Quantitative Tarfaya Basin Development, Morocco*

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Abstract

The Southern Morocco on- and offshore continental margin includes a Permian to Neogene basin fill of up to 10,000 m thick. Three composite dip-oriented transects (TR1-3) have been investigated by high-resolution quantitative sequence stratigraphy and inverse flexural basin modeling. The subsidence/uplift history of the Tarfaya Basin shows nine trends (ST1-9), which show lateral variations in rates and timing but appear throughout the basin. The basin history includes the Late Permian to Triassic rift, sag and early drift stages (ST1), covering 61 m.y. (250-189 Ma). The average subsidence rate was 68 m/m.y. and the average sediment flux 15 m^2/m.y. Thermo-tectonic subsidence was the main component of total subsidence during the rift to early drift basin stages. A uniform basin-wide subsidence trend does not exist in ST1. ST2-4 of Toarcian to Tithonian age are bounded by the Post-Rift Unconformity (PRU) and the Mature Drift Unconformity (MDU). They extended from the onset of sea-floor spreading to final carbonate platform development. ST2 (189-164.4 Ma) and ST4 (154-144.2 Ma) show a decreasing trend in subsidence, while ST3 (164.4-154 Ma) shows an increasing subsidence trend. Subsidence rates vary between zero to 50 m/m.y. with a maximum of >75 m/m.y. in ST3. Sediment flux varies between three and six m^2/m.y. during the Jurassic with a maximum of 15 m^2/m.y. in TR3 during ST3 and eight to twelve m^2/m.y. in TR1 and TR2 during ST4. Mature drift basin architecture, sediment infill and distribution differ considerably during the Early Cretaceous mature drift stages ST5 to early ST7. TR1 and TR2 were affected by salt mobilization, while TR3 remained unaffected for its location south of the Tarfaya salt province. Subsidence rates varied between -15 m/m.y (uplift) and 60 m/m.y. In TR3, the highest subsidence rates occurred in ST5 (144.2-132 MA). In TR2, peak subsidence developed in ST6 (132-123 Ma) and early ST7 (123-65) on TR1. Peak sediment flux with more than eight m^2/m.y. occurred in ST6 (TR3) and early ST7 (TR1). Sediment flux in TR2 stayed largely constant. The current model implies that subsidence trends where triggered by i) changes in intra-plate

balance forces induced by changes in sea-floor spreading rates; ii) shifts in the sea-floor spreading axes; iii) the stepwise migration of crustal separation and seafloor spreading from the Central Atlantic to the north; and iv) relative plate motions and convergence rates between Africa and Eurasia.

Reference

Wenke, A., R. Zuhlke, H. Jabour, and O. Kluth, 2011, High-resolution sequence stratigraphy in basin reconnaissance; example from the Tarfaya Basin, Morocco: First Break, v. 29/11, p. 85-96.

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Objectives

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- Database and workflow
- Stratigraphic framework (2nd order sequence stratigraphy)
- Time/depth conversion
- Flexural basin modeling
- Subsidence rates
- Sediment flux
- Summary & Conclusion

Database and key transects – Seq Strat

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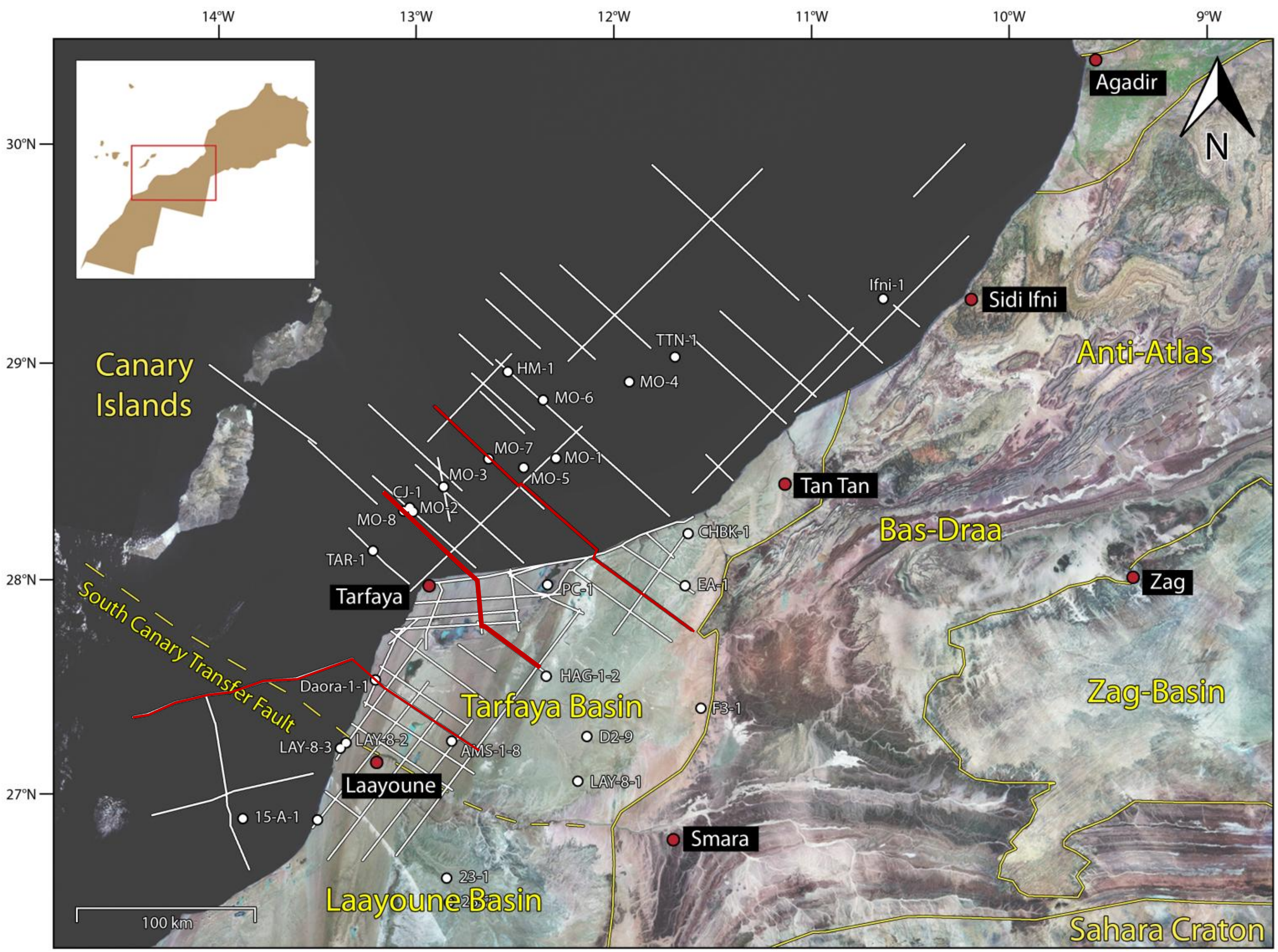

