Application of Chronostratigraphic and Lithostratigraphic Concepts to Deepwater Reservoir Characterization*

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Search and Discovery Article #40652 (2010)
Posted December 6, 2010

*Adapted from oral presentation at AAPG Convention, Calgary, Alberta, Canada, September 12-15, 2010

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Abstract

Deepwater siliciclastic sands were deposited by accumulations of external clastic materials carried by turbidite flows from shoreface or slope areas to the basins. However, whether the concepts of classic sequence stratigraphy model developed from relative coastal onlap and offlap can be applied to deepwater environment is still an issue of open debate, mainly because the magnitude of sea-level fluctuation in a typical third order cycle is much less than the total water depth of most deepwater basins. This paper presents a case study from a Gulf of Mexico deepwater reservoir currently under development to investigate the impact of relative sea level and sediment input in the development of submarine lobe system. A chronostratigraphic framework was constructed by integrating biostratigraphic data with regional seismic mapping using amplitude volumes. The framework was verified by quantitative analysis of petrographic, geochemical, and pressure data, and correlated to the GOM sequence chart. The top boundary of each sequence is capped by a shale interval that serves as the vertical barrier for flows, and limits the interval deposition of multi-sand zones, each with unique pressure trend, and representing subsequence deposition at higher frequencies. Subsequence deposition of reservoir scales was accomplished by two major processes, downlapping and backstepping, as revealed by investigation on seismic acoustic impedance (AI) volumes. The resultant depositional model allows us to successfully predict the occurrence of sand depositional events during the development drilling. We conclude that classic sequence stratigraphic concepts can be applied in deepwater turbidite environment in order to construct a chronostratigraphic framework, while by applying advanced seismic technology, profound lithostratigraphic correlation within each 3rd order sequence can be performed to characterize the pattern of flow unit distribution, greatly enhancing the effects of reservoir modeling on field development.

Reference

Plink-Bjorklund, and R.J. Steel, 2002, Sea level fall below the shelf edge, without basin-floor fans: Geology, v.30, p. 115-118.

Application of Chronostragraphic and Lithostratigraphic Concepts to Deepwater Reservoir Modeling

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(AAPG International Conference, Calgary, September 14, 2010)

