East Africa: from Anza to Madagascar: a relic and active 4,000km Intraplate Strike Slip Corridor

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AAPG ACE 2018 ANNUAL CONVENTION & EXHIBITION
ACE 101: Bridging Fundamentals and Innovation

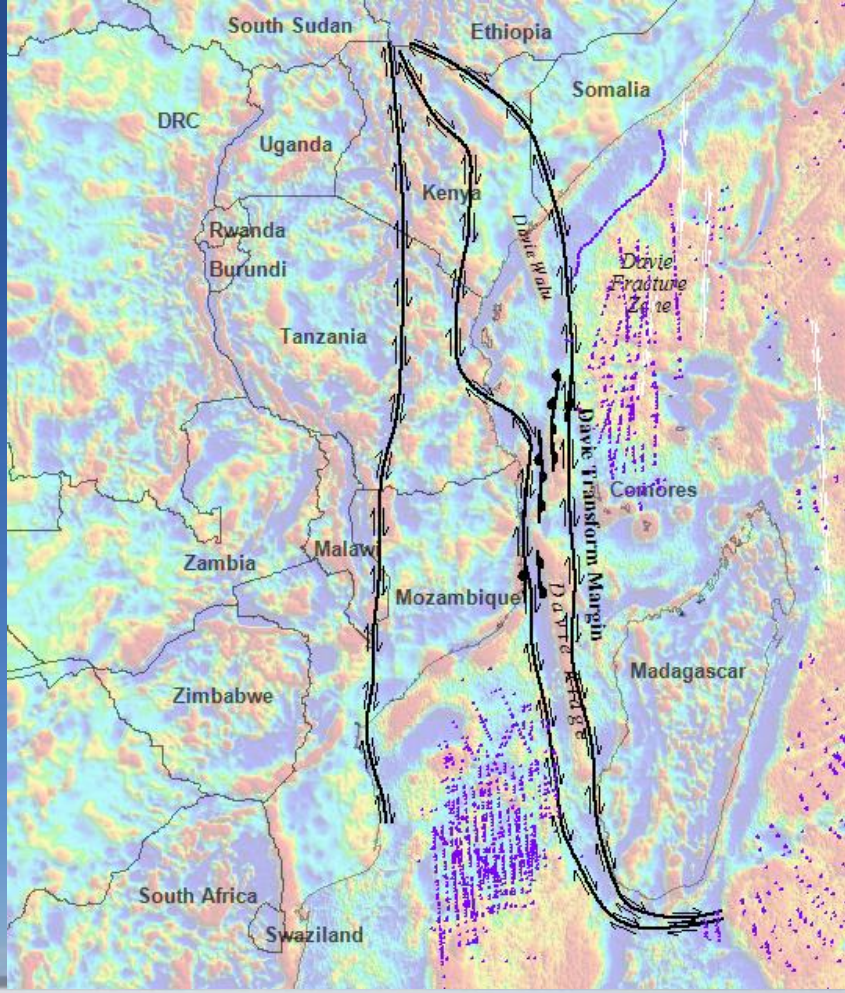
Introduction

Evolution of the East African Transform Margin

Method

Structural Architecture of the Davie Transform Margin

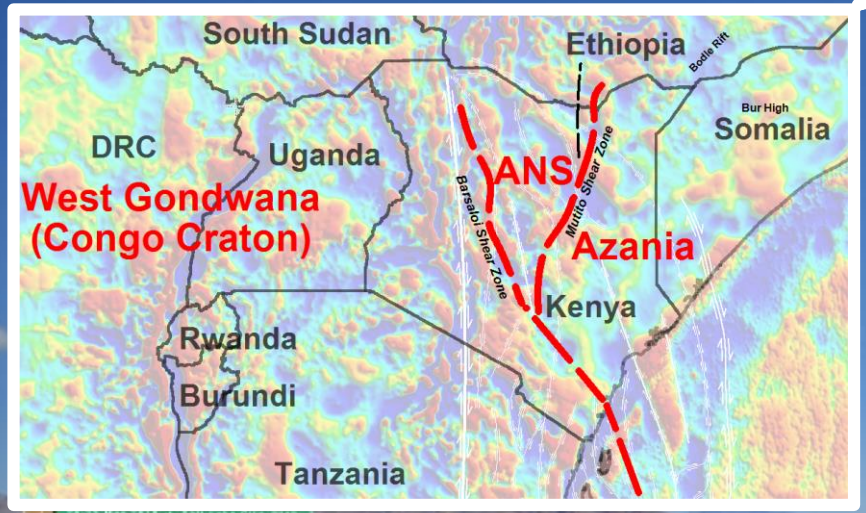
Conclusions

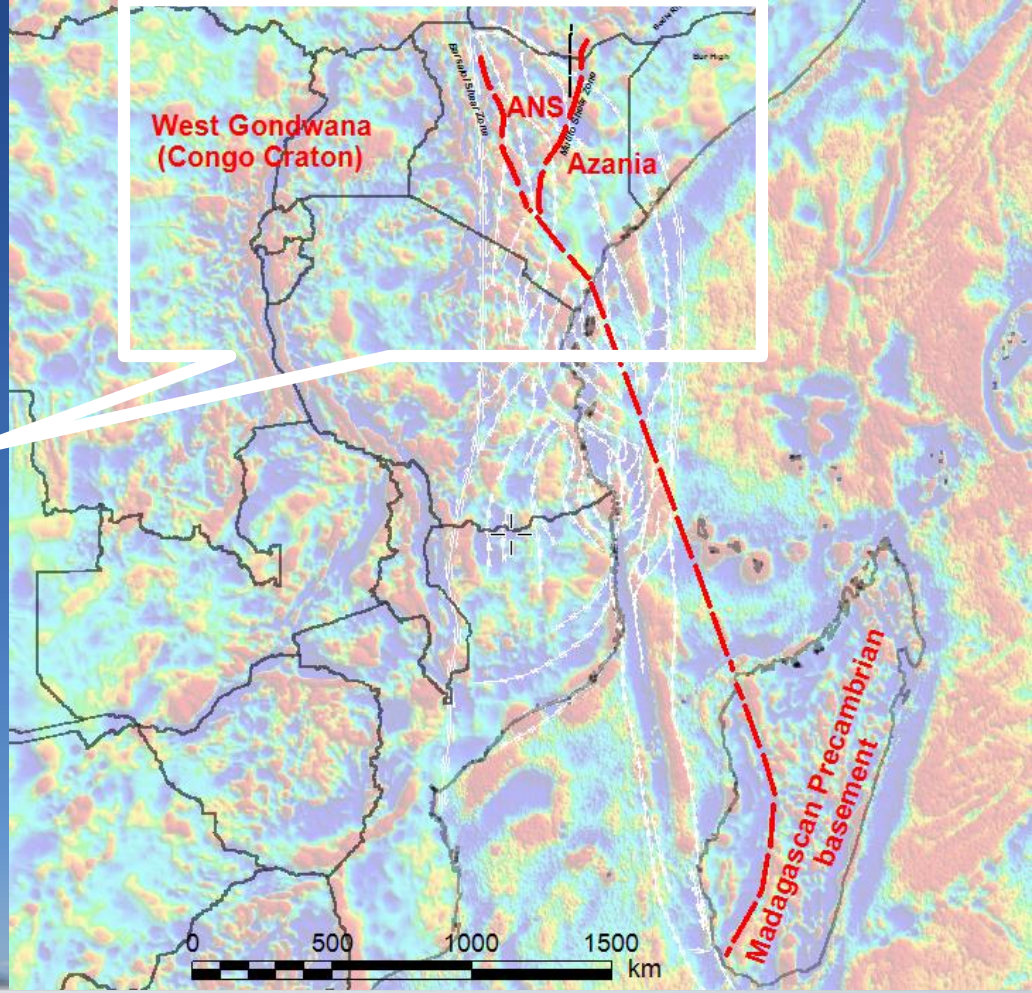


Tectono-stratigraphy East Africa

Late Precambrian suturing to form Gondwana

Azania Northern Suture (Fritz, 2013) **underlies Anza Basin**

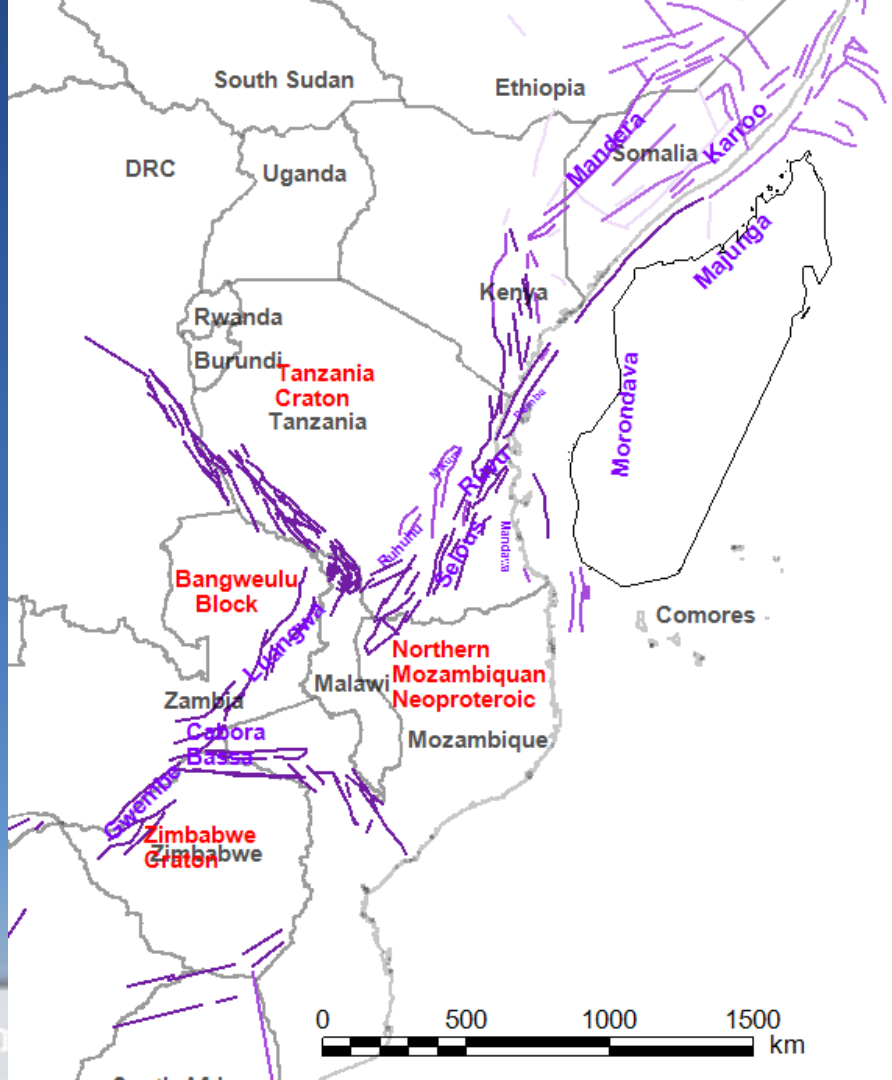




Tectono-stratigraphy East Africa

Permo- Triassic episodic intracontinental rifting extending north to Tethys

Utilizing older zones of weakness between cratonic and sutured Neoproterozoic crust