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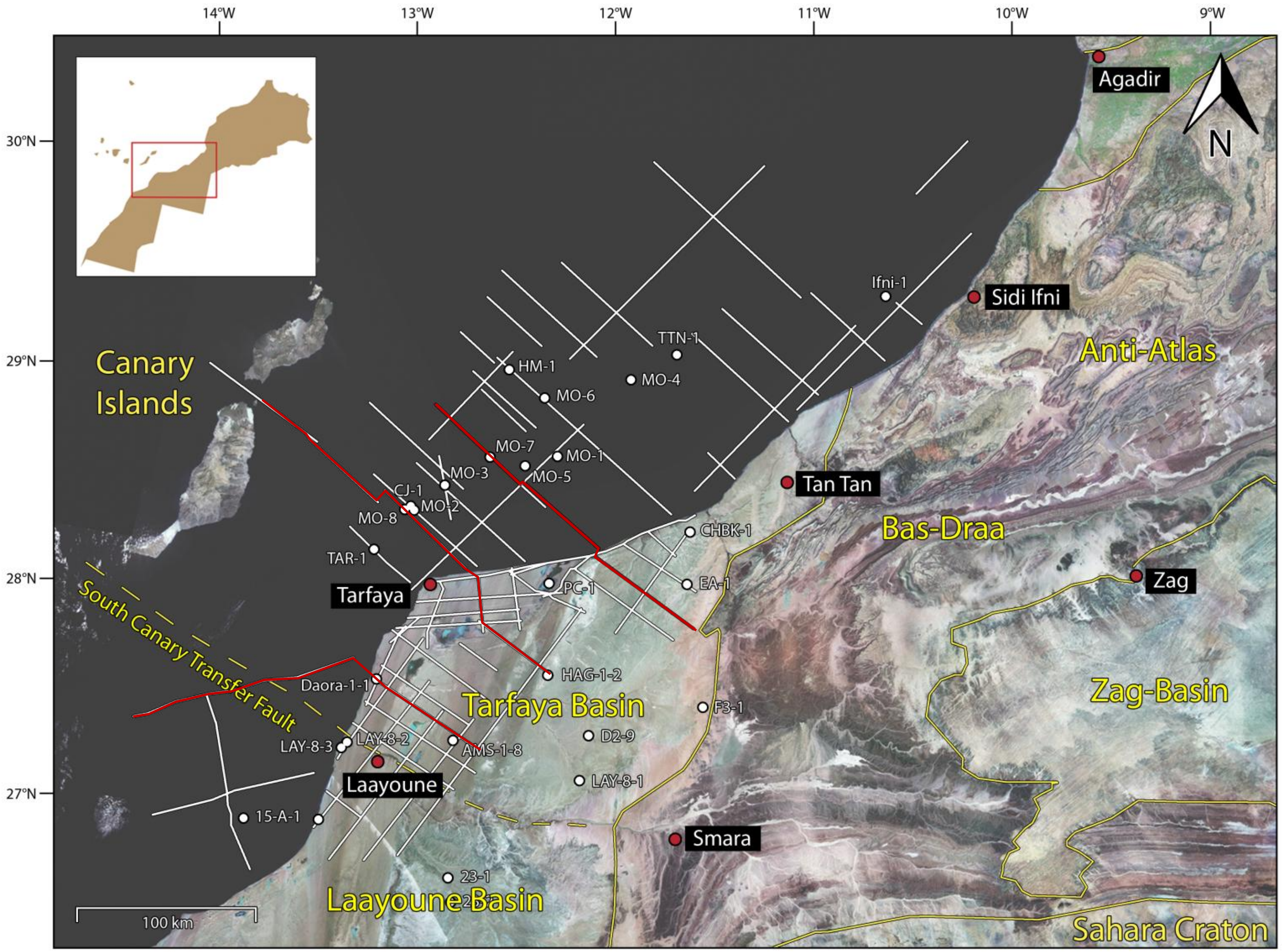
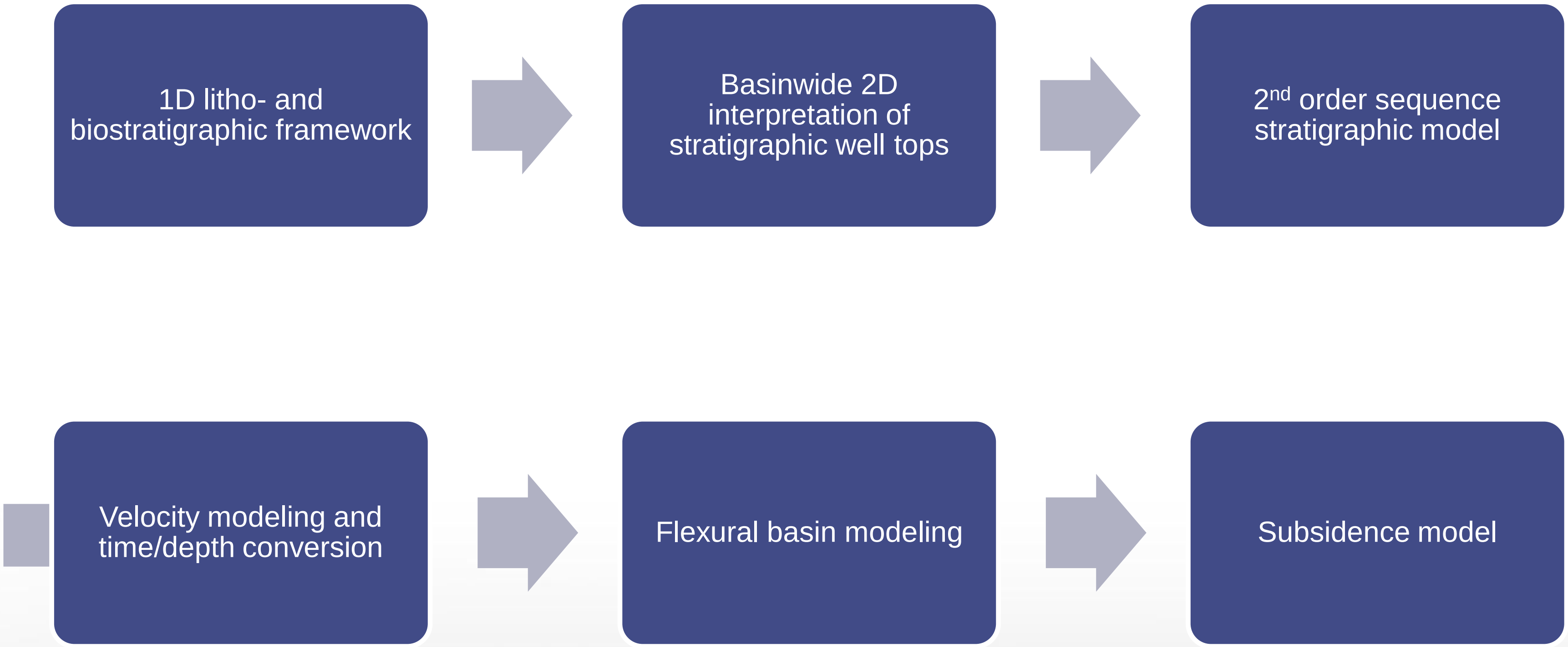


Workflow


1D litho- and biostratigraphic framework
Basinwide 2D interpretation of stratigraphic well tops
2nd order sequence stratigraphic model
Velocity modeling and time/depth conversion
Flexural basin modeling
Subsidence model

