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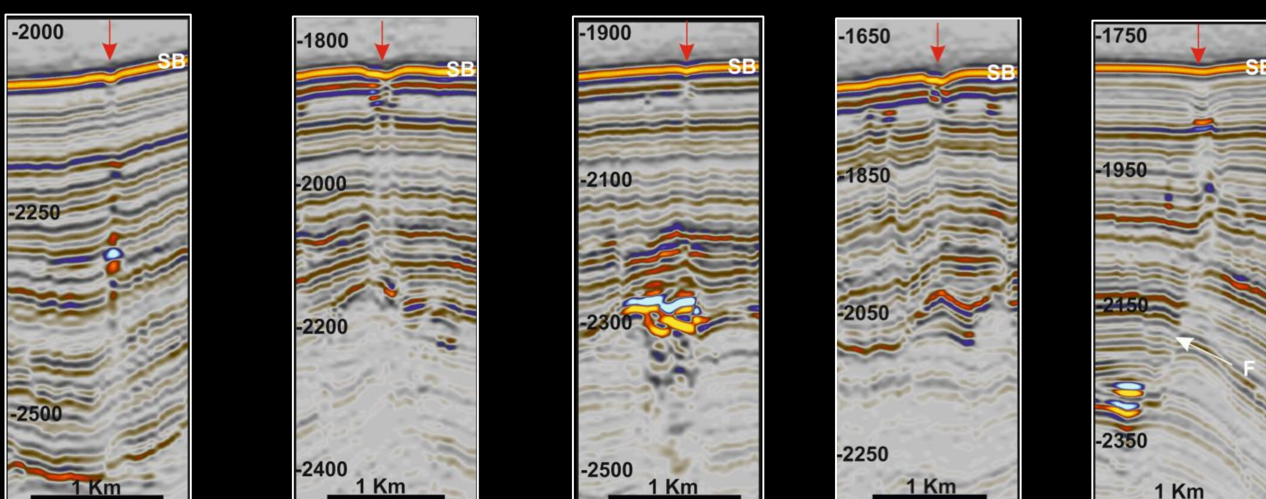
HYDROCARBON PROSPECTIVITY ON THE WEST AFRICAN TRANSFORM MARGIN – A CASE STUDY FROM NIGERIA



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Supervised by Prof. Mads Huuse

AAPG PROSPECT AND PROPERTY EXPO
ISLINGTON, LONDON
7TH MARCH 2019

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ACKNOWLEDGEMENT

Full sponsorship of research

Research location, UK

Provided seismic data

Software provider (University Grant)

Seismic data approval

Event organizer

Sponsoring for the event

PRESENTATION OUTLINE

Background of the study

- Location of Study Area
- Rationale of Study
- Seismic Stratigraphy

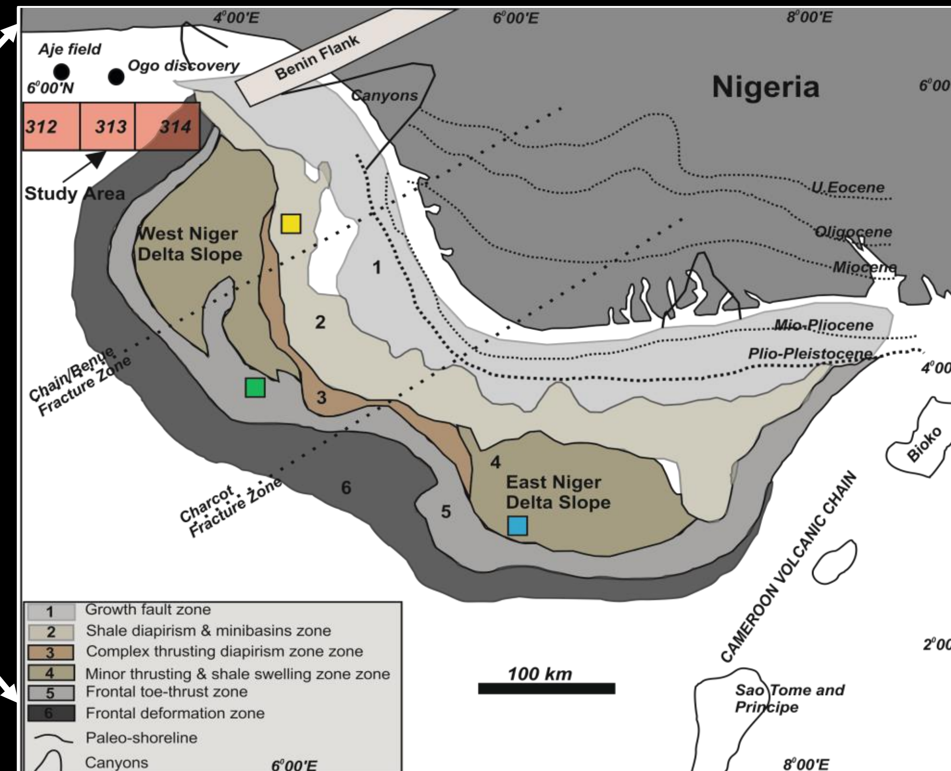
Seismic Characterization

- Seabed Morphology
- Mass Transport Complexes
- Direct Hydrocarbon Indicators (DHI) and Fluid-Flow Phenomena

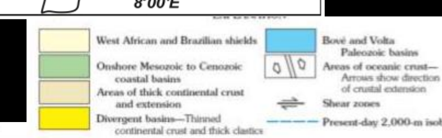
Implications for Hydrocarbon Prospectivity

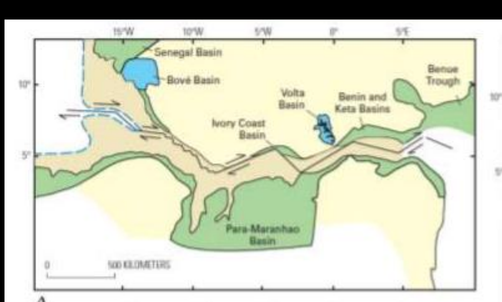
Conclusions

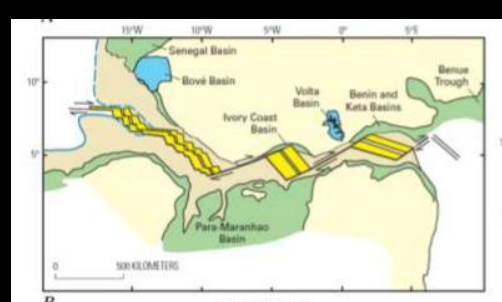
LOCATION AND GEOLOGY OF STUDY AREA

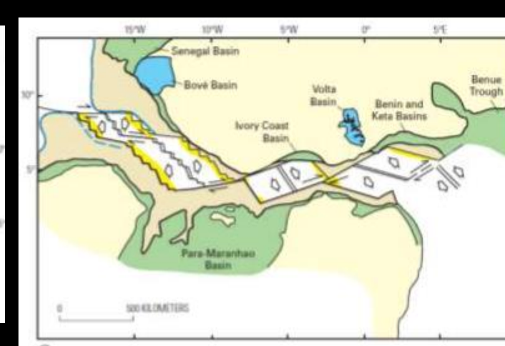


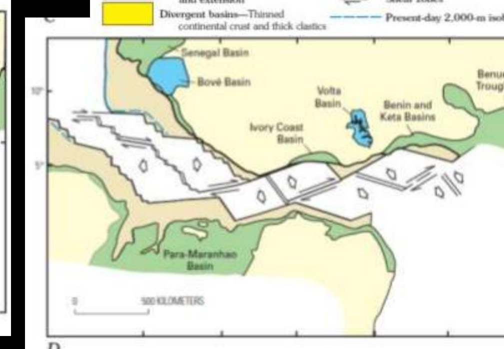
- Dahomey-Benin Basin, Western Niger Delta
- Part of E-W aligned basins within GOG











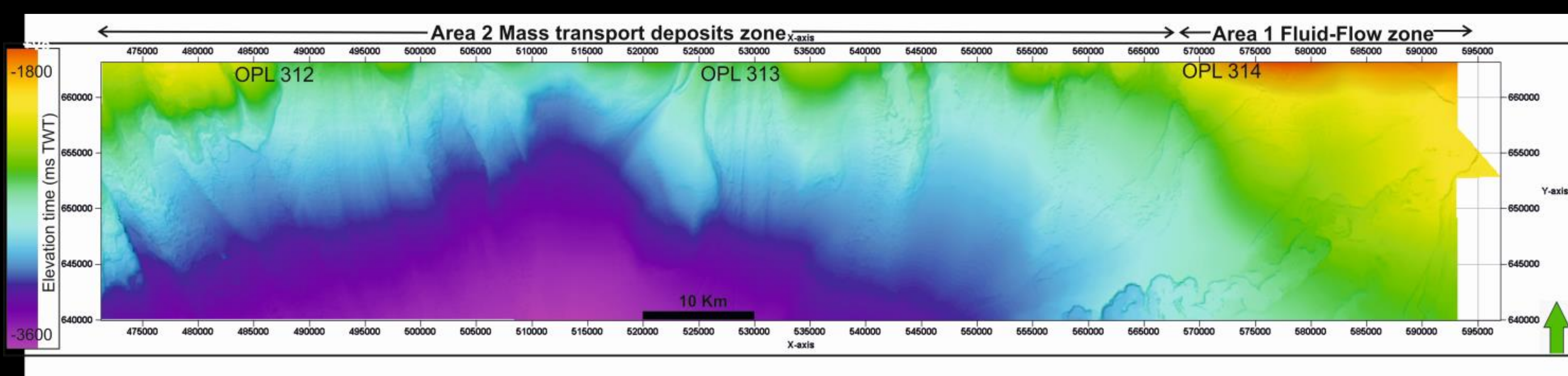
- African and South American plates rifting – Late Jurassic
- Transform/wrench faults (Greenhalgh et al., 2011) and complex tectonic history in 3 phases
- Mid-Late Cretaceous, incisions on shelf transported large turbidity basin fans into the deep-ultra deep part of the basin and these forms the main reservoirs/targets in the region in fields/discoveries such as Aje, Ogo and nearby Jubilee, Fifa, Hihon)

RATIONALE OF STUDY

INTEREST
Earliest fields discovered in 60's & 70's – small potential until recent breakthroughs e.g Jubilee Field, Aje Field

DATA
3D seismic survey was acquired to confirm the presence hydrocarbon potential of Cretaceous plays

