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Tectono-Stratigraphic Evolution of the Centaur 3-D Survey, Exmouth Plateau, North West Shelf, Australia*

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Search and Discovery Article #11062 (2018)**
Posted April 2, 2018

*Adapted from presentations at 2017 AAPG Annual Convention & Exhibition, Houston, Texas, 2017 International Conference & Exhibition, London, England, and 2016 International Conference & Exhibition, Barcelona, Spain.

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Abstract

This project illustrates the tectono-stratigraphic evolution of the Exmouth Plateau, a deep-water sub-basin within the Northern Carnarvon Basin, completed by a full seismic interpretation of the Centaur survey and regional data. The hydrocarbon potential of the region was assessed after a detailed qualitative and quantitative seismic analysis of the structural and stratigraphic elements. The Centaur provided spectacular imaging of the highly-segmented rift-border faults that make up the main graben-forming boundaries formed between the Late Triassic and Early Cretaceous, as a consequence of rifting of Greater India from Australia. Since the Late Cretaceous, the plateau has been subjected to subsidence, slumping, minor episodic fault reactivation, and Neogene inversion, which produced a localized anticlinal structure. Several lines of evidence suggest that the overall structural evolution of the fault geometry was influenced by the reactivation of pre-existing structures, these include, 1) existence of fault-propagation folding of Triassic rift-border faults, 2) along strike variations in geometry and orientation of rift faults, and 3) the appearance of faults propagating upwards obliquely through pre-rift Lower Triassic strata. Seismic facies analysis of the Triassic has shown a multitude of stratigraphic elements including deltaic channel systems, igneous intrusions, and hydrothermal vent complexes. Amplitude extractions identified these as potential stratigraphic traps, including potential structural traps in tilted Triassic fault blocks. The results suggest varying levels of risk and reward in the prospective play targets

for petroleum exploration. While the Triassic strata provide potential hydrocarbon targets, fault reactivation since the Early Cretaceous, mass-transport complexes and fluid escape features of the Top Triassic pose a threat to the seal quality of trapped hydrocarbons and slope stability for drilling infrastructure.

Reference Cited

Hall, R., 2012, Late Jurassic-Cretaceous Reconstructions of the Indonesian Region and the Indian Ocean: Tectonophysics, v. 570-571, p. 1-41.

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Advisors: Prof. Ken McClay & Dr. Nicola Scarselli