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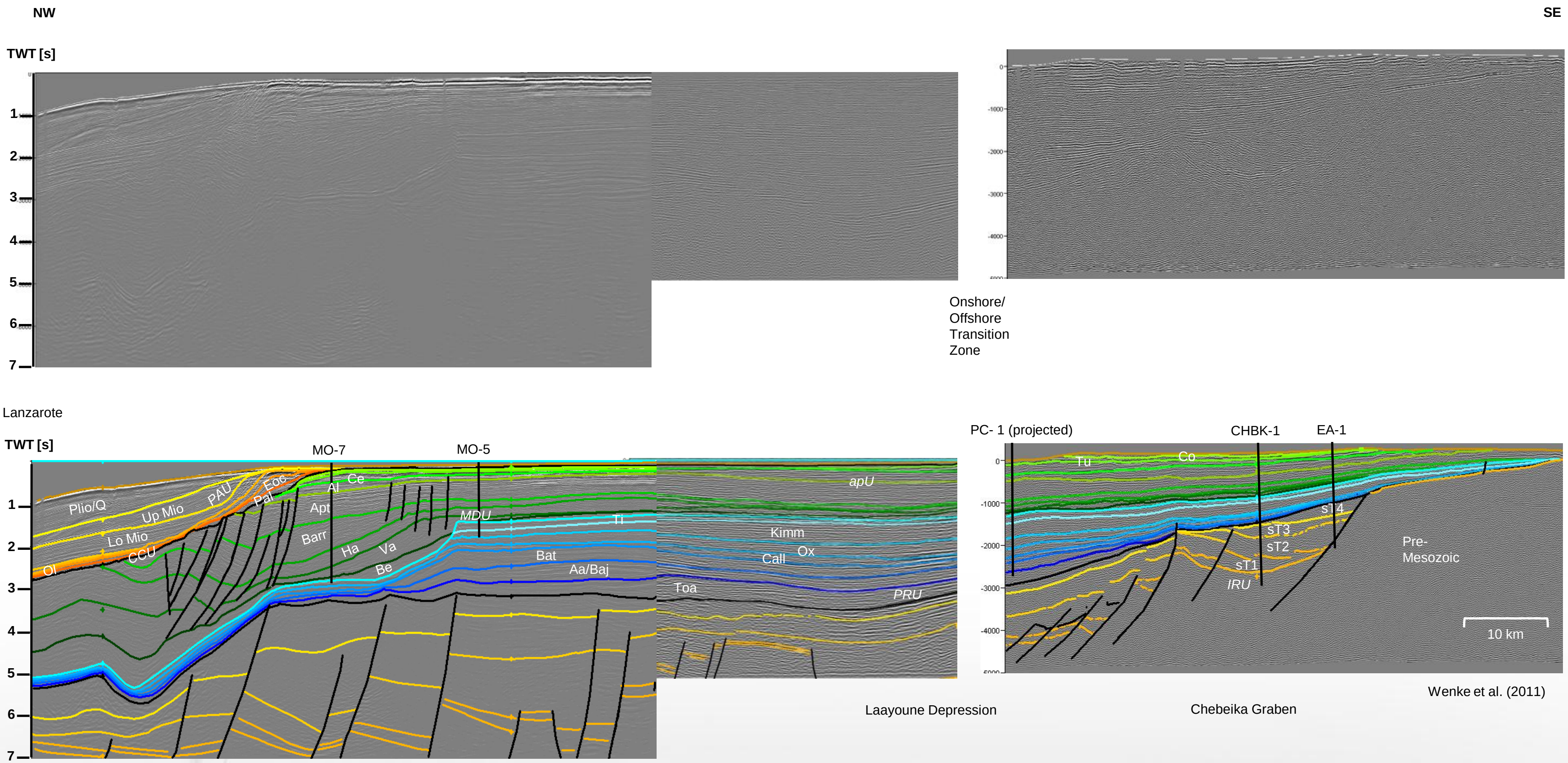
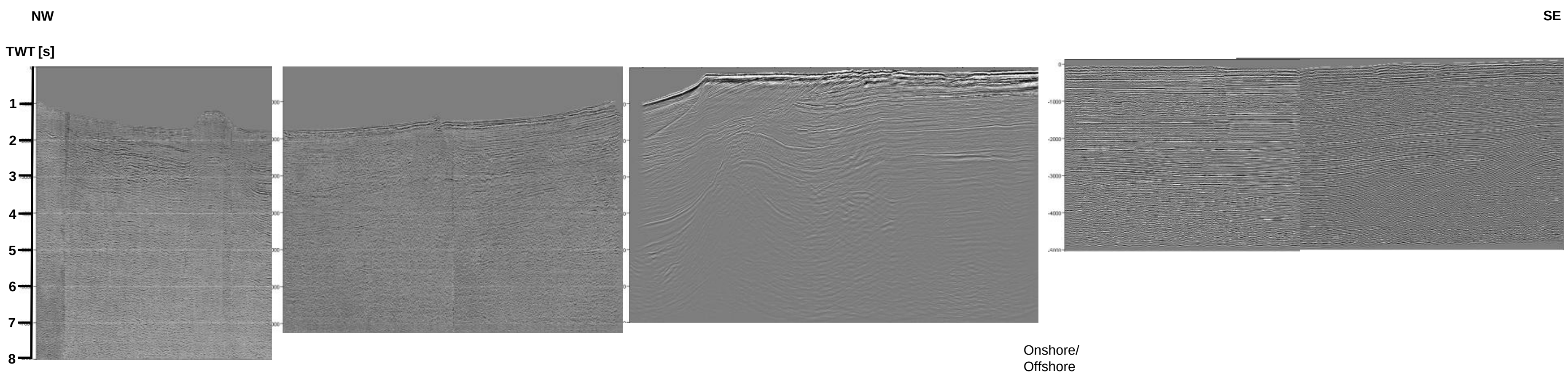
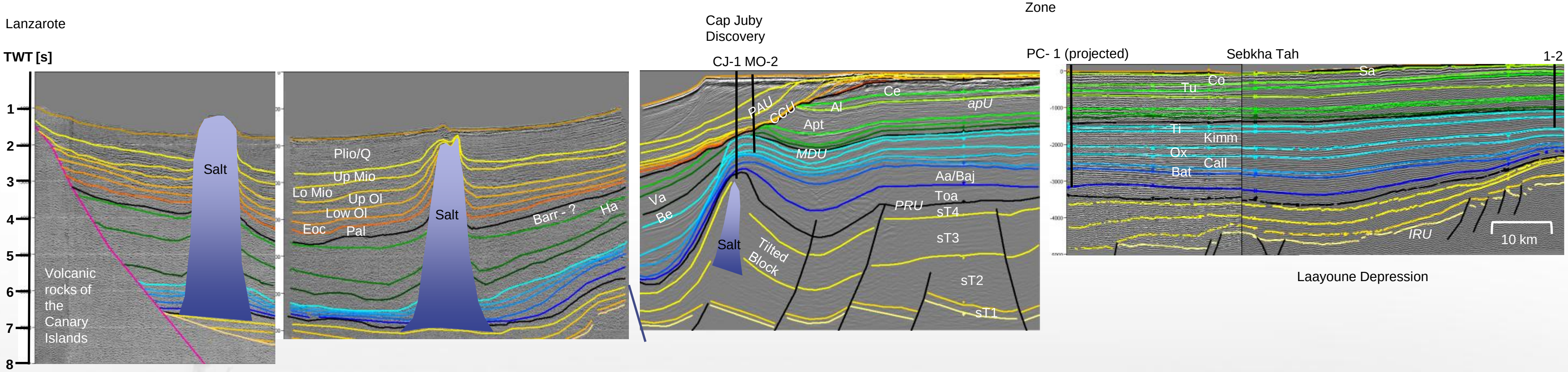
Stratigraphic Framework