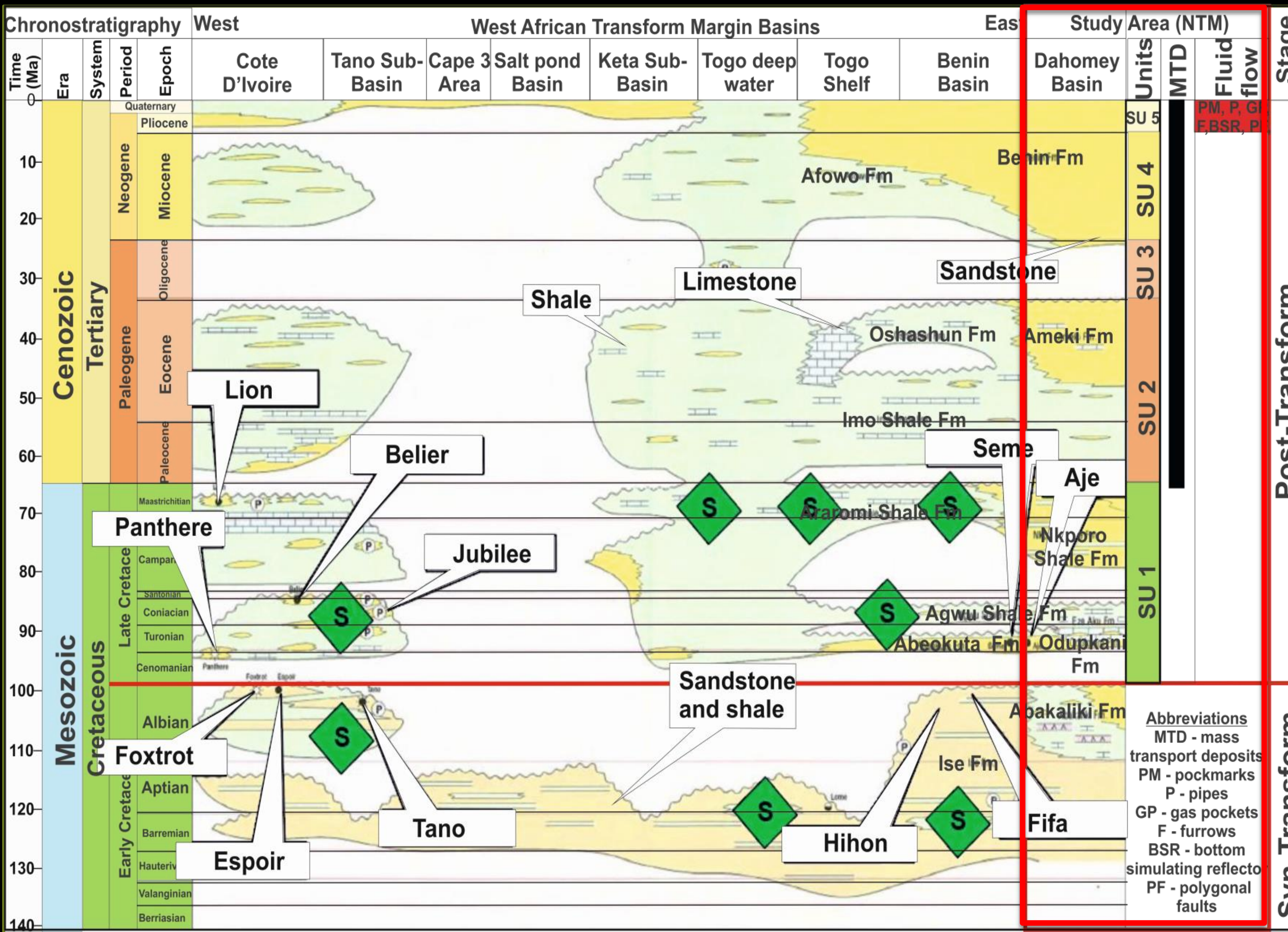
AIM
To analyse the Cenozoic slope deposits, investigate evidence Fluid-Flow Phenomena, Hydrocarbon Indicators (DHIs) and implications



Very good quality 3D Seismic data – 2,845 km^2.

No wells drilled yet

GENERAL LITHOSTRATIGRAPHY



Pre-Transform - Late Proterozoic to Late Jurassic

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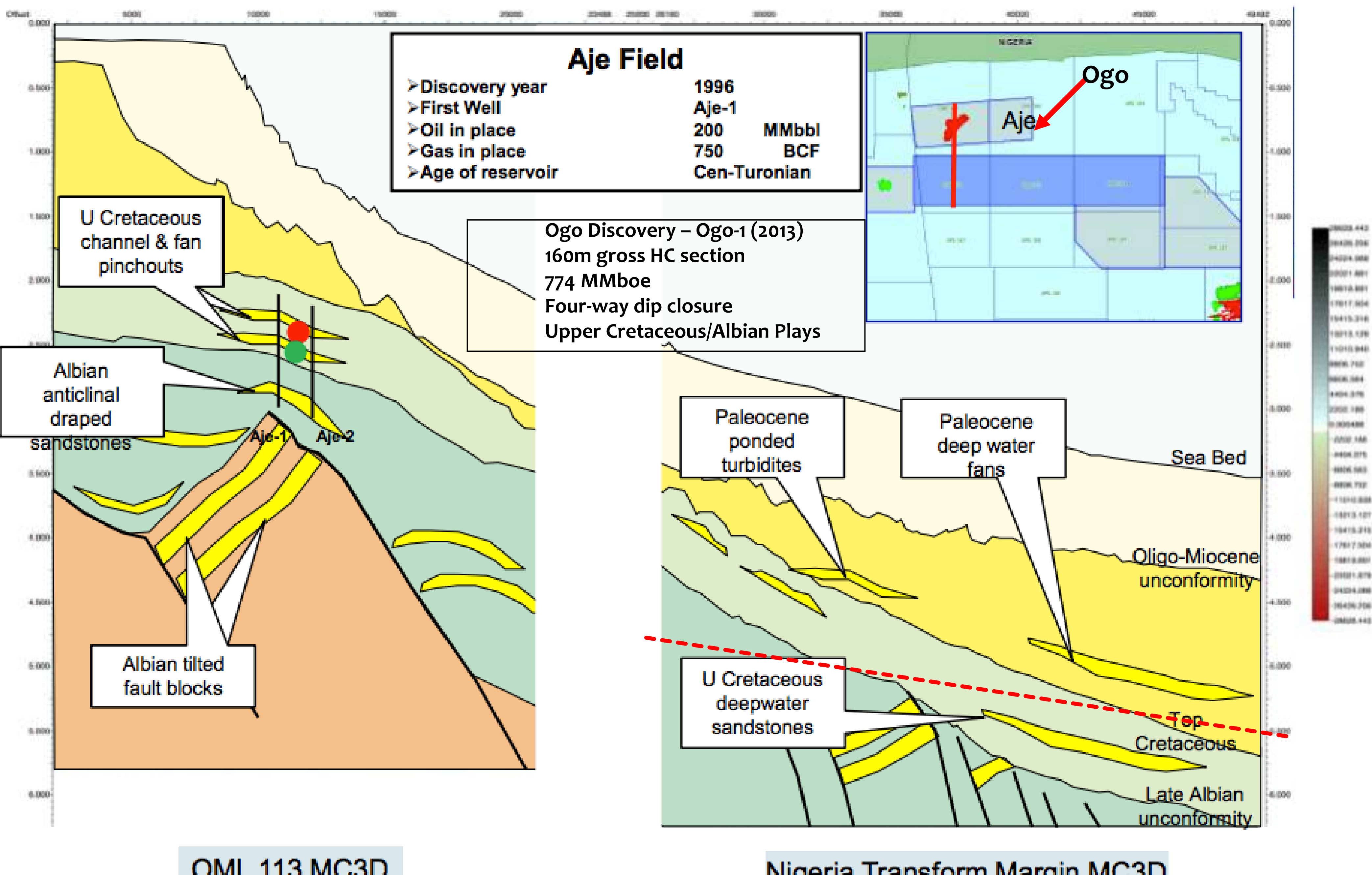
REGIONAL STRATIGRAPHY – AJE FIELD/OGO DISCOVERY



Dip Seismic Line through Aje and study area (Borsato et. al, 2012)

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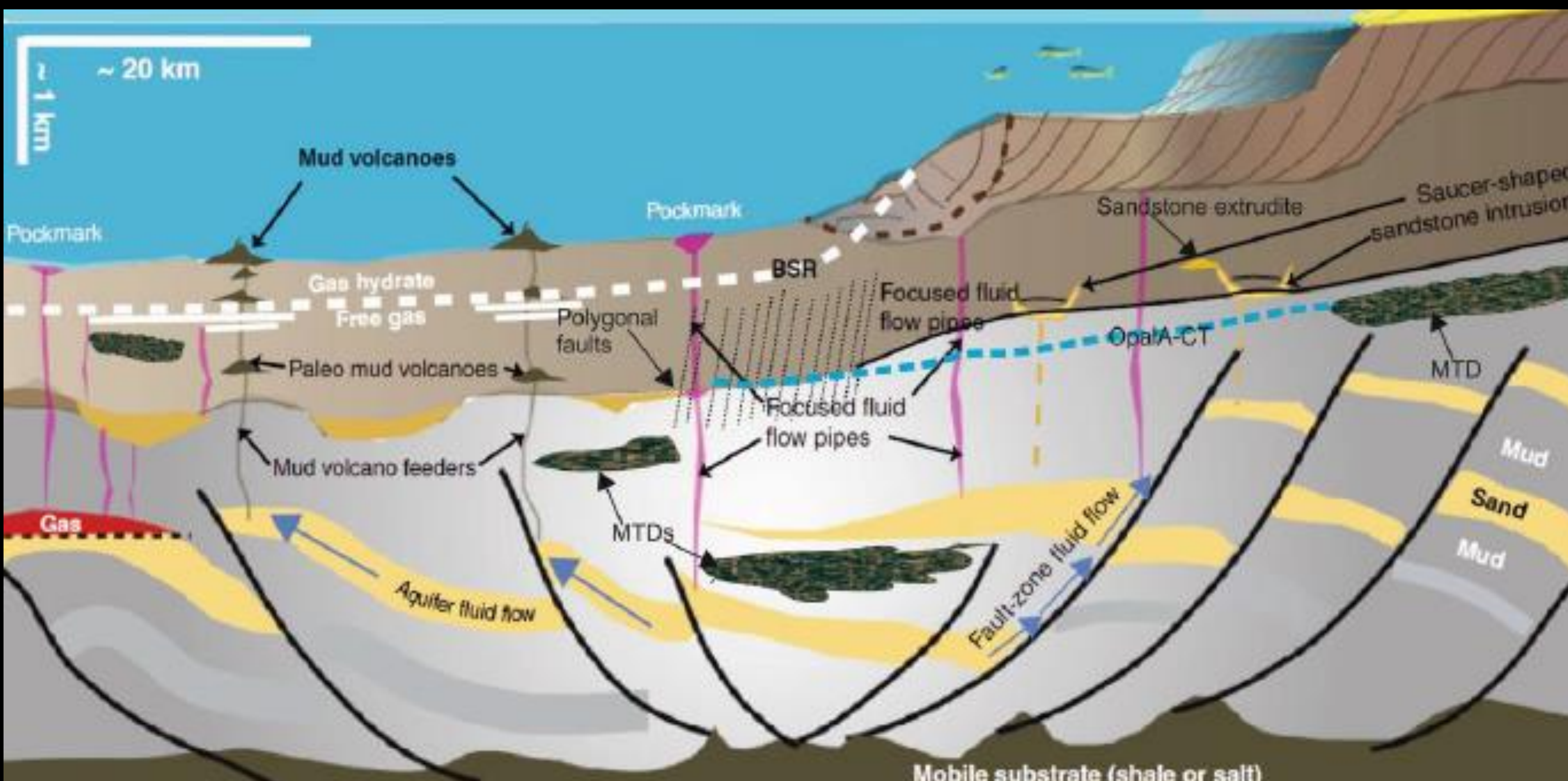
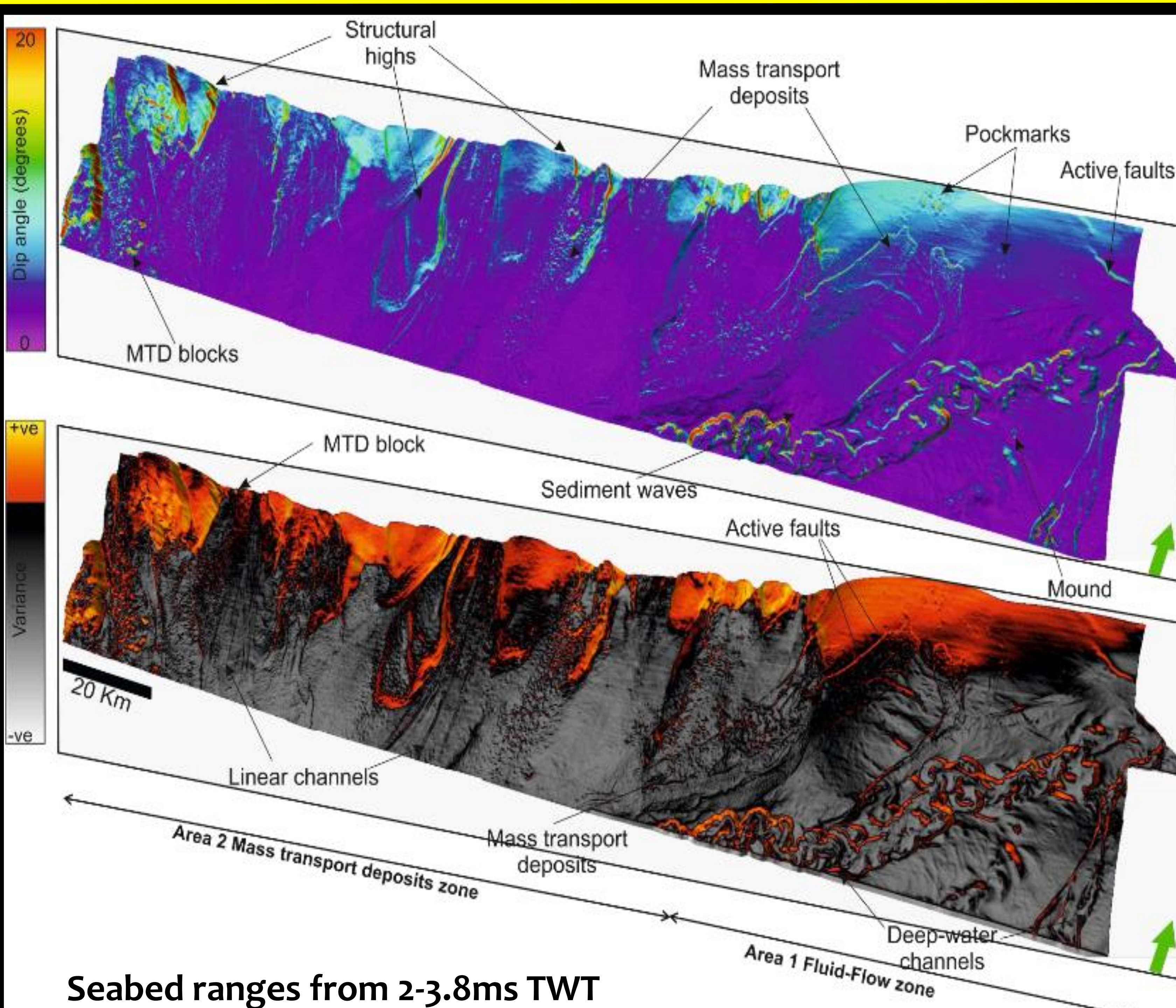
FLUID-FLOW PHENOMENA