Marathon

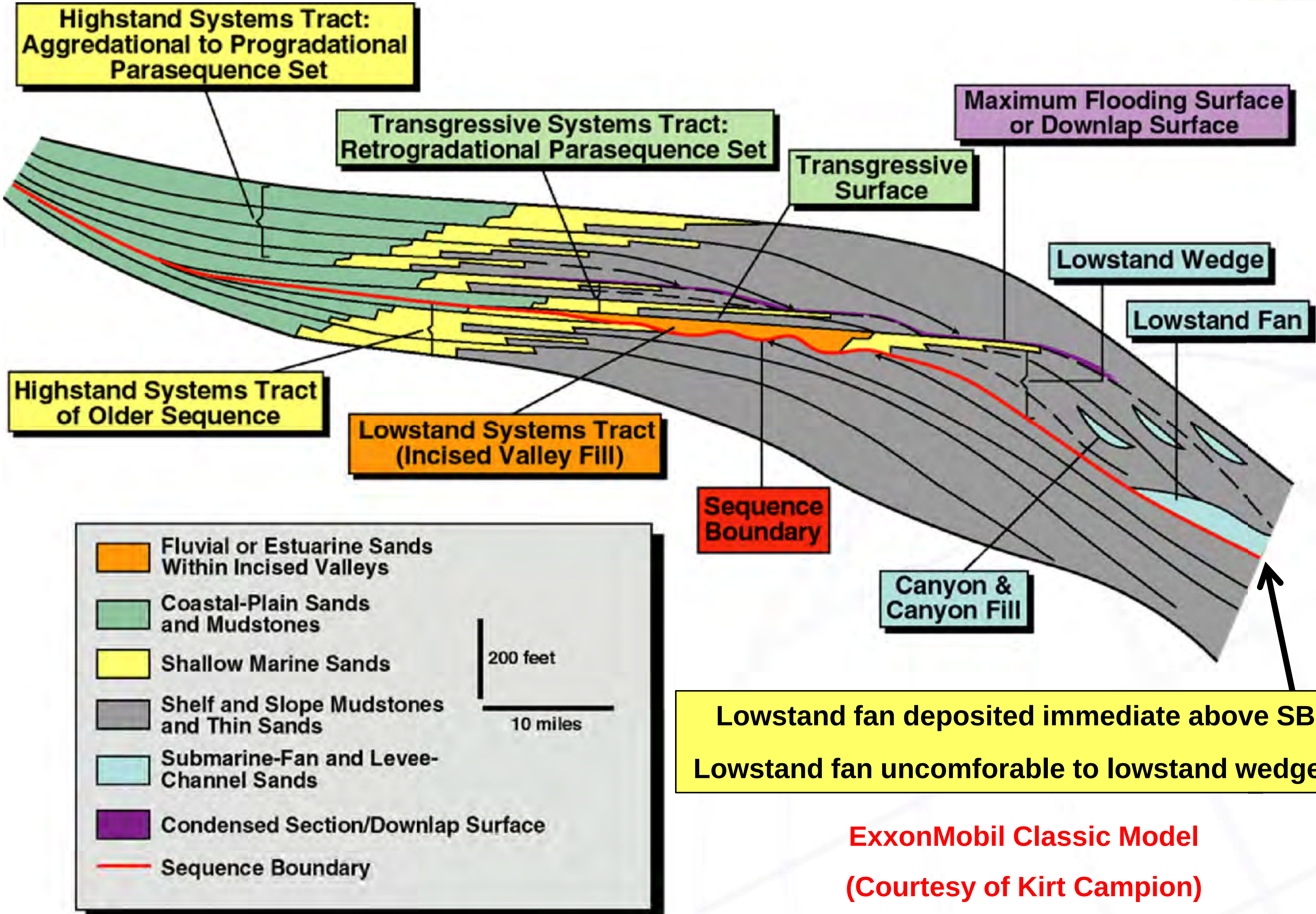
ACKNOWLEDGMENTS

- Marathon Oil Company
- CGG-Veritas for allowing the author to show the seismic lines
- Co-workers: Dave Petro, George Laguros, Rodrige Bastidas, Madhav Kulkarni, Johnny Carroll, Don Caldwell, Julia Khadeeva, Hung-Lung Chen, and Moji Enilari
- AAPG and all of you!

Turbidite Deposition Process and Its Link to Sequence Stratigraphy Framework

- **The issue:**
  - **Need for predictive reservoir models in deep-water reservoir development**
    - **Reservoir connectivity / disconnectivity**
    - **Field development design / completion scenario**
- **The questions:**
  - **Can concepts of classic sequence stratigraphy model be applied to deepwater environment?**
  - **If so, can an *ad hoc* depositional model be constructed based on first-order principles?**
  - **Is the model consistent with an integrated dataset?**
- **The approaches:**
  - **General model to specific field study**

General Sequence Stratigraphy Model and Systems Tracts



Lowstand fan deposited immediate above SB

Lowstand fan uncomforable to lowstand wedges

ExxonMobil Classic Model

(Courtesy of Kirt Campion)

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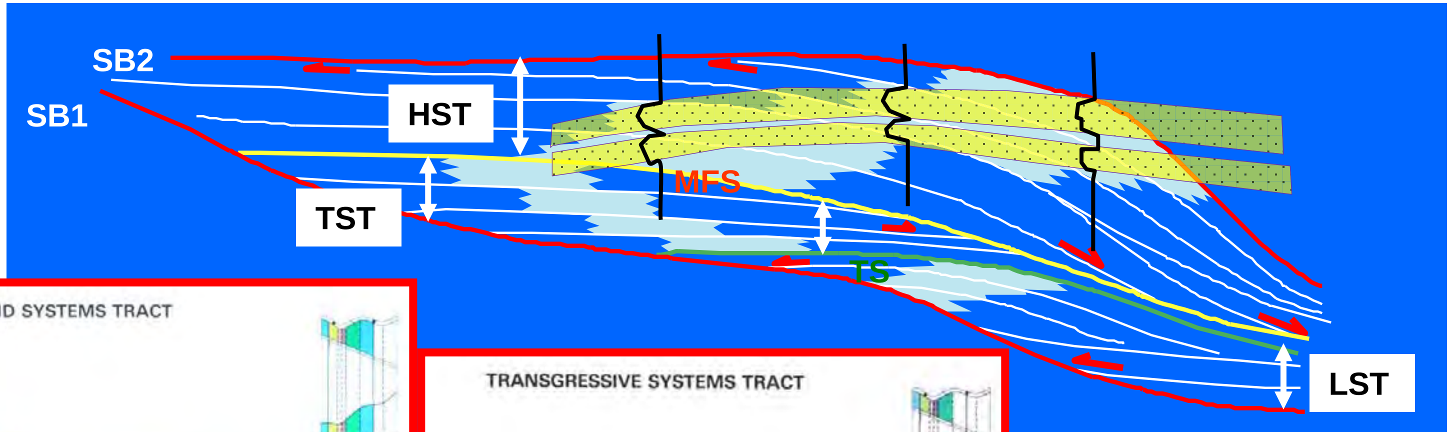
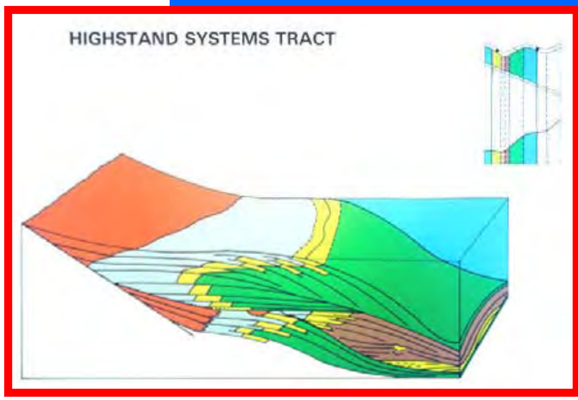
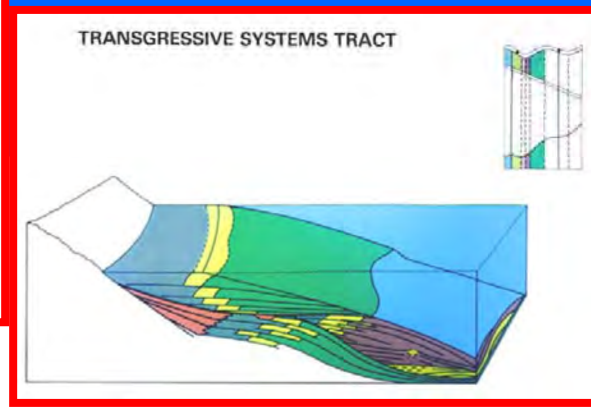
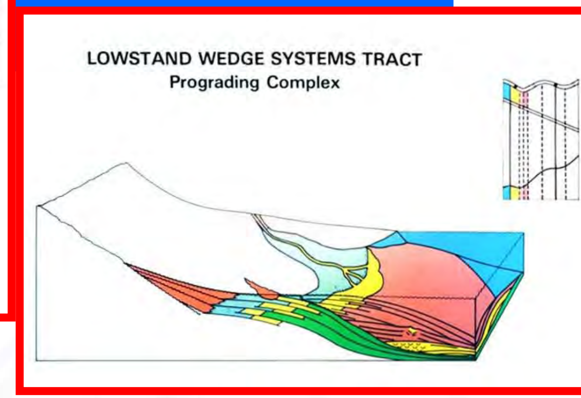
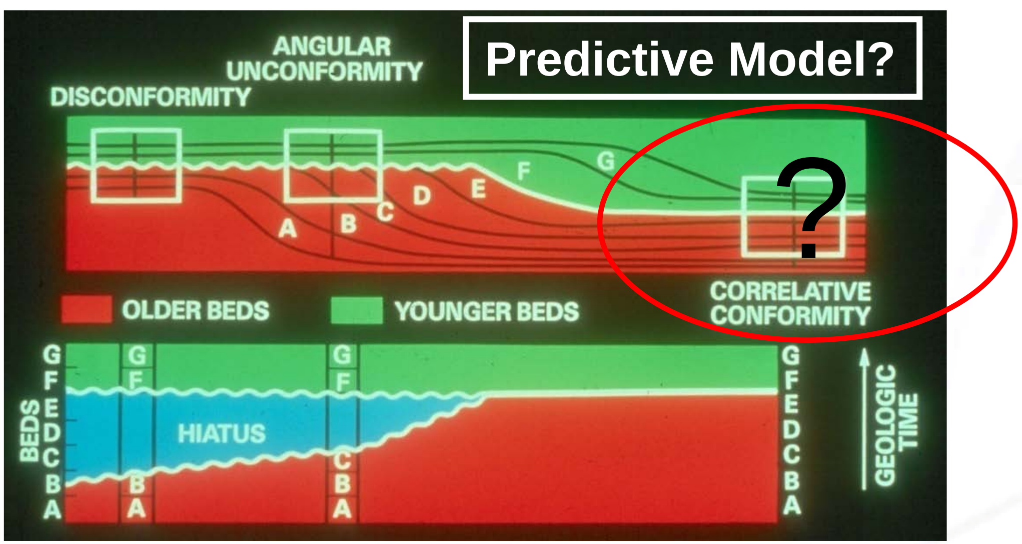
Click to View Notes by Presenter











