Structural Styles in the Jubba Deep Basin, Offshore Somalia

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Abstract

One of the critical elements in petroleum system assessment with a controlling influence on hydrocarbon prospectivity is the timing of trap formation. Structural analysis of thin-skin deformation identified on a regional 2D seismic dataset in the Jubba Deep Basin, offshore Somalia, demonstrated multiple episodes of structurization. Multiple detachment surfaces with toe thrusts were identified, including salt and shale mobilization episodes and recent shale diapirism. This deformation was linked to episodes of volcanic activity and tectonism related to regional geodynamic evolution.

The continental crust of the basin was highly stretched during Late Triassic rifting, with a proto-oceanic basement formed during the Early Jurassic rifting period (190 Ma. – 175 Ma.). Evaporite occurrences of this age are reported in the literature in onshore basins of East Africa and Madagascar. The oceanic spreading followed, and the separation of Madagascar from the African-Arabian plate was complete by Aptian times (120 Ma.). The Jubba Deep basin received large volumes of sediments delivered via Anza graben and fluvial input from the north, diverted by margin uplift in the Palaeocene.

Three main episodes of thin-skinned deformation in the Jubba Deep basin were interpreted: 1. Lower Cretaceous: allochthonous salt mobilization followed by the emplacement of a salt canopy deformed Upper Jurassic to Lower Cretaceous strata. 2. Palaeocene: gravity-driven processes triggered the Kismaayo Fold-Thrust Belt. The main transport direction was towards the southeast, with detachment at the base of the Late Cretaceous. 3. Pliocene - Quaternary: gravity-driven processes triggered the Barawee Fold-Thrust Belt on the northeastern side of the Kismaayo fold-thrust belt. The main transport direction was southeast, with a detachment level at the top of the Palaeocene.

The first two episodes are associated with major uplift events (mantle processes) along the southern part of the African continent that triggered significant input of sediments into the basin. The final episode is contemporary to the active Kenyan - Ethiopian doming, a leading active element of the East African Rift System.

Detailed analysis of the evolution of the basin will require 3D data and is likely to identify prospective traps with access to charge: rotated blocks, toe-thrusts, sub-thrusts, salt-core anticlines, sub-canopy anticlines, and mud-core anticlines.

References

De Vera, J., Granado, P., and McClay, K. (2010), Structural evolution of the Orange Basin gravity-driven system, offshore Namibia, Marine and Petroleum Geology 27: 223–237

Gaina, C., Torsvik, T., van Hinsbergen, D., Medvedev, Werner, S., and Labails, C. (2013), *The African Plate: A history of oceanic crust accretion and subduction since the Jurassic, Tectonophysics, 604: 4-25*

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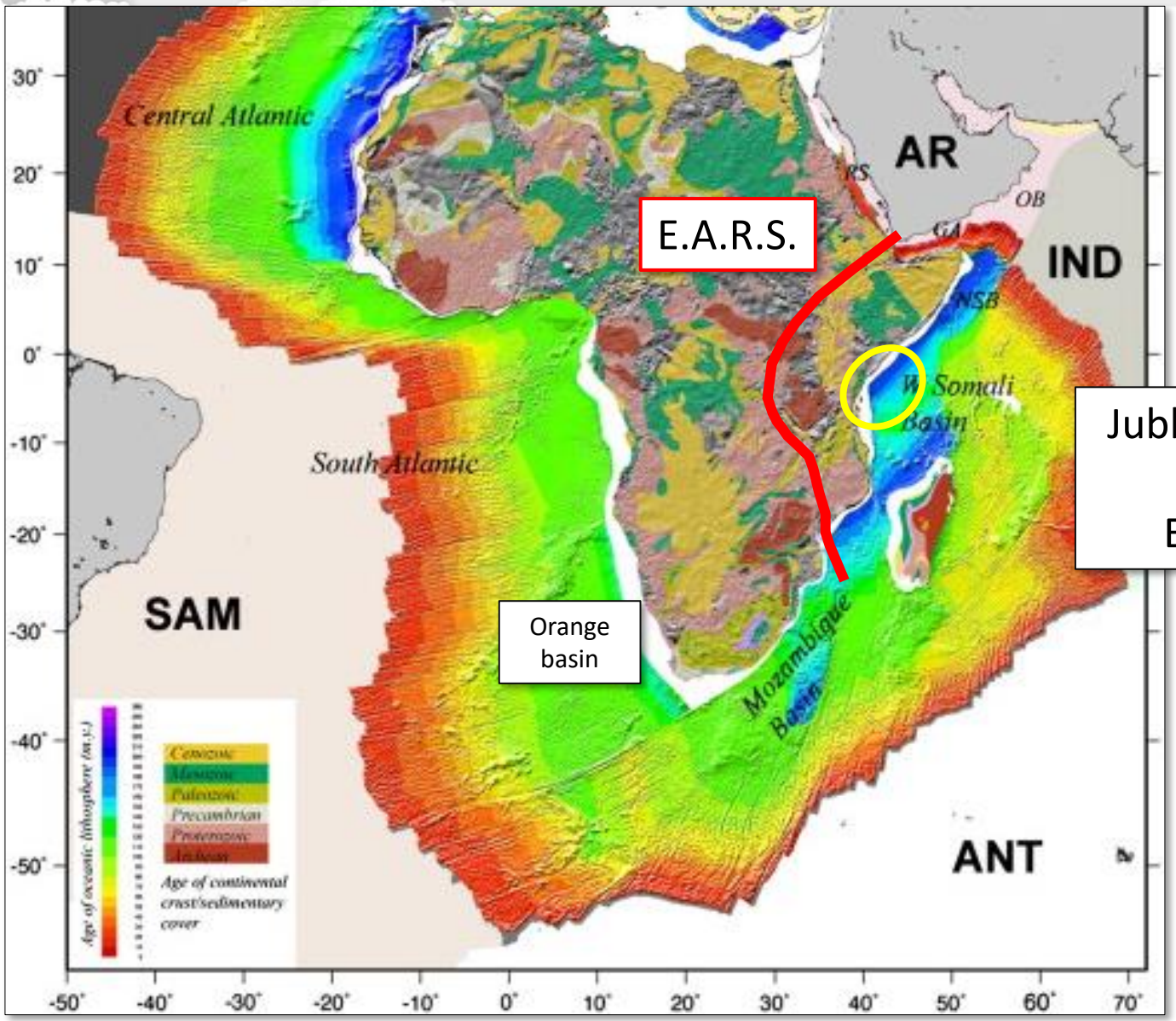
Agenda

- Summary
- Introduction
- Data base
- Discussion

Summary

- Critical element (Pet-Sys): Trap timing analysis, linked to a valid Geodynamic setting / evolution.
- Several episodes of thin-skin deformations.
- Several detachment levels (from 2d seismic).
- Mobile Shales (Tertiary) and Mobile Evaporites (Mesozoic).
- Late Tr. - E. Jr Rifting (190 Ma. - 175 Ma.).
- Oceanic Spreading ended at 120 Ma. (Aptian).
- 3 main episodes of thin-skin deformations: Lower Cretaceous, Paleocene, and Pliocene – Quaternary.
- Detailed analysis to identify prospective traps with access to charge (rotated blocks, toe-thrusts, sub-thrusts, salt-core anticlines, sub-canopy anticlines, and mud-core anticlines) will require 3D seismic data.