Fluid-Flow Phenomena results from the movement of fluid (pore water or hydrocarbon) into a unit, which is triggered by internal or external mechanism within the sedimentary basin. e.g North Sea Basin, Lower Congo Basin, Niger Delta, San Joaquin etc (Huuse *et al*., 2010; Andresen 2012).



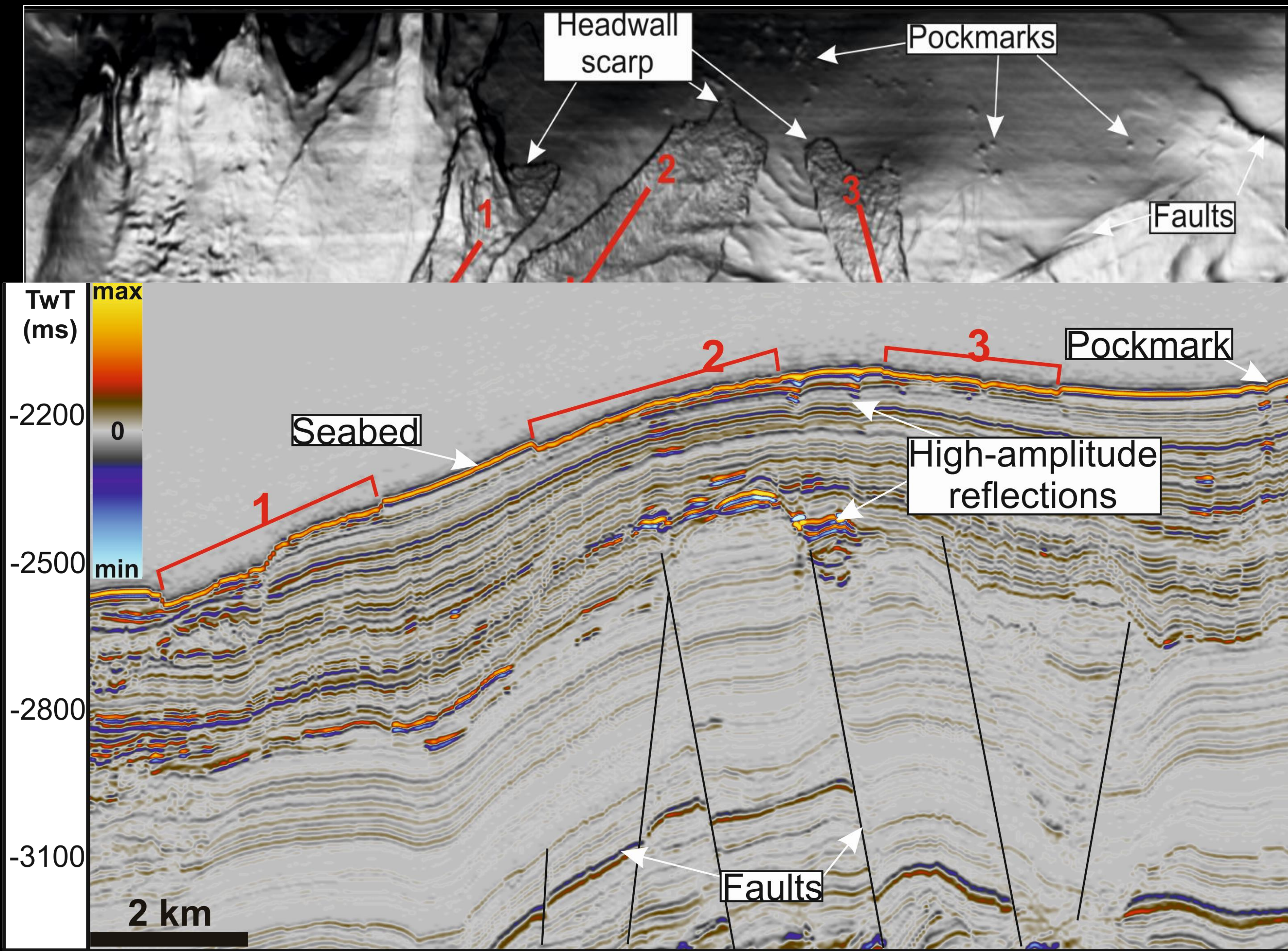
Sediment remobilization and fluid flow on a typical continental margin (modified after Huuse et al., 2009)

