Insights from Quantitative Sequence Stratigraphic Analysis of Cyclic Peritidal Carbonates: Triassic, Sultanate of Oman*

Michael Obermaier[1], Thomas Aigner[1], and Suleiman Al-Kindy[2]

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[1]Department of Geosciences, Sedimentary Geology, University of Tübingen, Tübingen, Germany (michael_obermaier@gmx.de)
[2]Petroleum Development Oman, Muscat, Oman

Abstract

The Triassic in the Northern Oman mountains consists largely of peritidal dolomites of a flat epeiric carbonate ramp. To unravel the sequence stratigraphic framework, different quantitative sequence stratigraphic analyses were applied:

1. A rooting index, quantifying the severity of rooting, was used to identify the order of a cycle boundary. High-order sequence boundaries (3rd-/2nd-order) tend to be heavier rooted and (karst-)brecciated than low-order cycle boundaries (5th-/4th-order).
2. Facies proportion curves were applied in combination with gamma-ray trends to establish a 3-fold cycle hierarchy. Since proximal facies in this peritidal environment typically show higher natural gamma radiation (K, Th), they can clearly be differentiated from distal grain-dominated facies of rather low GR values.
3. Stacking pattern diagrams visually accentuate facies changes through time and highlight high-frequency fluctuations in relative sea level. Interpreted medium-scale cycles (< 10 m) show lateral facies changes and occasionally pinch-outs on a scale of several kilometers.
4. Fischer plots provide a proxy for accommodation space. Pronounced peaks depict high accommodation space and therefore maximum flooding events; low peaks, sequence boundaries. Fischer plots were also compared regionally, revealing different behavior of the plots in different parts of the study area. These patterns are most likely due to locally varying subsidence and presumably indicate paleo-high or paleo-low structures.

Techniques of quantitative sequence stratigraphy are thus useful for establishing a solid high-frequency sequence stratigraphic framework. They complement each other and help to verify or falsify different scenarios of cycle picks, cycle hierarchies, and regional correlation. In some cases they can even be used as first-pass indicators for regional paleotectonic relationships. This has several implications for reservoir occurrence and quality--relevant for both regional exploration and field development.

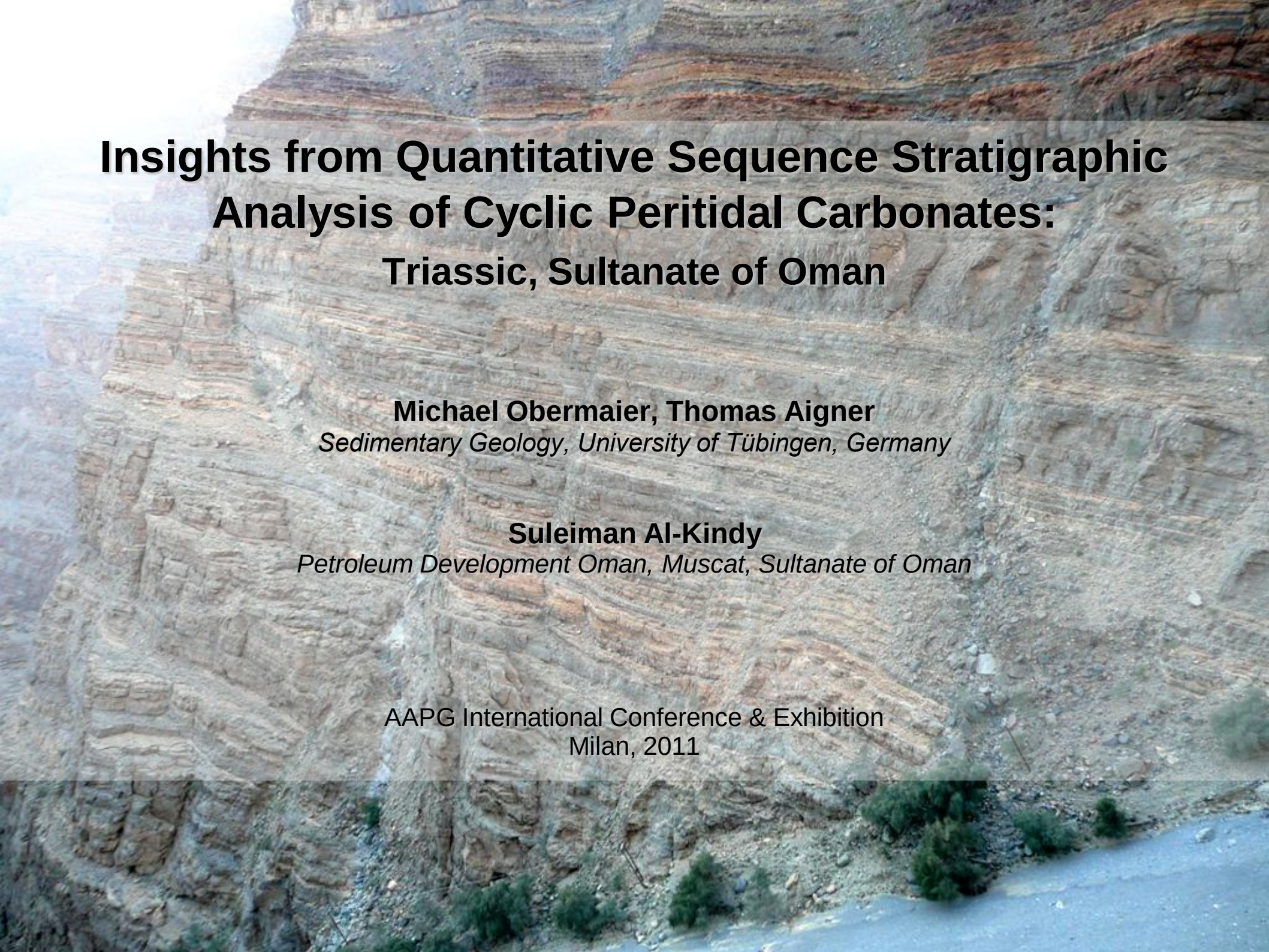
The authors would like to thank Petroleum Development Oman and the Sultanate of Oman Ministry of Oil and Gas for permission to present this work.

Selected Reference

Ziegler, M.A., 2001, Late Permian to Holocene paleofacies evolution of the Arabian plate and its hydrocarbon occurrences: GeoArabia, v. 4, p. 445-504.

Selected Website

Scotese, C.R., 2001, Early Triassic: Paleomap Project, Web accessed 30 January 2012, http://www.scotese.com/newpage8.htm



Insights from Quantitative Sequence Stratigraphic Analysis of Cyclic Peritidal Carbonates:

Triassic, Sultanate of Oman

Michael Obermaier, Thomas Aigner
Sedimentary Geology, University of Tübingen, Germany

Suleiman Al-Kindy
Petroleum Development Oman, Muscat, Sultanate of Oman

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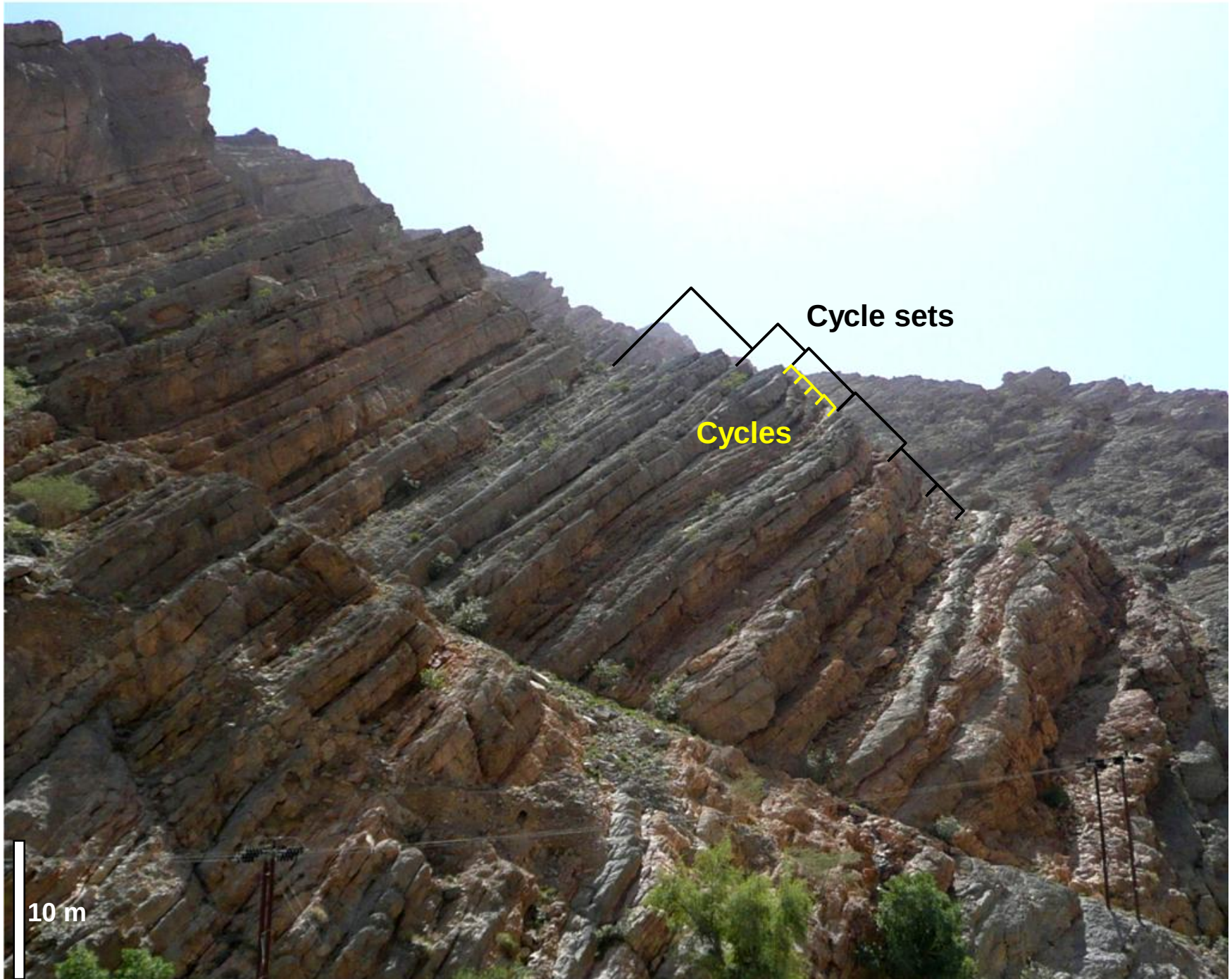
- Shuram Oil & Gas (Logistics)