Systems Tracts

- Linkage of contemporaneous depositional systems, each associated with a specific part of the relative sea-level curve.
- Chronostratigraphy vs. lithostratigraphy

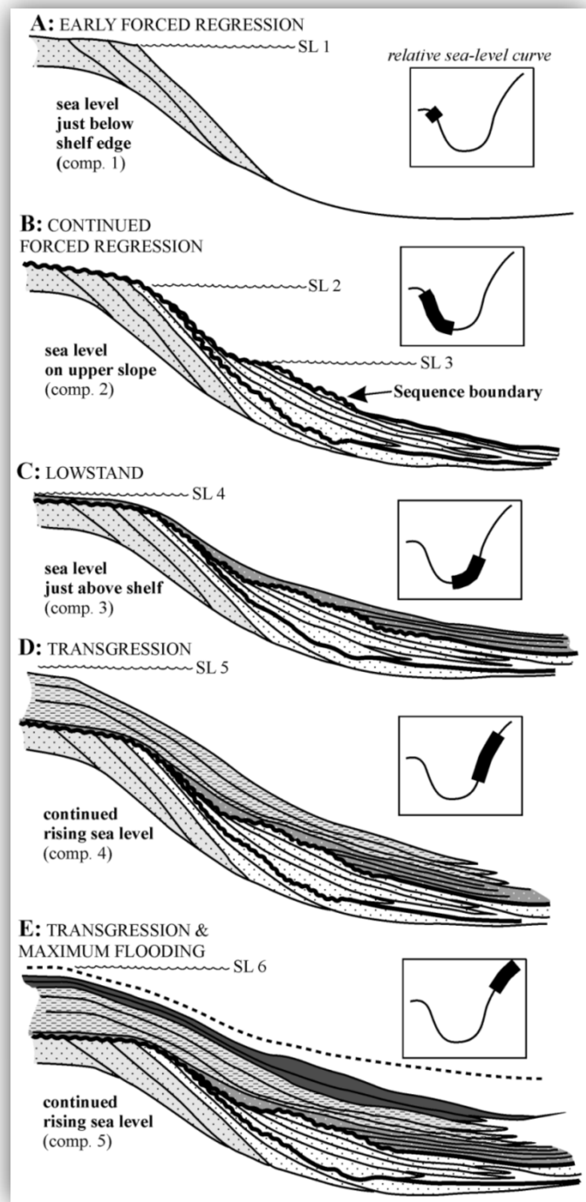
(Courtesy of Kirt Campion)

Notes by Presenter (for previous slide):