2nd order seq strat framework – TR 2

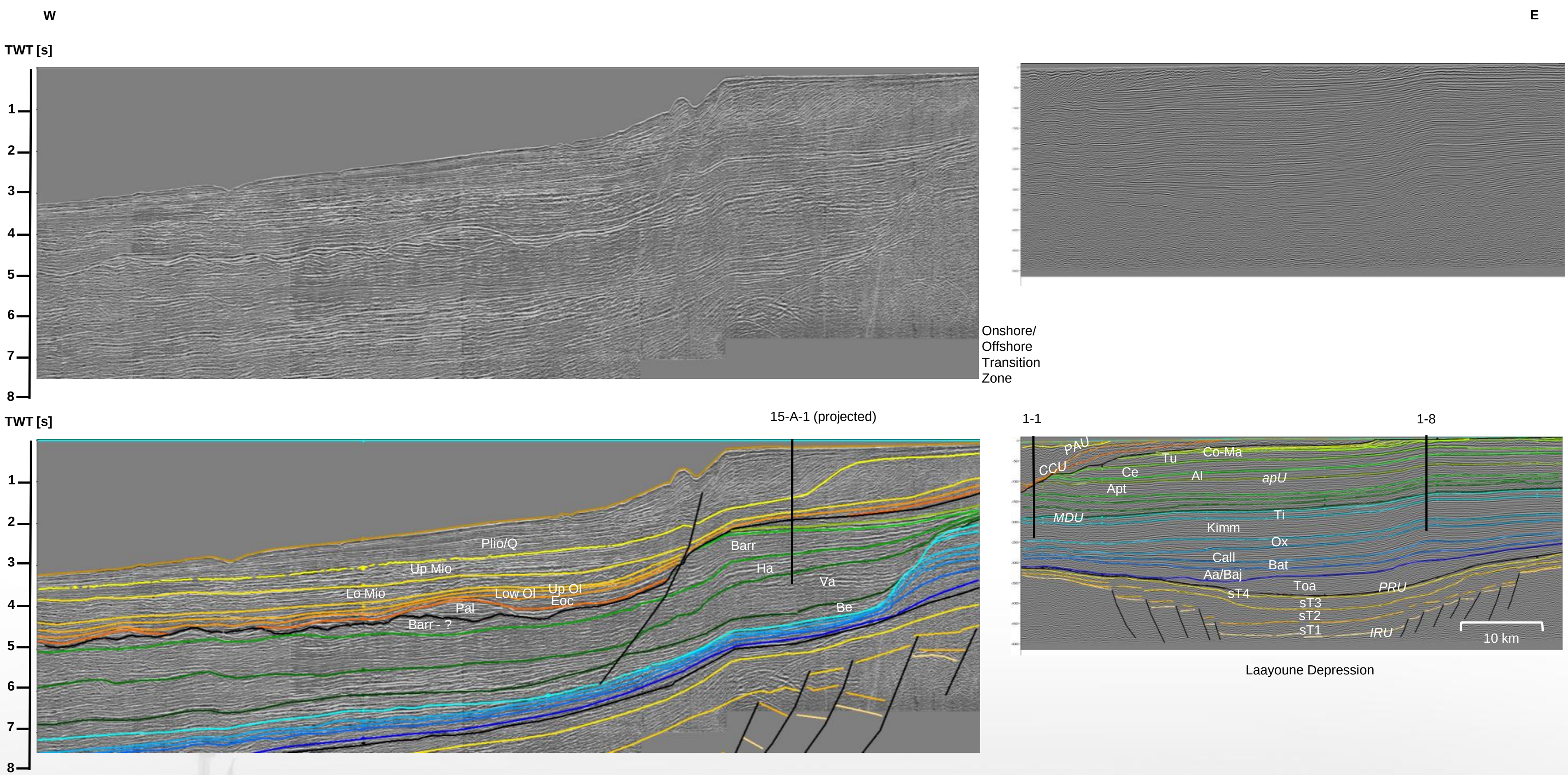


2nd order seq strat framework – TR 2



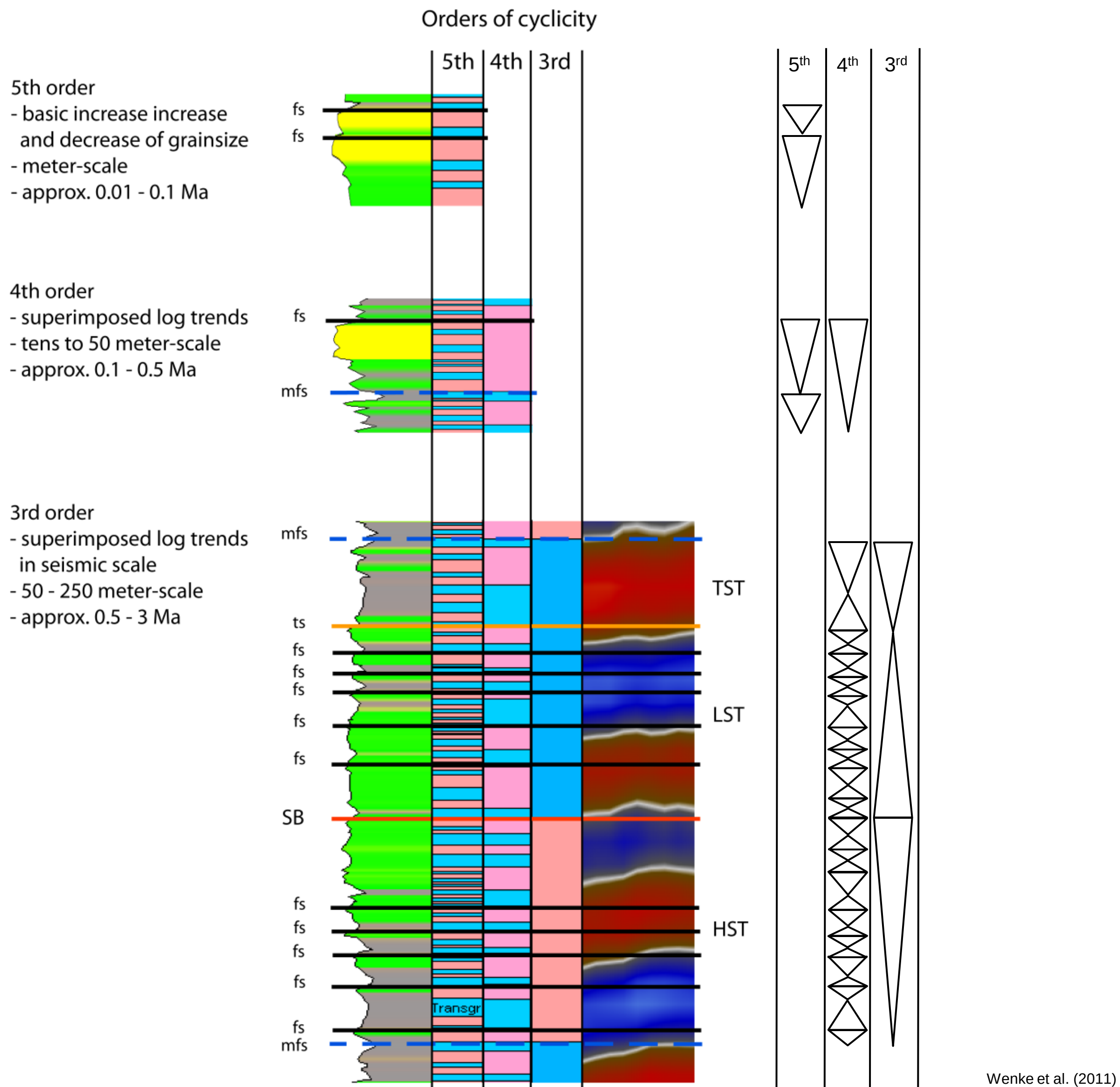


2nd order seq strat framework – TR 3



Well Sequence Stratigraphy

Log Patterns



Well Sequence Stratigraphy – TR1

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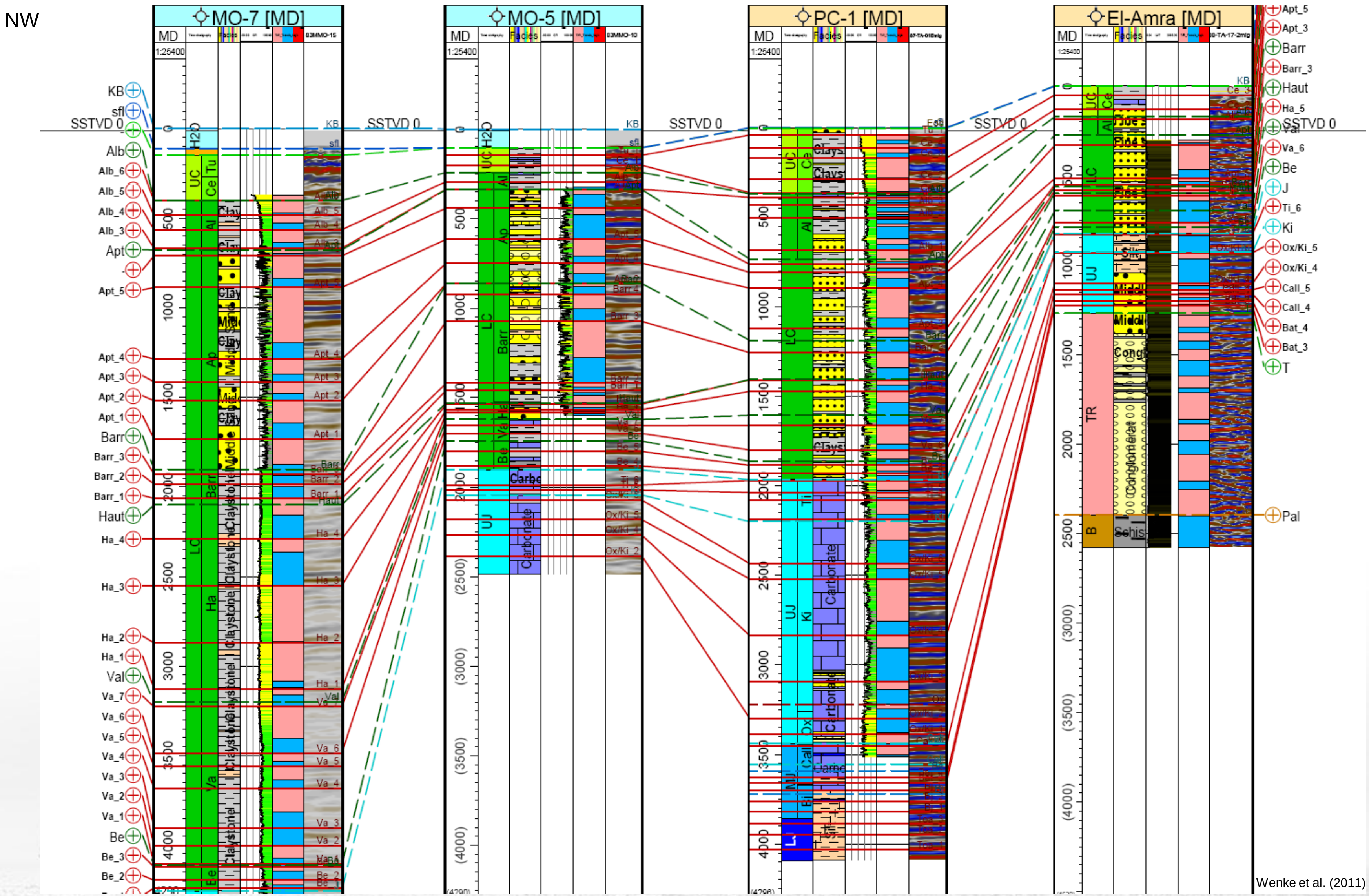

Wenke et al. (2011)

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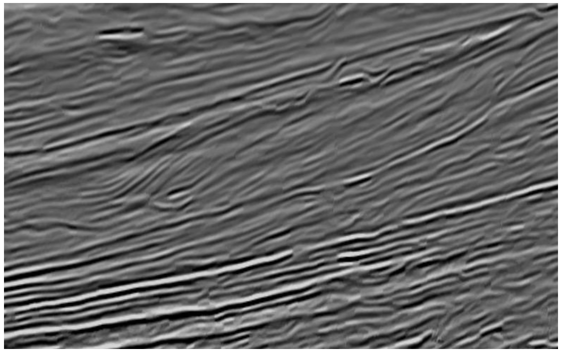
Seismic Sequence Stratigraphy