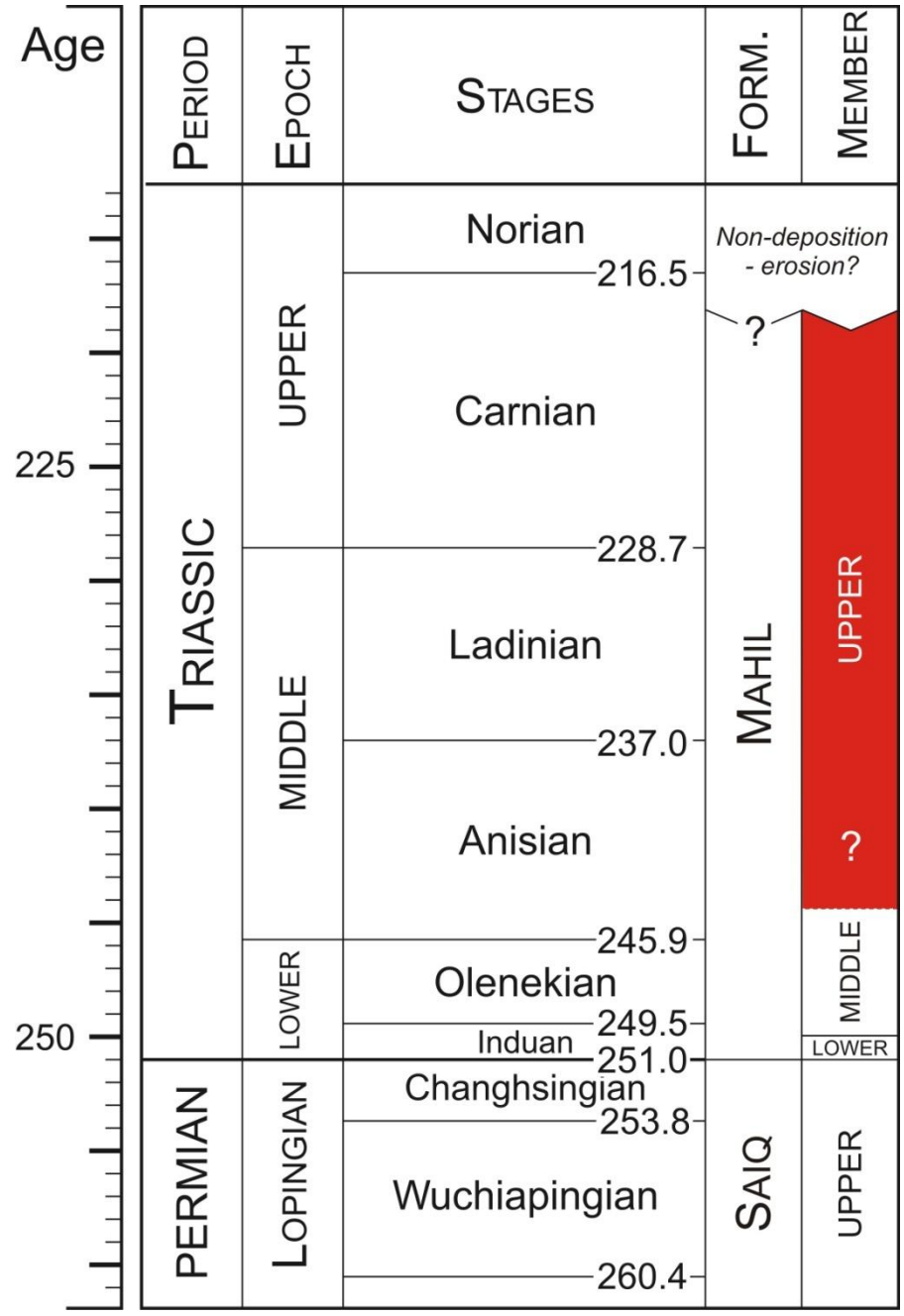
Goal: robust sequence stratigraphy



Outline

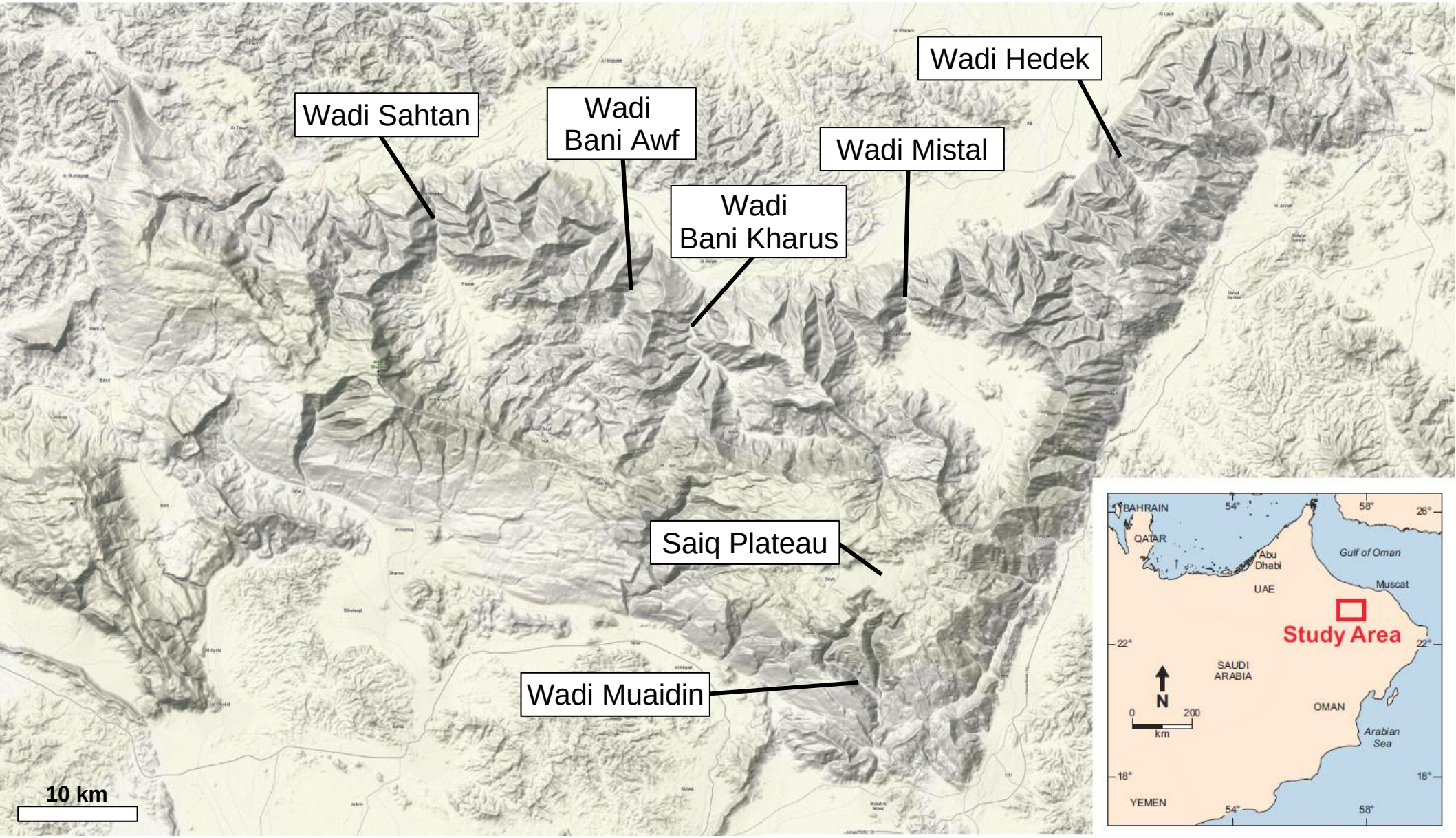
- Case Study
- Methodology
  - Facies proportions curves
  - Stacking pattern diagrams
  - Rooting index
  - Fischer plots
- Integrated Approach