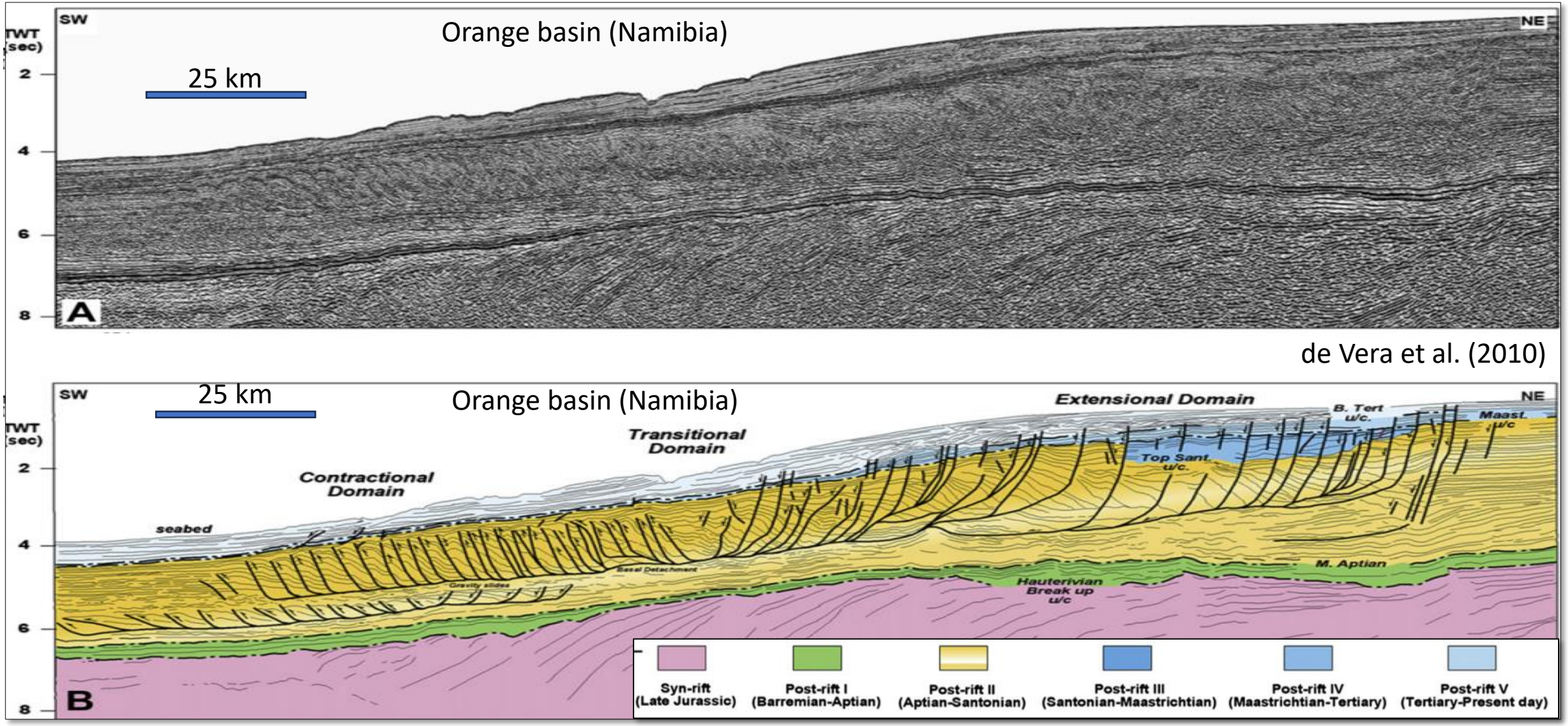
Jubba Basin location



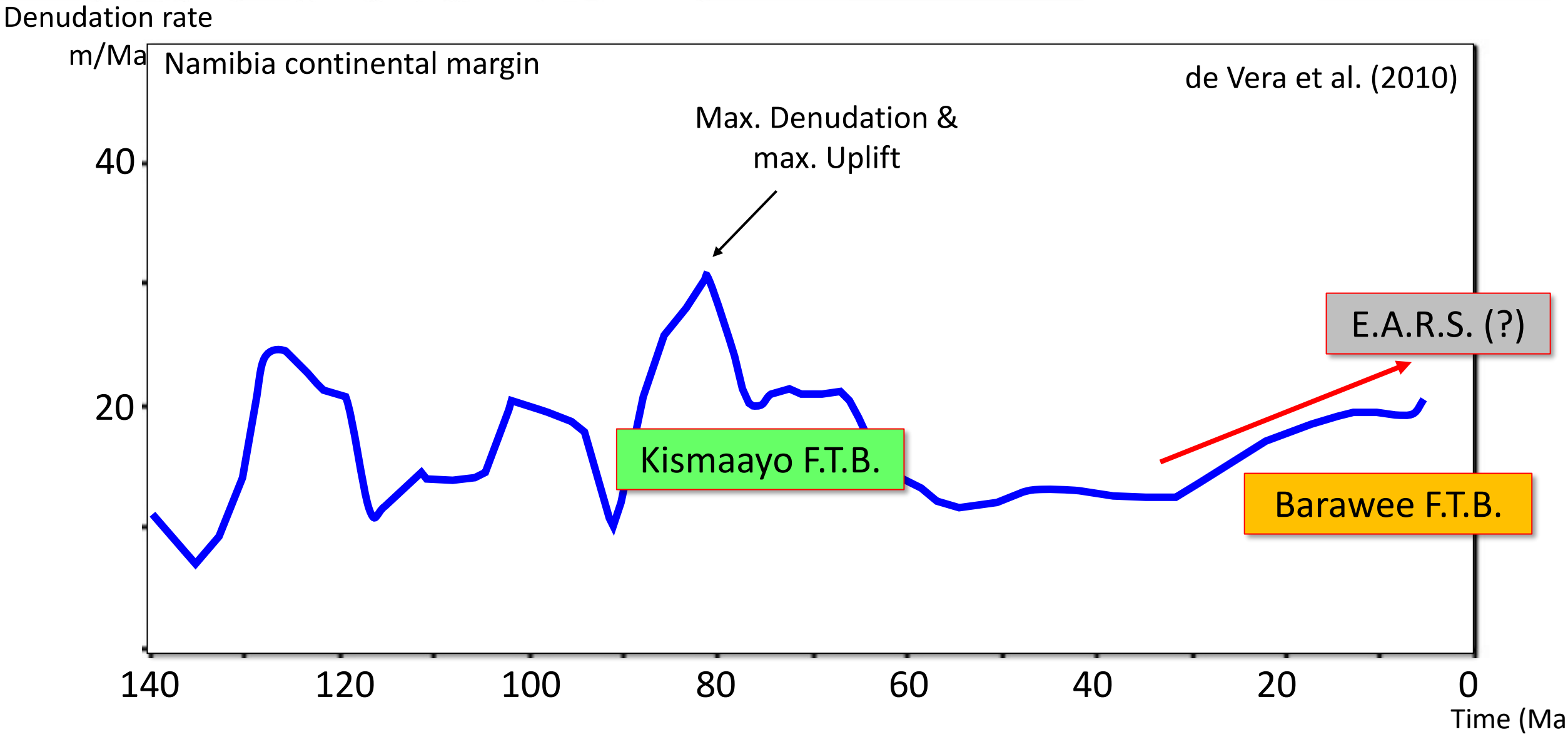
Jubba basin is located to the east of East Africa Rift System

Gaina et al.(2013)