SEABED MORPHOLOGY

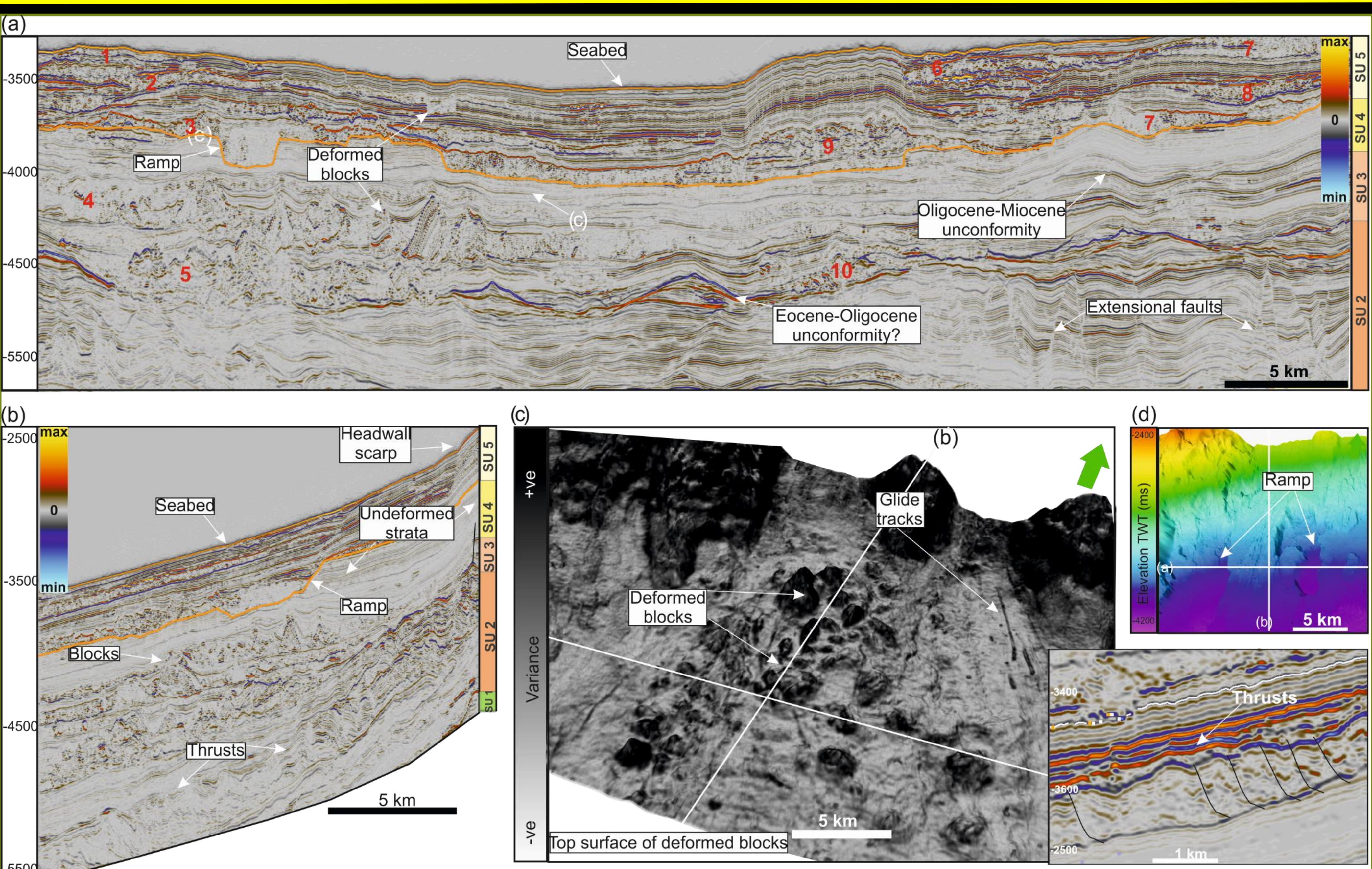


Seabed ranges from 2-3.8ms TWT

SEABED MORPHOLOGY – AREA 1

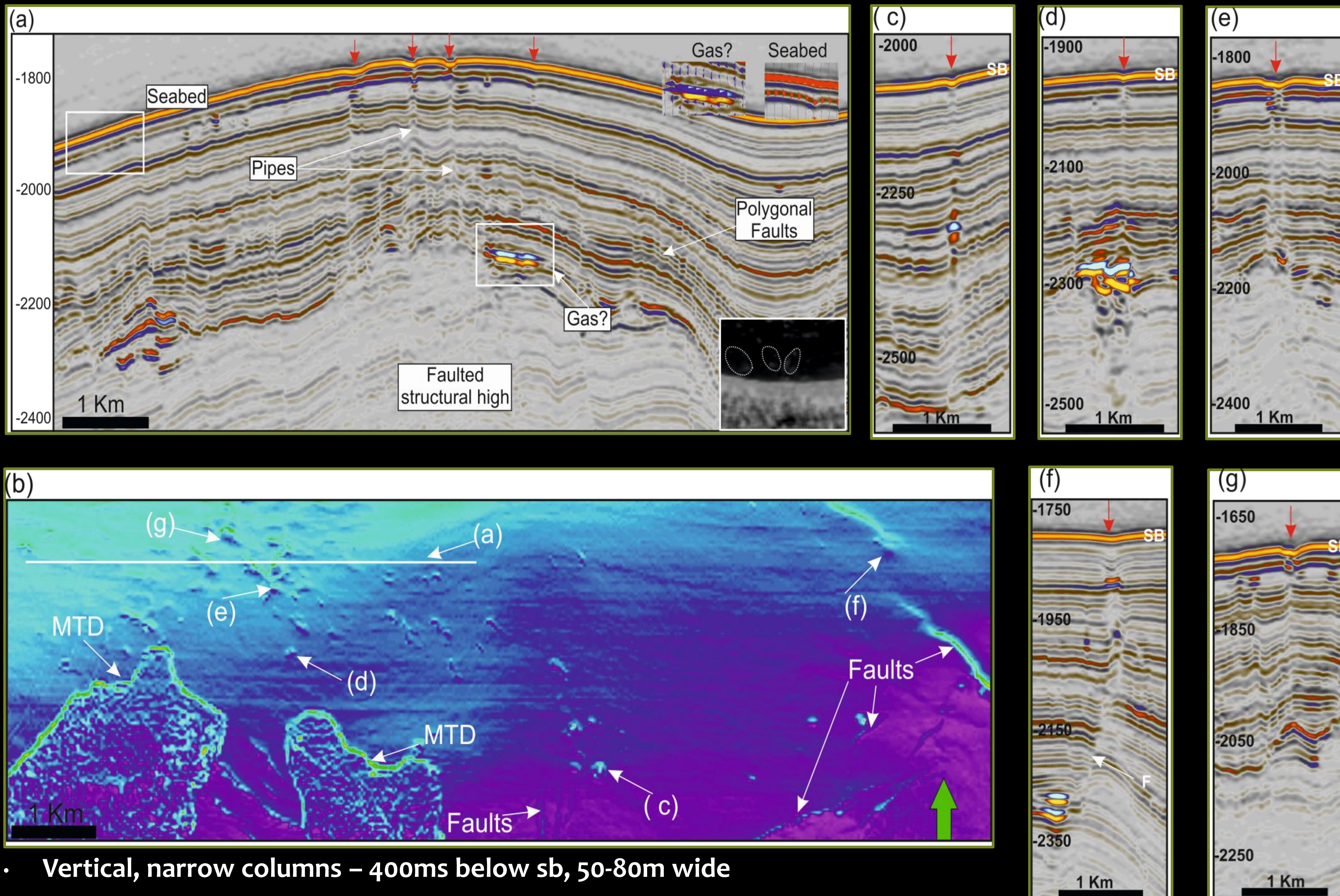


MASS TRANSPORT DEPOSITS (MTDs) – AREA 2



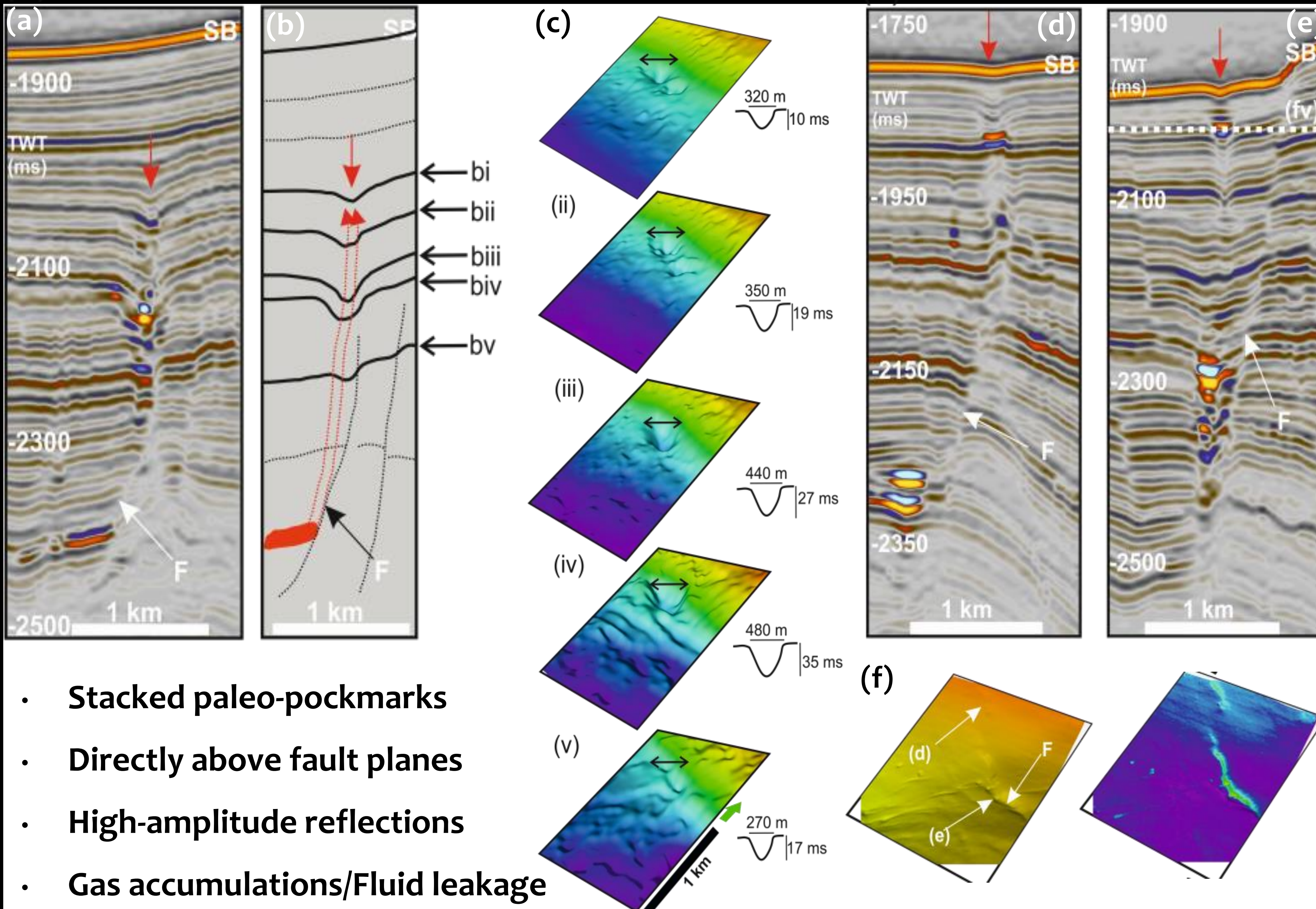
- Chaotic seismic facies and laterally extensive - repeated occurrence
- Size range from 100s of m to 10s of km upto 25% of stratigraphy

DIRECT HYDROCARBON INDICATORS – PIPES & POCKMARKS



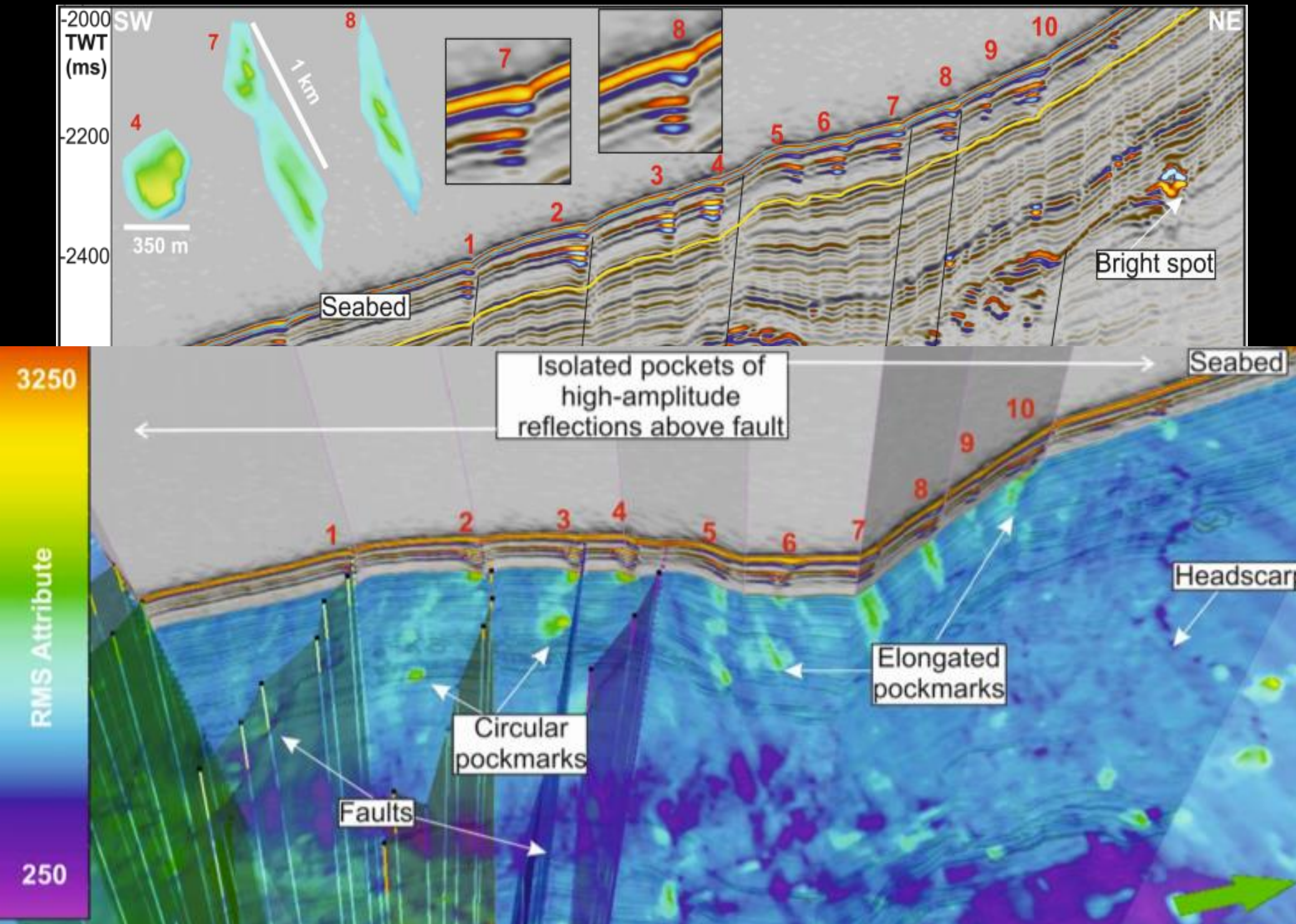
- Vertical, narrow columns – 400ms below sb, 50-80m wide
- Located below depressions on the seabed – pockmarks and related to faulted high
- High-amplitude reflections, negative polarity from seabed – Gas accumulations?

