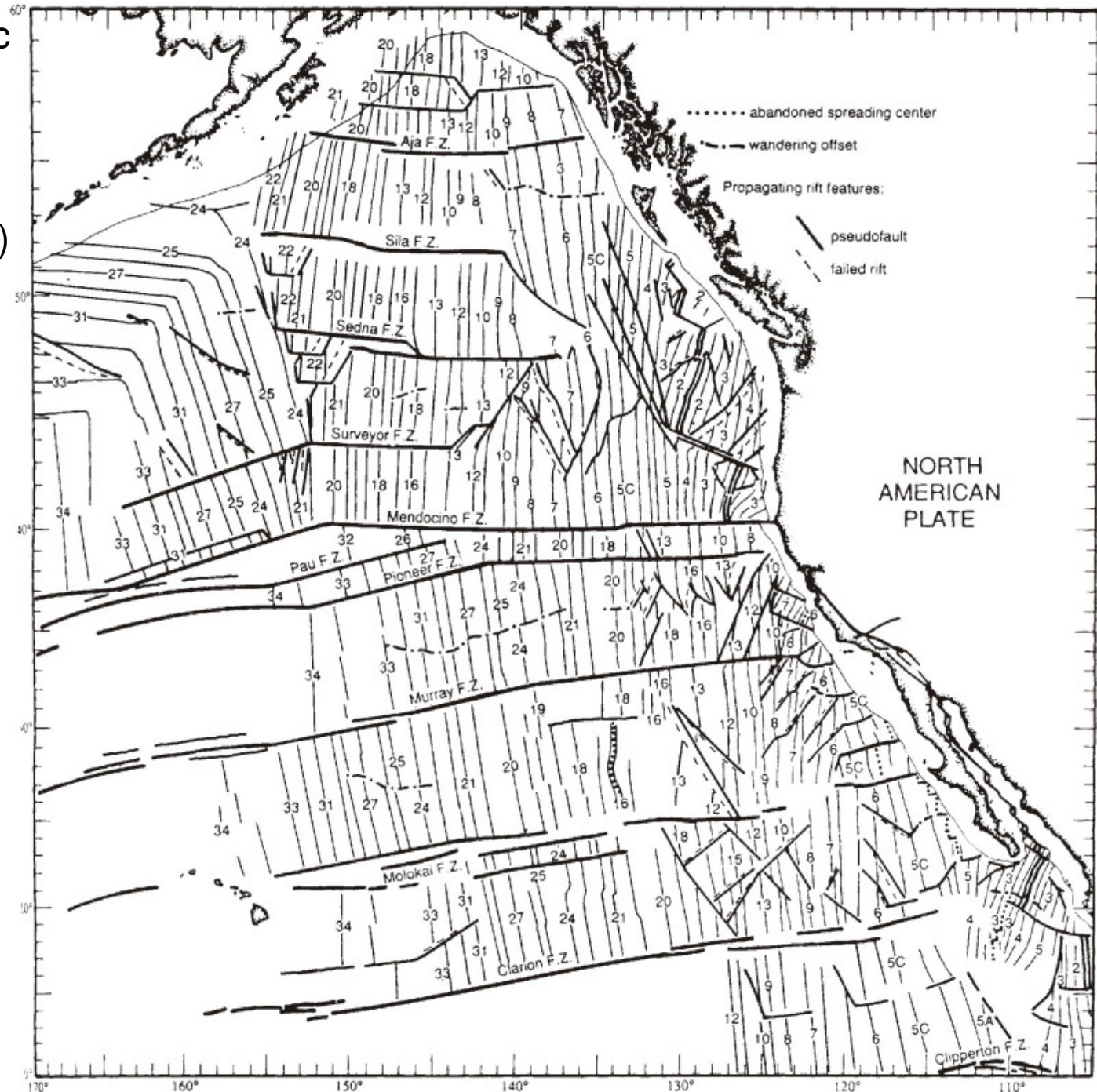


Kane Fracture Zone

Pockalny et al. (1988) JGR 93: 3179-3193

age pattern of oceanic lithosphere of Pacific Plate

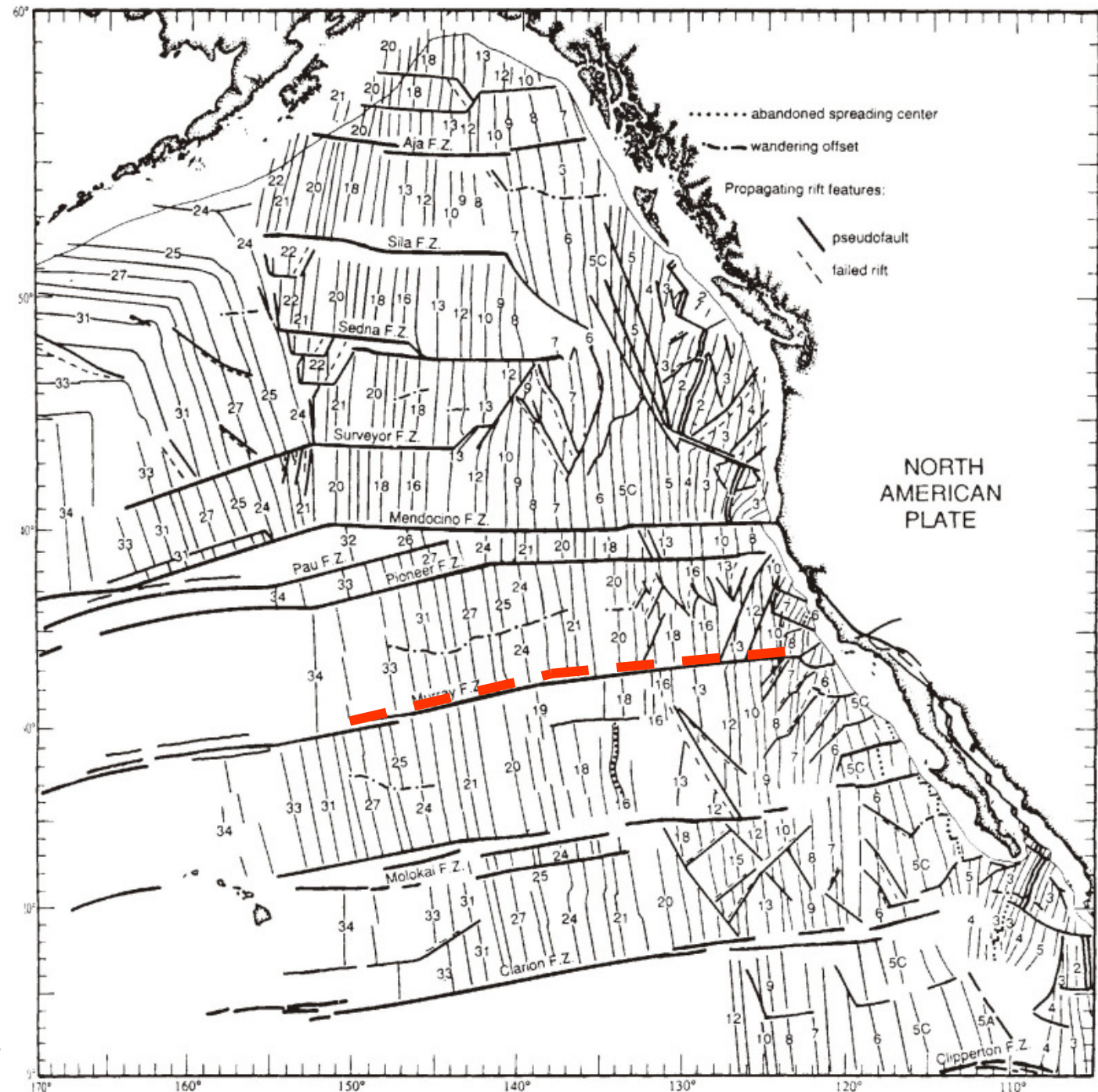
(labels according to magnetic stratigraphy)



from Atwater T. (1989) in Winterer et al. (eds.): The Geology of North America

Murray Fracture Zone

(the transform was between Pacific and Farallon Plate)



from Atwater T. (1989) in Winterer et al. (eds.): The Geology of North America

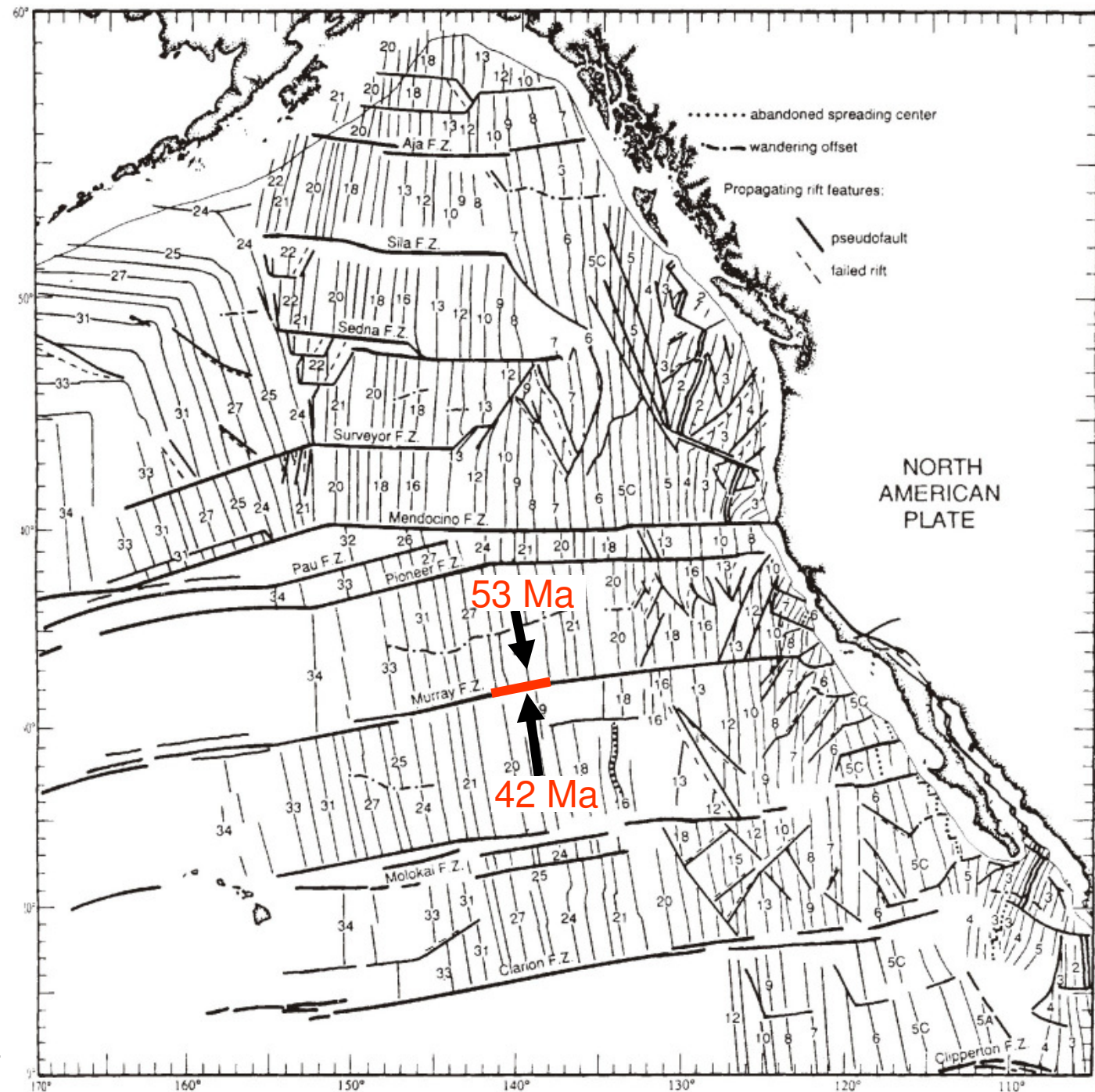
Murray Fracture Zone

(the transform was between Pacific and Farallon Plate)

Offset

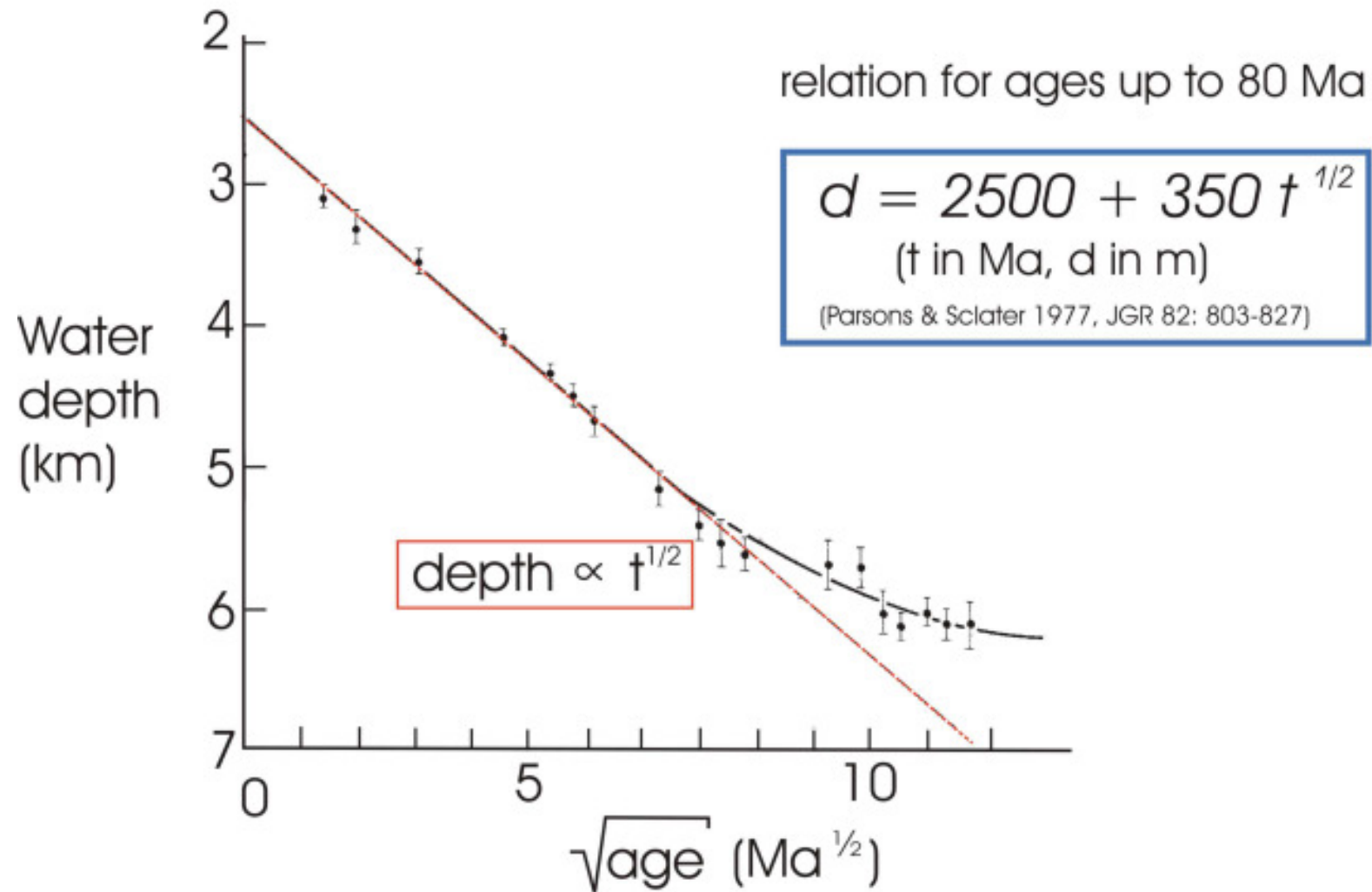
ca. 11 m.y.