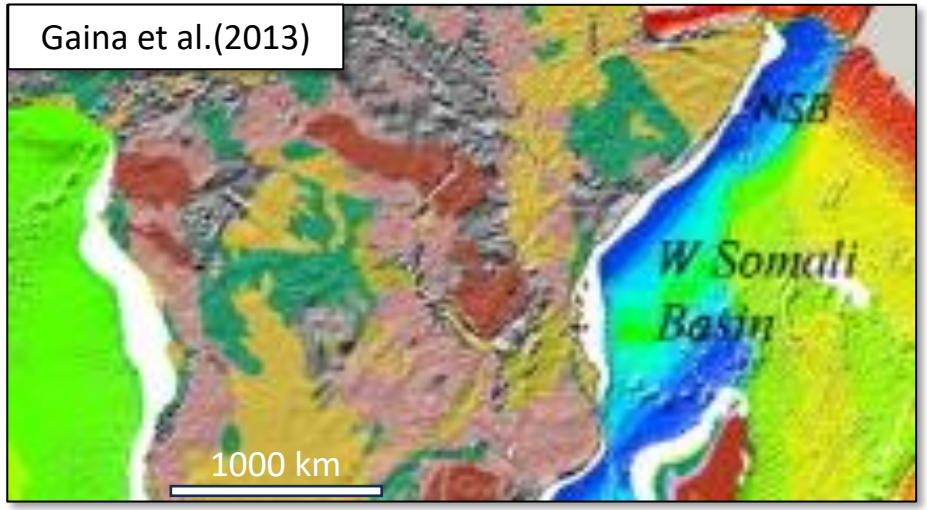
Possible analogue: 2 gravity-driven F.T.B.'s

