Deep-Marine to Shelf-Margin Deltaic Sedimentation, Silurian Succession, Saudi Arabia*

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Abstract

A thick Silurian succession, up to 5,000 feet, fills a sag basin in eastern Saudi Arabia. It consists of deep-marine, shelf-margin to inner-shelf deltaic, and fluvial deposits. The deep-marine and shelf-margin deposits are called, respectively, the Lower and the Mid-Qusaiba Sand. This study uses subsurface cores and seismic data to investigate the relation between the deep-marine and the shelf-margin deltaic sedimentation. Core logging allowed the recognition of turbidite, hybrid turbidite-debrite, hyperpycnite, mass-transport, and mouth bar facies. The turbidite facies were deposited, from high- and low-concentration density flows, in deep-basin and slope fans. The hybrid facies were deposited, from transitional turbulent to laminar flows, on the fringes of the fan lobes. They consist of banded and homogeneous muddy sandstones containing floating mud clasts and sheared sand injections. The hyperpycnites were deposited, from sustained and fluctuating river-born flows, in both the deep-marine fans and shelf-margin deltas. They vary spatially in scale and stratification. Distal hyperpycnites are thin- to medium-bedded, centimeter- to decimeter-scale, and display well-developed inverse to normal grading. Medial hyperpycnites can be very thick-bedded, meter-scale, and exhibit alternating structureless and laminated/rippled divisions. Proximal hyperpycnites have internal erosional surfaces and may lack the lower inverse graded division. They are commonly hosted in slope channels, where they intercalate with trough cross-stratified sandstones, indicating alternating suspension fallout; sediment bypass; traction current reworking and bedload transport. The mass-transport deposits interfinger with slope shales and include distal debrites and proximal slumps. The mouth bar facies comprise current-rippled and laminated sandstones that record buoyancy processes in shelf margin deltas. Seismic data depict low-angle sigmoidal and relatively high-angle dipping reflectors that represent slope clinoforms. The former are associated with an ascending shelf-edge trajectory and are related to slope progradation during rising sea-level conditions. These provided accommodation for the development of the shelf-margin deltas. The latter coincide with a horizontal to descending shelf-edge trajectory that reflects slope degradation during falling sea-level conditions. These induced failure of the shelf-margin deltas, sediment bypass via slope channels, and deep-basin sedimentation.

References Cited

Mulder, T., J.P.M. Syvitski, S. Migeon, J.C. Fauge´res, and B. Savoye, 2003, Marine Hyperpycnal Flows: Initiation, Behavior and Related Deposits: A Review: Marine and Petroleum Geology, v. 20, p. 861–882. doi:10.1016/j.marpetgeo.2003.01.003.

Zavala, C., J. Ponce, D. Drittanti, M. Arcuri, H. Freije, and M. Asensio, 2006, Ancient Lacustrine Hyperpycnites: A Depositional Model from a Case Study in the Rayoso Formation (Cretaceous) of West-Central Argentina: Journal of Sedimentary Research, v. 76, p. 41–59. doi:10.2110/jsr.2006.12.

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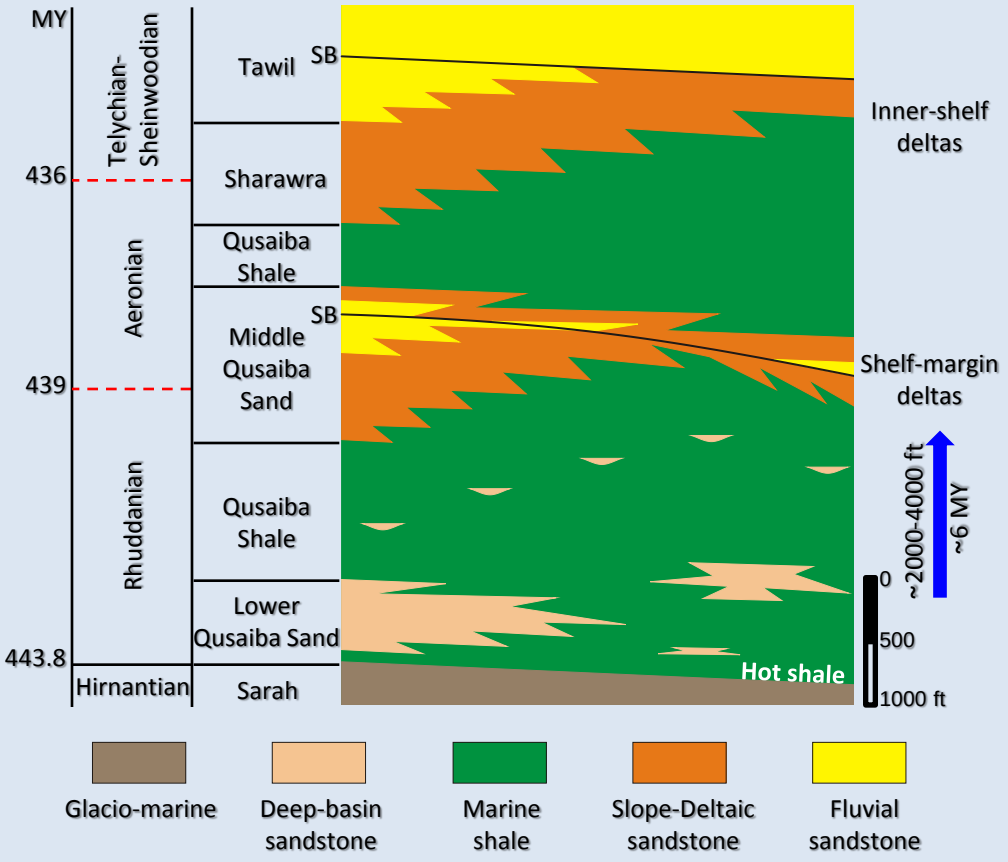
June 1st, 2015

Location

Stratigraphy



Objectives

- Facies characterization
- Evolution of the Silurian depositional systems

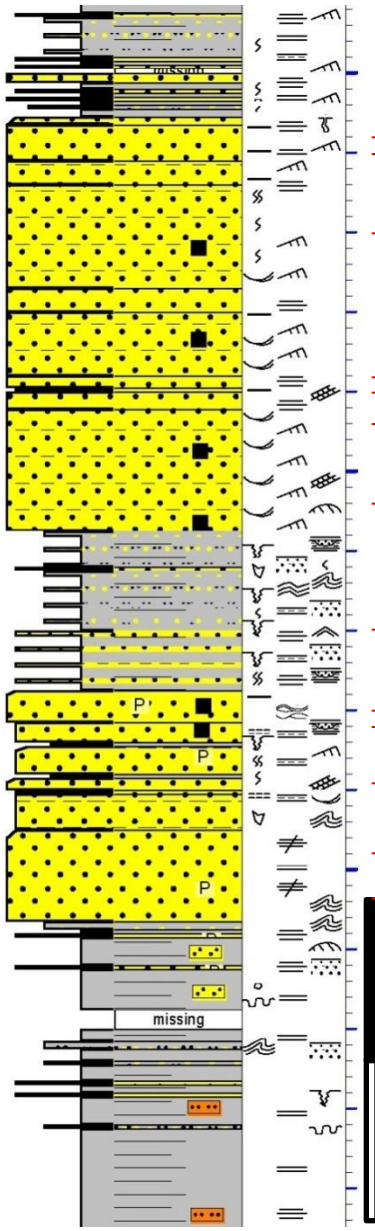
Outline

- Introduction
- Facies Associations
- Facies successions
- Facies stacking patterns
- Stratigraphic architecture
- Slope clinoforms
- Evolution of the Silurian depositional systems
- Conclusions