(Magnetic Anomalies 19/24)



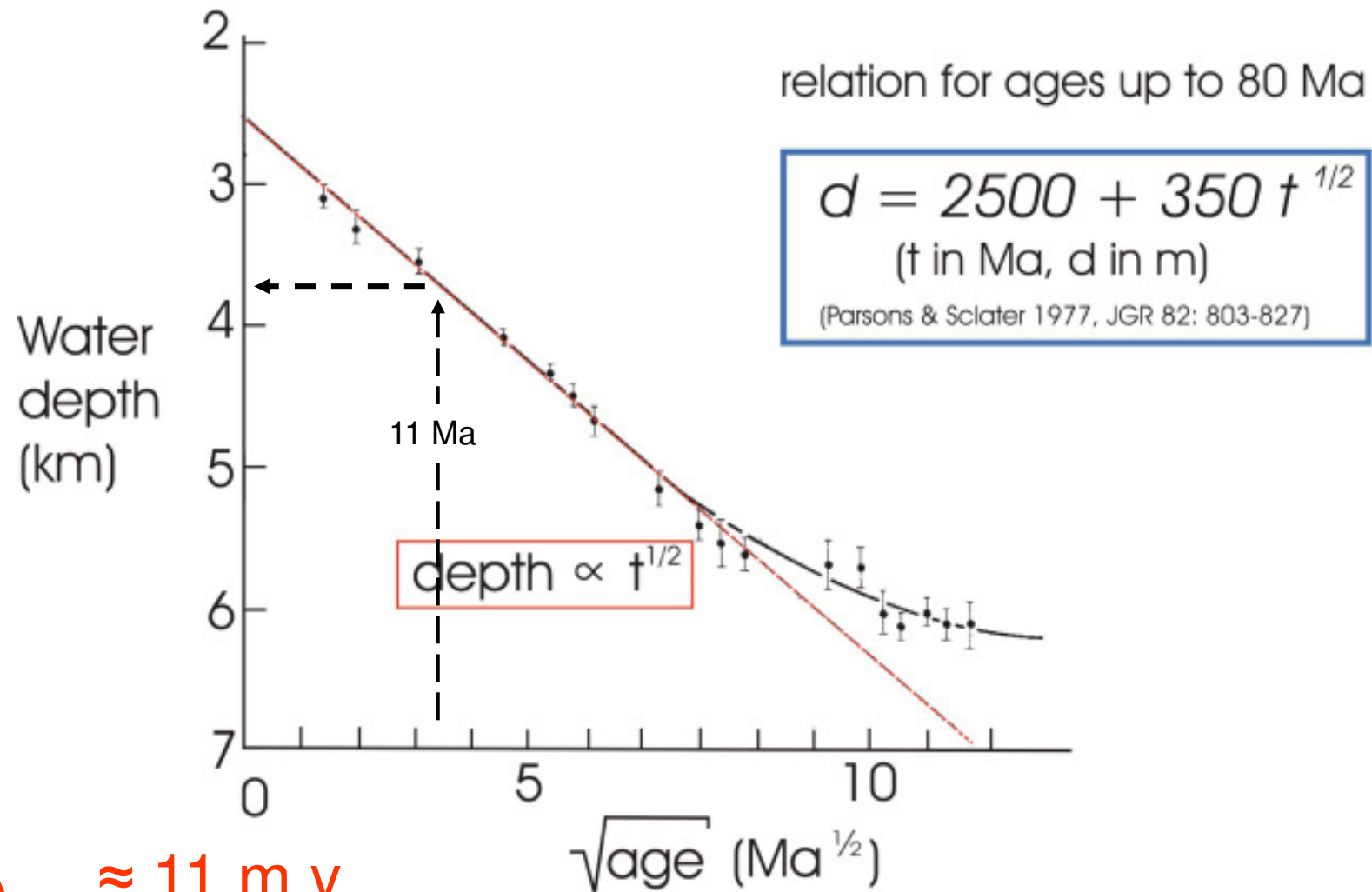
from Atwater T. (1989) in Winterer et al. (eds.): The Geology of North America

Ocean depth and age of oceanic lithosphere



from: Bott M.H.P. (1982) The interior of the Earth (Arnold)

Ocean depth and age of oceanic lithosphere



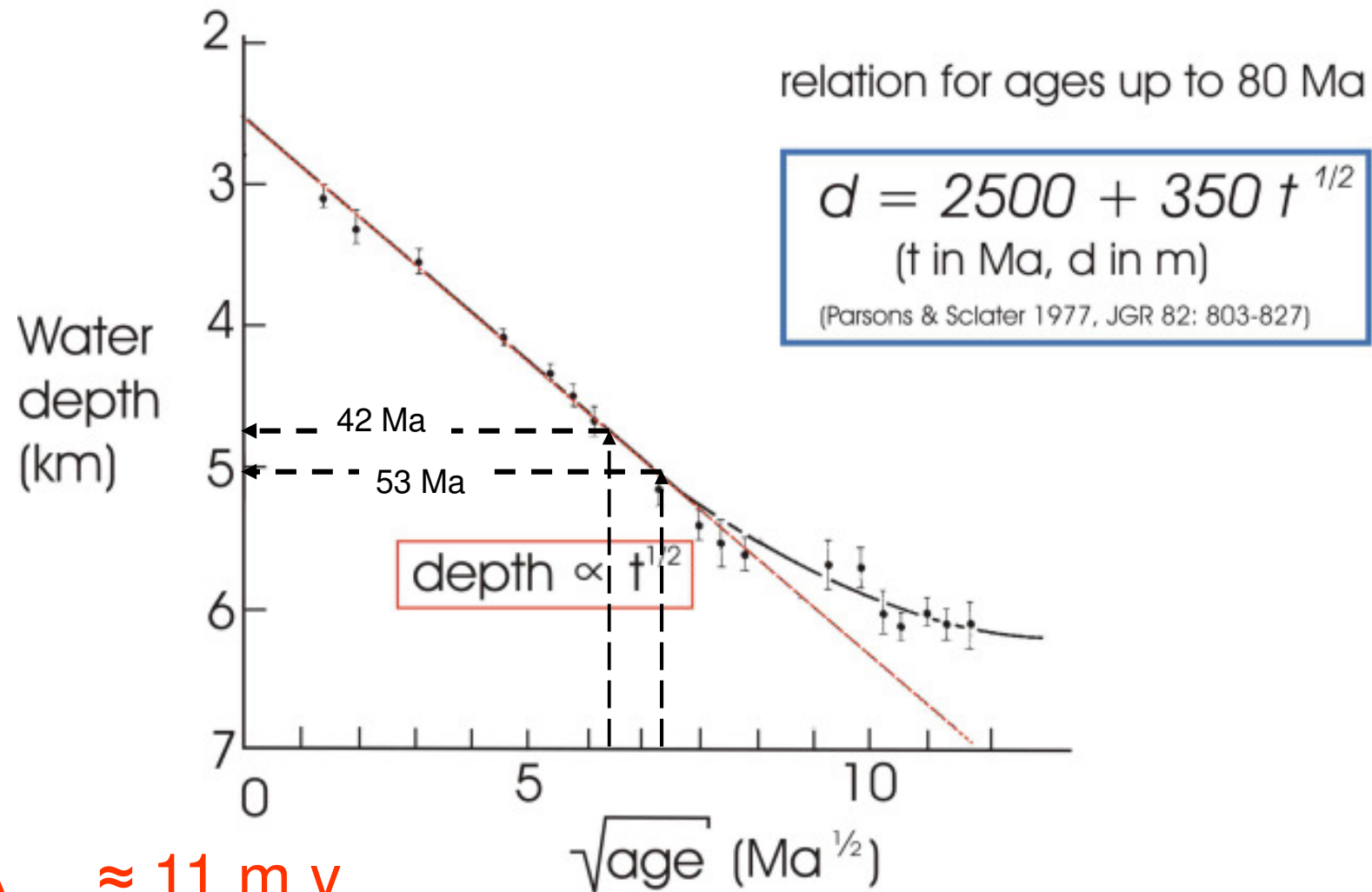
$$\Delta_{\text{age}} \approx 11 \text{ m.y.}$$

$$\Delta d \approx 1.2 \text{ km}$$

newly formed

from: Bott M.H.P. (1982) The interior of the Earth (Arnold)

Ocean depth and age of oceanic lithosphere



$$\Delta_{\text{age}} \approx 11 \text{ m.y.}$$

$$\Delta d \approx 0.3 \text{ km}$$

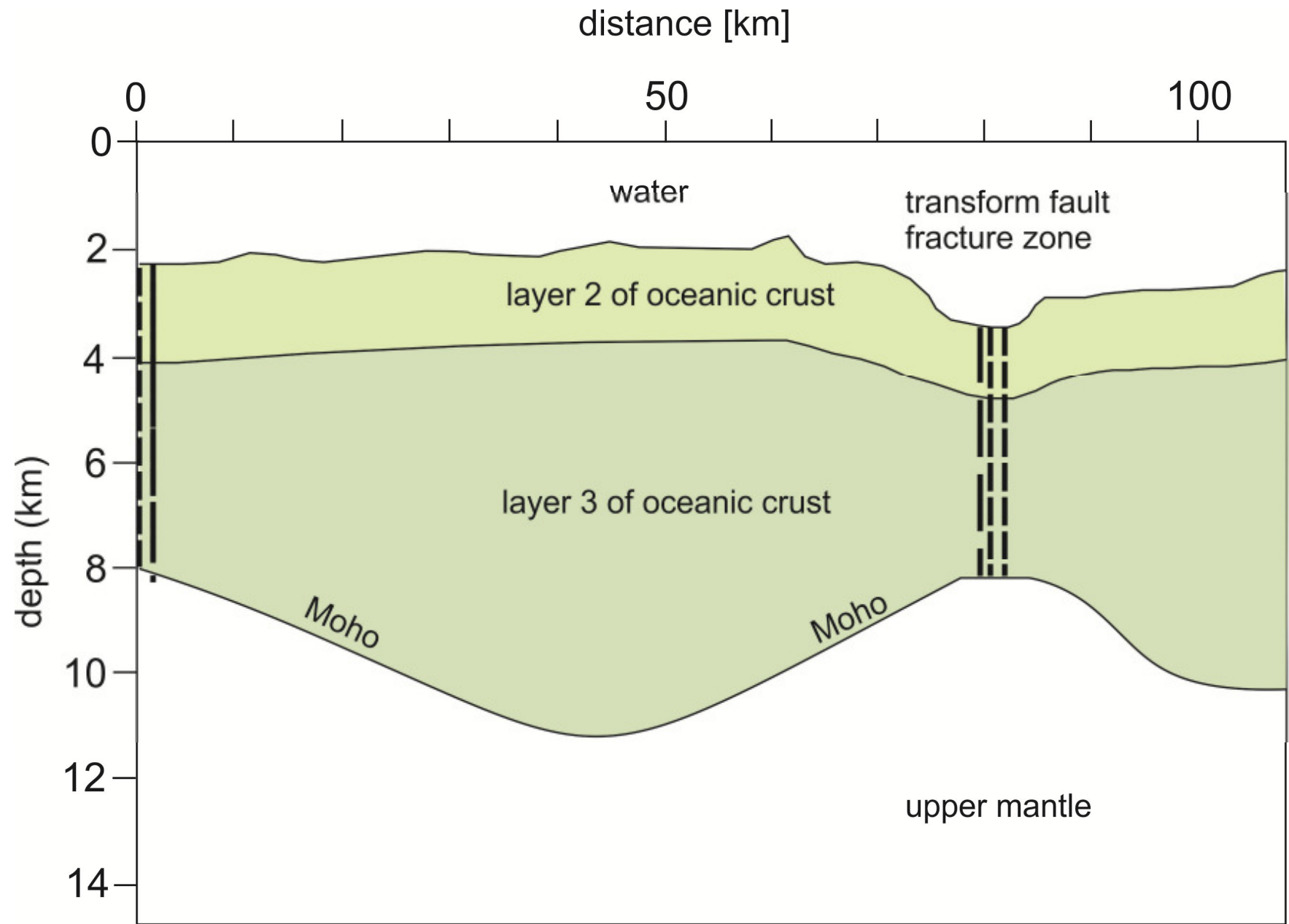
42 vs. 53 Ma

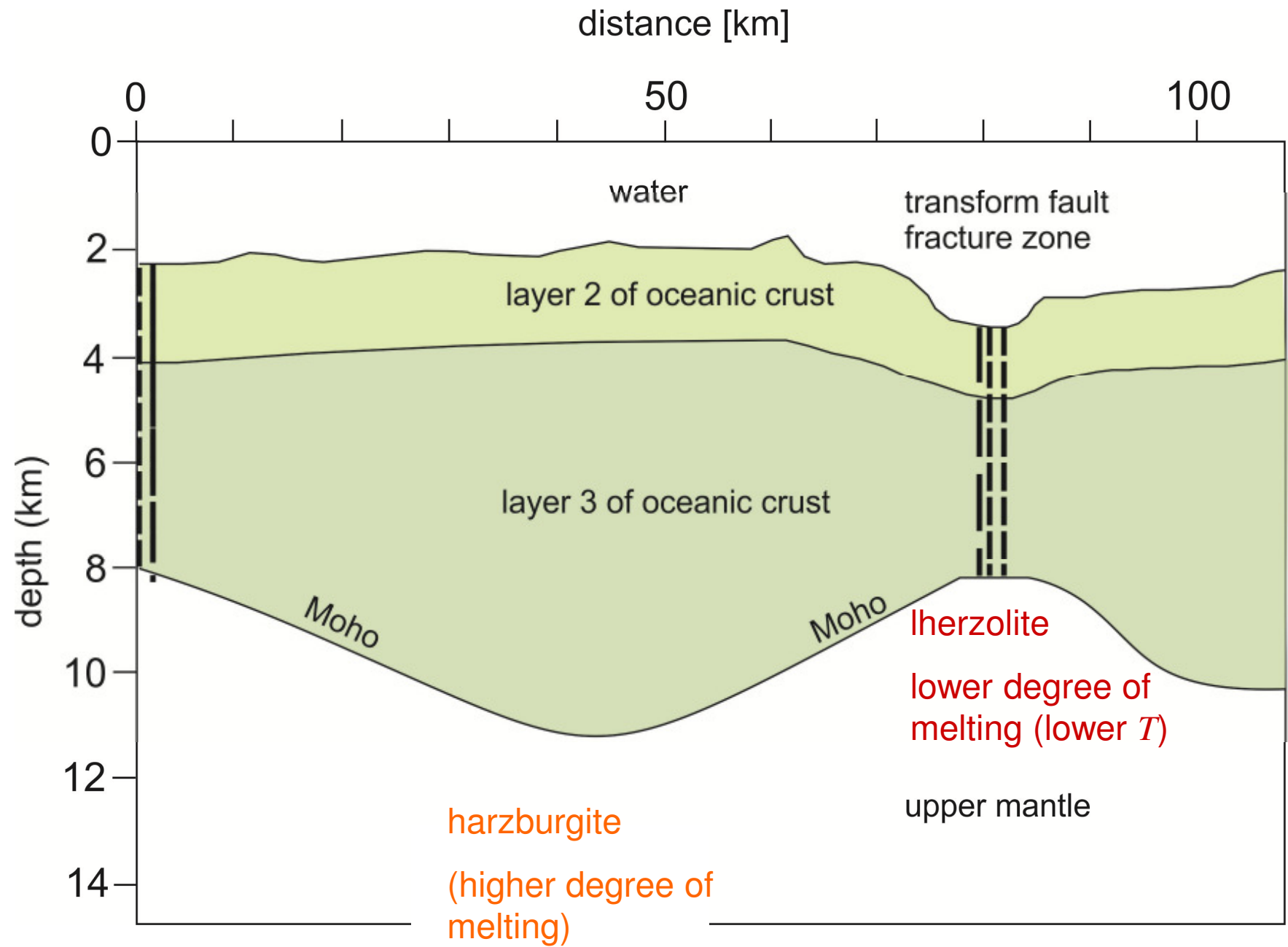
from: Bott M.H.P. (1982) The interior of the Earth (Arnold)