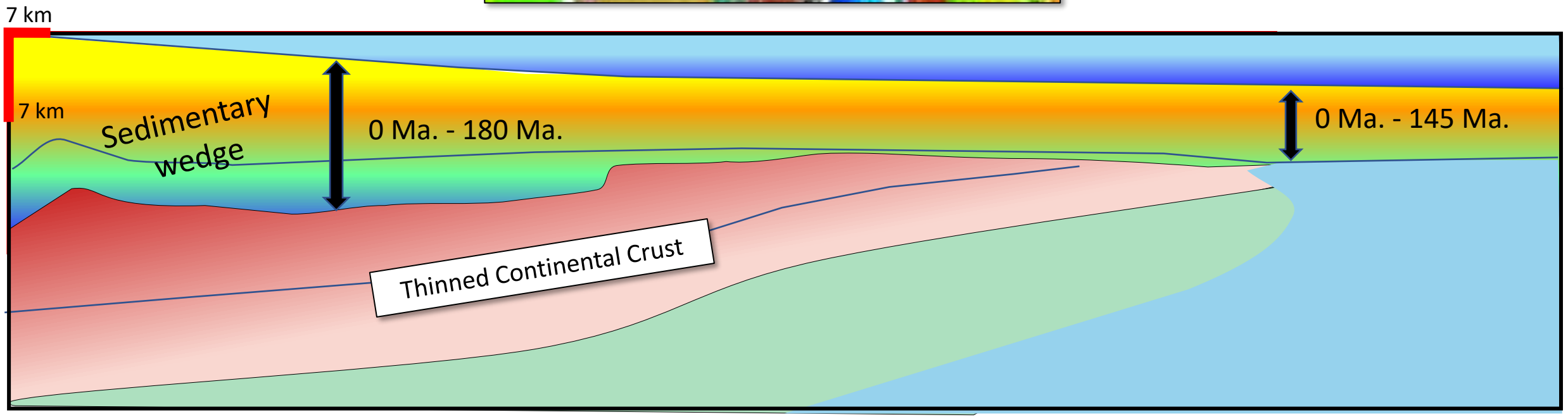


Gravity gliding vs. Denudation rate



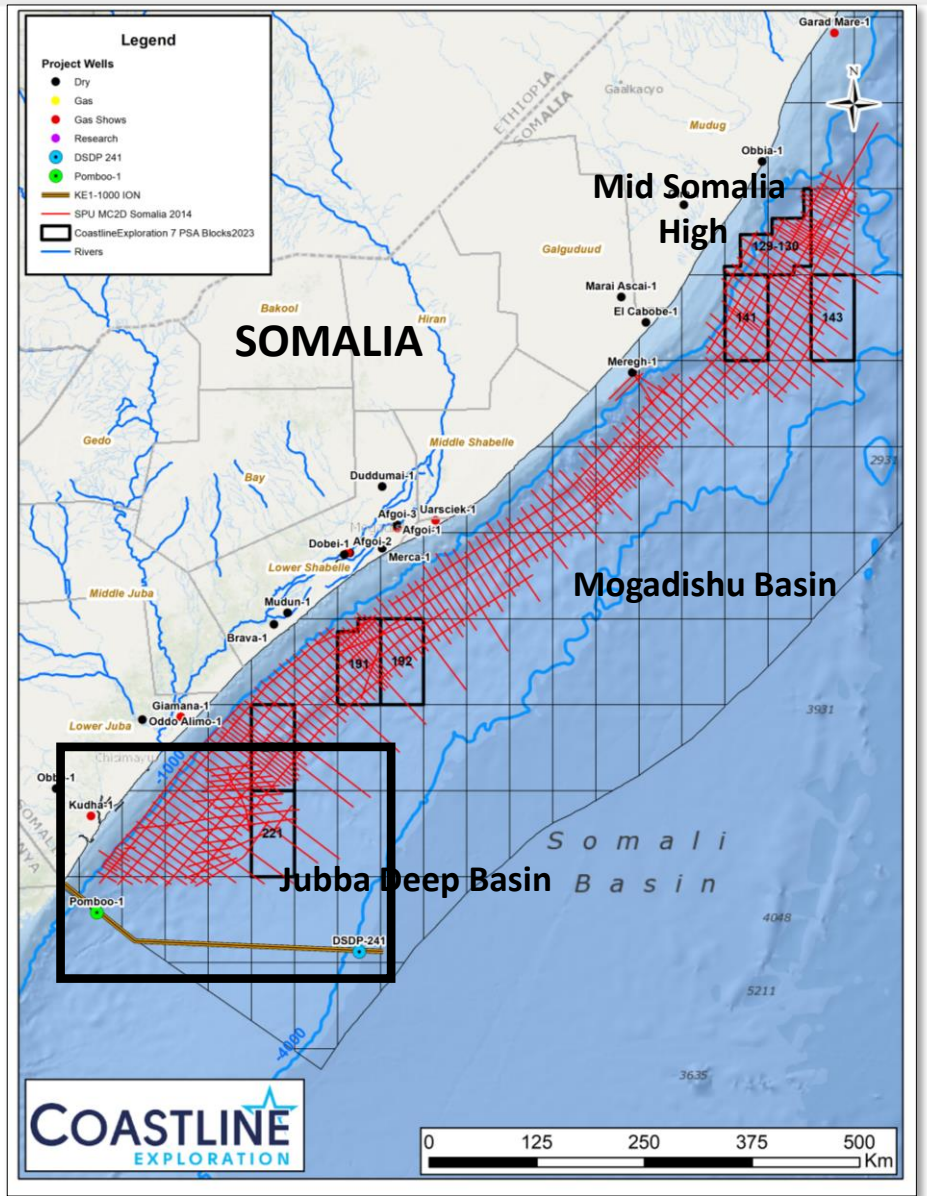
Lithospheric model





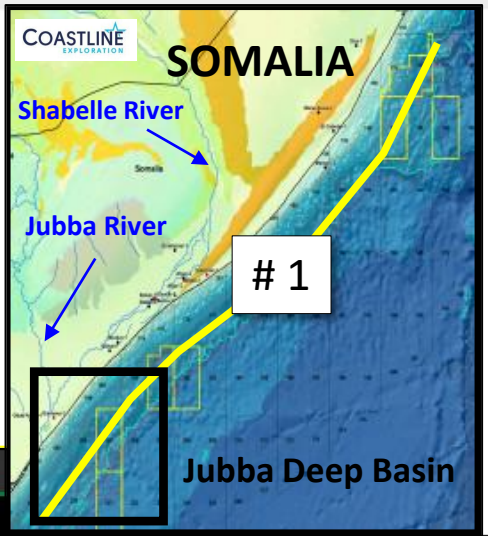
Location and Database

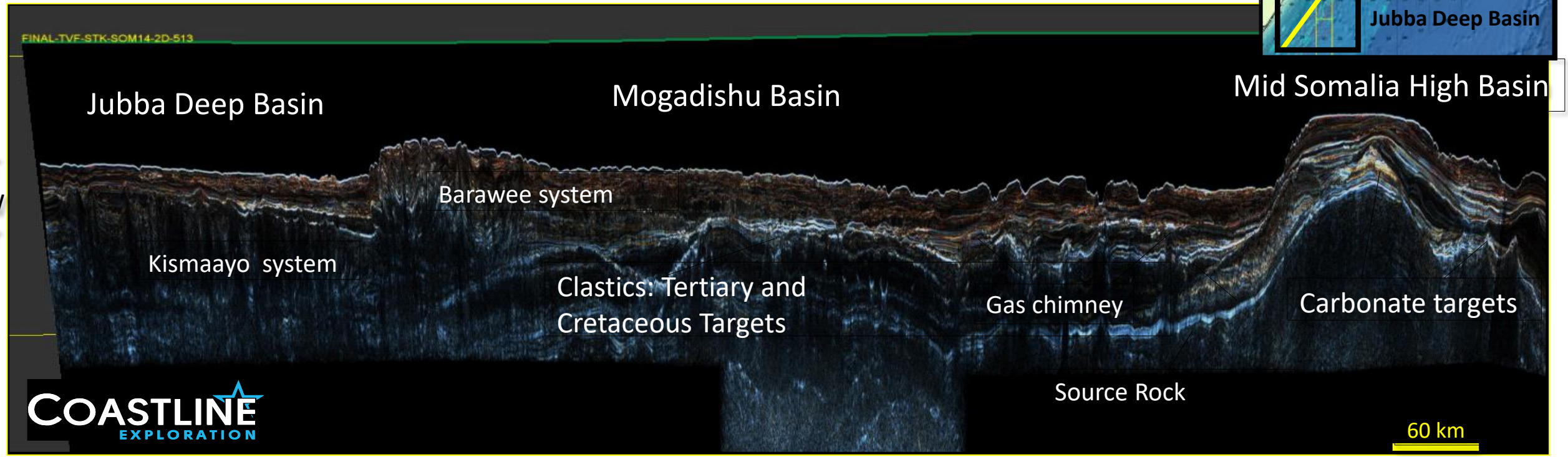
- 20,000 line-km Regional 2D seismic dataset.
- Wells - stratigraphic studies and early petroleum. Exploration drilled in 1950's-1980's.
- Satellite gravity.
- Onshore geology.
- ODP studies.
- Offshore magnetic anomalies interpretations.
- Slick and seeps study.
- Literature.
- UTIG Plates modified model.



Regional 2d seismic section # 1

Spectral Decomposition





Regional Tectonic events

PERIOD	EPOCH
	Present
	Holocene
	Pleistocene
Neogene	Pliocene
	Miocene
Paleogene	Oligocene
	Eocene
	Paleocene
Cretaceous	Upper
	Lower
Jurassic	Upper
	Middle
	Lower
Triassic	Upper
	Middle
	Lower

Seismic Horizons

E.A.R.S. (*) to N. & W. Kenya & Ethiopian Domings

30 – Red sea opening

55 India-Eurasia Collision

90-65 structuring event on Mid-Somalia high (MSH)

120-90 Somali Passive Margin quiescent- the Tethyan subduction zone north of India was organizing

