Interplay of Tectonics and Sedimentation: Comparative Syn-Rift Fills at the Rift Branch and Rift-Segment Scale

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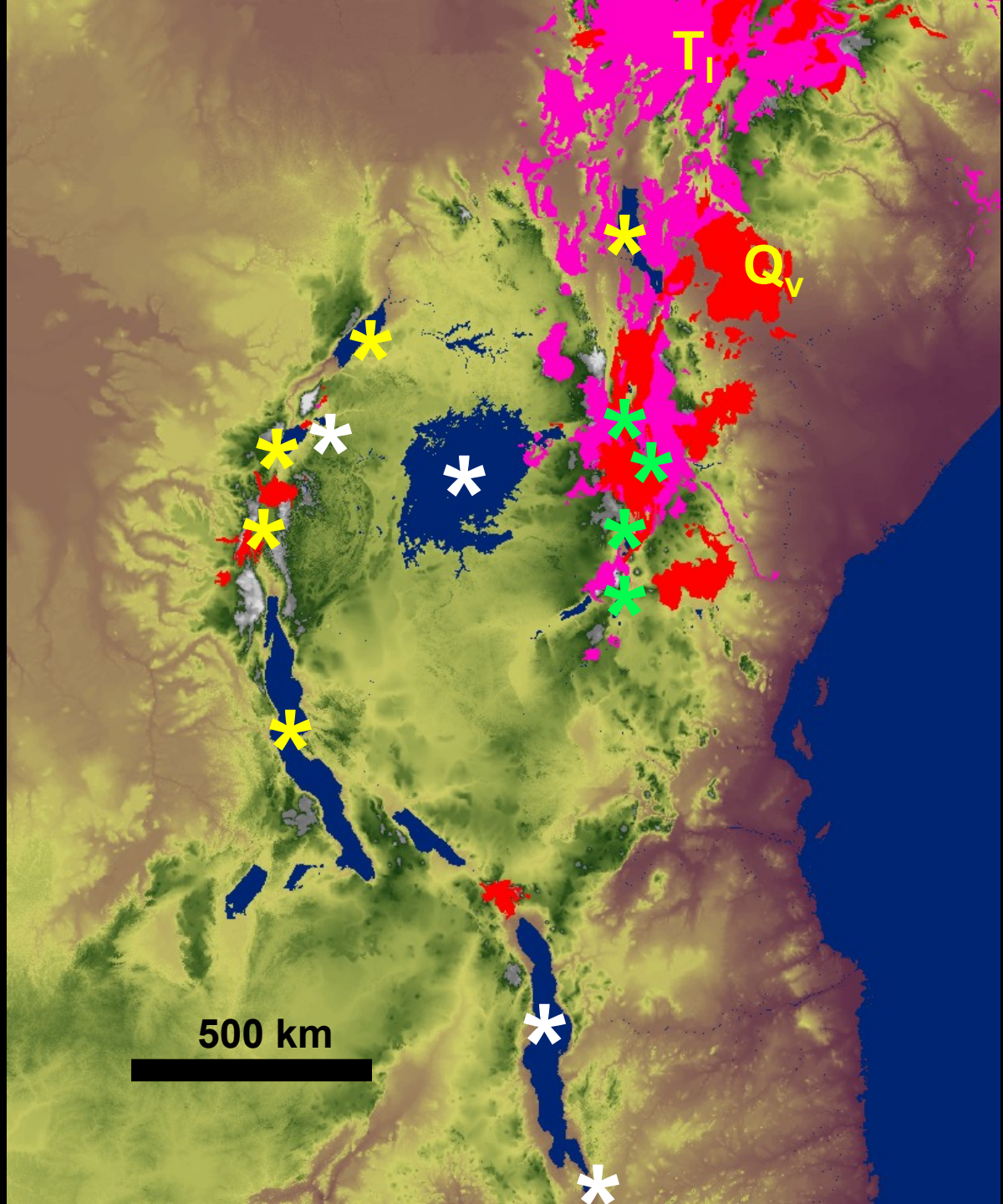
- Magmatic versus amagmatic rifting and influence on sedimentation and stratigraphy
- Influence of rift topography on drainage evolution and rift fill facies architecture
- Variations in style of basin infilling along the western branch of the EAR

East Africa Elevation
(SRTM DEM)