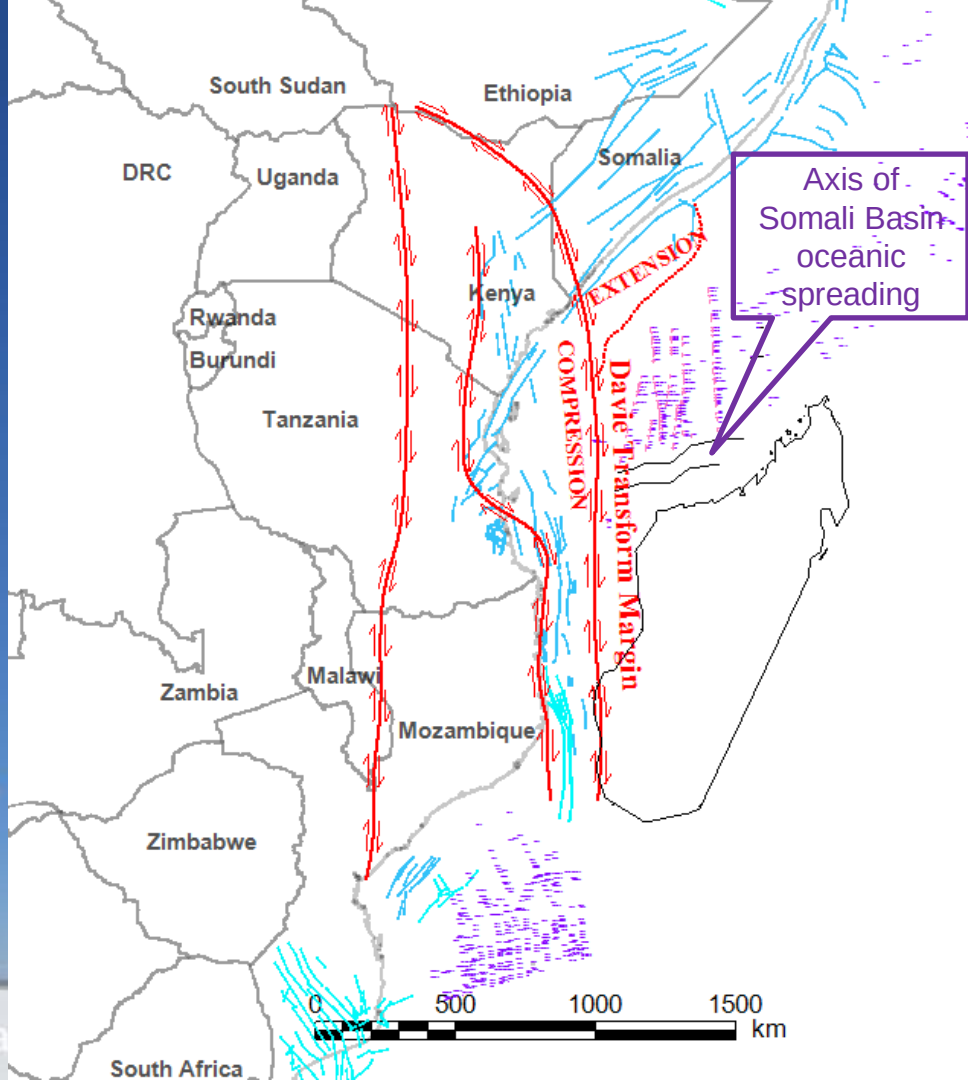
Left: Cratonic areas (red), Permo- Triassic faulting (purple) from MacGregor (2017). Approximate location of Madagascar in Triassic after Boote (2017)

Tectono-stratigraphy East Africa

Early Jurassic strike slip propagation southward east of the axis of the Davie Walu Ridge bounding extensional oblique rifting between northern Madagascar and Somalia in the east, and compressional segmentation to the west of the present-day Davie Walu axis.

Mid-Late Jurassic oceanic spreading in the Somali Basin following oblique rifting between the Madagascan Majunga and the offshore Lamu Basin.

Left: Jurassic faulting (blue) from MacGregor (2017). Davie Transform Margin (red) from this work and Long (2017). Chron picks for oceanic spreading from Seton (2014)

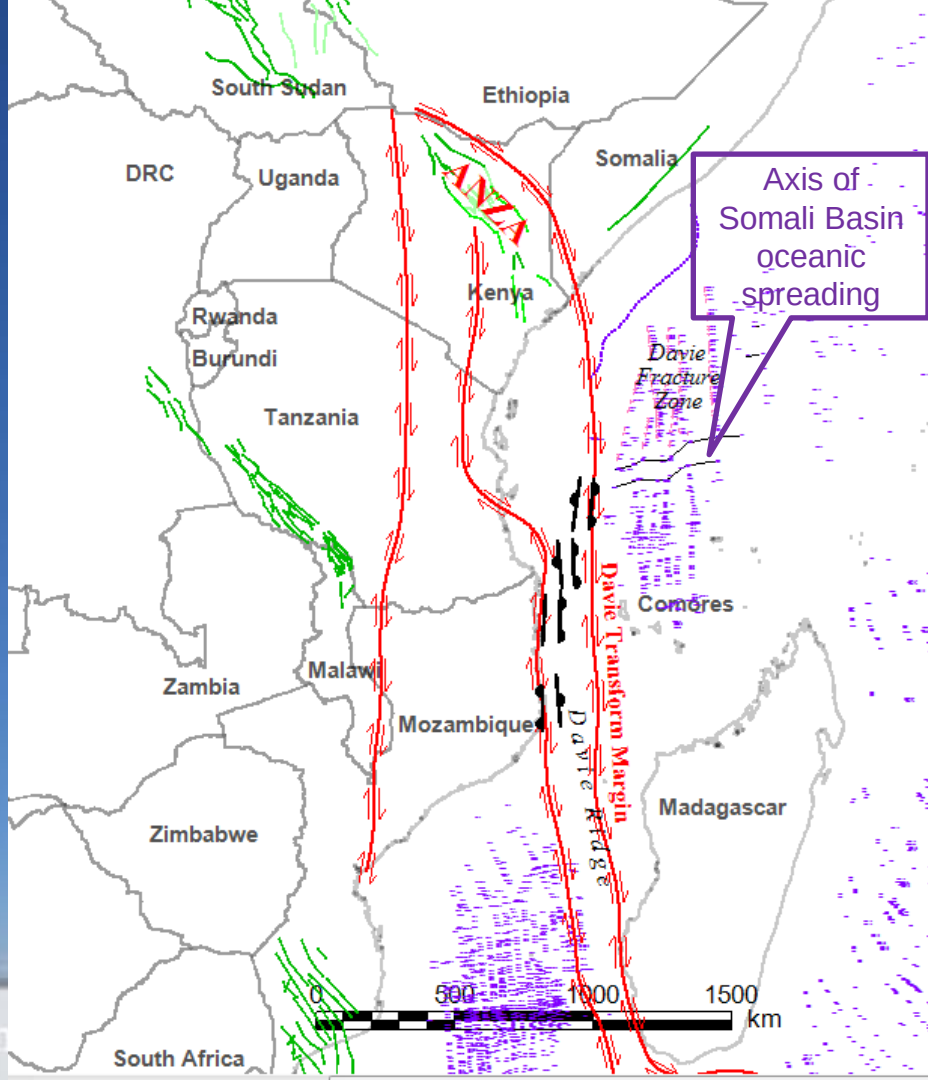


Tectono-stratigraphy East Africa

Early Cretaceous (Guiraud 1992) extension was responsible for a new transcontinental rift system stretching across Central Africa to Anza Graben and Lamu Basin of Kenya where it now merges with the Davie-Walu Ridge at the northern end of the Davie Transform.

Aptian oceanic spreading cessation in Somalia Basin, accompanied by the end of East Gondwana's southerly drift. The transform margin became dormant at this time.