General Stratigraphy & Study Area



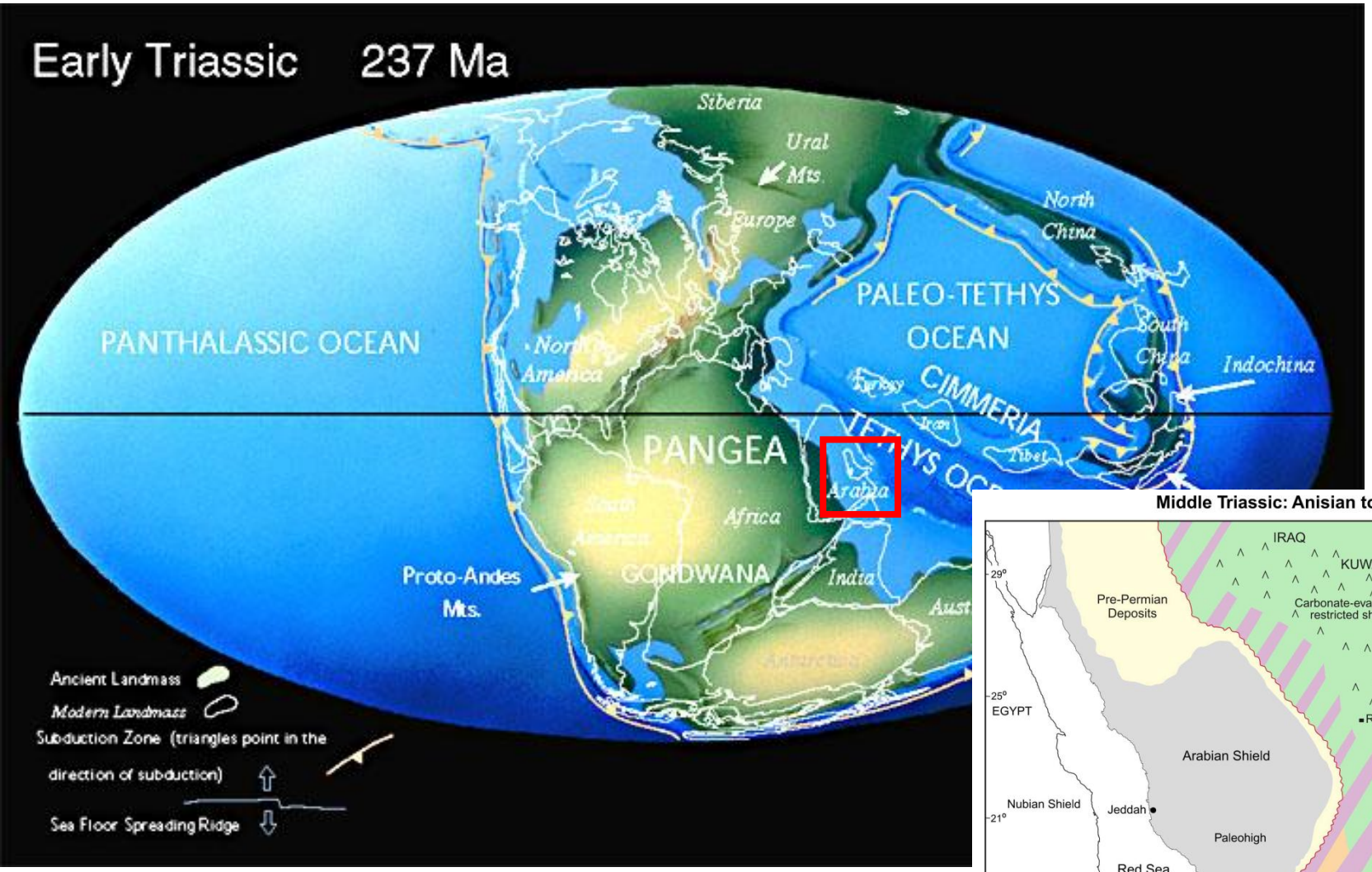
http://www.metmuseum.org

Location map – *Oman Mountains*

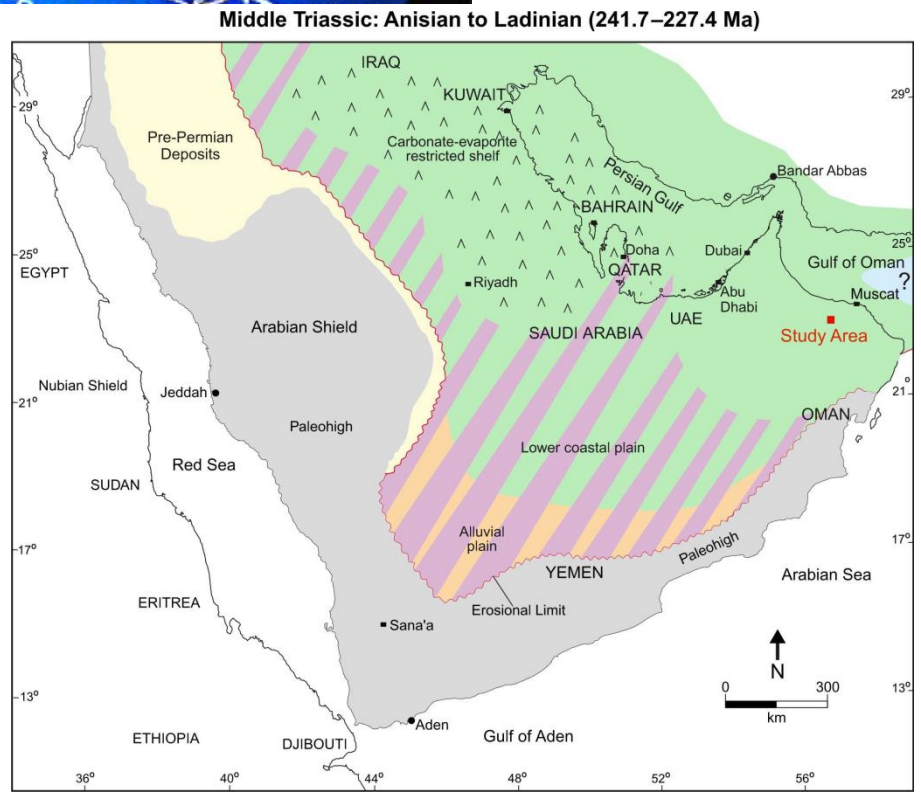


http://maps.google.com

Paleogeography



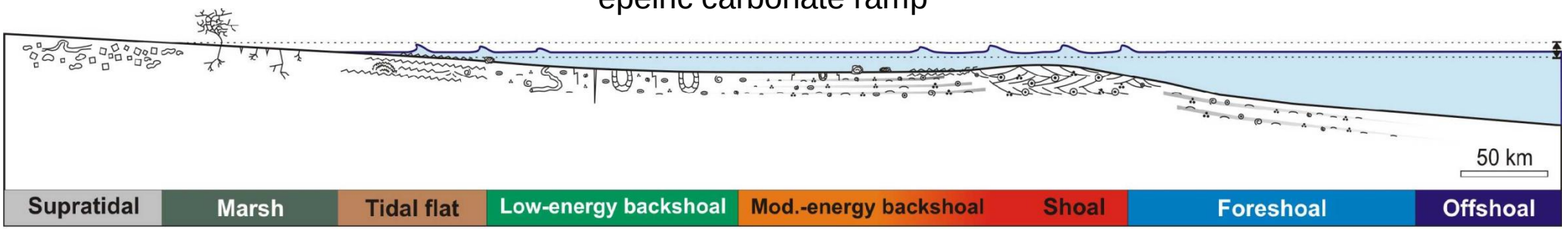
Scotese (2001) – paleomap project



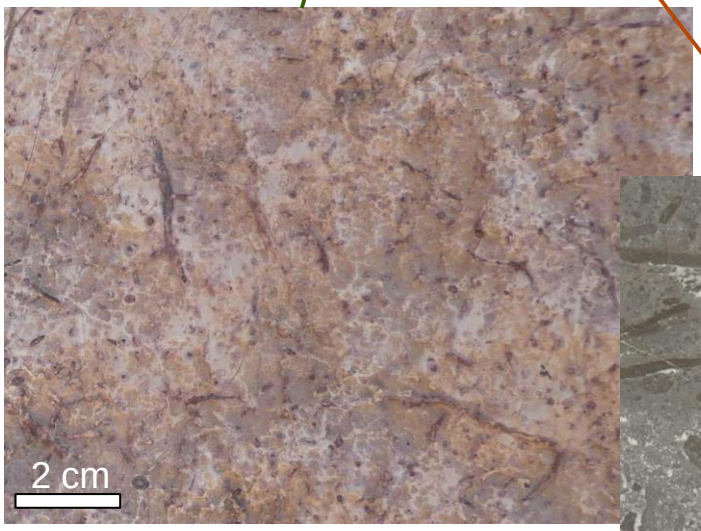
Ziegler (2001)

Depositional Environment & Facies

epeiric carbonate ramp



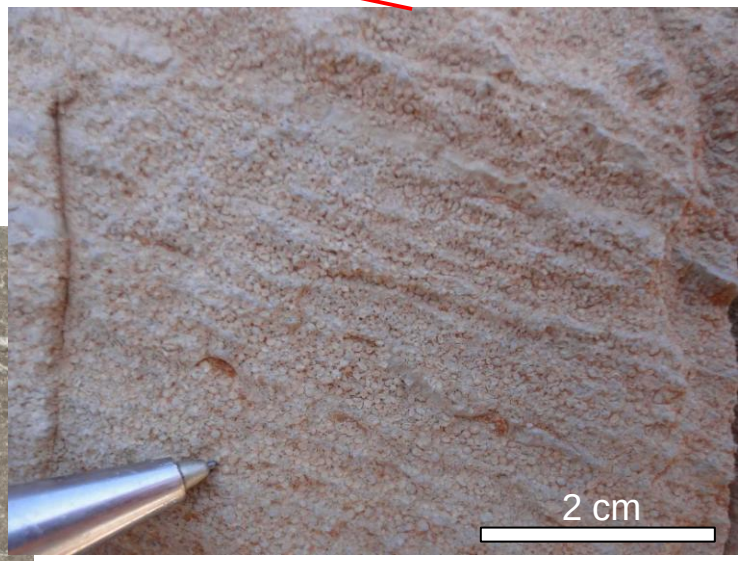
Lateral range of Upper Mahil outcrop facies