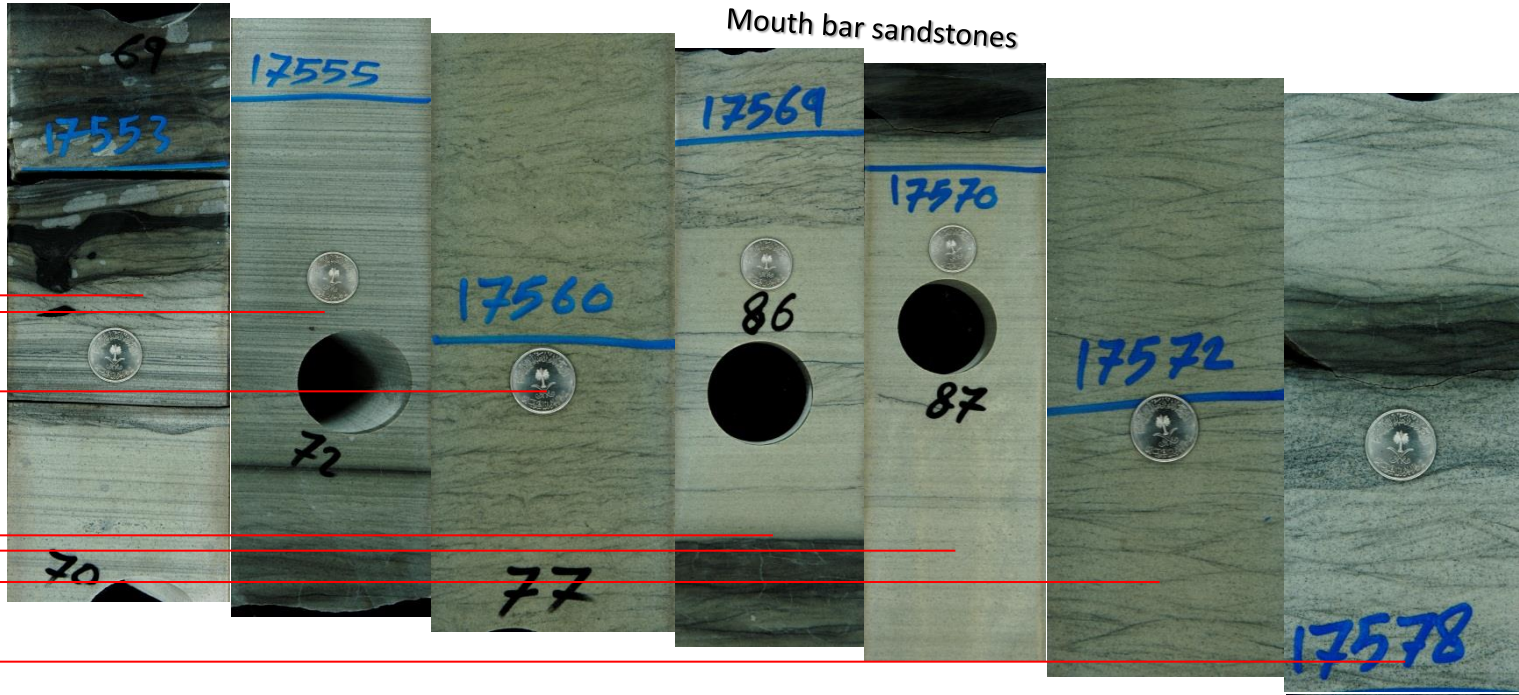
Facies Associations

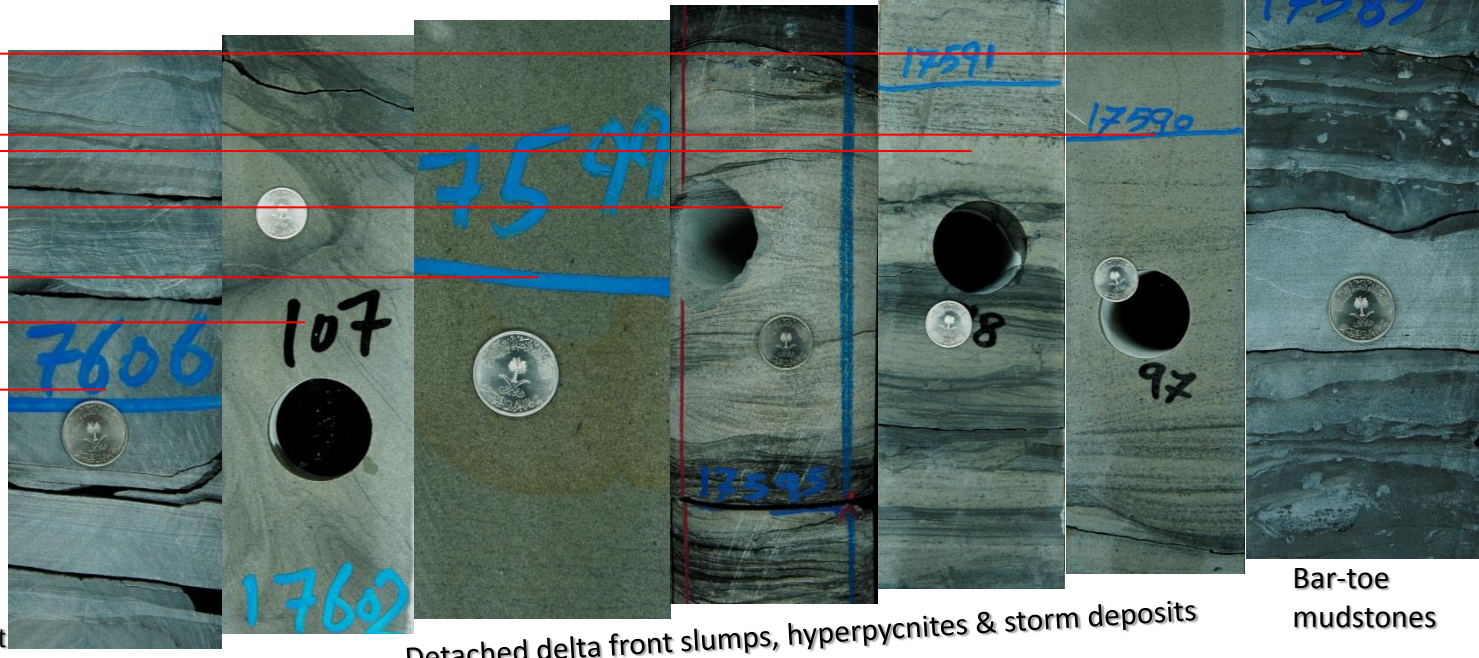
- River mouth bar
- Tempestites
- Slope channel
- Gravity flow deposits
  - Hyperpycnites
  - High- and low-density turbidites
  - Hybrid turbidites-debrites
- Mass-transport deposits
  - Slumps
  - Debrites

River Mouth Bar
Facies Association
(shelf-margin deltas)