Left: Cretaceous faulting (green) from MacGregor (2017). Davie Transform Margin (red) from this work and Long (2017). Chron picks for oceanic spreading from Seton (2014)



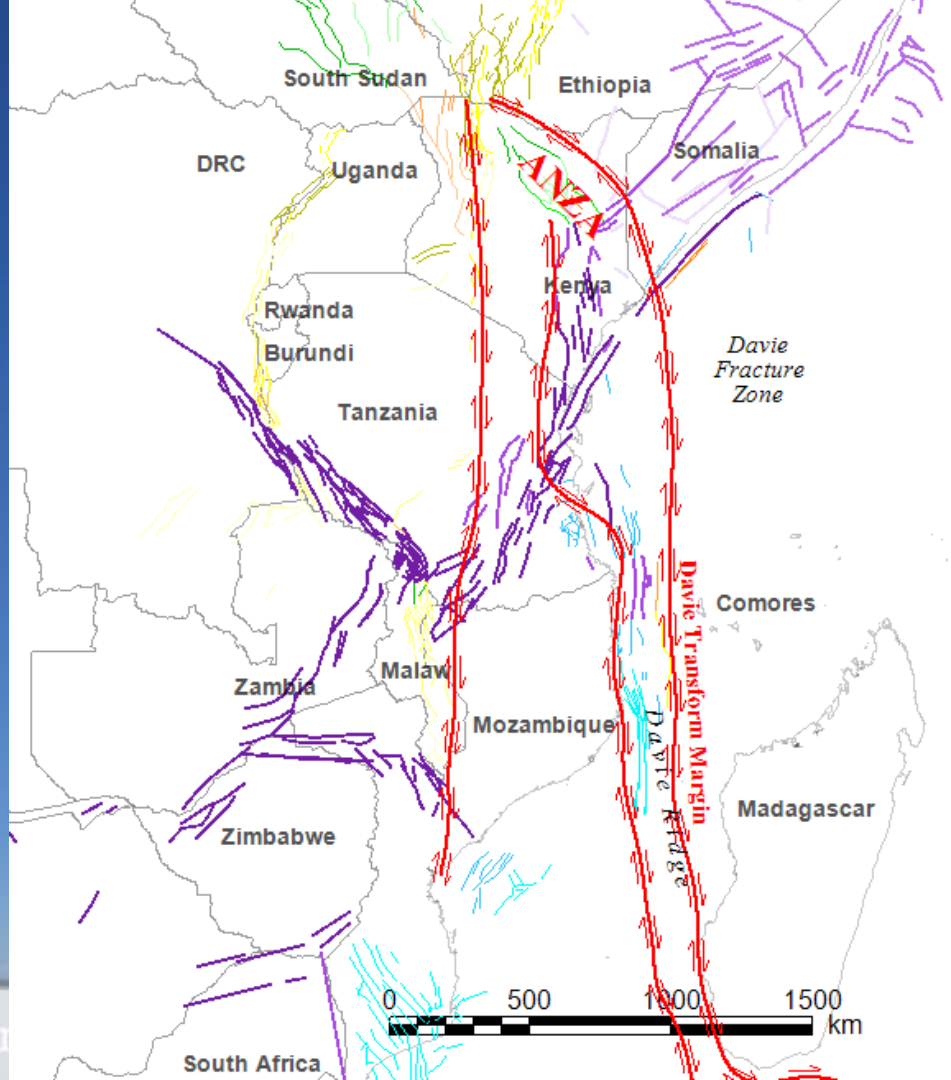
Tectono-stratigraphy East Africa

Late Cretaceous India subcontinent breakup, Turonian volcanism and transform margin subsides

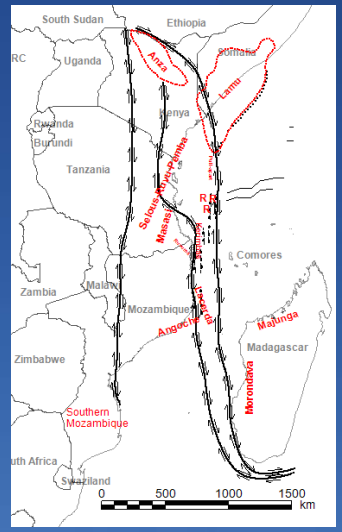
Neogene onset of East African Rift System – locked to western margin of the Davie Transform System

Neogene to Plio Plistocene transform margin reactivated – secondary wider zone of transpressional to transtensional faulting

Left: Tertiary faulting (yellow), all from MacGregor (2017). Davie Transform Margin (red) from this work and Long (2017)



Methodology



Correctly processed (LaFehr, 1991) derivatives of:

Sandwell's Free Air Gravity (Sandwell et al 2014)
Enhanced Magnetic Model 2015 (Chulliat et al 2015)

to yield:

(1) decompensative residual gravity (Cordell et al 1991)

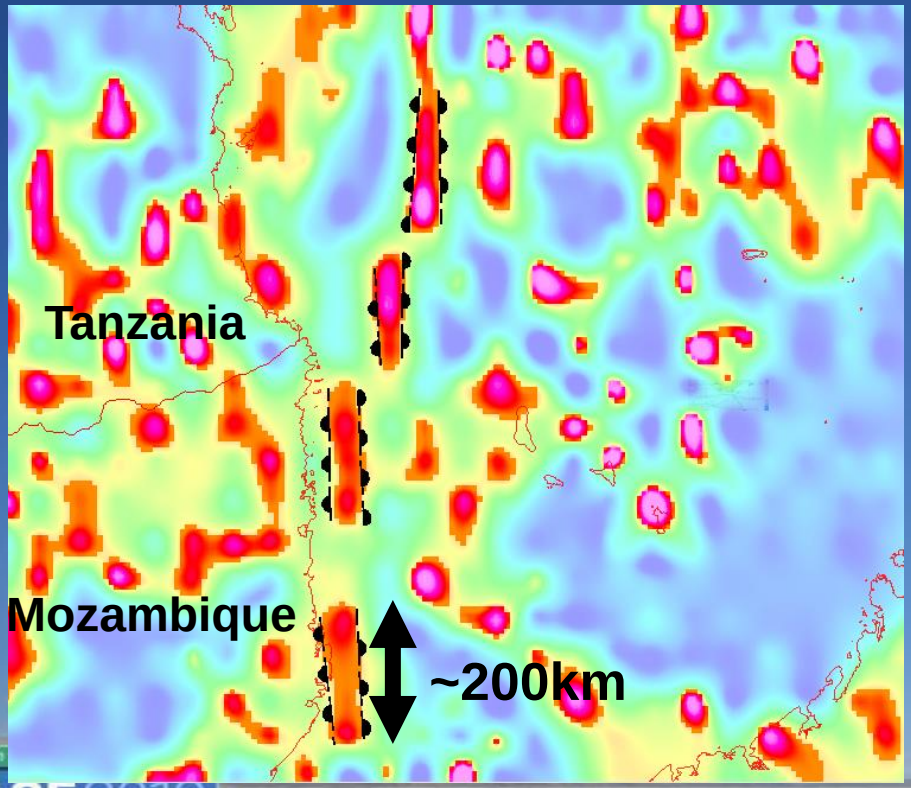
(2) IGRF corrected, variable reduced to pole, and amplitude gain corrected (Rajagopalan, S. and Milligan 1994) residual magnetics.

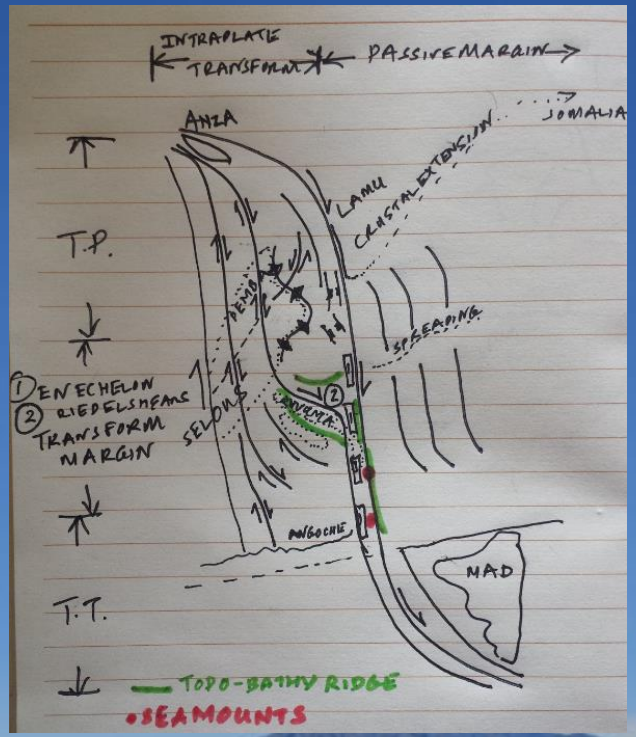
Assumption of Airy Heiskanen isostasy (Simpson et al 1983)

(1) residual gravity enables interpretation of shallow crustal structure and density variation that is relevant to basin exploration

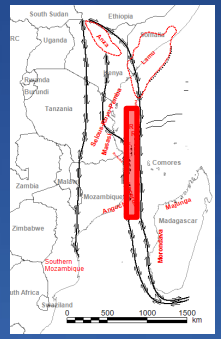
(2) lower resolution magnetic record links deeper crustal, magnetized structural controls on the shallow propagation and growth of faulted structures in the overburden. (Long, 2017, 2018)

Echelon crustal blocks



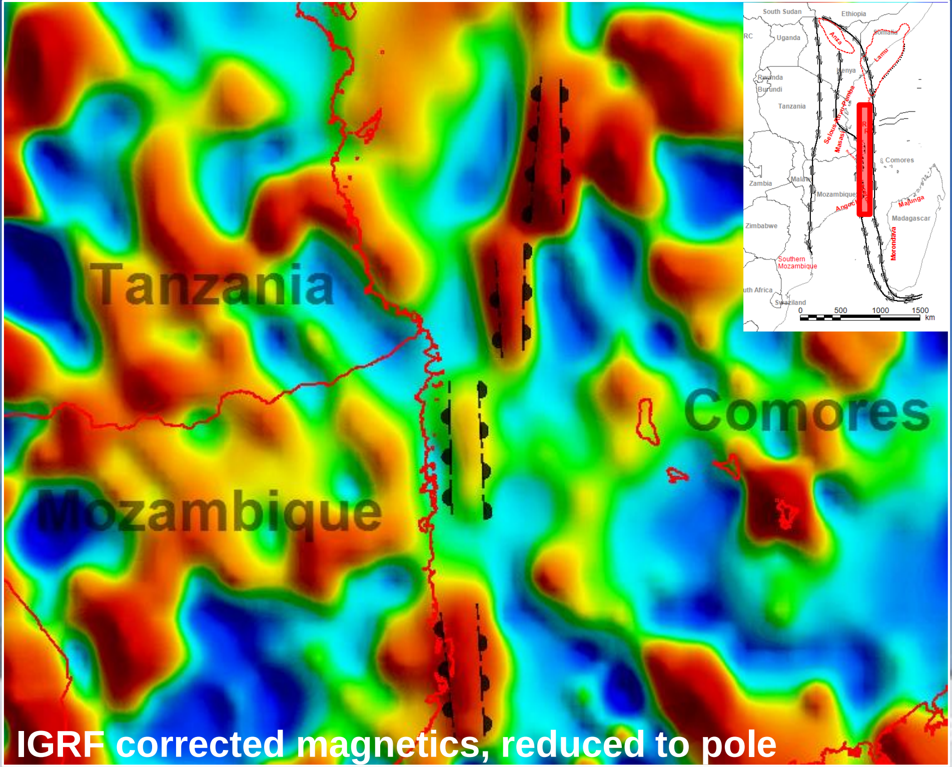


Early model, May 2017 (pers. comm.)