Quaternary and Tertiary Volcanics

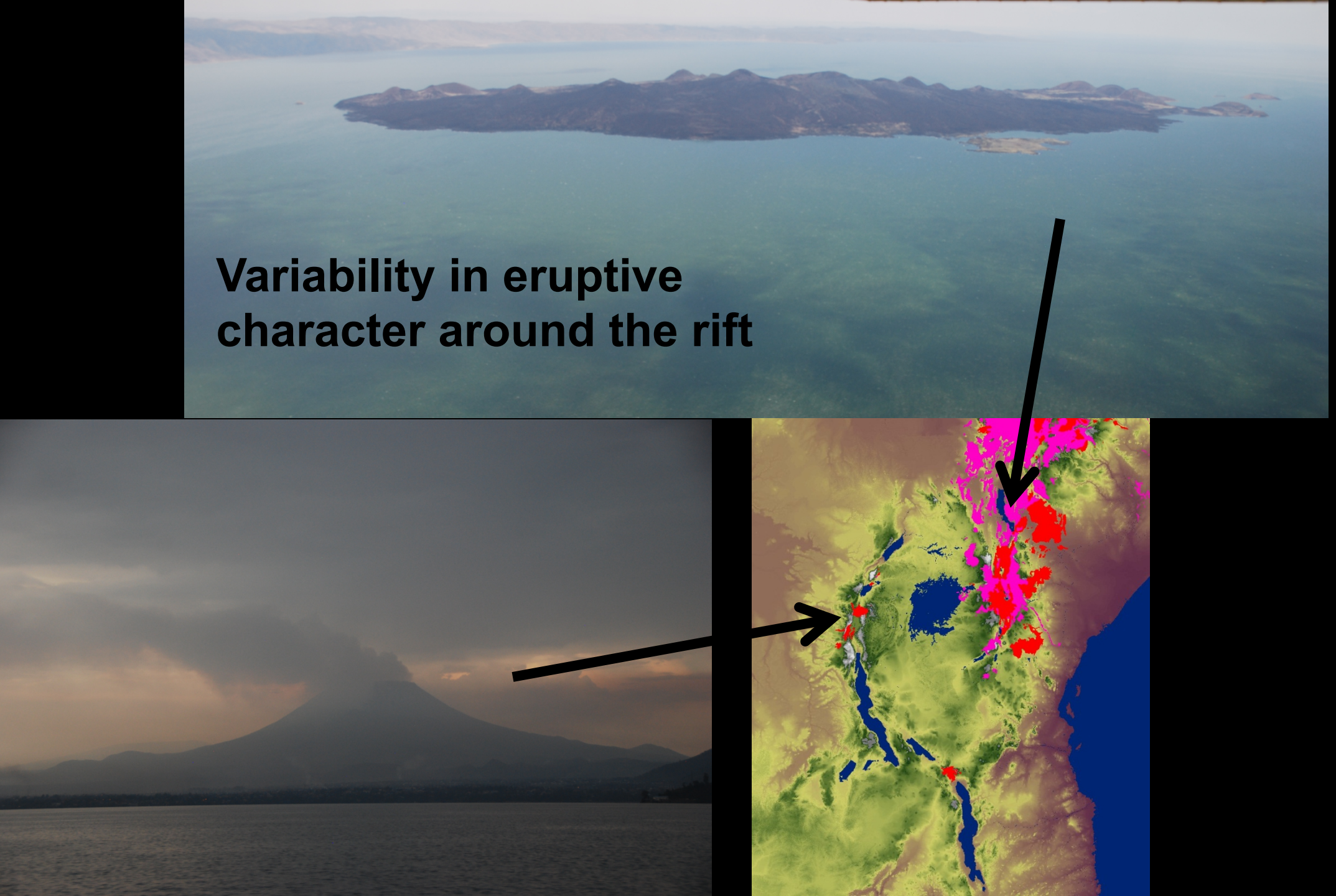


Class I lakes
(low total concentrations of ions)

Class II lakes
(higher total ion concentrations)

Class III lakes
saline lakes, with alkalinity usually greater than 60 meq/L, conductivity of 6000-160,000 µS

Classification of Talling and Talling, 1965


Variability in eruptive
character around the rift

Western/Amagmatic Rifts

- Longer border faults; fills >4 km
- Sediment-starved; lo sed rates
- Fill = water, siliciclastics
- Catchment bedrock: Precambrian crystalline rocks
- Drainages: Axial + transverse

Eastern/Volcanic Rifts

Shorter BF(?), sed.fills <2 km

Mod/hi sed rates

Fill = volcanics, water, carbonates, siliciclastics

Tertiary, Quaternary volcanics

Drainages: Axial

Western/Amagmatic Rifts

- Freshwater lakes
- Hydrologically-open
- Regional “sumps”; limited seepage
- Mg^{+} K^{+} SO_4^{-}
- Variable clays
- Hi-Mg Calcite, Aragonite