Mouth bar sandstones

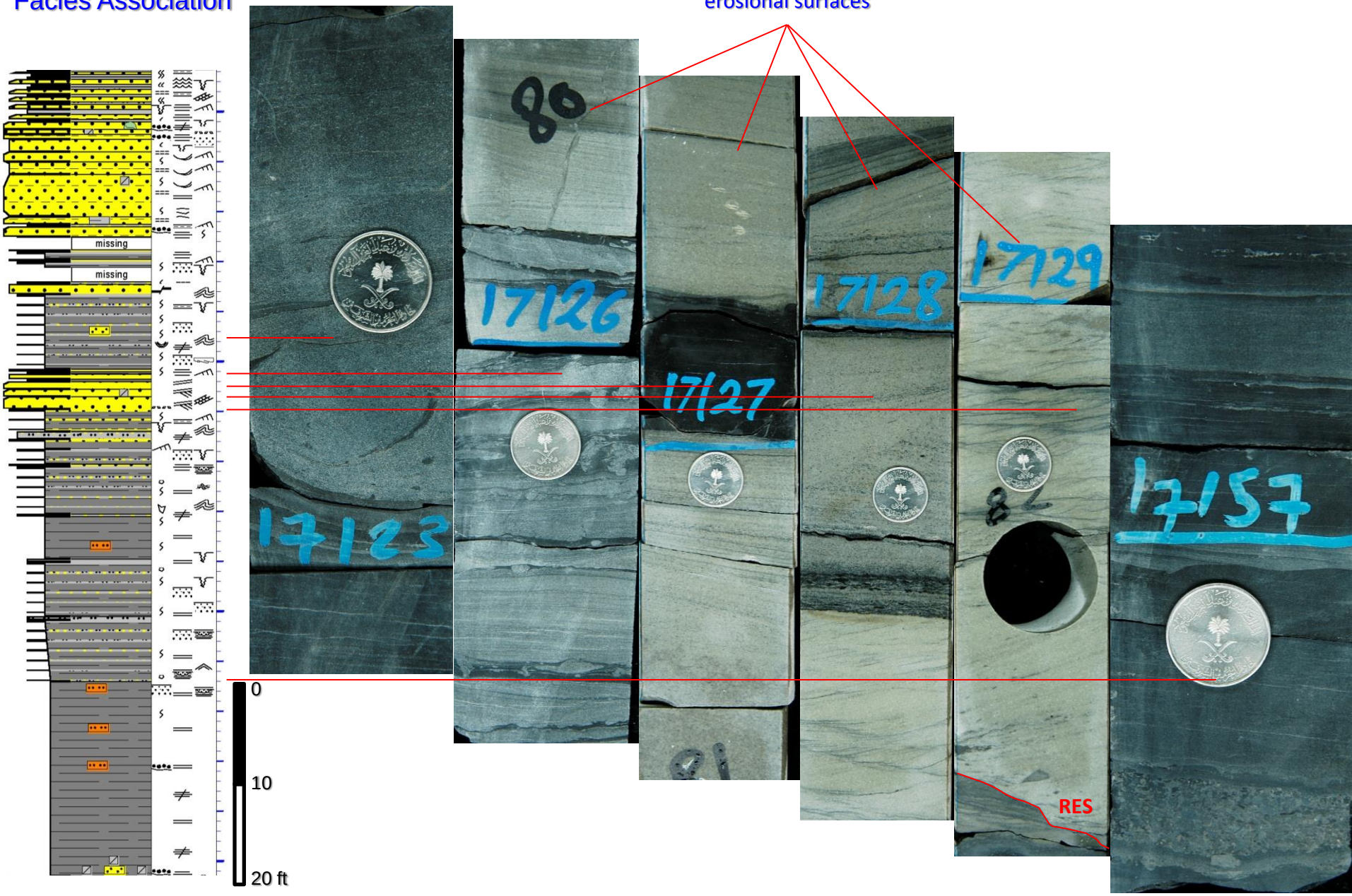




Detached delta front slumps, hyperpycnites & storm deposits

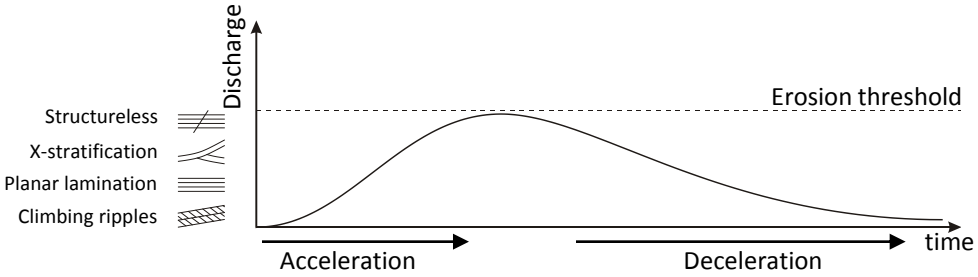
Bar-toe
mudstones

Slope Channel Facies Association



Alternating suspension fallout, sediment bypass, traction reworking and dune migration

Hyperpycnites

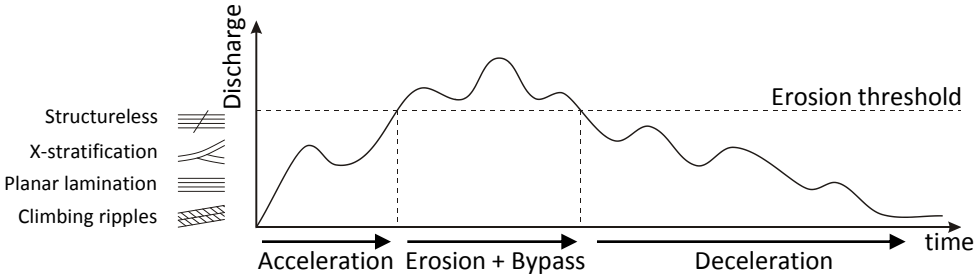


A conceptual model of a simple hyperpycnal flow (modified after Mulder et al., 2003)

