

Effects of Tides on Deltaic Deposition: Causes and Responses*

Piret Plink-Bjorklund¹

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Abstract

This article explores the response of deltas to tidal reworking and discusses the conditions at which deltas may become strongly tide-influenced or tide-dominated. Four case studies are used, from the Cretaceous Western Interior, the Devonian Baltic Basin, the Eocene Central Basin of Spitsbergen, and the Permian Karoo Basin in South Africa. All datasets contain extensive outcrop data; the Baltic Basin dataset also includes extensive core data. The presentation aims to show that, beyond the commonly recognized morphological features and the recognizable tidal facies, the main effects of tidal reworking of deltas are associated with delta-clinoform morphology, delta-lobe-switching rates, delta progradation rates, and the nature of the delta plain. Strong tidal influence is here documented to promote subaqueous, rapid progradation of deltas, by efficiently removing sediment from river mouth and thus reducing mouth-bar aggradation and fluvial- delta-plain construction rates. Such subaqueous progradation of the delta front is decoupled from shoreline progradation. Delta plain of such tide-dominated deltas consists of a few distributary channels and tidal flats. The delta-front clinoforms become gentler and longer, as tidal currents efficiently transport sediment to the basin. Tide-dominated deltas tend to maintain a funnel shape and show low lobe-switching rates, compared to fluvial-dominated and tide-influenced deltas.

This article emphasizes topographic restrictions or invaginations, caused by incision, delta-lobe deposition or tectonic uplift and subsidence, as significant controls on the occurrence of strongly tide-influenced deltas. The role of such topographic restrictions is twofold, by reducing wave energy and amplifying tidal energy. Significantly, such invaginations are not restricted to inner-shelf reaches as commonly assumed, but they may also occur at the shelf edge, promoting tidal reworking of shelf-edge deltas. Moreover, in very shallow epicontinental seas, significant tidal reworking may occur throughout the basin evolution, independent of sea-level cycles or sediment supply.

Selected References

Ponten, A., and P. Plink-Bjorklund, 2009, Regressive to transgressive transits reflected in tidal bars, Middle Devonian Baltic Basin: *Sedimentary Geology*, v. 218/1-4, p. 48-60.

Tanavsuu-Milkeviciene, K., and P. Plink-Bjorklund, 2009, Recognizing tide-dominated versus tide-influenced deltas; Middle Devonian strata of the Baltic Basin: *Journal of Sedimentary Research*, v. 79/12, p. 887-905.

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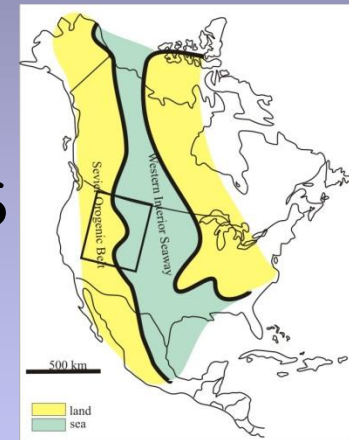
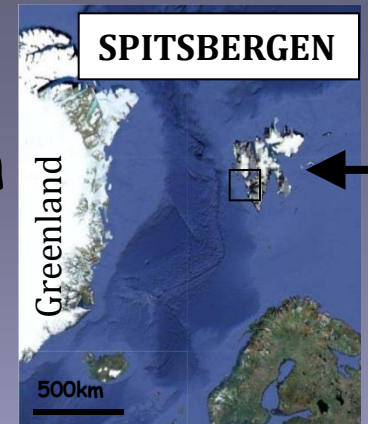
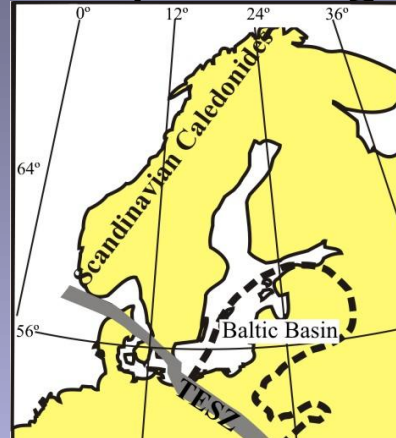
FOCUS:



- Response of deltas to tidal reworking:
 - Delta-plain and delta-front nature
 - Clinoform shape and dimensions
 - Delta-progradation style and rate
- Conditions that favor tide-dominated and -influenced delta formation
- Position of tide-dominated and -influenced deltas along the shelf-margin profile

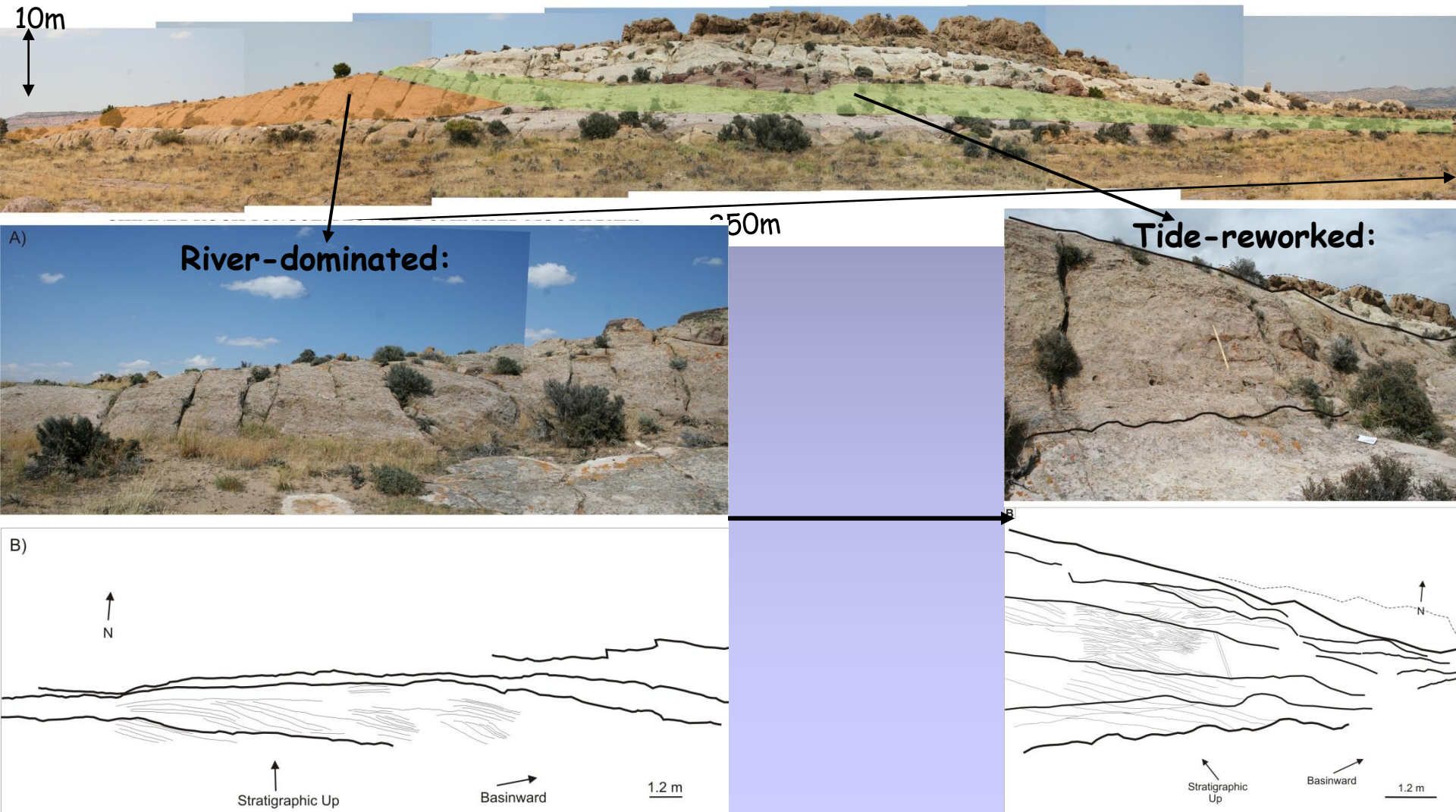
DATASET:

- Eocene Central Basin of Spitsbergen
- Devonian Baltic Basin
- Campanian Chimney Rock Sandstone, WIS
- Permian Karoo Basin



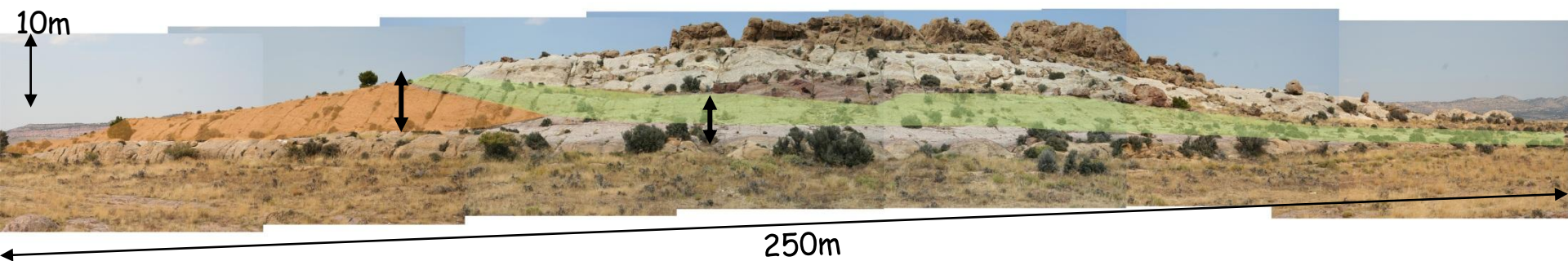
CLINOFORM SHAPE: river-dominated vs strongly tide-reworked mouth bars

Chimney Rock Sandstone: Mouth-bar complex



CLINOFORM SHAPE: height

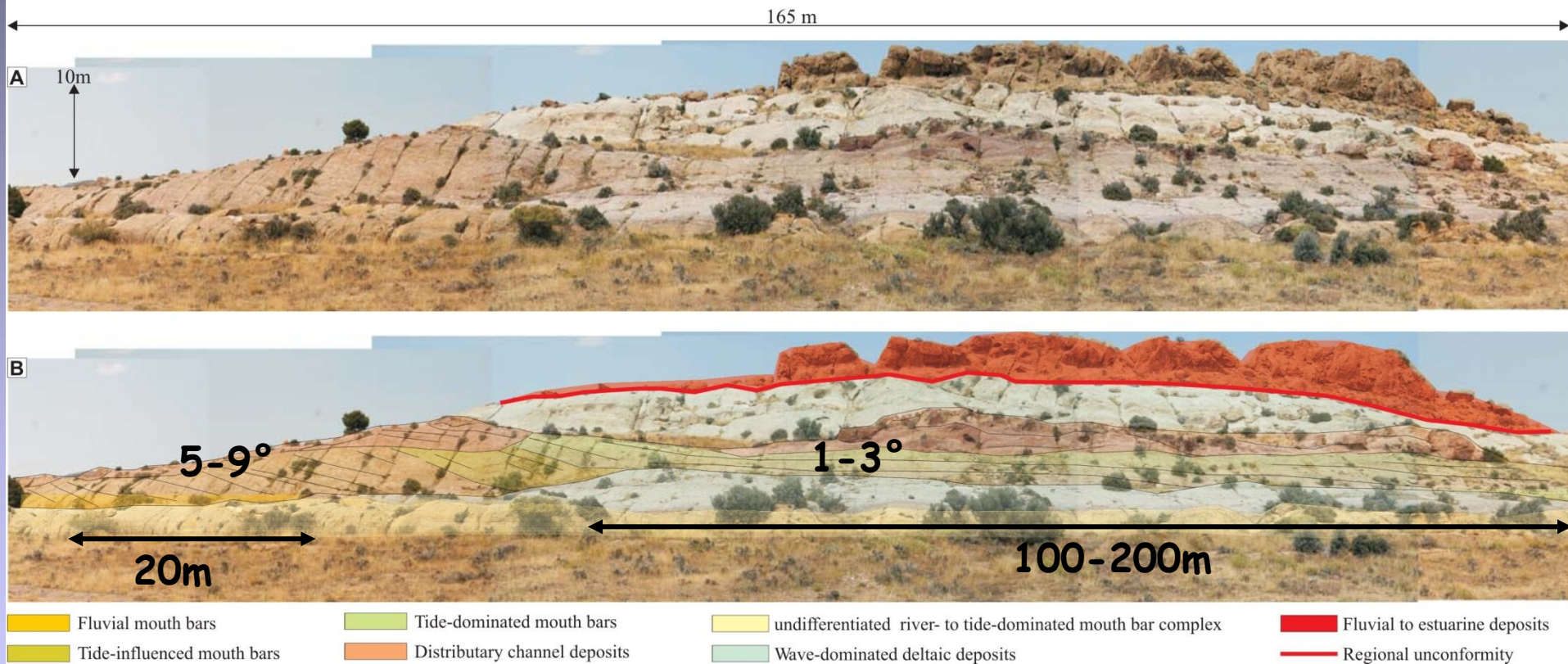
Chimney Rock Sandstone: Mouth-bar complex