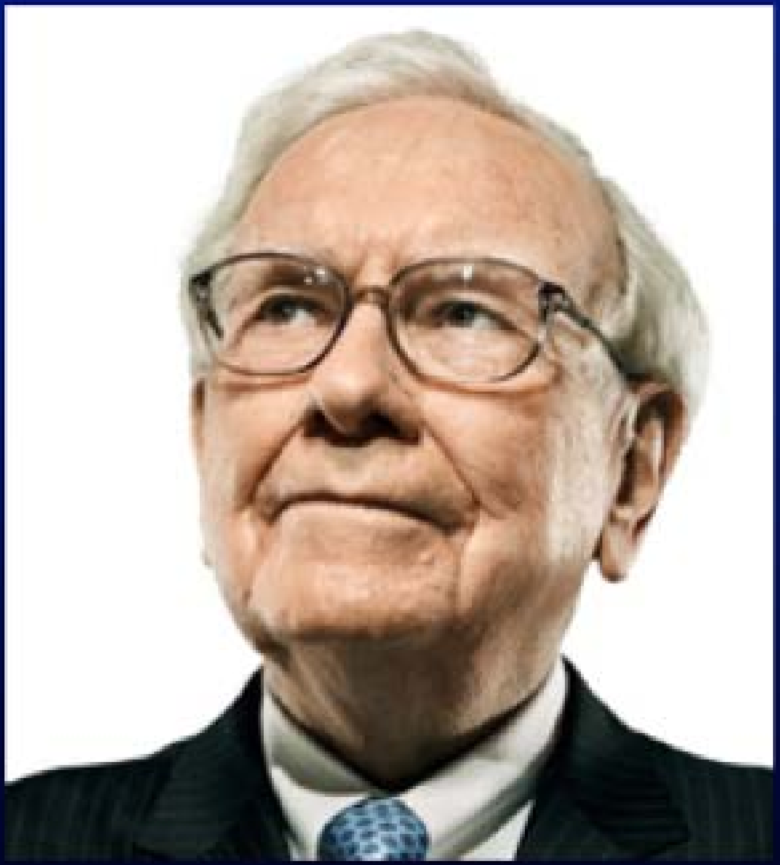
Fault Dynamics

Australian Government
Geoscience Australia

STAR Structural Analogues for Reservoirs

Project Aims

+

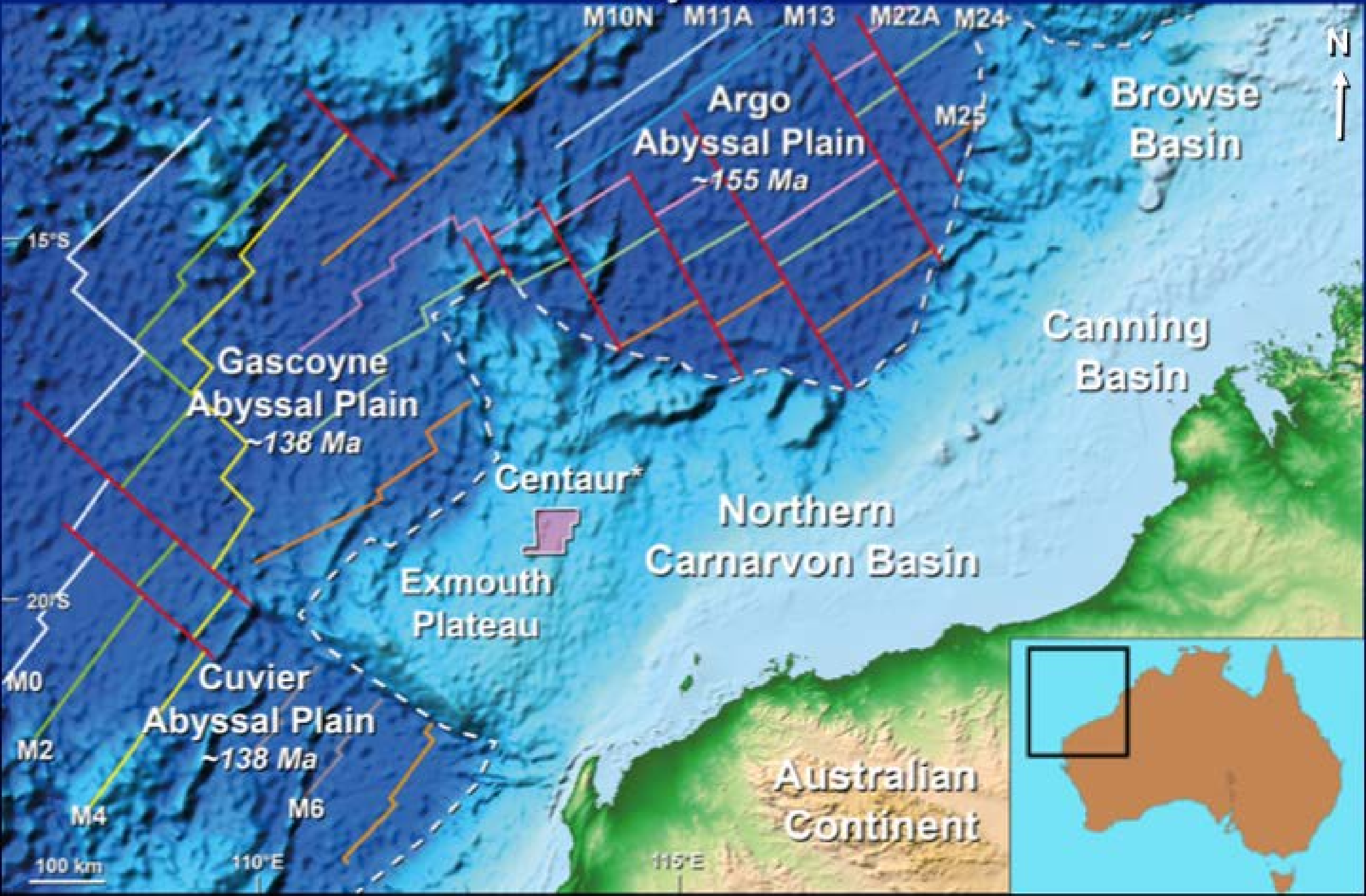


Technical Science

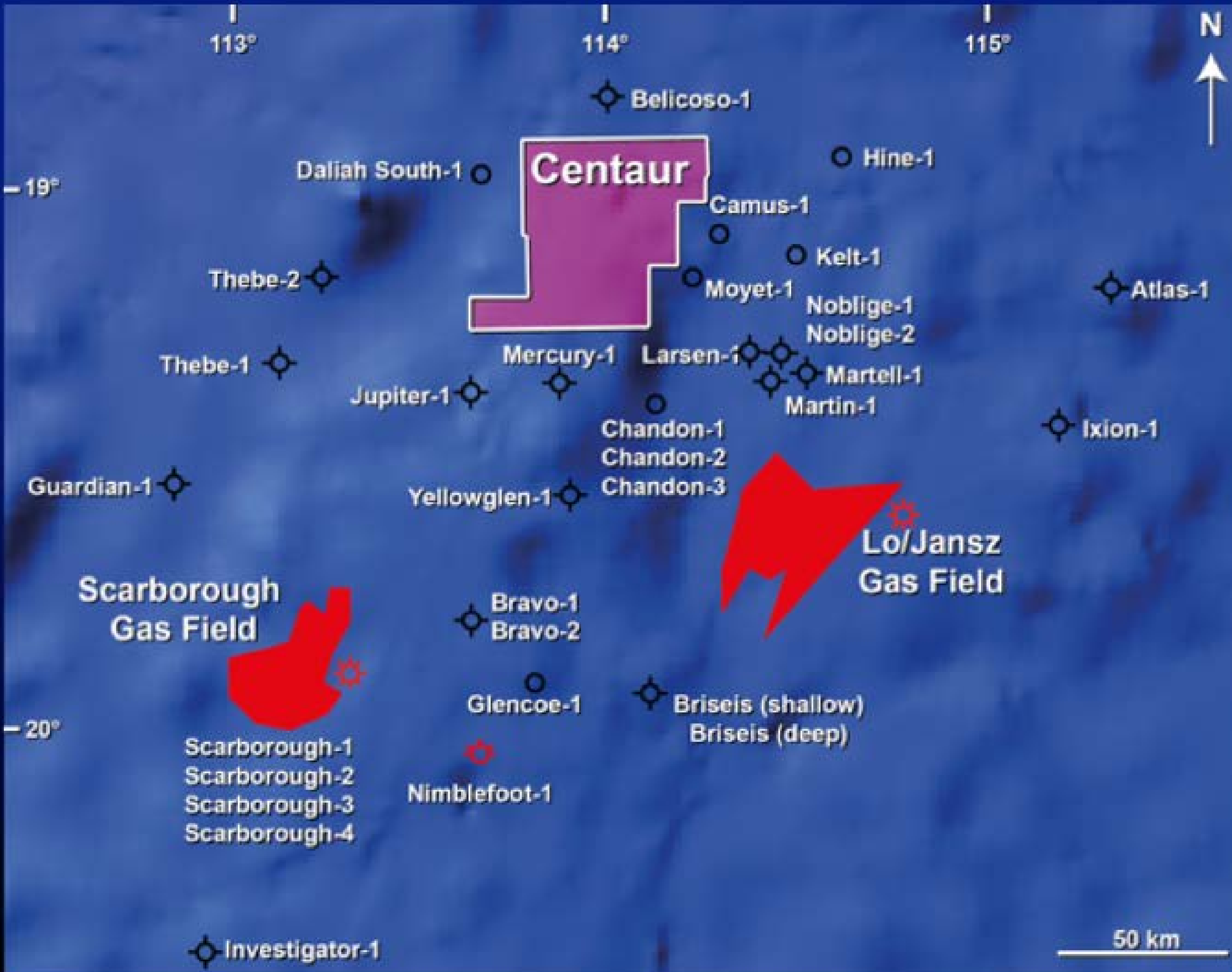
Potential Business Opportunity

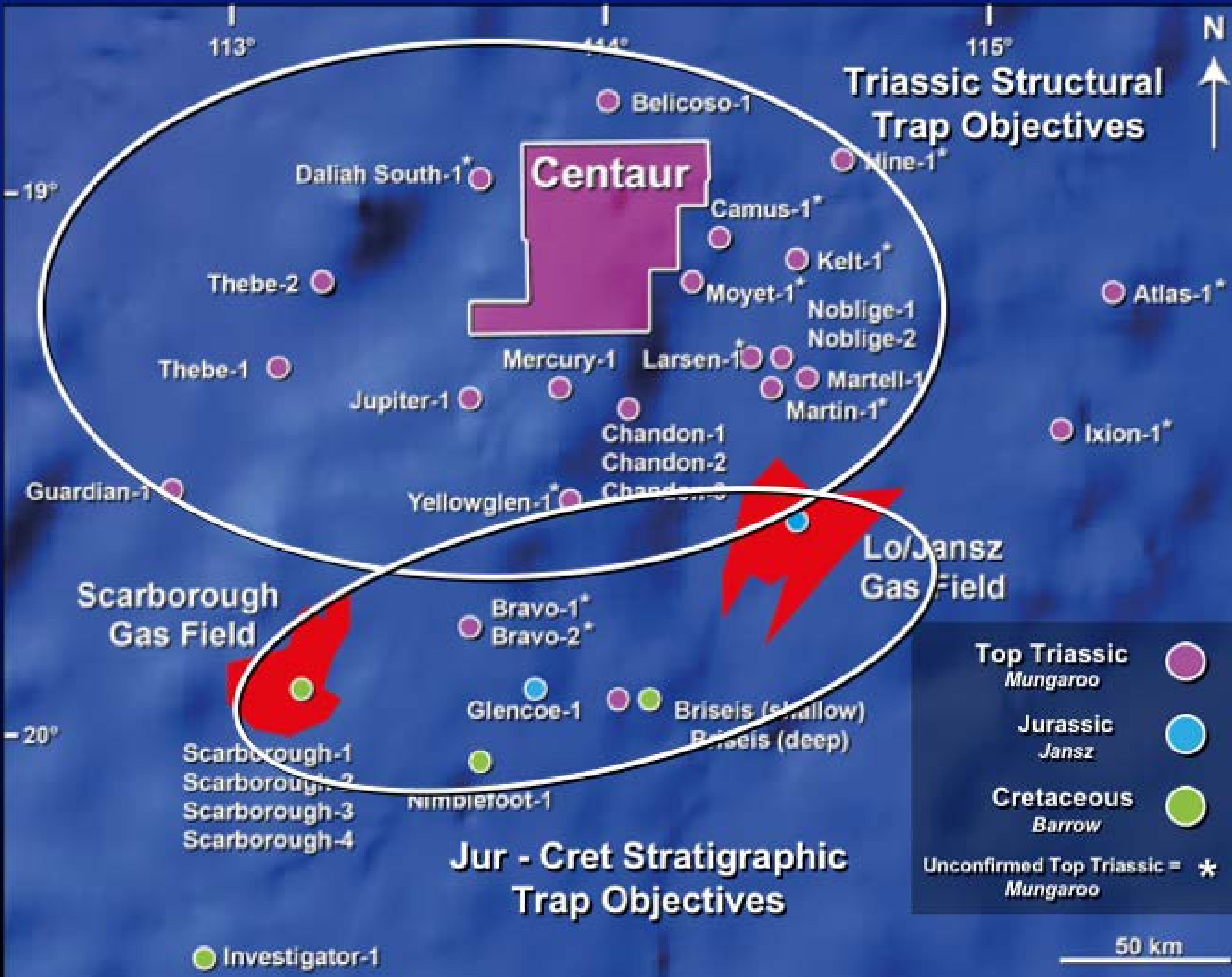
Motivation

Study Area

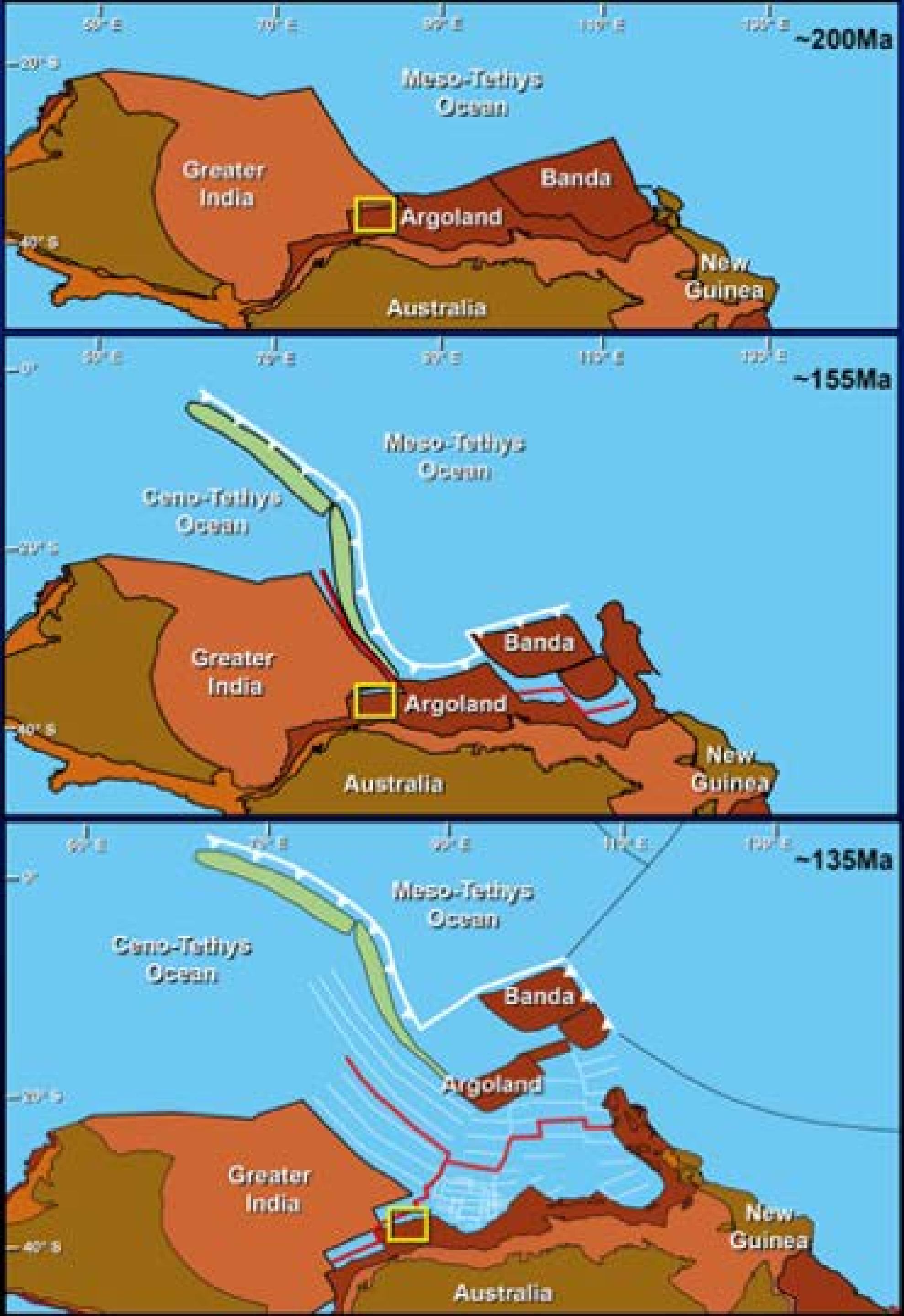


*survey size not to scale


113°
114°
115°
N
19°
20°
Belicoso-1
Centaur
Hine-1
Daliah South-1
Camus-1
Kelt-1
Thebe-2
Moyet-1
Atlas-1
Noblige-1
Noblige-2
Thebe-1
Mercury-1
Larsen-1
Martell-1
Jupiter-1
Martin-1
Chandon-1
Chandon-2
Chandon-3
Ixion-1
Guardian-1
Yellowglen-1
Lo/Jansz
Gas Field
Scarborough
Gas Field
Bravo-1
Bravo-2
Glencoe-1
Briseis (shallow)
Briseis (deep)
Scarborough-1
Scarborough-2
Scarborough-3
Scarborough-4
Nimblefoot-1
Investigator-1
50 km



113°
114°
115°
19°
20°
N
Triassic Structural Trap Objectives
Belicoso-1
Centaur
Daliah South-1*
Hine-1*
Camus-1*
Kelt-1*
Thebe-2
Moyet-1*
Atlas-1*
Noblige-1
Noblige-2
Thebe-1
Mercury-1
Larsen-1*
Martell-1
Jupiter-1
Martin-1*
Ixion-1*
Chandon-1
Chandon-2
Guardian-1
Yellowglen-1*
Lo/Jansz Gas Field
Scarborough Gas Field
Bravo-1*
Bravo-2*
Top Triassic
Mungaroo
Glencoe-1
Briseis (shallow)
Briseis (deep)
Jurassic
Jansz
Scarborough-1
Scarborough-2
Scarborough-3
Scarborough-4
Nimblefoot-1
Cretaceous
Barrow
Unconfirmed Top Triassic = *
Mungaroo
Jur - Cret Stratigraphic Trap Objectives
Investigator-1
50 km



Breakup

Structural Formation

1 Late Triassic *(~200 Ma)*

- Rift initiation

2 Mid-Jurassic *(~155 Ma)*

- Main extension

3 Early Cretaceous *(~135 Ma)*

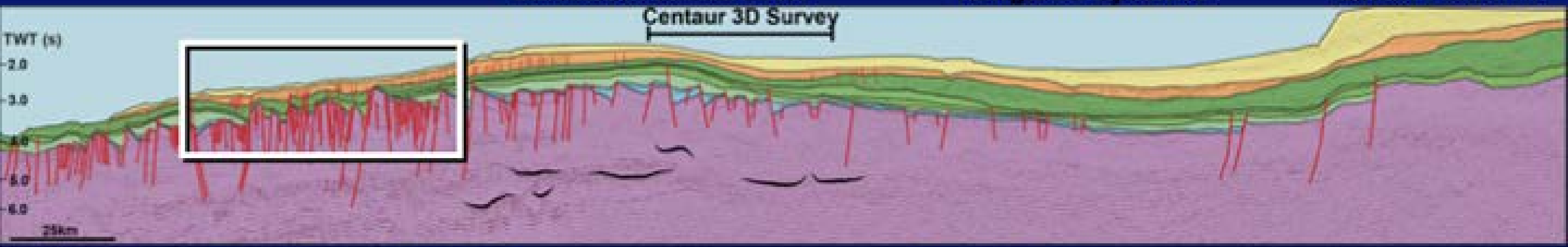
- Breakup
- Reactivation

(Hall, 2012)

= Estimated study area

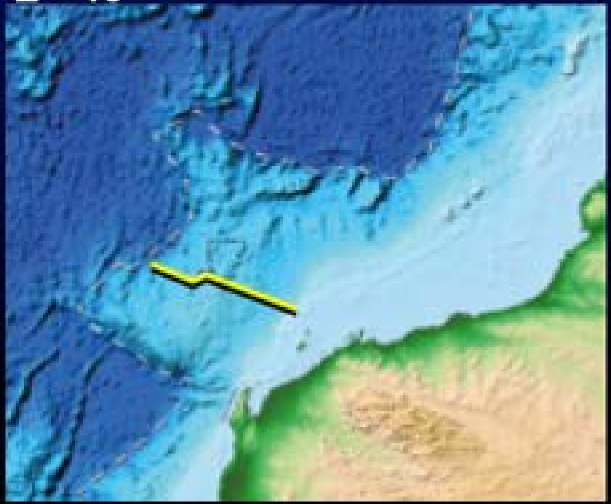
WNW **Regional Cross-section** ESE

Exmouth Plateau Arch | Kangaroo Syncline | Rankin Platform

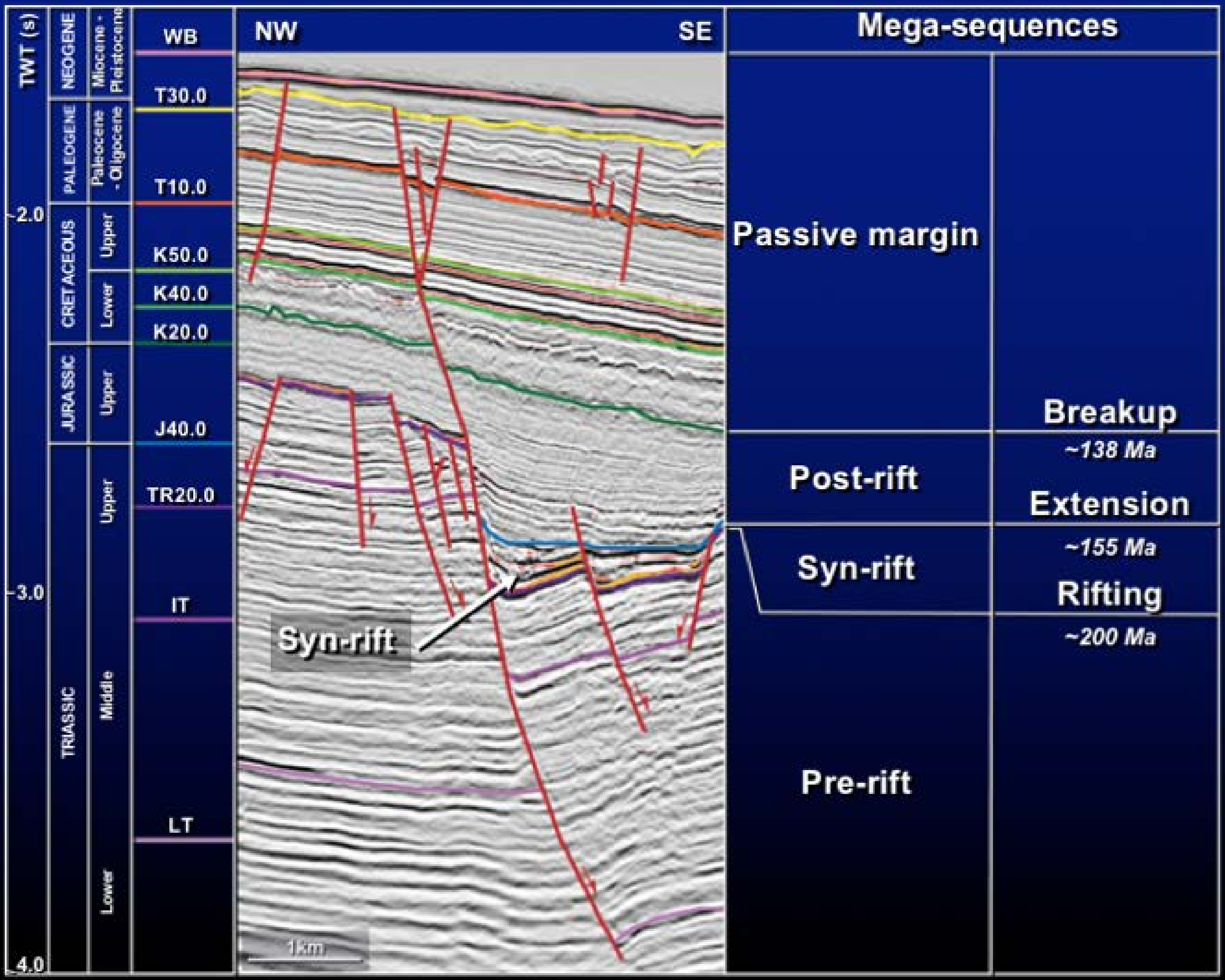


Pre-rift	Syn-rift	Post-rift	Passive Margin				
Triassic & Older	Upper Jurassic	Berresian - Valanginian	Valanginian - Aptian	Aptian - Turonian	Turonian - Maastrichtian	Paleocene - Mid. Oligocene	Mid. Oligocene - Present

Z = 10



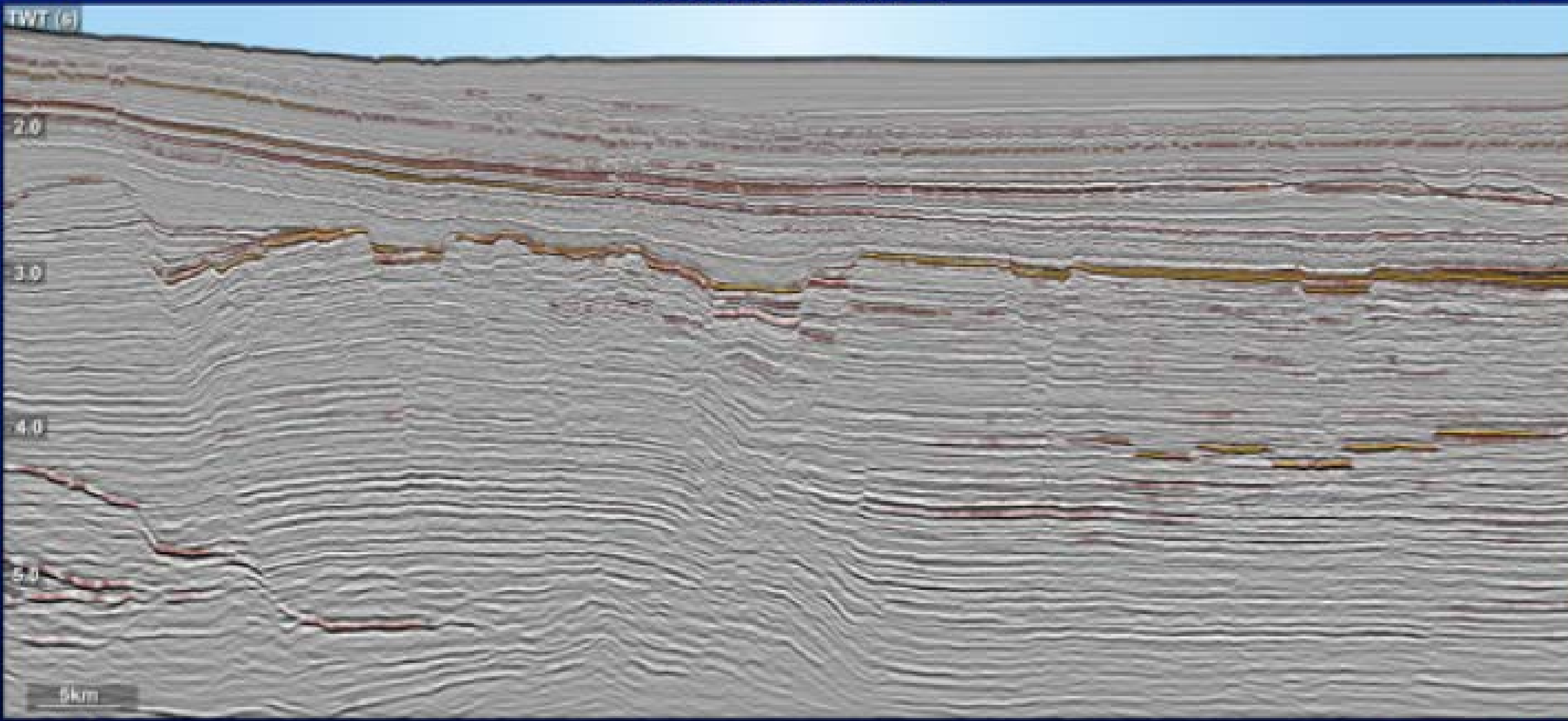
- Carbonate progradation
- Thin post-Triassic sedimentation
- MTC's & slumping in footwall blocks
- Minor horizontal extension