Proximal — Decreasing velocity (depletive flow) — Distal

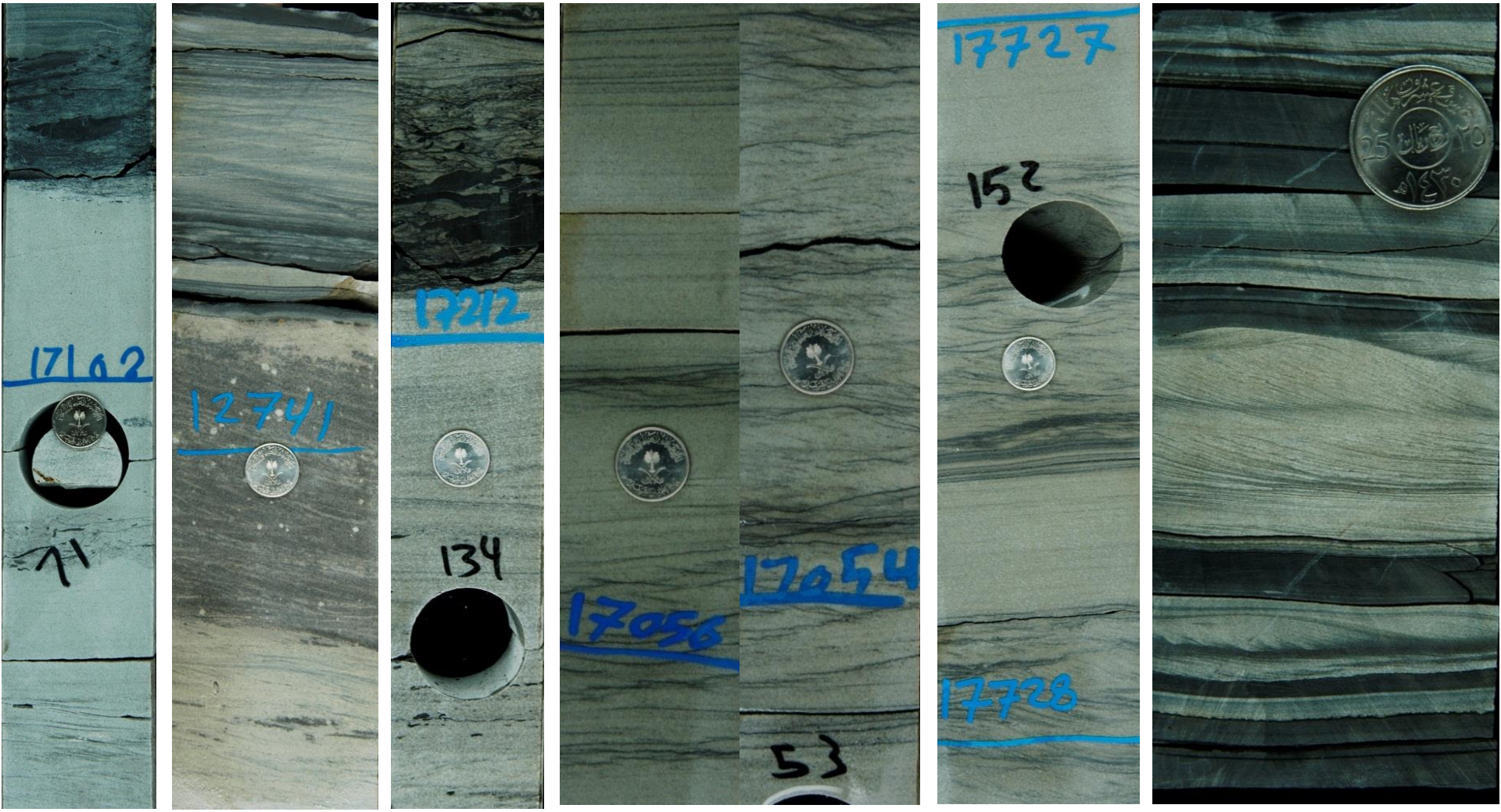
Simple hyperpycnites

Hyperpycnites



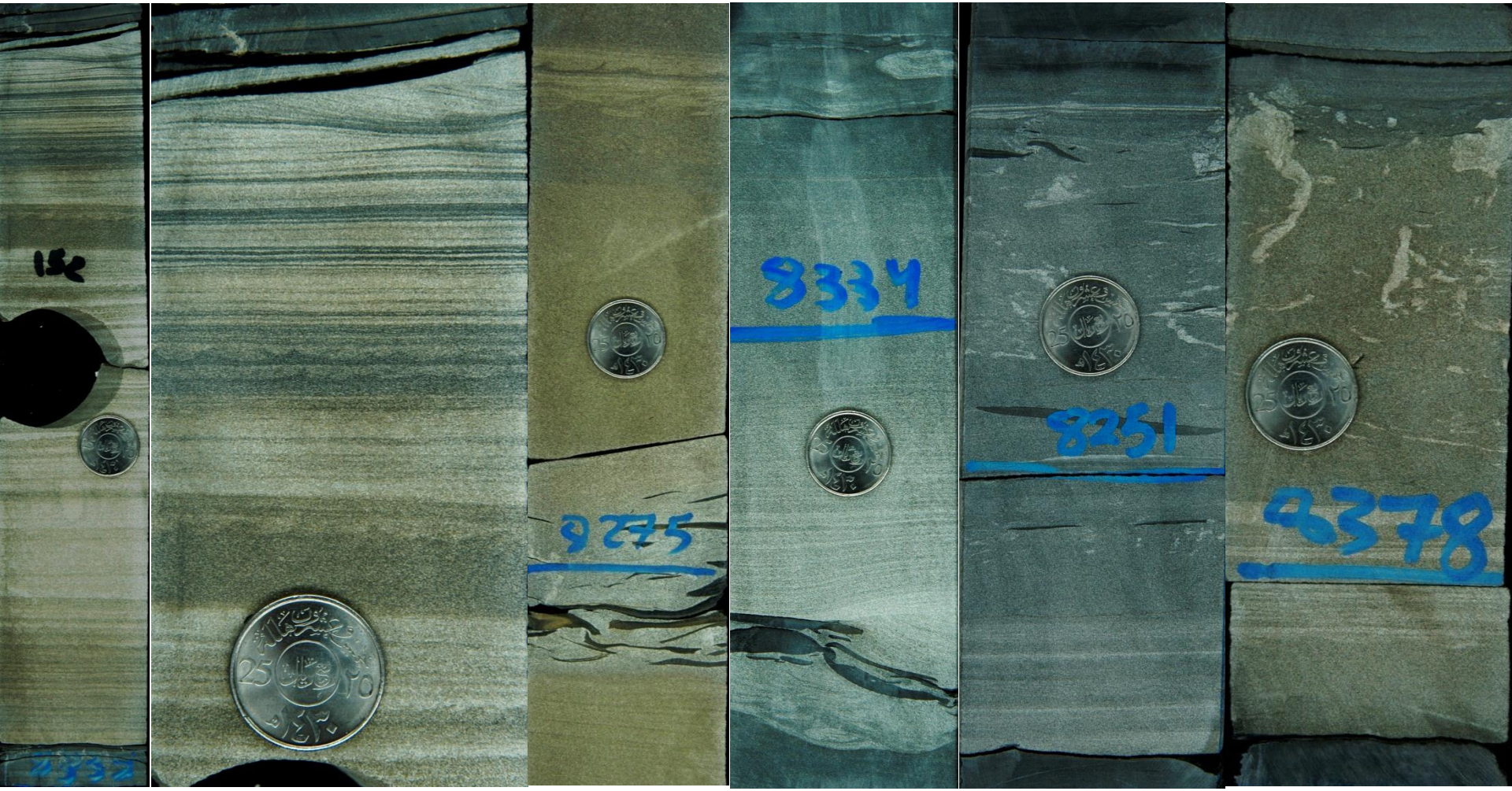
A conceptual model of a long-lived fluctuating hyperpycnal flow (modified after Zavala et al., 2006)