DIRECT HYDROCARBON INDICATORS – FAULTS & POCKMARKS

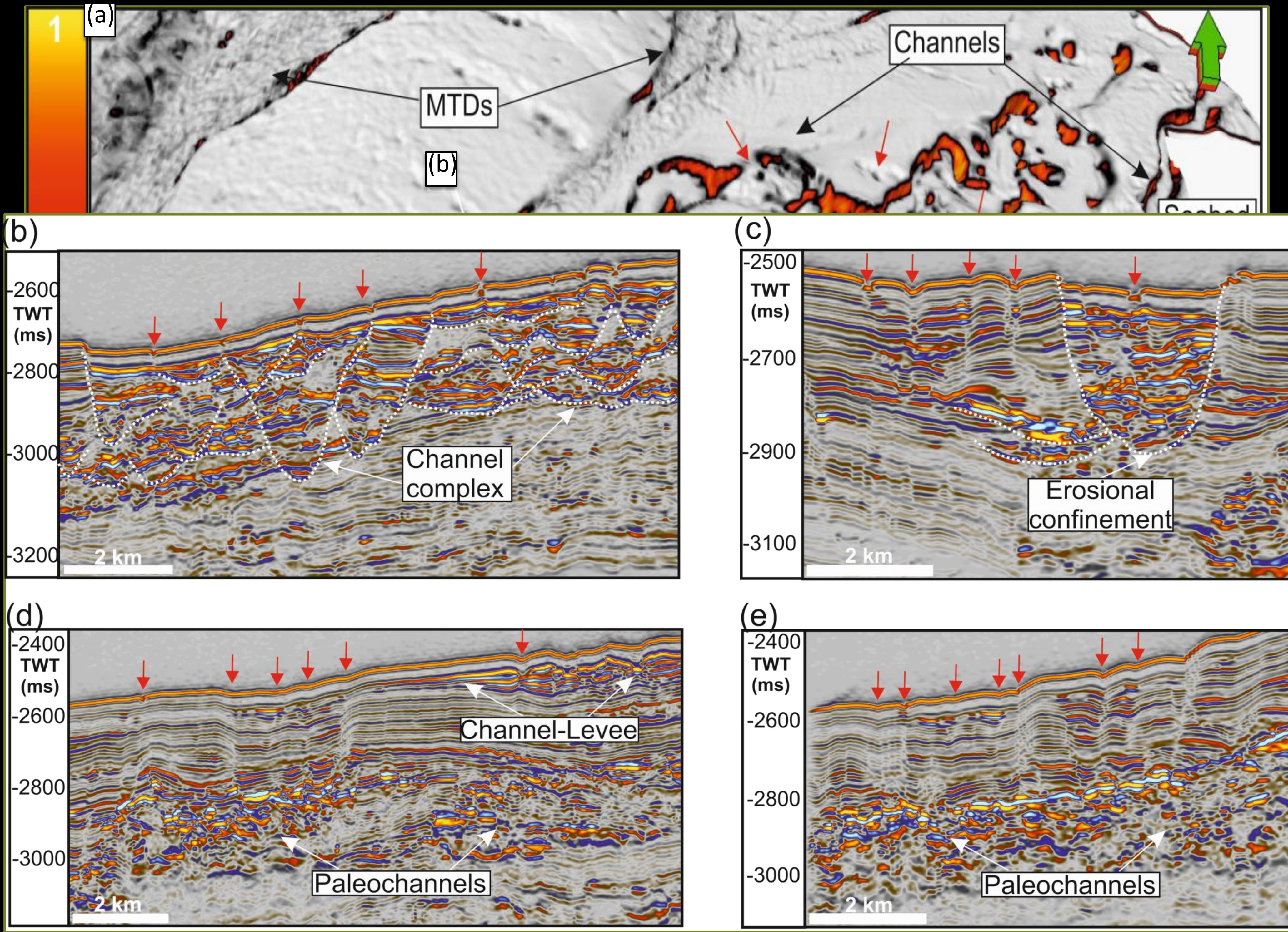


- Stacked paleo-pockmarks
- Directly above fault planes
- High-amplitude reflections
- Gas accumulations/Fluid leakage

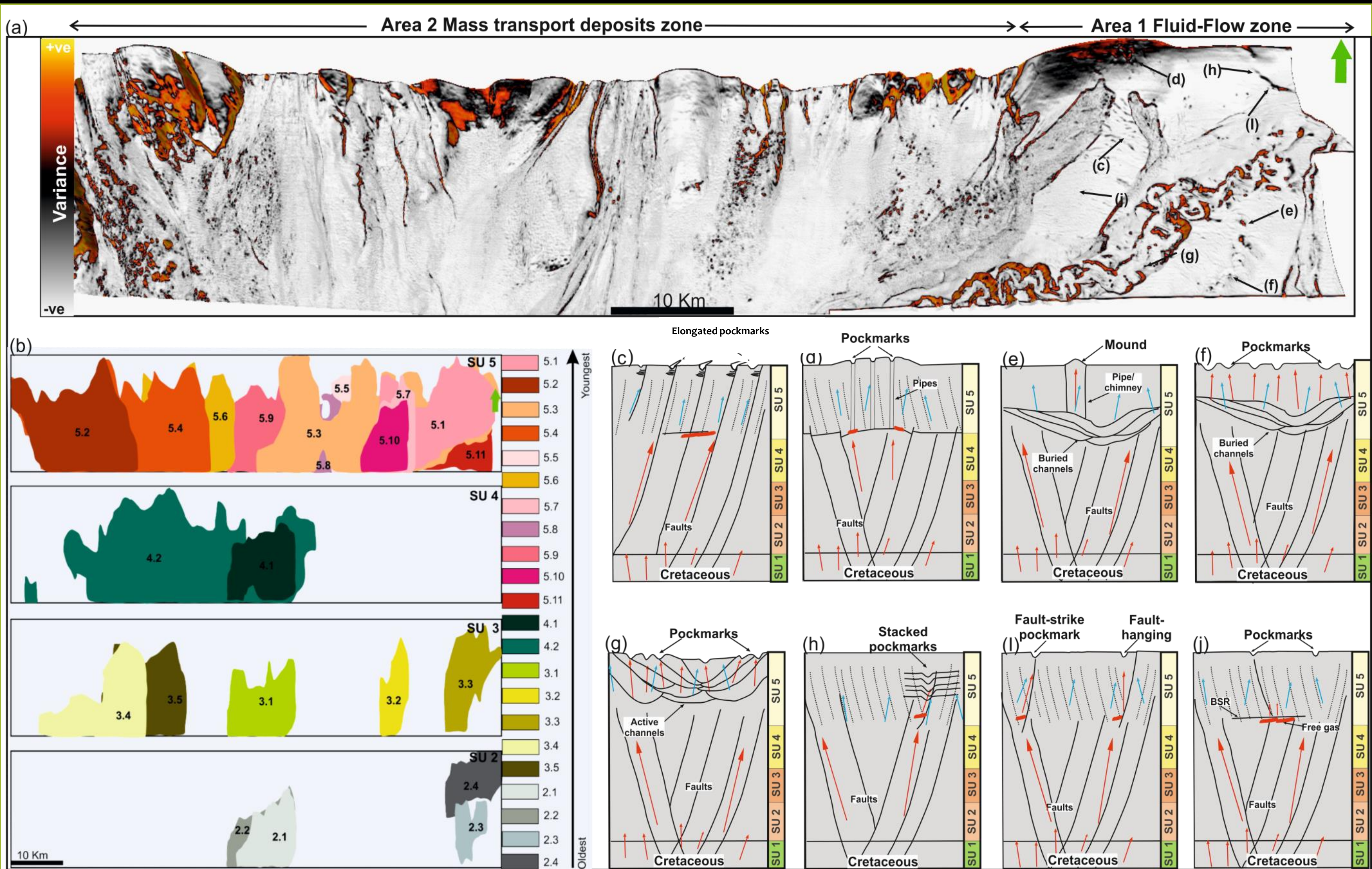
DHI's, POCKMARKS & DEEP-SEATED FAULTS



CHANNEL-RELATED POCKMARKS



GENERAL SYNTHESIS



Area 1 – Hydrocarbon Indicators and Fluid-flow features related to underlying systems

Area 2 – MTDs – could form seals – hence reason for devoid of fluid-flow features

FLUID TYPE, SOURCE AND MECHANISM

Fluid type

Gas/Oil/Pore Water?

high-amplitude anomalies – DHI's

Oil and gas in neighbouring fields and discoveries

Fluid source

Biogenic/Thermogenic/Both

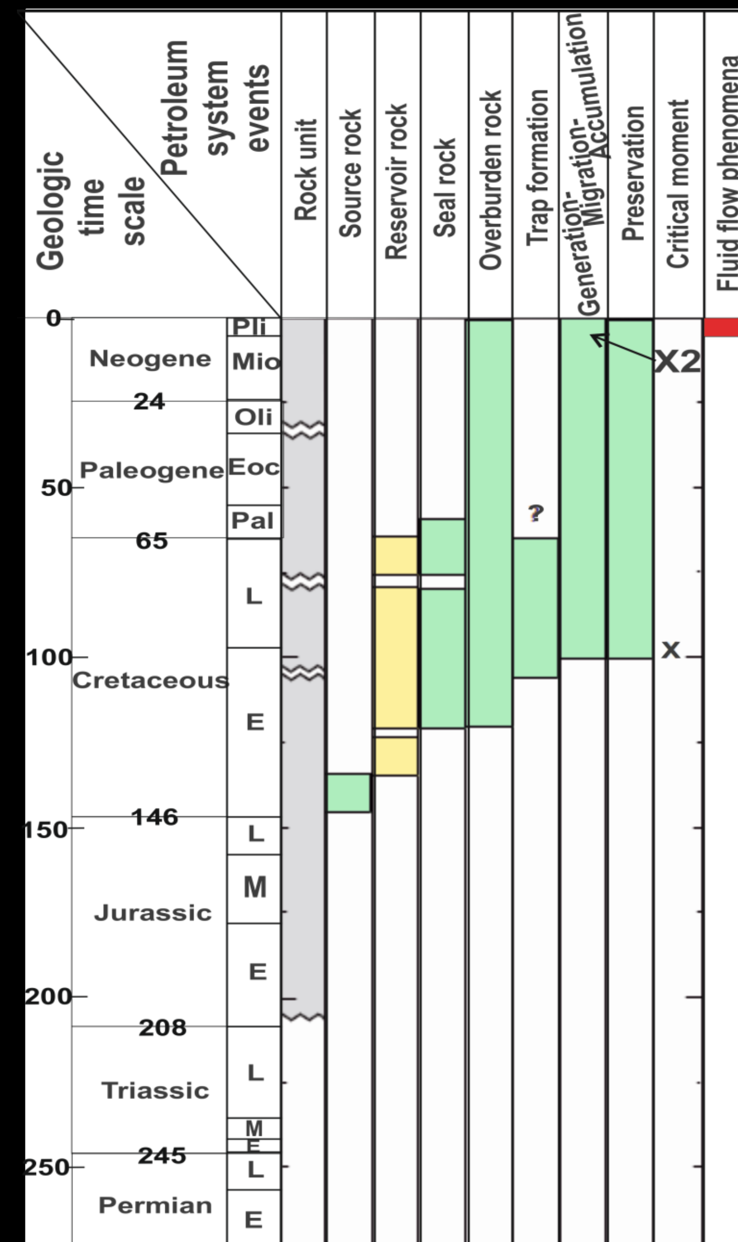
Relationship of DHI's and Fluid-Flow Features with underlying structural and erosional features

Driving mechanism

Occur within shallow interval (SU5) – Pliocene to recent?