rooted mudstones

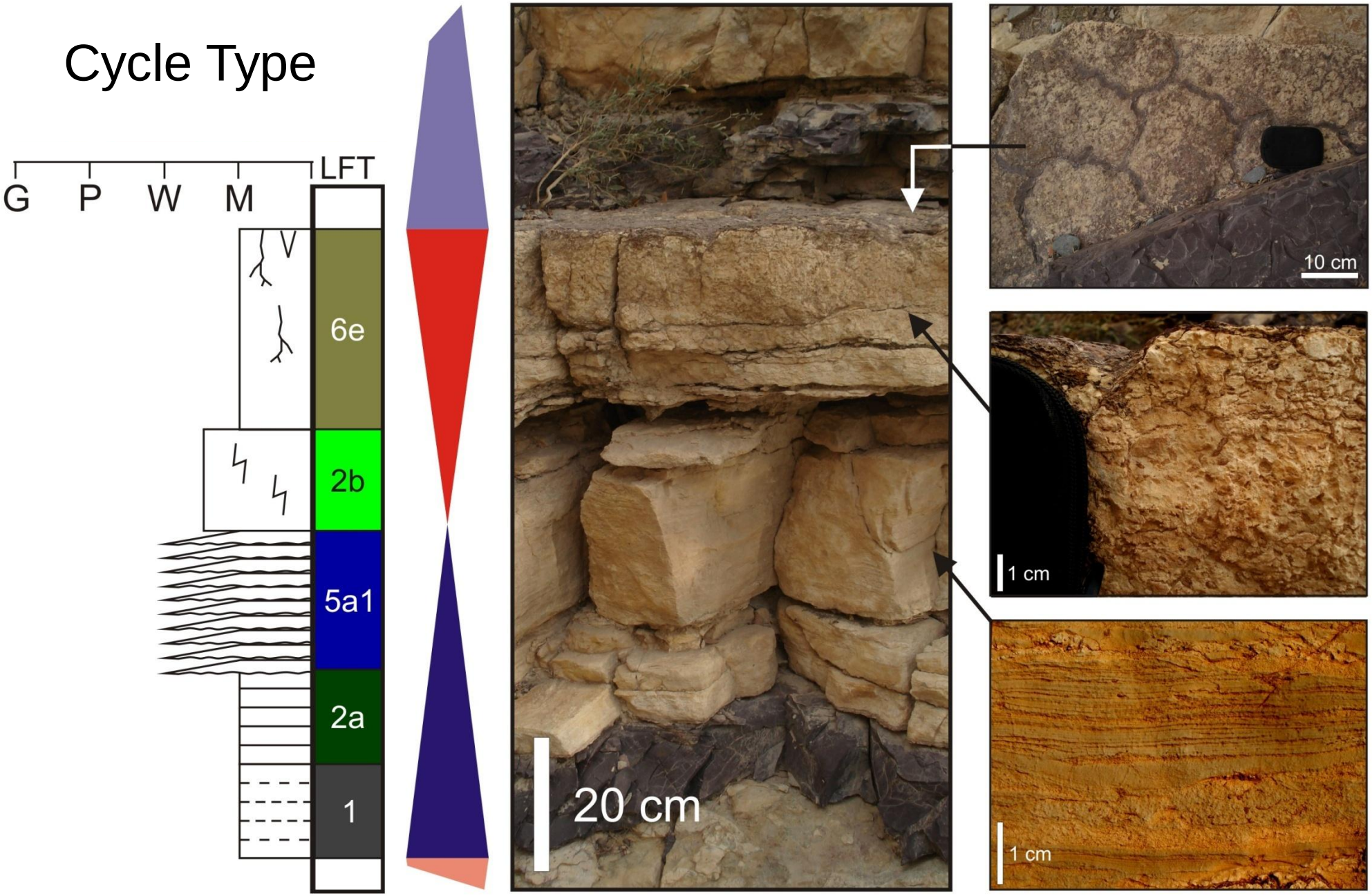
microbial laminites

peloidal/bioclastic packstones

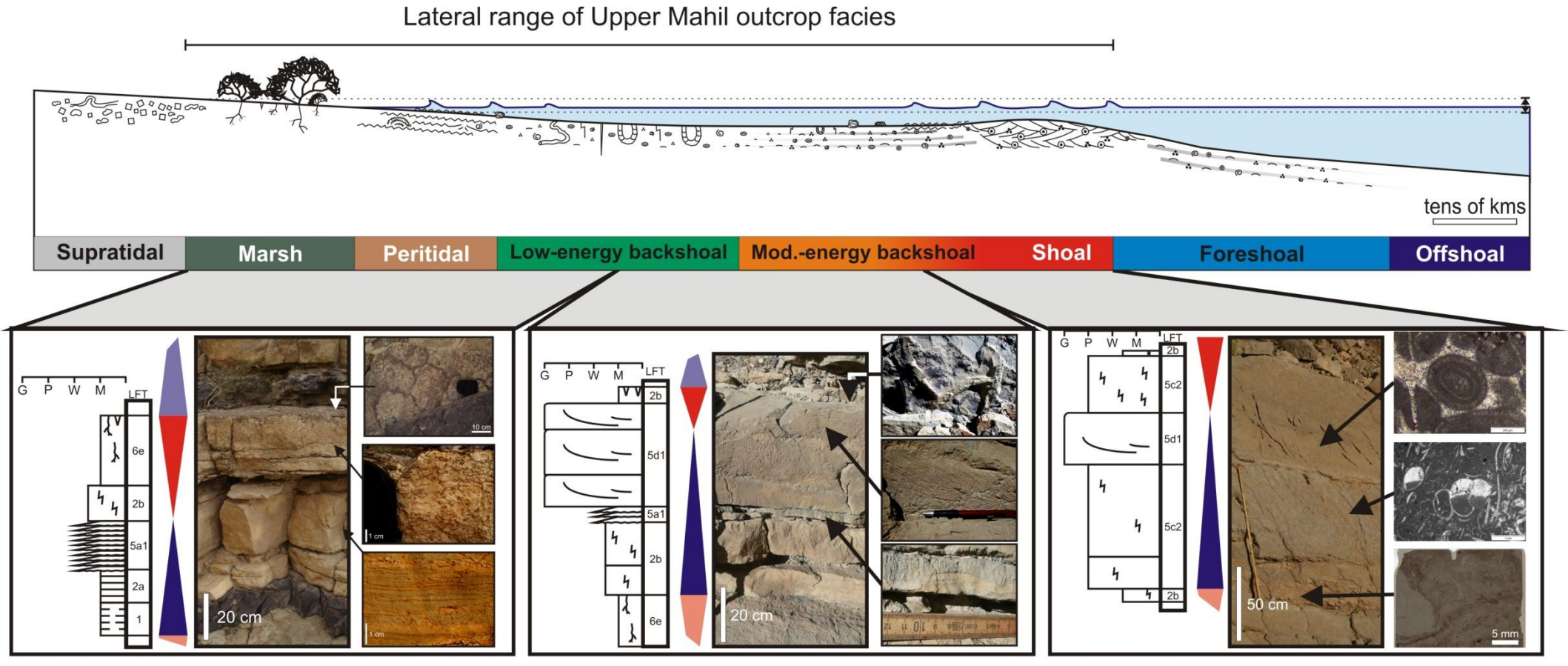


oolitic grainstones

Weathering profile indicates cyclicity



Small-scale cycle types



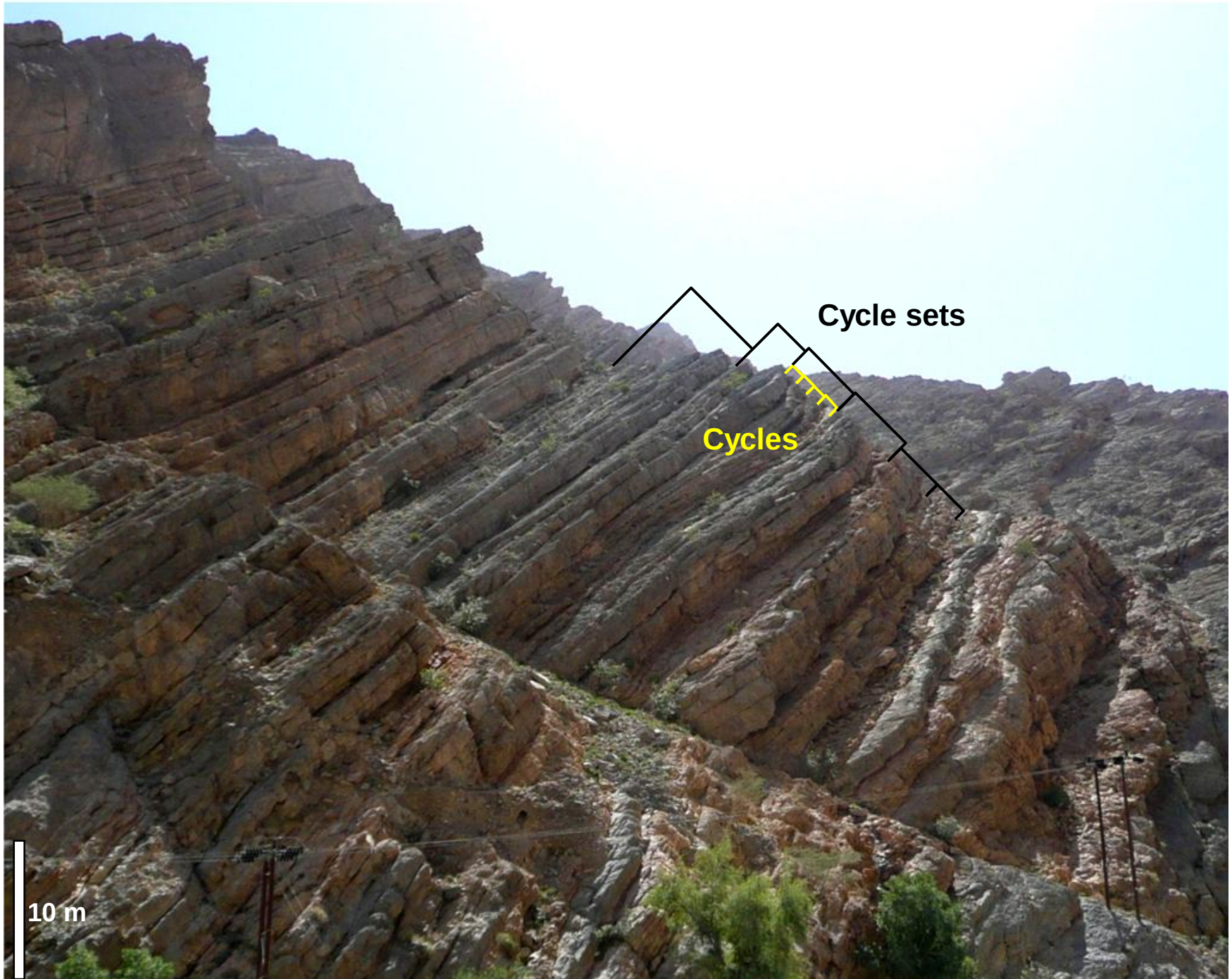
Muddy Backshoal Cycle | Grainy Backshoal Cycle | Shoal to Backshoal Cycle

cycle thickness: 0.8 m | 1.0 m | 2.5 m

increase in accommodation space (thicker cycles)

increase in grain-dominated facies

Multi-fold cyclicity



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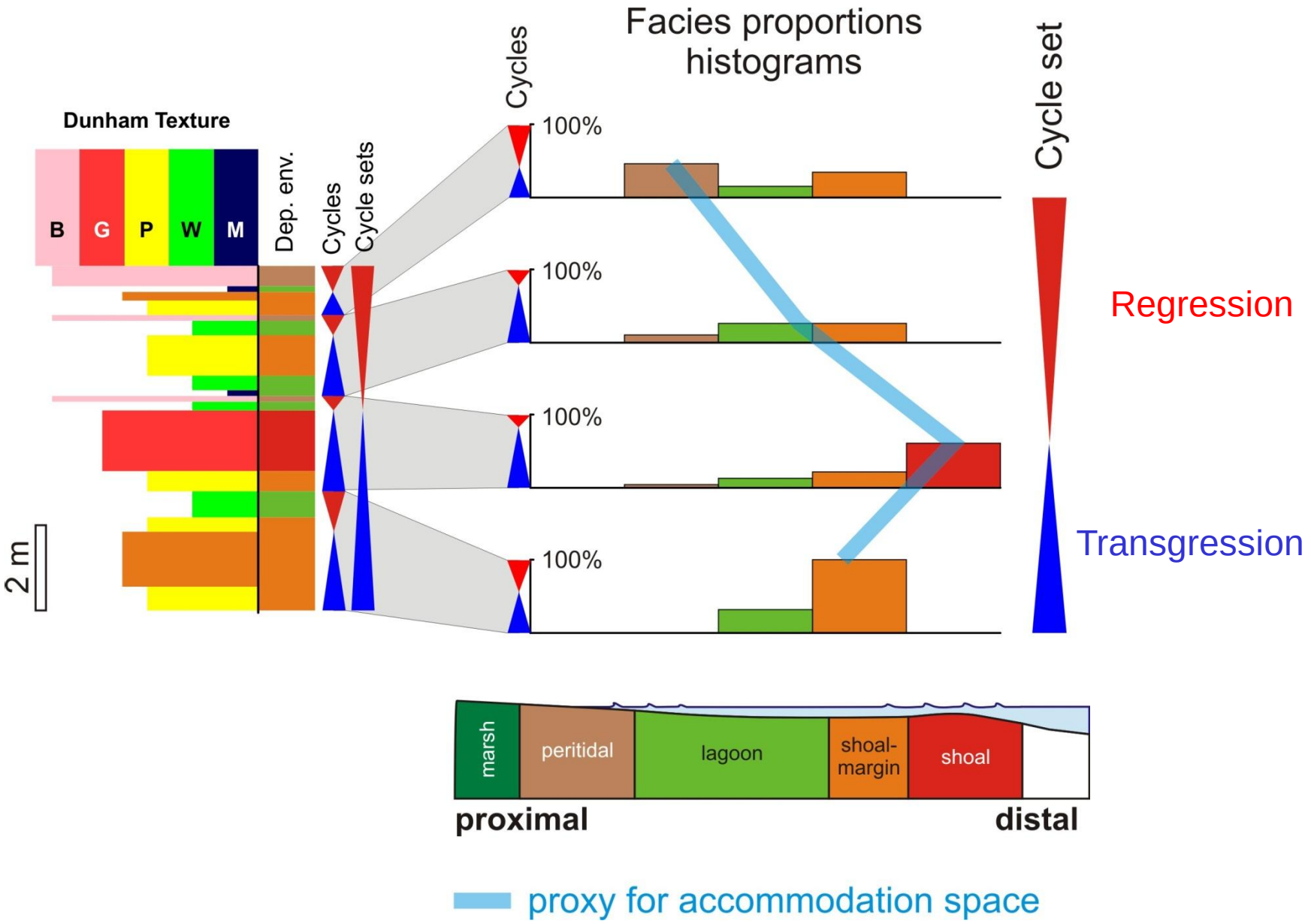
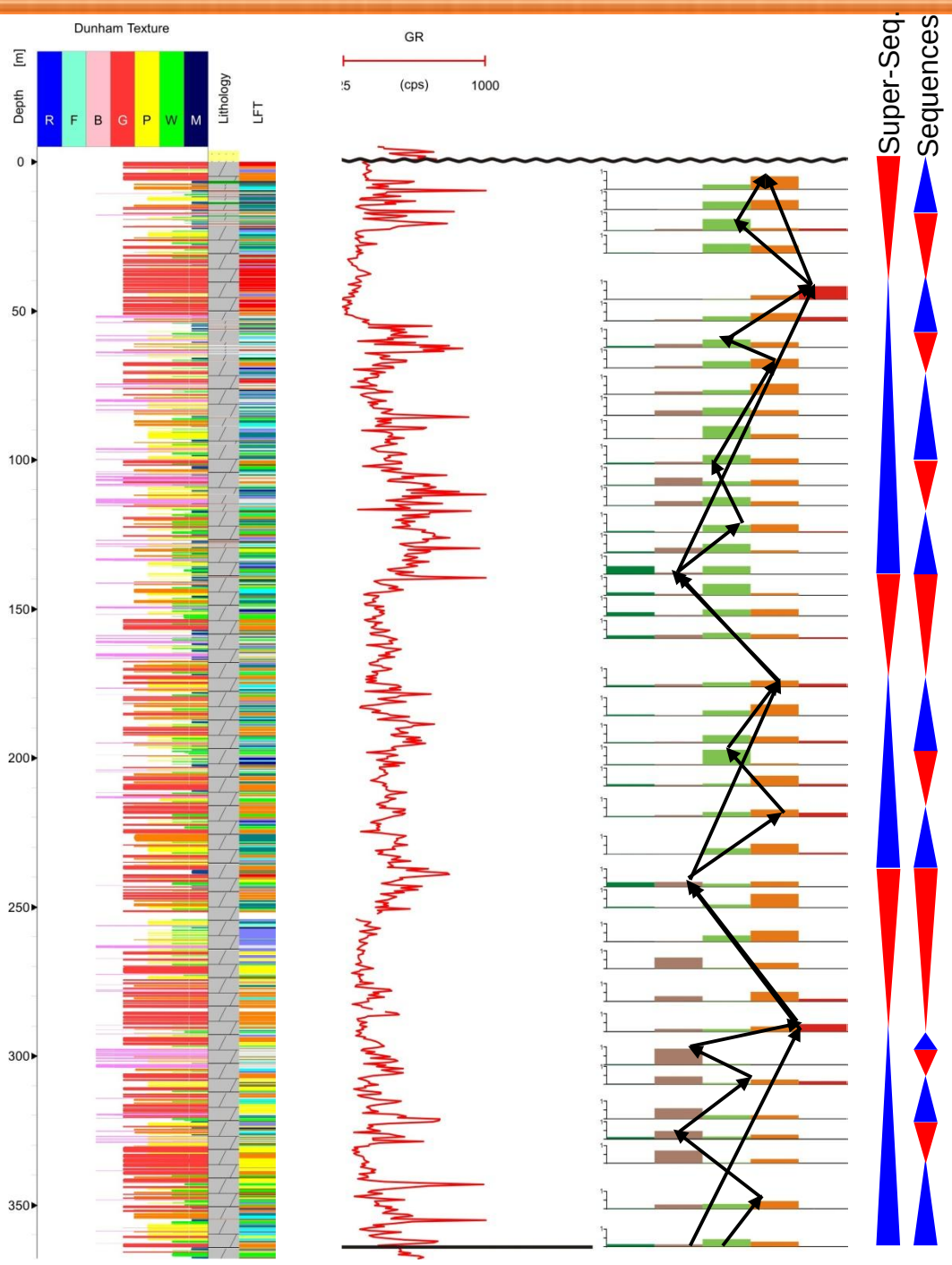
  - Facies proportions curves
  - Stacking pattern diagrams
  - Rooting index
  - Fischer plots
- Integrated Approach