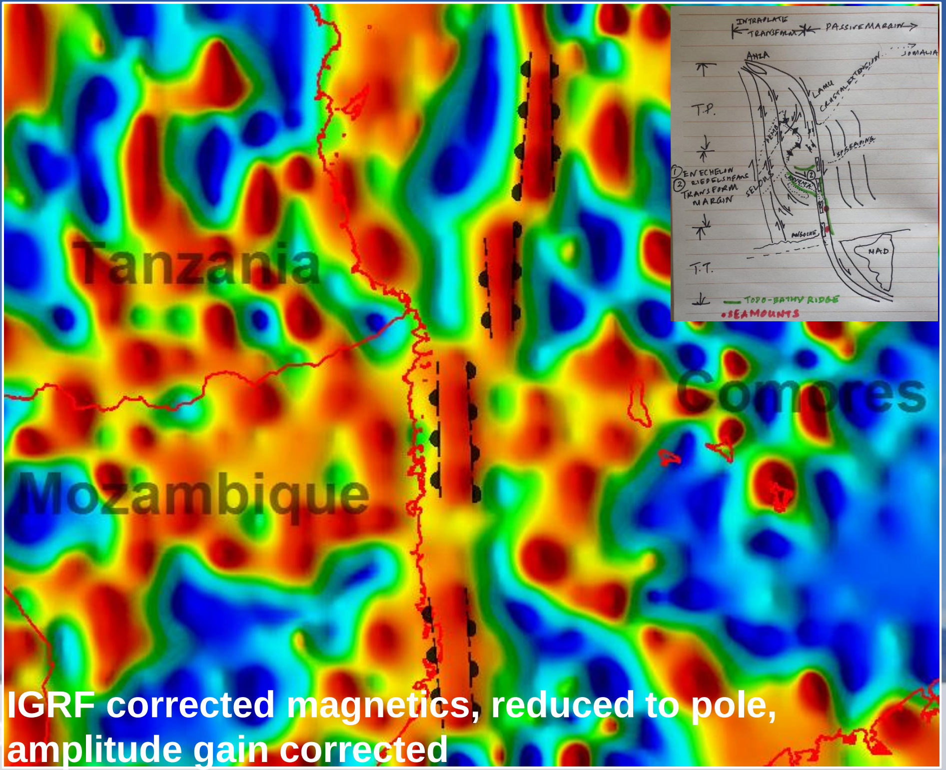


Echelon crustal blocks

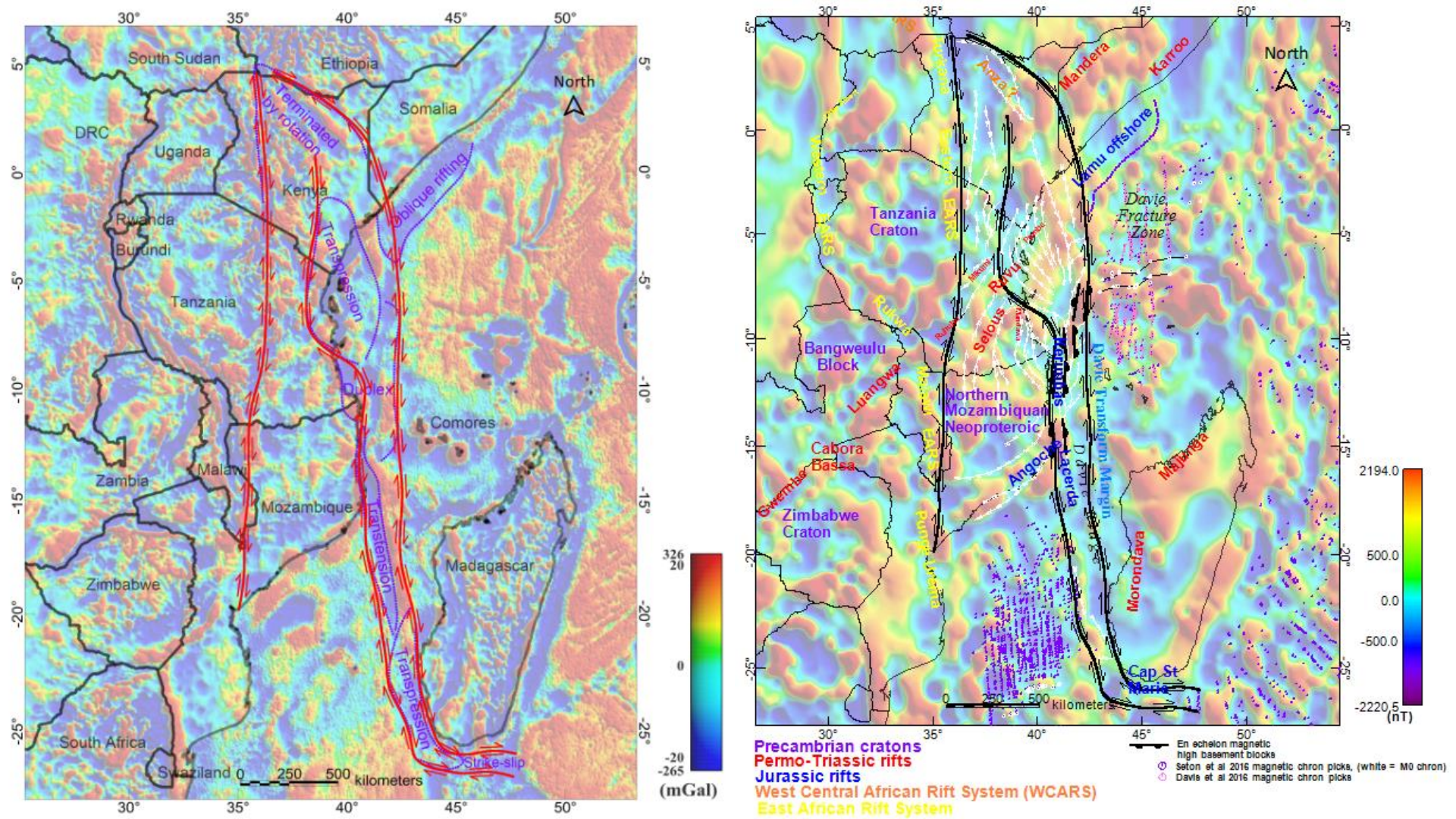
In a dextral strike slip setting, indicative of duplexing (e.g. **Woodcock and Fischer, 1986**)



IGRF corrected magnetics, reduced to pole



IGRF corrected magnetics, reduced to pole, amplitude gain corrected


South Sudan
Ethiopia
Somalia
DRC
Uganda
Kenya
Rwanda
Burundi
Tanzania
Zambia
Malawi
Mozambique
Zimbabwe
South Africa
Swaziland
Comores
Madagascar
North
Terminated by rotation
Oblique rifting
Transpression
Dudlex
Transtension
Transpression
Strike-slip
0 250 500 kilometers
326
20
0
-20
-265
(mGal)
Tanzania Craton
Bangweulu Block
Northern Mozambiquan Neoproterozoic
Zimbabwe Craton
Cabora Bassa
Davie Fracture Zone
Davie Transform Margin
Lamu offshore
Mandera
Karroo
Selous
Ruvu
Rukwa
Luangwa
Gwembe
Angoche
Lacerda
Morondava
Majunga
Cap St Marie
0 250 500 kilometers
2194.0
500.0
0.0
-500.0
-2220.5
(nT)
Precambrian cratons
Permo-Triassic rifts
Jurassic rifts
West Central African Rift System (WCARS)
East African Rift System
En echelon magnetic high basement blocks
Seton et al 2016 magnetic chron picks, (white = M0 chron)
Davis et al 2016 magnetic chron picks

Anza – the northern strike slip closure by rotation

Correlative strike slip fault offsets, transform margin, crustal extension, and oceanic boundary

Storti et al, 2003 intraplate strike slip tectonics

"During divergence, they act as transfer zones that segment rifts, passive continental margins and, ultimately, oceanic spreading ridges…

form major persistent zones of apparent weakness whose influence may be felt over many hundreds or even thousands of million years."