Hydrocarbon generation and migration began in the Late Miocene and continued till date

Overpressure



Petroleum systems chart for Lower Cretaceous along the margin (Brownfield & Charpentier 2006)

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CONCLUSIONS AND IMPLICATIONS

WHAT WE KNOW

Presence of depositional, DHI's and fluid-flow features

Related to faults, pipes, structural highs and channels

Active petroleum systems in the region

HC generation and migration in the basin is Late Miocene

WHAT WE THINK WE KNOW

Possible presence of hydrocarbon in deeper parts

Could thermogenic or biogenic or combination of both

Breach in seal integrity due to seal-by-pass systems above faults, pipes, channels

WHAT WE DON'T KNOW

Exact fluid type – Requires geochemical analysis and seabed sampling, drilling to find out – seabed seeps

Maybe its all artefacts?

AND MANY MORE WE DON'T KNOW WE DON'T KNOW

Evidence of presence of an active, deeply buried petroleum system, which gives indications for hydrocarbons and could bode well for hydrocarbon prospectivity

Provides evidence of fluid leakage from the deep and ultra-deep petroleum systems such that the fluids could have migrated through zones of weaknesses of faults and channel margins – seal integrity is compromised – TRAP?

Pockmarks, mounds and MTDs on seabed may affect installations of drilling equipment and must be carefully mapped prior to installation and must be accounted for when building reservoir/geologic models for future exploration

THANK YOU

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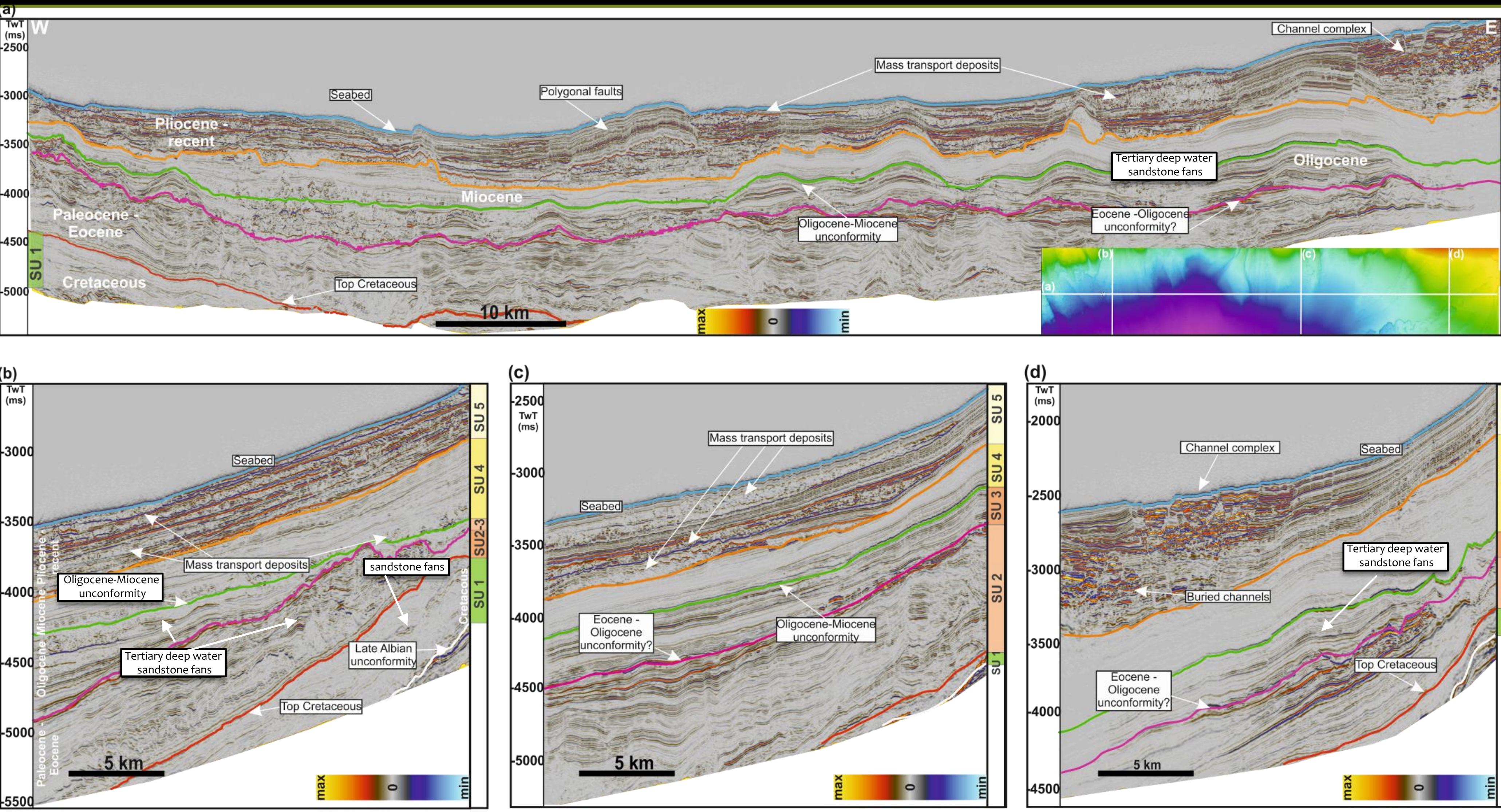
SEISMIC STRATIGRAPHY – STUDY AREA



- Horizons from nearby Aje Field. Missing underlying Cretaceous intervals
- Variable seismic reflections. Often chaotic reflections within units
- Deep water systems - MTDs, Sandstone Fans and Channel Systems
- Similar Cretaceous fans from Aje Field are observed

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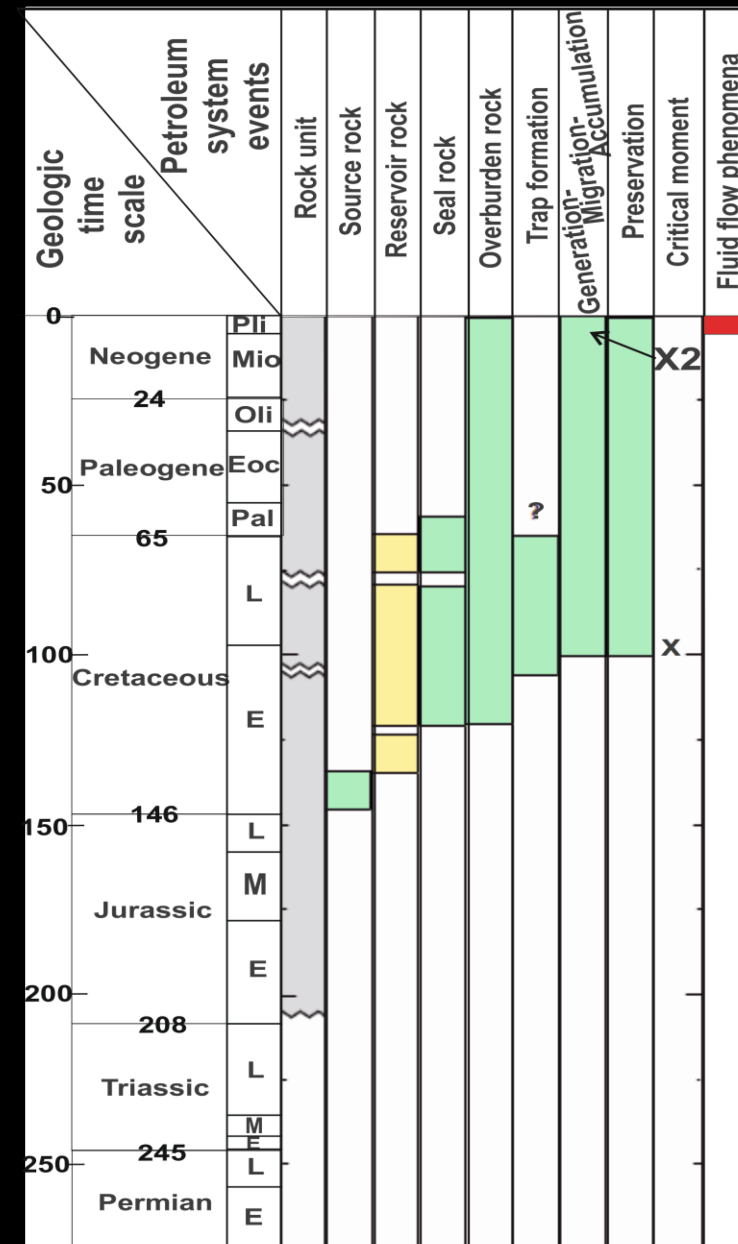
Overpressure in channels



Petroleum systems chart for Lower Cretaceous along the margin (Brownfield & Charpentier 2006)

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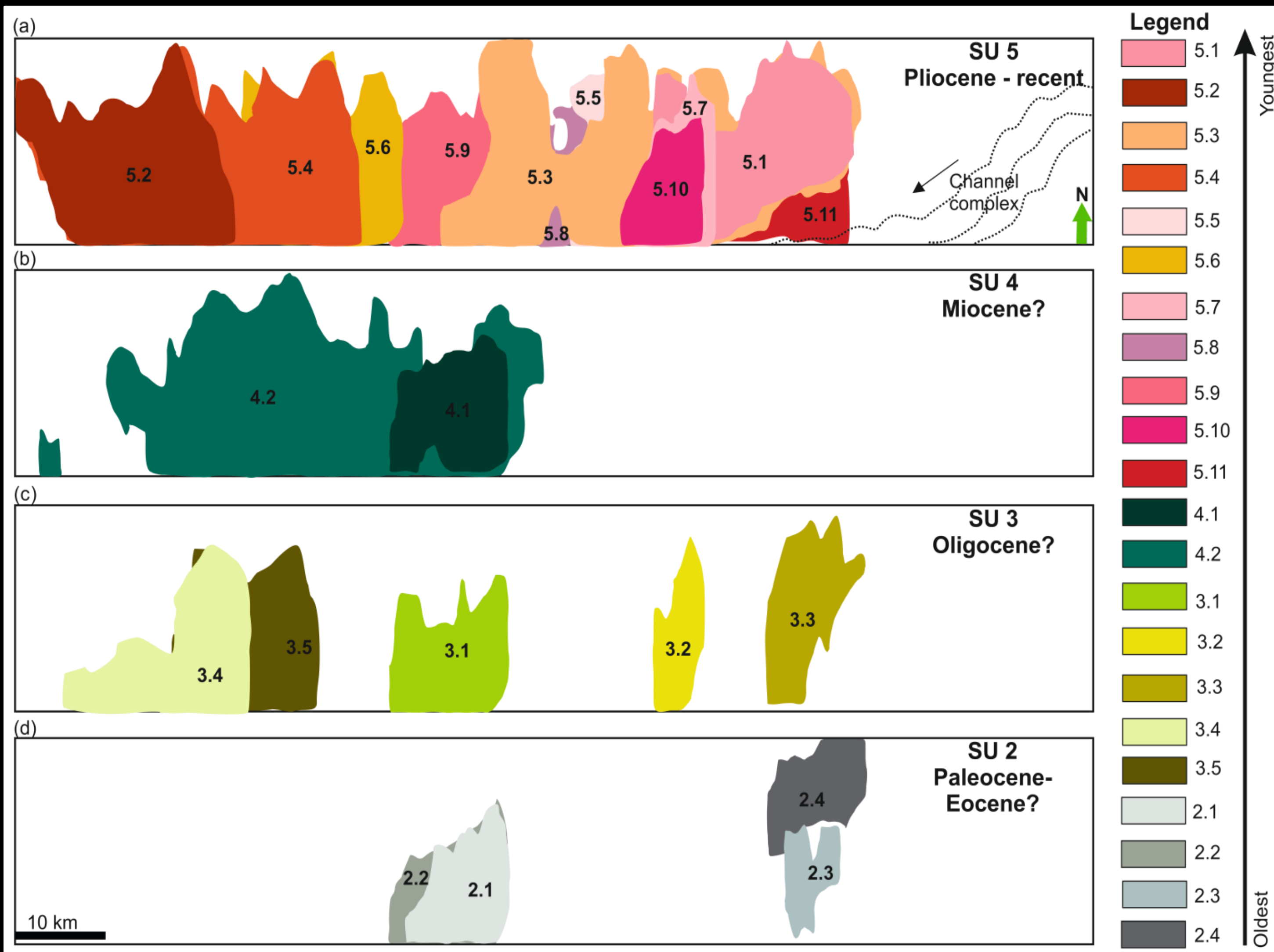
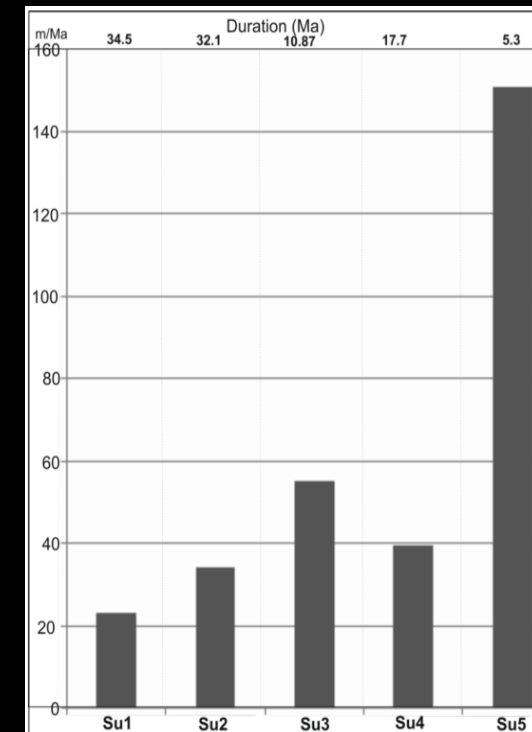
MTDs – SCALE, DISTRIBUTION AND SEDIMENTATION RATES