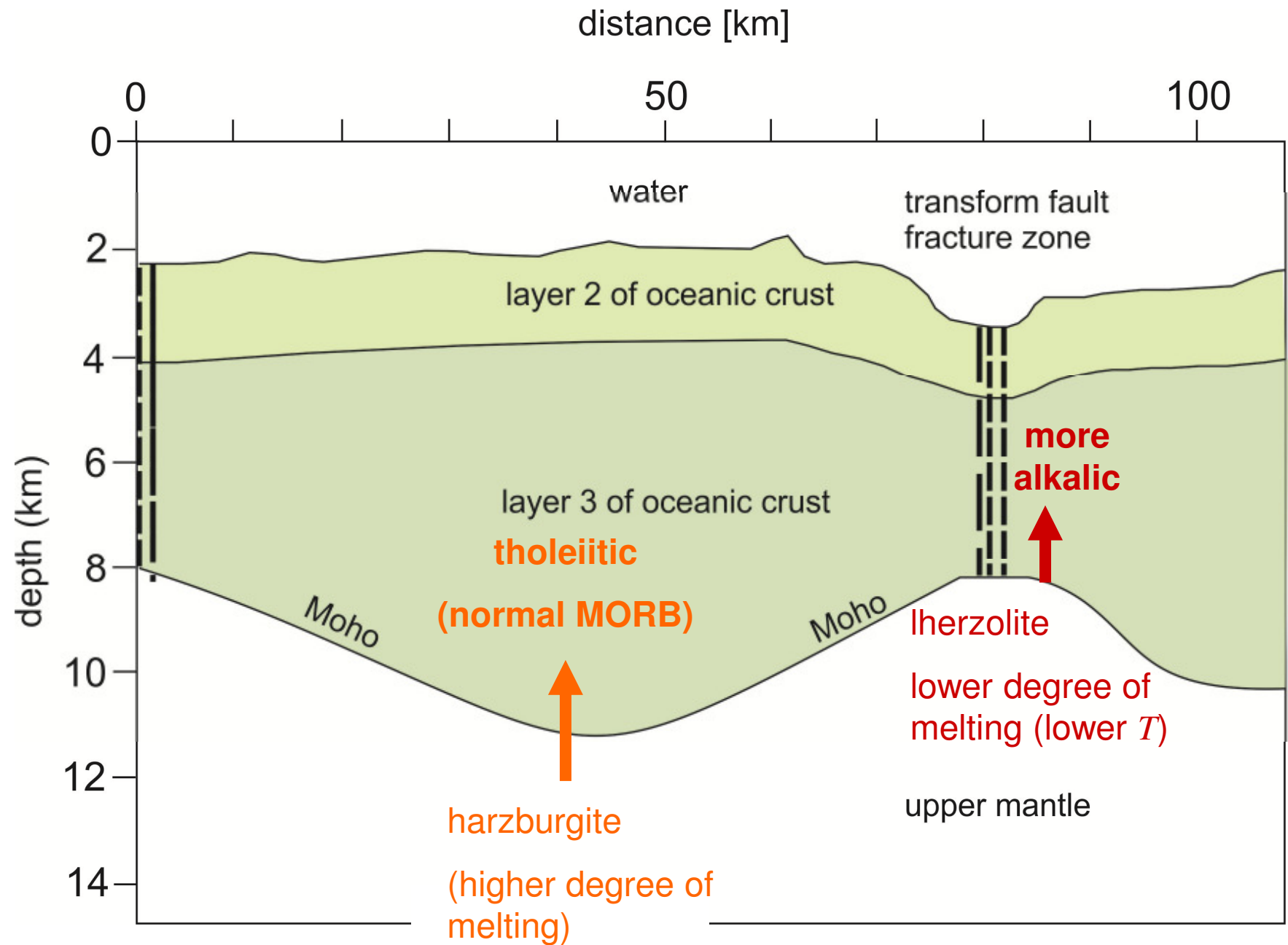
age contrast - depth contrast

- For the same reason (cool lithosphere opposite to active MOR at RTI) the degree of partial melting is low near RTI

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- Low degree of melting means thin oceanic crust



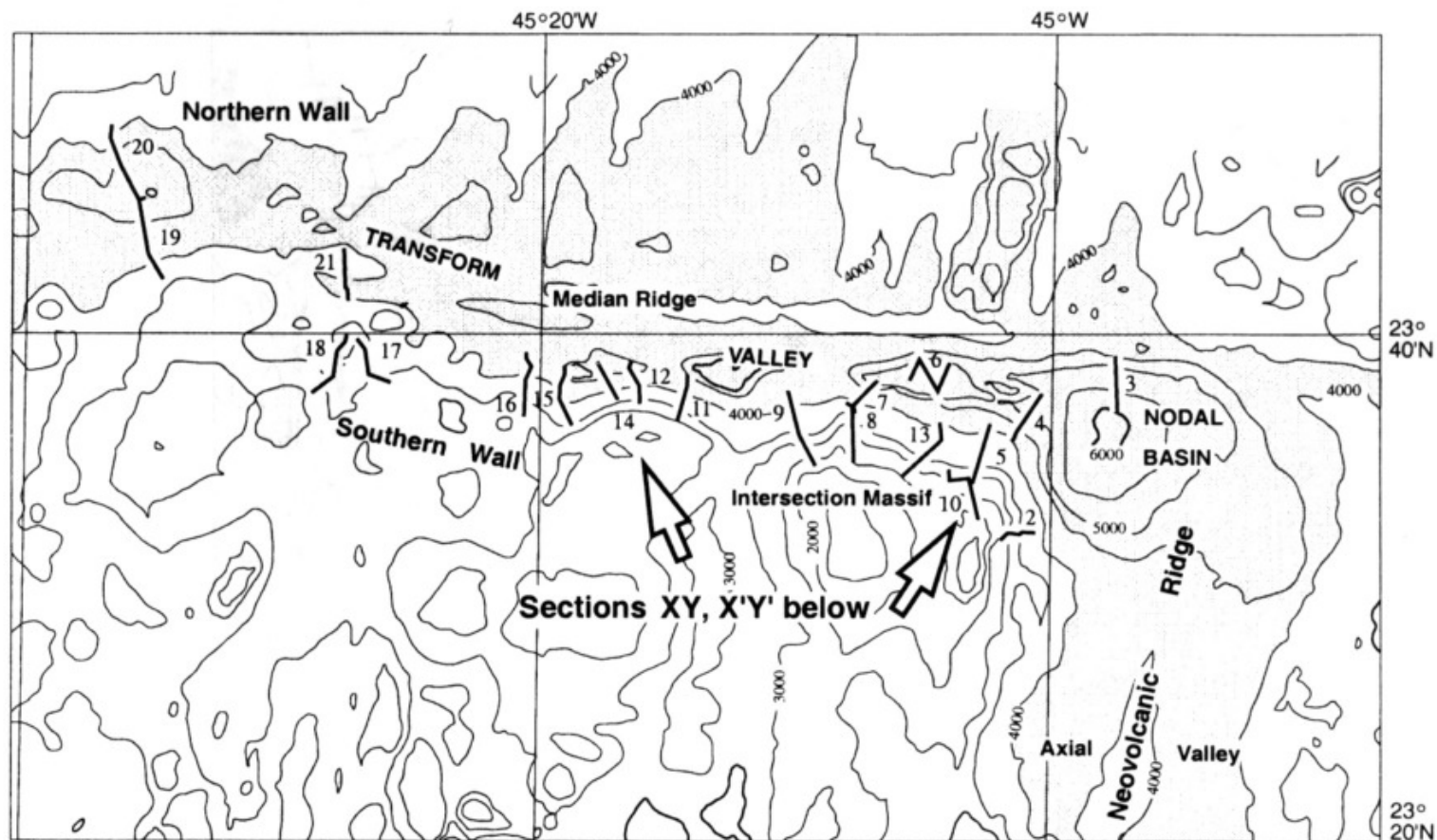




- For the same reason (cool lithosphere opposite to active MOR at RTI) the degree of partial melting is low near RTI
- Low degree of melting implies thin oceanic crust
- Low degree of melting implies **residual lherzolite** (instead of harzburgite) and **more alkalic** (instead of tholeiitic) basalt composition

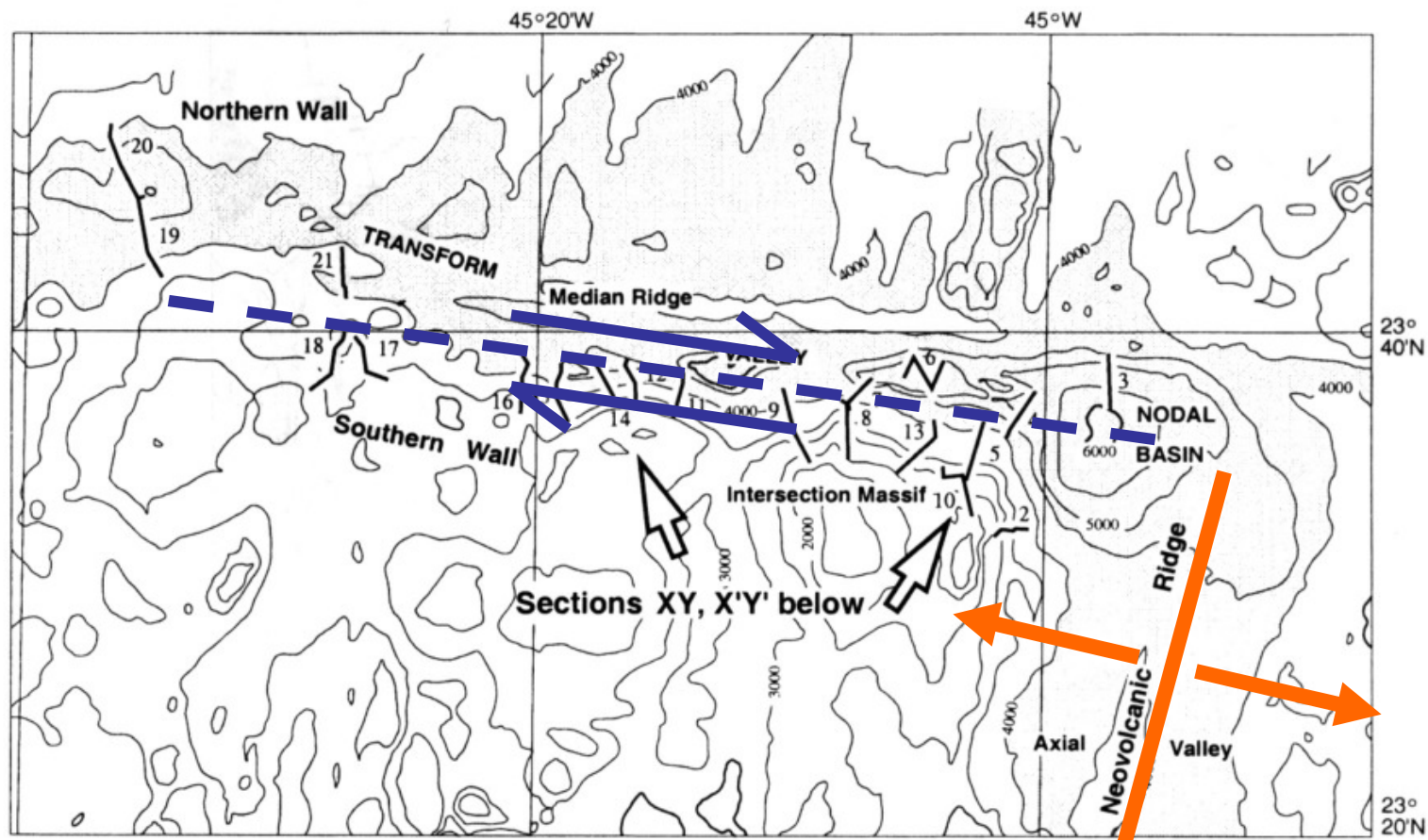
Geological mapping at Kane Fracture Zone (MAR 23° 40'N)

Lagabrielle et al. (1998) Geophysical Monograph 106: 153-176



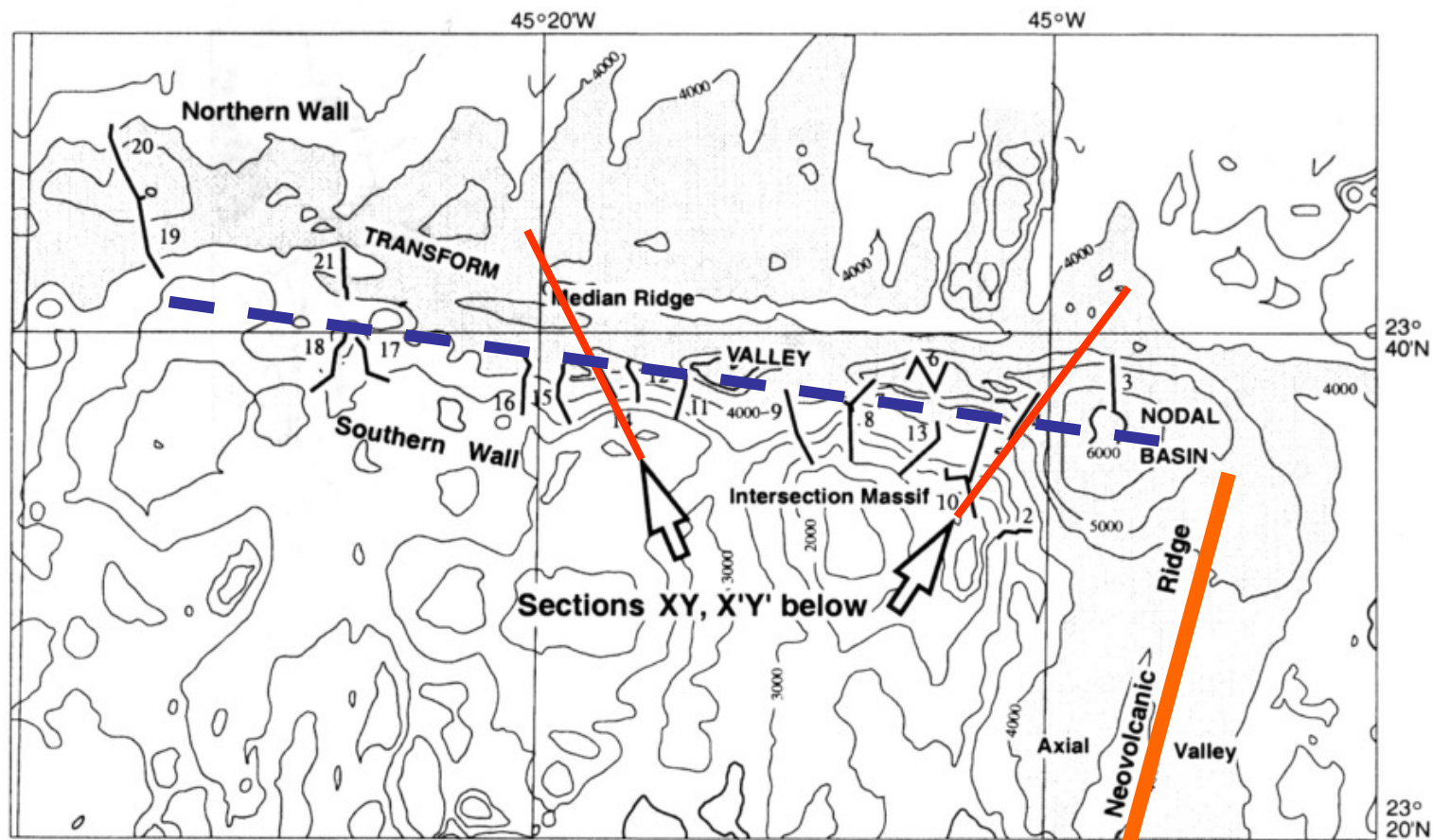
Geological mapping at Kane Fracture Zone (MAR 23° 40'N)