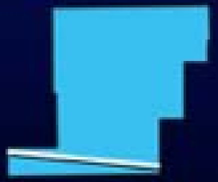
TWT (s)
2.0
3.0
4.0
NEOGENE
PALEOGENE
CRETACEOUS
JURASSIC
TRIASSIC
Miocene - Pleistocene
Paleocene - Oligocene
Upper
Lower
Upper
Upper
Middle
Lower
WB
T30.0
T10.0
K50.0
K40.0
K20.0
J40.0
TR20.0
IT
LT
NW
SE
Syn-rift
1km
Mega-sequences
Passive margin
Breakup
~138 Ma
Post-rift
Extension
~155 Ma
Syn-rift
Rifting
~200 Ma
Pre-rift

Seismic Line 1

NW SE

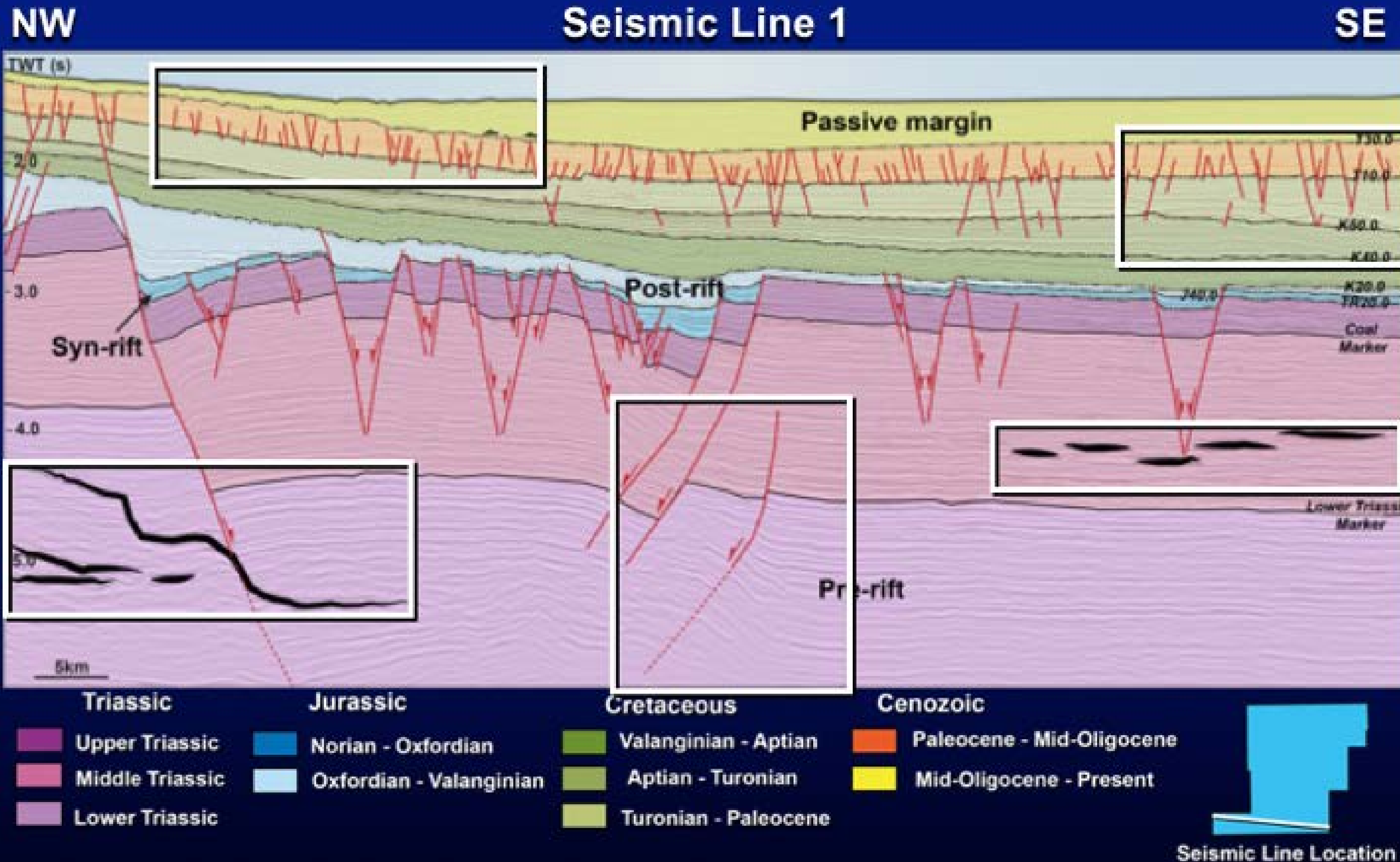


Z = 5



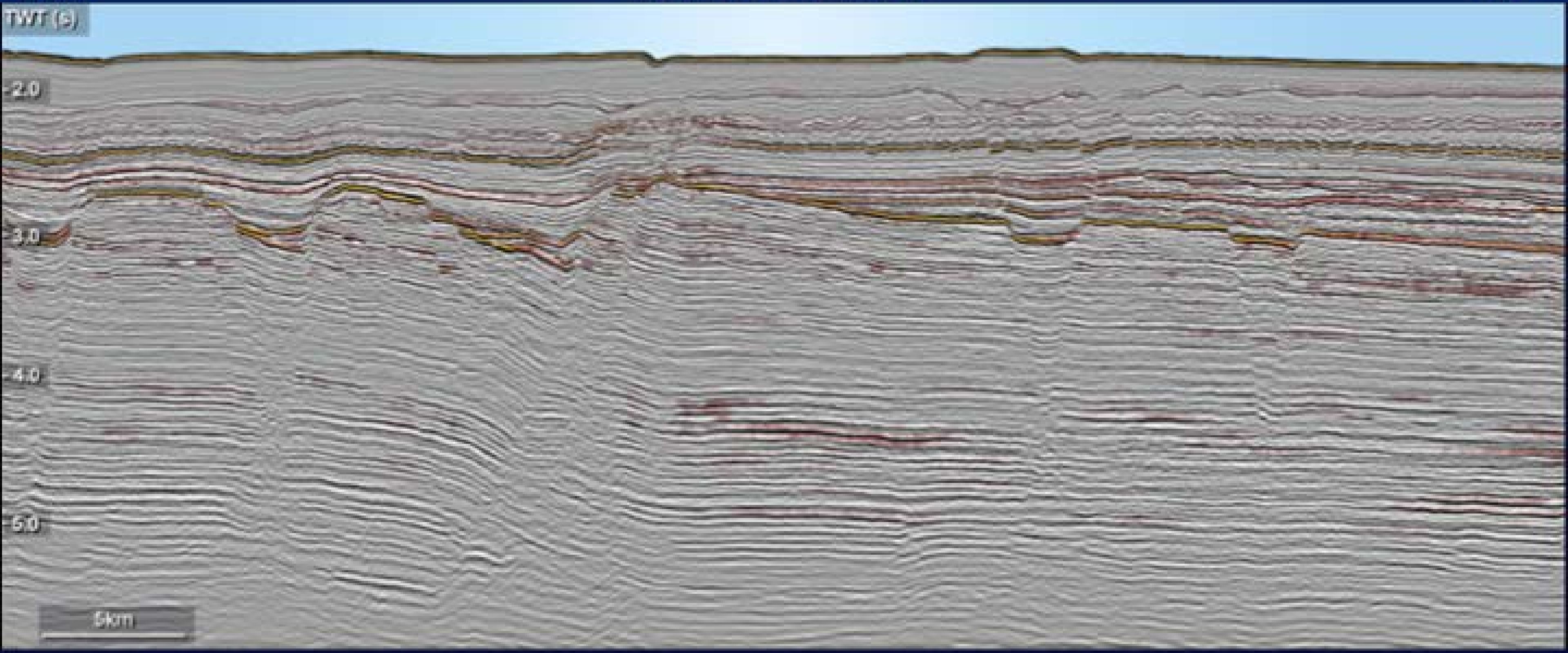
Seismic Line Location

Seismic Line 1



- Structures propagating upwards in Lower Triassic
- Igneous intrusions
- MTC's & onlap