Eastern/Volcanic Rifts

Saline/alkaline lakes

Hydrologically-closed

Bedrock seepage due volcanic bedrock

Na^{+} HCO_3^{-} dissolved SiO_2

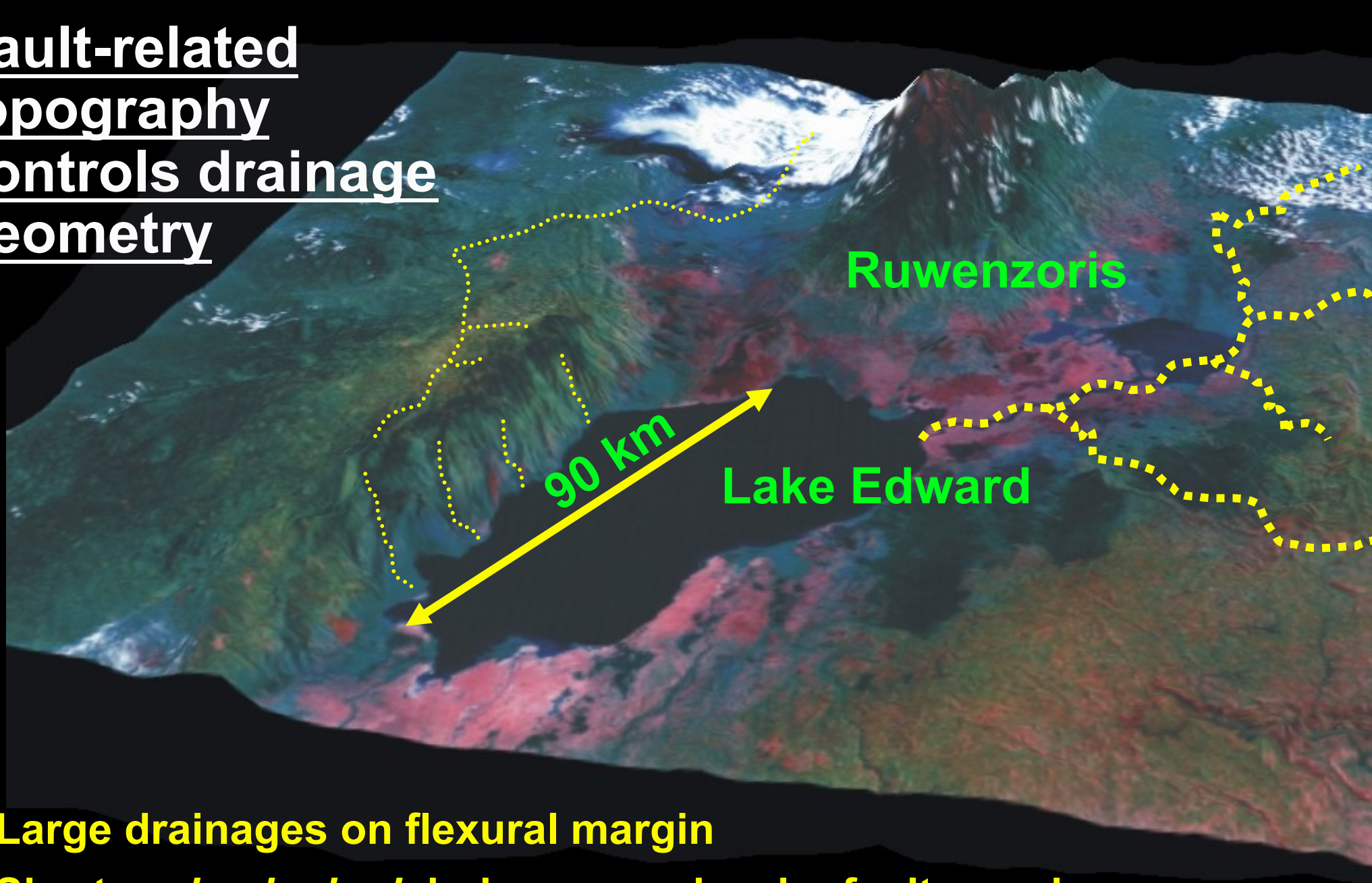
Smectite

Lo-Mg Calcite

Chemistry of lake systems – Volcanic vs. Amagmatic Rifts

	Salinity	*H_2O Depth*	*%Na*	*Clay minerals*
Malawi	**0.2 ‰**	**700 m**	**21**	**Illite, Kaolinite Nontronite, Smectite**
Tanganyika	**0.6 ‰**	**1450 m**	**24**	**Chlr, Kaol, Illite, Smectite**
Magadi	**>40 ‰**	**~1 m**	**56**	**Evaporites Zeolites, Smectite**
Turkana	**2.5 ‰**	**78 m**	**48**	**Smectite, Illite, Kaolinite, Calcite**

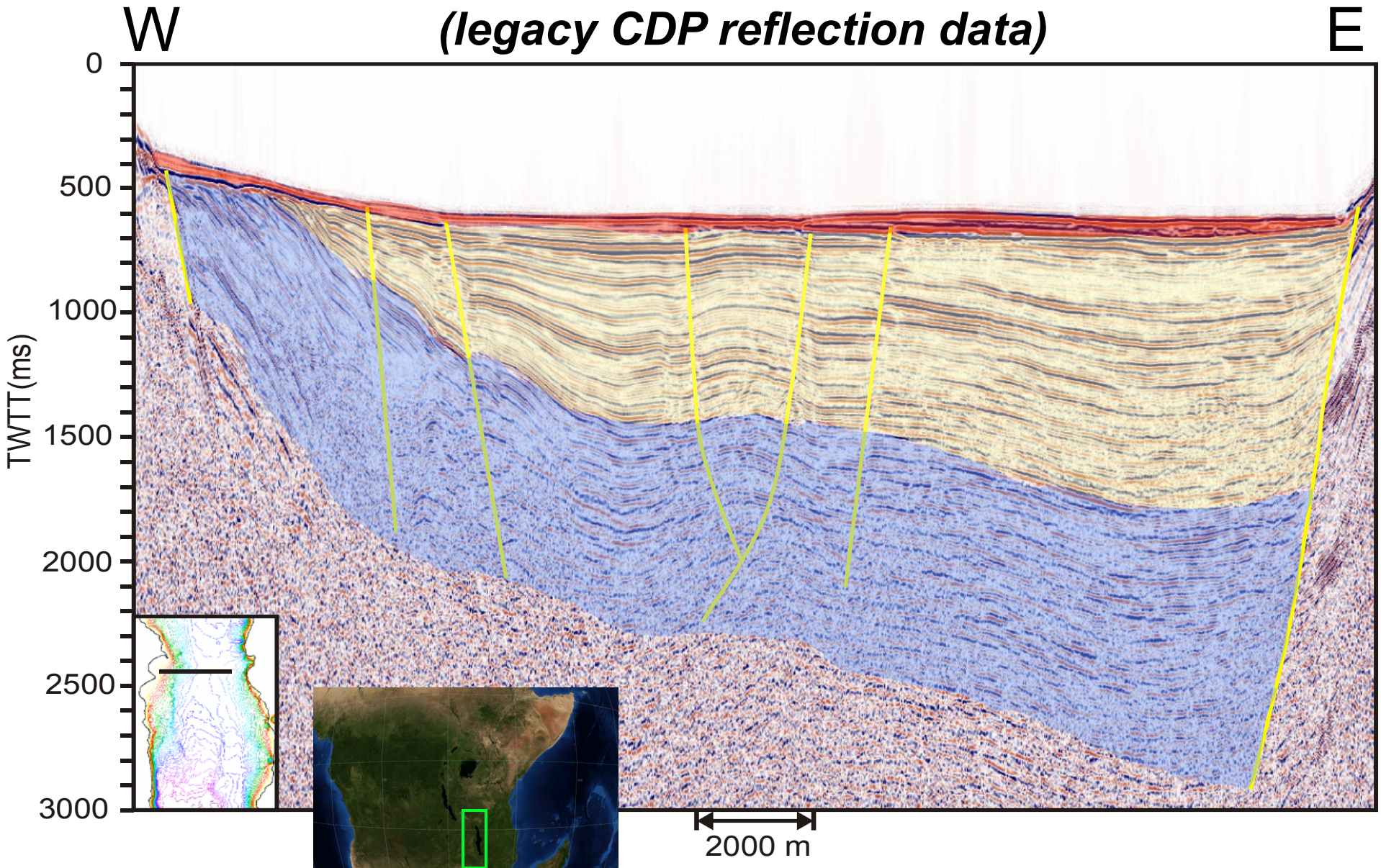
Fault-related topography controls drainage geometry