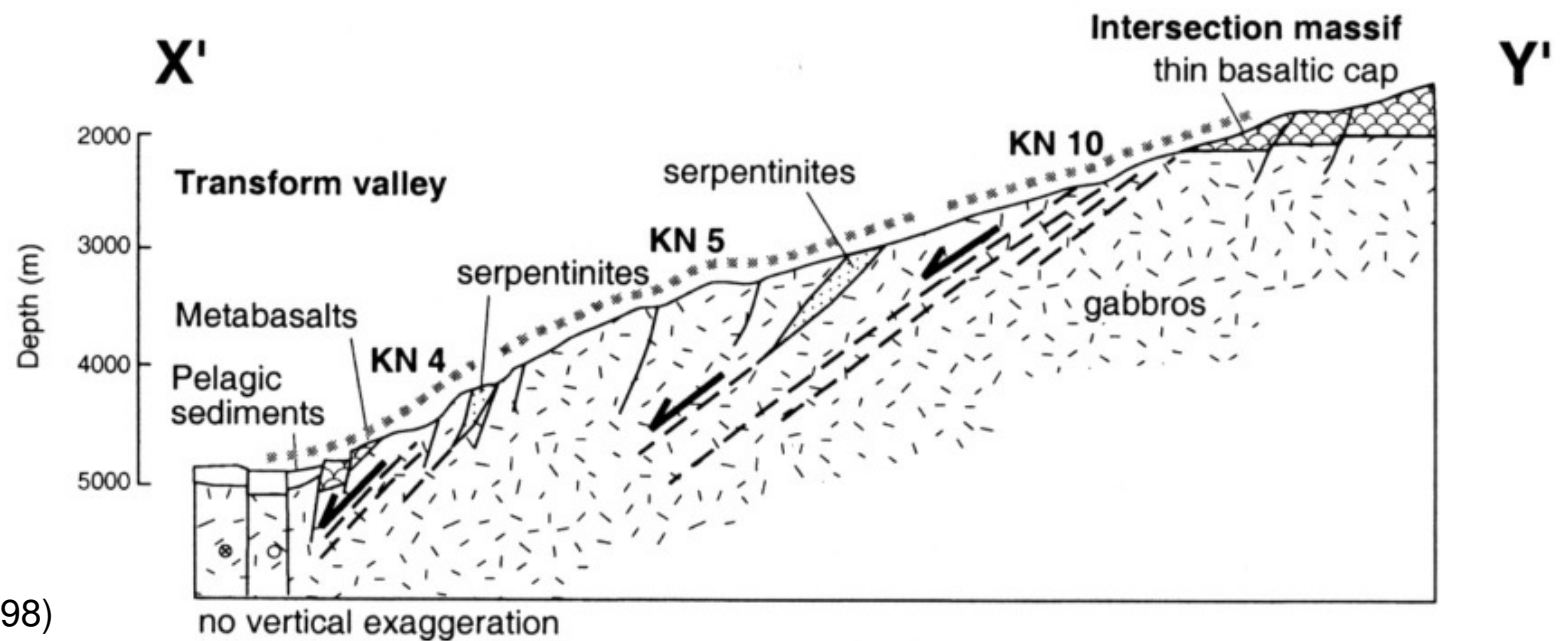
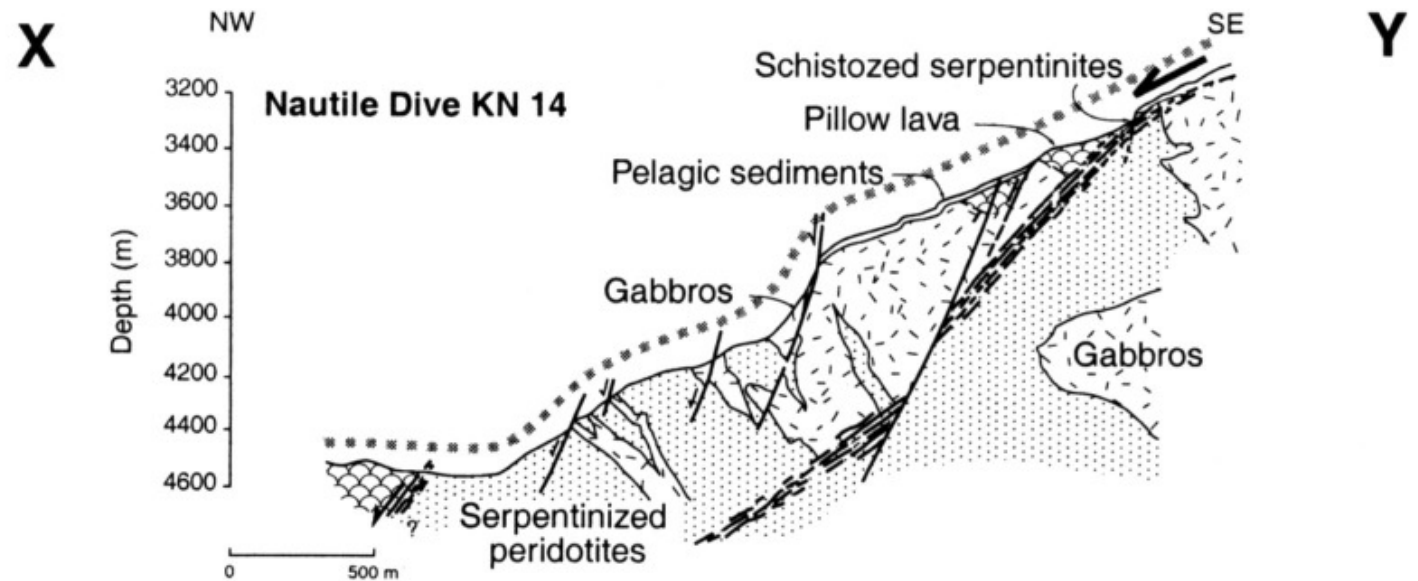
Lagabrielle et al. (1998) Geophysical Monograph 106: 153-176



Geological mapping at Kane Fracture Zone (MAR 23° 40'N)

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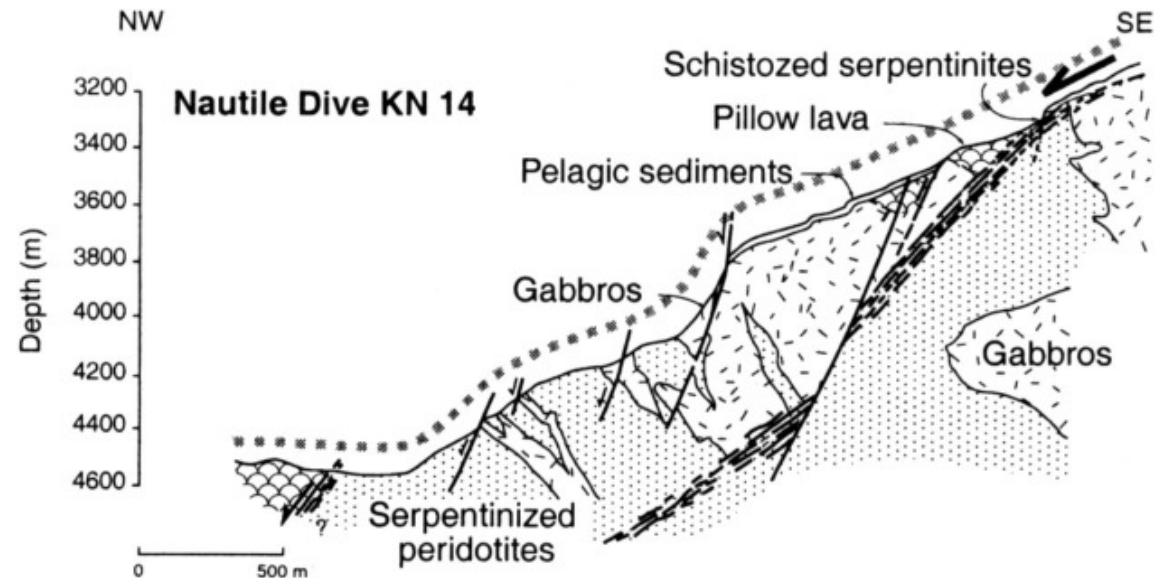




✓ main ductile shear zones * * * * * Track of Nautilé dive (Kanaut cruise, KN)

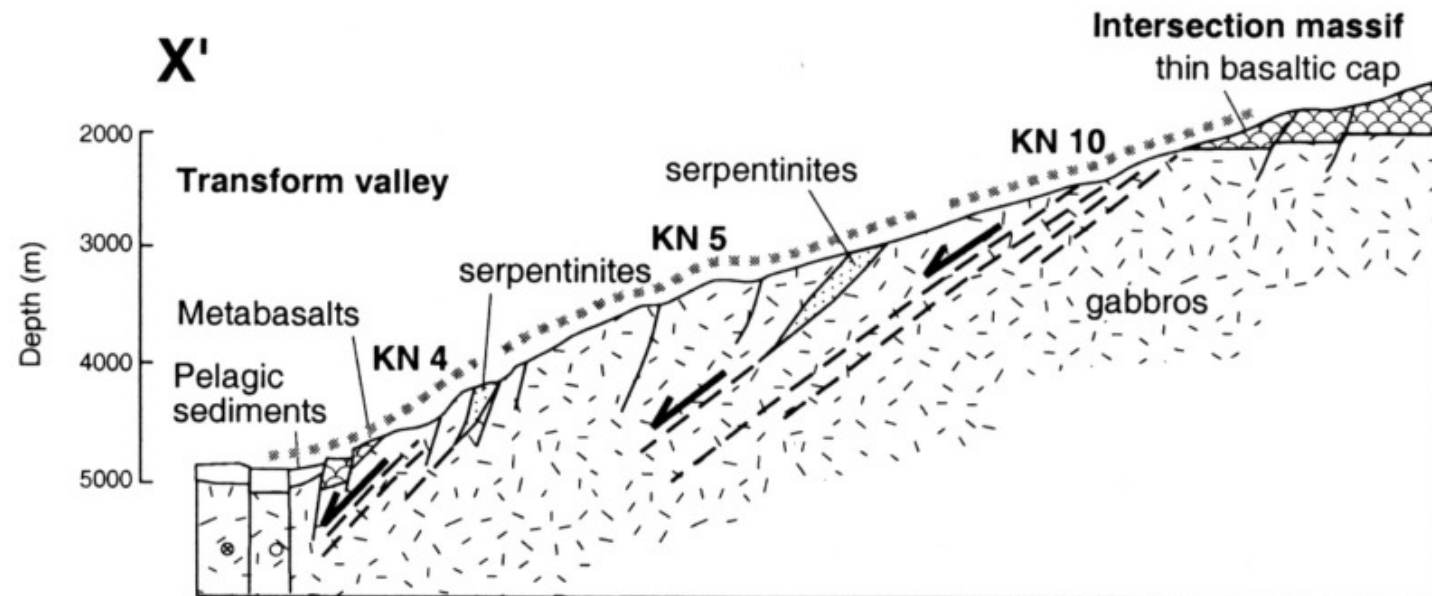
gabbro (layer 3)
and **serpentinized
peridotite** (mantle)
can be exposed at
the walls of the
transform valleys
(and along the
inactive OFZ)

X



Y

X'



Y'

Lagabrielle et al. (1998)
Geophysical Monograph
106: 153-176



main ductile shear zones



Track of Nautilé dive (Kanaul cruise, KN)

At transform faults the ocean floor can be composed of e.g.:

- gabbro (deformed)
- serpentinite (deformed; diapirs)
- peridotite (blocks in serpentinite)
- sedimentary breccia and oceanic mass flow deposits

At transform faults the ocean floor can be composed of e.g.:

- gabbro (deformed)
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What about a field trip to inspect such rock associations?