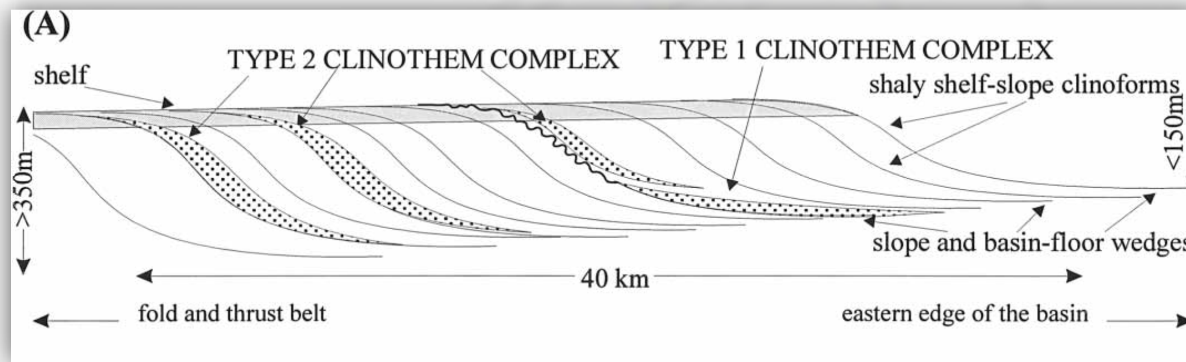
System tracts consist of a contemporaneous linked set of EOD's. For example: clastic fluvial drainage basin, delta, and offshore bars (Mississippi River, delta) or carbonate system (Great Bahamas Bank).

As relative sea level changes, how do these environments respond? As the EOD's produce and accumulate sediment in short-term cycles, the stratal packages stack and track the long-term sea level change, from LST to TST to HST.

Basin-floor sand deposits?



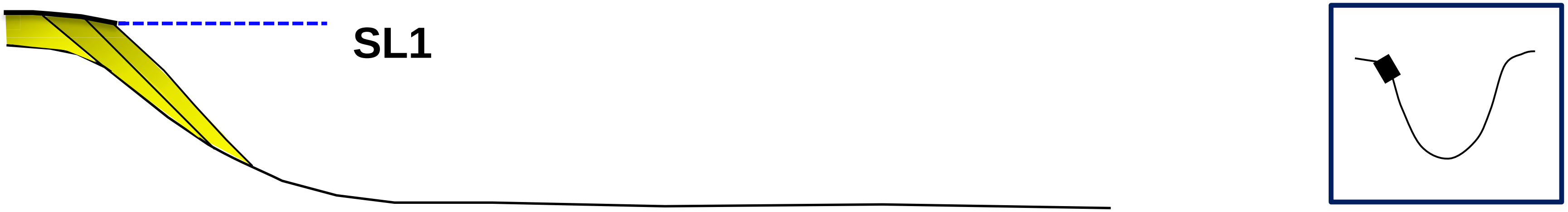
- Opposite to classic basin fan model, Bjorklund and Steel (2002, Geology) suggested:
  - Slope area can be extrmely sand prone
  - Sea-level fall below the shelf edge does not necessarily result in basin-floor sand deposits beyond the base of slope