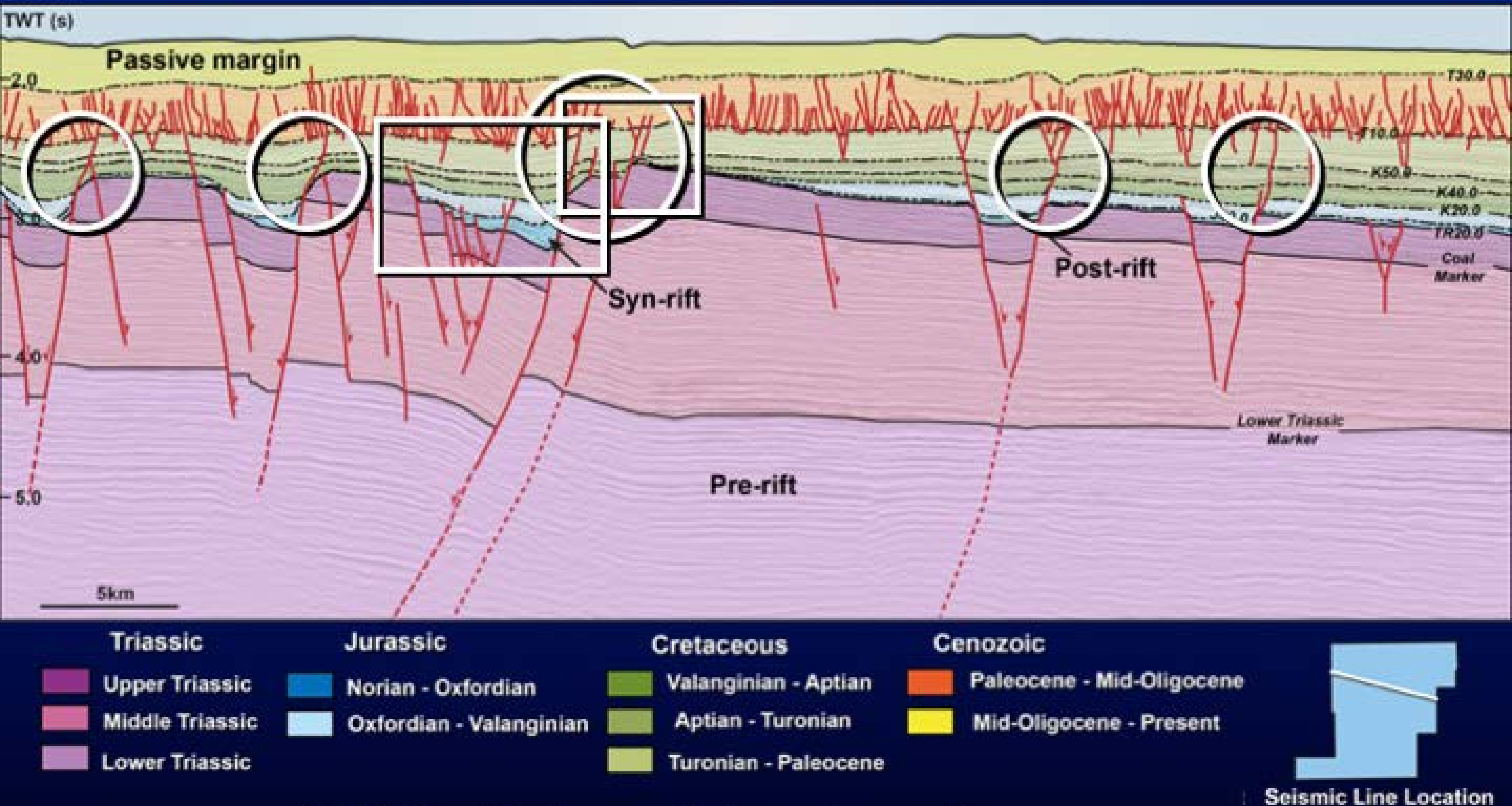
NW Seismic Line 2 SE



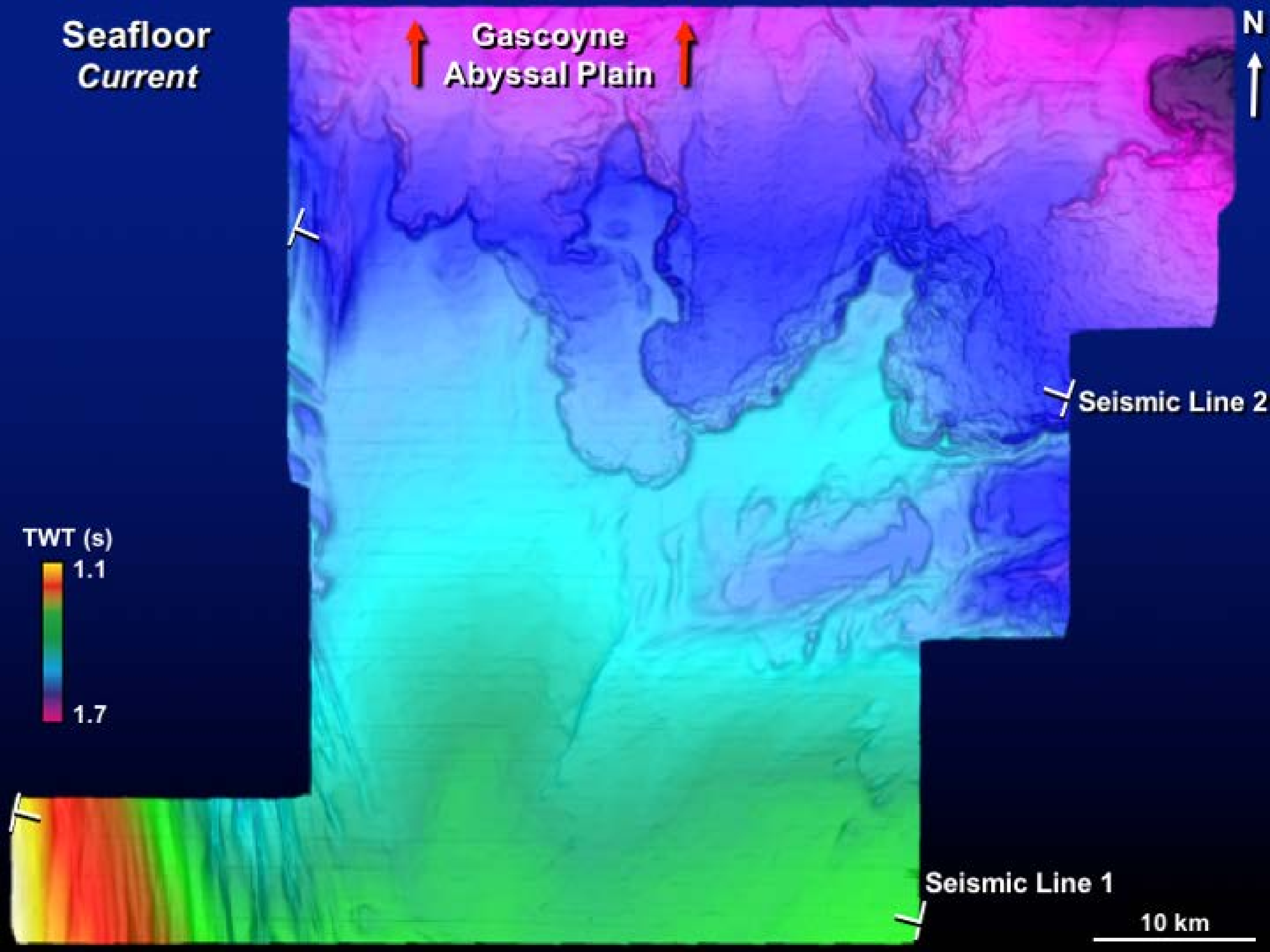
Z = 5

Seismic Line Location

Seismic Line 2



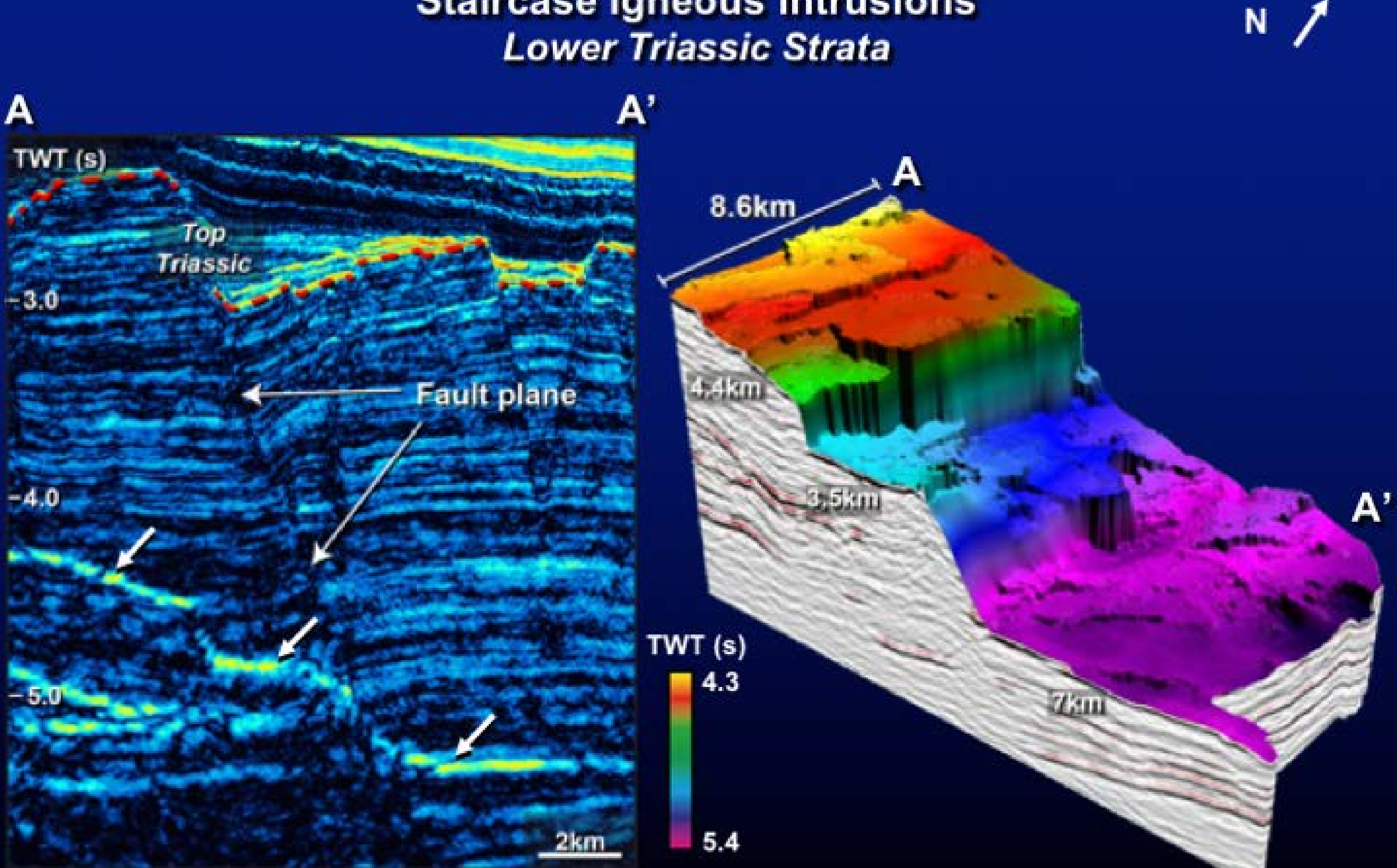
- Underfilled syn-rift hangingwalls
- Passive margin subsidence & fault reactivation
- Gas chimneys over some footwalls
- Tertiary polygonal faulting

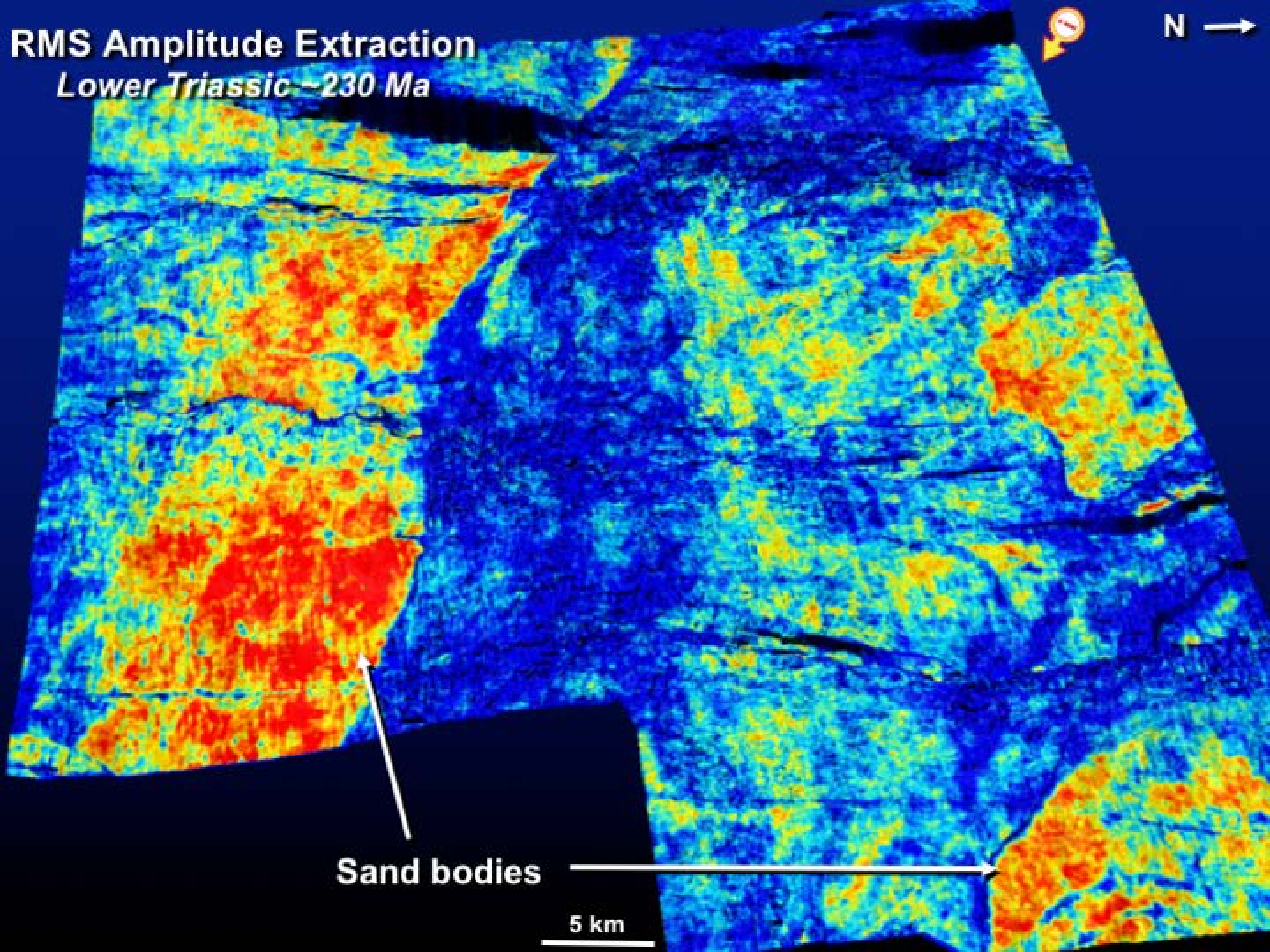


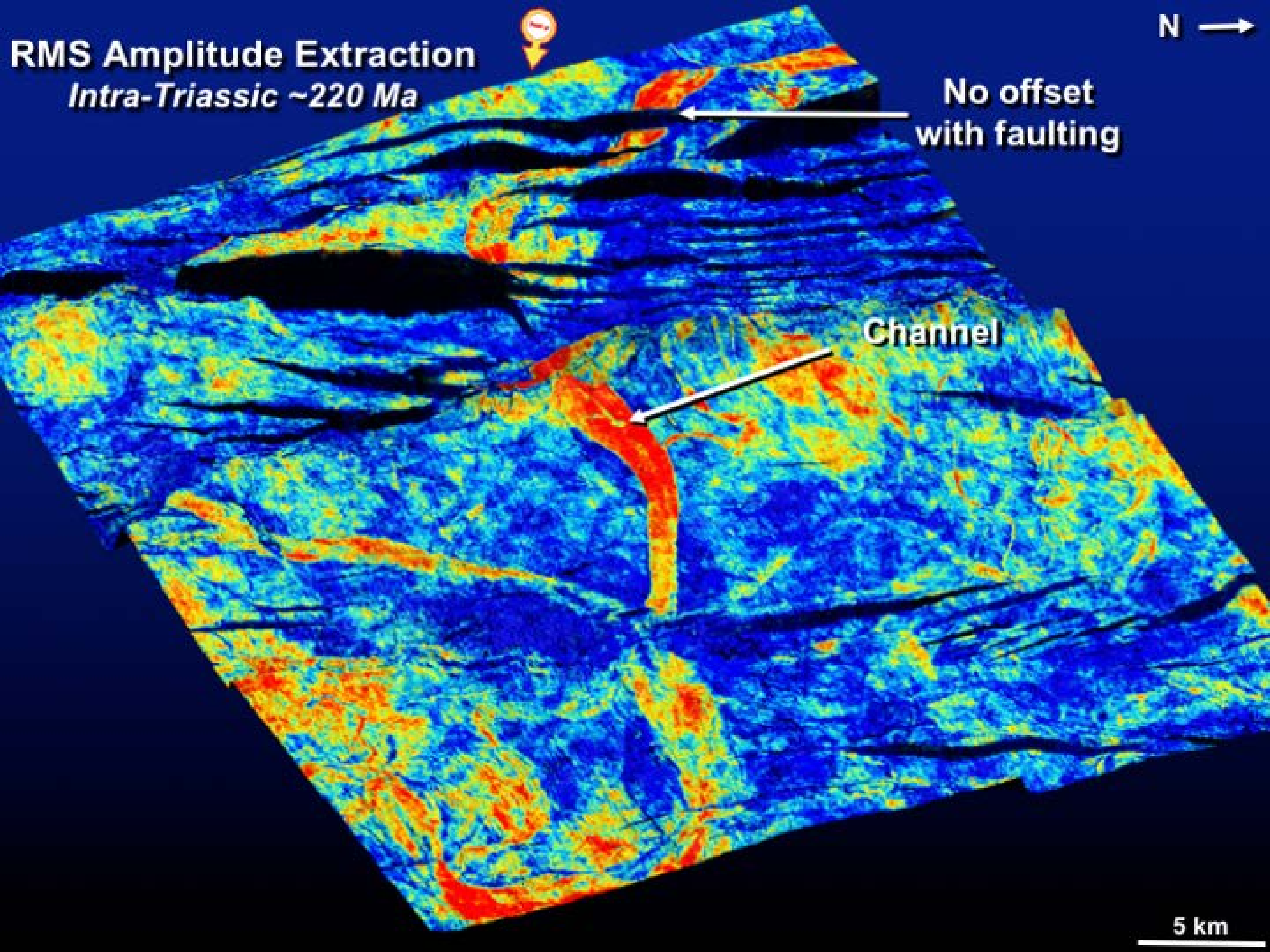
Seafloor
Current
Gascoyne
Abyssal Plain
N
TWT (s)
1.1
1.7
Seismic Line 2
Seismic Line 1
10 km