Example: Ophiolites of uppermost tectonic unit on Crete

Kedros



Image: B. Stöckhert

a possible fossil transform fault rock association



Image: B. Stöckert

a possible fossil transform fault rock association

brecciated serpentinite

Image: B. Stöckert

brecciated serpentinite



Image: B. Stöckhert

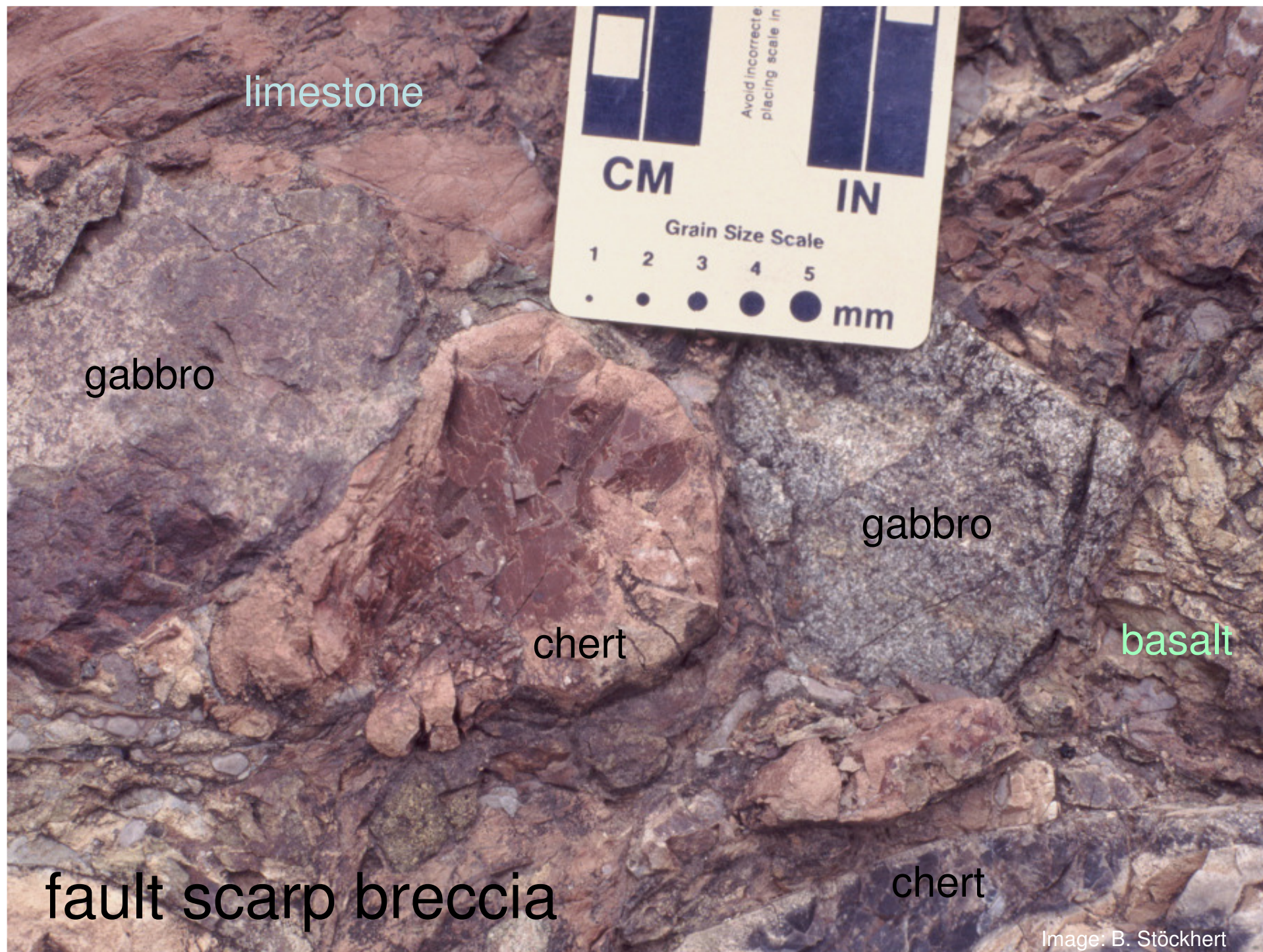
brecciated gabbro



Image: B. Stöckhert



fault scarp breccia



limestone

gabbro

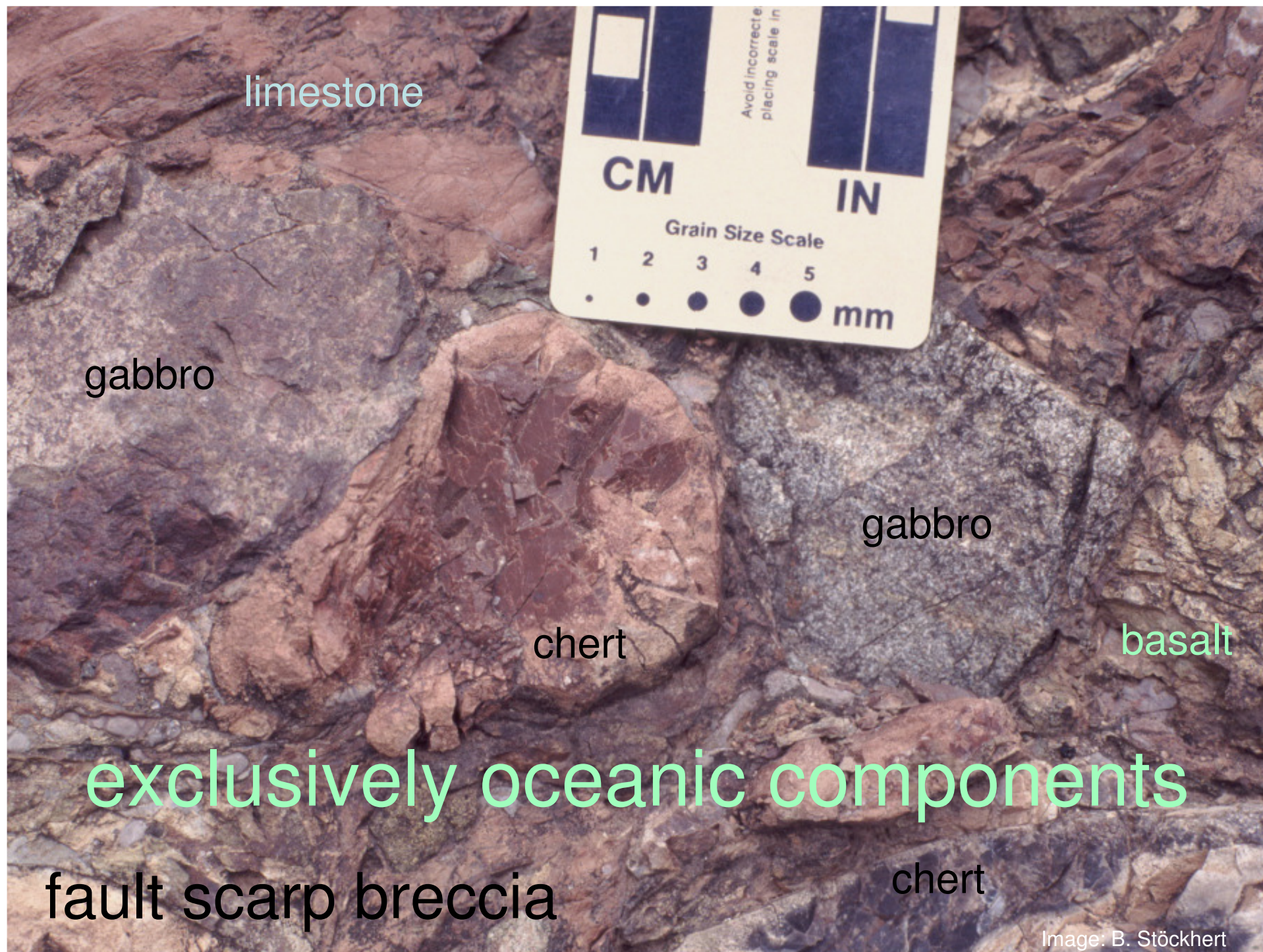
chert

gabbro

basalt

fault scarp breccia

chert



limestone

gabbro

chert

gabbro

basalt

exclusively oceanic components

fault scarp breccia

chert



Image: B. Stöckhert

Oceanic mass flow deposit

(deformed, metamorphic)

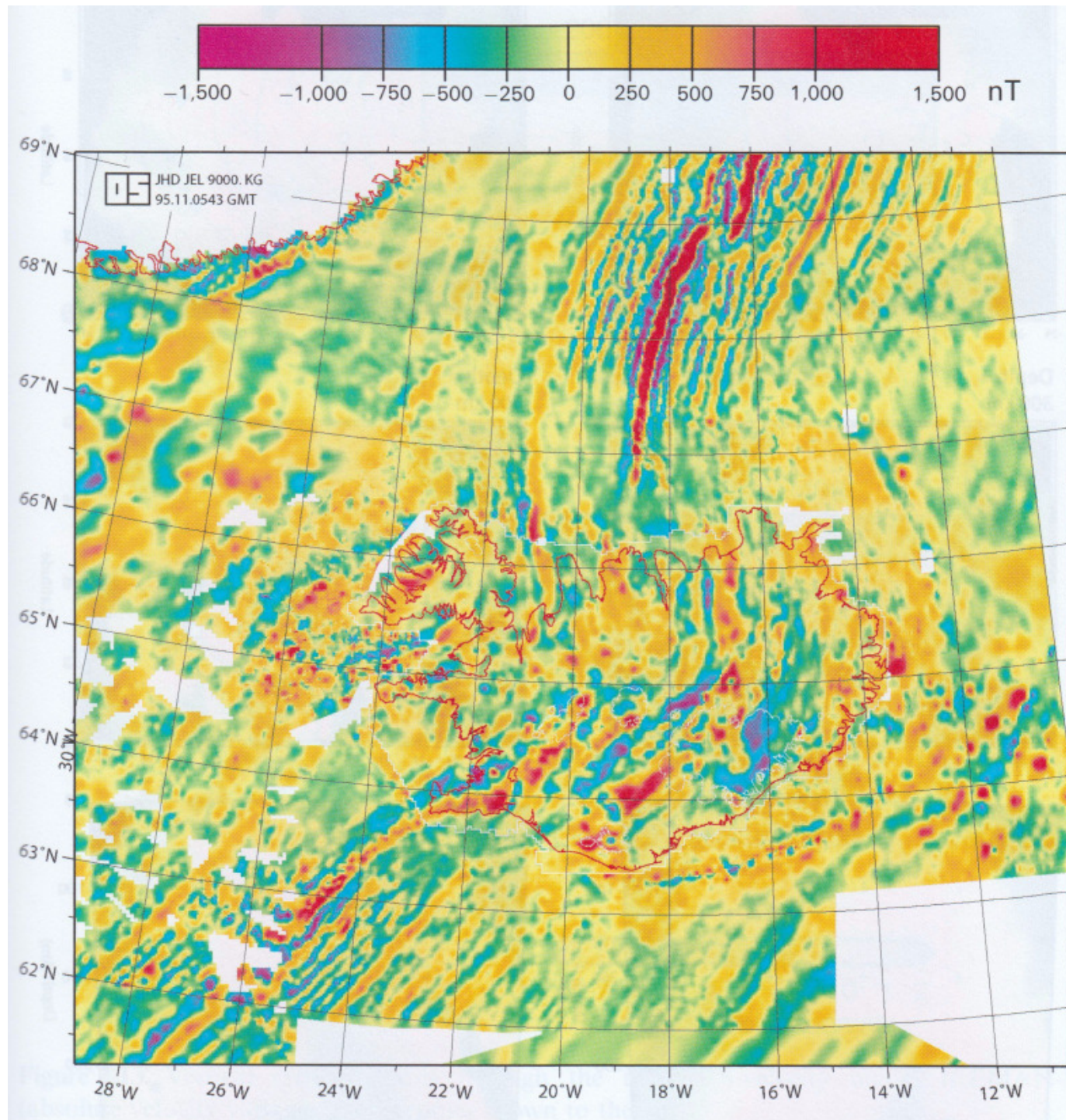
components:

- limestone
- chert
- basalt

deposited on serpentinite

Image: B. Stöckhert

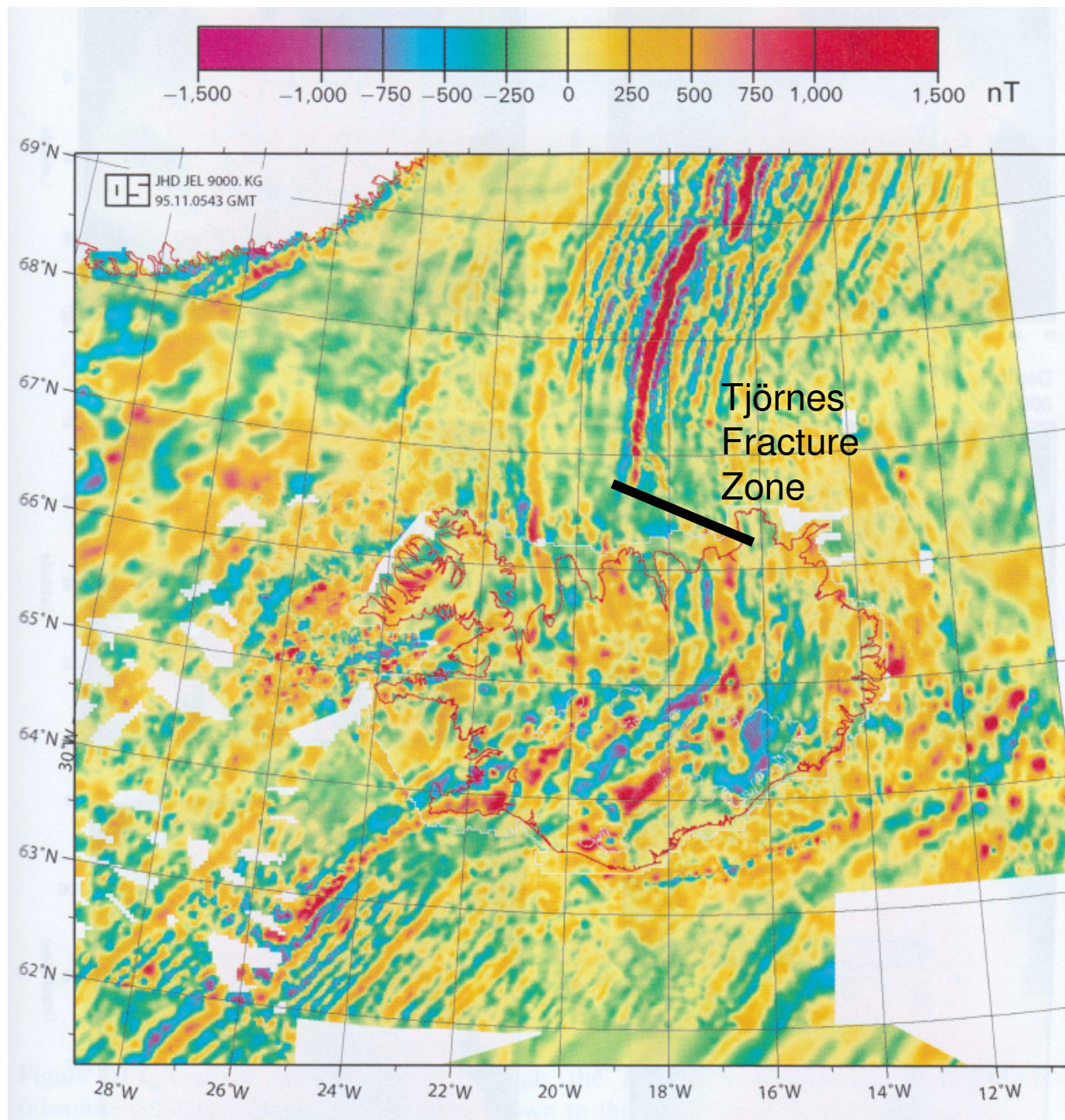
transform fault on Iceland



total
magnetic
field

from:

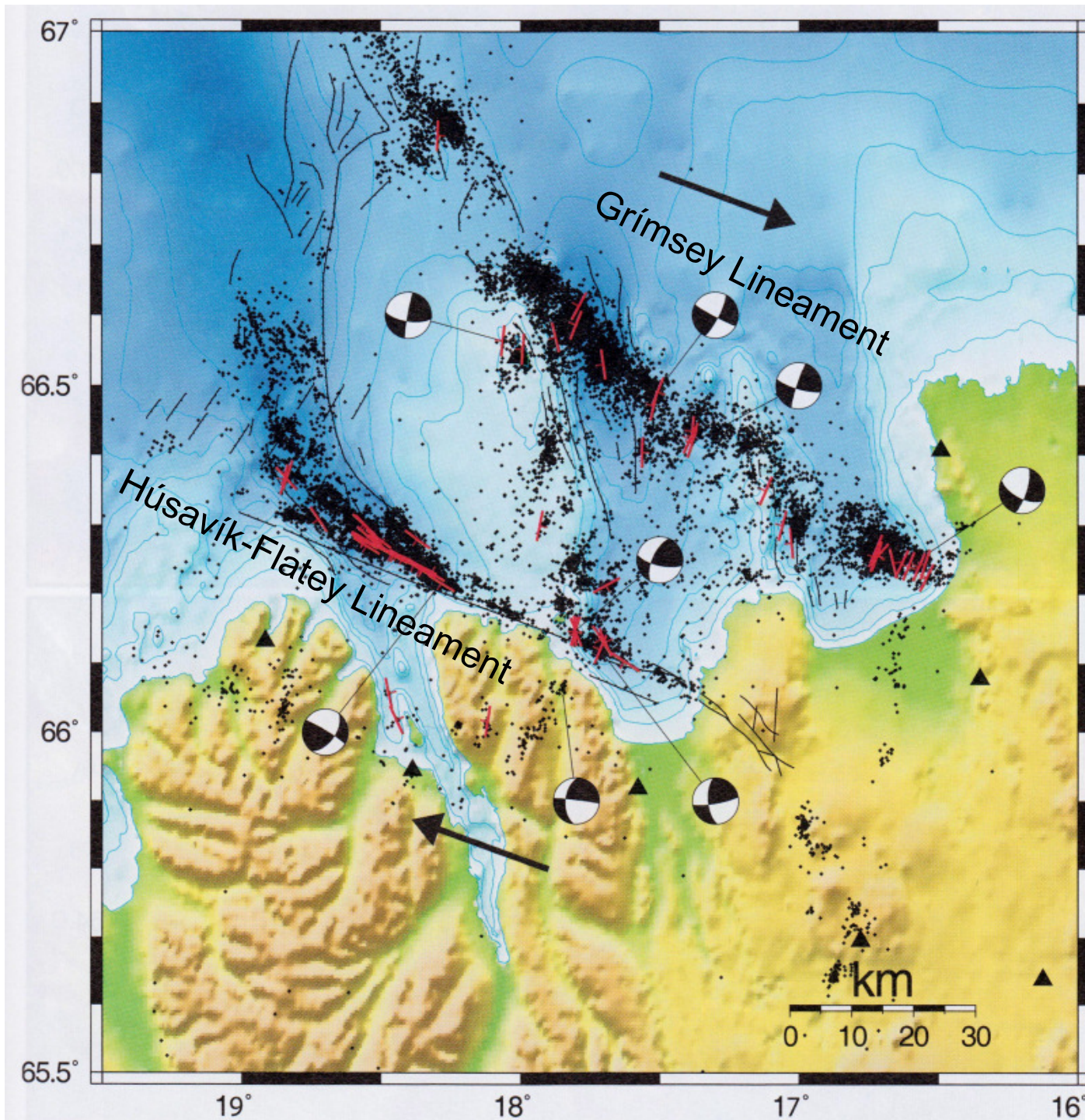
Sigmundsson F. (2006) Iceland
Geodynamics, 209 pp. (Springer)



total
magnetic
field

from:

Sigmundsson F. (2006) Iceland
Geodynamics, 209 pp. (Springer)