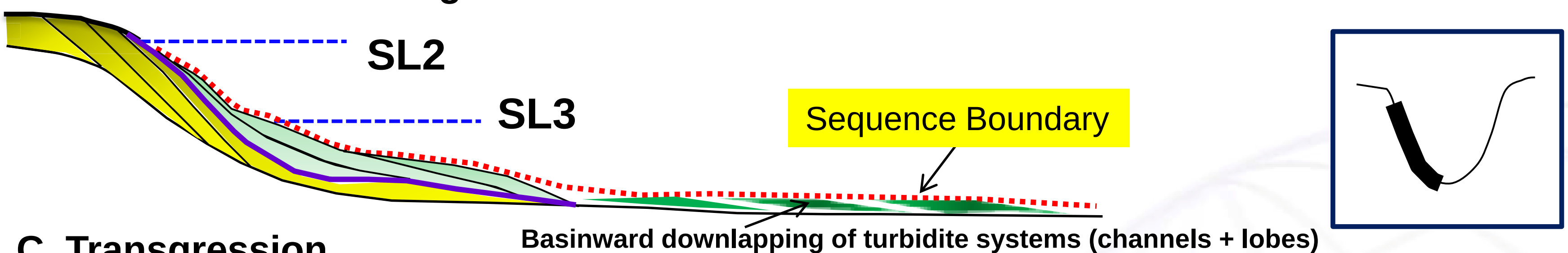
An Alternative Model

Sea-level curve/cycle position

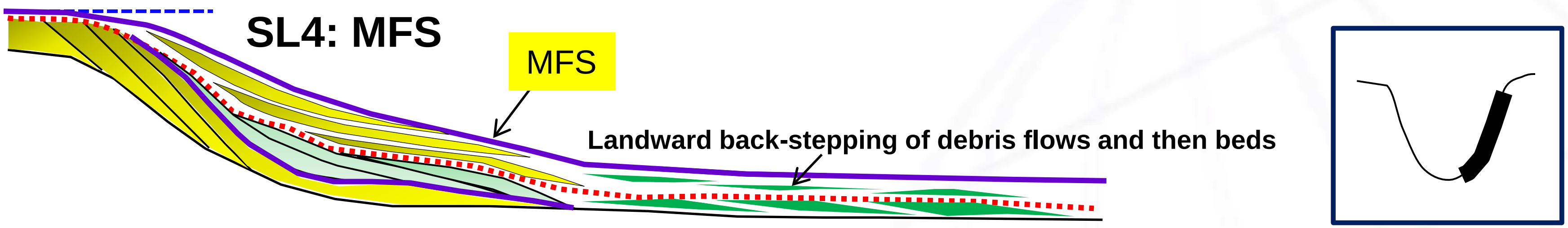
A. On-set of sea-level fall



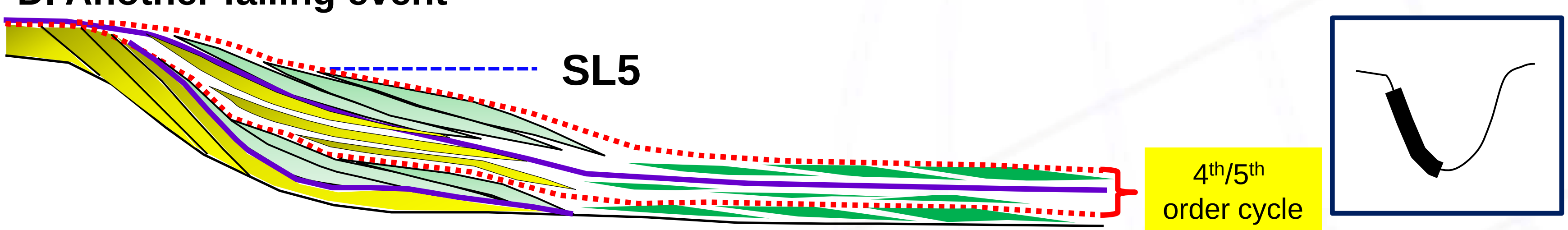