Strongly tide-reworked mouth bars are thinner

CLINOFORM SHAPE: height, gradient, length

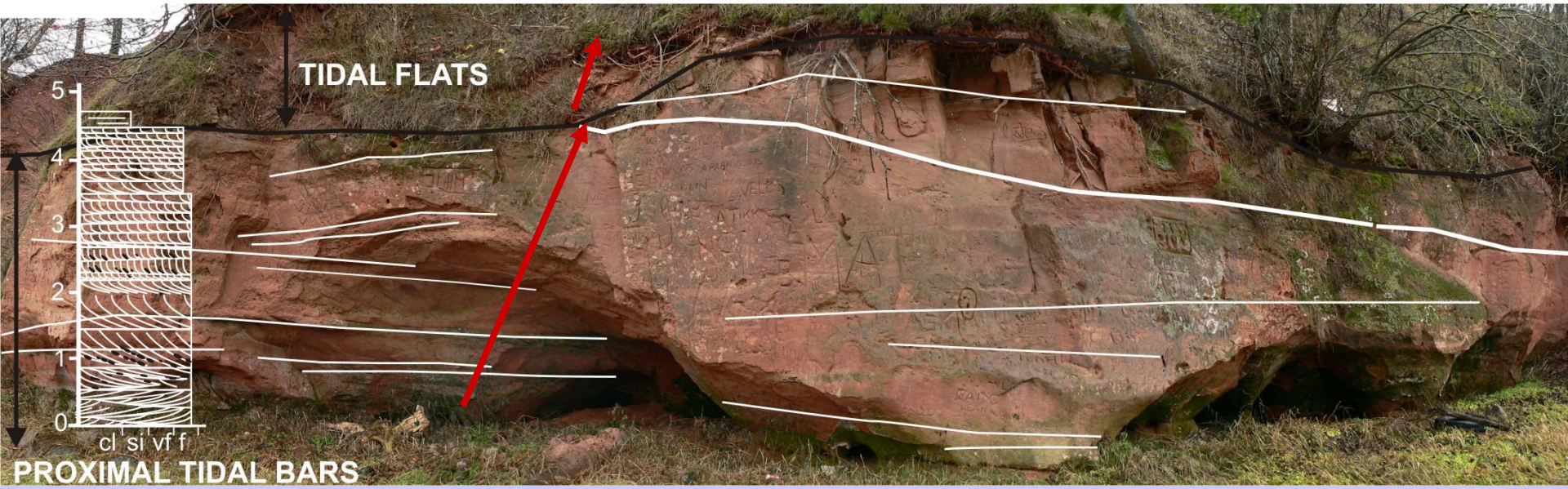
Chimney Rock Sandstone: Mouth-bar complex



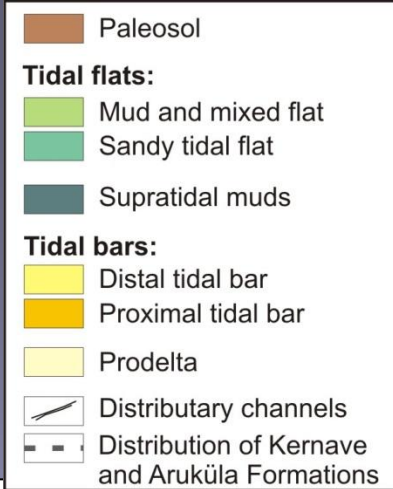
Strongly tide-reworked mouth bars are thinner, gentler , longer

CLINOFORM SHAPE: vertical facies transitions

Baltic Basin: Tide-dominated delta-front clinoforms

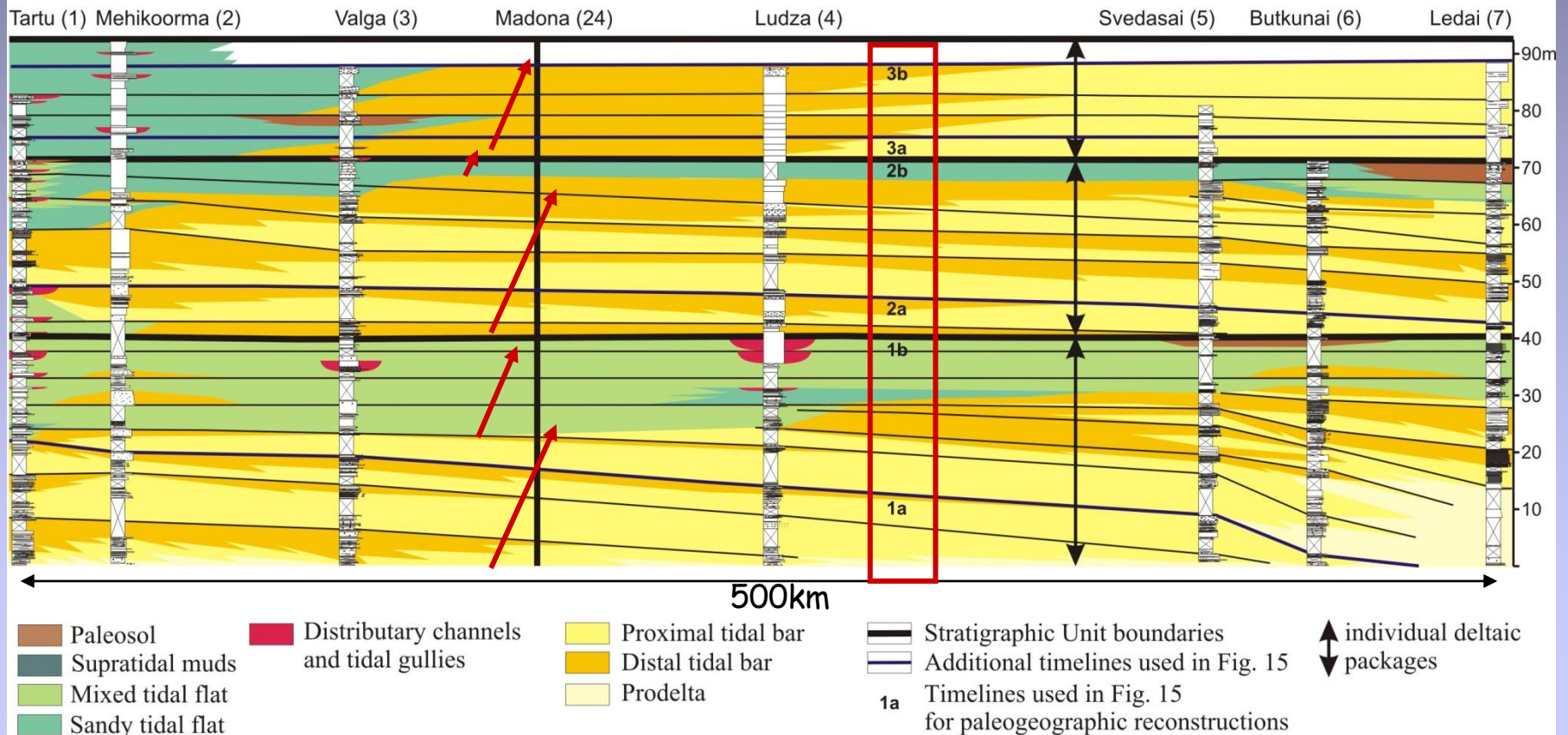


CLINOFORM SHAPE: vertical facies transitions



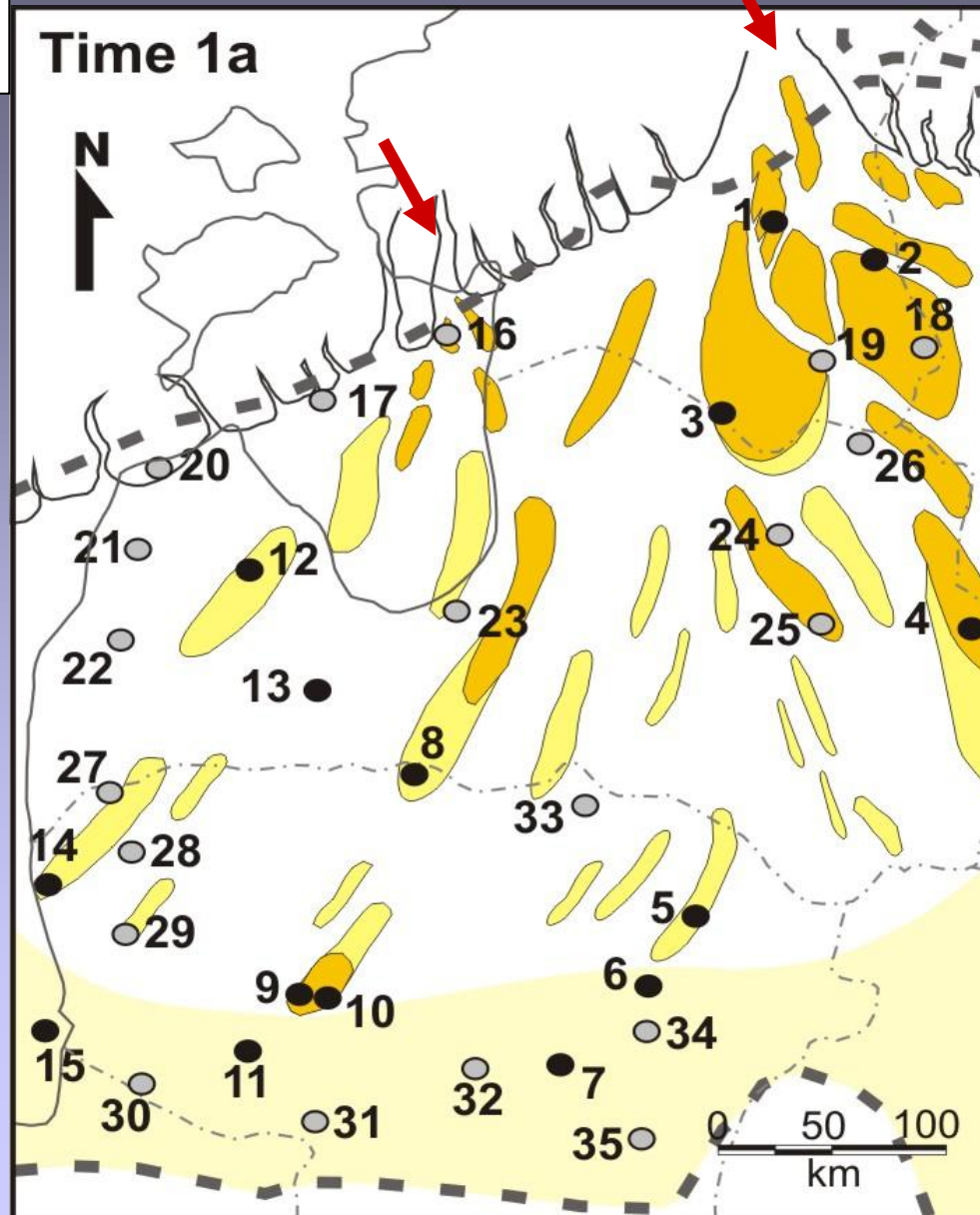
Fluvial delta plain minimal, delta front overlain by tidal flats