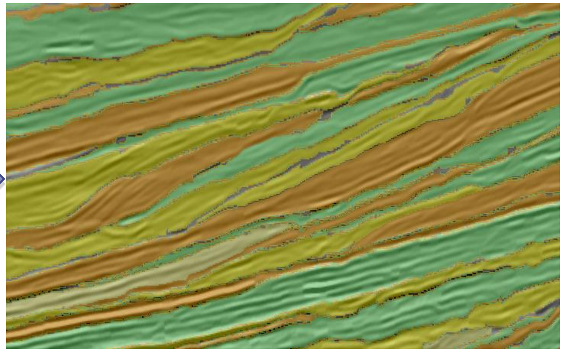
OpendTect SSIS Sequence analysis

- Semiautomatic chronostratigraphic order of seismic reflectors
- Systems tract analysis



Scaling and filtering of seismic transects

Chronostratigraphy of seismic reflectors



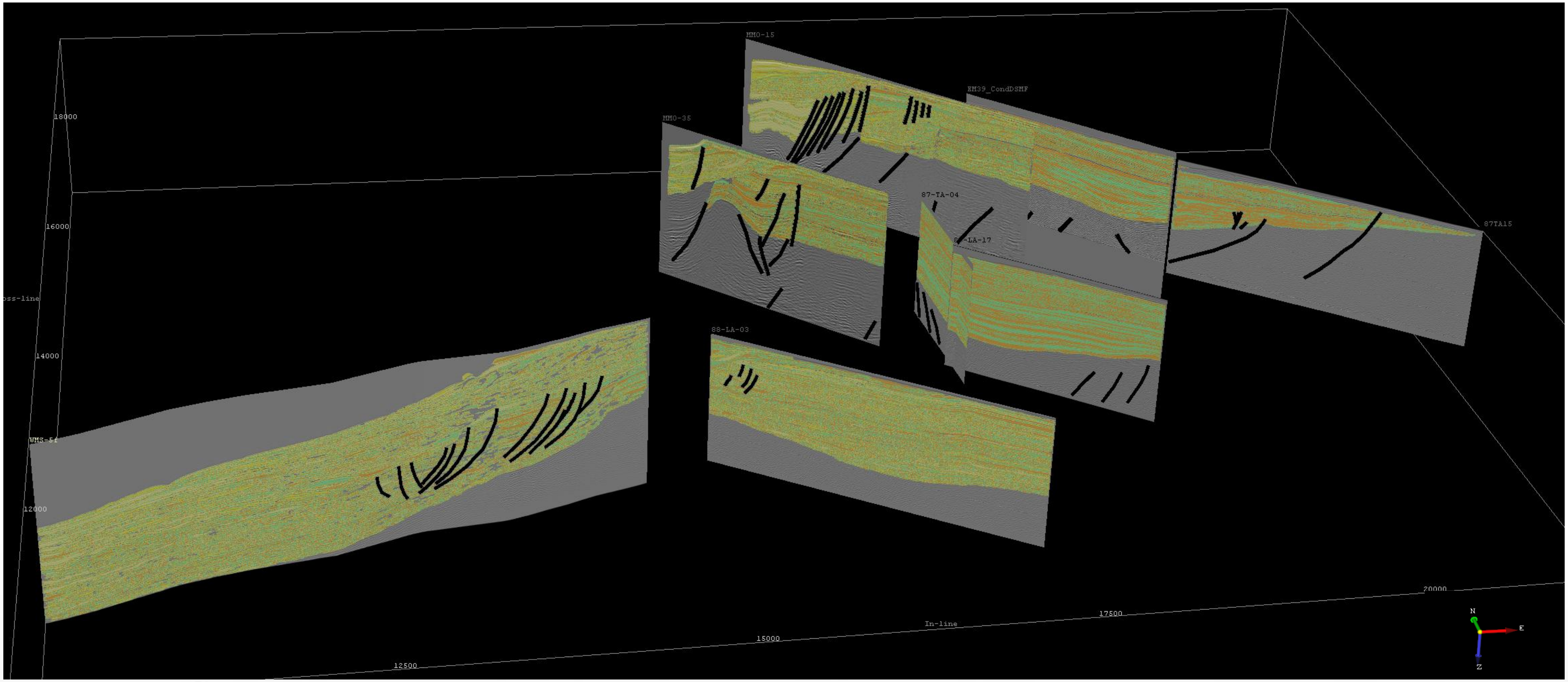
Determination of system tracts

HST

TST

LST

Seismic Sequence Analysis



Seismic Sequence Analysis

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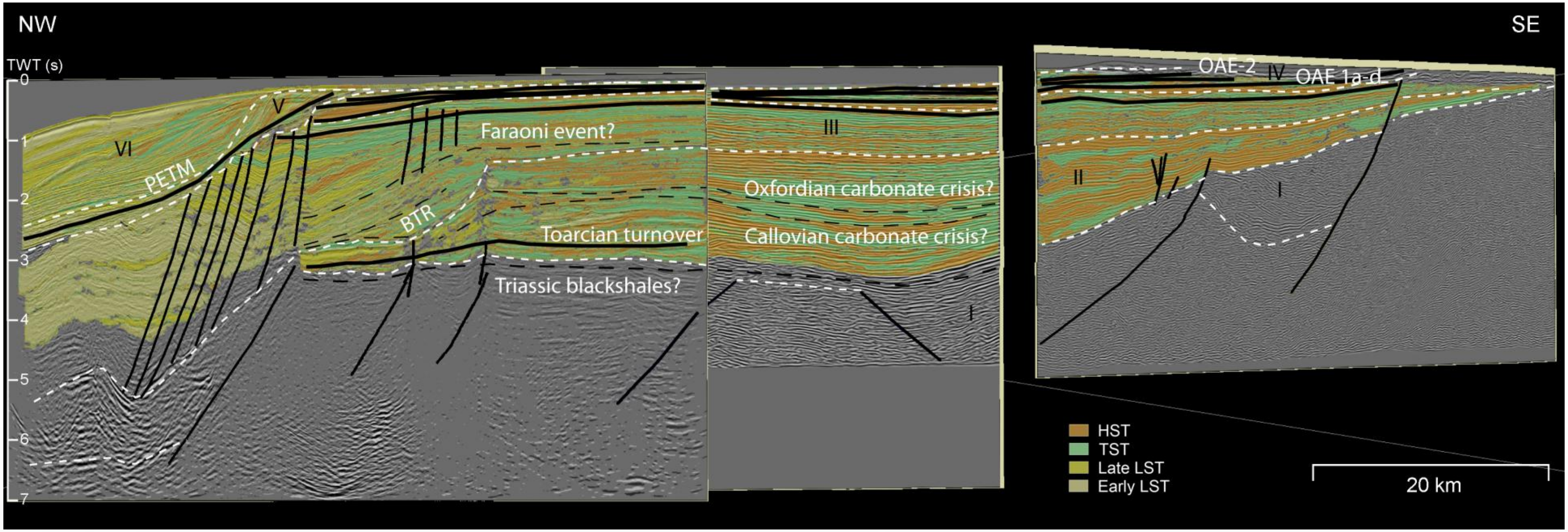
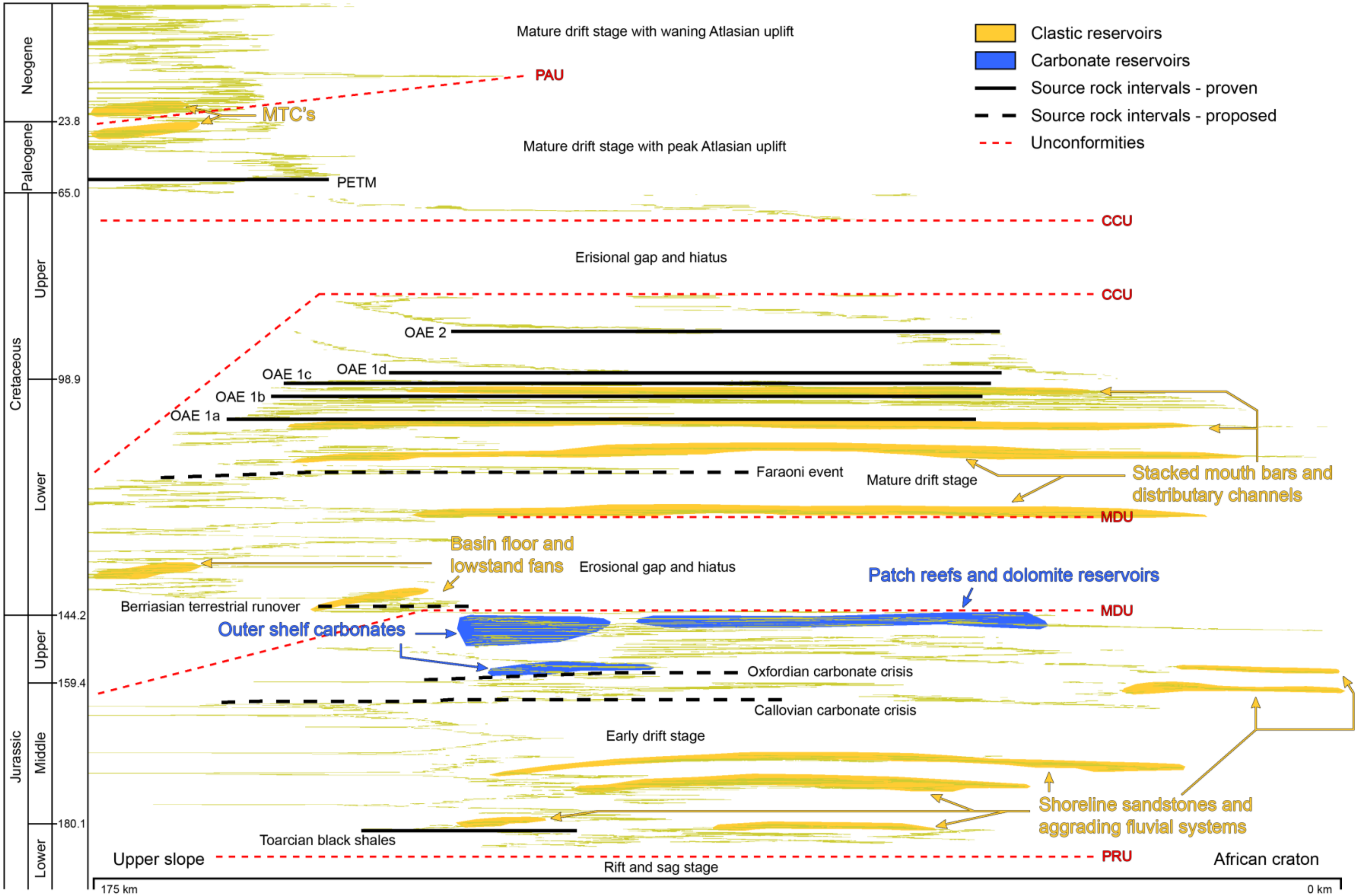