B. Continued forced-regression



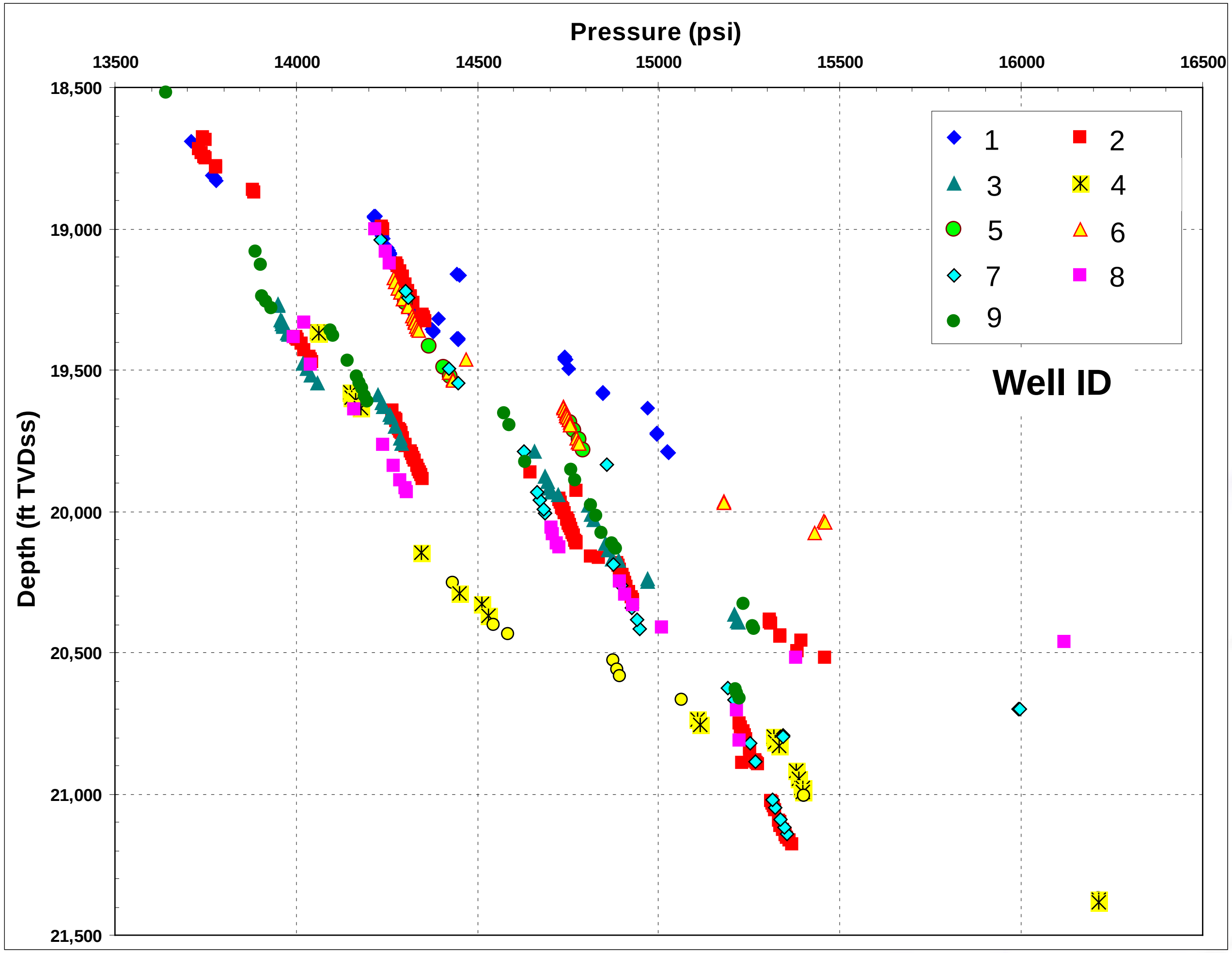
C. Transgression



D. Another falling event



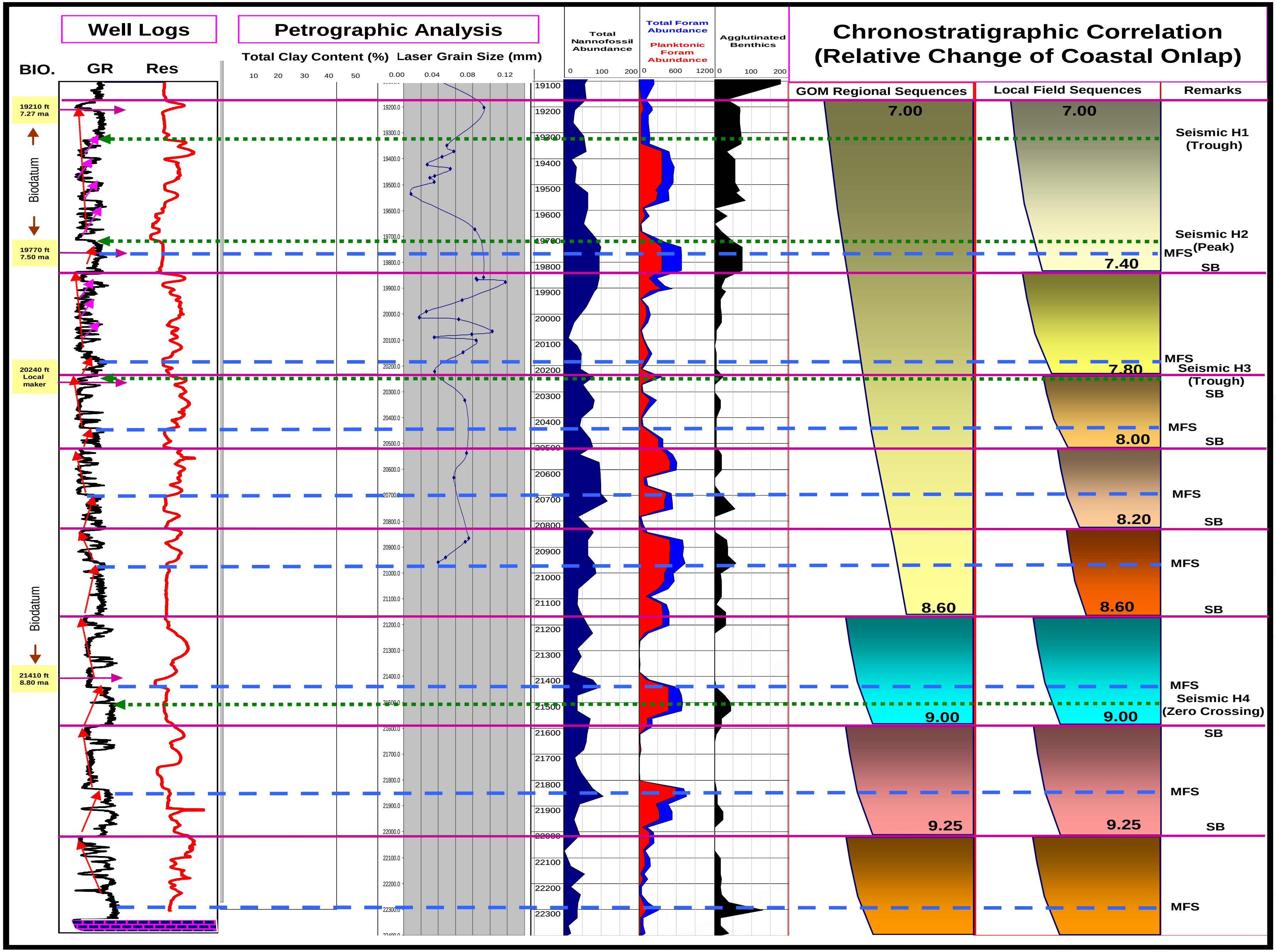
Case Study: Post-Drilling Pressure Trends