Neogene inversion – reactivation of transform margin

Depth of Anza, what lies on basement? Seismic not deep enough

Zone of suturing

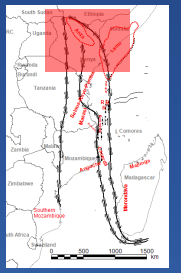
Anza has an ellipsoidal long axis parallel to the eastern transform margin

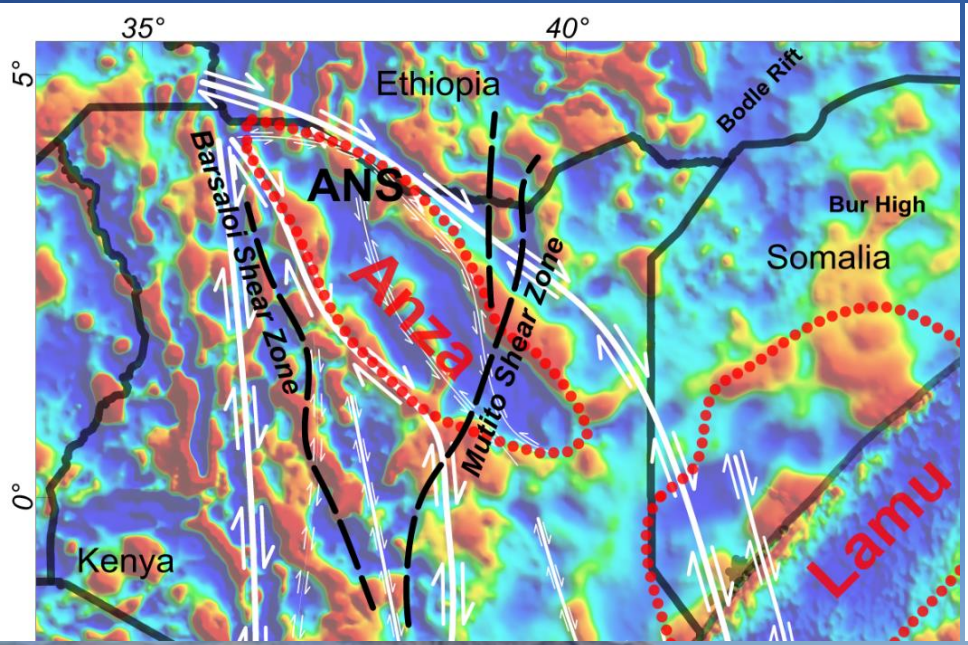
Has Anza been rotated?

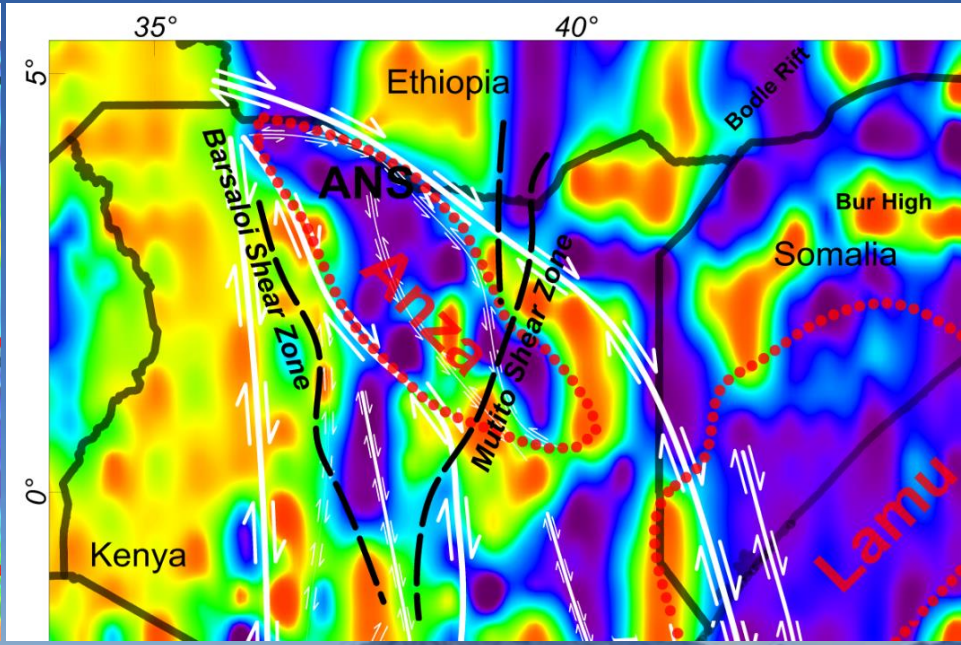
Highly rotated Cretaceous lower section, less rotated Palaeogene upper section (Morley, 1999)

Anza – the northern strike slip closure by rotation

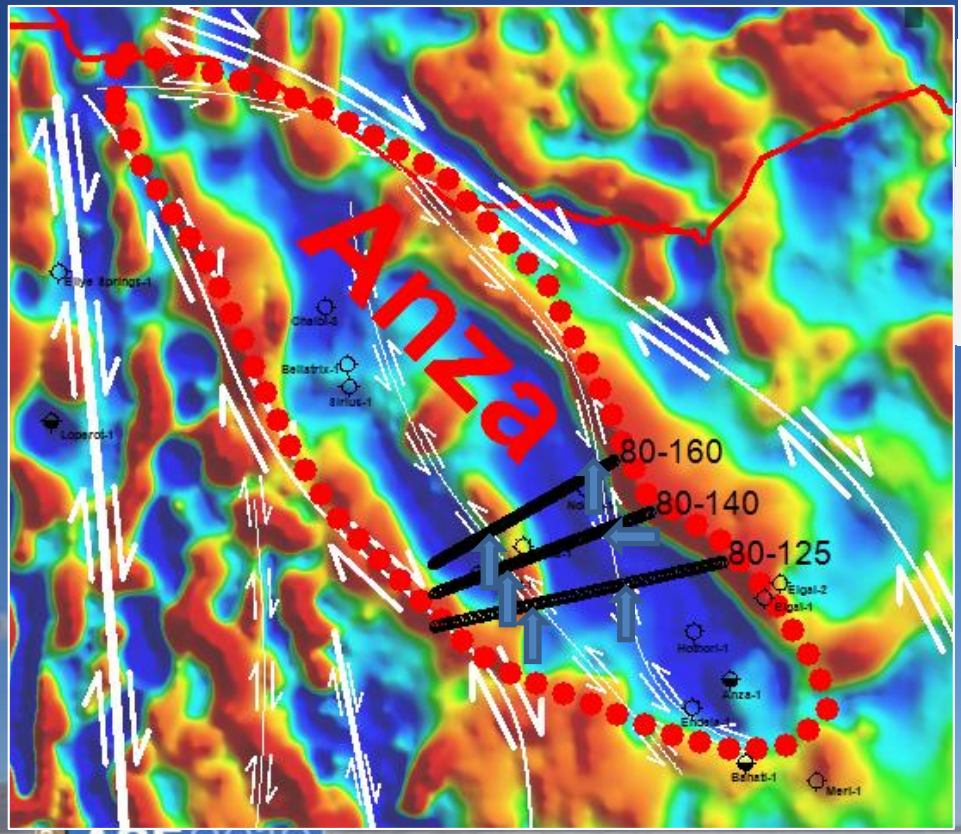
Below: Decompensative gravity, *below right*: IGRF corrected, reduced to pole magnetics

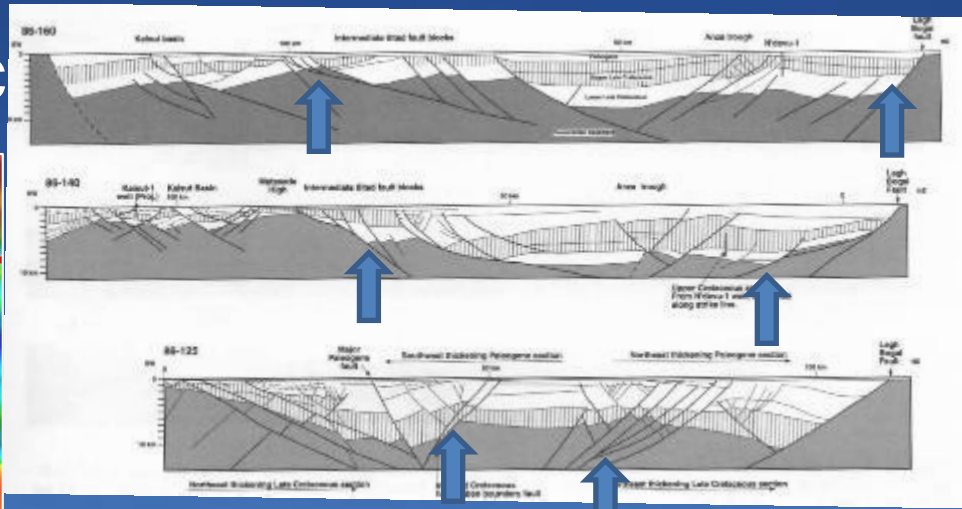






South east Anza: seismic



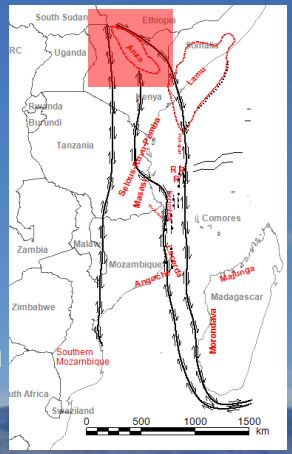


Above: figure 15, Morley et al, 1999
Left: Decompensative gravity

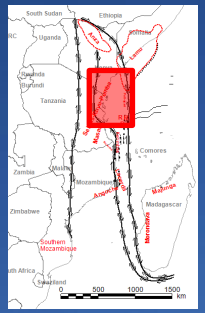
Kaisut (west central Anza): correlative deep basement faults