145 India rifted 145-120

175 opening started south of Mid-Somalia high in Magadishu

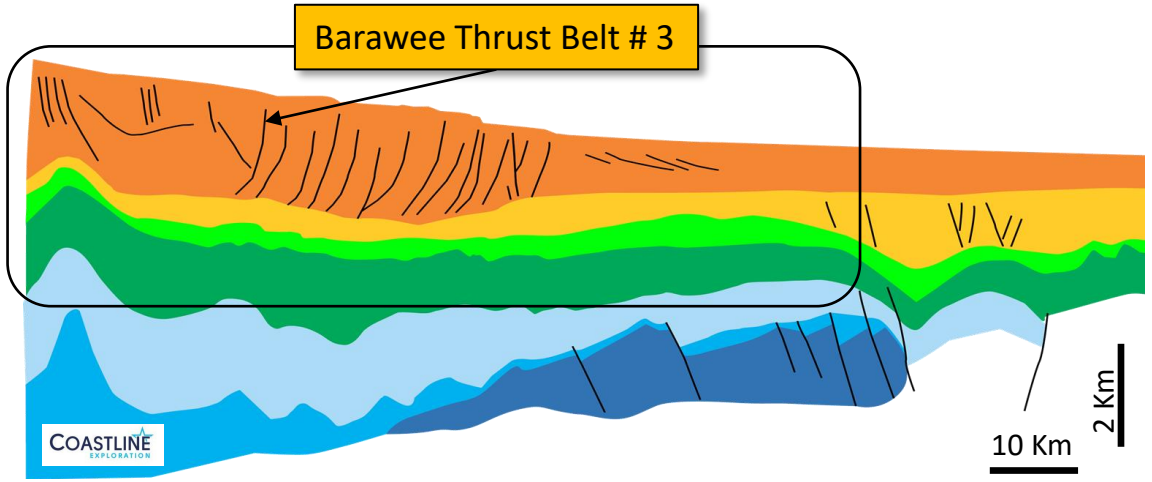
190 Continental rifting 190-175

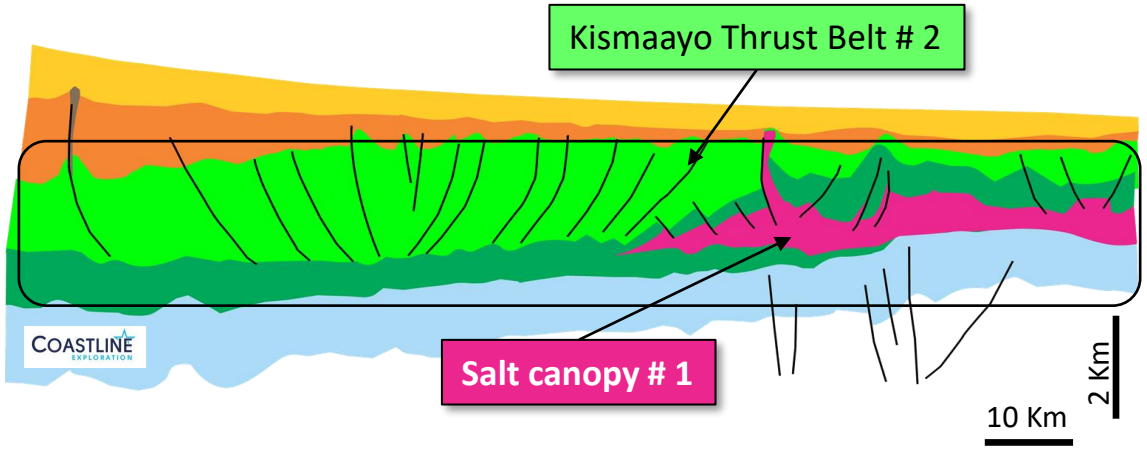
3

2

1

Extensional Basins
Passive Margin
Contractional structures

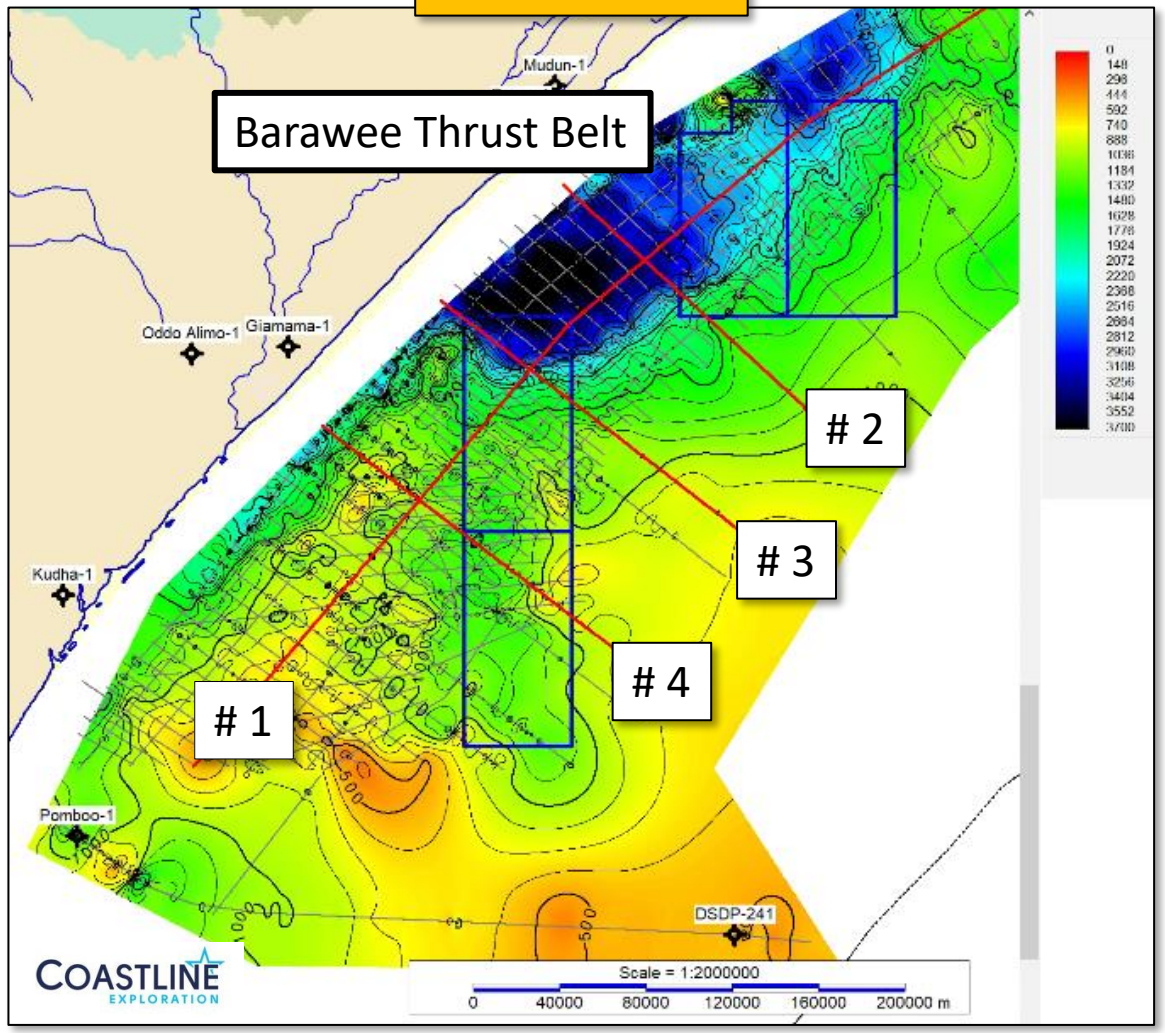




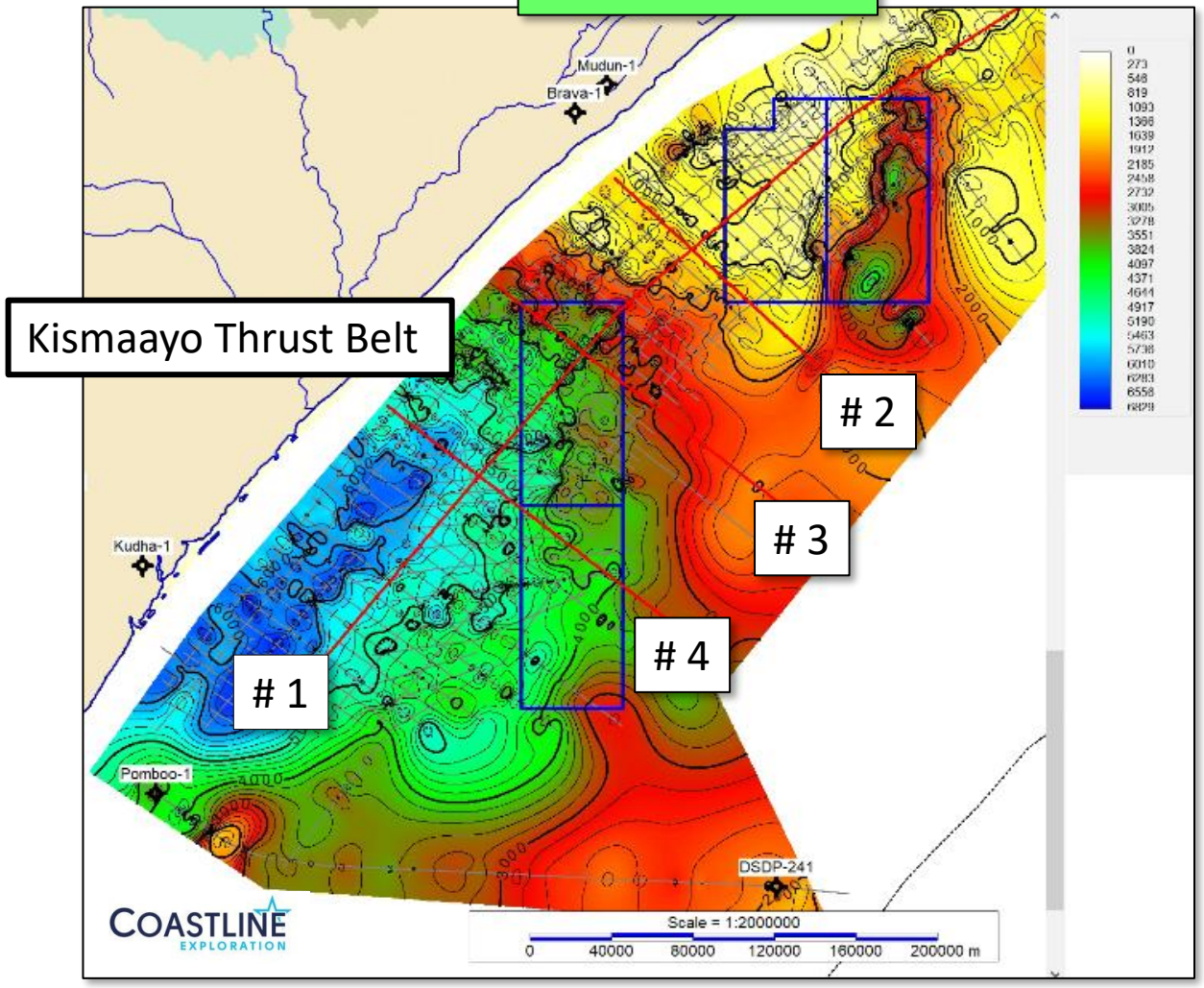
Continental Basement | Permo – Triassic | Early Jurassic Basement | Bajocian-Bathonian | Bathonian | Late Jurassic | Lower K | Upper K | Paleocene | Tertiary to Present

Isopach maps

O Ma. - 55 Ma.