- Large drainages on flexural margin
- Short, or *back-shed* drainages on border fault margin

Basin-scale stratigraphy in Lake Malawi/Niassa

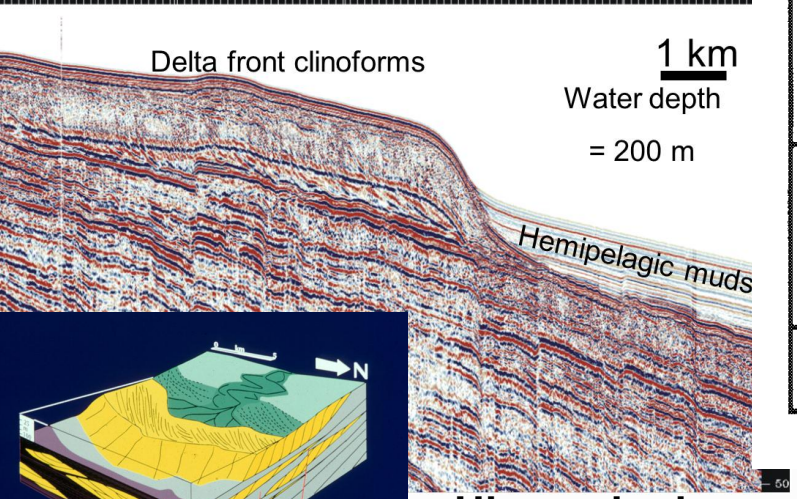
(legacy CDP reflection data)



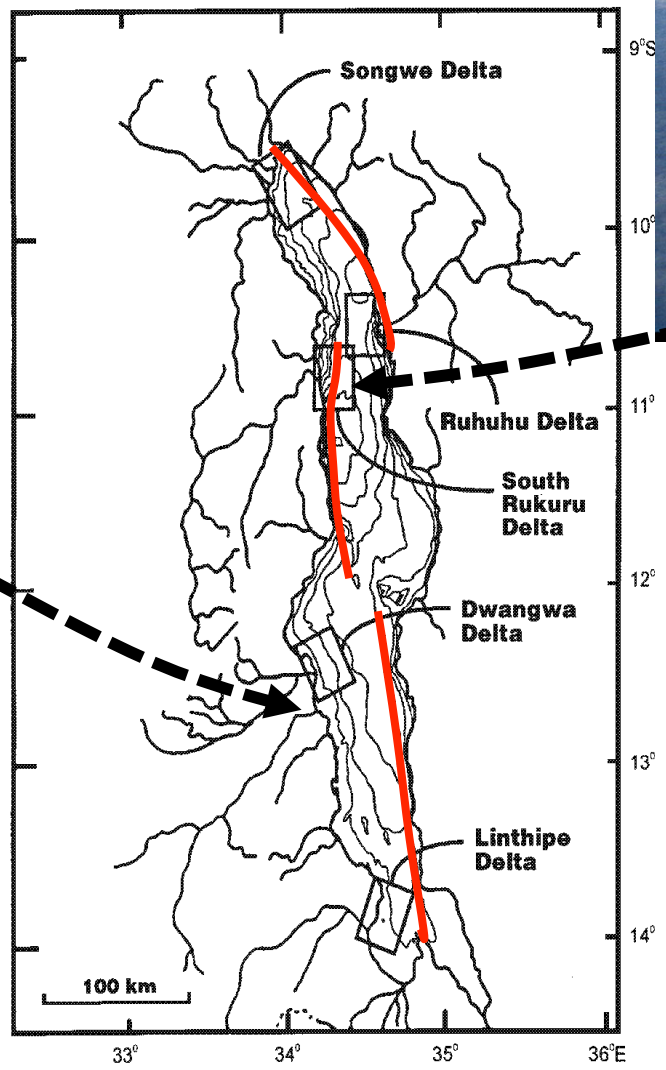
Rift basin asymmetry and the stratigraphic record

Flexural margin deltas

- Large transverse drainages
- low rates of subsidence
- limited accommodation space
- progradation & lateral aggradation



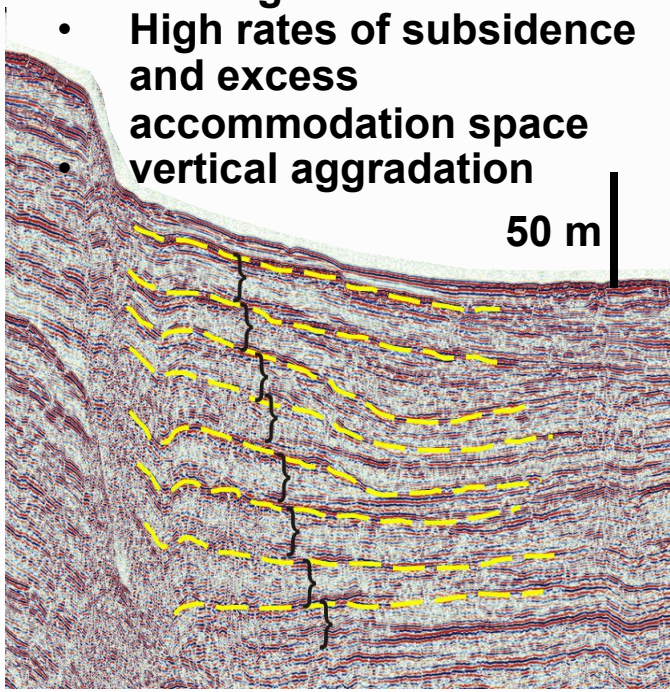
Hi-res single channel



Lake Malawi Lacustrine Deltas

Border fault margin deltas

- Commonly small drainages
- High rates of subsidence and excess accommodation space
- vertical aggradation