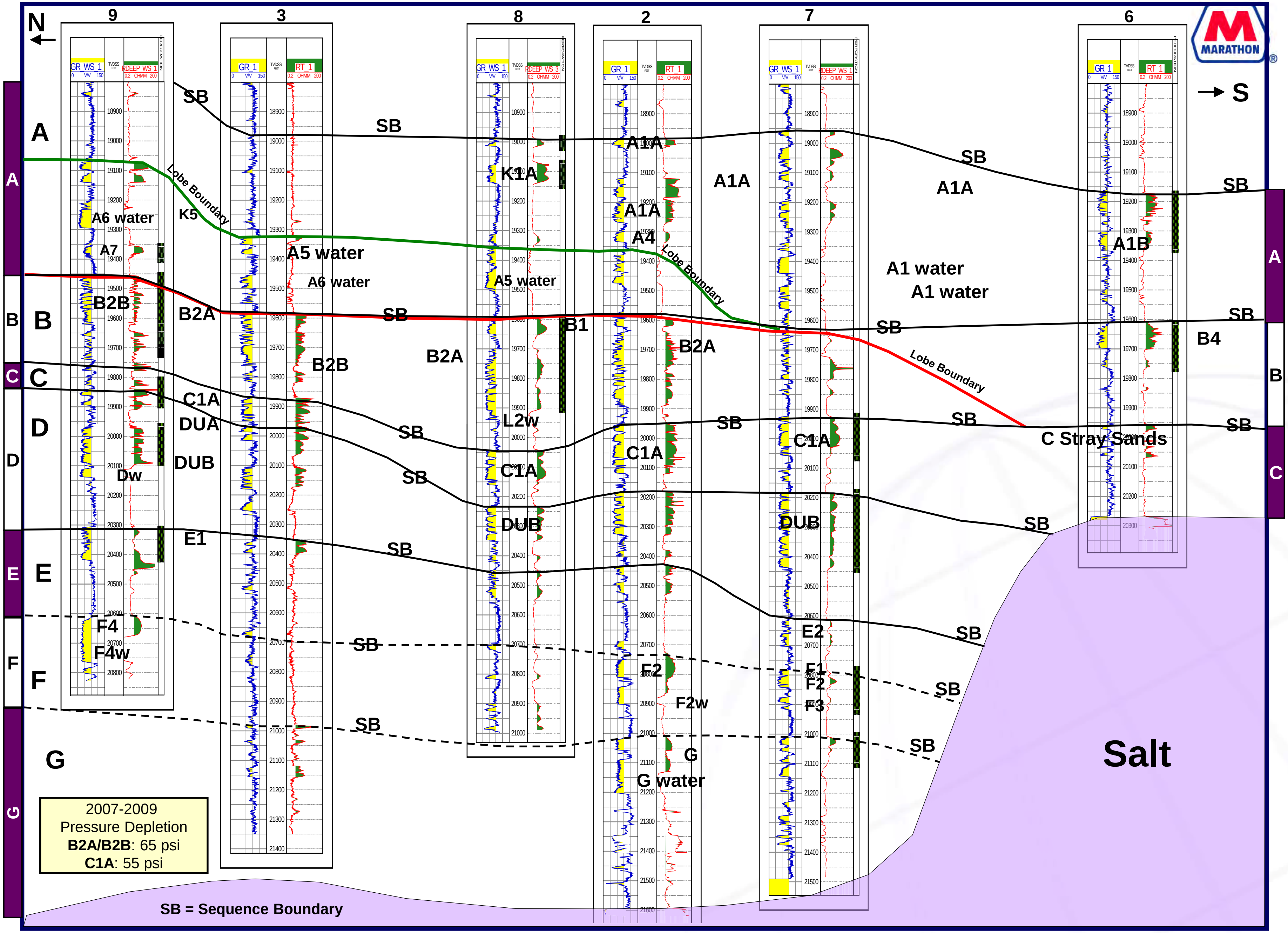
- Organized or disorganized?
- Overall trend: increasing pressure with depth
- Significant lateral variation
- Multi-compartments
- Development scenarios must handle all these issues

Our goal: To understand the compartmentalization of these reservoirs in order to formulate a feasible and efficient development plan

Well Log Sequence Stratigraphy: The Bounding Surfaces for Reservoir Model



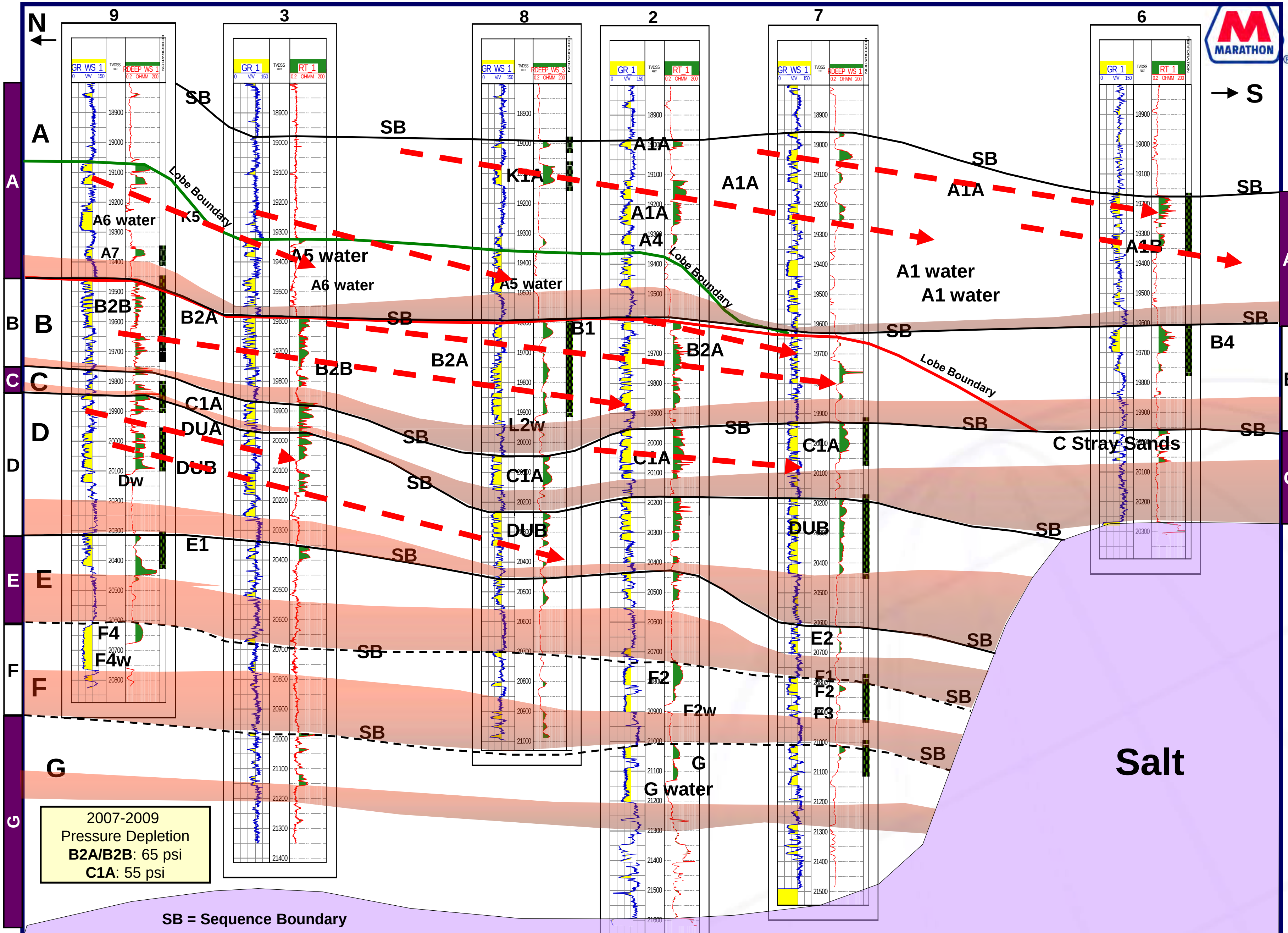
Major reservoir sand packages separated by capping shale intervals