Baltic Basin: Basin-scale dip-direction cross section of tide-dominated deltas



CLINOFORM PROGRADATION

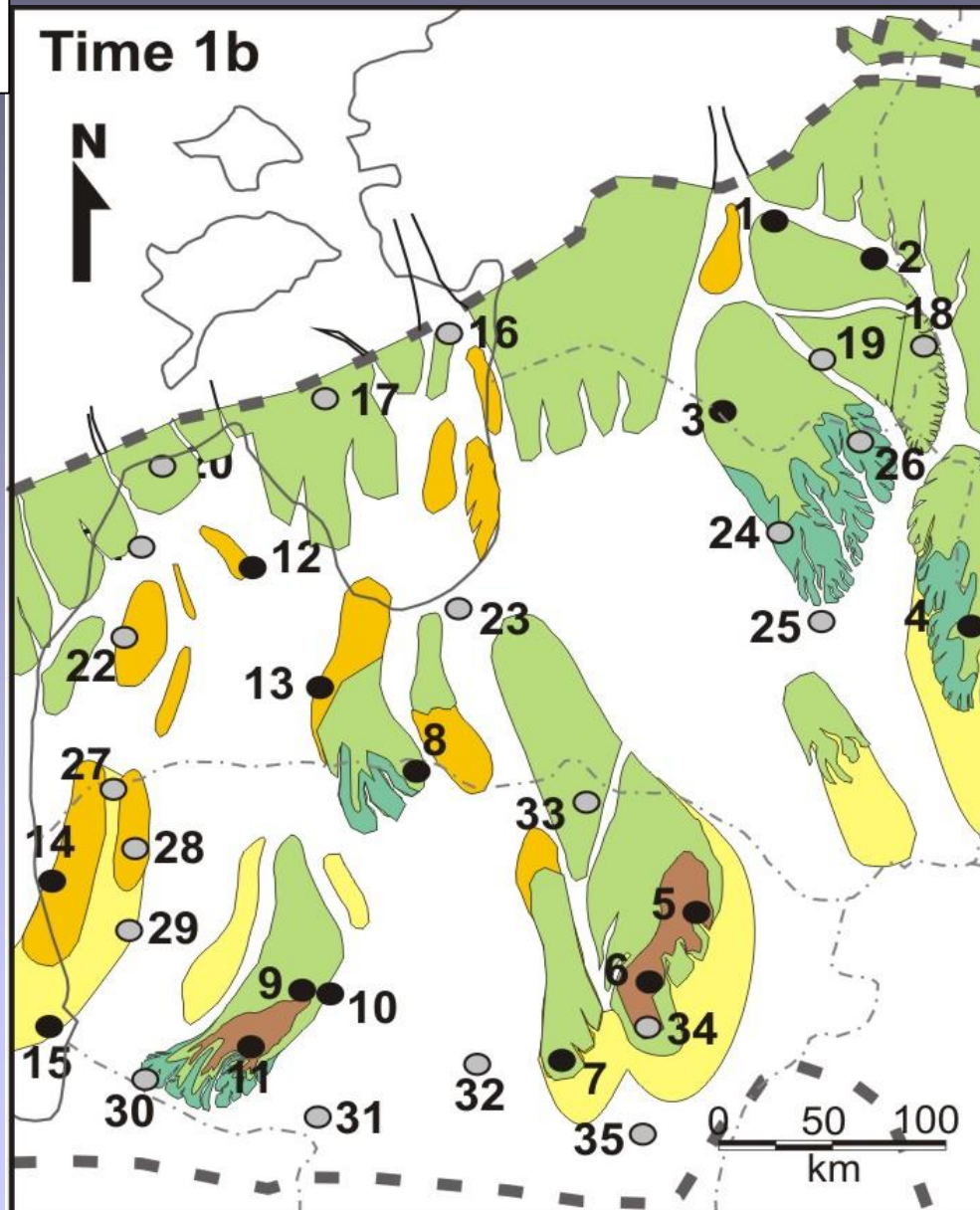
**Baltic Basin:
Tide-dominated
deltas**



Tanavsuu-Milkeviciene &
Plink-Bjorklund 2009

CLINOFORM PROGRADATION

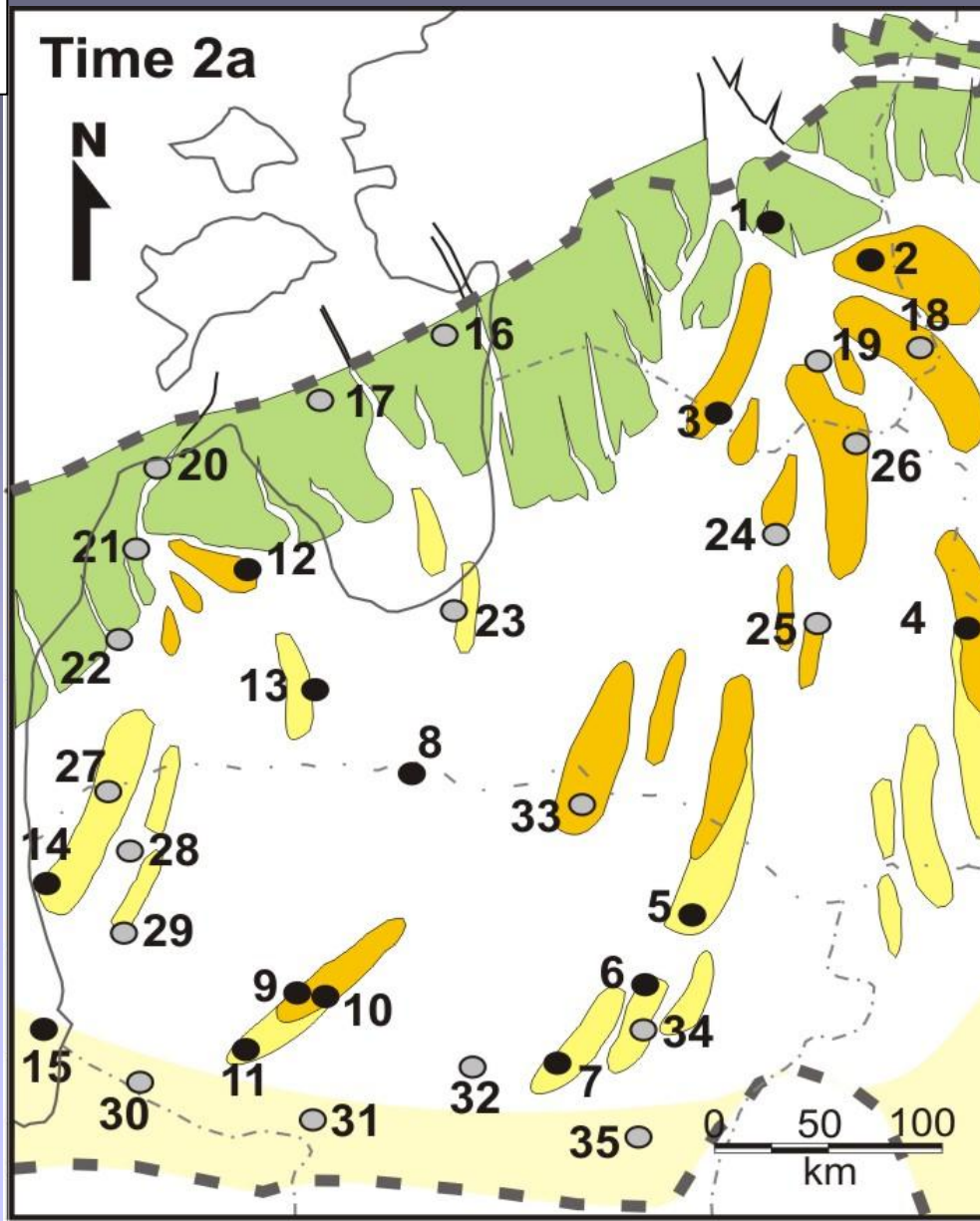
**Baltic Basin:
Tide-dominated
deltas**



- Paleosol
- Tidal flats:**
 - Mud and mixed flat
 - Sandy tidal flat
 - Supratidal muds
- Tidal bars:**
 - Distal tidal bar
 - Proximal tidal bar
 - Prodelta
- Distributary channels
- Distribution of Kernave and Aruküla Formations

CLINOFORM PROGRADATION

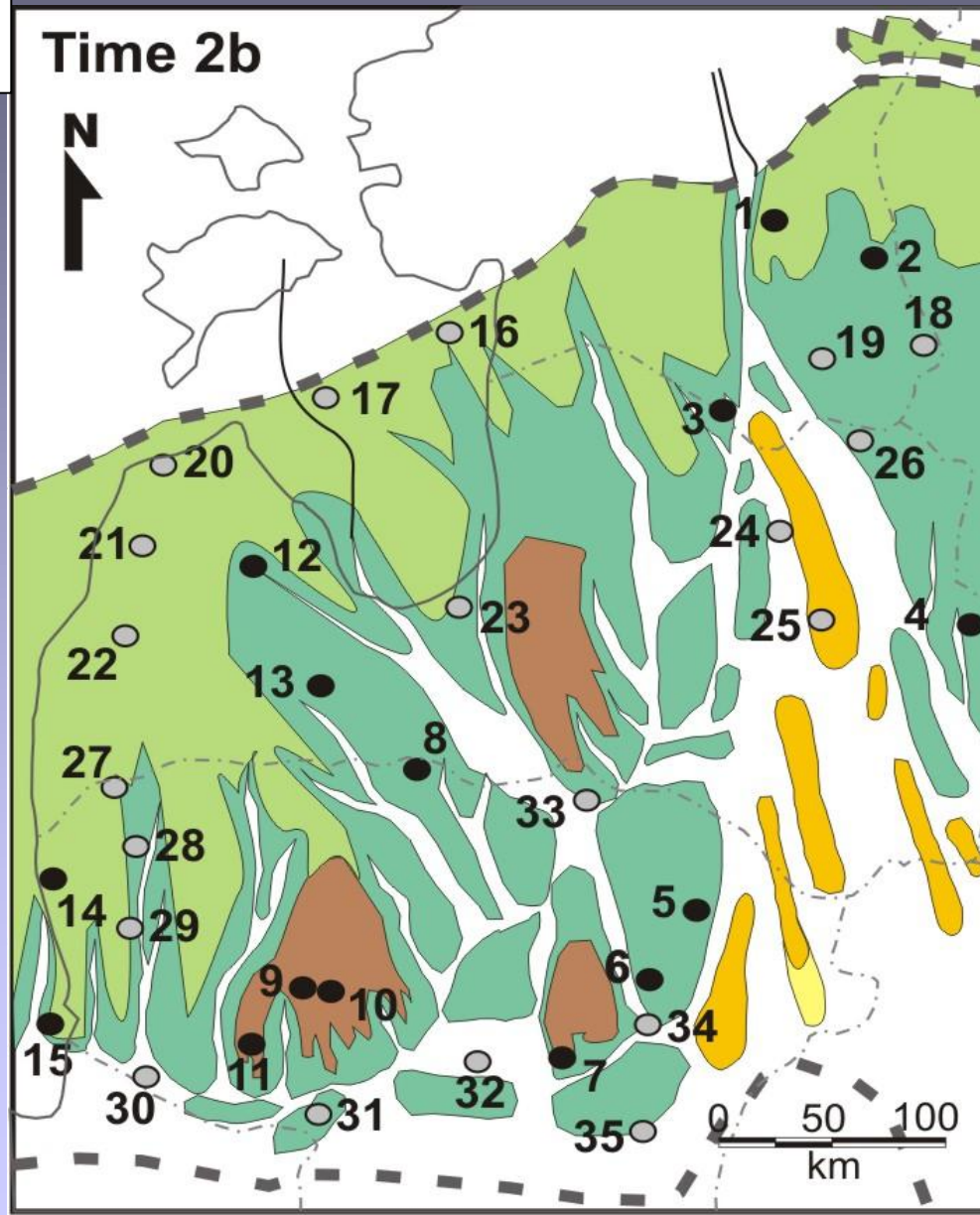
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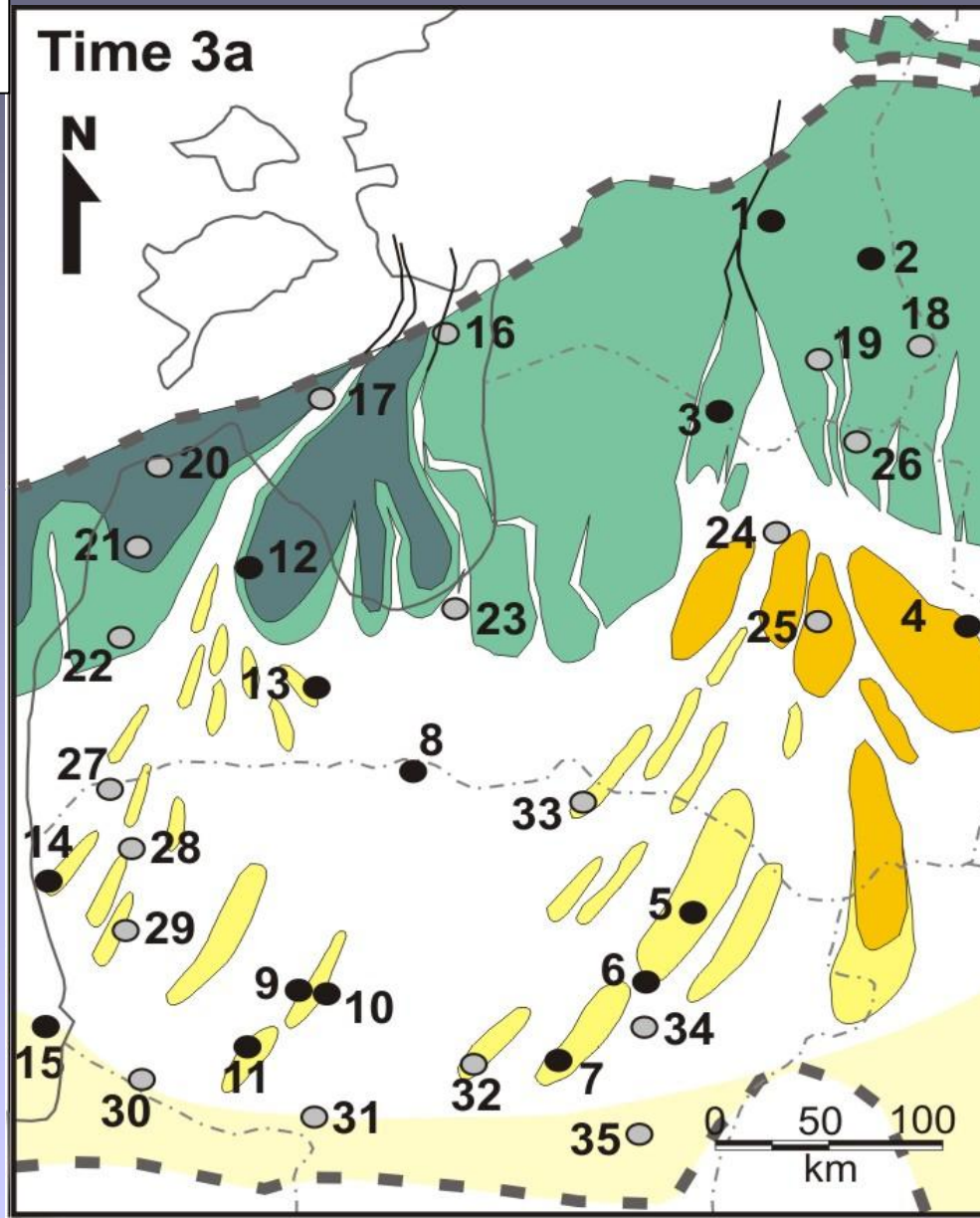
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CLINOFORM PROGRADATION