Wenke et al. (2011)

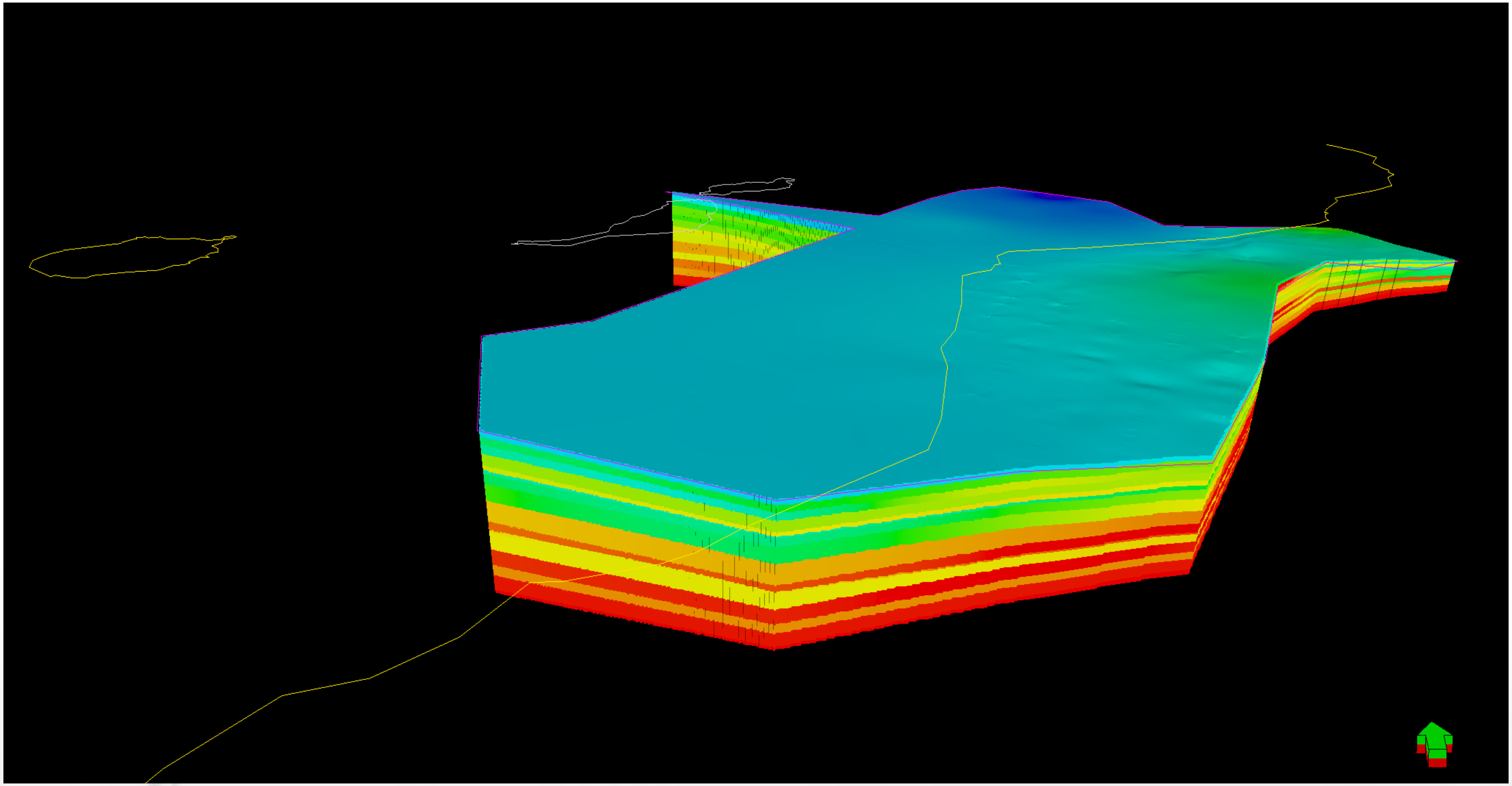
Seismic Sequence Analysis



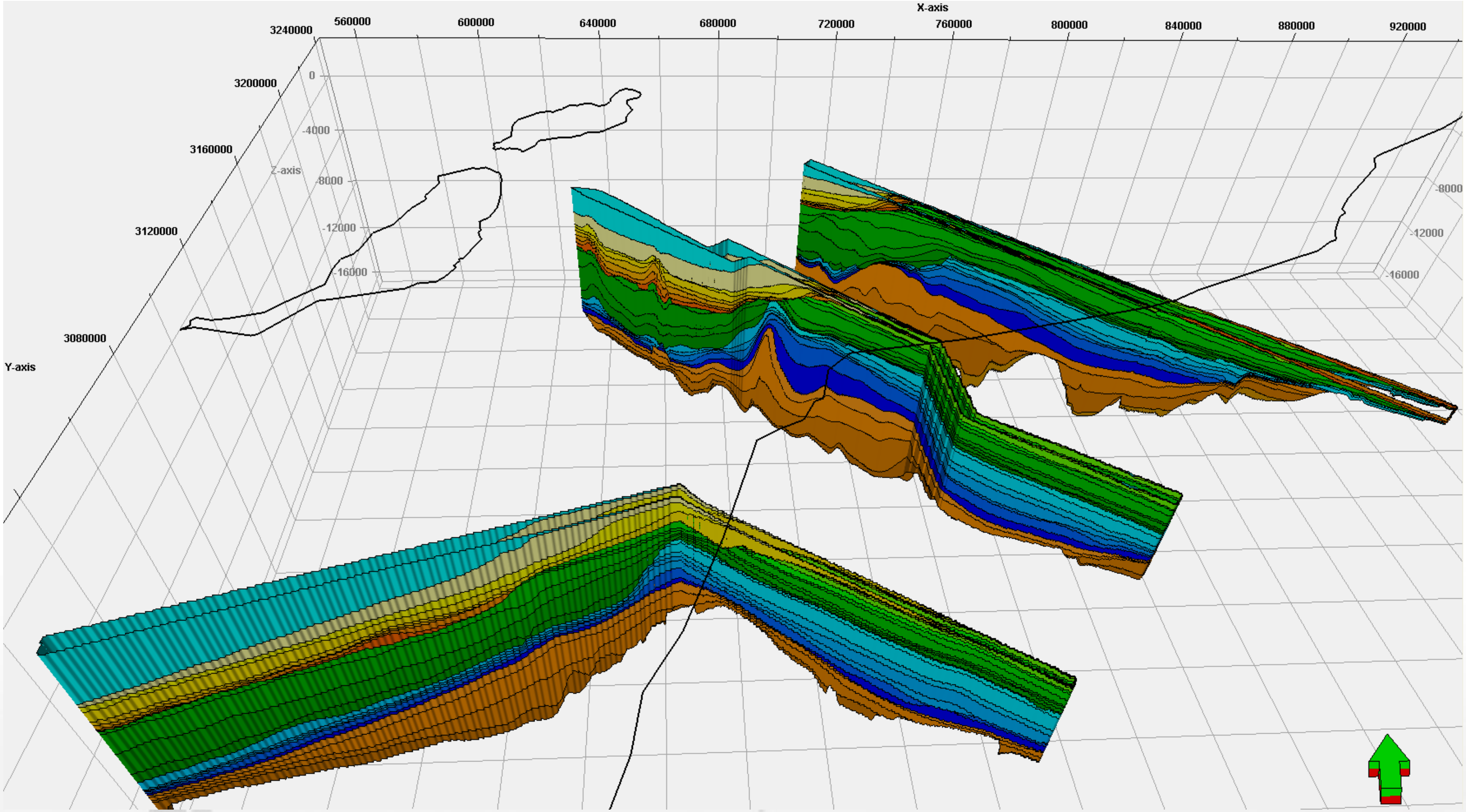
Wenke et al. (2011)