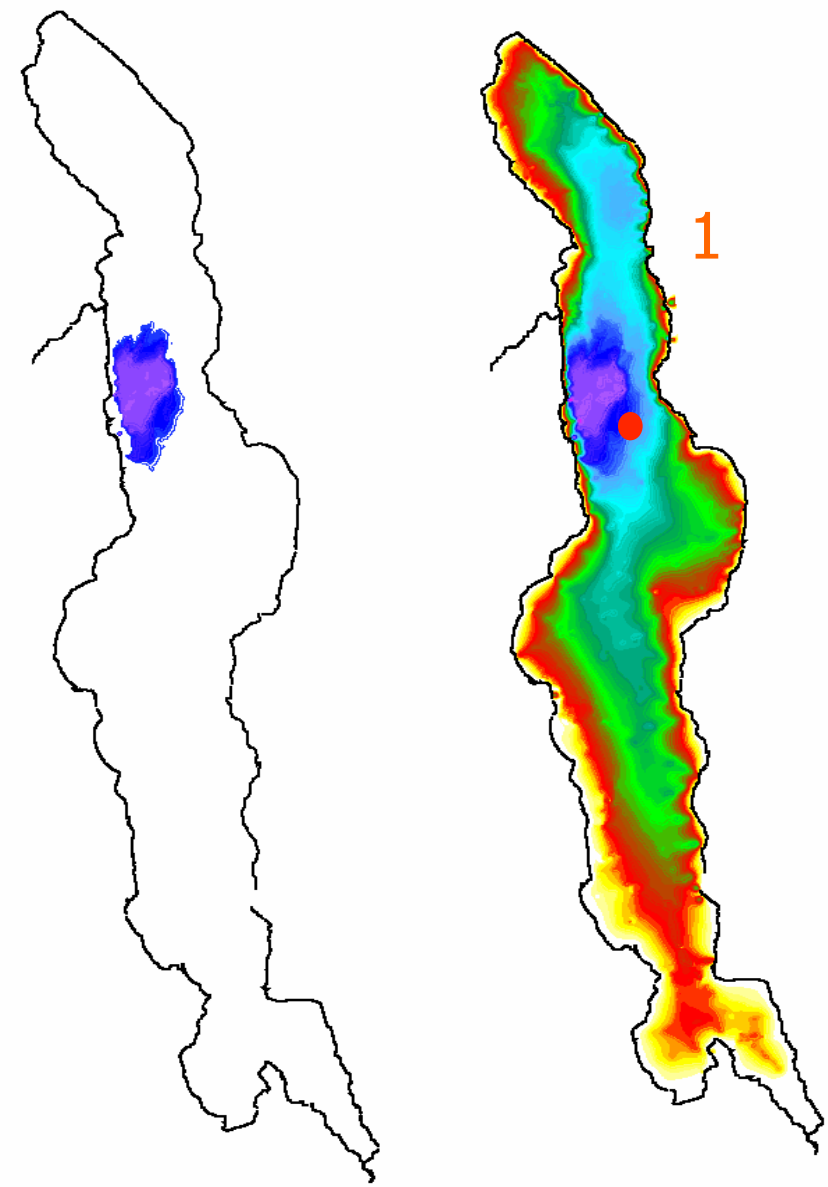
Hi-res single channel

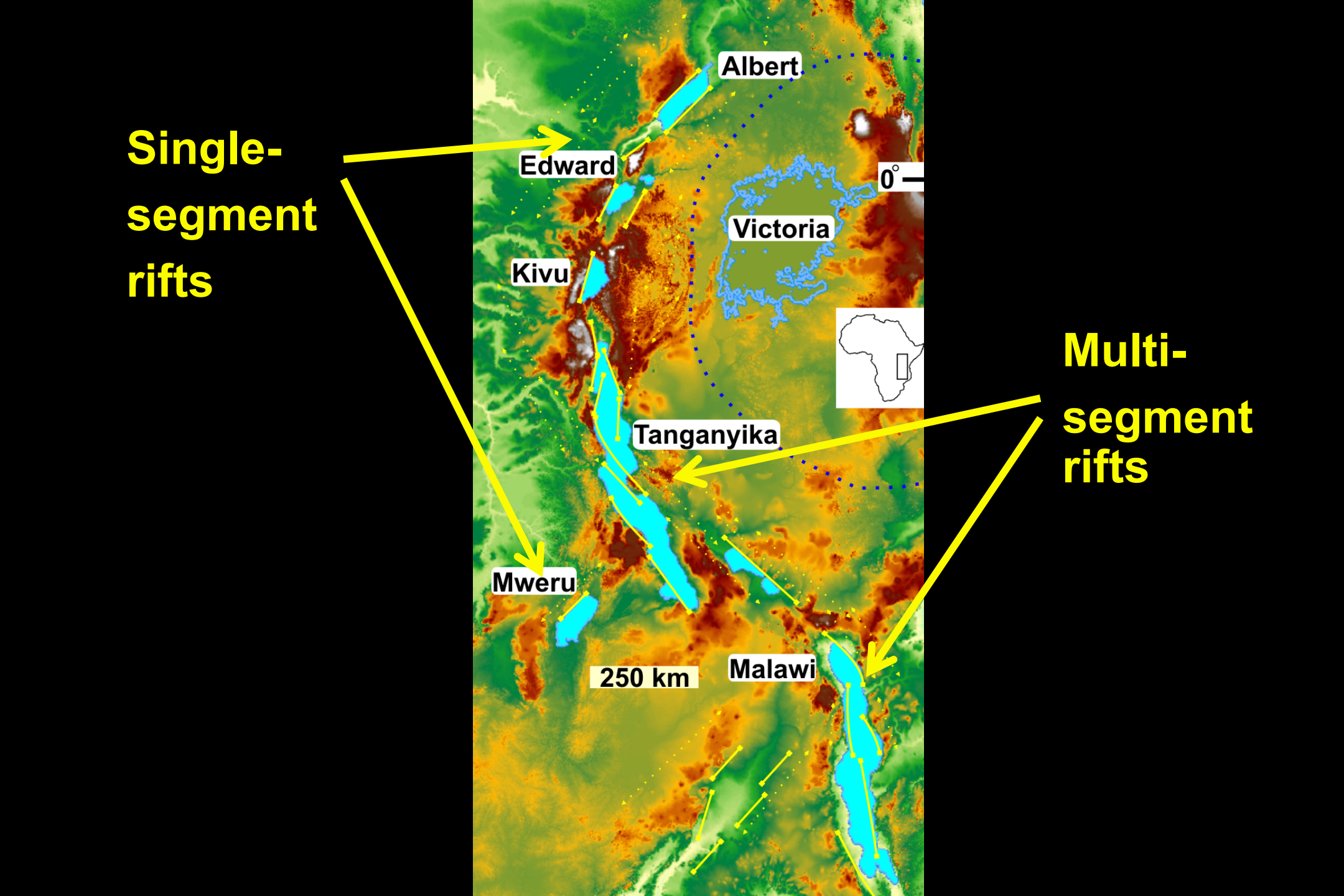
- 200 m (62,000 years ago)
- 350 m (75,000 years ago)
- 500 m (95,000 years ago)
- 550 m (135,000 years ago)