**Baltic Basin:
Tide-dominated
deltas**

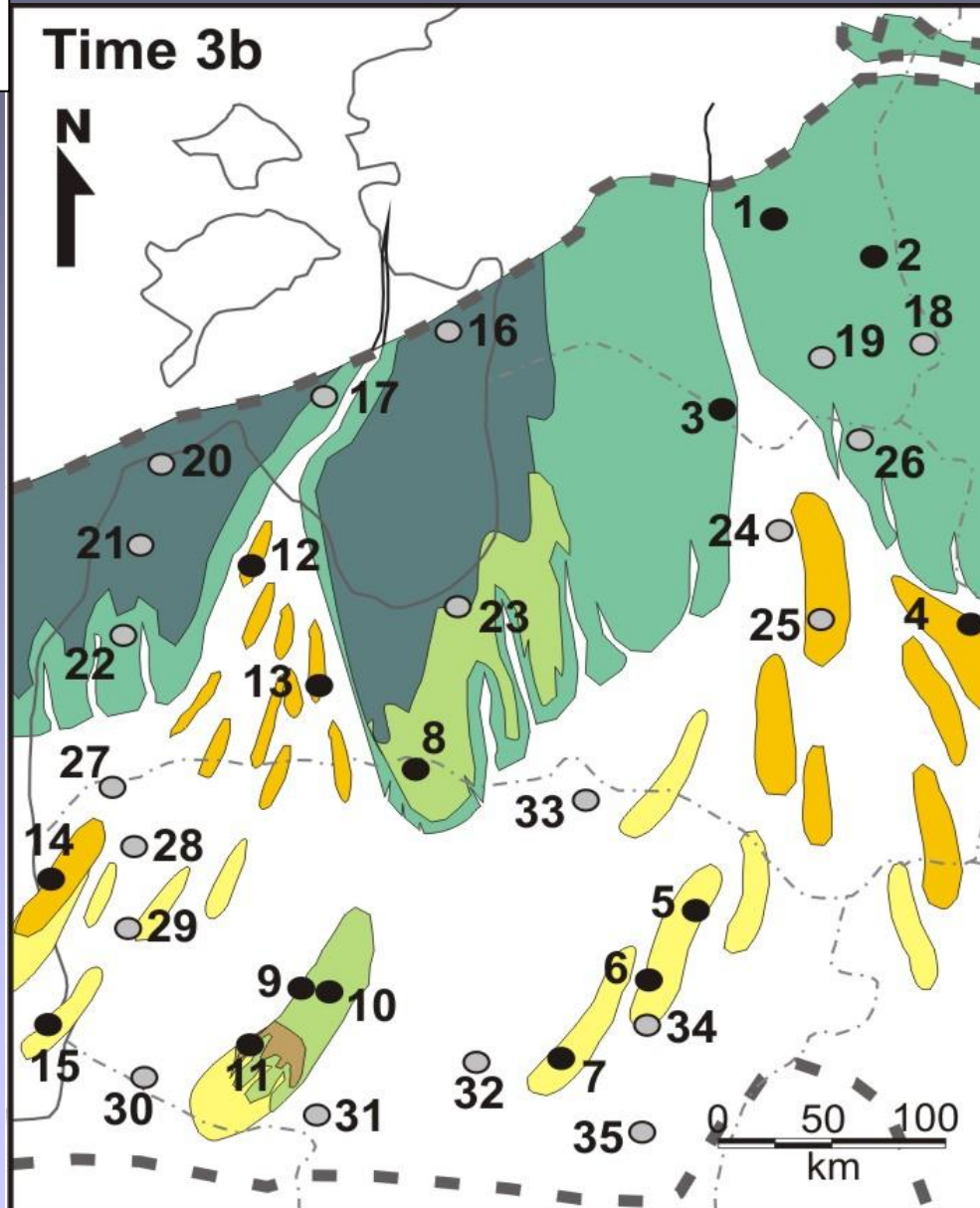


CLINOFORM PROGRADATION

Baltic Basin: Tide-dominated deltas

Fluvial delta
plain minimal,
delta front
overlain by
tidal flats

Elongate
clinoforms:
subaqueous
delta-front
progradation,
followed by
tidal-flat
progradation:
shoreline
decoupled from
delta-front
progradation



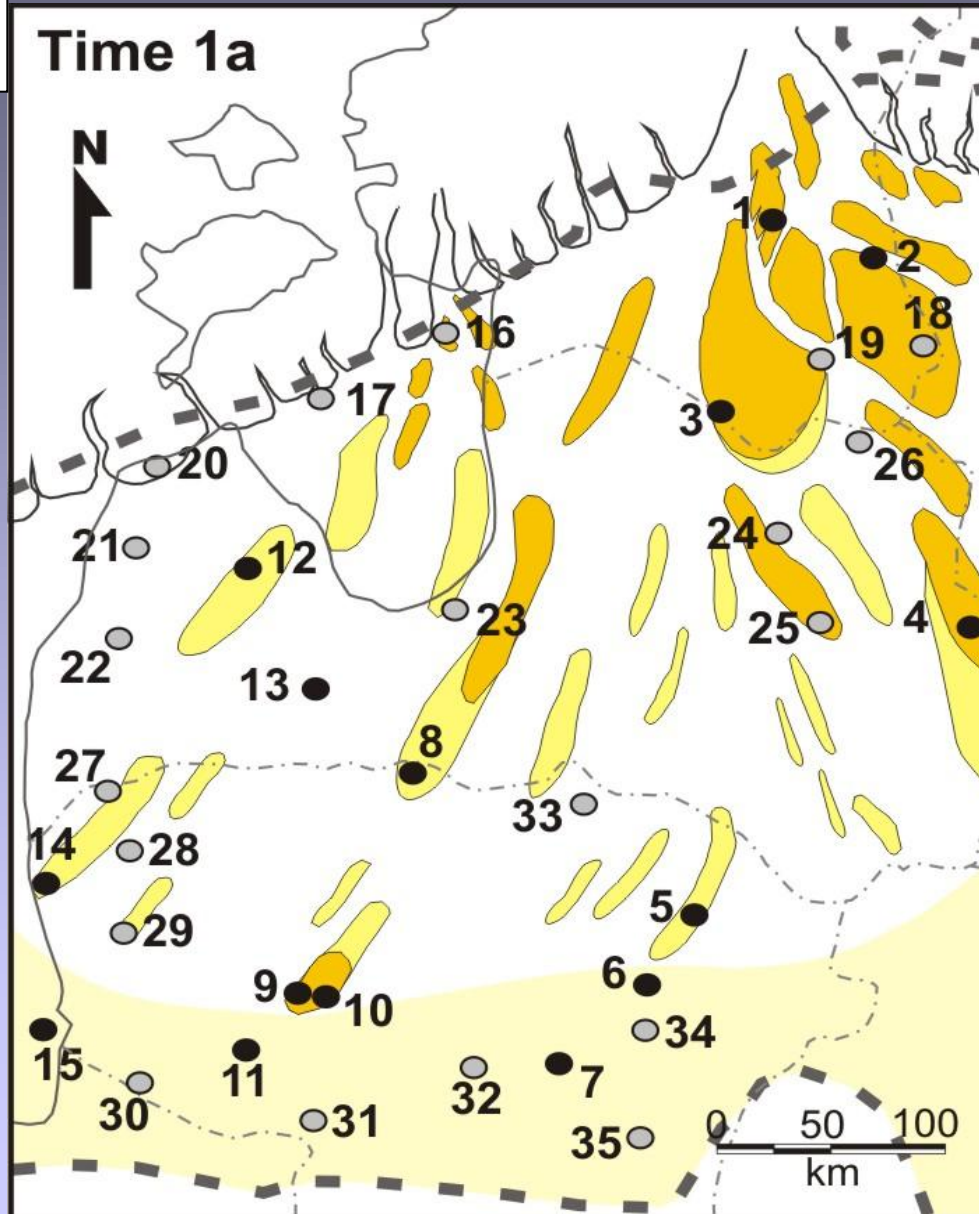
Funnel shape of
distributary
mouth

No delta-lobe
switching



CLINOFORM PROGRADATION

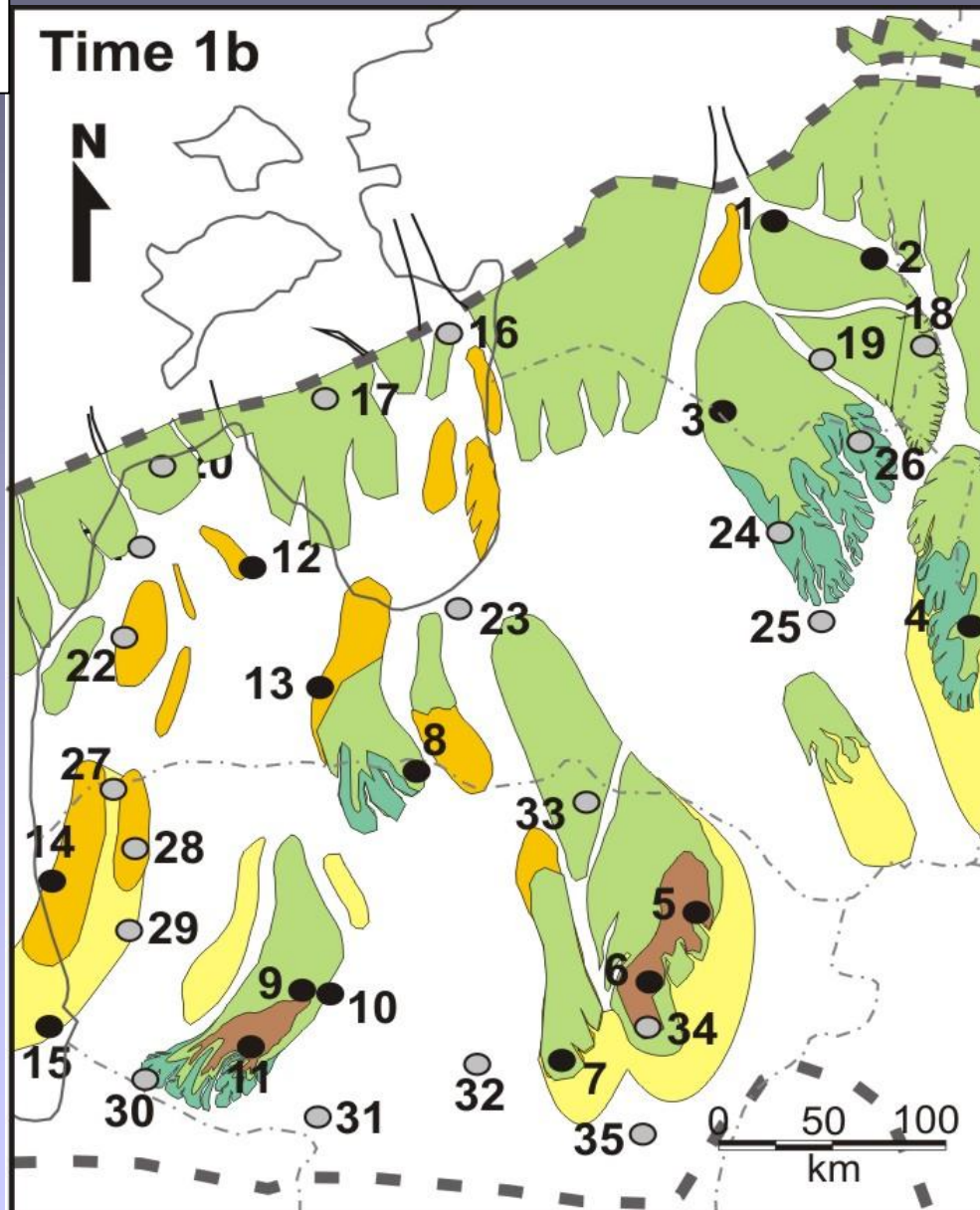
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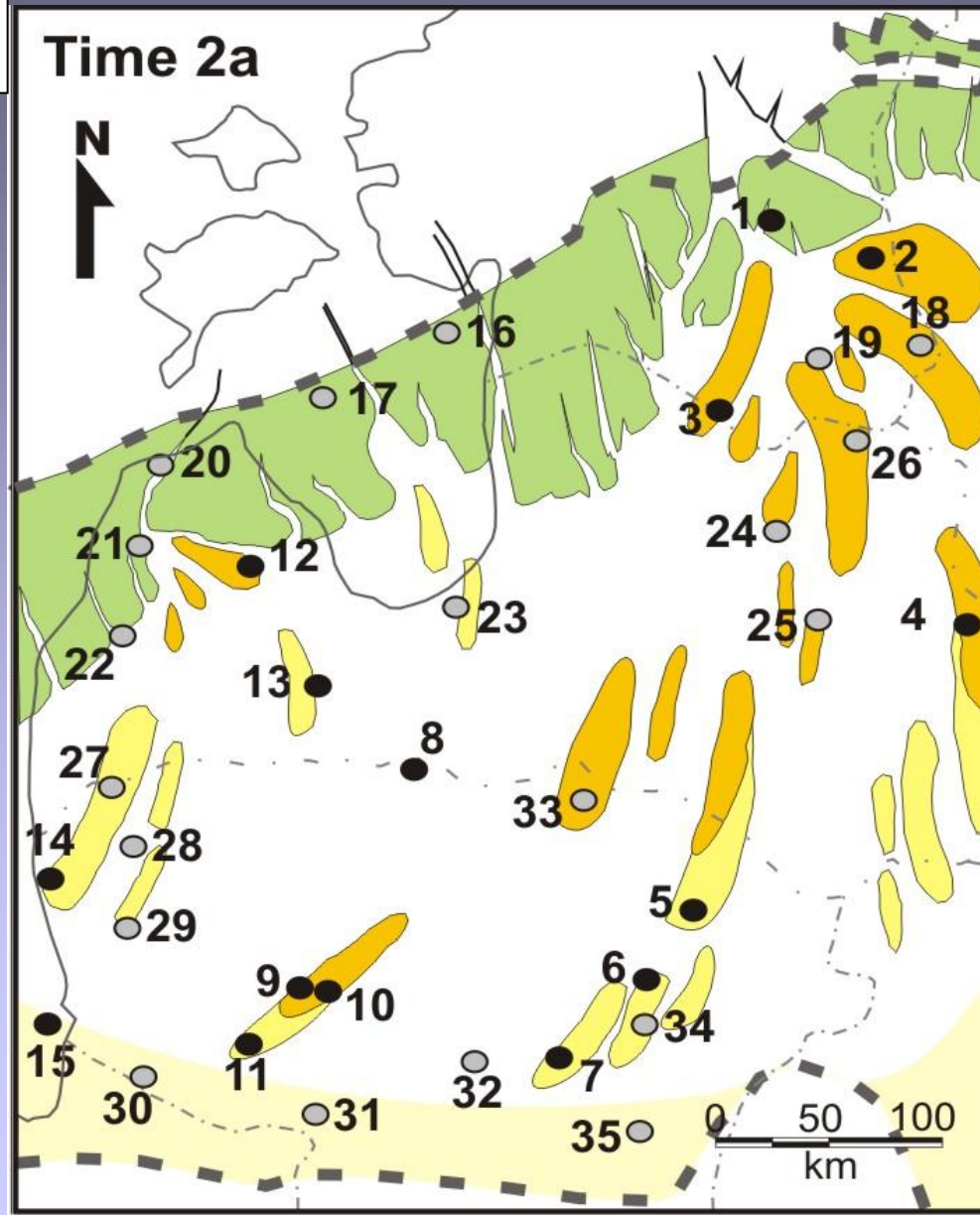
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CLINOFORM PROGRADATION