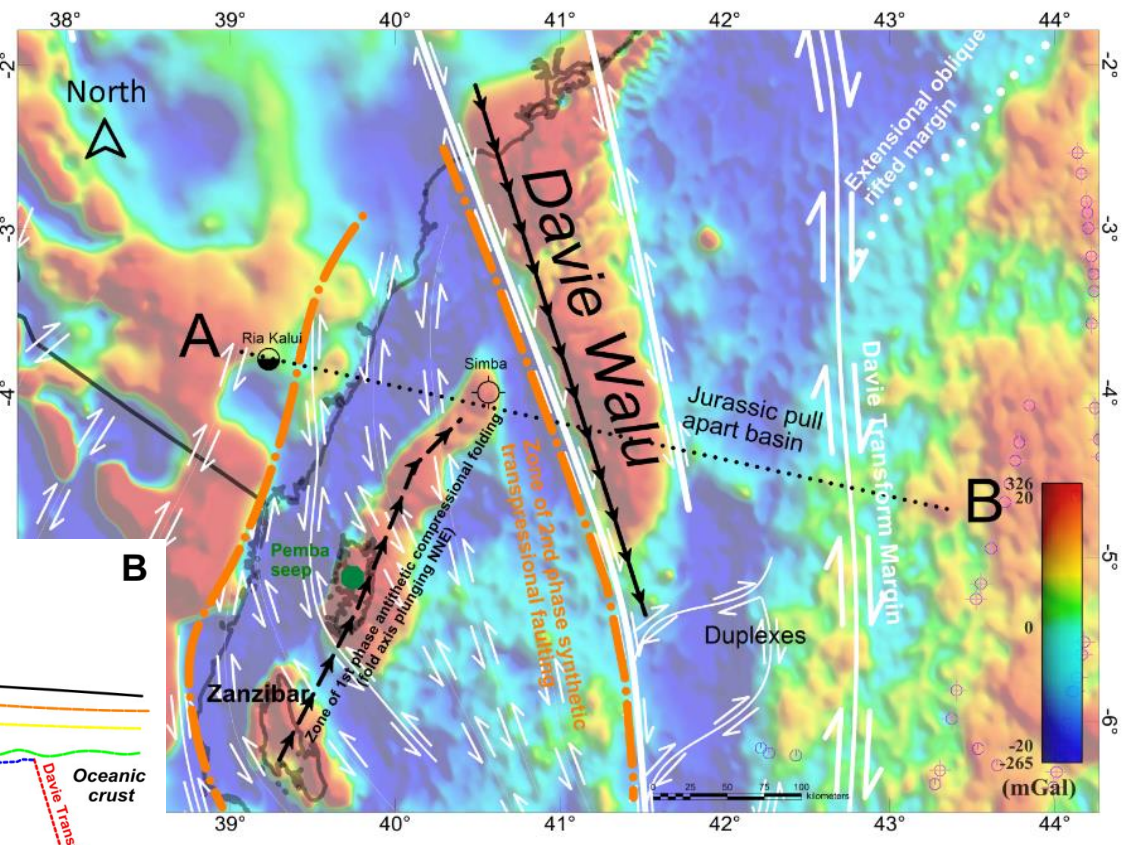
Highly rotated Cretaceous lower section, less rotated Palaeogene upper section (Morley, 1999)

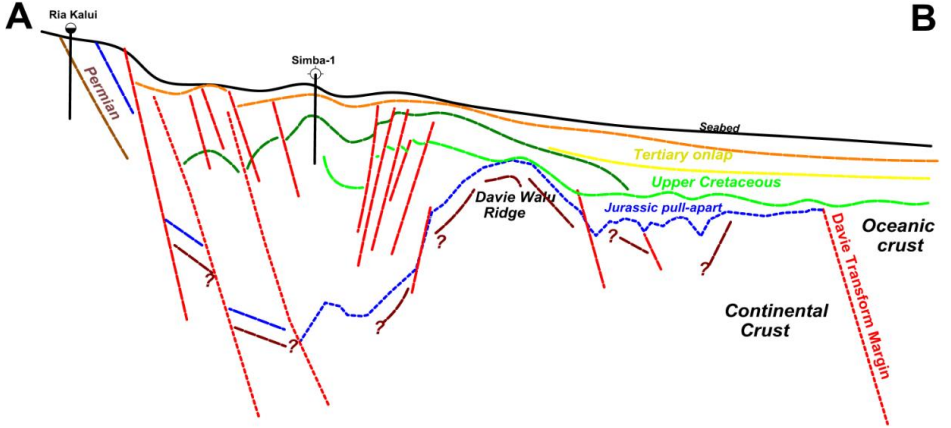
Early strike slip \ oblique rifting\ transform margin propagates
Later reactivation as inversion



Axis of Davie Walu Ridge and Pemba, Zanzibar, Mafia Islands, offshore Lamu







Residual gravity, with 1st and 2nd phase deformation structures annotated in the transpressional zone offshore Tanzania and Kenya