Climate forcing of rift-fills-
Results of 2005 Scientific Drilling

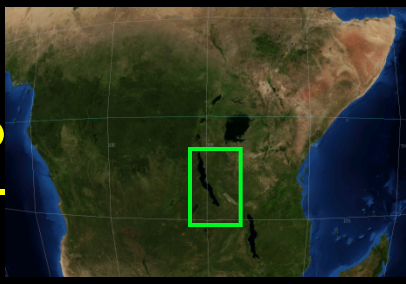
-150-60 kyr BP: very high variability in lake level (Precession modulated by eccentric earth orbit)

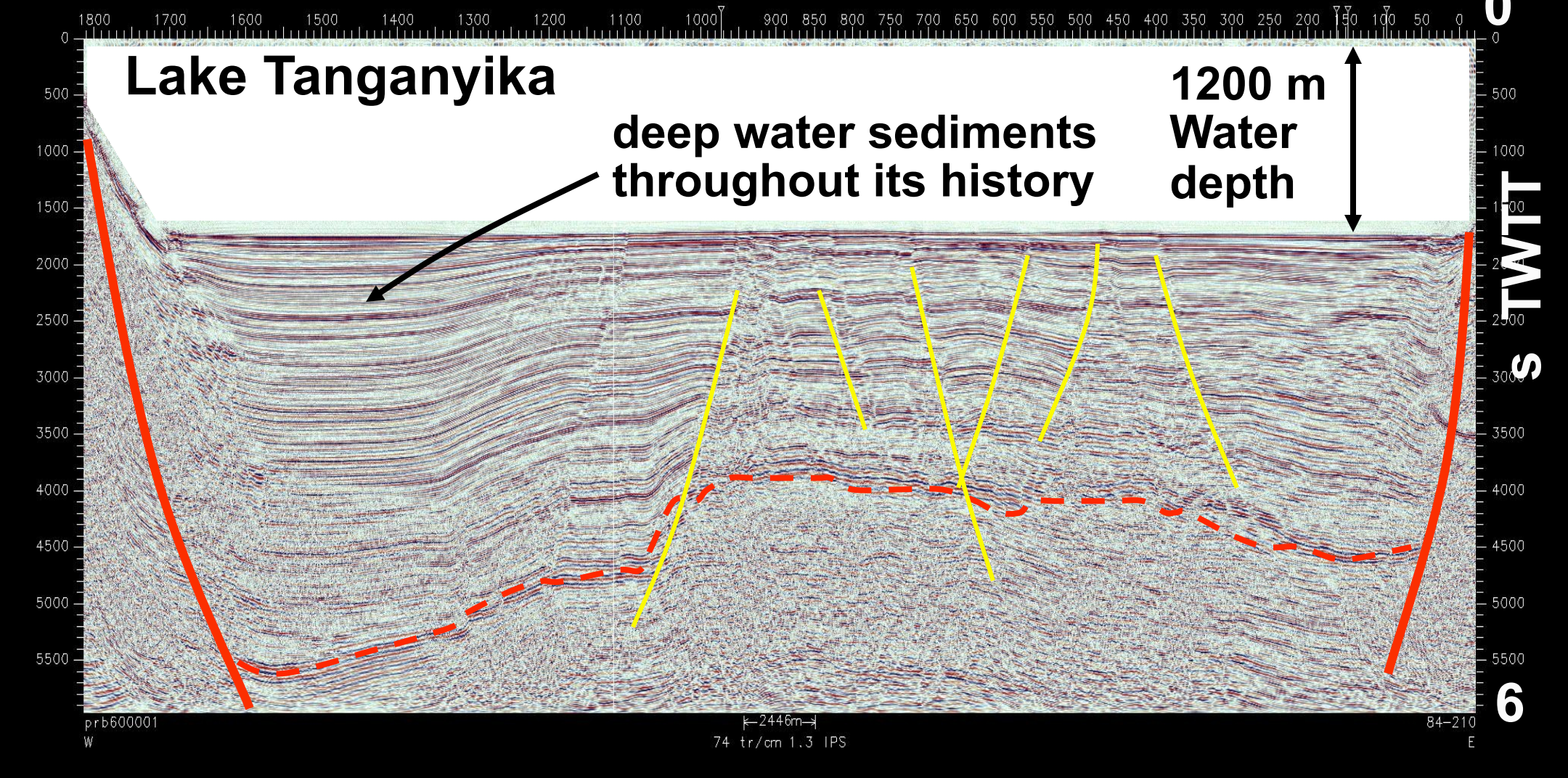
- After 60 kyr BP: tighter connection with high latitudes (low eccentricity/ more circular Earth orbit)




Single-segment rifts
Albert
Edward
0°
Victoria
Kivu
Multi-segment rifts
Tanganyika
Mweru
250 km
Malawi