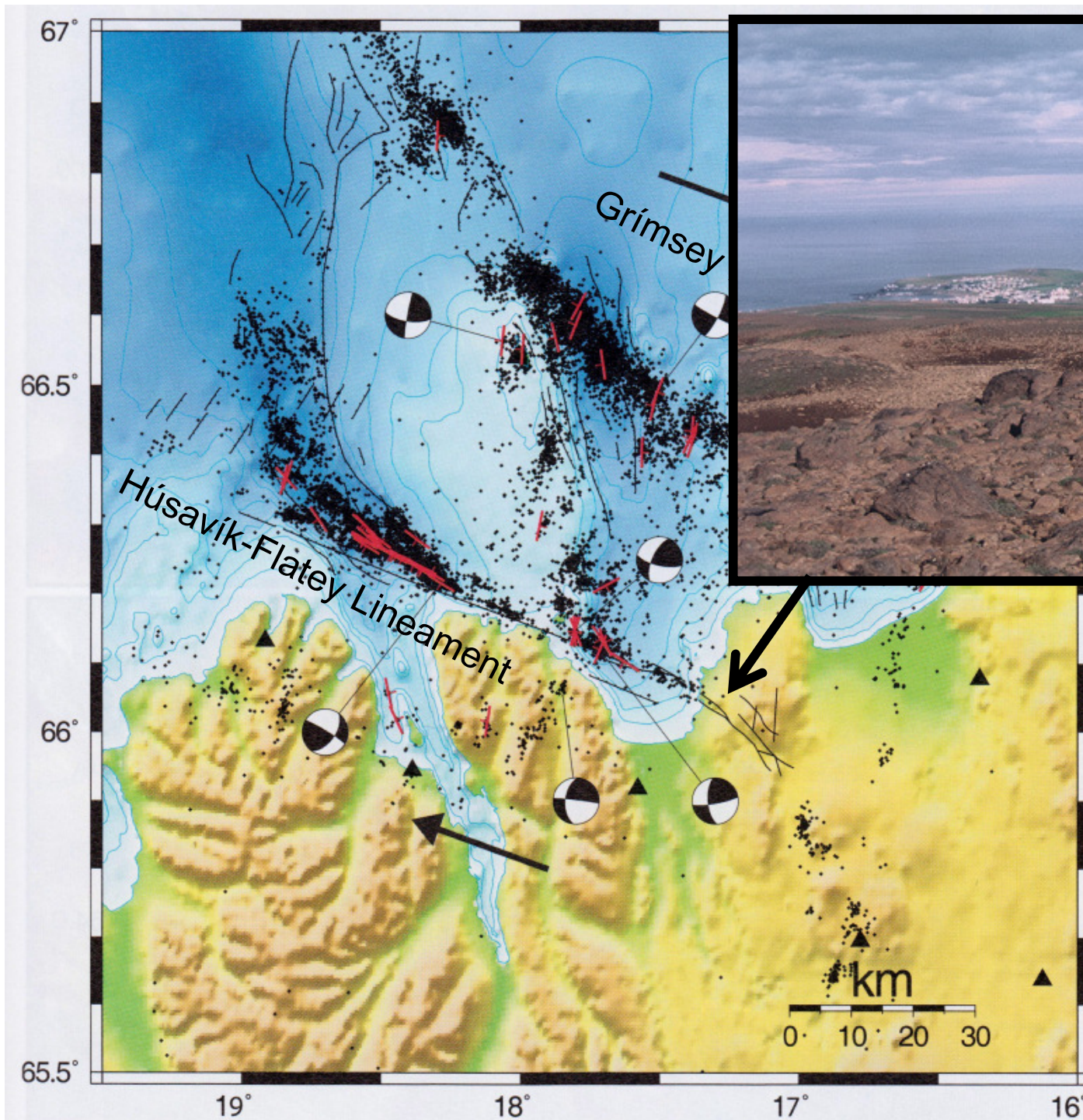


microseismicity

Tjörnes Fracture Zone

from:

Sigmundsson F. (2006) Iceland
Geodynamics, 209 pp. (Springer)



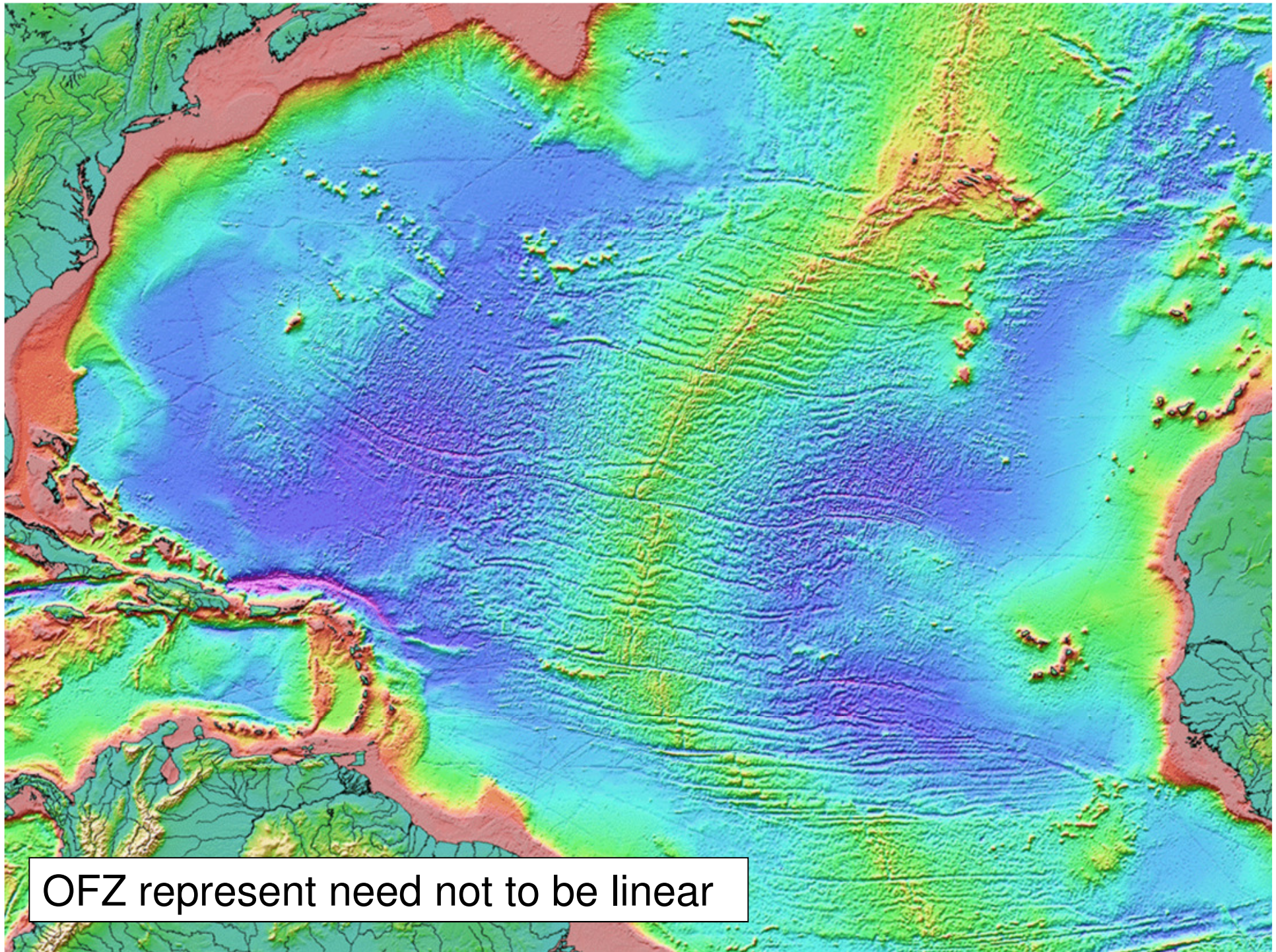
Húsavík fault (1400 m dip slip displacement)

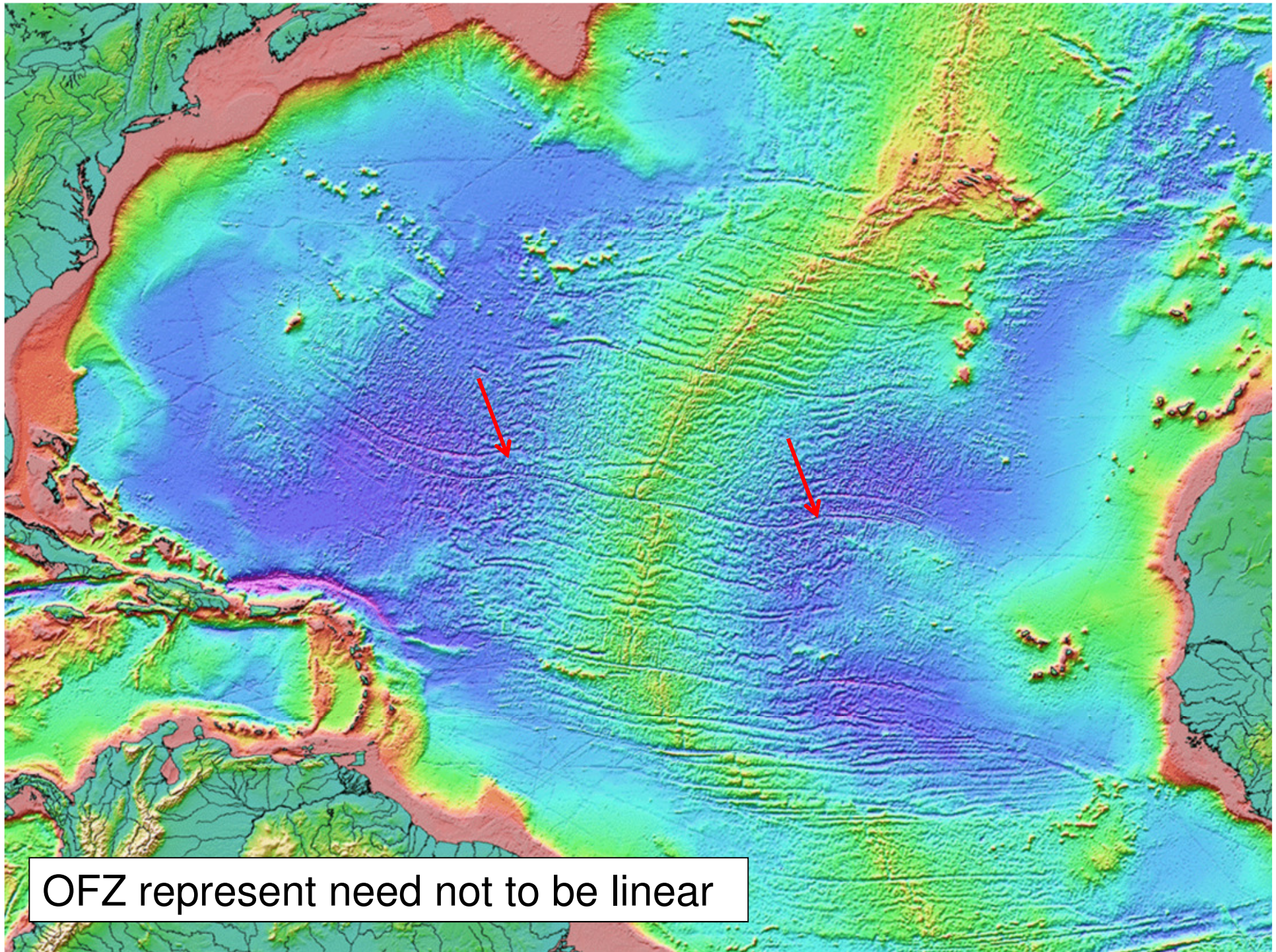
Grímsey Fracture Zone

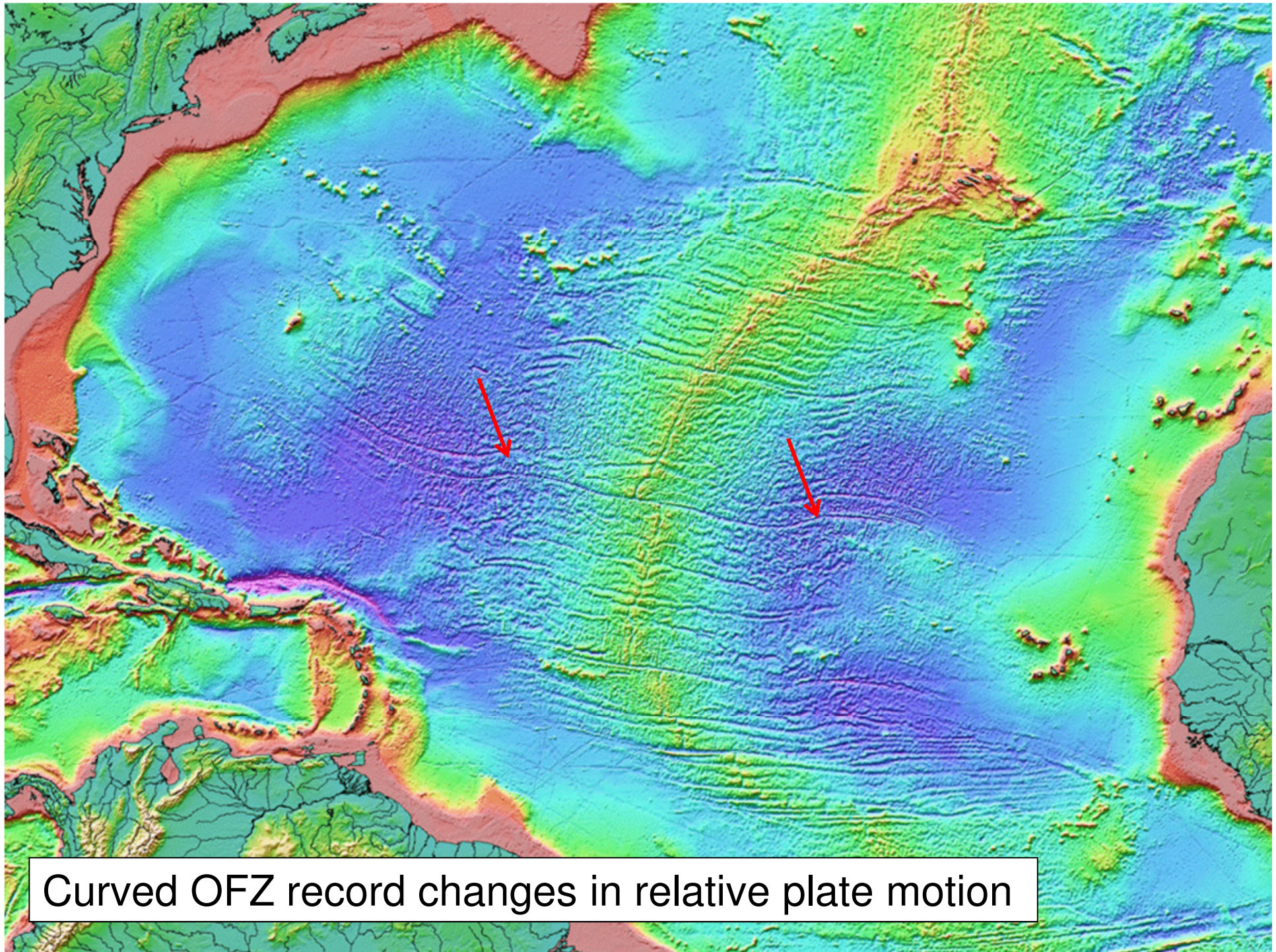
from:

Sigmundsson F. (2006) Iceland Geodynamics, 209 pp. (Springer)

transforms and history of plate motion

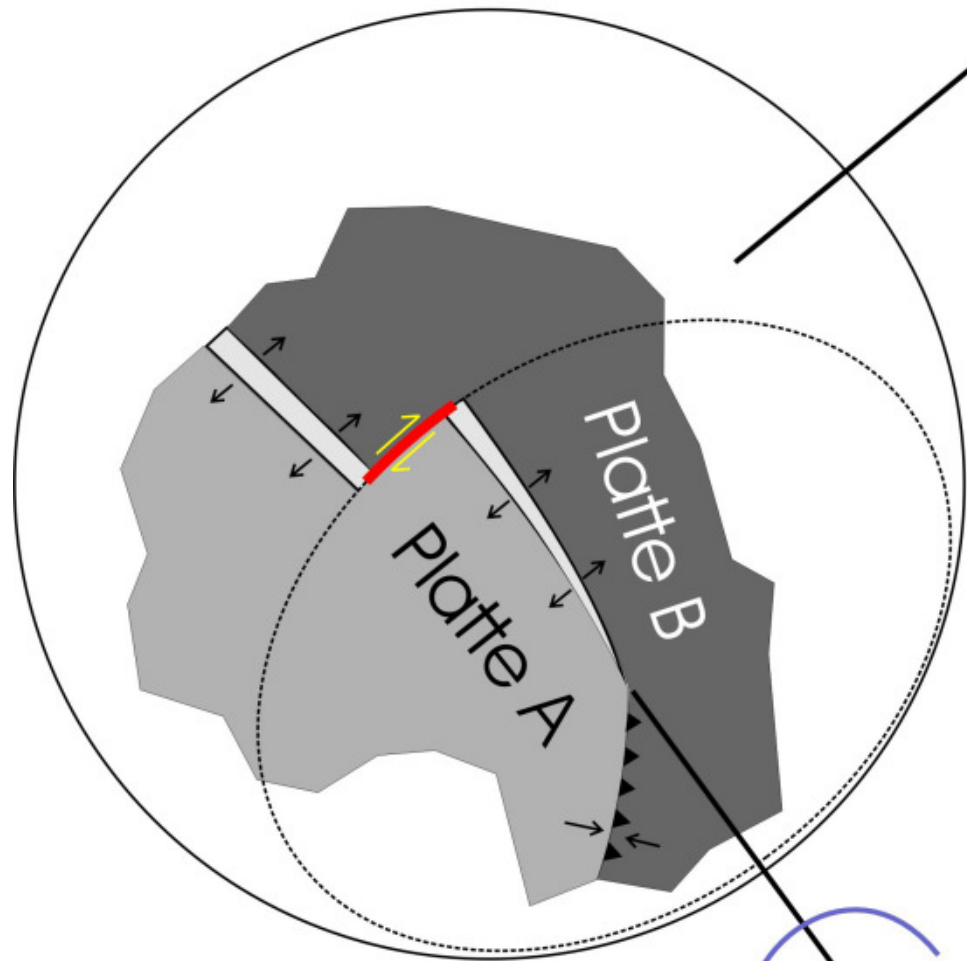






Curved OFZ record changes in relative plate motion

north pole (geographic)