Proximal — Decreasing velocity (depletive flow) — Distal

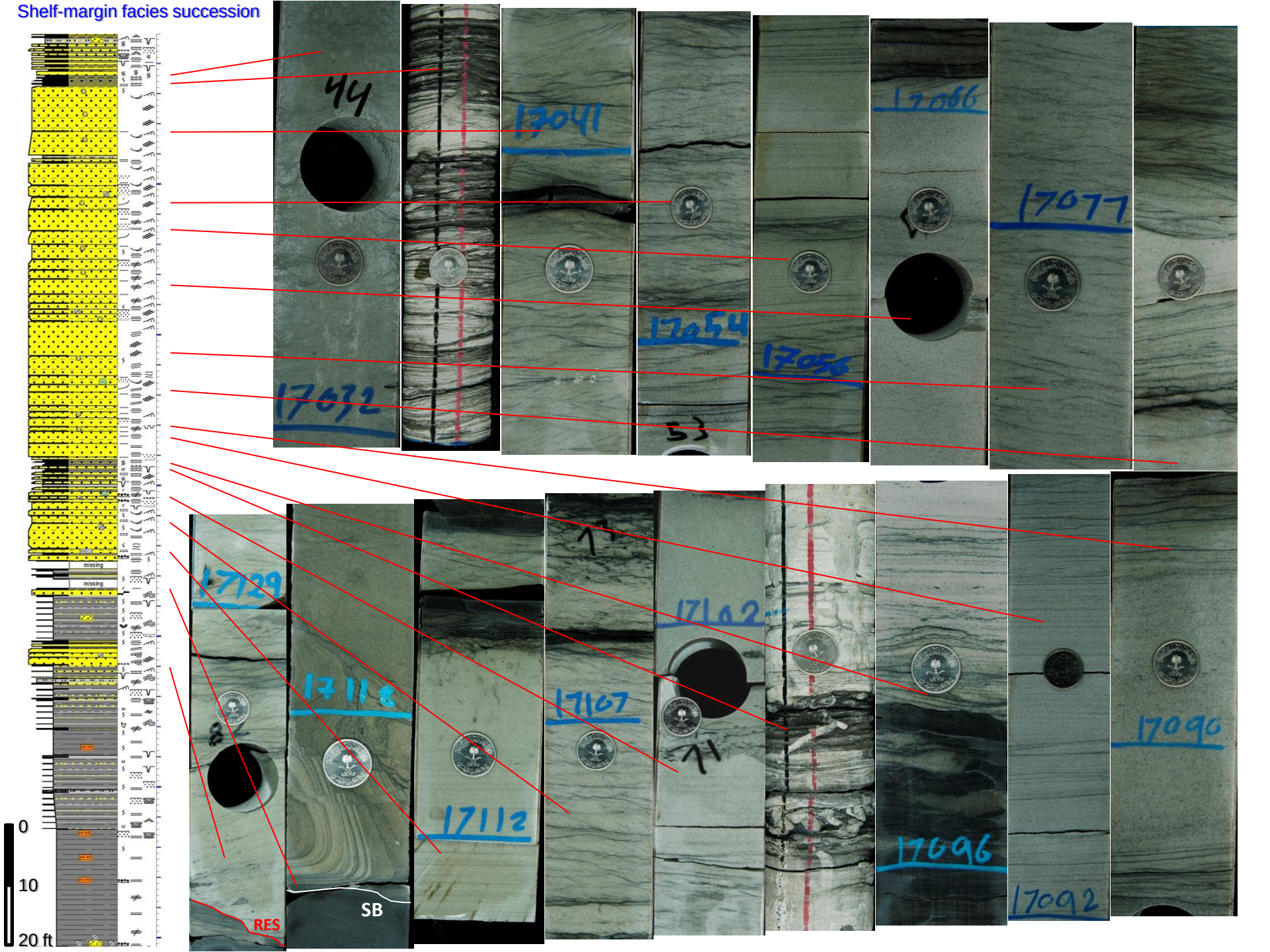


Composite hyperpycnites

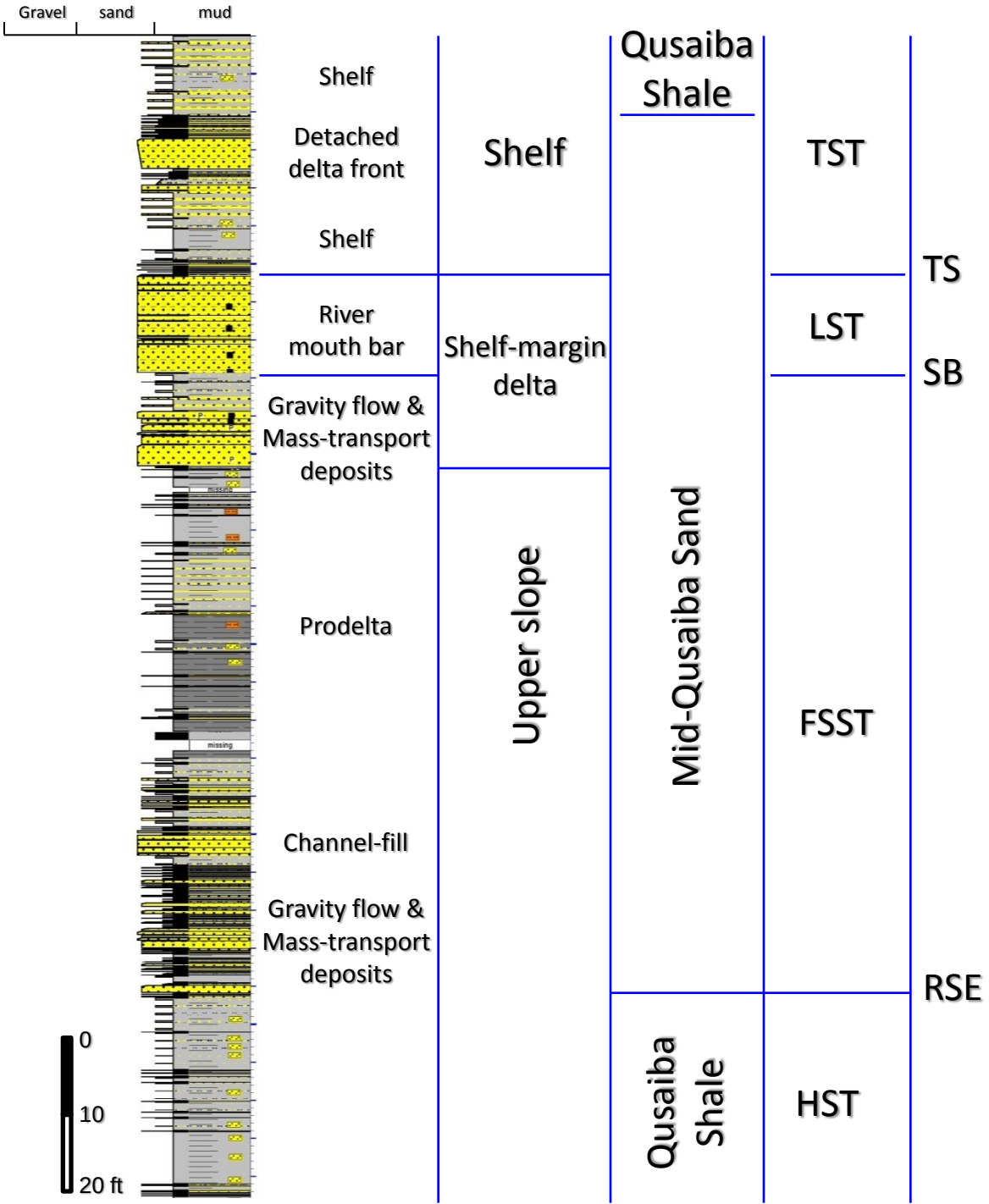
Hybrid turbidites-debrites



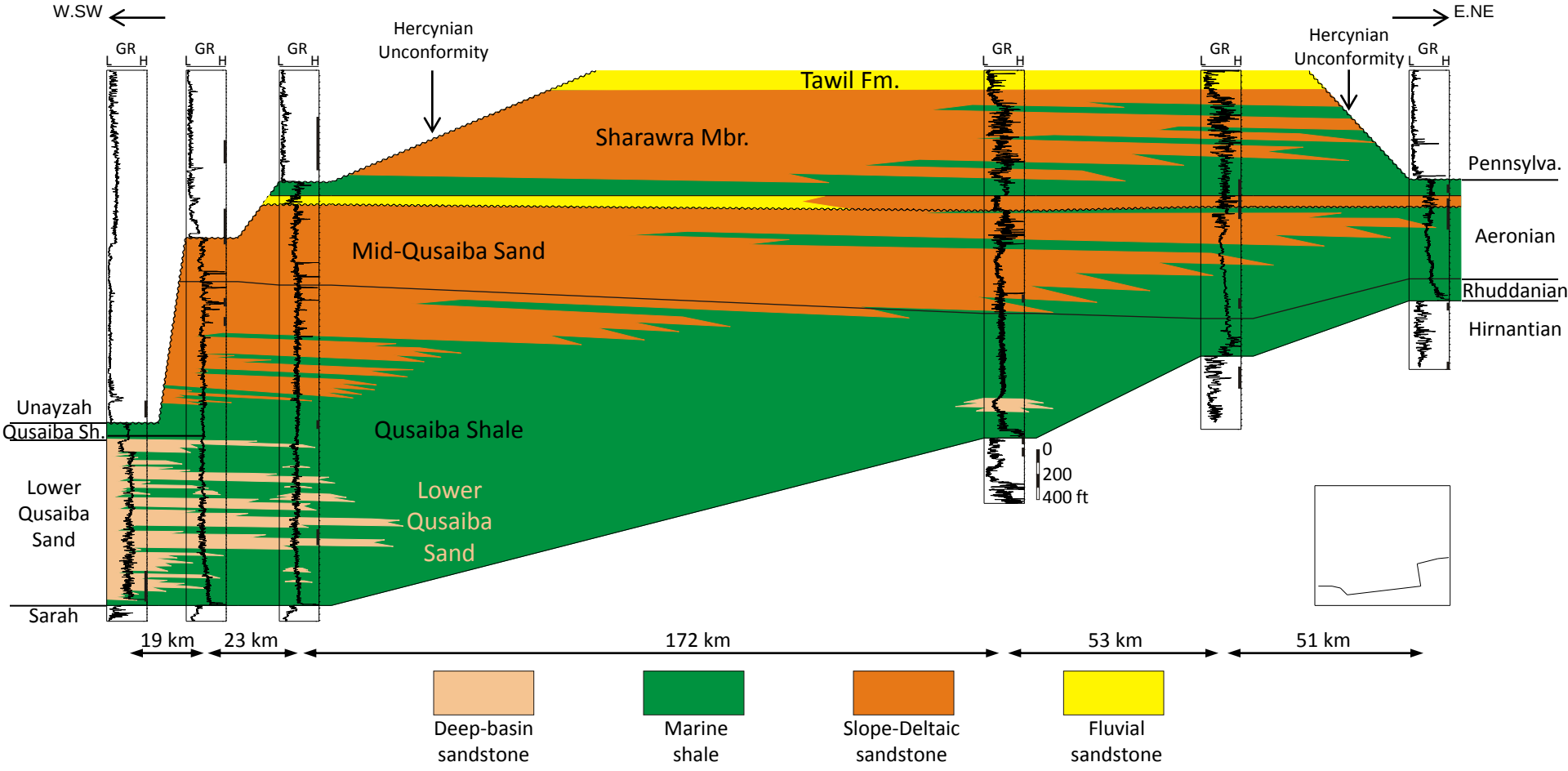
Deep-marine facies succession