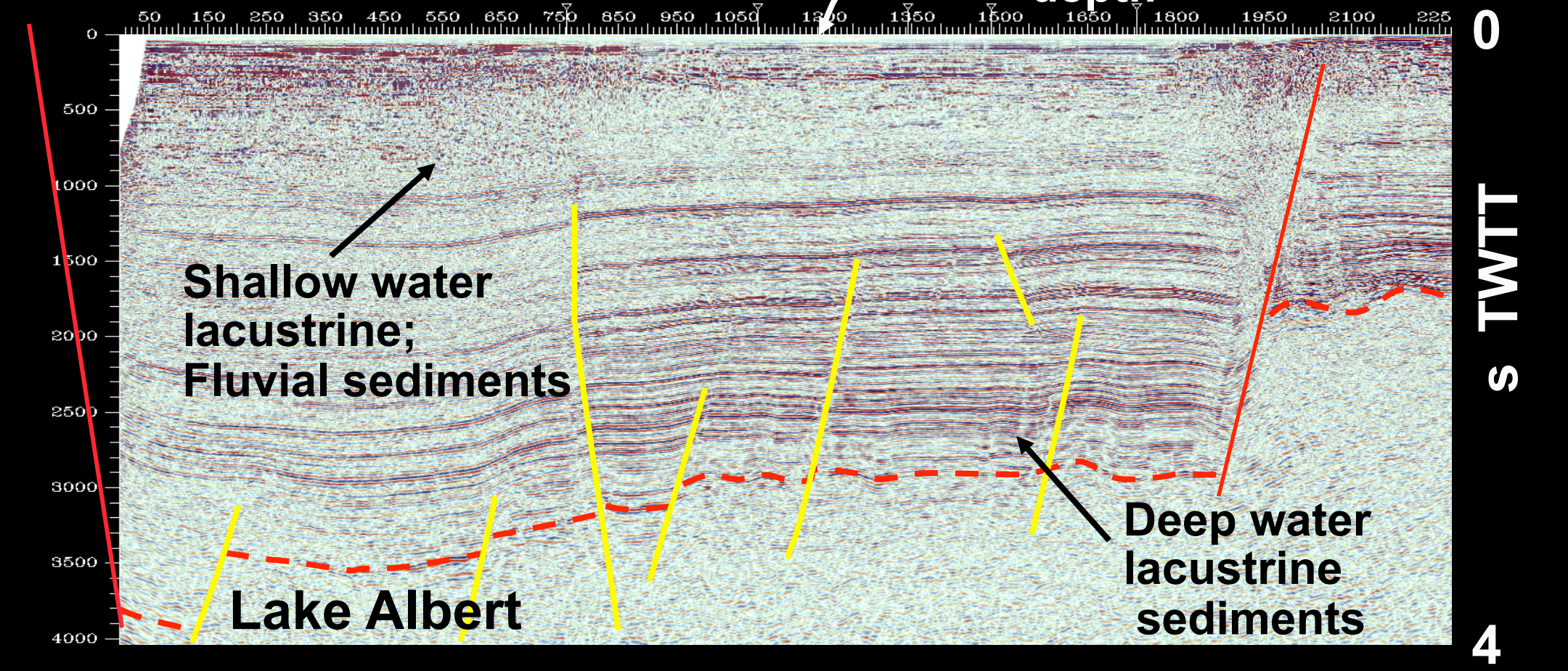
Lake Tanganyika – 9-12 million years old?