Facies proportions - principle



Facies proportion curve



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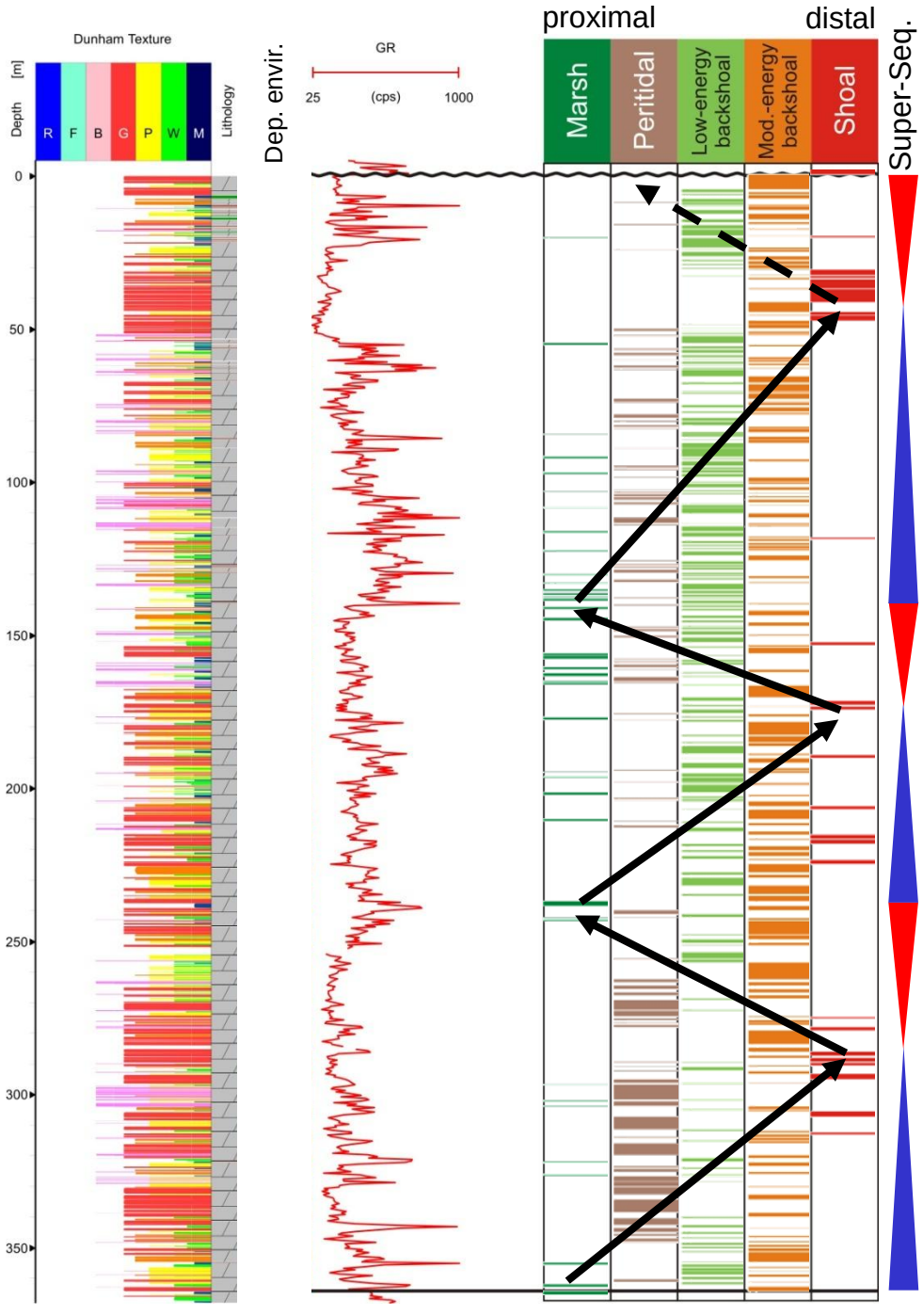
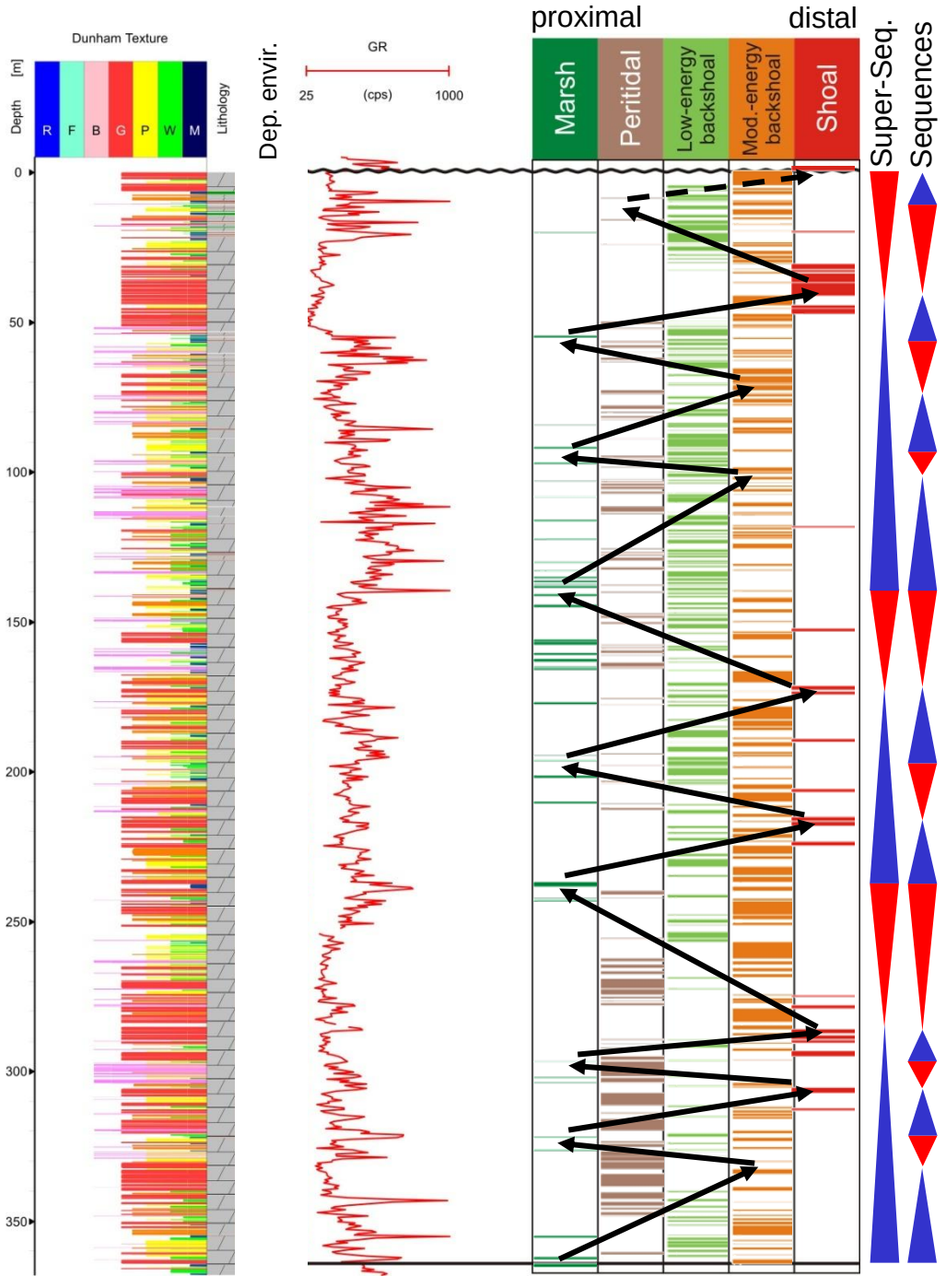
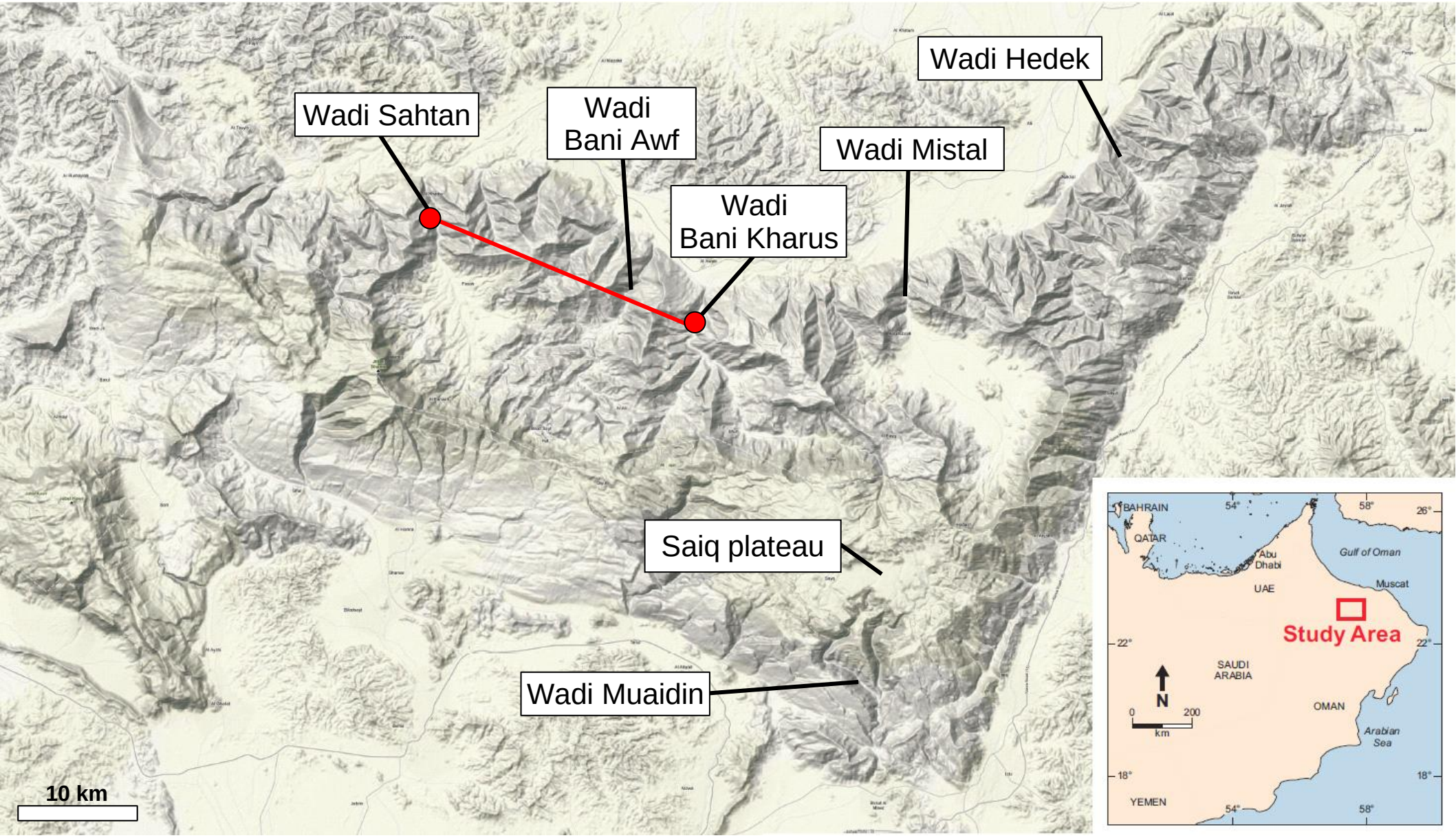
Stacking pattern diagram