Staircase Igneous Intrusions

Lower Triassic Strata

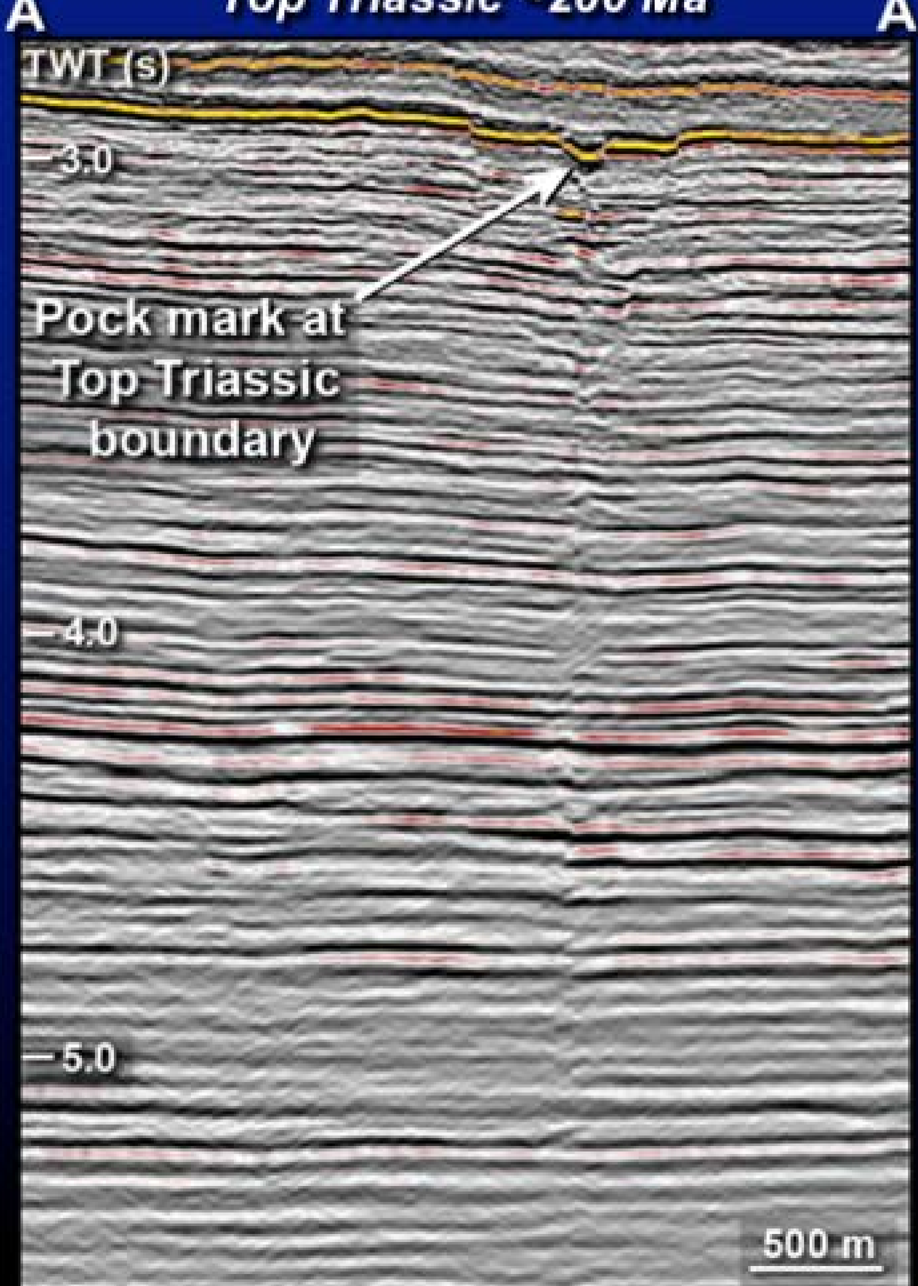


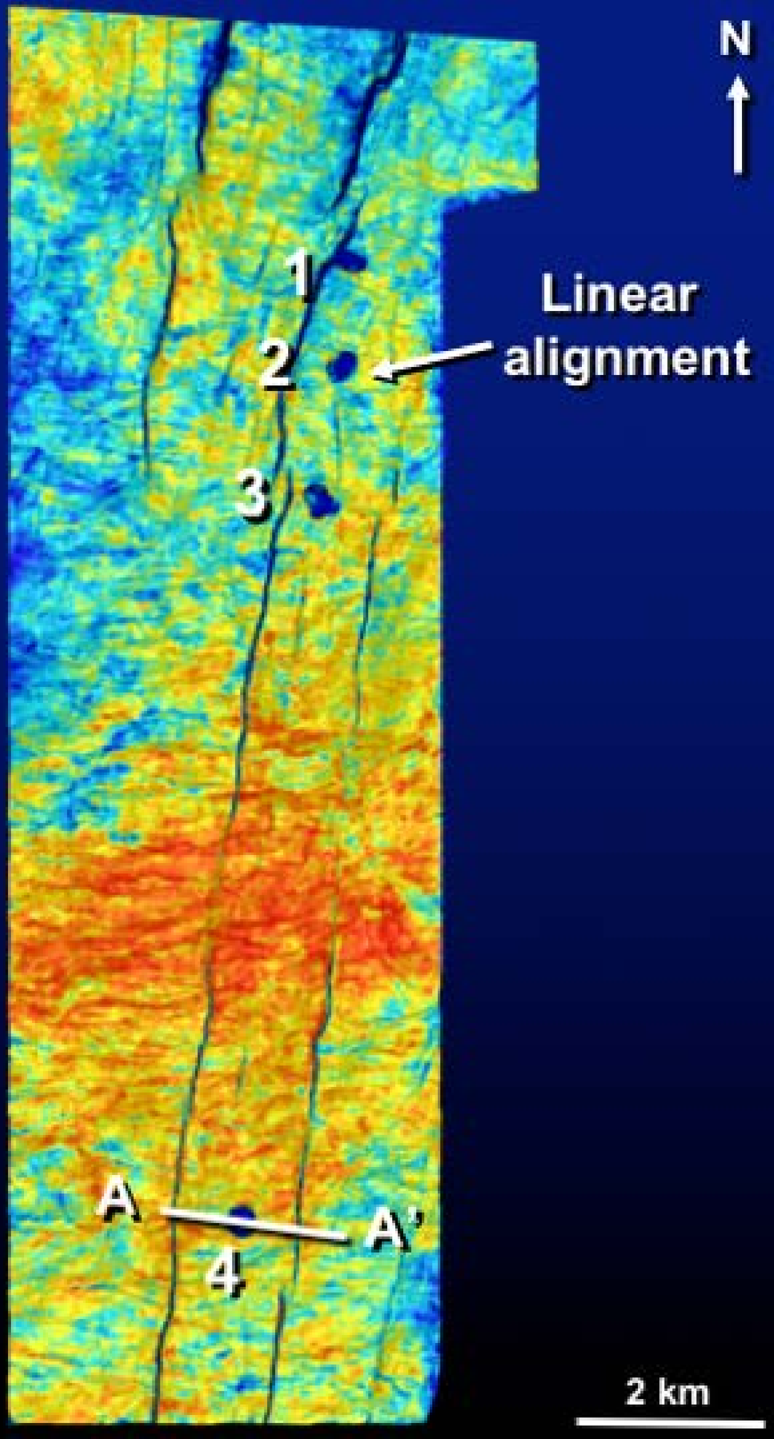

RMS Amplitude Extraction
Lower Triassic ~230 Ma
N
Sand bodies
5 km

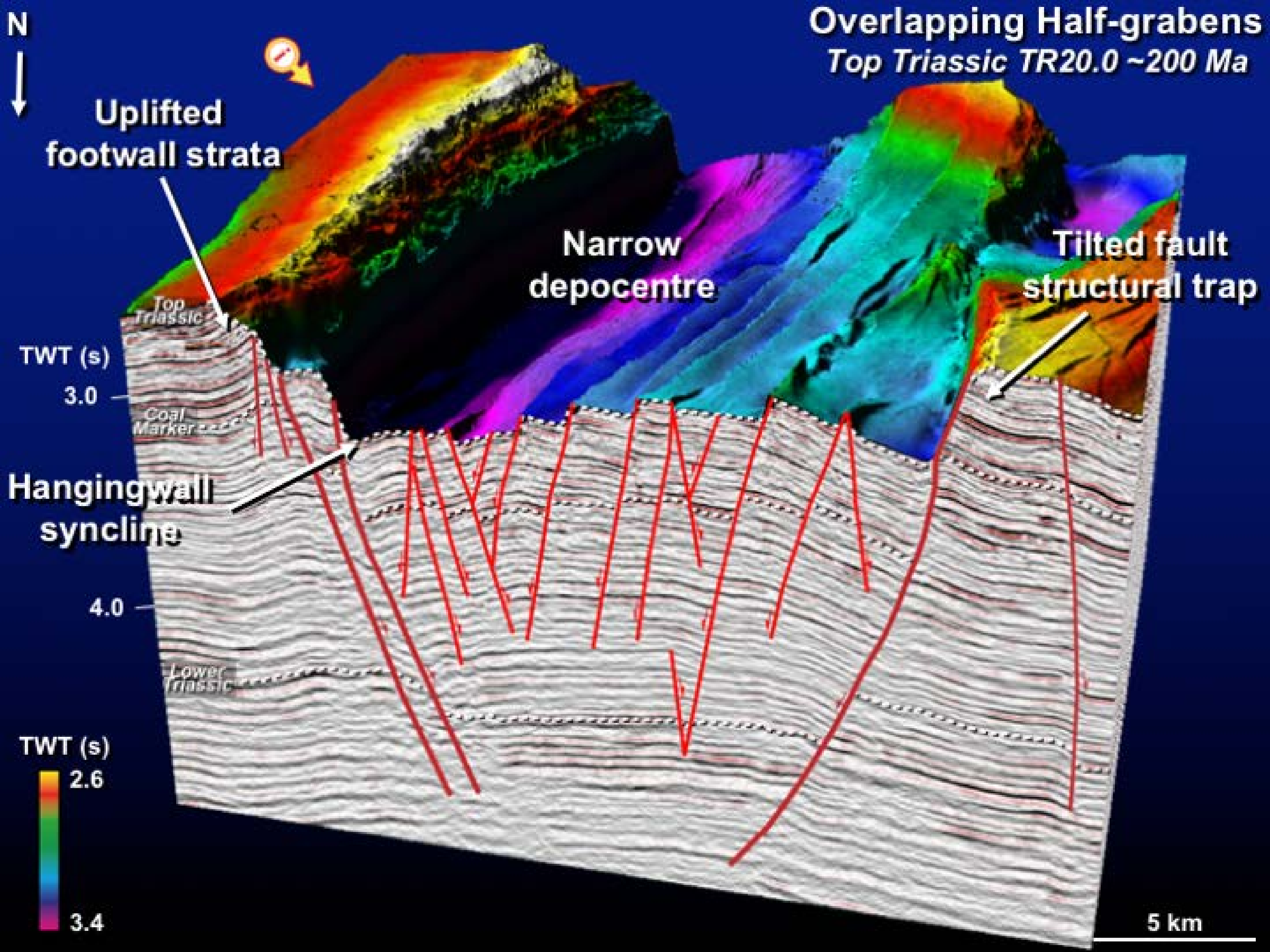

RMS Amplitude Extraction
Intra-Triassic ~220 Ma
N
No offset
with faulting
Channel
5 km