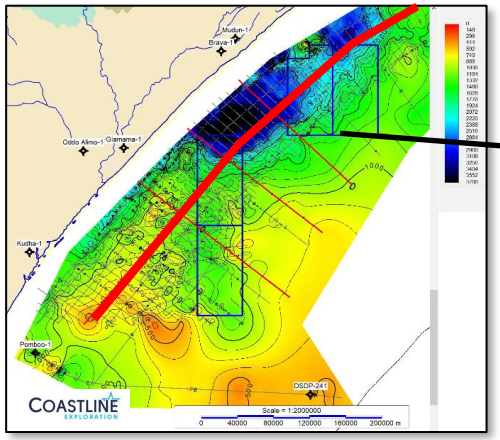


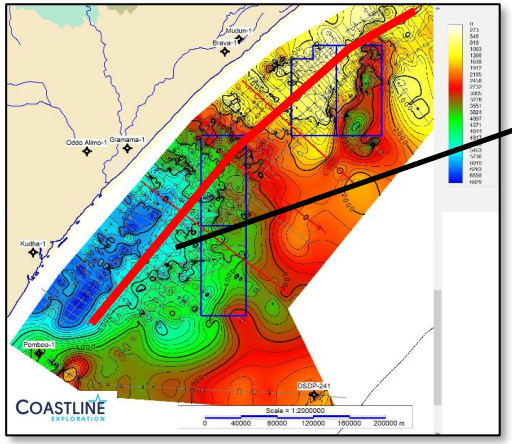
55 Ma. - 120 Ma.

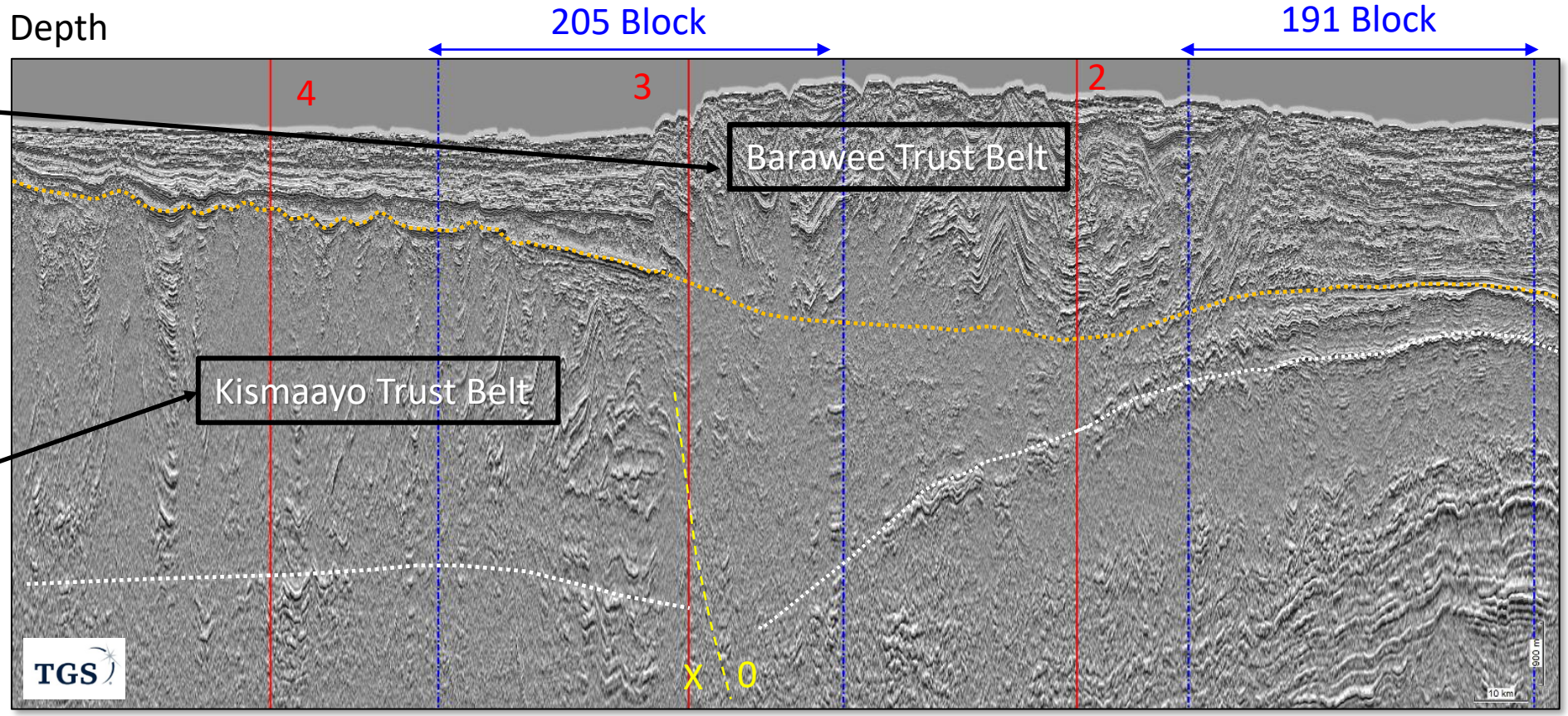


2D Line # 1

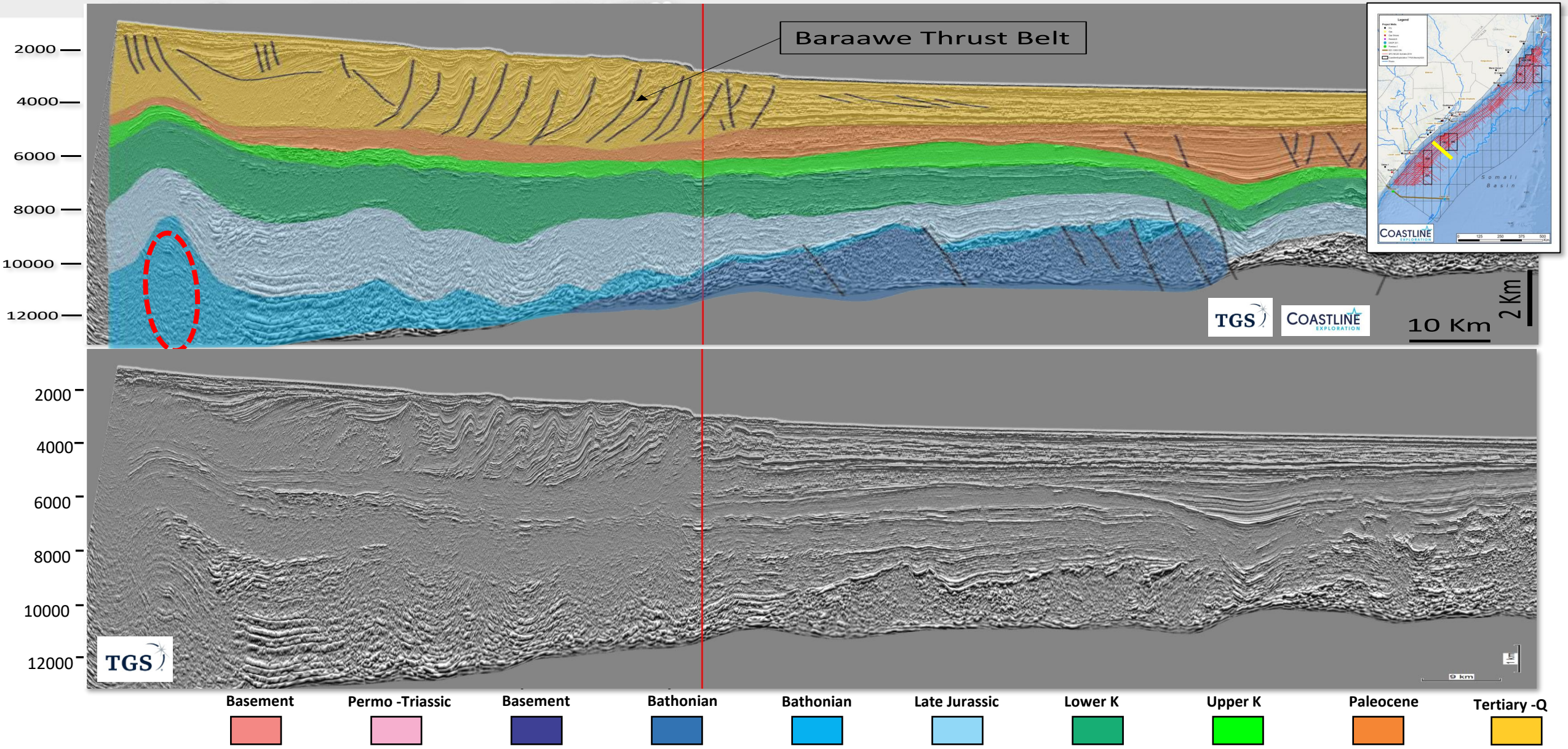
2D seismic line, co-blending amplitude and pseudo-relieve attribute