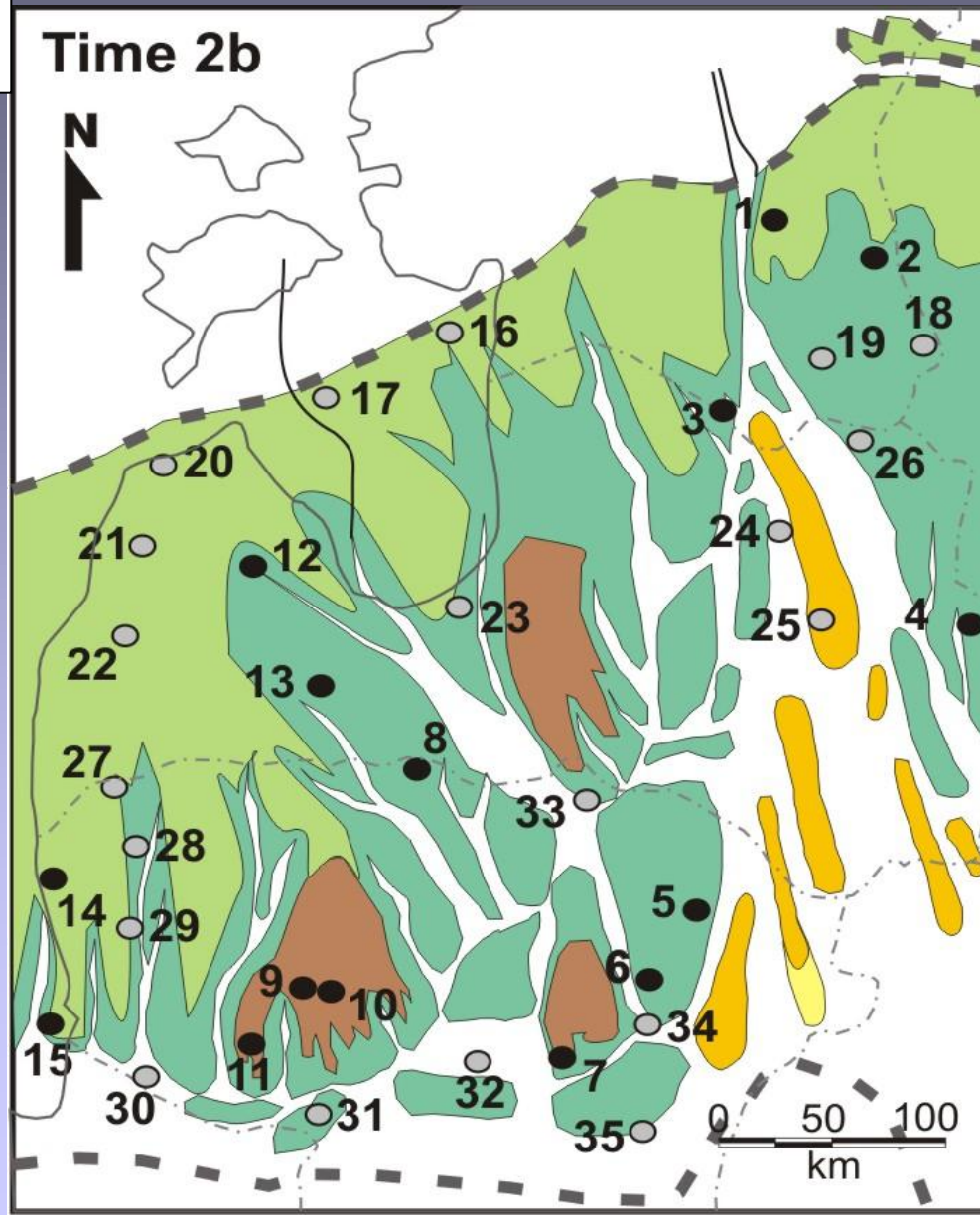
**Baltic Basin:
paleogeographic
reconstructions**



- Paleosol
- Tidal flats:**
 - Mud and mixed flat
 - Sandy tidal flat
 - Supratidal muds
- Tidal bars:**
 - Distal tidal bar
 - Proximal tidal bar
 - Prodelta
- Distributary channels
- Distribution of Kernave and Aruküla Formations

CLINOFORM PROGRADATION

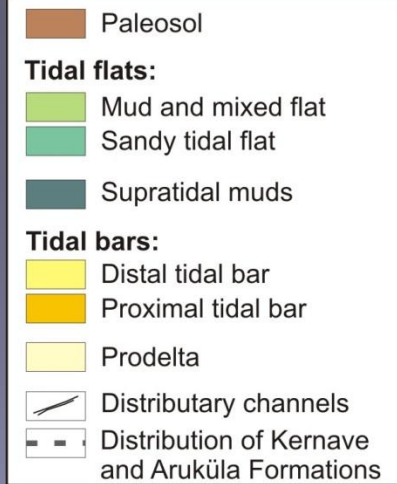
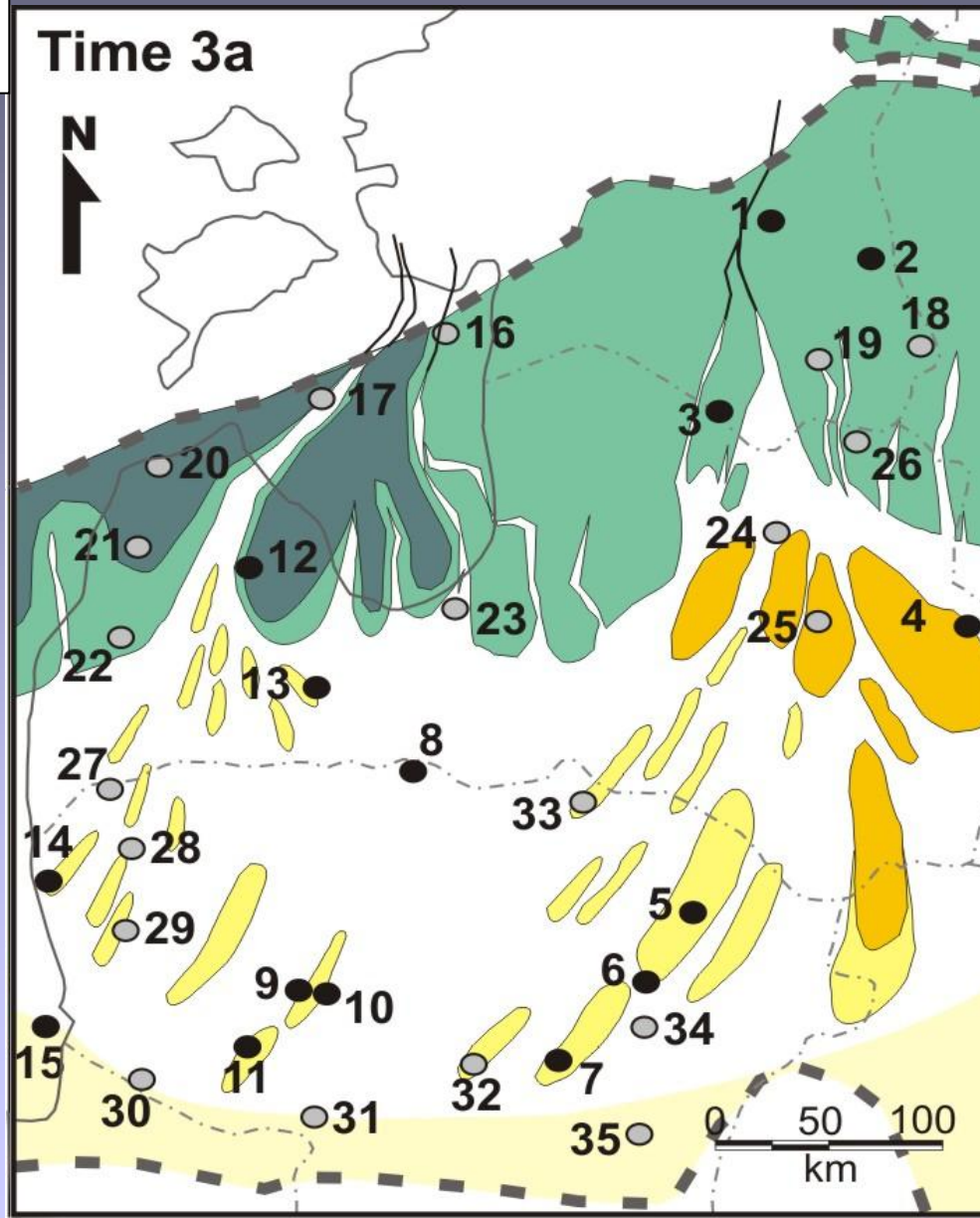
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CLINOFORM PROGRADATION

Baltic Basin:
Tide-dominated
deltas

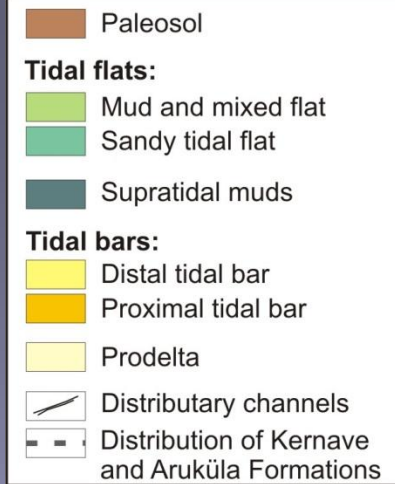
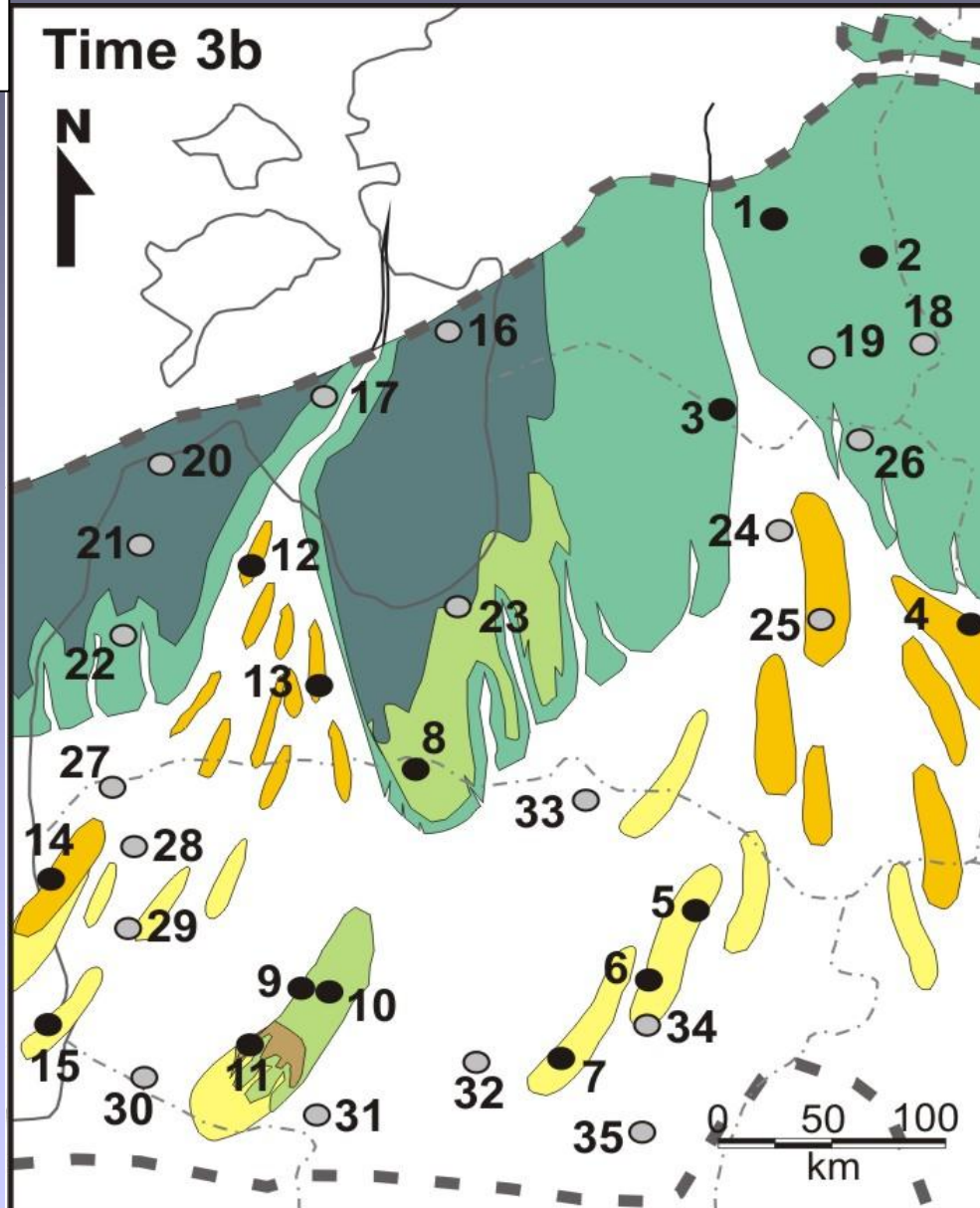