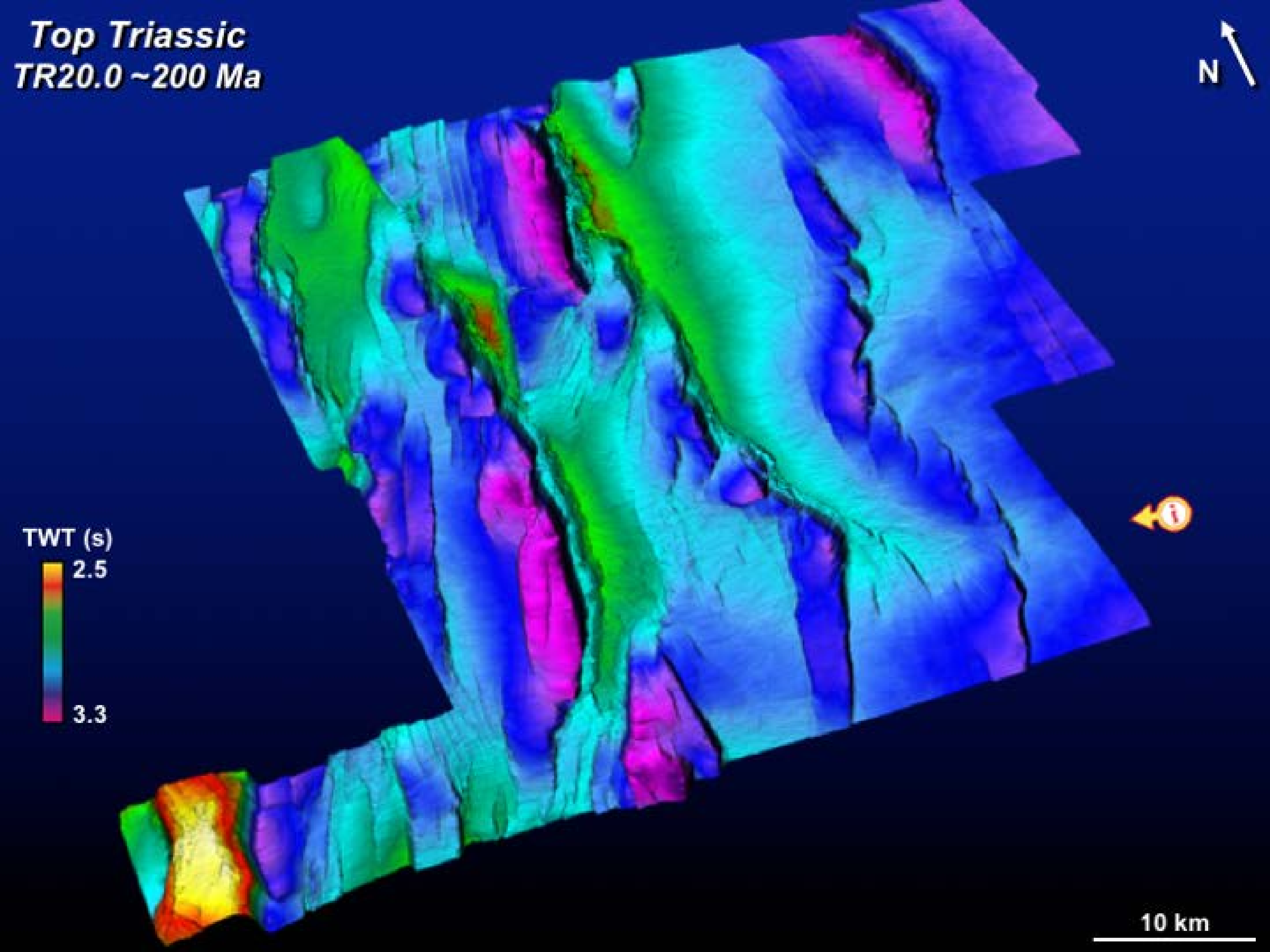
Fluid Escape Features

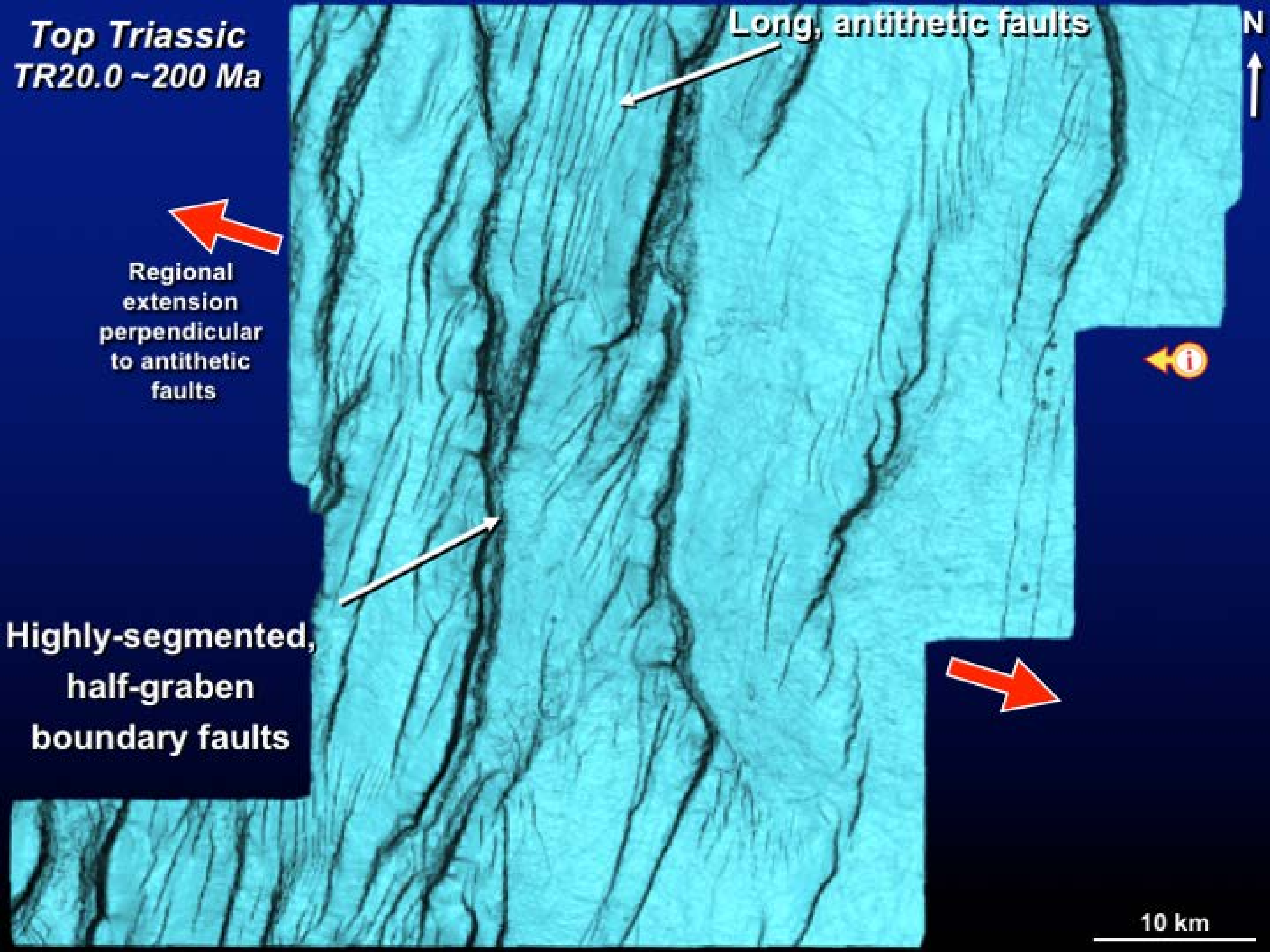
Top Triassic ~200 Ma

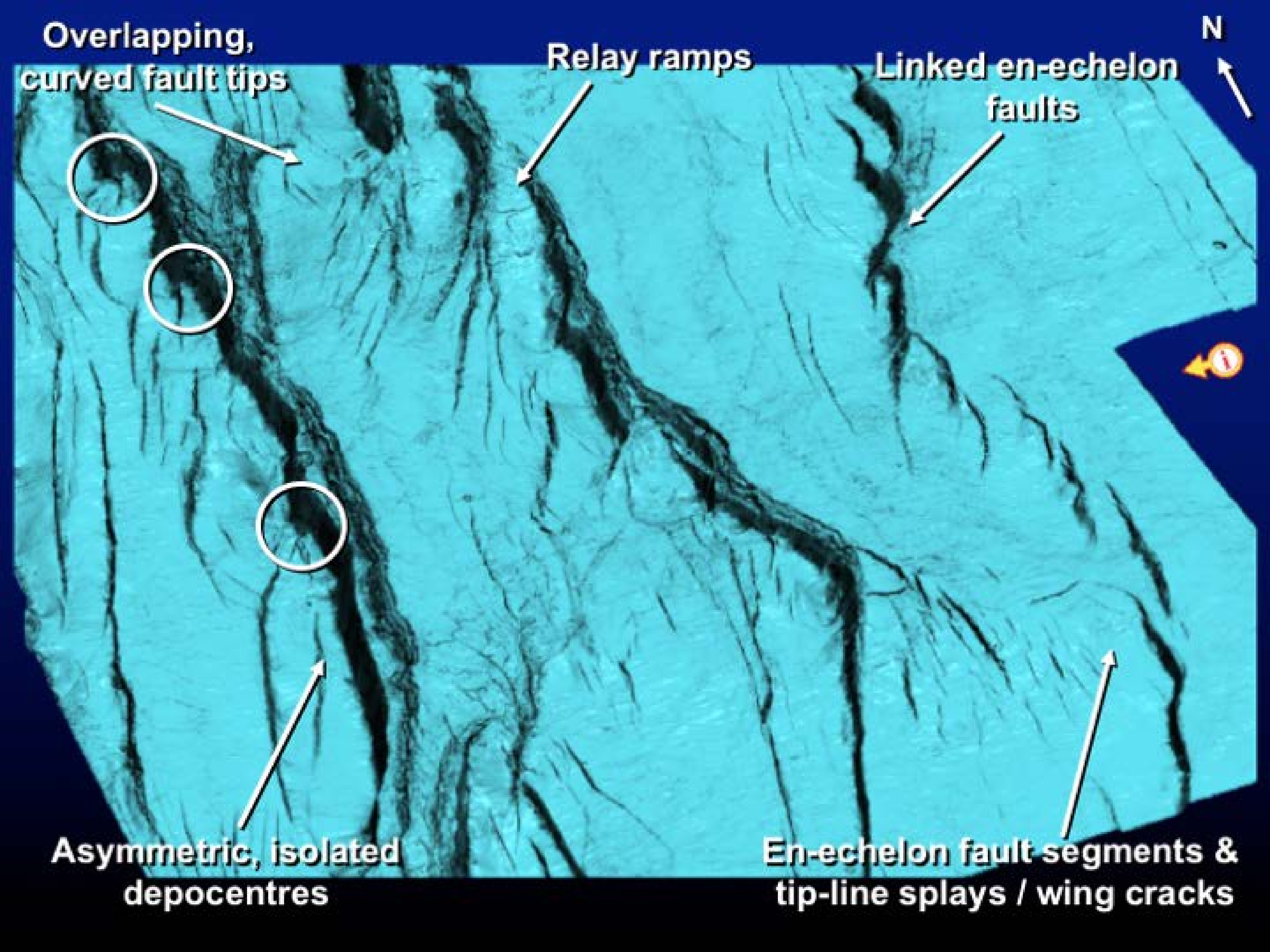


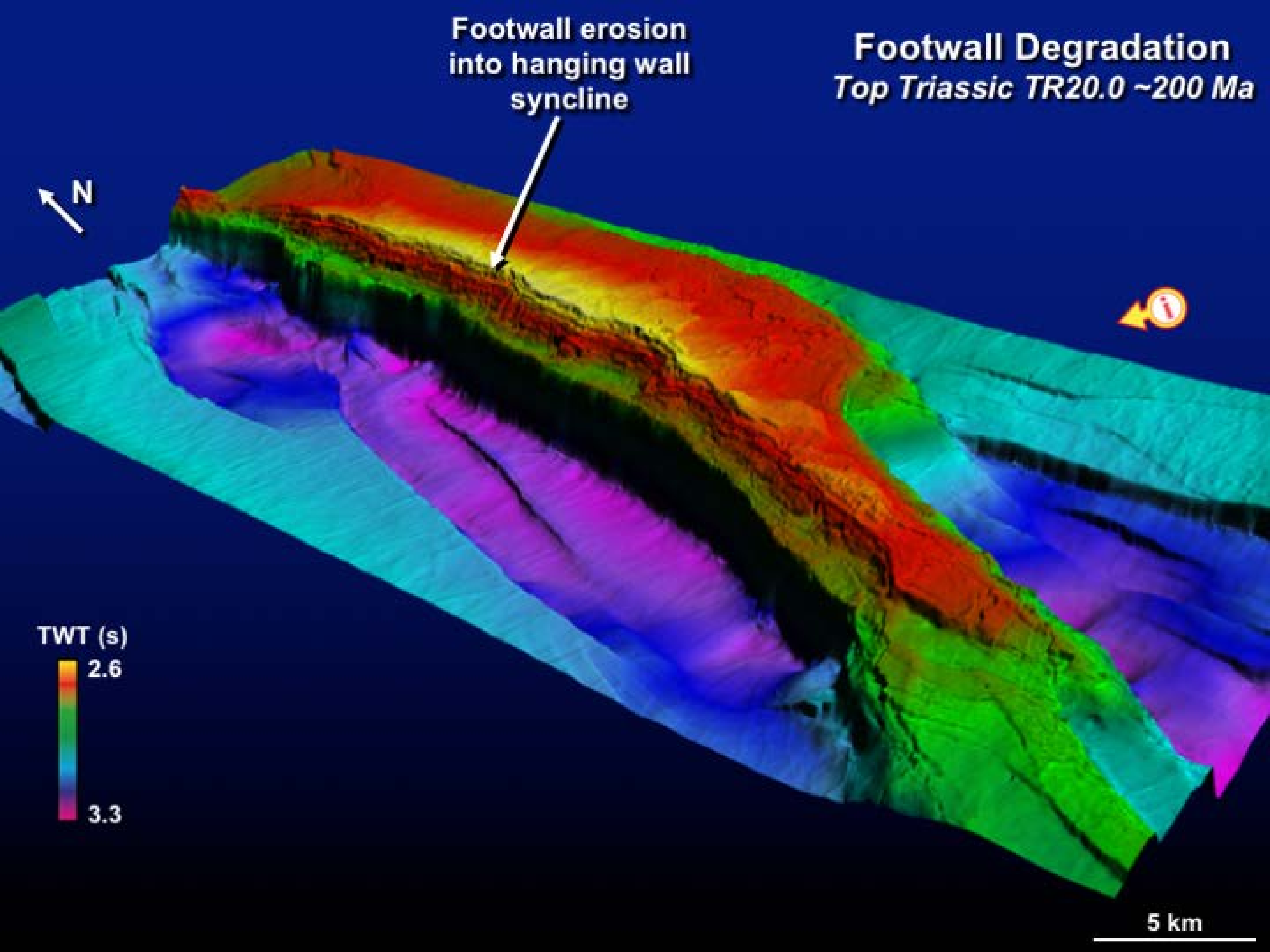



N
Overlapping Half-grabens
Top Triassic TR20.0 ~200 Ma
Uplifted
footwall strata
Narrow
depocentre
Tilted fault
structural trap
Top
Triassic
TWT (s)
3.0
Coal
Marker
Hangingwall
syncline
4.0
Lower
Triassic
TWT (s)
2.6
3.4
5 km


Top Triassic
TR20.0 ~200 Ma
N
TWT (s)
2.5
3.3
10 km

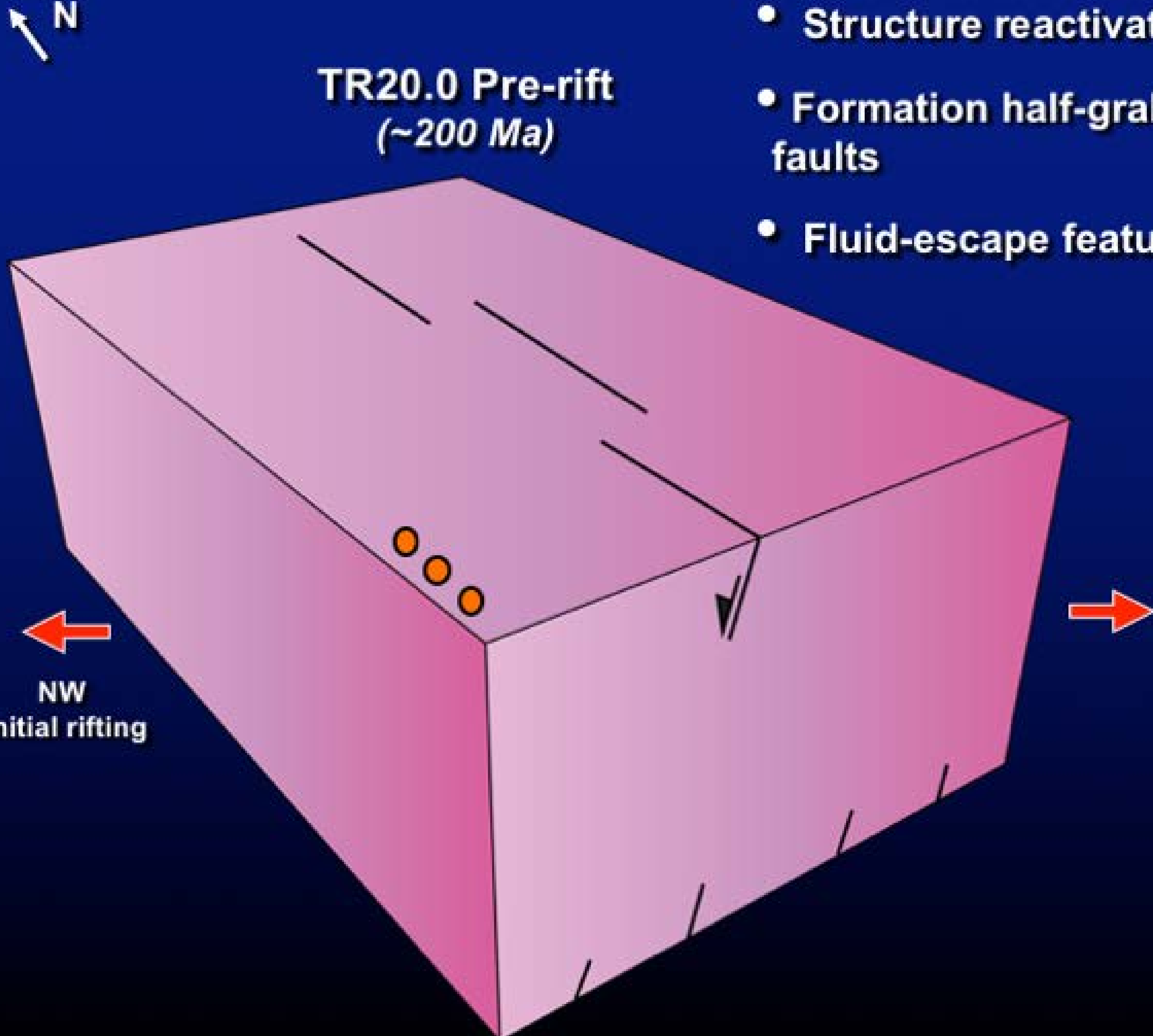

Top Triassic
TR20.0 ~200 Ma
Long, antithetic faults
N
Regional
extension
perpendicular
to antithetic
faults
Highly-segmented,
half-graben
boundary faults
10 km

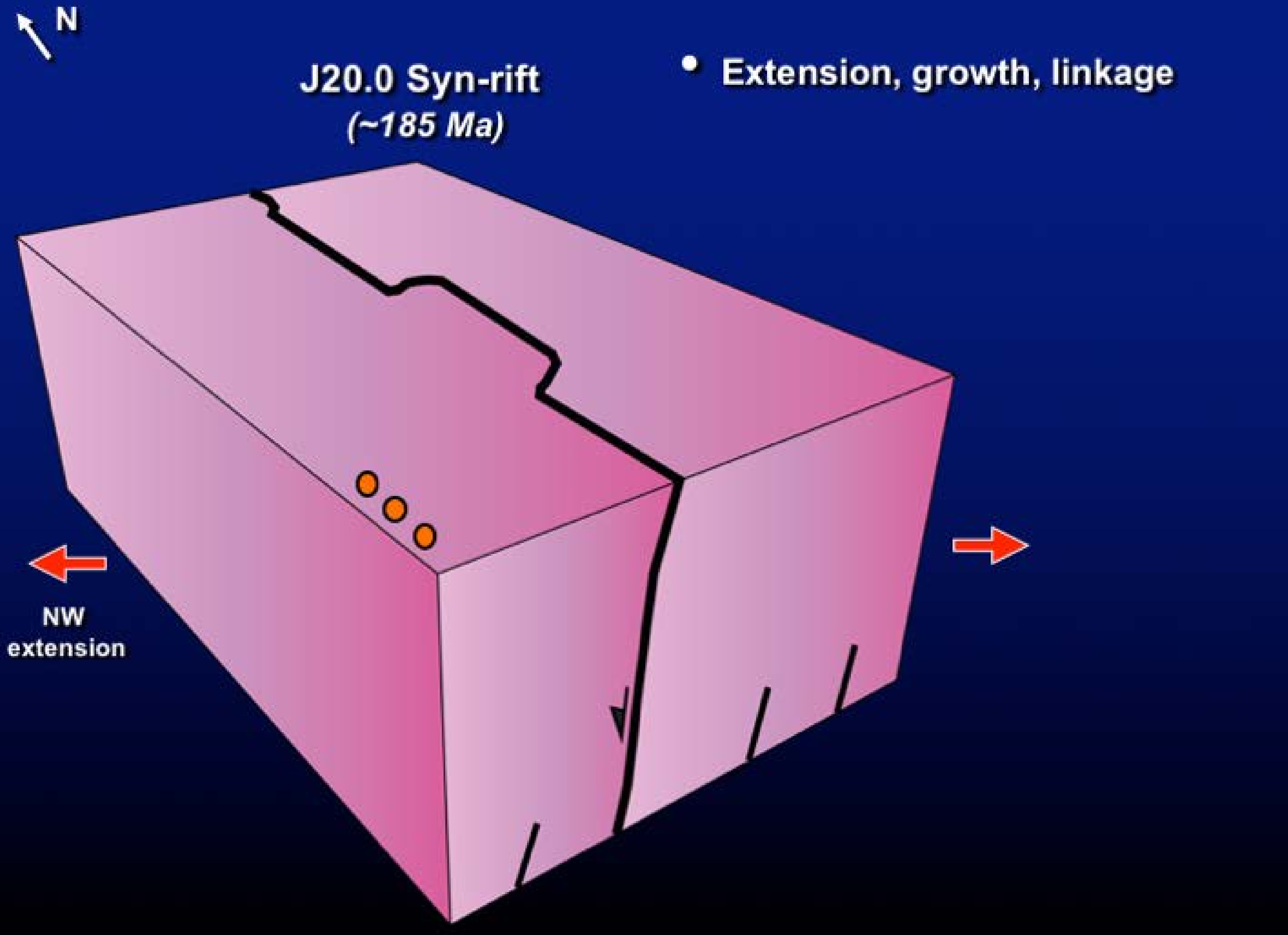

Overlapping,
curved fault tips
Relay ramps
Linked en-echelon
faults
N
Asymmetric, isolated
depocentres
En-echelon fault segments &
tip-line splays / wing cracks