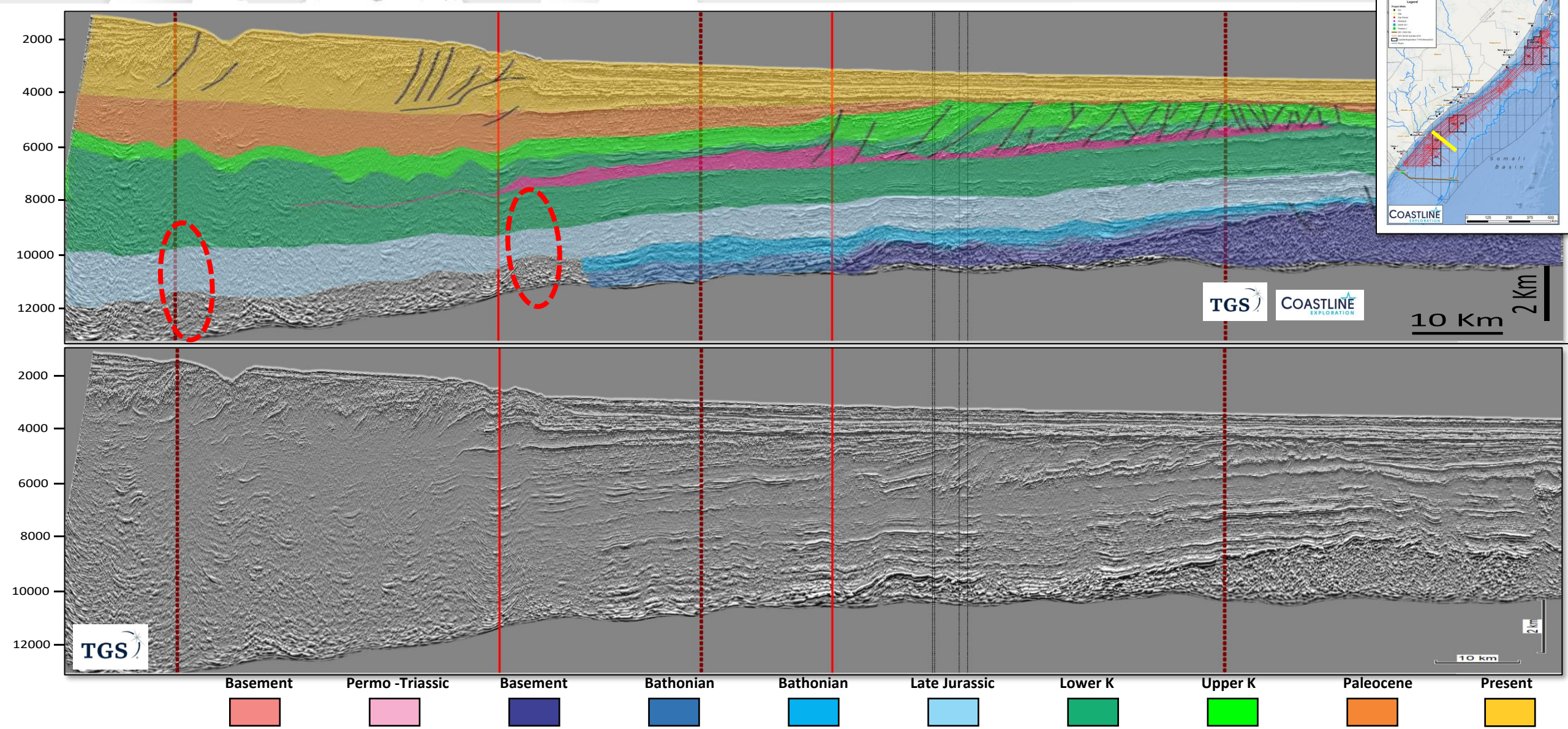




2D Line # 2

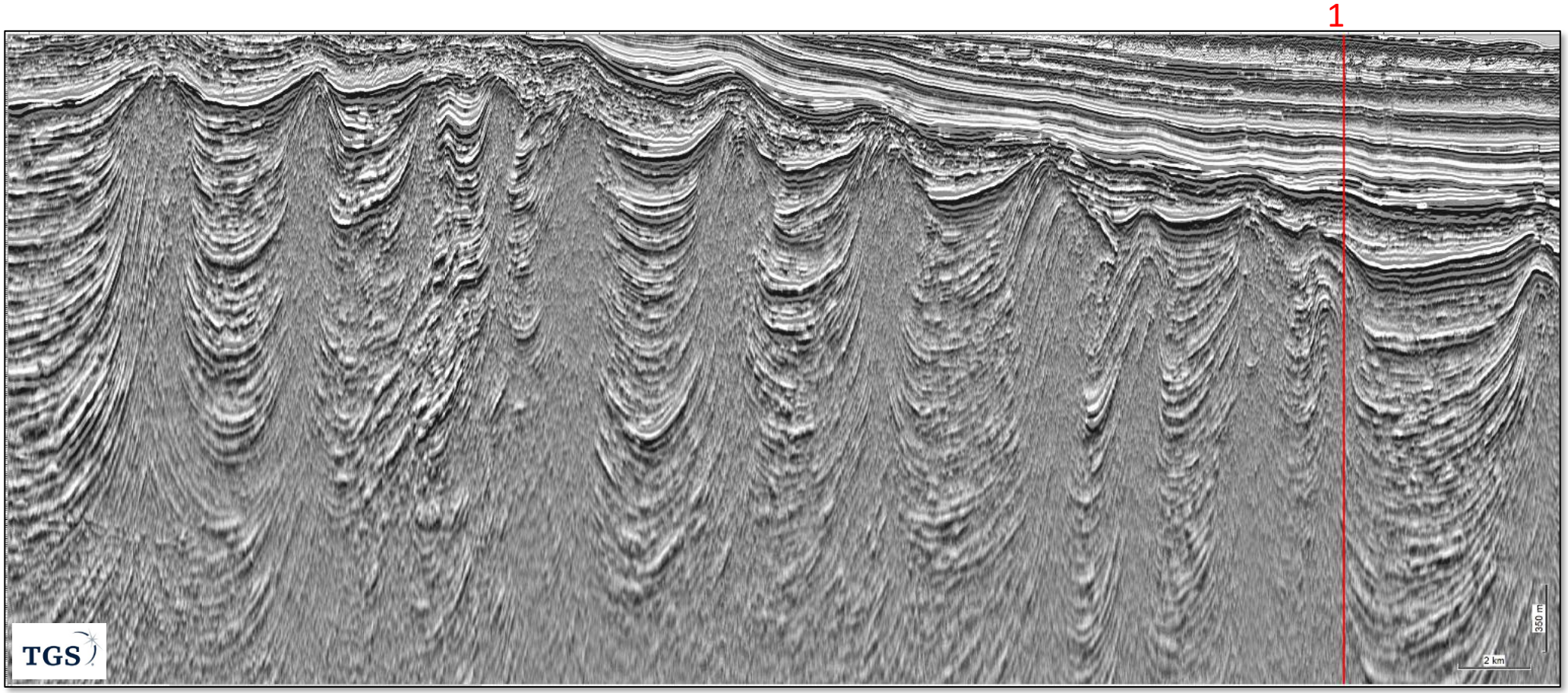

Baraawe Thrust Belt
2000
4000
6000
8000
10000
12000
TGS
COASTLINE EXPLORATION
10 Km
2 Km
Somali Basin
9 km
Basement
Permo -Triassic
Basement
Bathonian
Bathonian
Late Jurassic
Lower K
Upper K
Paleocene
Tertiary -Q

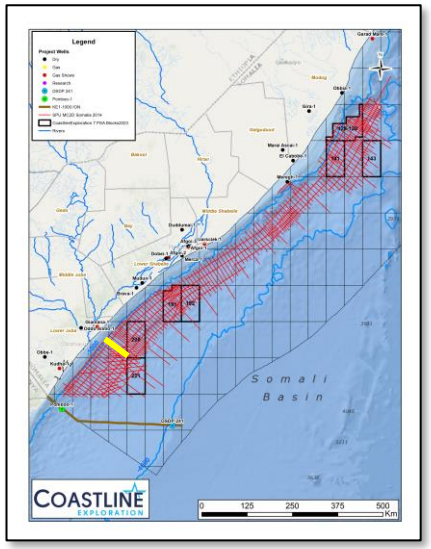
2D Line # 3


2000
4000
6000
8000
10000
12000
TGS
COASTLINE EXPLORATION
10 Km
2 Km
Somali Basin
2000
4000
6000
8000
10000
12000
TGS
2 km
10 km
Basement
Permo -Triassic
Basement
Bathonian
Bathonian
Late Jurassic
Lower K
Upper K
Paleocene
Present

2D Line 4

Toe-thrusts vs Shale diapirs ?



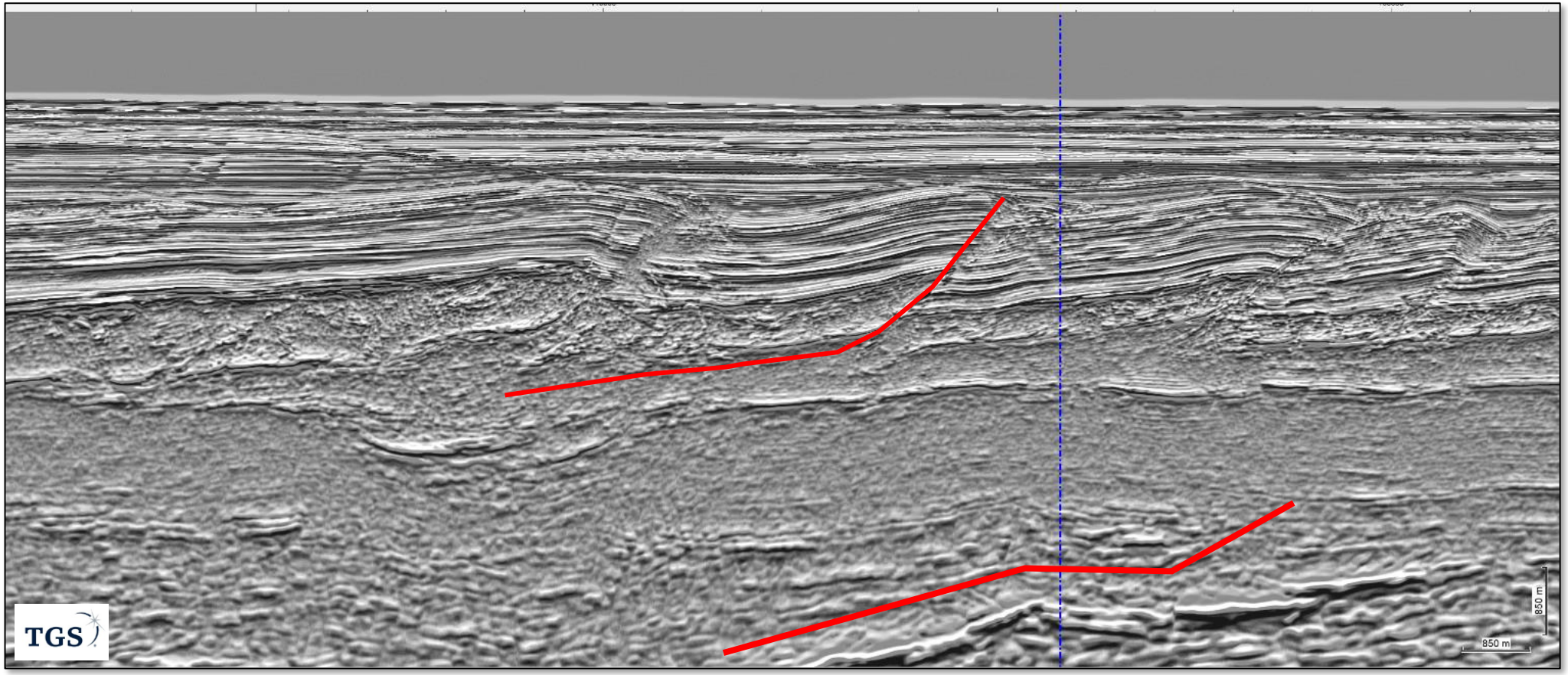


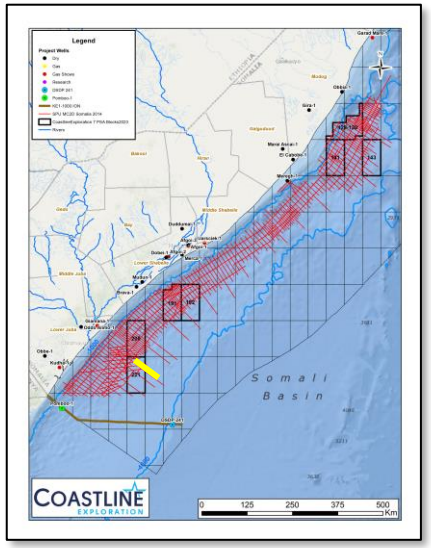
350 m

6 km

2D Line 4

Detachment levels





1700 m (1:1)

Discussion

Three main episodes of thin-skinned deformation in the Jubba Deep basin:

- Lower Cretaceous: Authochthonous salt mobilization, followed by the emplacement of a salt canopy. Upper Jurassic to Lower Cretaceous strata are deformed.
- Paleocene: gravity-driven processes triggered the Kismaayo Fold-Thrust Belt. The main transport direction was towards the southeast, with detachment at the base of the Late Cretaceous.
- Pliocene - Quaternary: gravity-driven processes triggered the Barawee Fold-Thrust Belt on the northeastern side of the Kismaayo fold-thrust belt. The main transport direction is southeast, with a detachment level at the top of the Paleocene
- The first two episodes are associated with major uplift events (mantle processes) along the southern part of the African continent that triggered significant input of sediments into the basin. The final episode is contemporary to the active Kenyan - Ethiopian doming, a leading active element of the East African Rift System.

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Acknowledgements

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COASTLINE EXPLORATION

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