CLINOFORM PROGRADATION

**Baltic Basin:
Tide-dominated
deltas**

Fluvial delta
plain minimal,
delta front
overlain by
tidal flats

Subaqueous
delta-front
progradation,
followed by
tidal-flat
progradation:
shoreline
decoupled from
delta-front
progradation



Funnel shape of
distributary
mouth

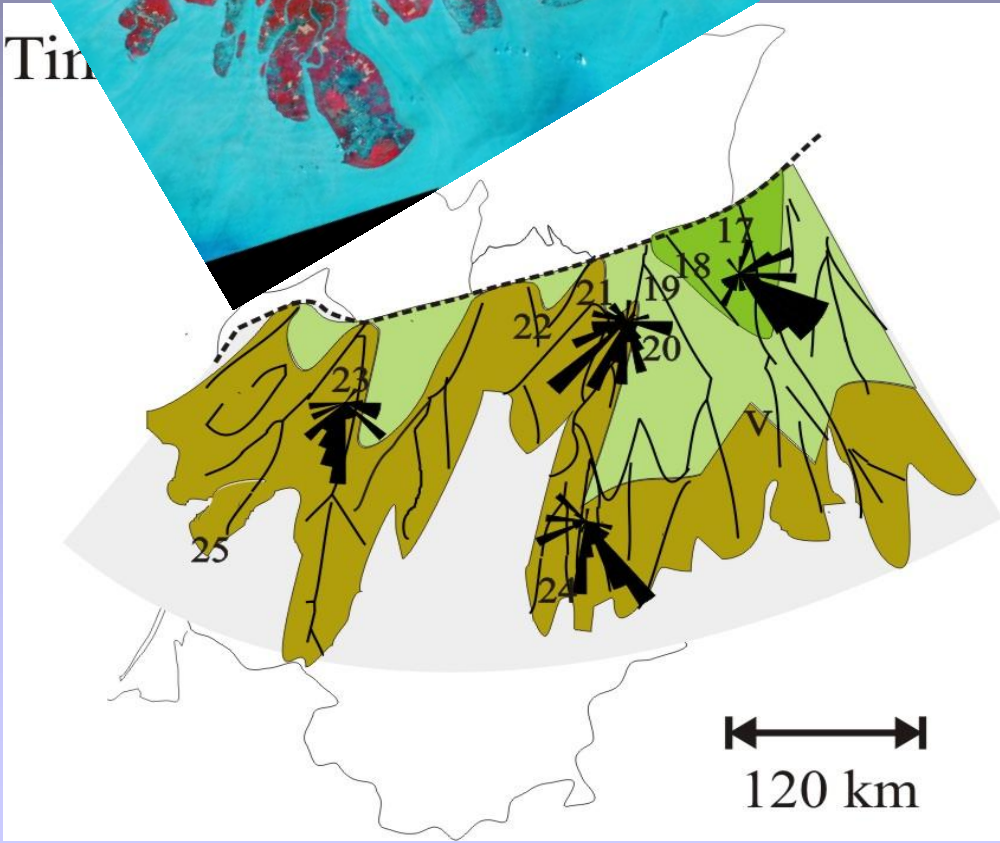
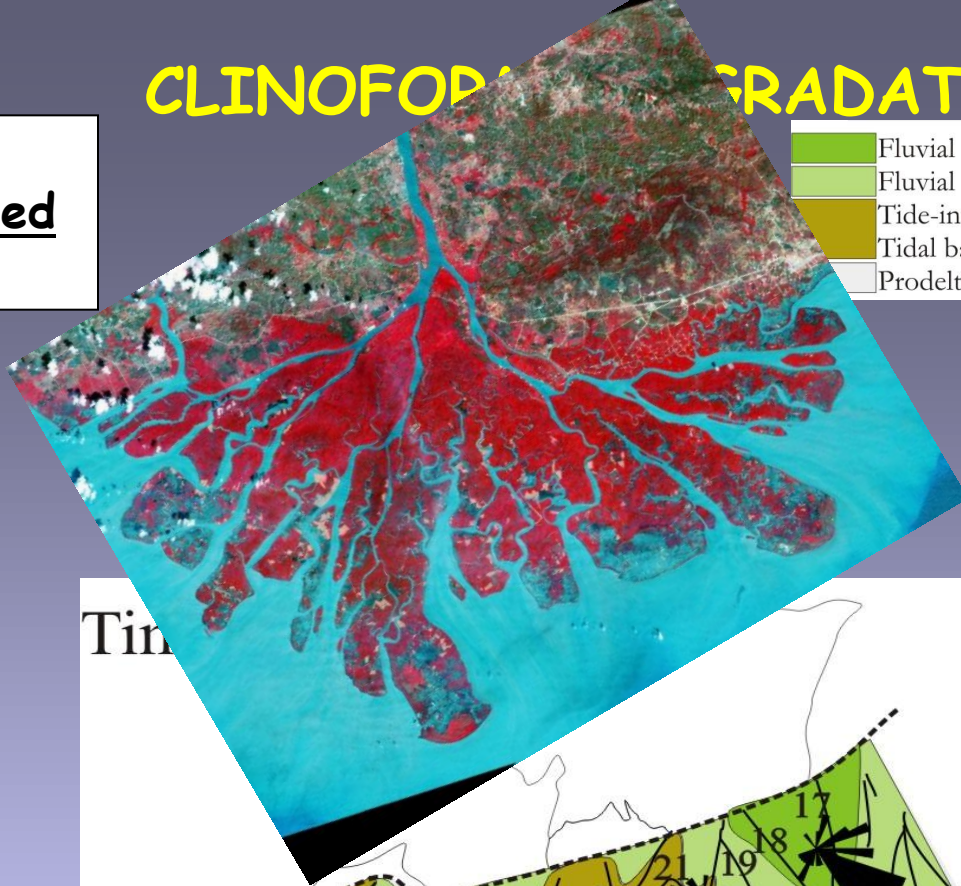
No delta-lobe
switching

Funnel shape
maintained by
efficient
sediment
removal from
river-mouth &
by tidal-flat
aggradation

CLINOFORM GRADATION

**Baltic Basin:
Tide-influenced
deltas**

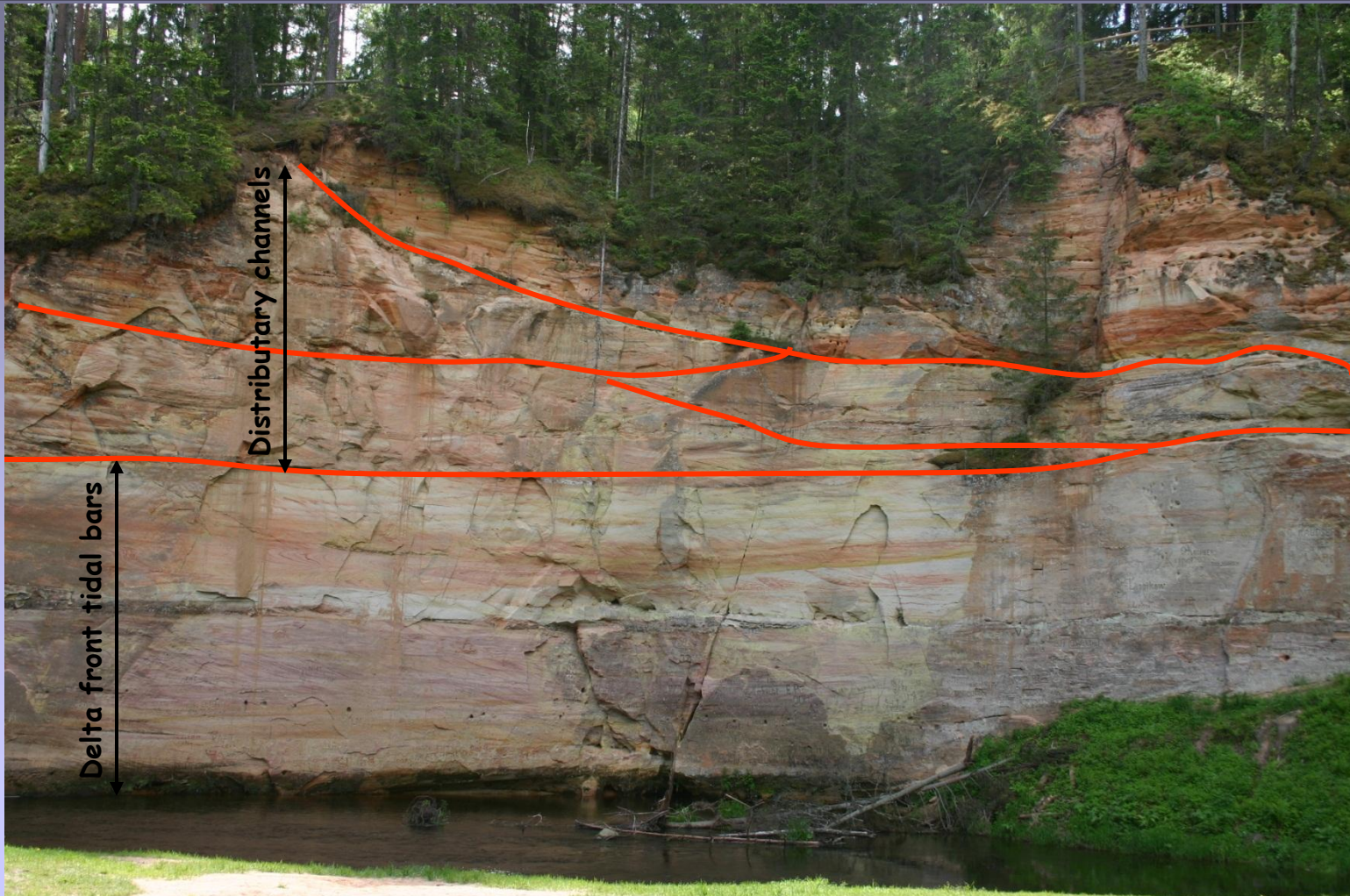
- Fluvial channel/mouth bar deposits
- Fluvial channel/mouth bar deposits with weak tide-influence
- Tide-influenced channel deposits
- Tidal bars
- Prodelta and delta-plain mudstones