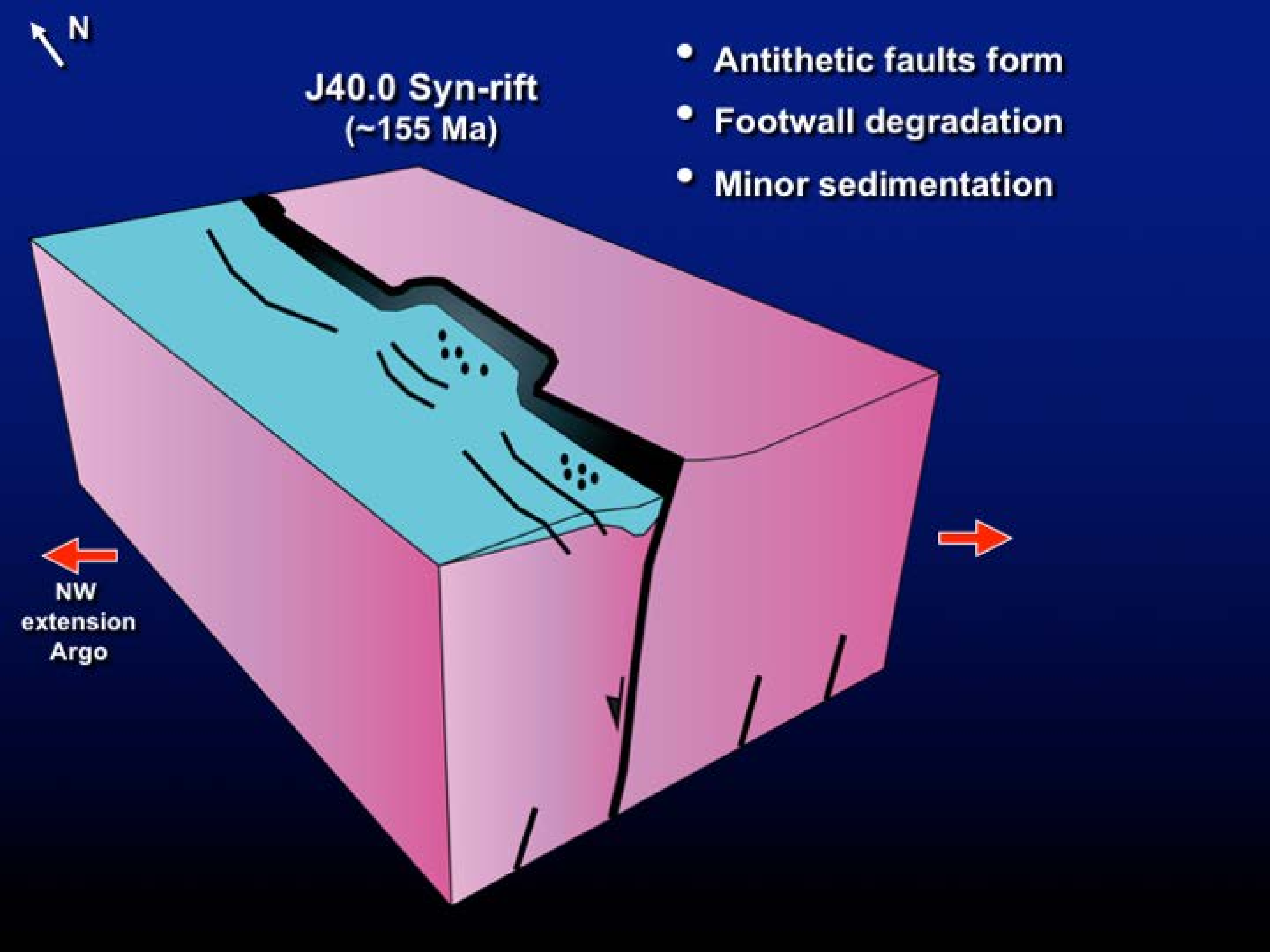

Footwall erosion into hanging wall syncline
Footwall Degradation
Top Triassic TR20.0 ~200 Ma
N
TWT (s)
2.6
3.3
5 km

TR20.0 Pre-rift
(~200 Ma)

- Structure reactivation
- Formation half-graben bounding faults
- Fluid-escape features



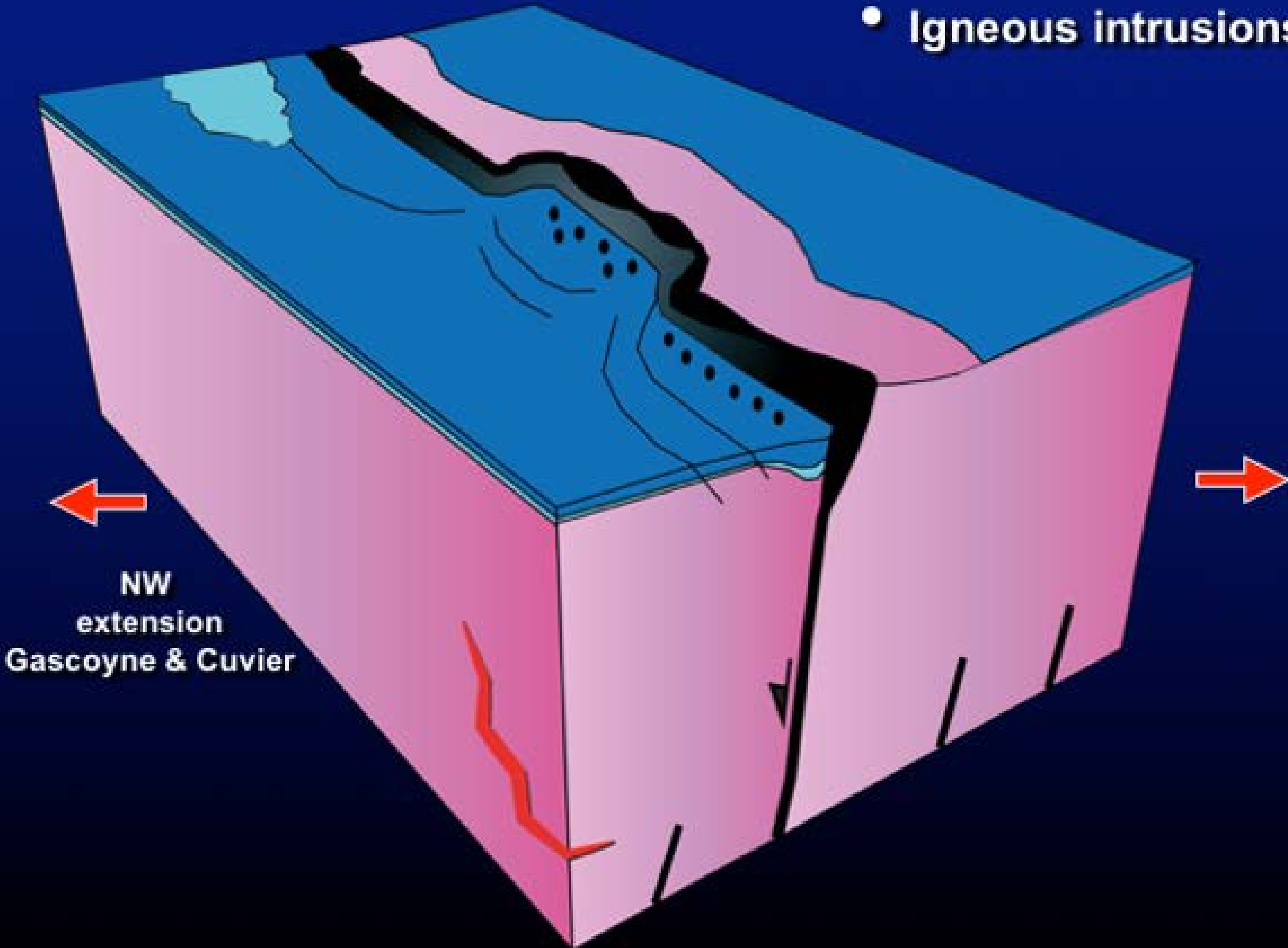

N
J20.0 Syn-rift
(~185 Ma)
• Extension, growth, linkage
NW
extension


N
J40.0 Syn-rift
(~155 Ma)
• Antithetic faults form
• Footwall degradation
• Minor sedimentation
NW
extension
Argo

N

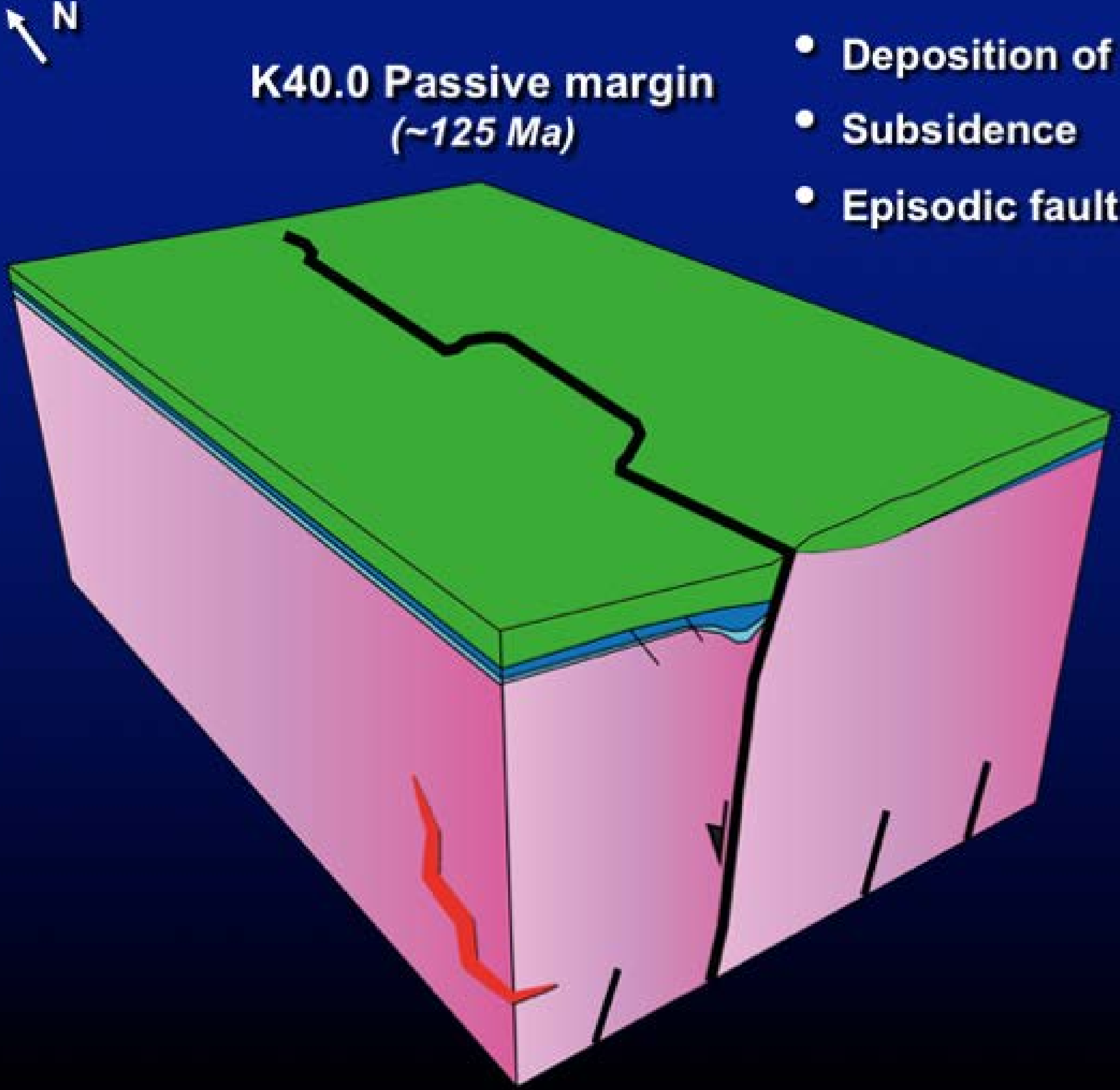
K20.0 Post-rift
(~138 Ma)

- Uplift, erosion
- Footwall degradation
- Igneous intrusions



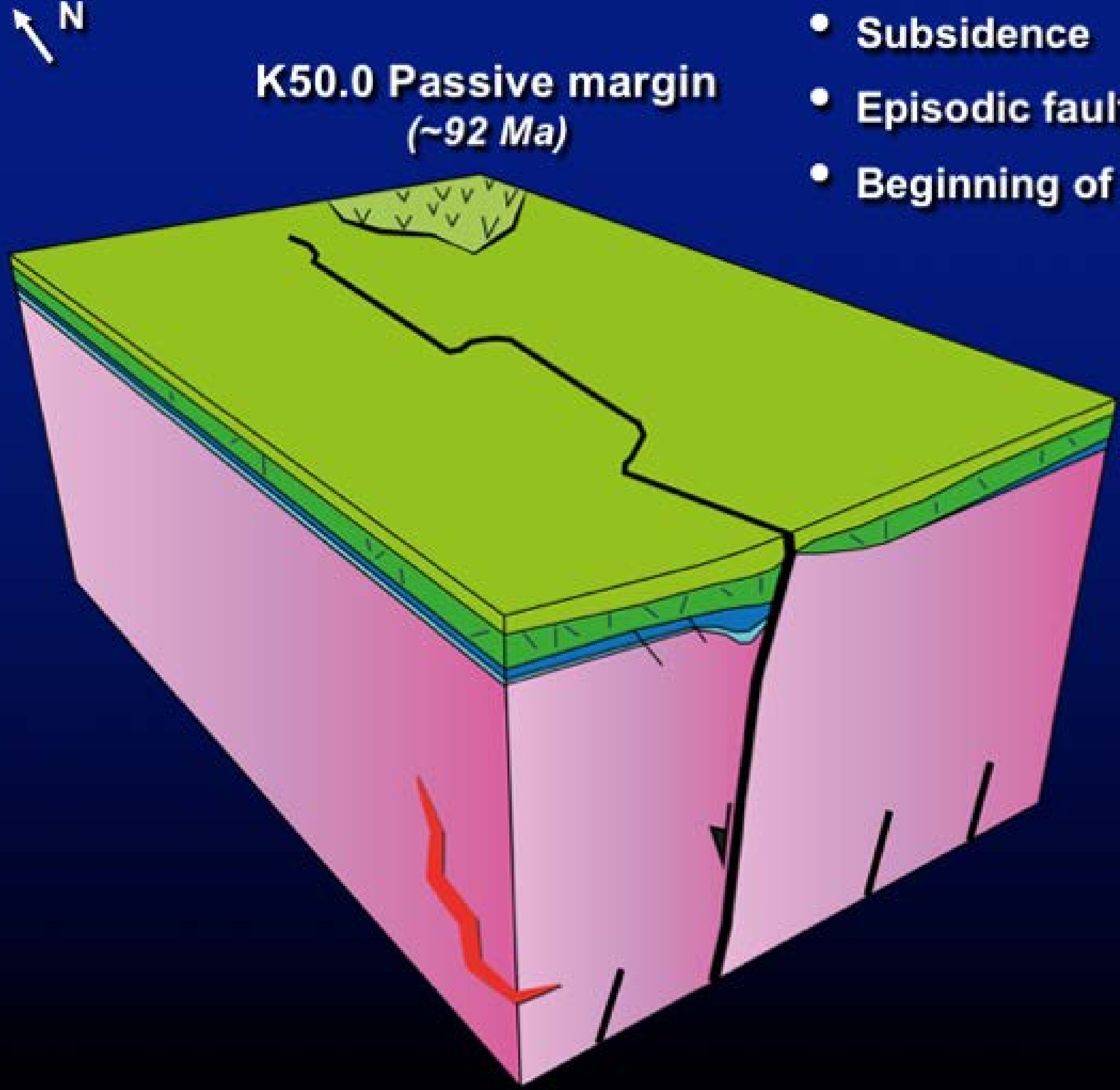
K40.0 Passive margin
(~125 Ma)

- Deposition of regional seal
- Subsidence
- Episodic fault reactivation



K50.0 Passive margin
(~92 Ma)