Stacking pattern diagram



Correlating stacking pattern diagrams



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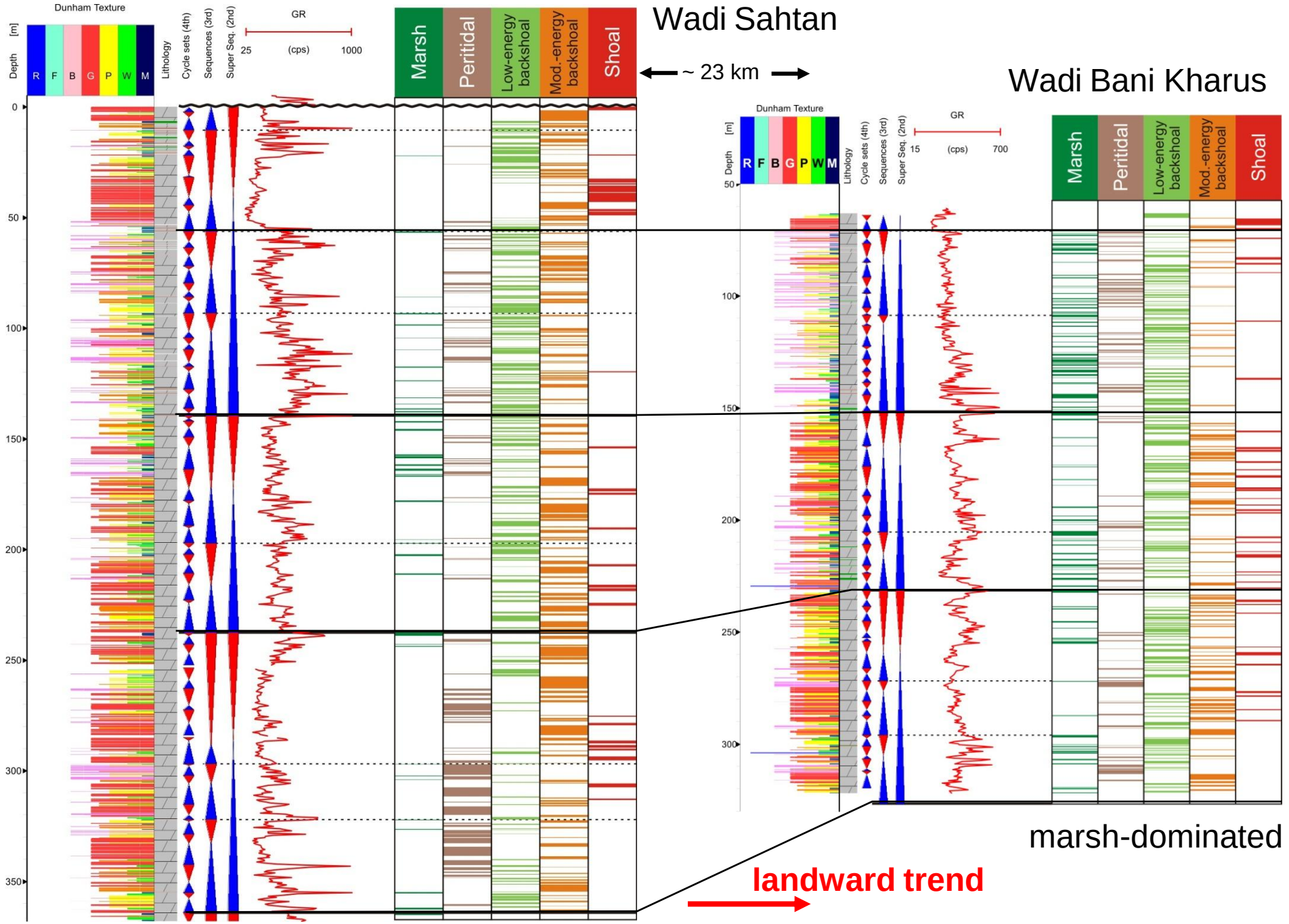
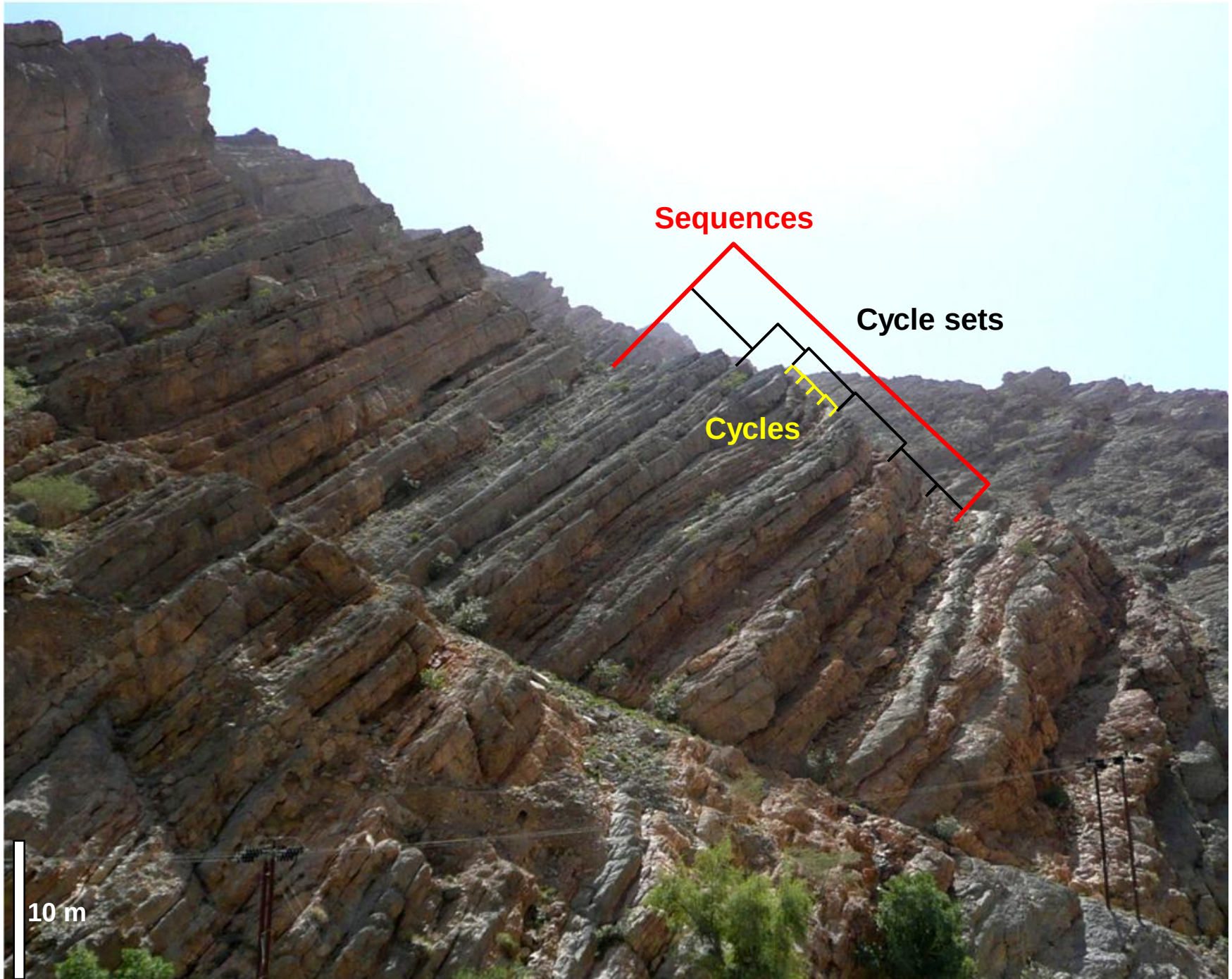
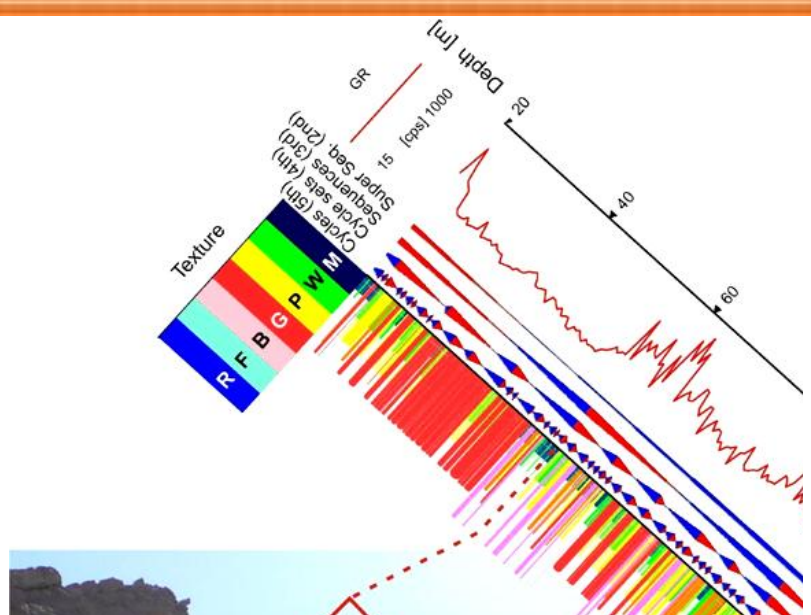
Correlating stacking pattern diagrams