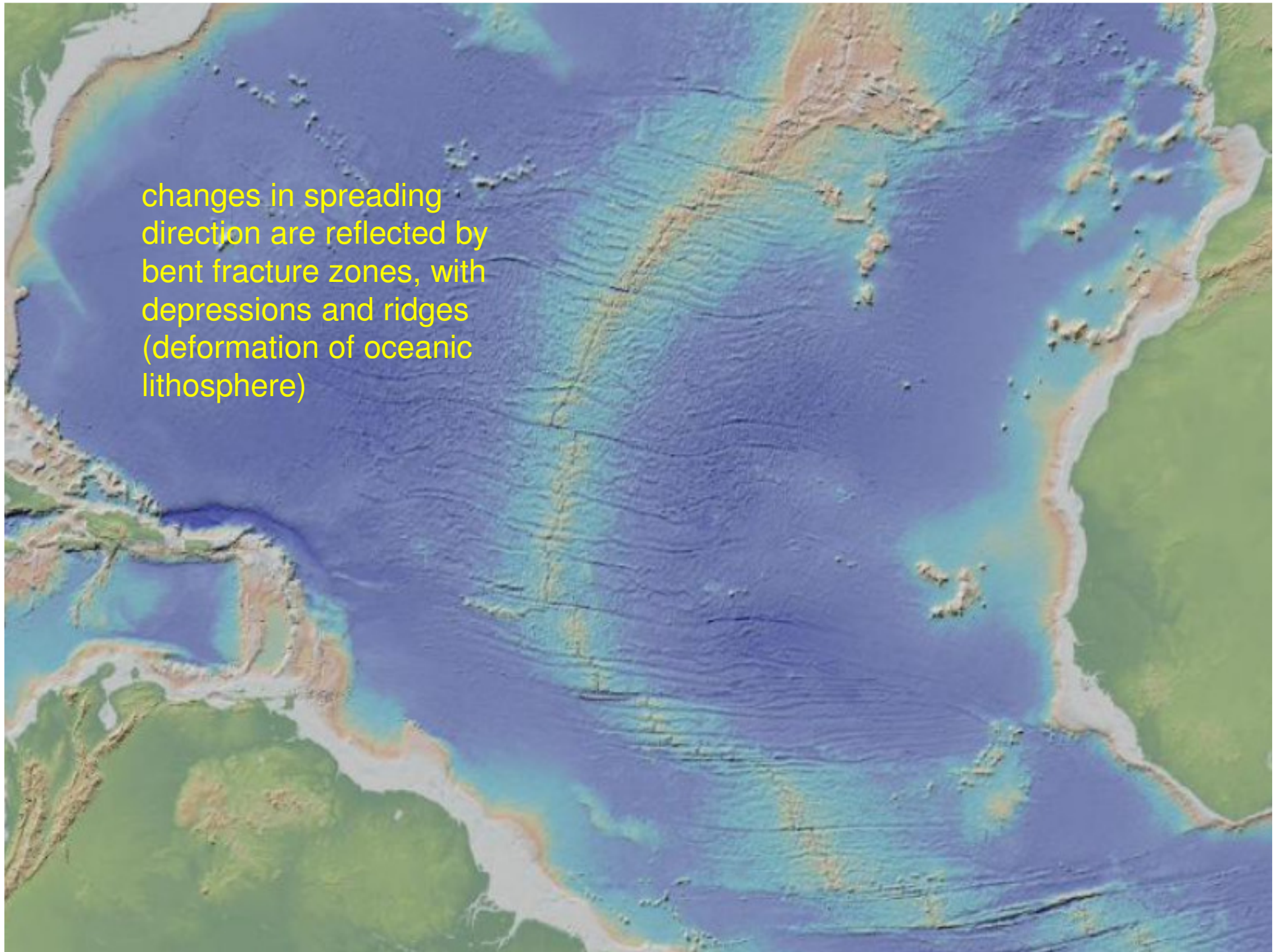
oceanic transform
(conservative plate boundary)

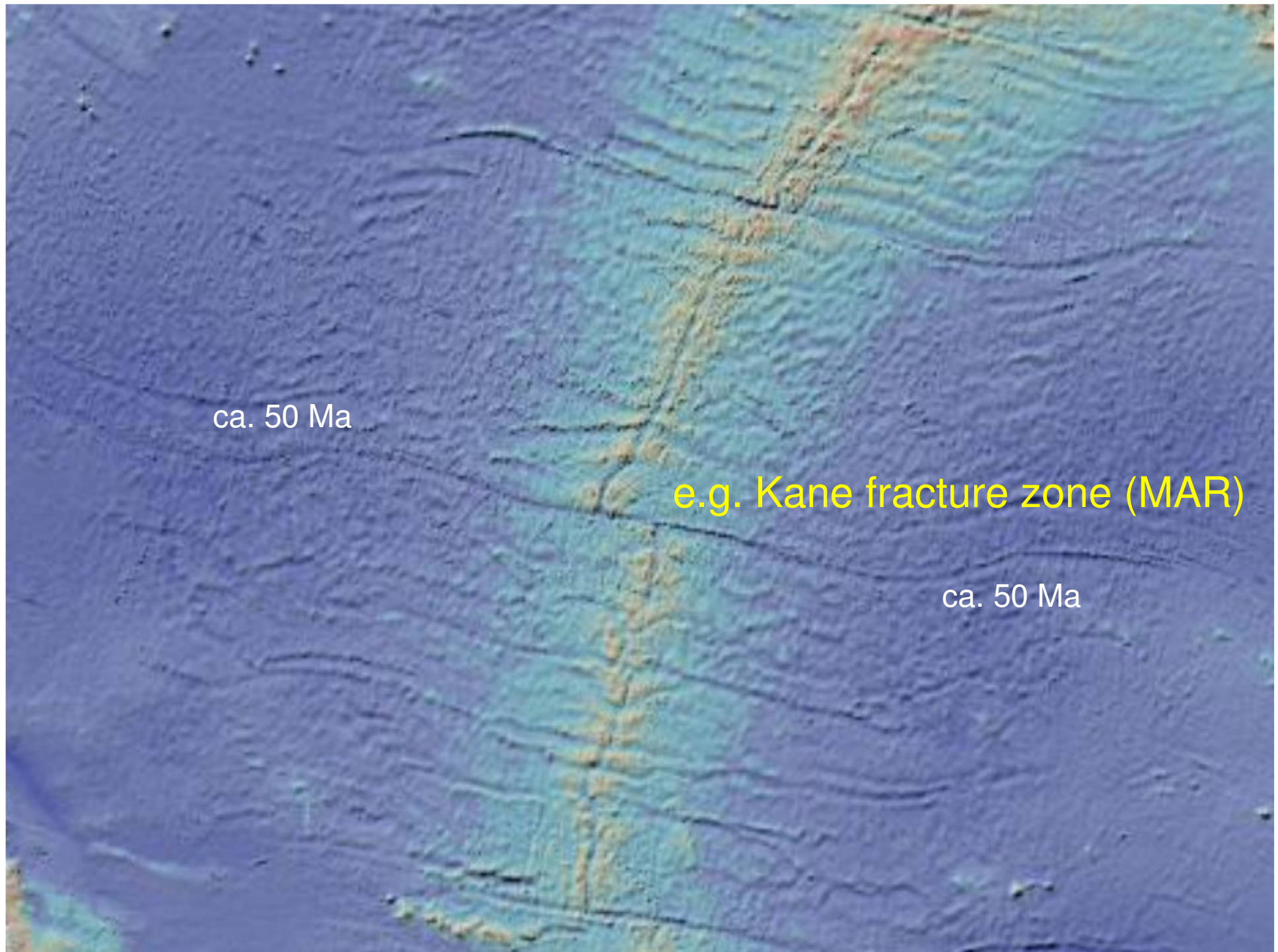
angular velocity ω

rotation pole

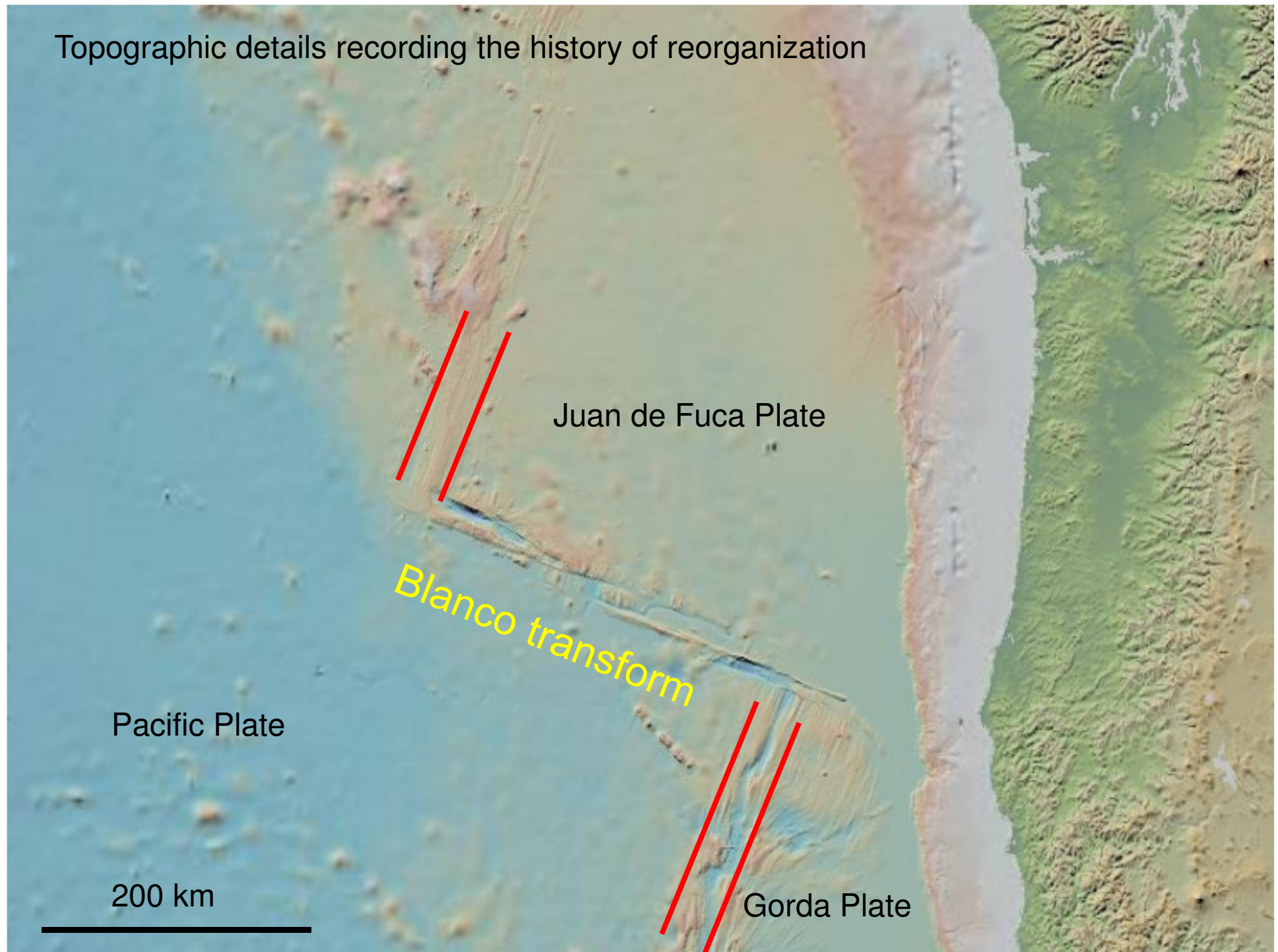
for relative motion between plates A and B

changes in spreading
direction are reflected by
bent fracture zones, with
depressions and ridges
(deformation of oceanic
lithosphere)