Time/Depth Conversion

3D velocity cube



Flexural modeling input data



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Flexural Basin Modeling

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Input data

- Stratigraphy
- Paleobathymetry
- Eustatic sea-level
- Crustal flexural paramteres (Te, taper limit, mantle density)

Results

- Basin architecture in time
- Subsidence evolution
- Sediment flux

Reverse modeling – TR1

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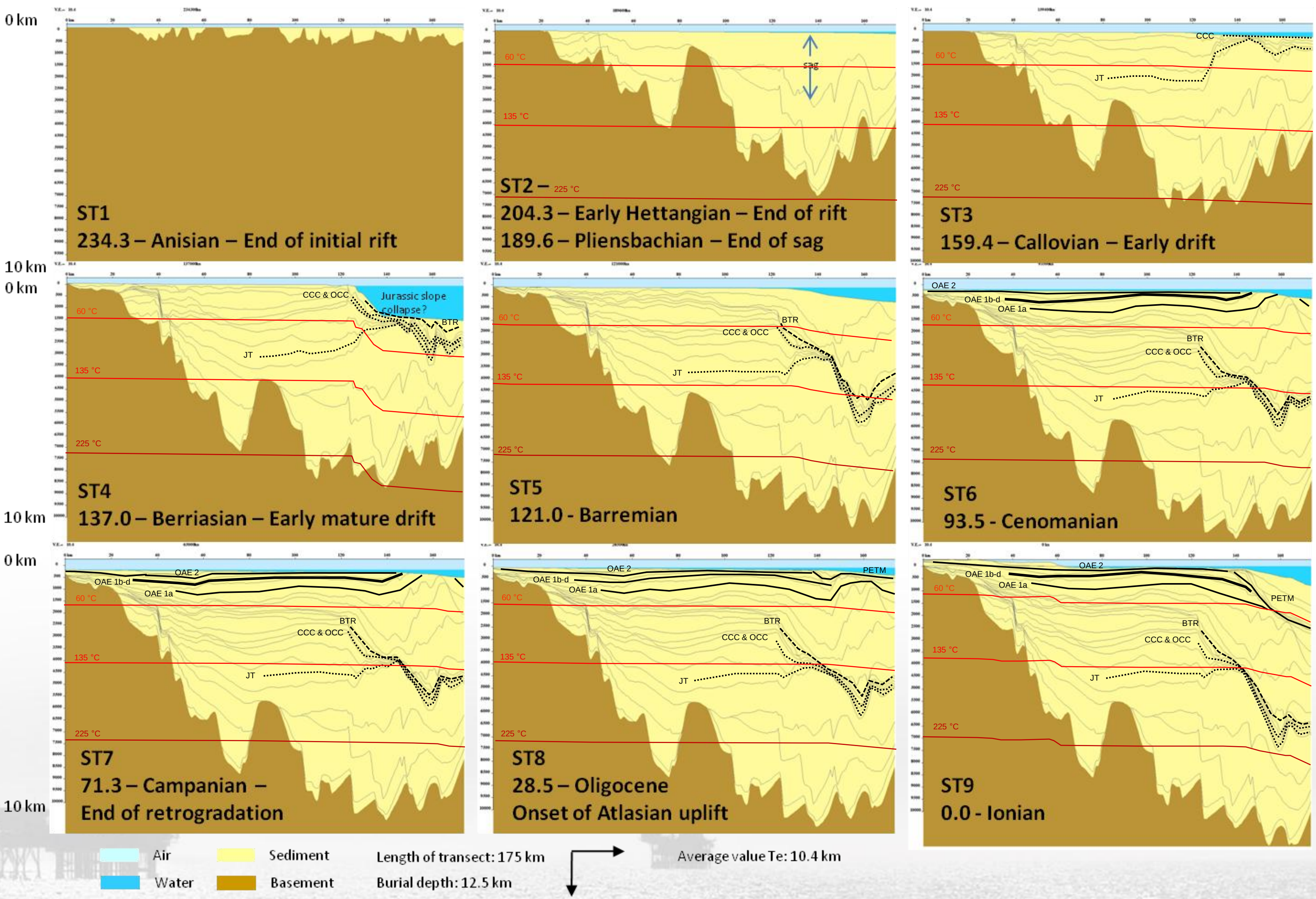