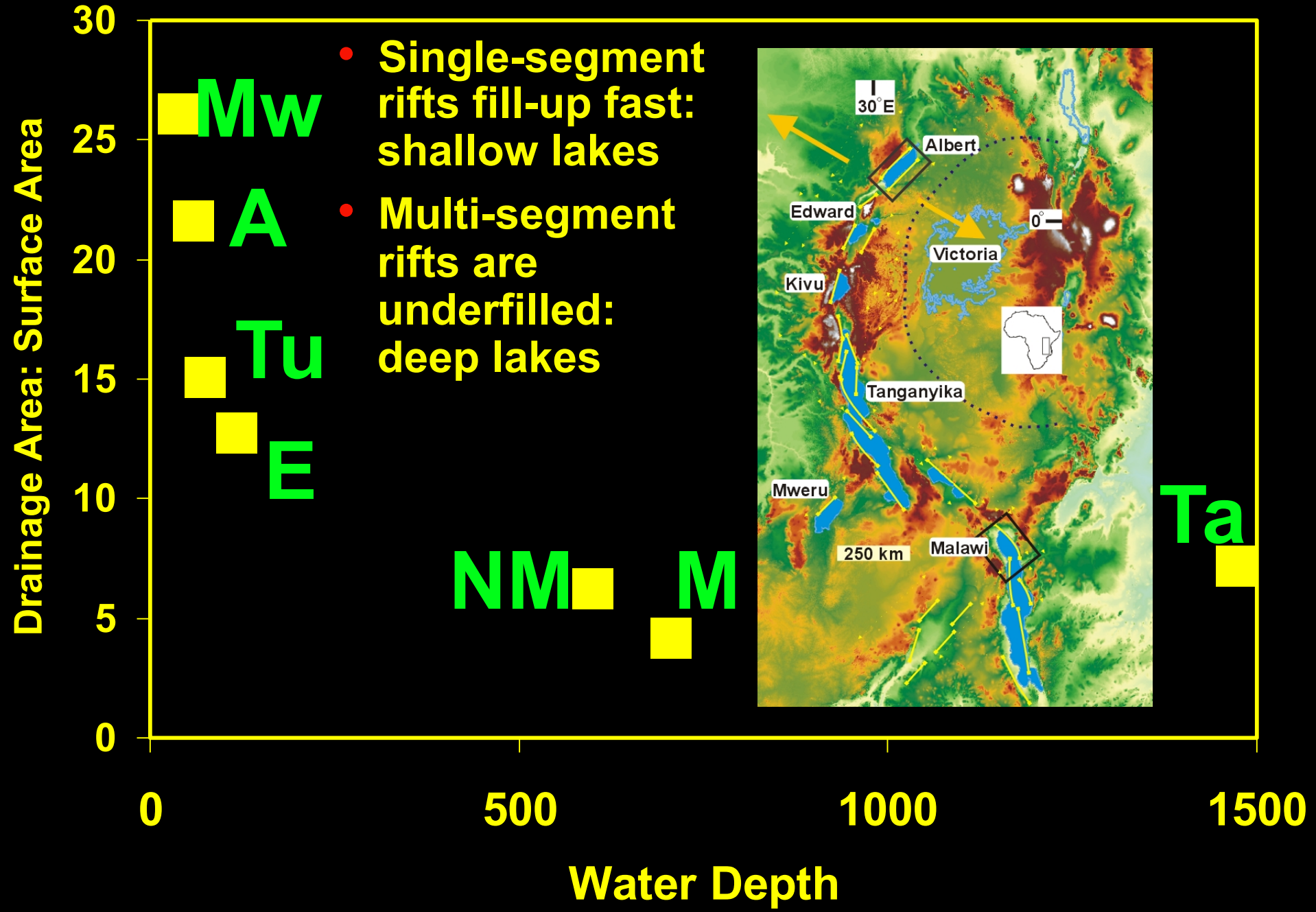




Lake Albert

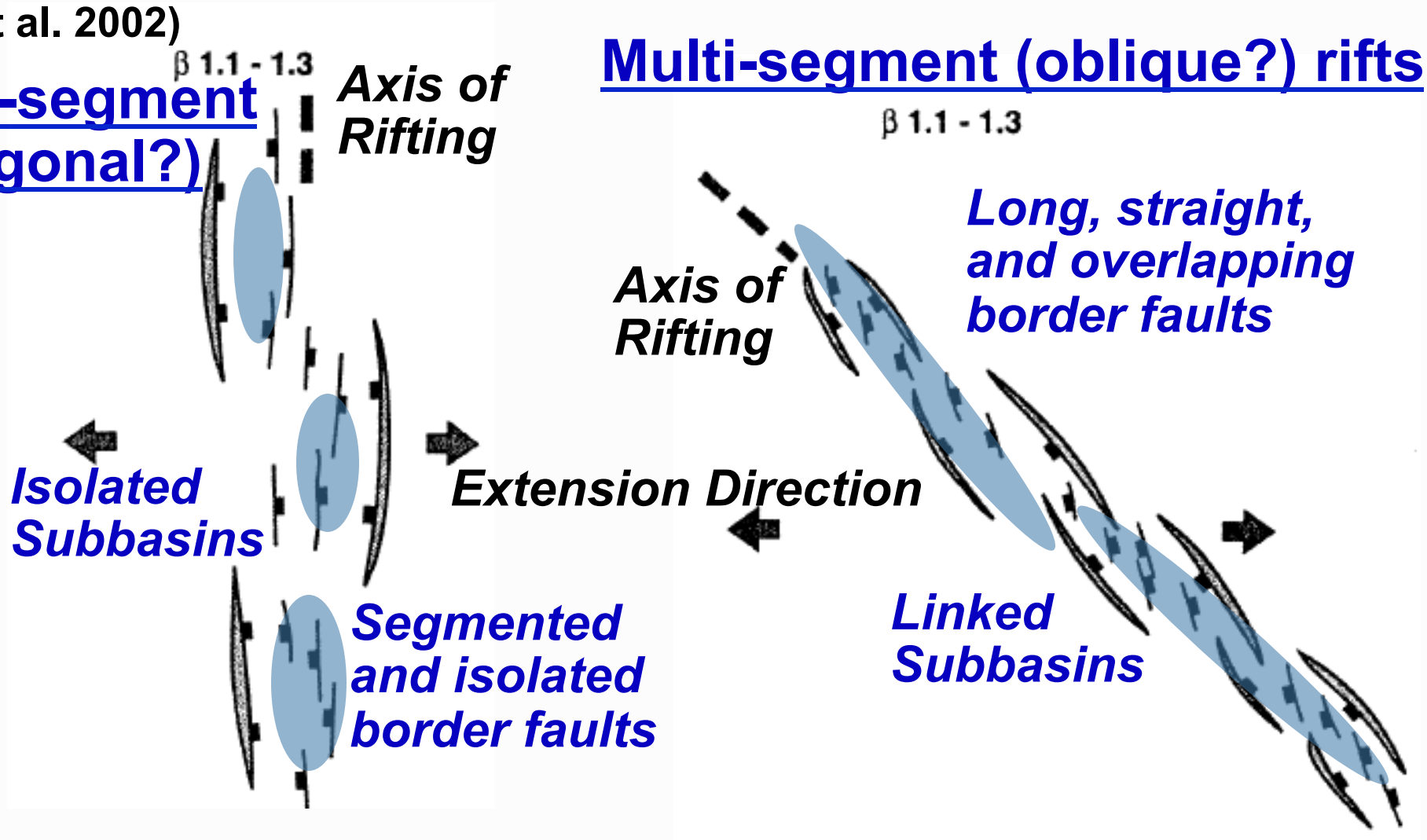
Change from deep water to shallow/fluvial conditions in the Quaternary




Drainage Area: Surface Area
30
25
20
15
10
5
0
0
500
1000
1500
Water Depth
Mw
A
Tu
E
NM
M
Ta
• Single-segment rifts fill-up fast: shallow lakes
• Multi-segment rifts are underfilled: deep lakes
30°E
Albert
Edward
0°
Victoria
Kivu
Tanganyika
Mweru
250 km
Malawi

Strain localization in oblique rifts: tightly overlapping faults; Orthogonal rifts – isolated fault segments

(Results from scaled physical models sandbox models using quartz sand, from McClay et al. 2002)



Summary

- Magmatic activity has significant influence on basin fill sediment composition, drainage evolution
- Rift asymmetry exerts control on internal facies architecture
- Pre-existing structure may influence style of rift fills:
- Single-segment rifts: isolated rapidly-filled basins
- Oblique extension perhaps promoting under-filled multi-segment rifts