Topographic details recording the history of reorganization

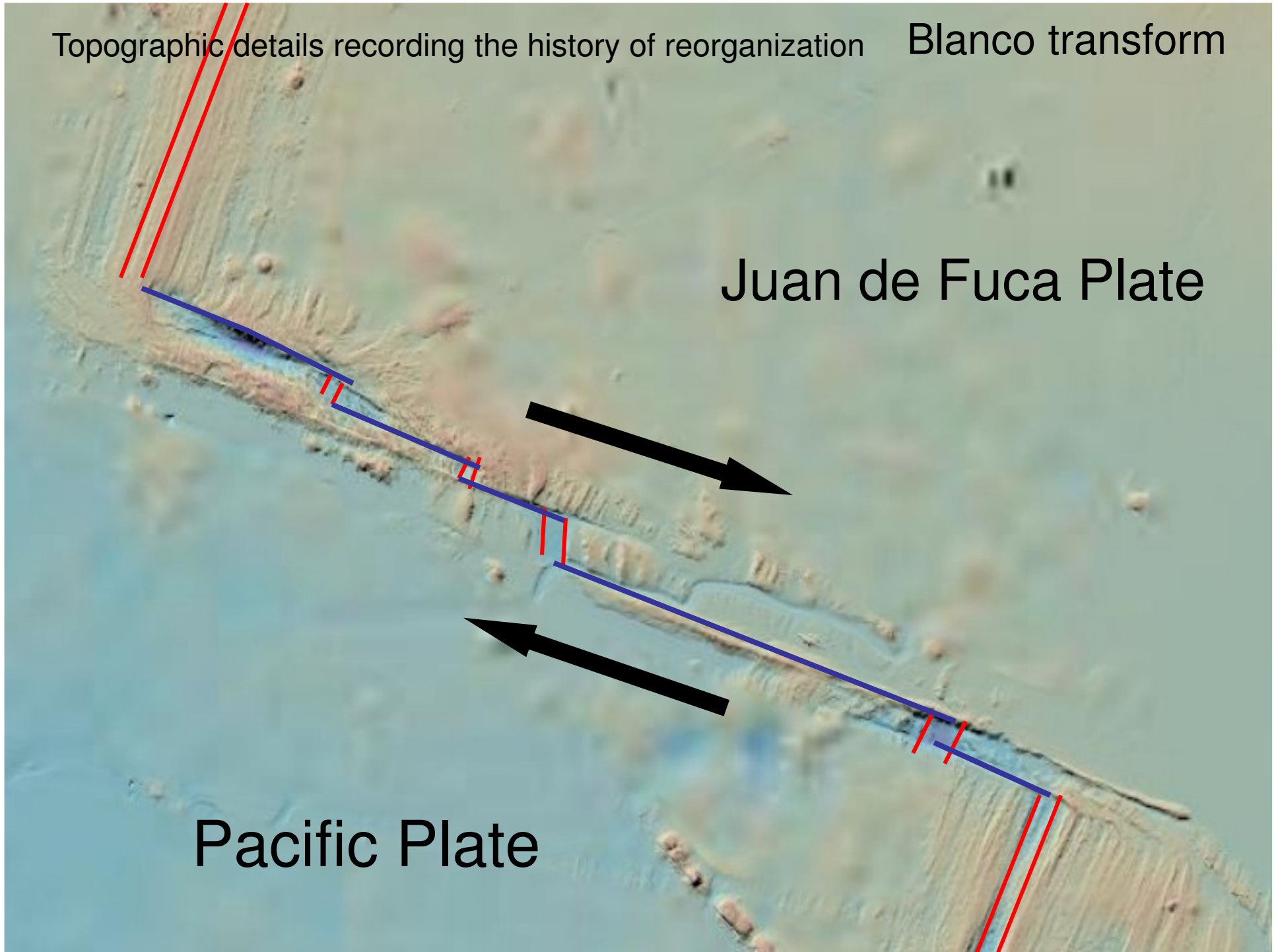


Topographic details recording the history of reorganization

Blanco transform

Juan de Fuca Plate

Pacific Plate



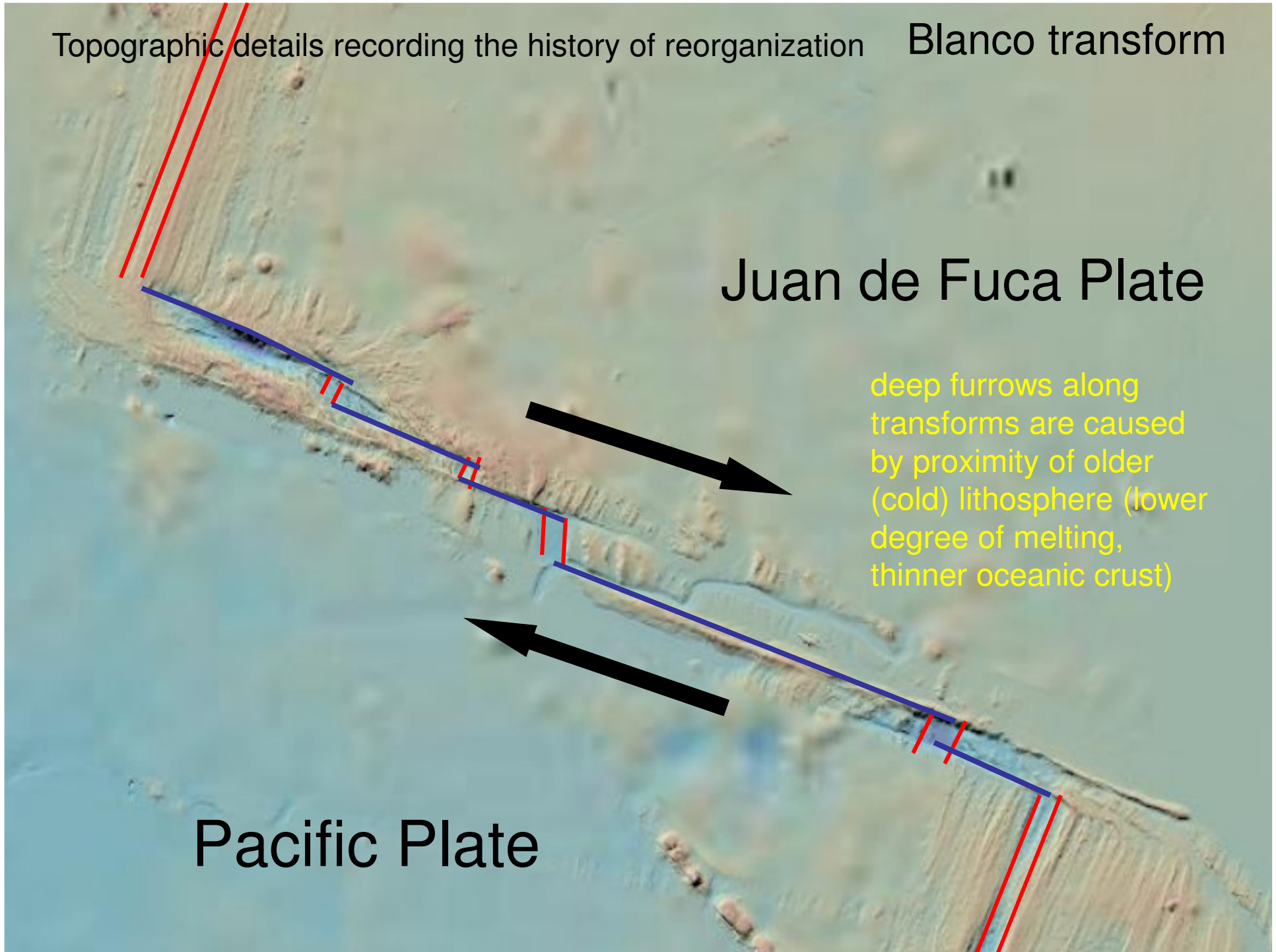
Topographic details recording the history of reorganization

Blanco transform

Juan de Fuca Plate

deep furrows along
transforms are caused
by proximity of older
(cold) lithosphere (lower
degree of melting,
thinner oceanic crust)

Pacific Plate



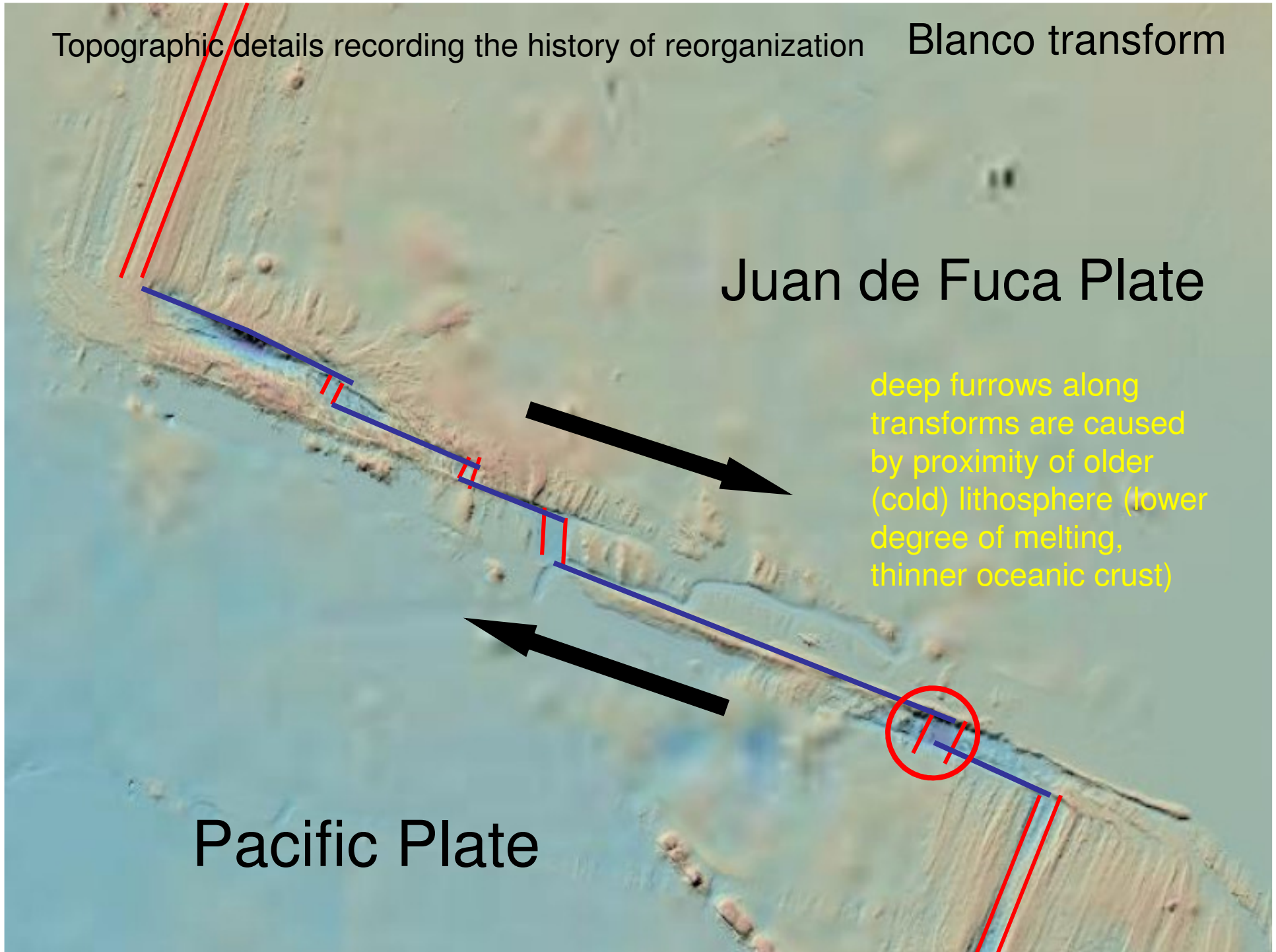
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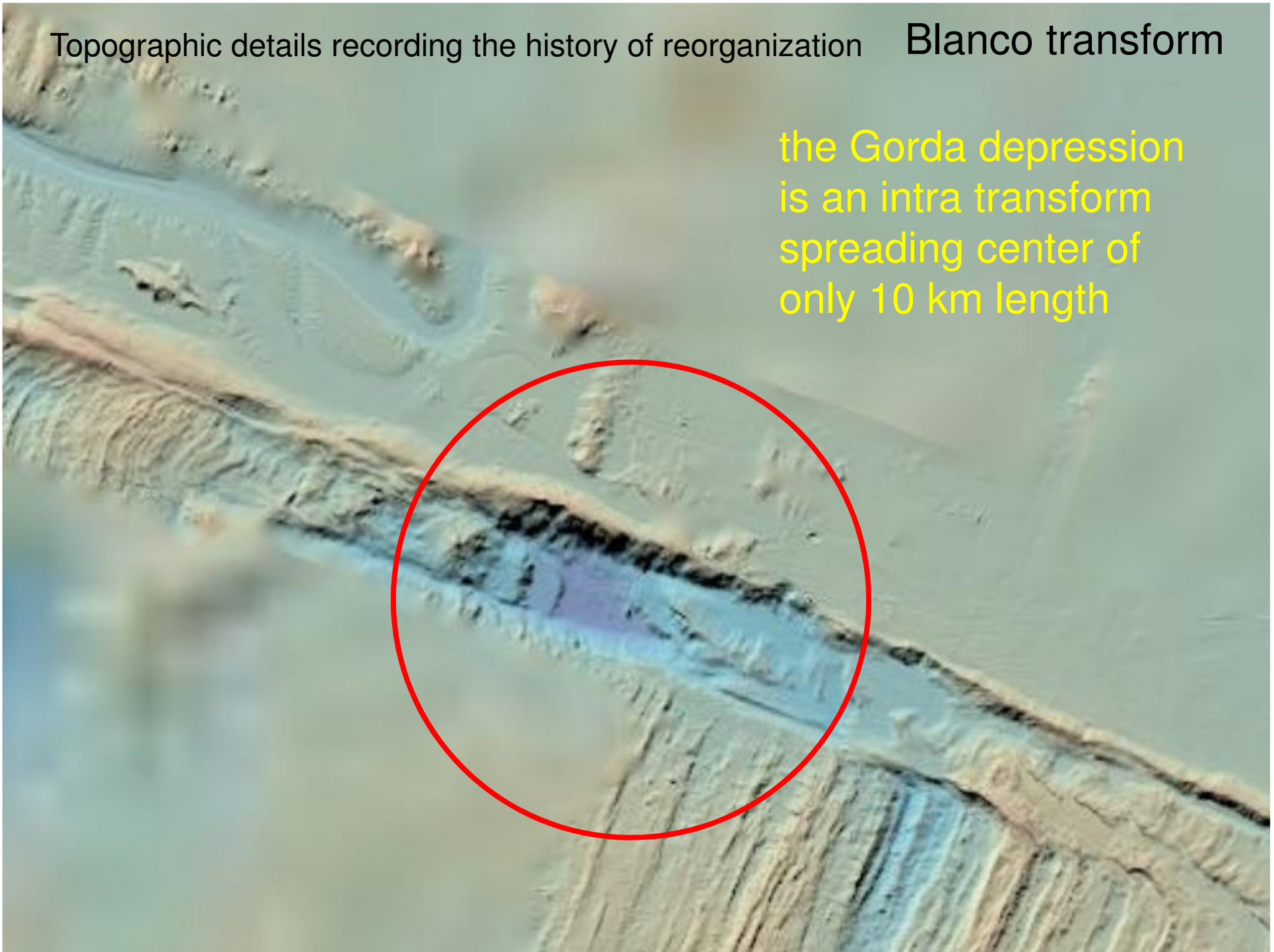
Pacific Plate



Topographic details recording the history of reorganization

Blanco transform

the Gorda depression
is an intra transform
spreading center of
only 10 km length



Topographic details recording the history of reorganization

Blanco transform

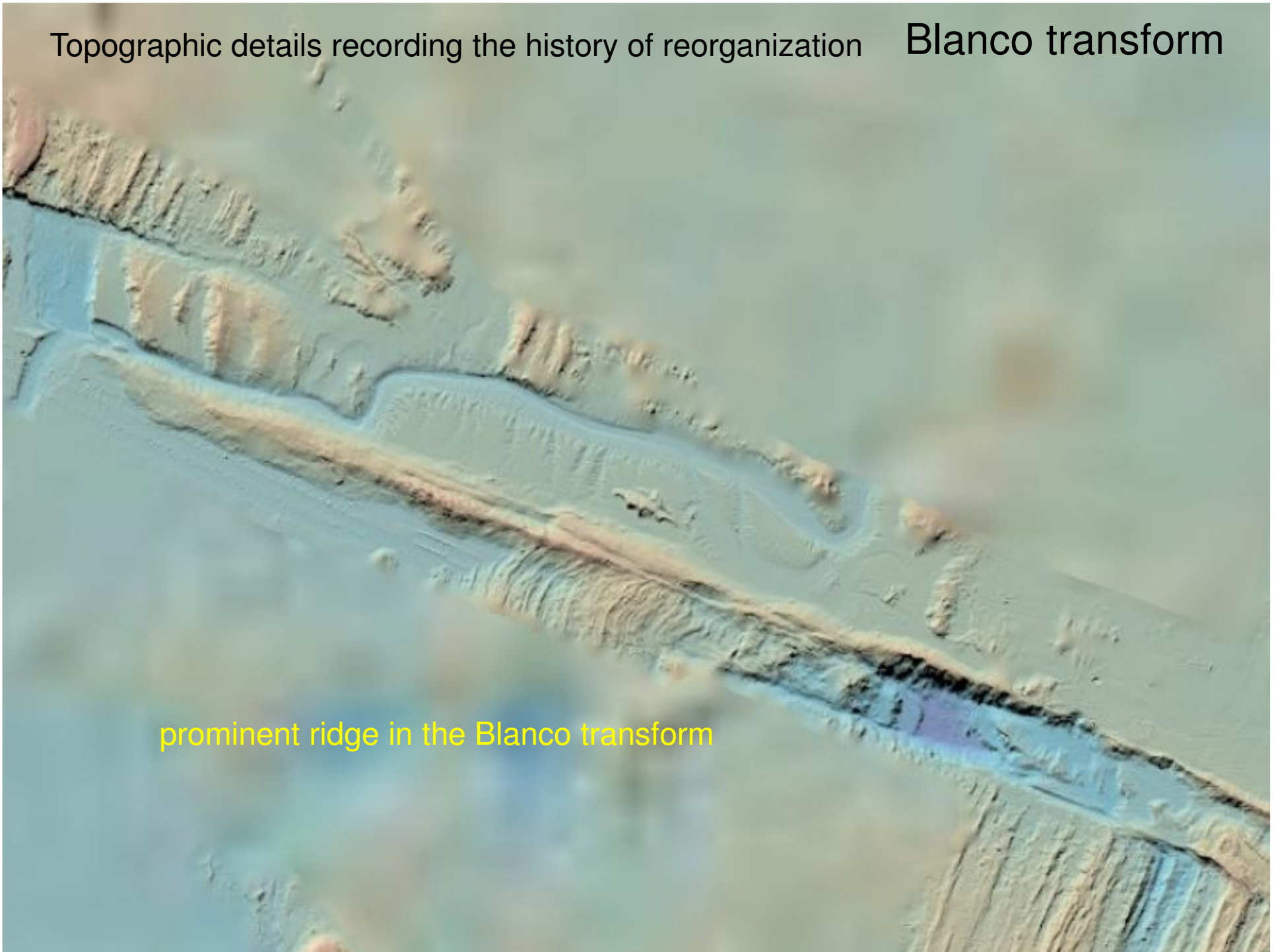
some spreading centers are well defined, others show evidence of rotation



Topographic details recording the history of reorganization

Blanco transform

prominent ridge in the Blanco transform



next chapter