Reverse modeling – TR2

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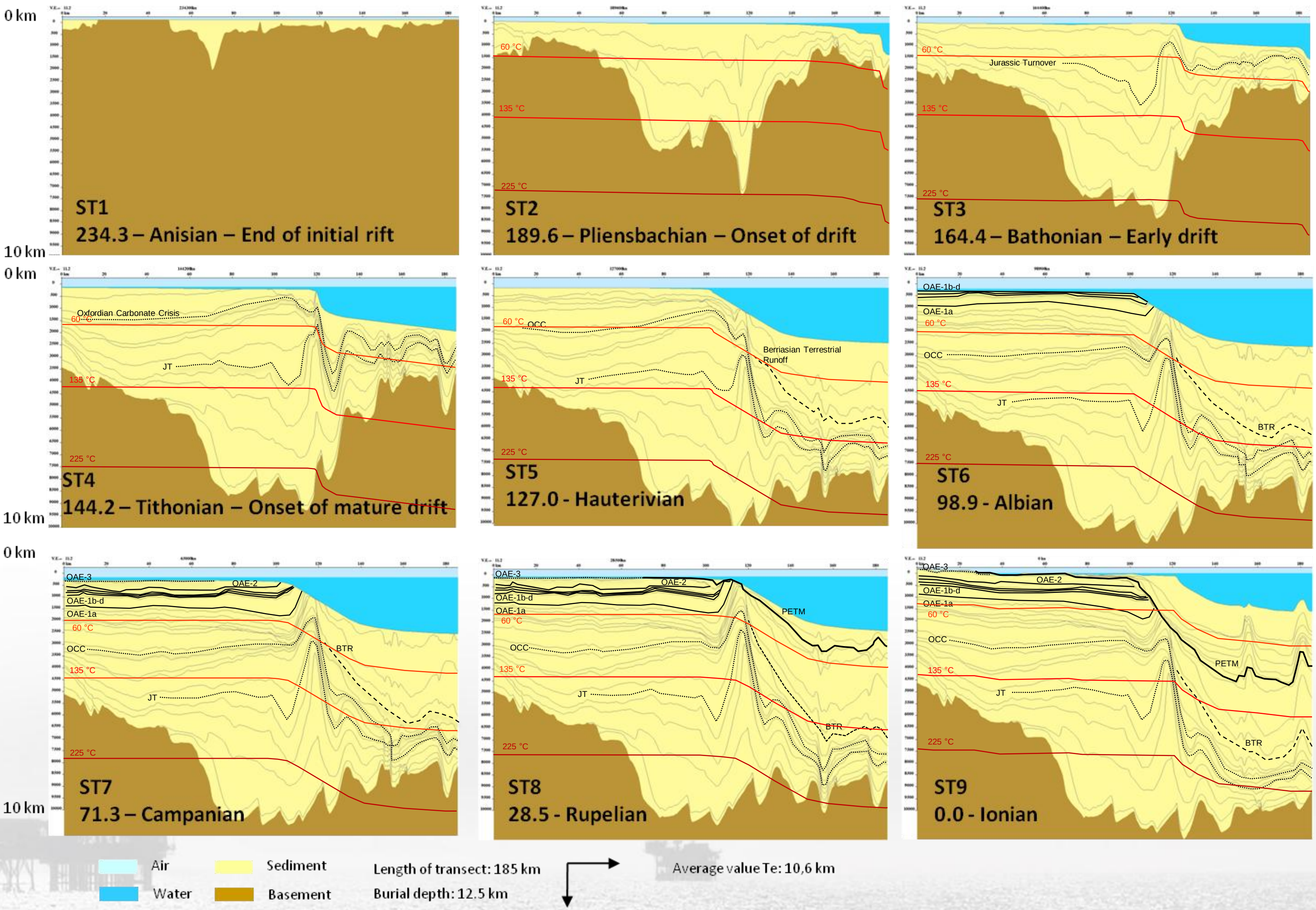
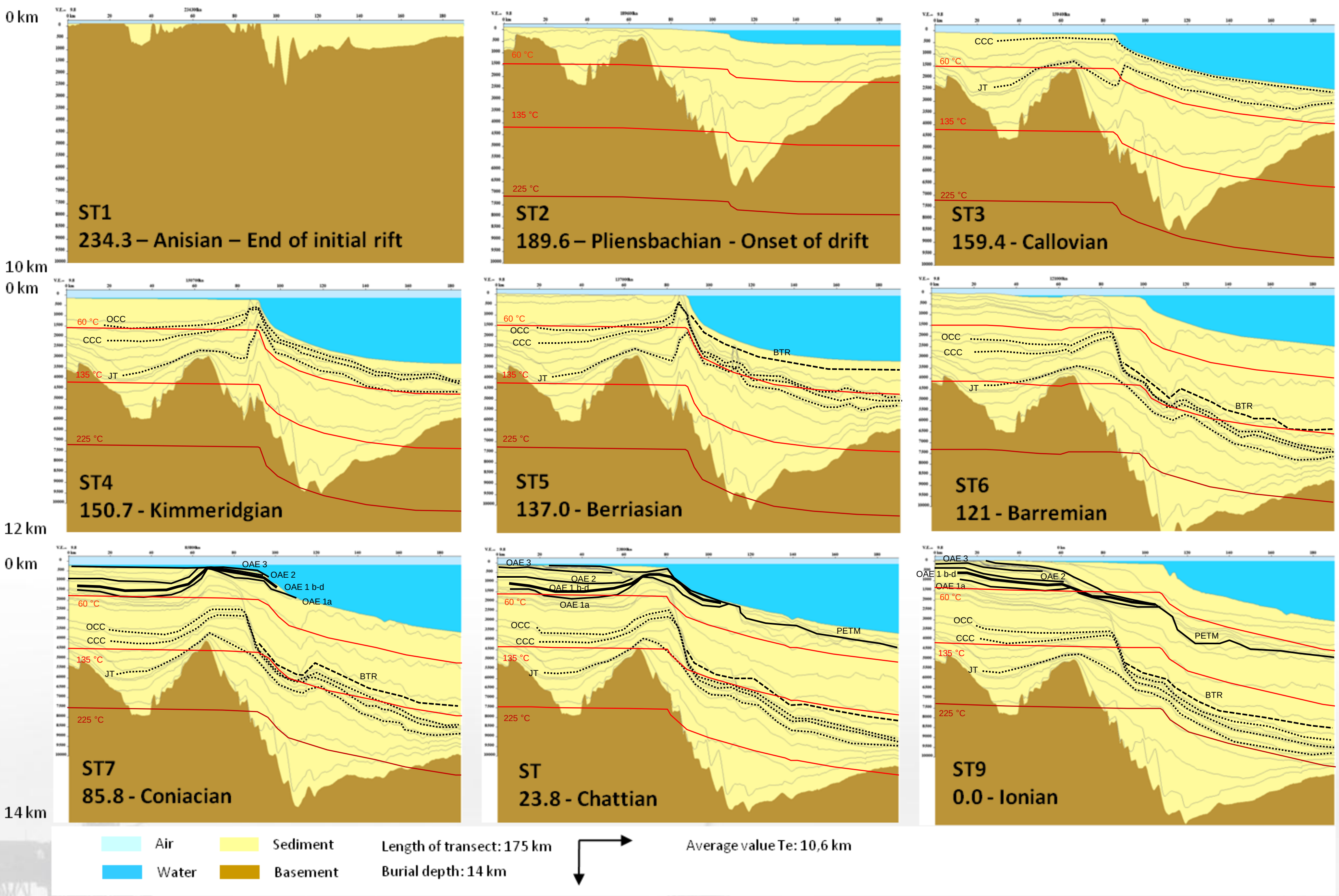


Reverse modeling – TR3



Subsidence rates and sediment flux

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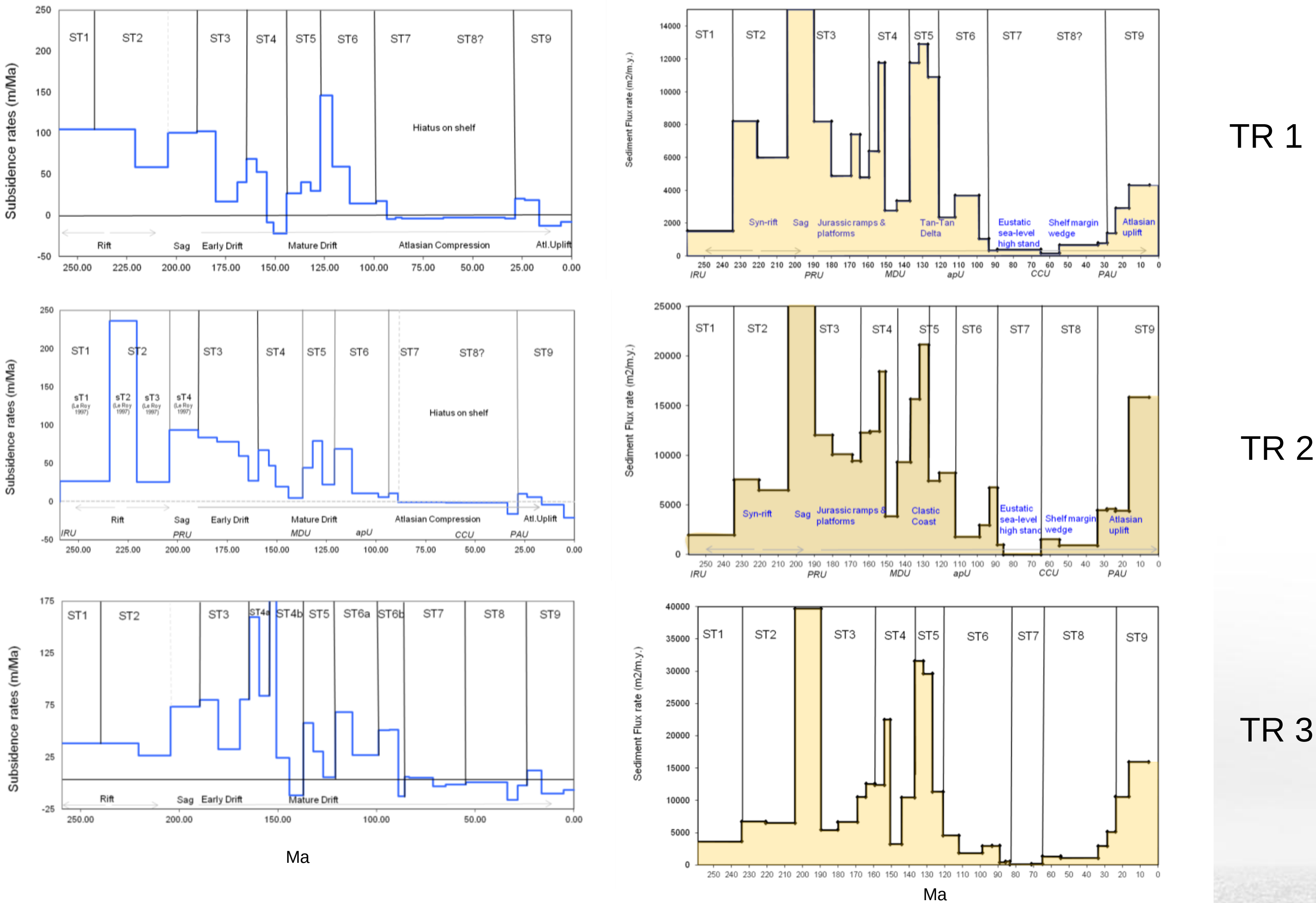

Summary & Conclusion

- Accomodation space primarily controlled by subsidence and sediment input
- Basinward migration of depocenters during Meso- to Cenozoic
  - 259.3-144.2 Ma, ST1-4 (Kazhanian – Tithonian): shelf
  - 144.2-71.3 Ma, ST 5-7 (Berriasian – Early Maastrichtian): shelf, slope and basin
  - 71.3-0 Ma, ST 8&9 (Late Maastrichtian – Neogene): slope and basin
- Shelf margin subsidence peaks vary moderate during basin development
- Shelf margin subsidence show cyclicity with a decrease of amplitude through time
- Regional effects overprint the spreading signal in ST6 (salt movement) and ST9 (Atlasian uplift)
- Subsidence history of the northern LB is independent from central and northern TB development
- Peaks in sediment flux took place during ST2 (Rift), ST3/ST4 (carbonate production), ST5/ST6 (Tan Tan and Boujdour Deltas) and ST9 (Atlasian uplift and erosion)

Thank you!