**Fluvial-delta
plain**

CLINOFORM PROGRADATION & DELTA PLAIN

Baltic Basin: tide-influenced delta-front clinoforms & delta plain



CLINOFORM PROGRADATION & DELTA PLAIN

Baltic Basin: tide-influenced delta plain

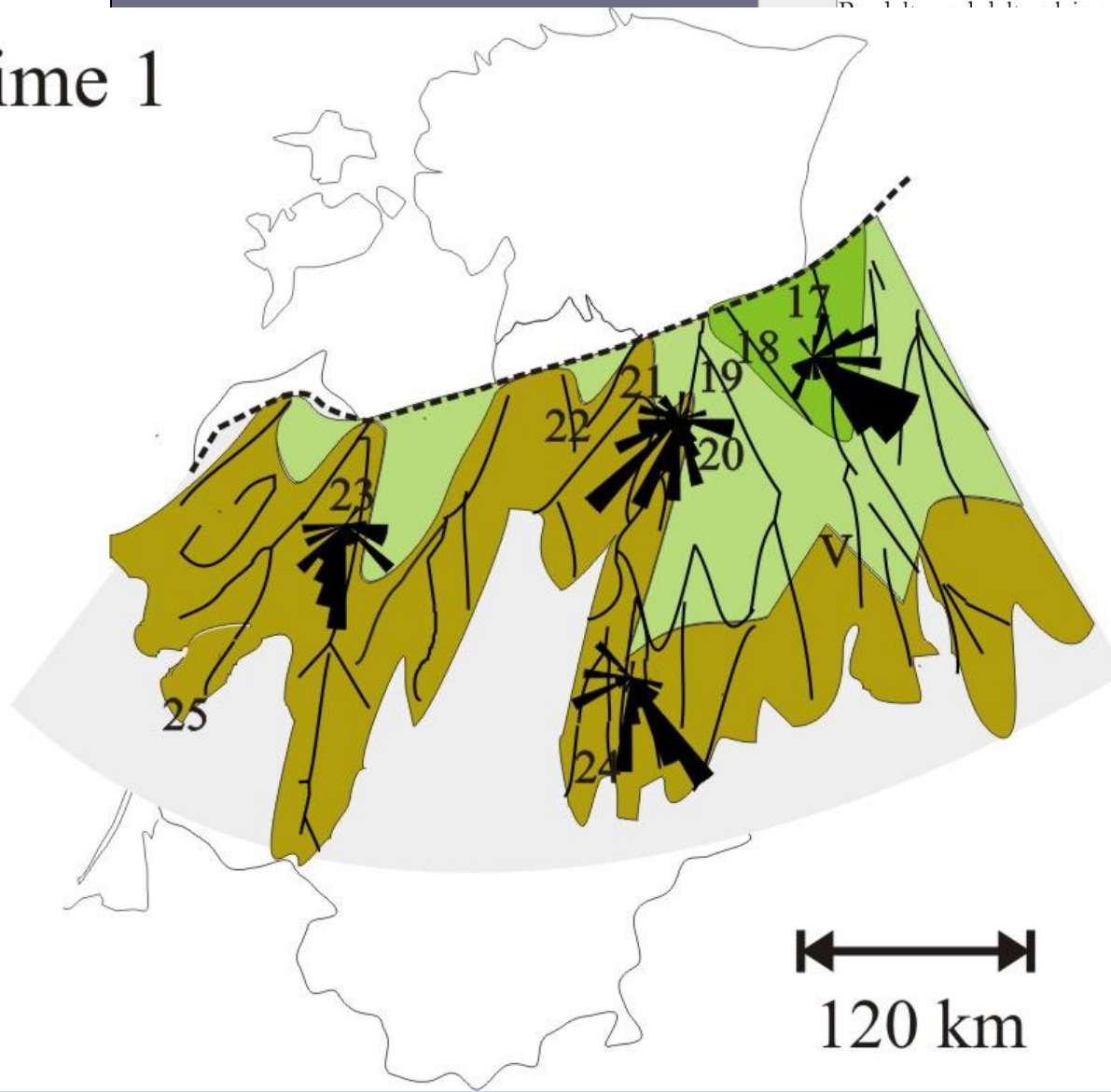


CLINOFORM PROGRADATION

**Baltic Basin:
Tide-influenced
deltas**

- Fluvial channel/mouth bar deposits
- Fluvial channel/mouth bar deposits with weak tide-influence
- Tide-influenced channel deposits
- Tidal bars
- Basal sandstones

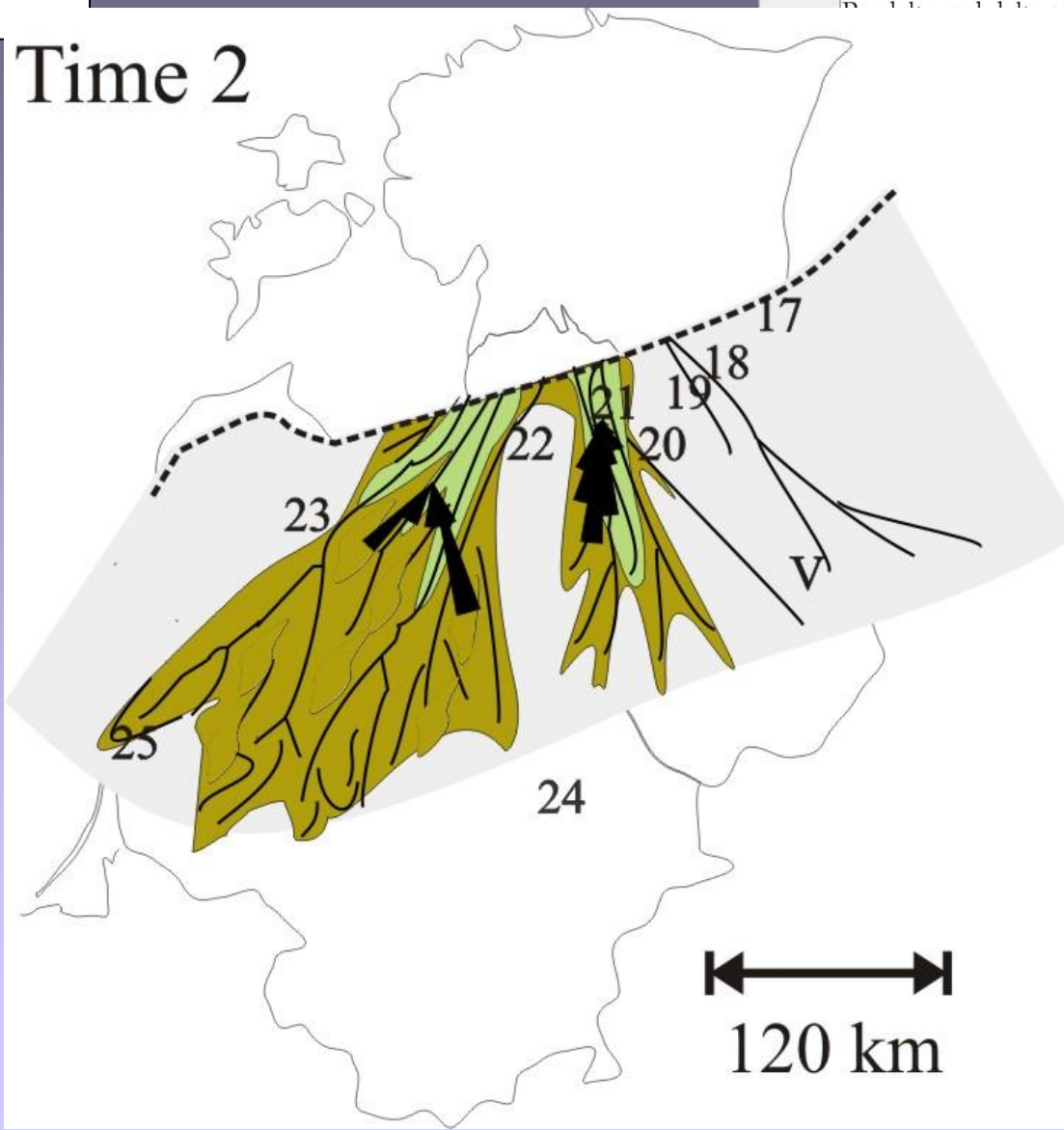
Time 1



CLINOFORM PROGRADATION

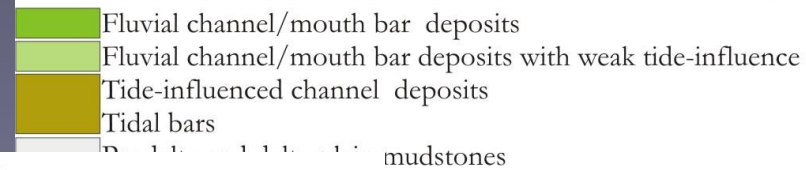
**Baltic Basin:
Tide-influenced
deltas**

- Fluvial channel/mouth bar deposits
- Fluvial channel/mouth bar deposits with weak tide-influence
- Tide-influenced channel deposits
- Tidal bars
- Basal channel deposits in mudstones

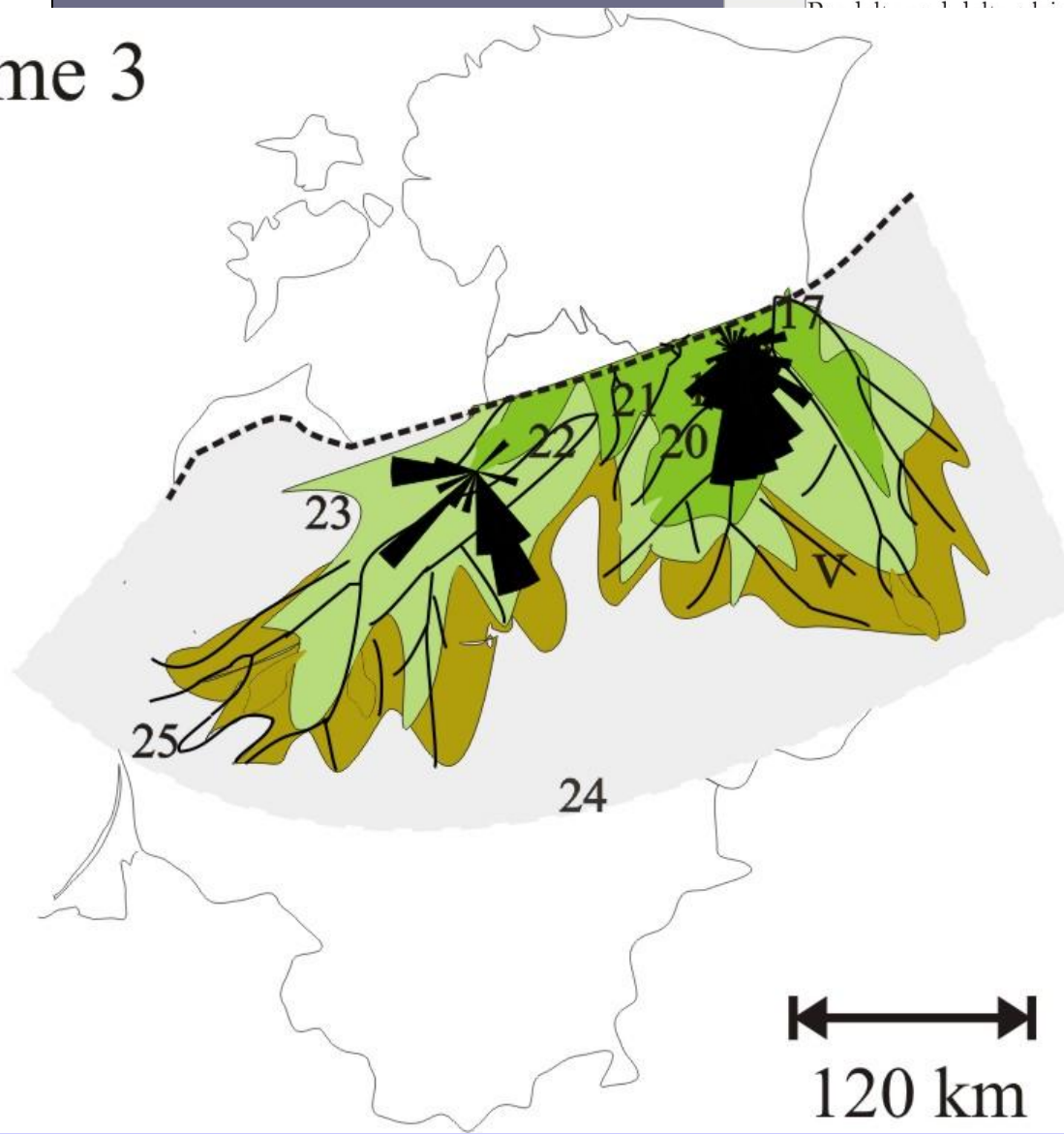


CLINOFORM PROGRADATION

**Baltic Basin:
Tide-influenced
deltas**



Time 3



**Delta-lobe
switching**

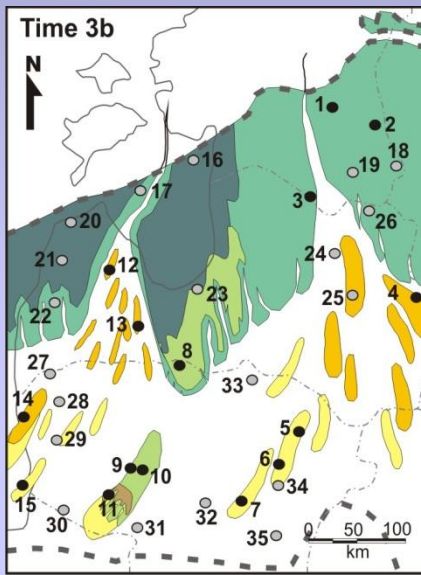
CONCLUSION 1:

•Effect:

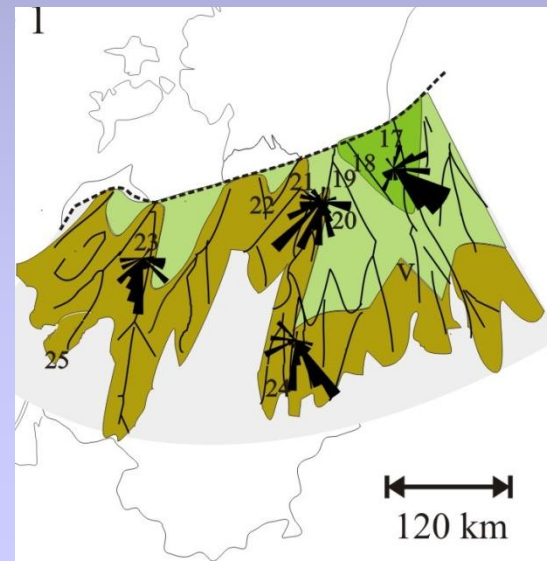
- Longer, thinner, gentler clinoforms with subaqueous progradation
- Rapid seaward progradation, decoupled from shoreline progradation
- No fluvial-delta plain or lobe switching as funnel is maintained

•Cause:

- Tidal-reworking capacity at the river mouth



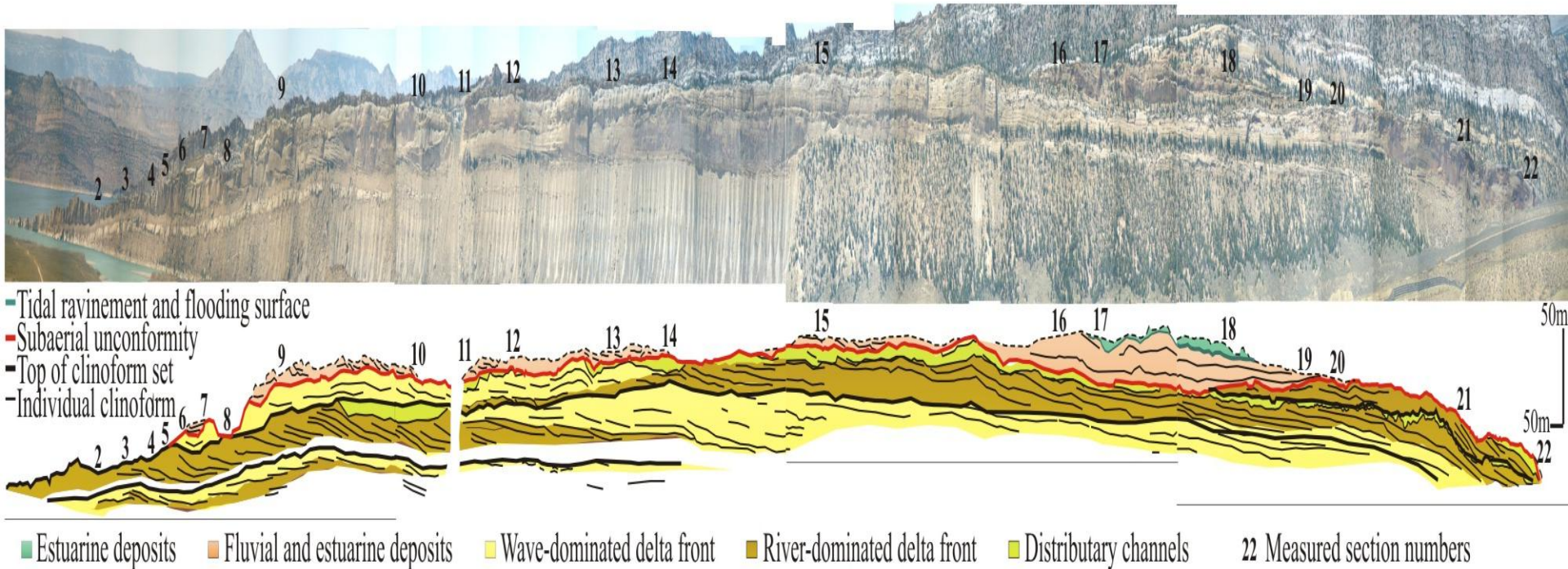
Tidal reworking exceeds fluvial input



Tidal reworking does not exceed fluvial input

CONDITIONS:

Chimney Rock Sandstone: River- & wave-dominated deltas

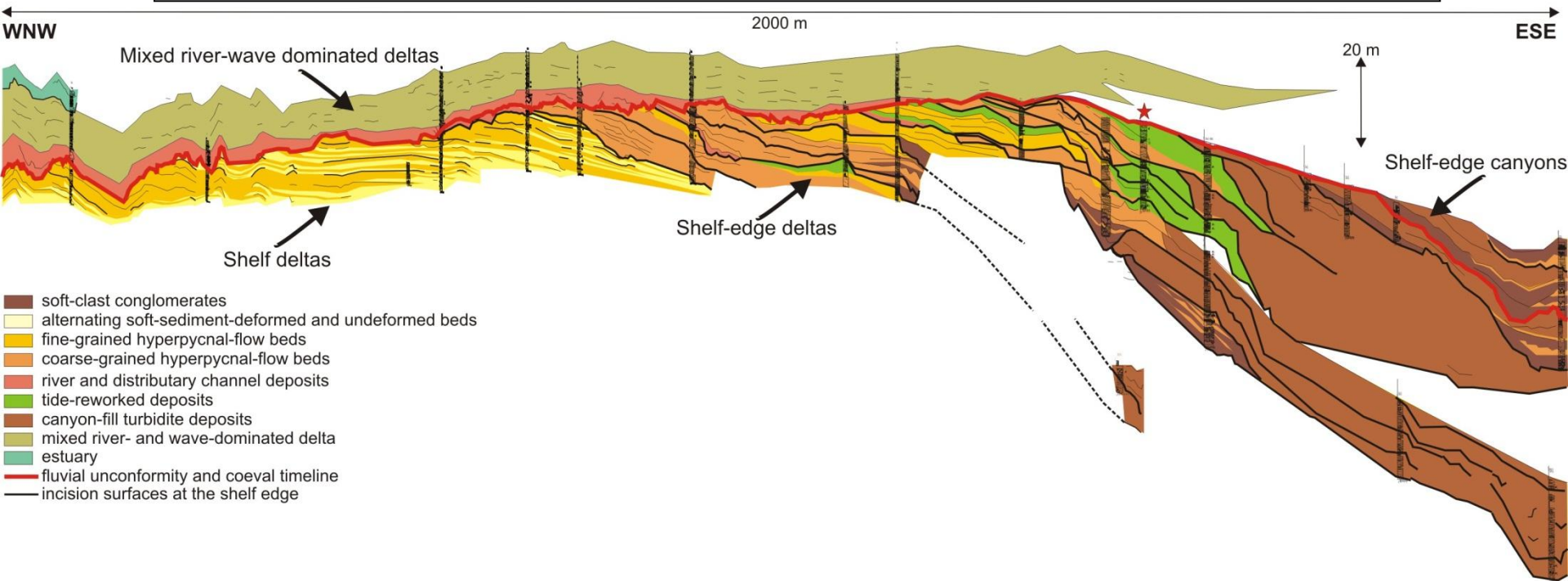


Tidal deposits occur only in distributary channel mouths and in some fluvial mouth bars associated with river-dominated, not wave-dominated delta clinoforms

Lateral restriction, dissipated wave energy

CONDITIONS:

Eocene Central Basin of Spitsbergen: shelf to slope cross section

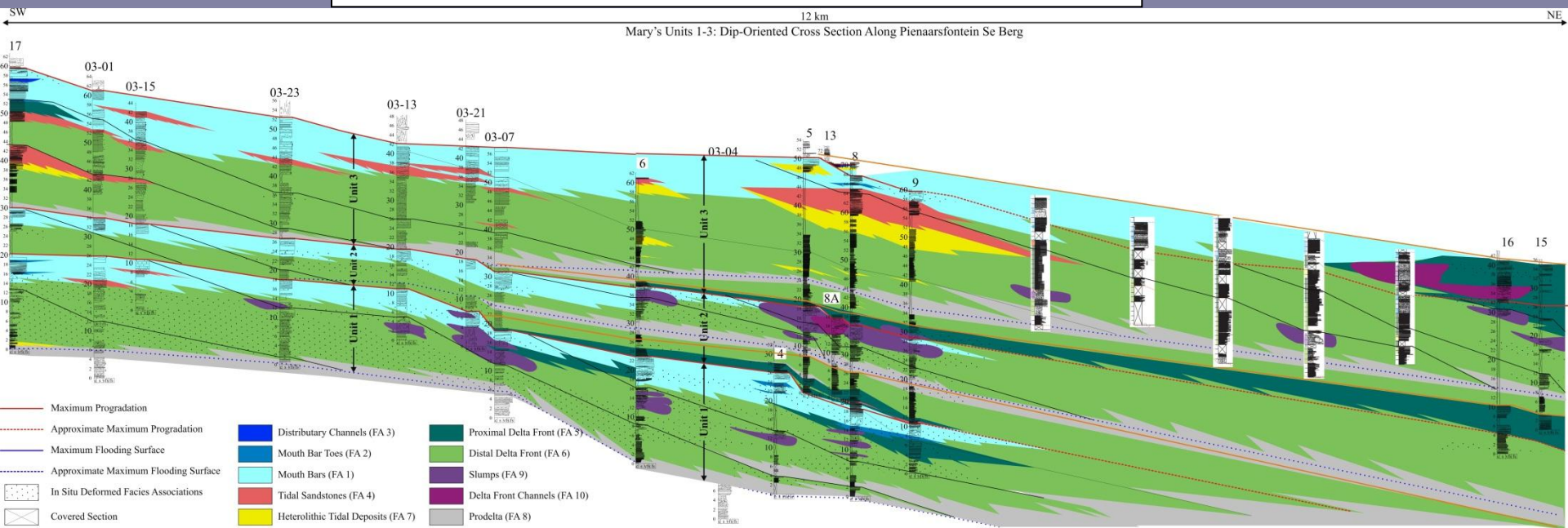


only some delta fronts in shelf-edge canyons are tide-influenced

Lateral restriction, relatively lower fluvial sediment supply

CONDITIONS:

Karoo Basin: shelf to slope cross section

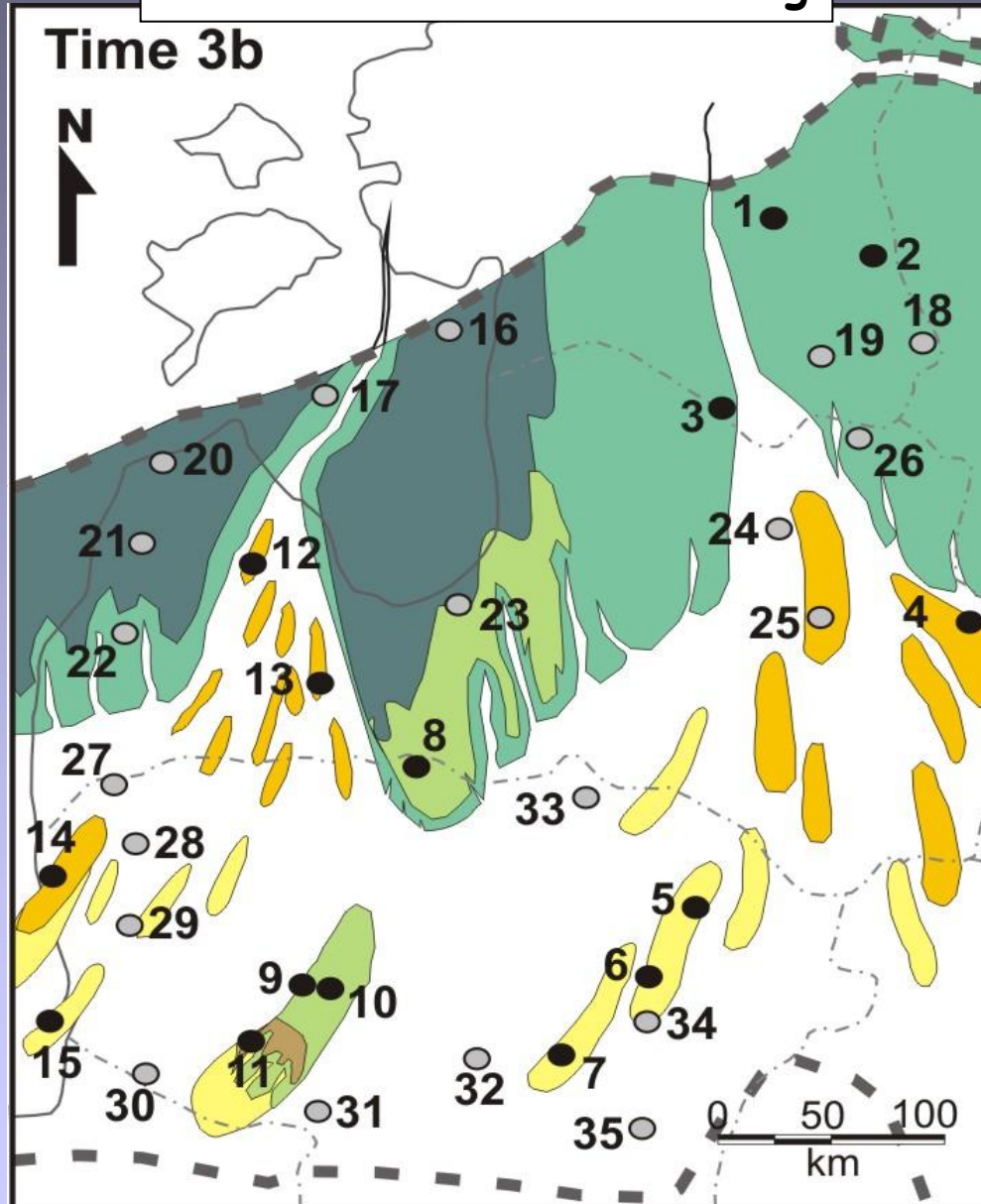


Tide-reworked deltas occur along the whole shelf to shelf-edge profile

CONDITIONS:

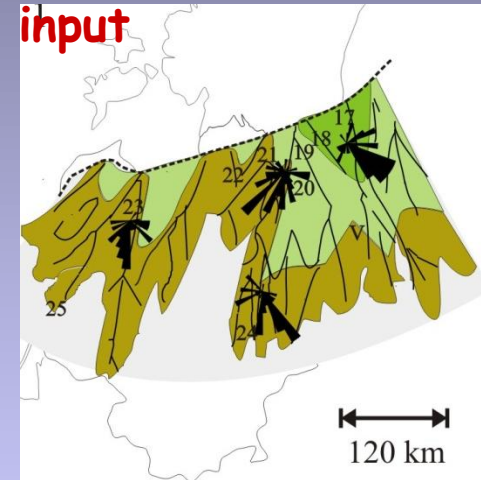
Baltic Basin: tidal reworking

Time 3b



Across the whole basin in shallow restricted basins

Fluvial-sediment input



CONCLUSION 2:

- **Conditions:**

- Topographic restriction
- Tidal-reworking efficiency in relation to fluvial-sediment supply

- **Occurrence:**

- Along the whole shelf-margin profile if the above conditions exist



QUESTIONS?