Shelf-margin facies succession
missing
missing
0
10
20 ft
17072
17041
17054
17056
17066
17077
17090
17092
17096
17102
17107
17112
17116
17129
RES
SB

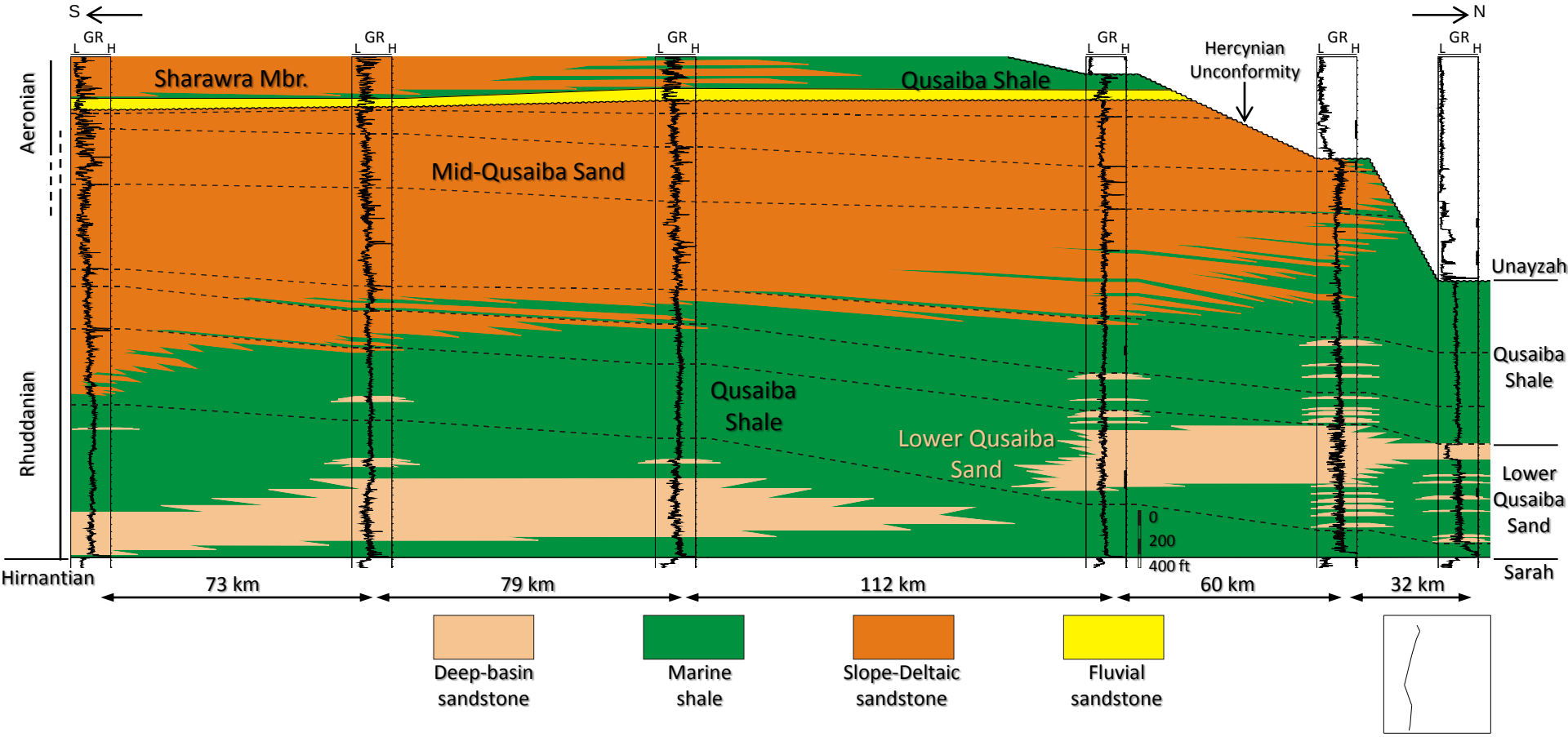
Facies stacking patterns (shelf-margin deltas)