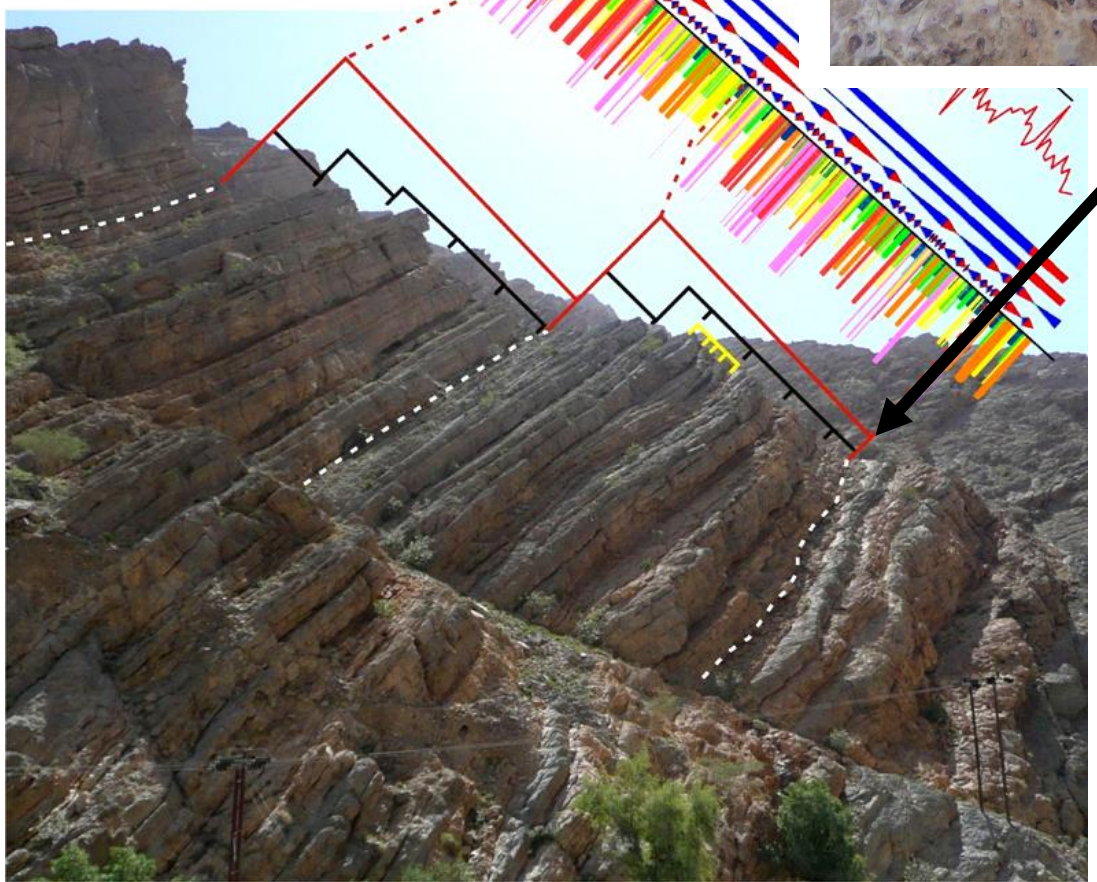


Multi-fold cyclicity



Multi-fold cyclicity





rootlets

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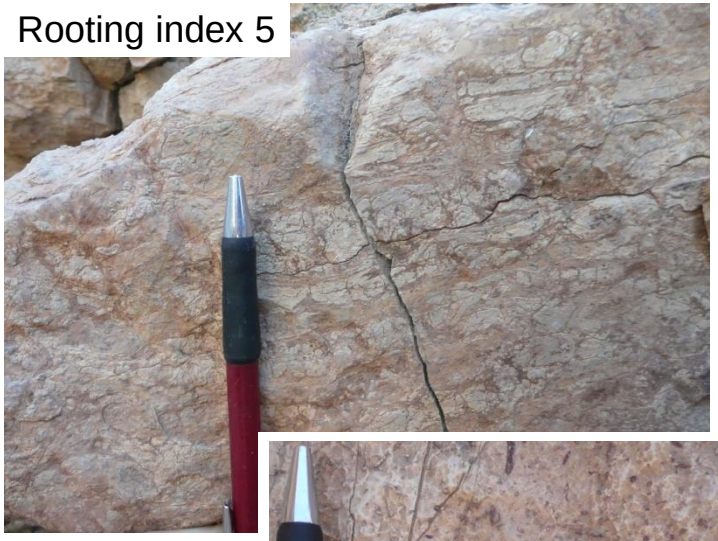
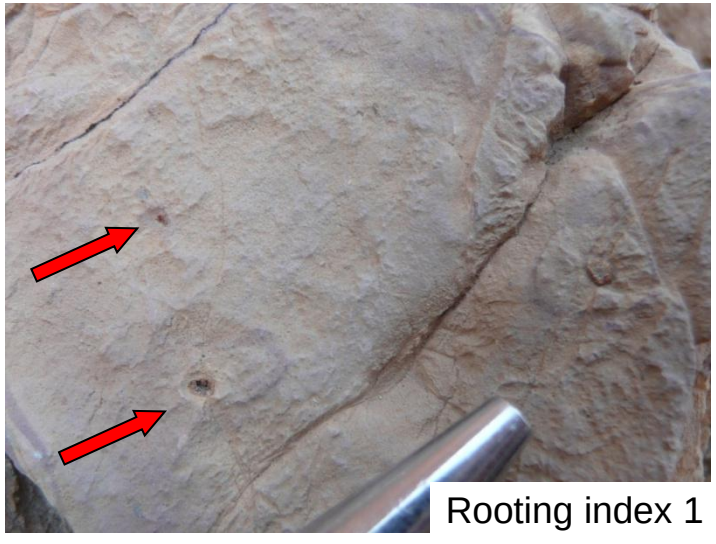
Degree of rooting

Rooting index 5

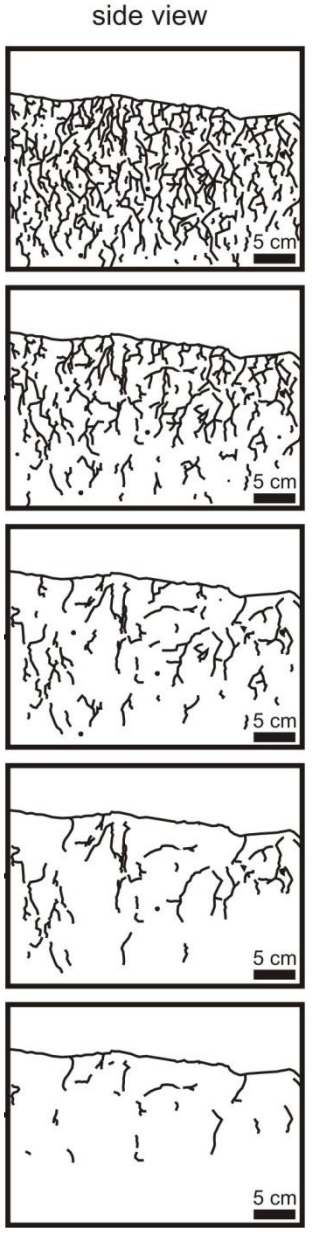


Rooting index 3



Rooting index 1

semiquantitative tool to determine order of a sequence boundary from outcrops & subsurface cores



large-scale sequence boundaries

small-scale cycle boundaries

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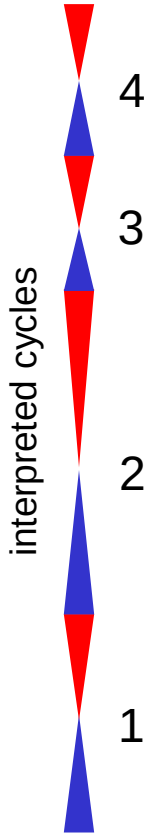
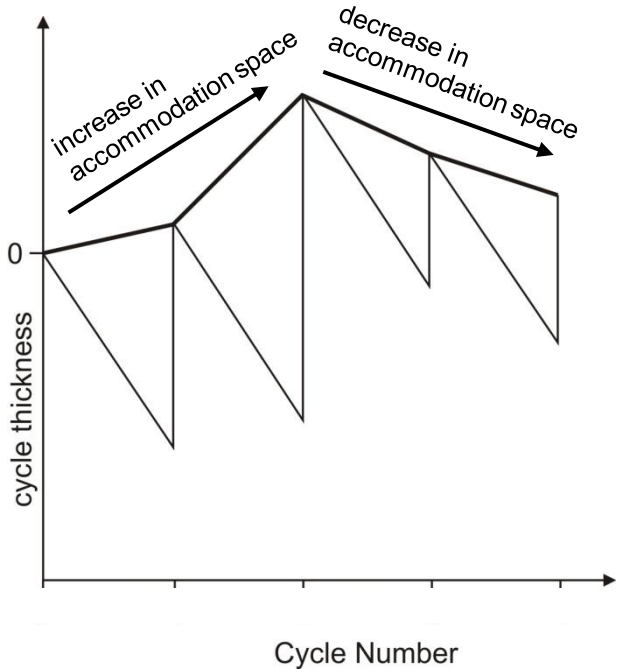
Fischer plot - principle



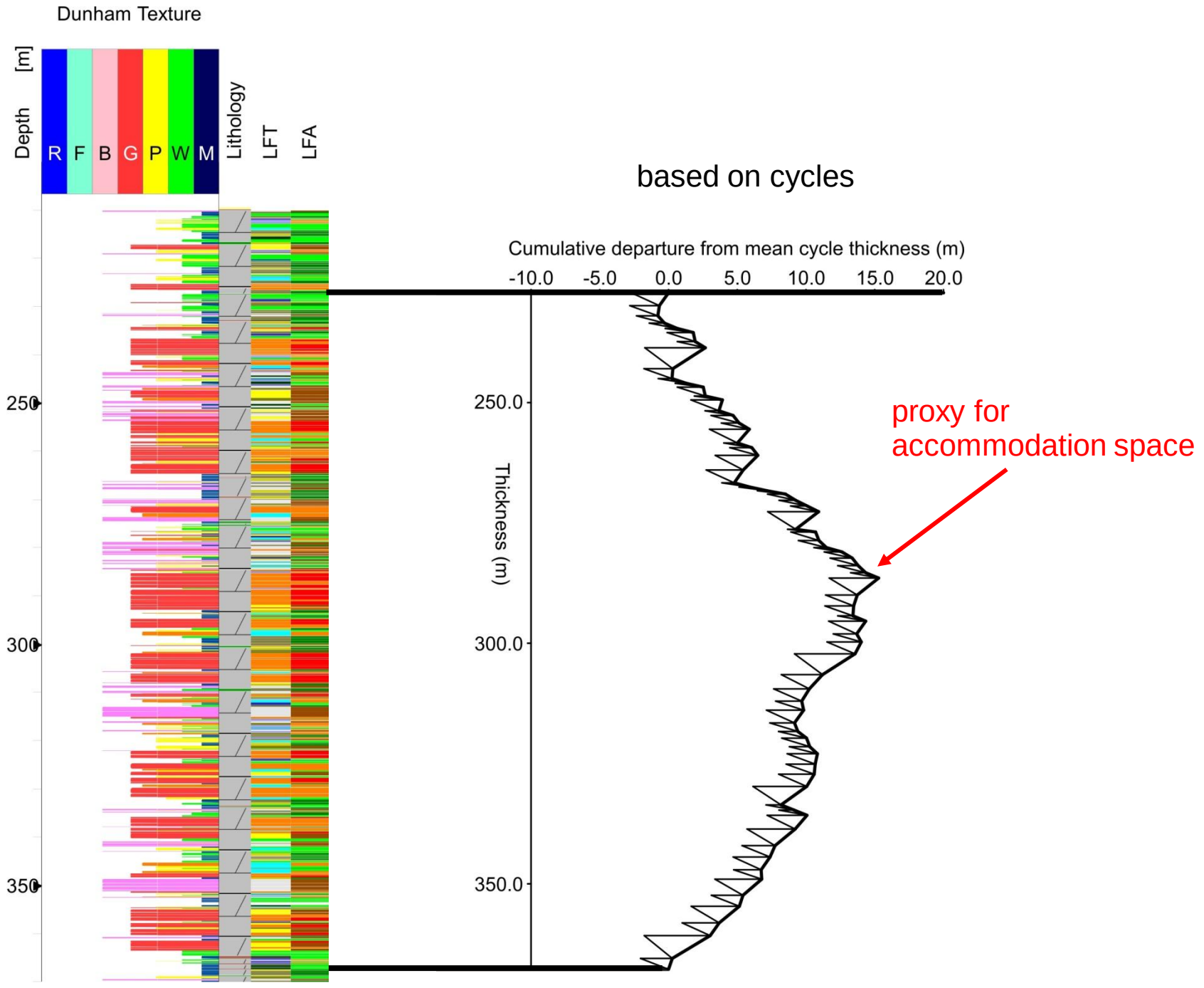


Assumptions:

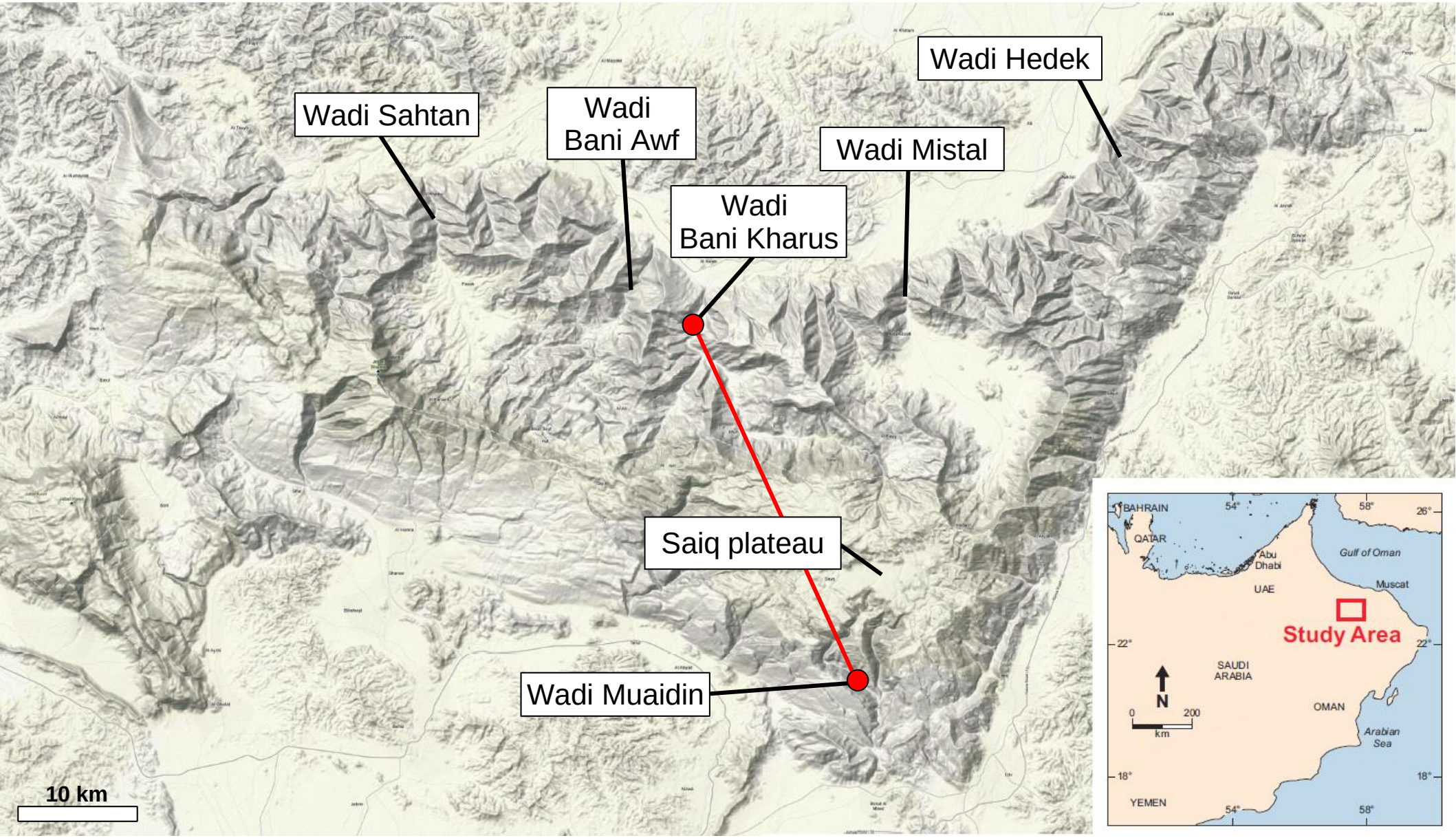
- peritidal environment with shallowing-upward cycles ✓
- same cycle duration ✓
- linear subsidence rate ✓

→ cycle thickness reflects available accommodation space

Fischer plot – *Wadi Muaidin*

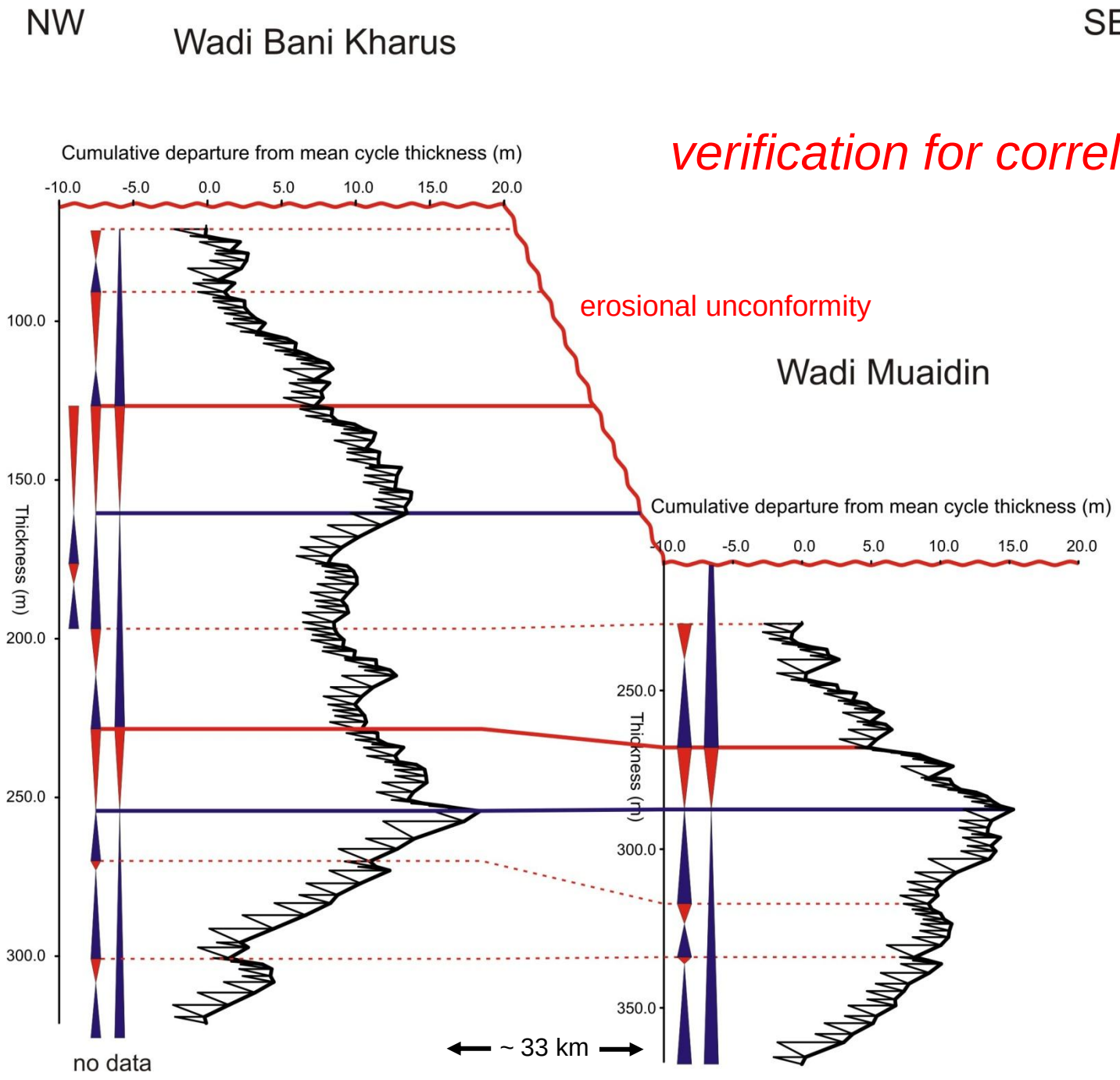


Fischer plot correlation



http://maps.google.com

Fischer plot correlations



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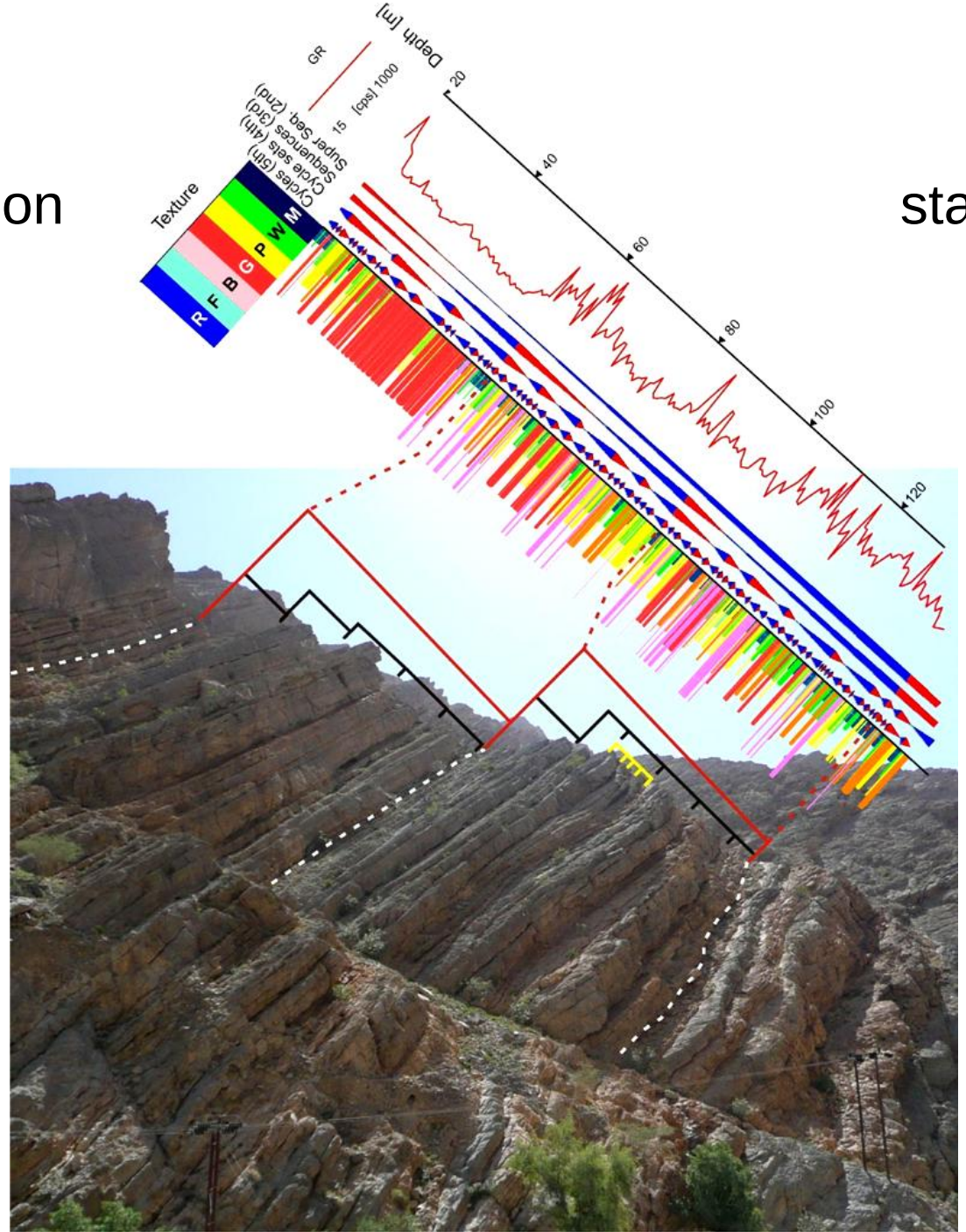
Integrated Approach

- Facies proportion curves & stacking pattern diagrams
  - ➔ determination of sequence stratigraphic framework
- Rooting index
  - ➔ first-pass indicator of order of a seq. boundary
- Fischer plots
  - verification of correlation

Multiple criteria: robust seq. stratigraphy

facies proportion curves

stacking pattern diagrams



rooting index

fischer plots