Offshore Tanzania, failed rifting and onset of early extensional duplexing

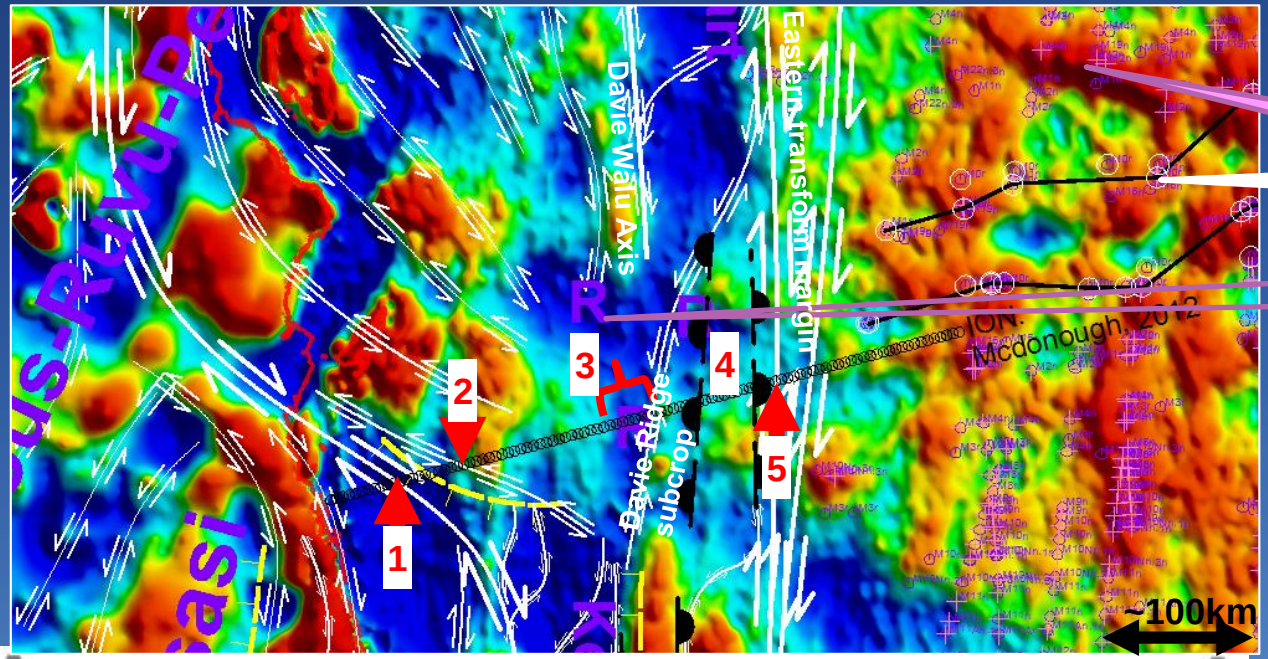
1 Transpression restraining fault

2 Transpression restraining fault

3 Failed triple R aulacogen

4 Outer high

5 Eastern Transform Margin

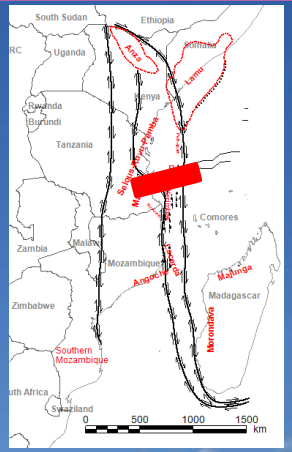


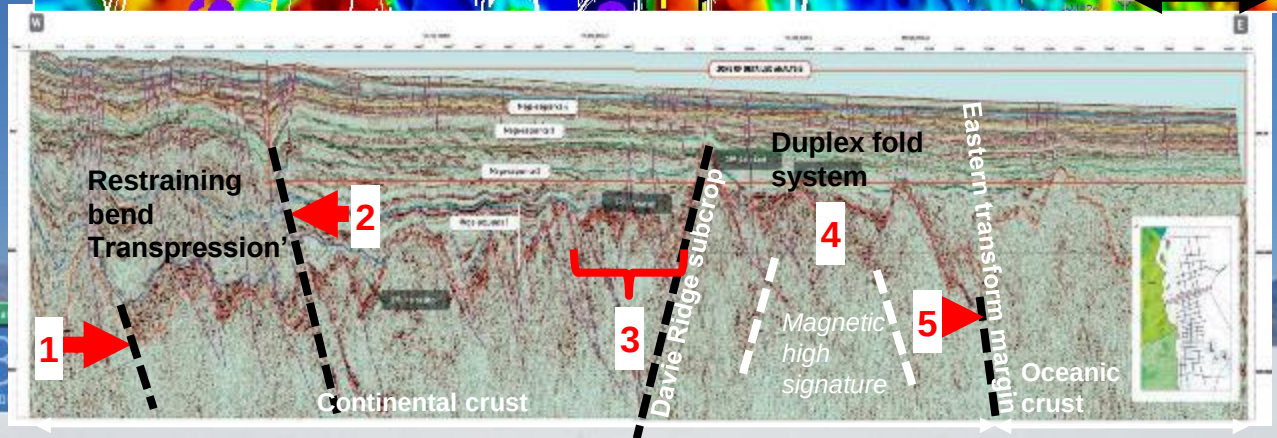
Left: Decompensative gravity

Published magnetic chron picks

Davis, 2016, M0 trace

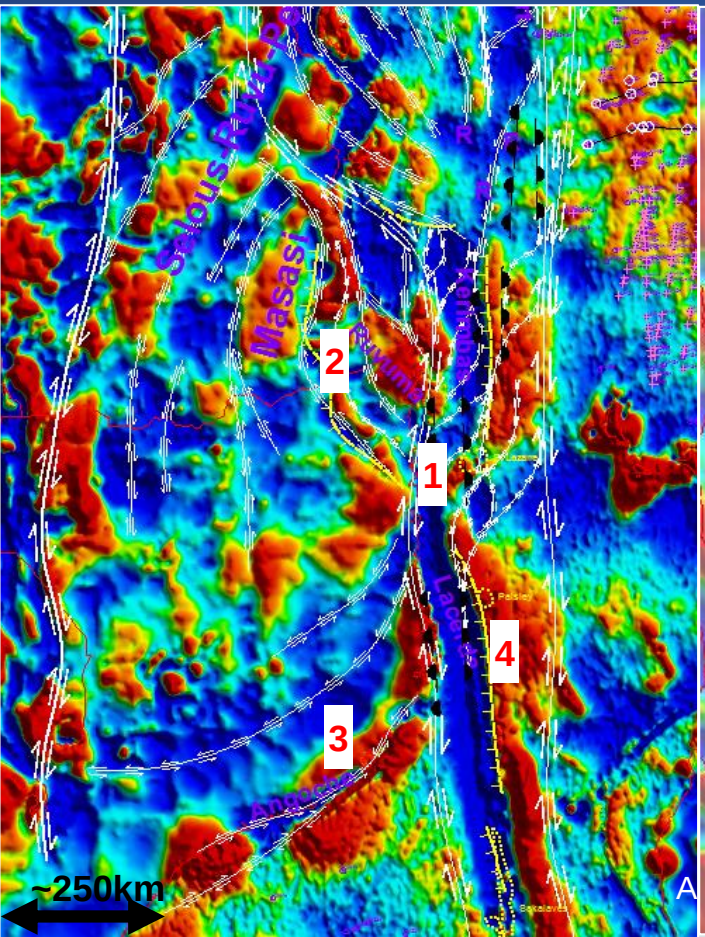
Triple R failed aulacogen on M0 axis

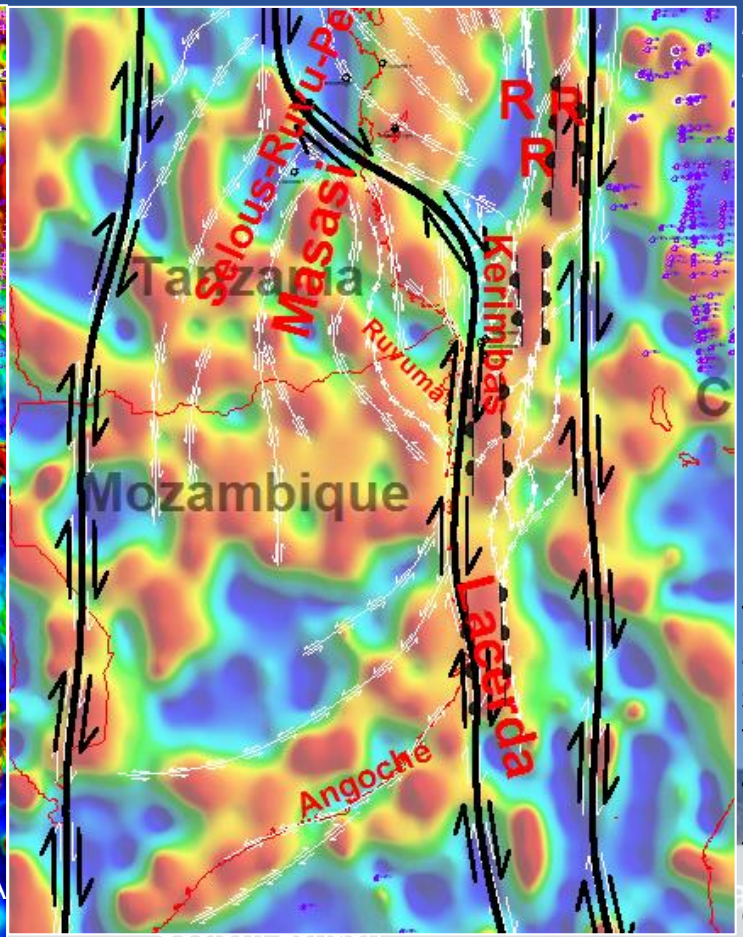




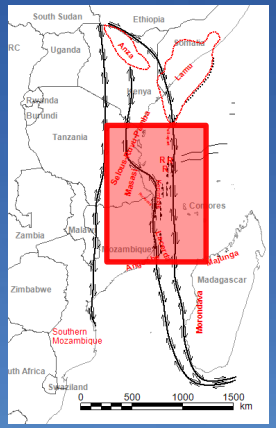
Left: ION line: *TZ3-2700 after* **McDonough et al, 2012**

Offshore Mozambique Kerimbas-Lacerda duplex to transtension





Left: Decompensative gravity
Right: EMM, IGRF corrected, reduced to pole magnetics



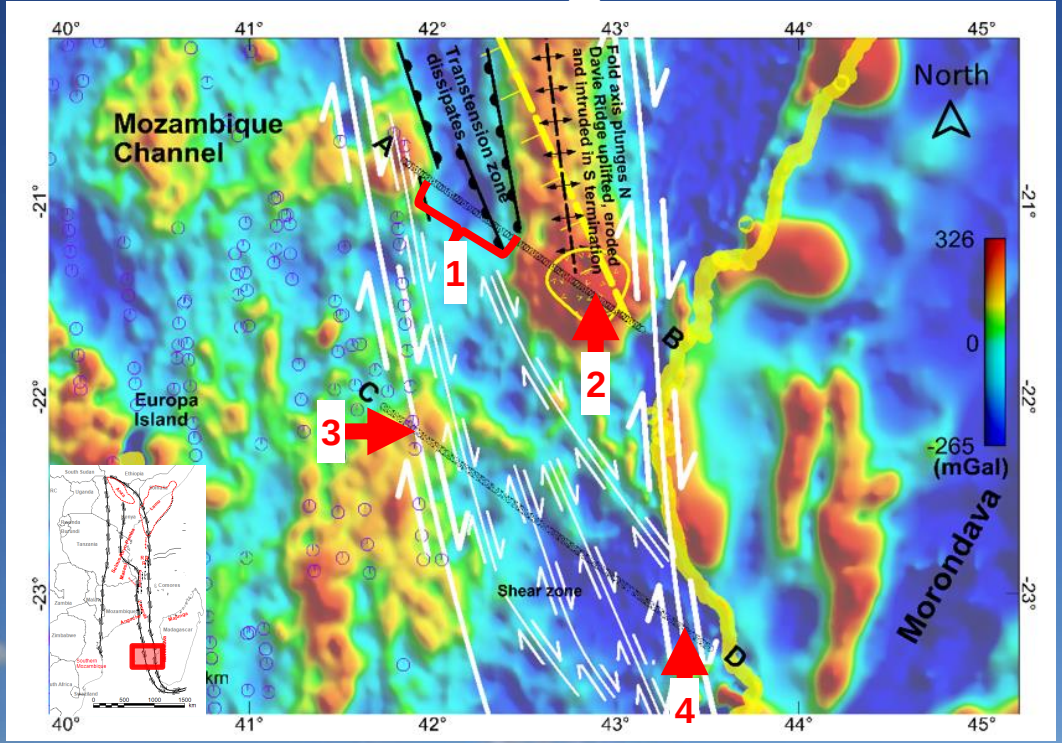
1 Southern onset of narrow transtensional zone (Lacerda basin)

2 Rotation of Rovuma

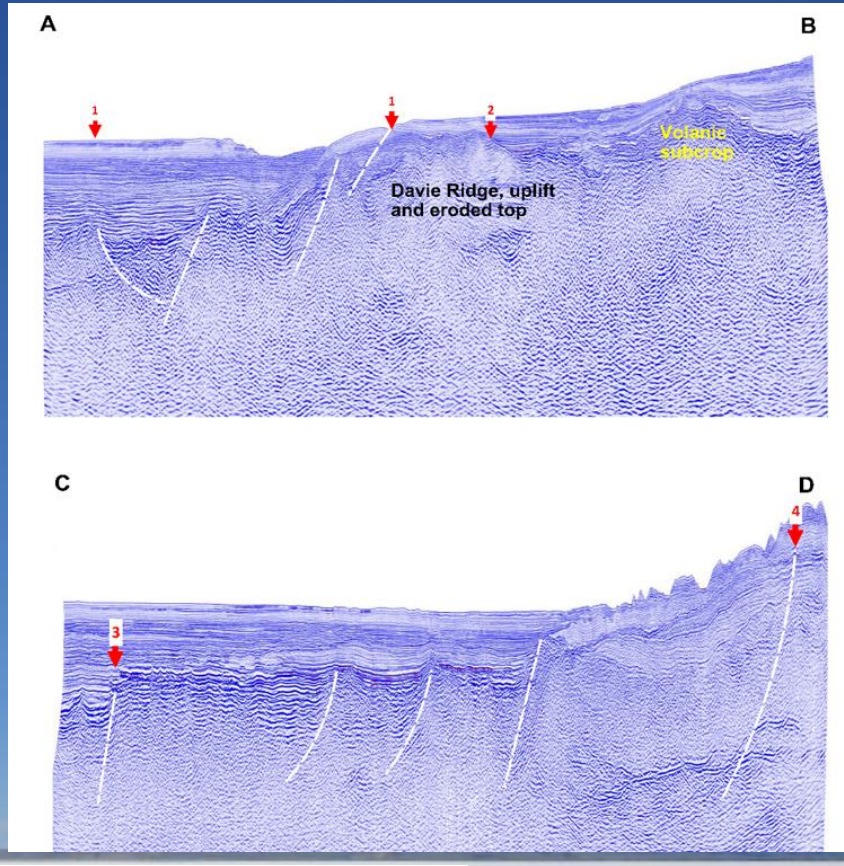
3 Angoche pull-apart, antithetic fault zone

4 Offshore Tertiary uplift - easterly bound by deep basement blocks, form bathymetric ridges (yellow lineaments) binds Davie Ridge to east

Davie Ridge and the Morondava Basin



1 transtensional zone narrows 3 the western oceanic crust margin
2 volcanic seamount intrusion 4 the eastern strike slip margin



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Seismic data courtesy of TGS