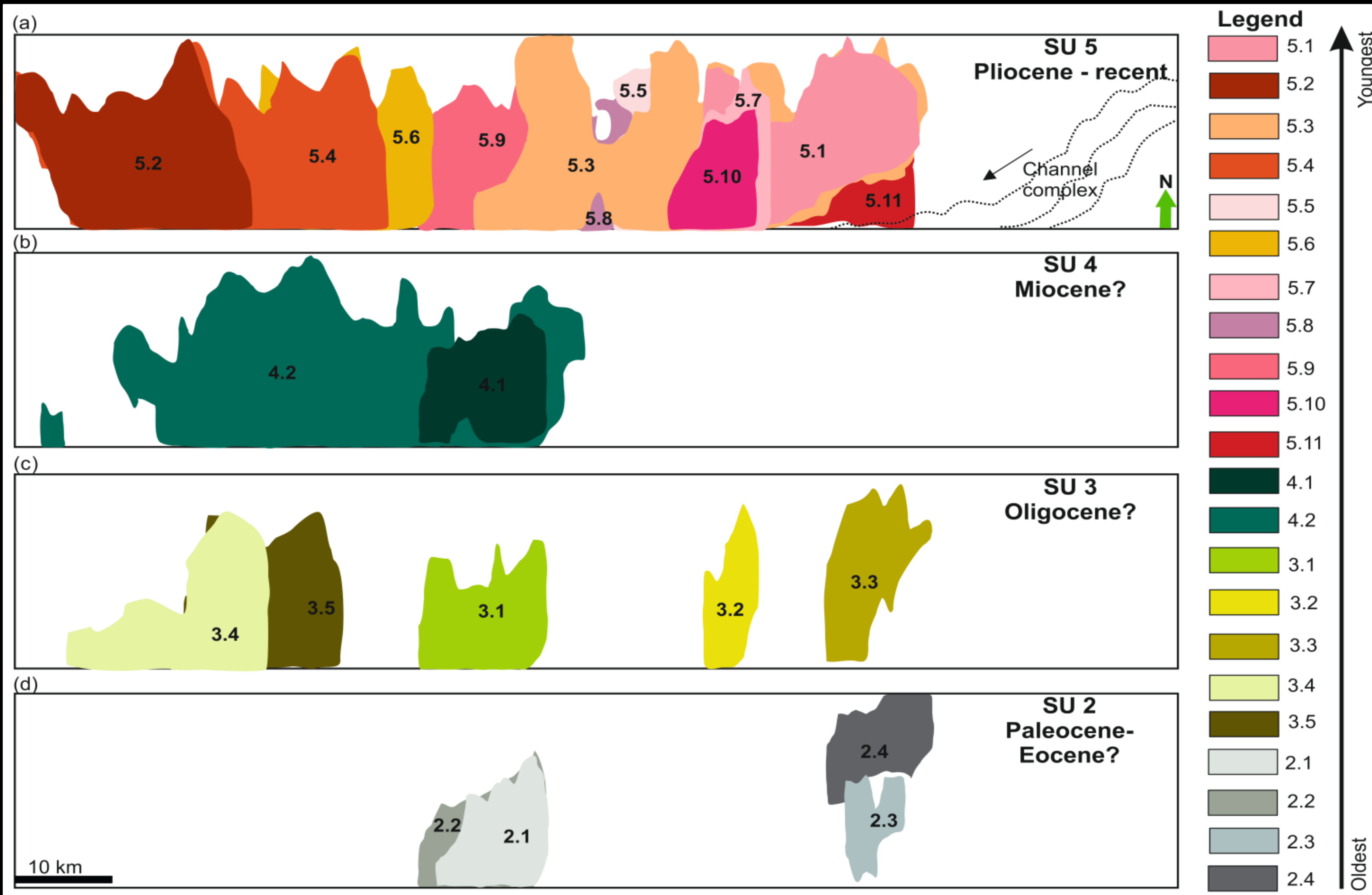


Graphical representation of estimated sediment accumulation rates on the Nigeria Transform Margin. Note (1) this was based on assuming a constant in all the intervals (2) Ages are uncertain (3) Erosion and compaction also unaccounted for.

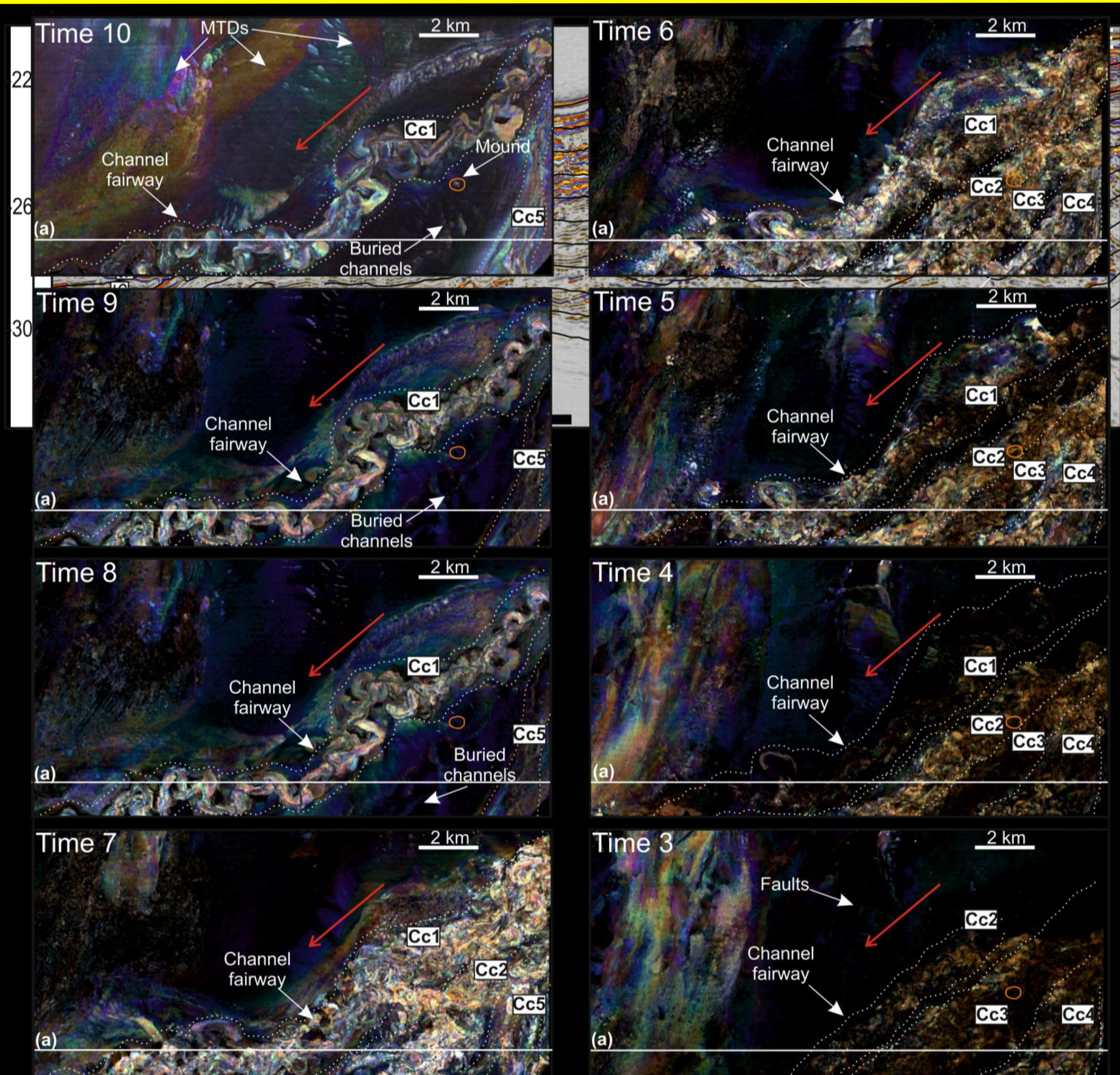
- Base of MTDs mapped – 22 presented here
- Repetitive and increased occurrence through time
- Magnitude of sediment failure corresponds with rate of sedimentation
- Complex tectonism during margin evolution

SEISMIC UNITS	SERIES	DURATION (Ma)	THICKNESS (ms) max	VELOCITY (Km/s)	NET ACC. RATE (m/Ma) max
SU1	Late Cretaceous	34.5	800	2	23.2
SU2	Paleocene-Eocene?	32.1	1100	2	34.3
SU3	Oligocene?	10.87	700	2	55.2
SU4	Miocene?	17.7	900	2	39.5
SU5	Pliocene to date?	5.3	1100	2	150.9