Stratigraphic architecture

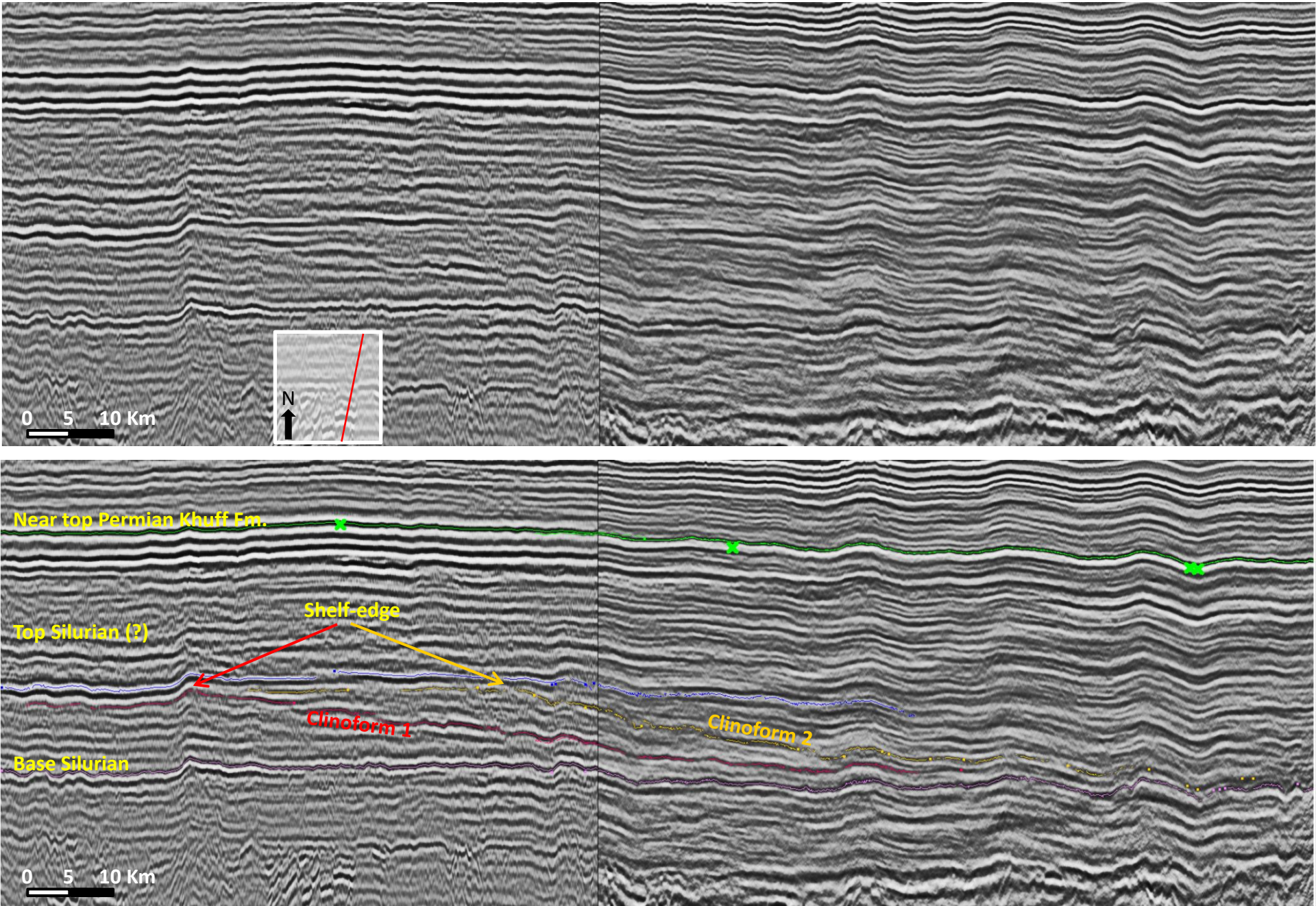


Stratigraphic architecture



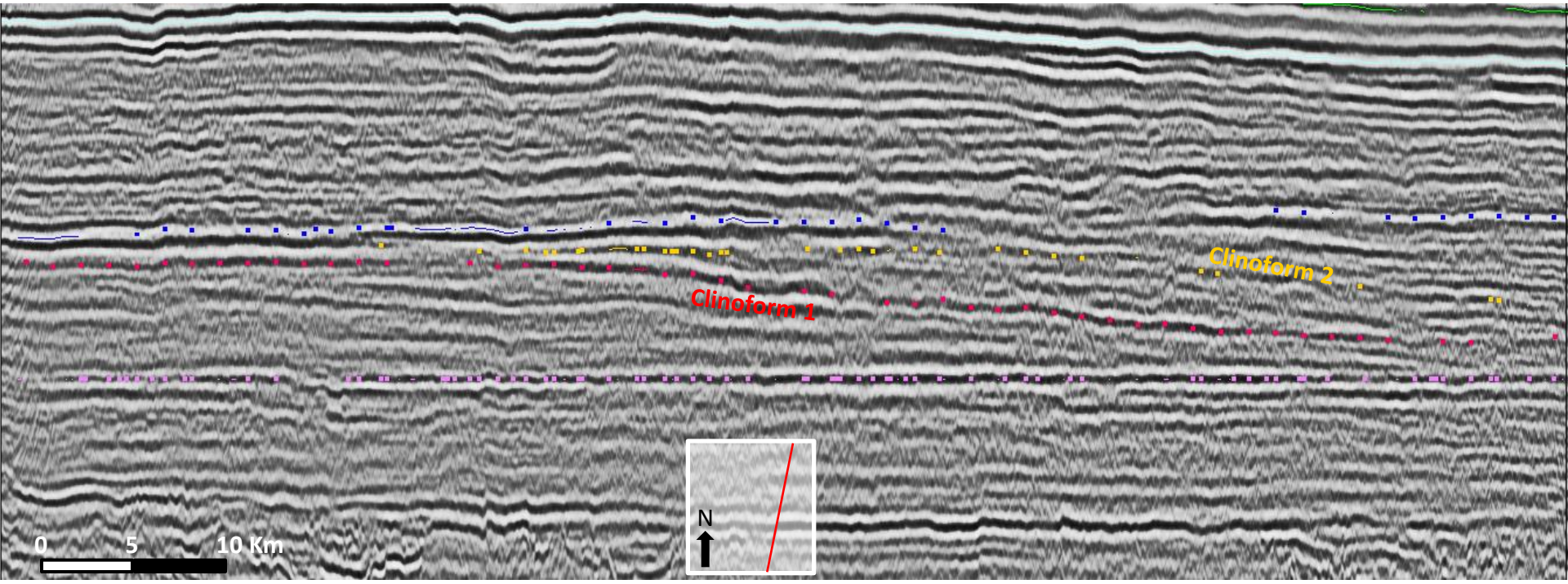
Slope clinoforms

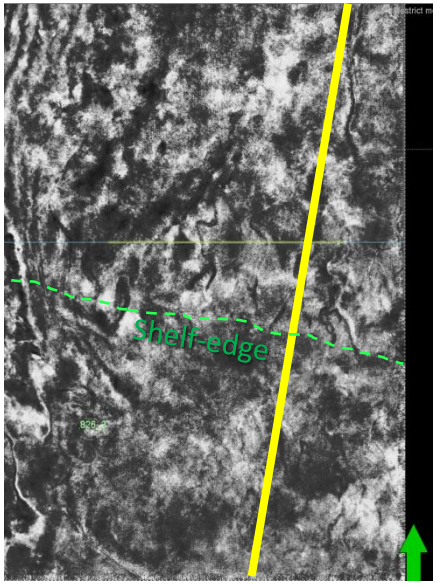
S.SW ← → N.NE



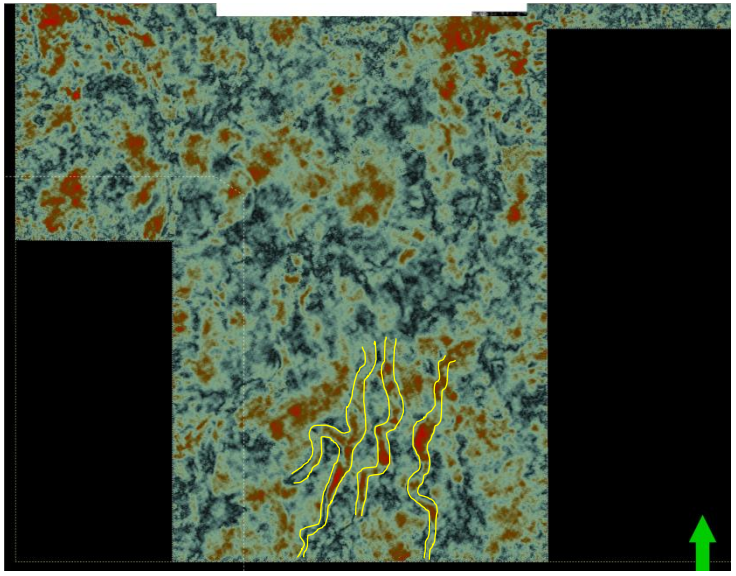
Slope clinoforms & channels

S.SW ← → N.NE



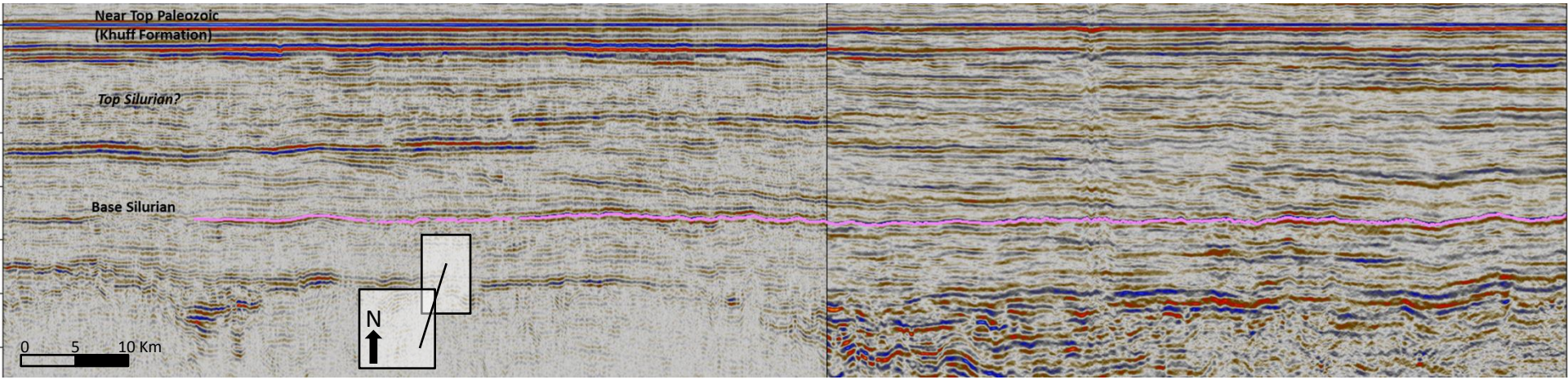


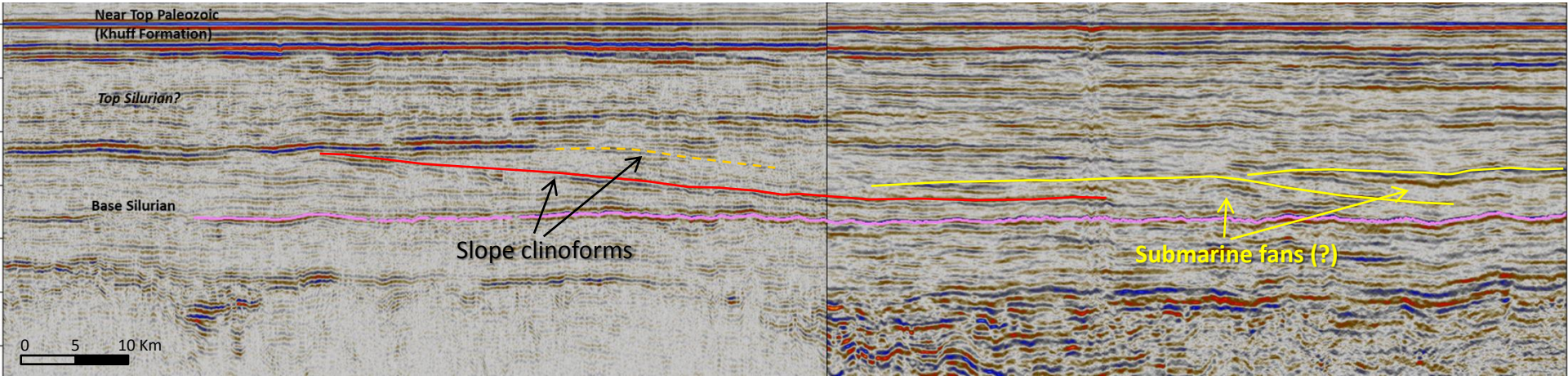
Horizon Slice at Dipping Reflector 1 (Amplitude slice)



Horizon Slice at Dipping Reflector 2 (Sweetness slice)

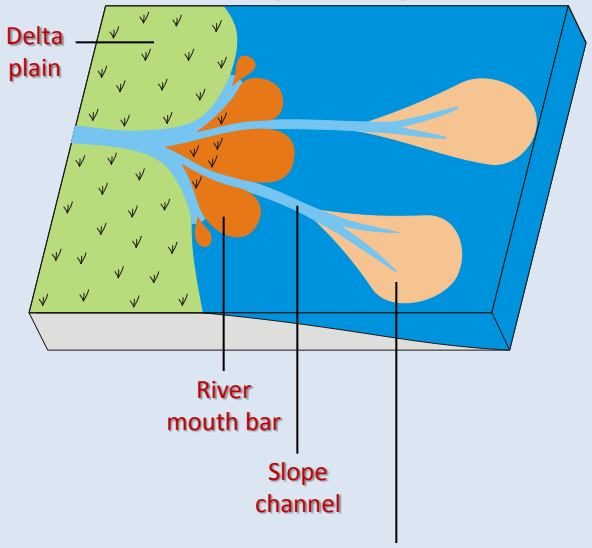
Slope clinoforms & submarine fans (?)

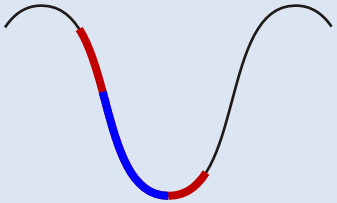




Evolution of Silurian depositional systems

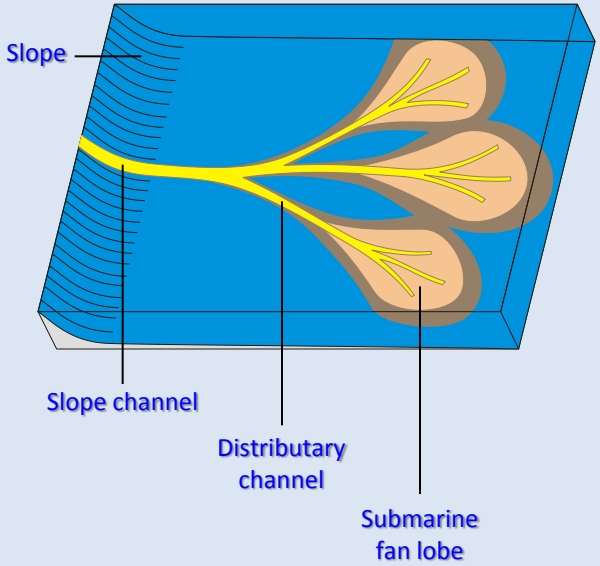
Shelf-margin delta
(Aeronian)

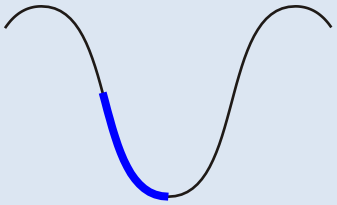




Early falling and
Late Lowstand
Sea-level

Deep-basin fan
(Rhuddanian)





Late falling to lowstand
Sea-level

Conclusions

1. Evolving deep- to shallow-marine and fluvial depositional systems.
2. Seismic clinoforms reflecting shelf-slope-basin geometry.
3. Potential deep-basin fans deposited during falling to earliest lowstand sea-level conditions.
4. Shelf-margin deltas formed mainly during the latest lowstand sea-level conditions. These were controlled by river floods, which generated hyperpycnal flows. These transferred sediments into the deep-basin during the earlier falling to lowstand sea-level conditions.

Acknowledgement

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Thank you

Questions?