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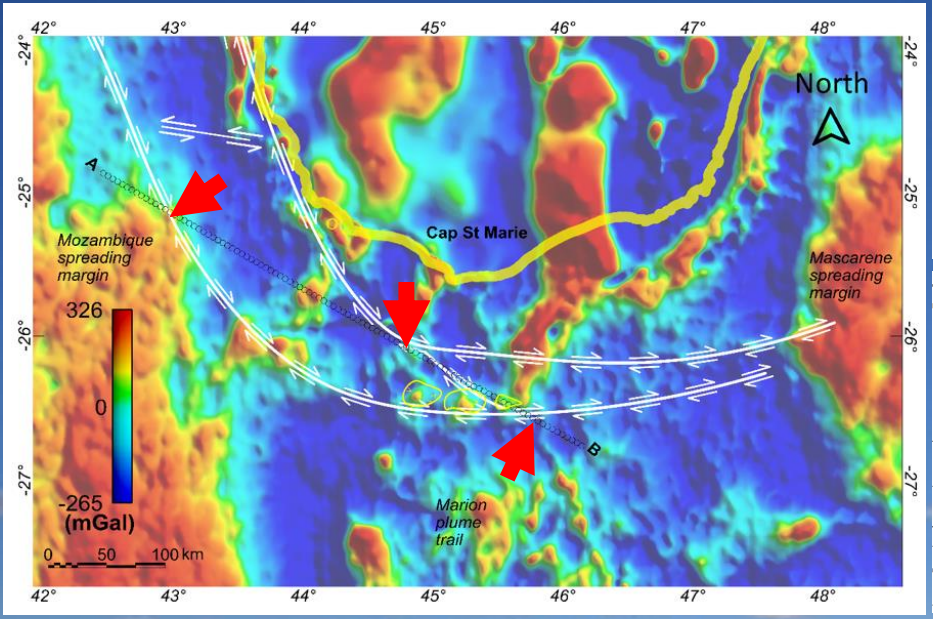
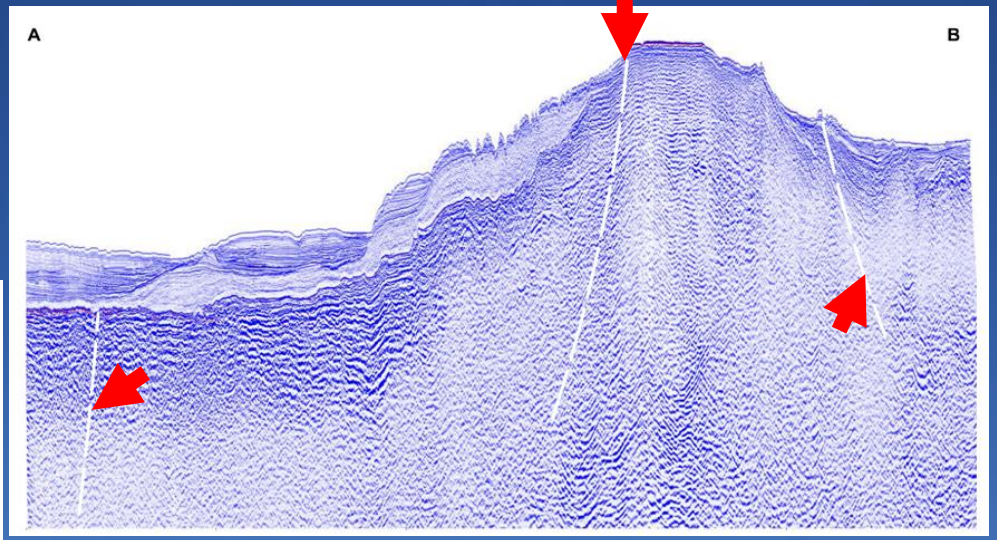
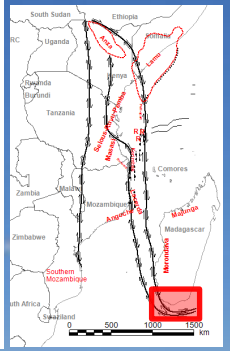
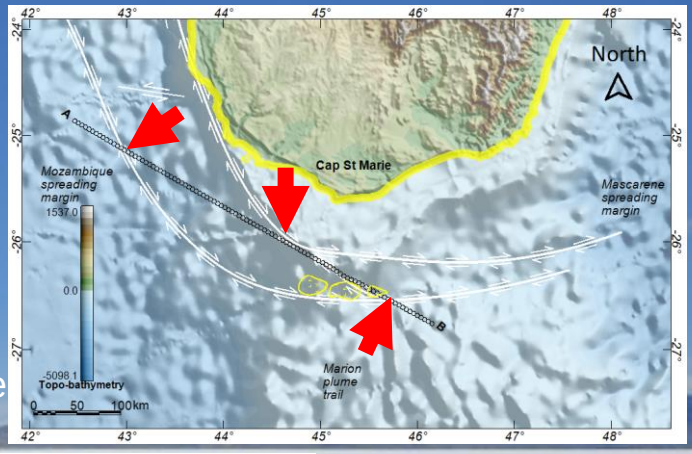
Davie Transform Margin, closure in active strike slip, offshore Madagascar









Above: Decompensative gravity

Right: Topo-bathymetry offshore southern Madagascar

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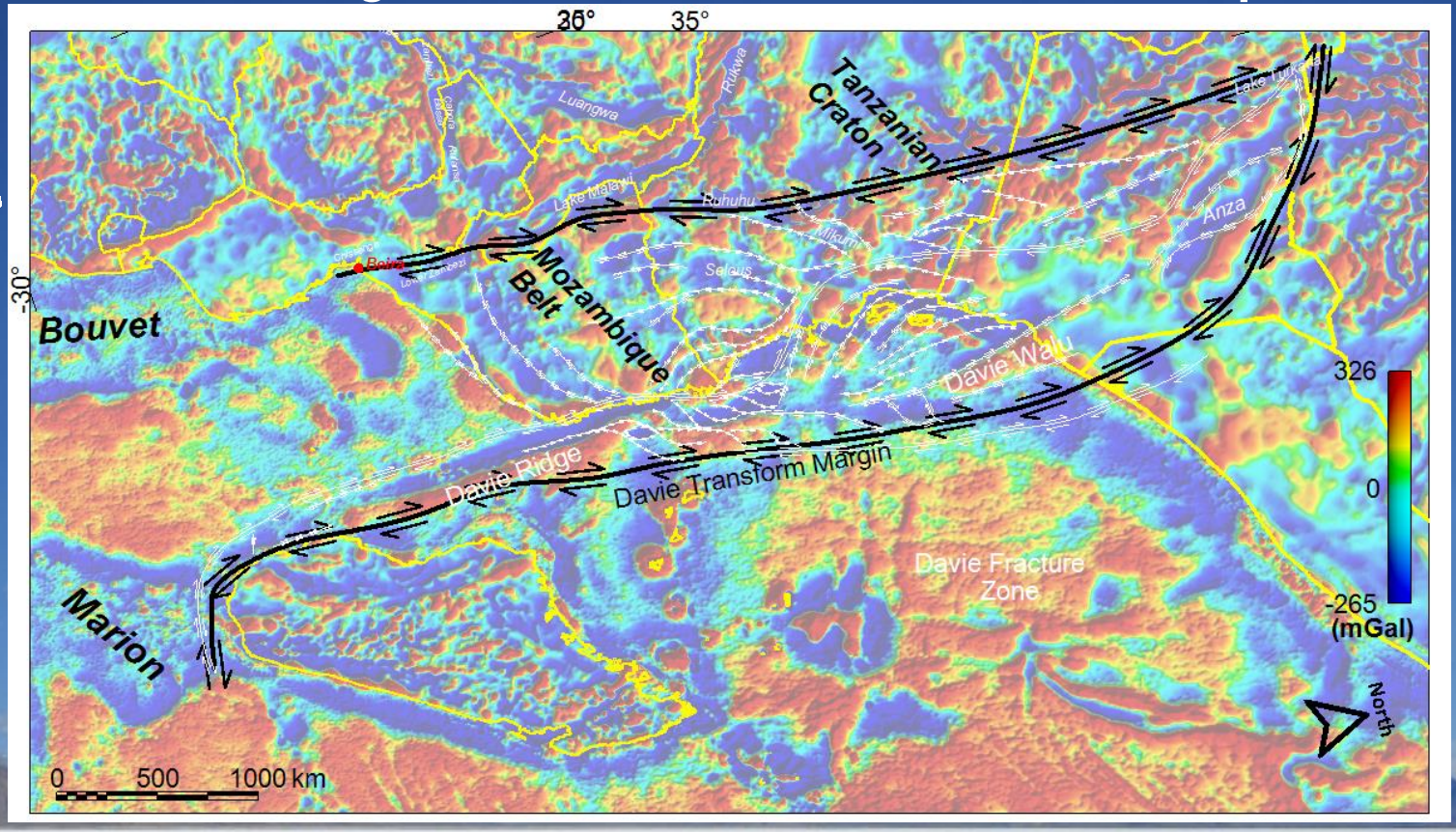
Western transform margin and Central, Southern Mozambique



Conclusions

The transform margin has evolved from a Jurassic extensional dextral strike slip system into a sigmoidal complex system defined by many common shear structures associated with strike slip tectonics, spanning over 4,000km arcuate length.

The margin propagated from as far north west as Anza, which is believed to overlie the original Neoproterozoic suture between West Gondwana cratonic centre and Azania, East Gondwana.

The Davie Transform Margin extends much further east into the Indian Ocean, this has important consequences for deepwater exploration of extractive resources. It's western margin is defined by the West Gondwana cratonic front, comprising the Zimbabwe, Tanzanian and Congo cratons.

Tertiary EARS onshore has been locked by the strike slip corridor, and modern seismicity indicates that fault movement is still active in several zones of the transform margin (Long 2017).

There are other examples of long lived strike slip faults that have influenced basin evolution, rifting, oceanic spreading and subduction as the fault system propagates (Long, 2018)

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