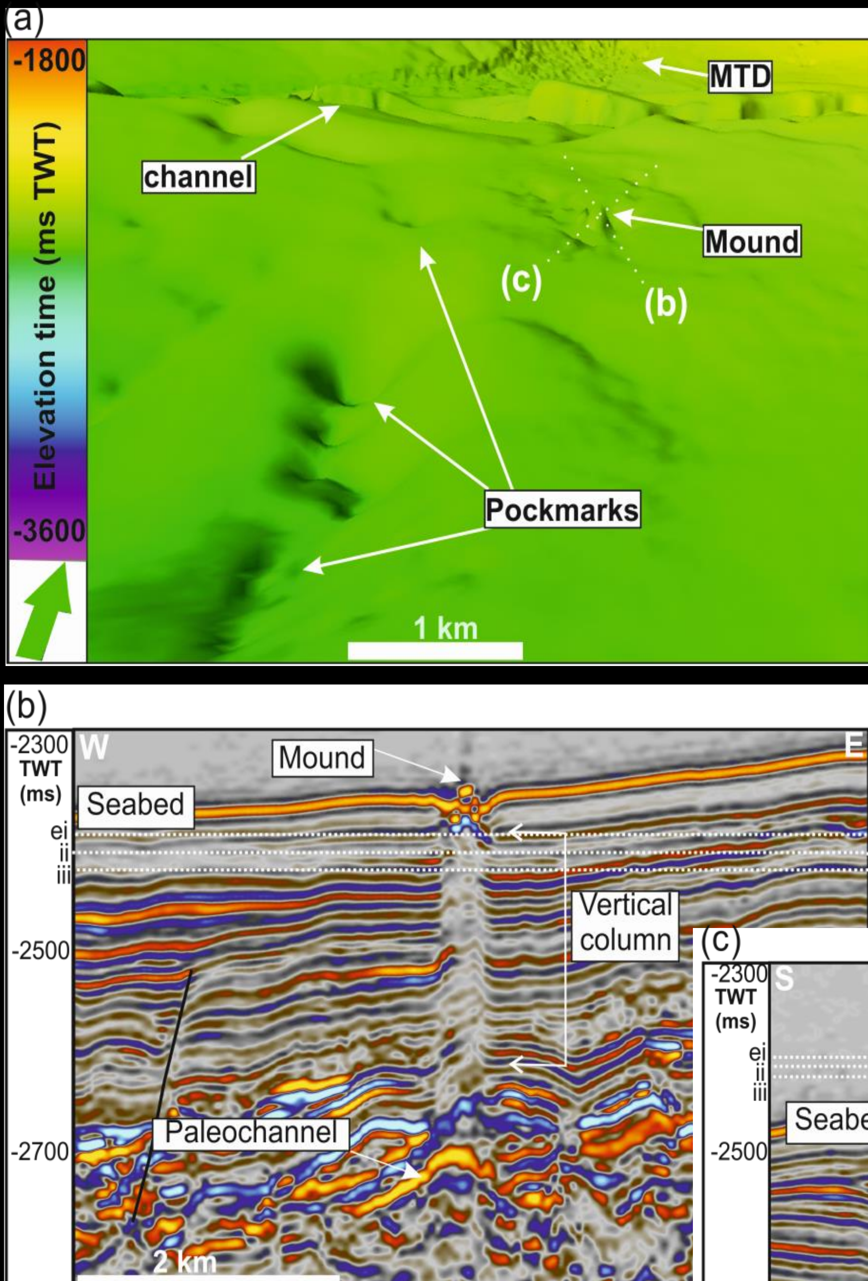
MTDs – SCALE, DISTRIBUTION AND SEDIMENTATION RATES



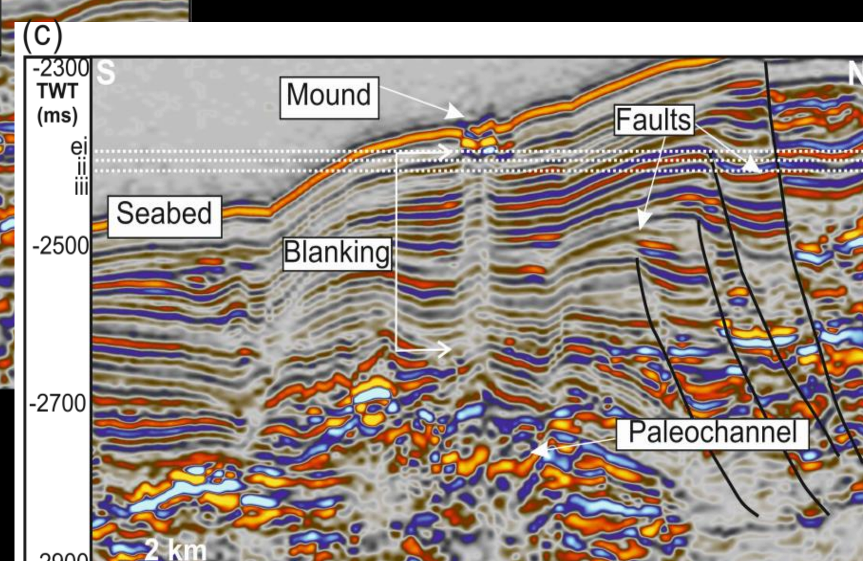
DEEP-WATER CHANNEL SYSTEMS

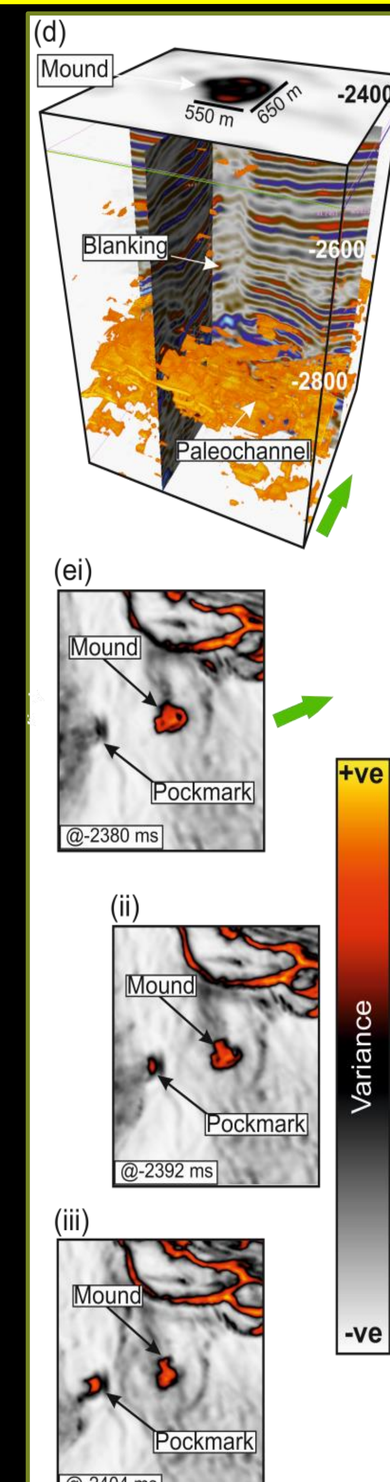


FLUID-FLOW PHENOMENA – SEABED MOUND

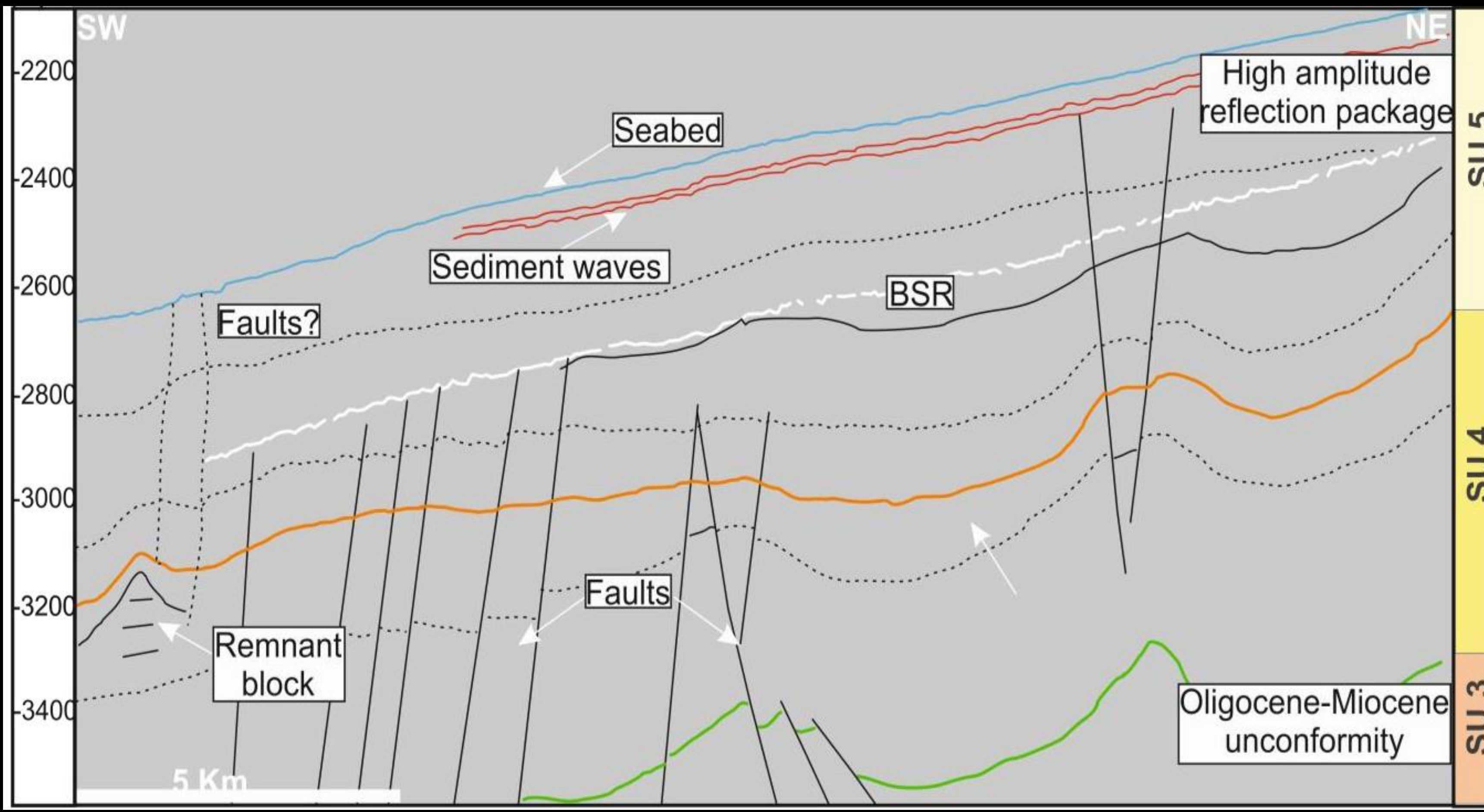


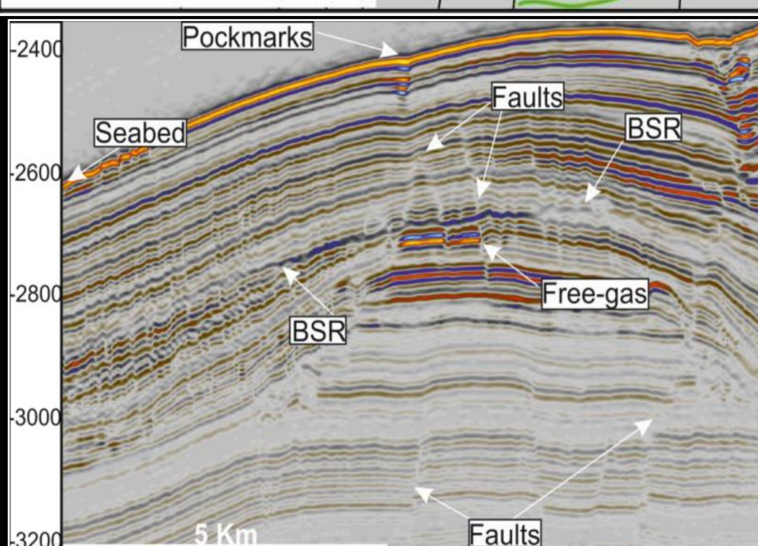
- Positive topography on the seafloor
- Circular in planview
- ~30 ms high and 500 m wide
- Occur above paleo-channels
- Carbonate or sand mound?





FLUID-FLOW PHENOMENA – BOTTOM SIMULATING REFLECTIONS (BSRs)





- Continuous reflection – tracks SB
- Negative polarity with the seabed
- Cross-cutting reflection
- Associated with gas hydrates
- Bottom of GHSZ
- -ve response due to velocity contrast
- Observed with faults and pockmarks