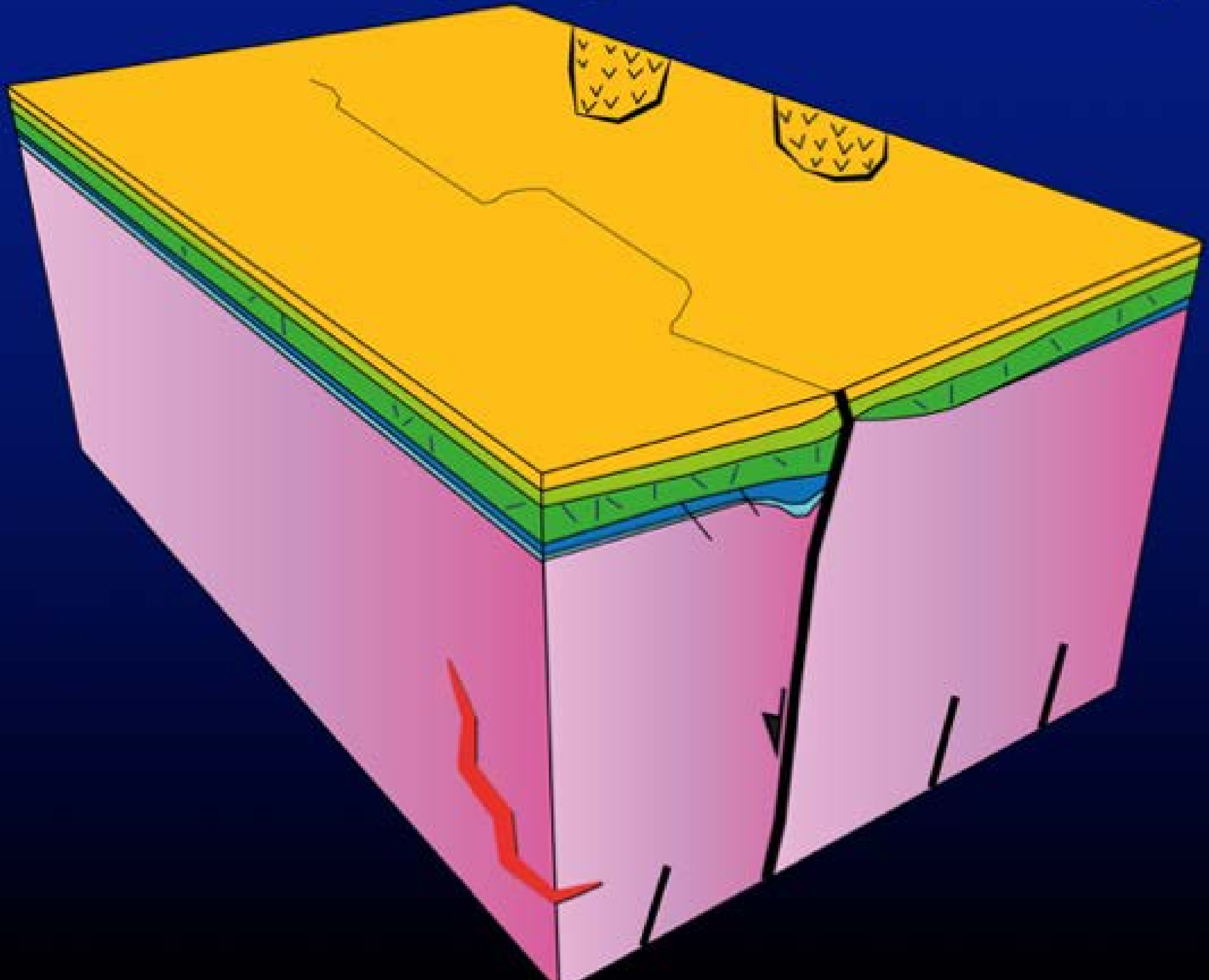
- Subsidence
- Episodic fault reactivation
- Beginning of MTC's



N

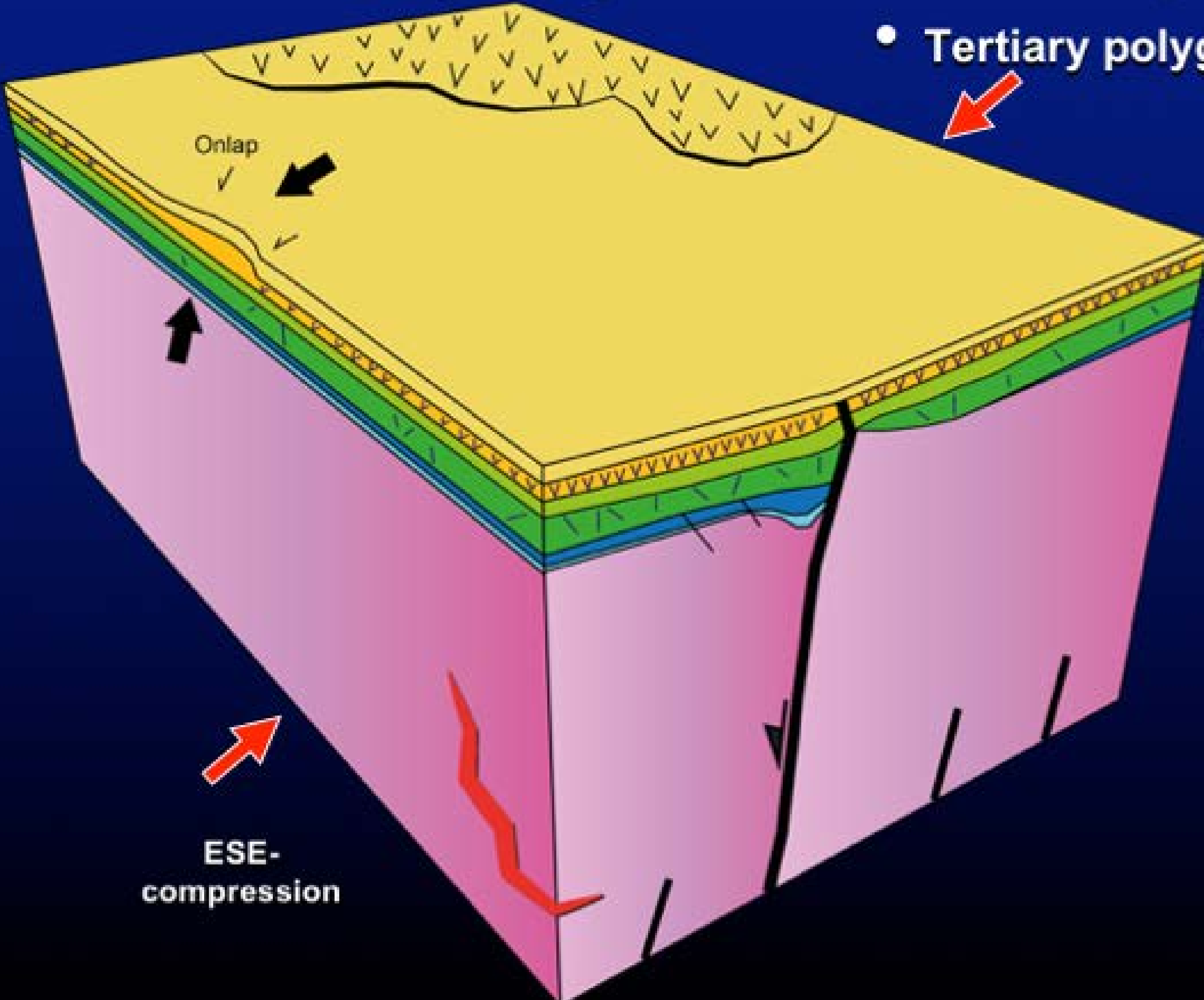
T10.0 Passive margin
(~65 Ma)

- Minor episodic fault reactivation
- Mass-transport complexes

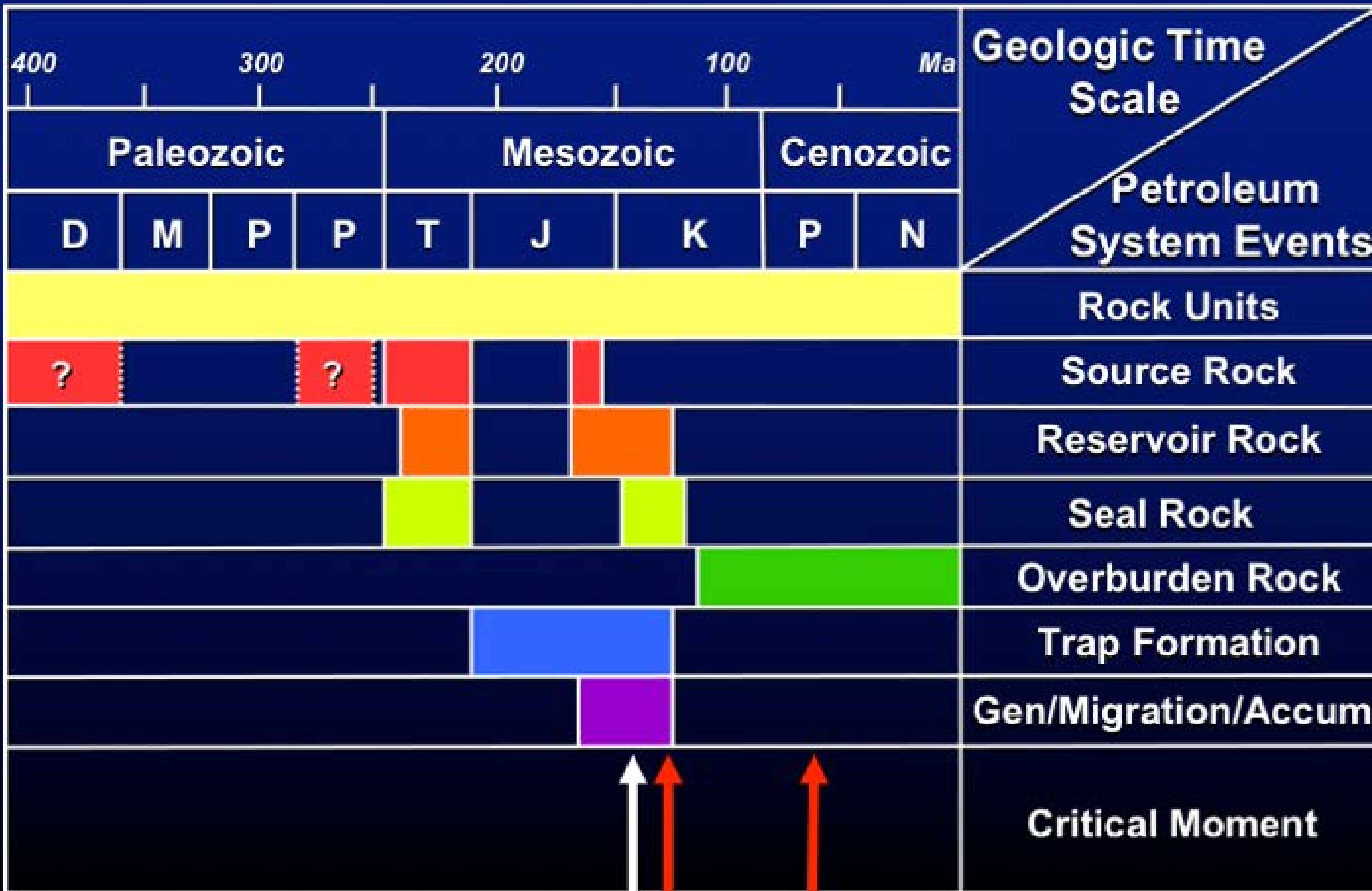


T30.0 Passive margin
(~30 Ma)

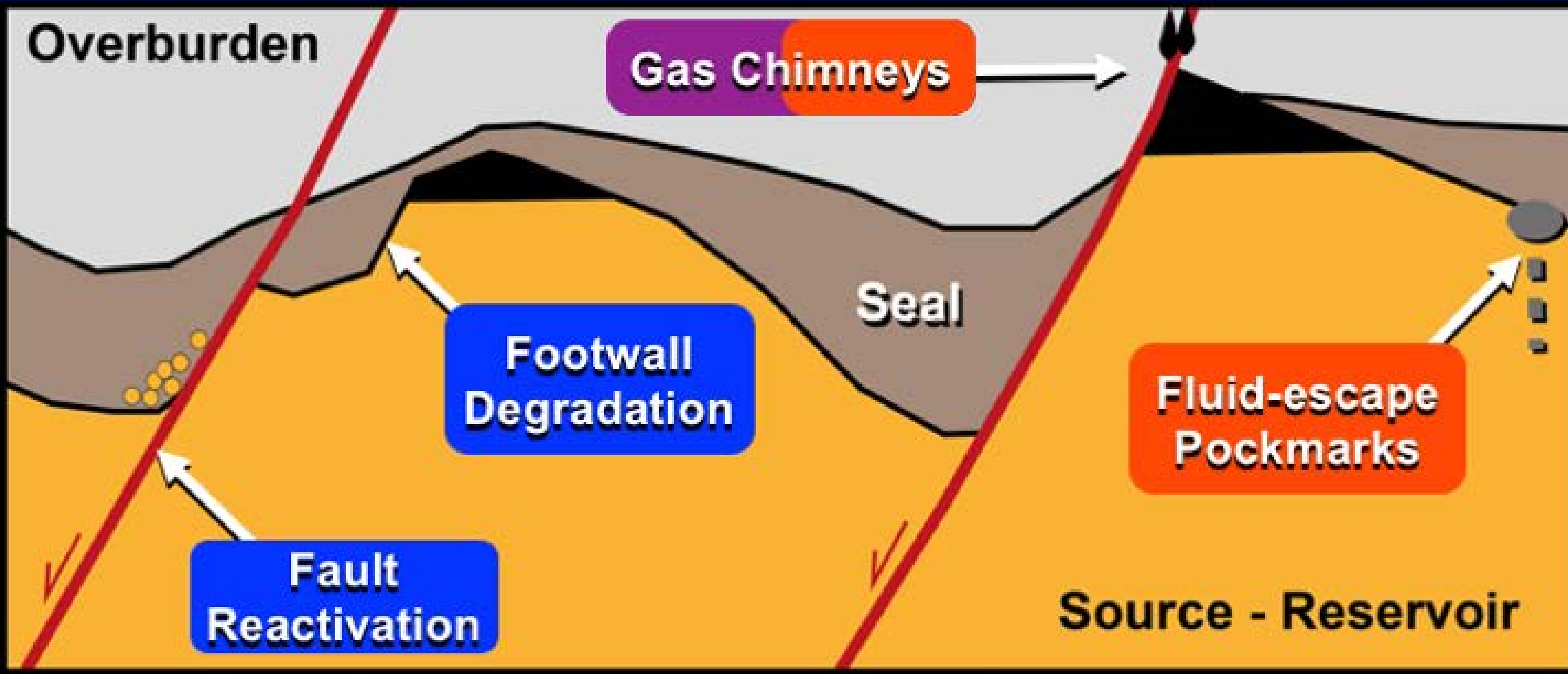
- Inversion, uplift
- Mass-transport complexes
- Tertiary polygonal faults



Petroleum Systems Chart



Prospectively Risk of Structural Traps in Survey



1. Trap Integrity | **2. Seal Integrity** | **3. Volume Remaining**

*Diagram not to scale

**Drilling risks not included

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Final thoughts:

Too much risk in structural trap integrity for the hydrocarbons to have stayed put

So What?

..... Not here

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Acknowledgements

- **Geoscience Australia -** Centaur survey dataset
- **Halliburton Landmark -** Seismic interpretation software **DecisionSpace & Geoprobe**
- **Badley's Geoscience -** Fault analysis software **Limited TrapTester**

3GiG

Australian Government

Geoscience Australia

HALLIBURTON

STAR Structural Analogues for Reservoirs

Badleys

Badley Geoscience Limited

Fault Dynamics