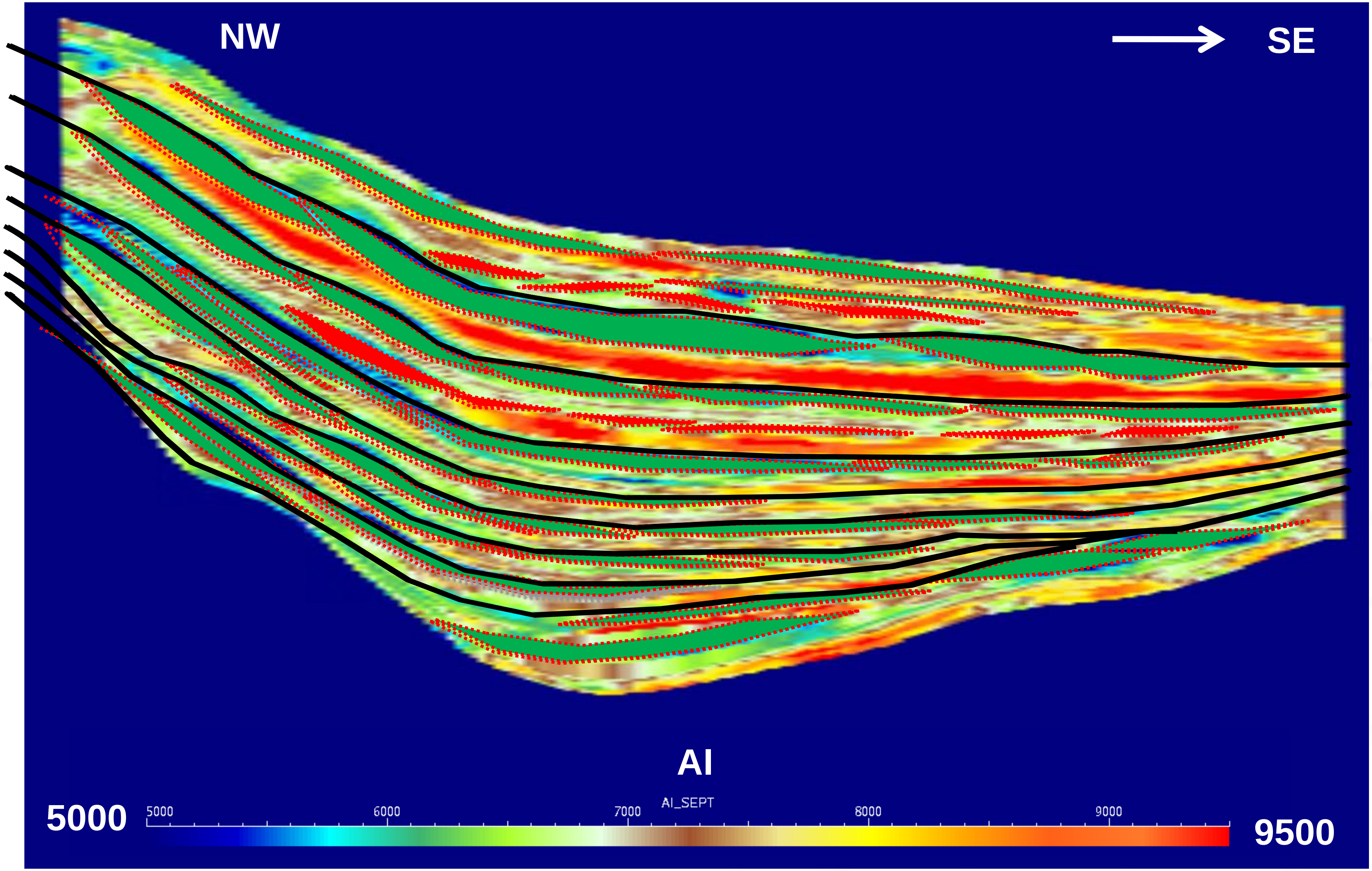
2007-2009
Pressure Depletion
B2A/B2B: 65 psi
C1A: 55 psi

SB = Sequence Boundary

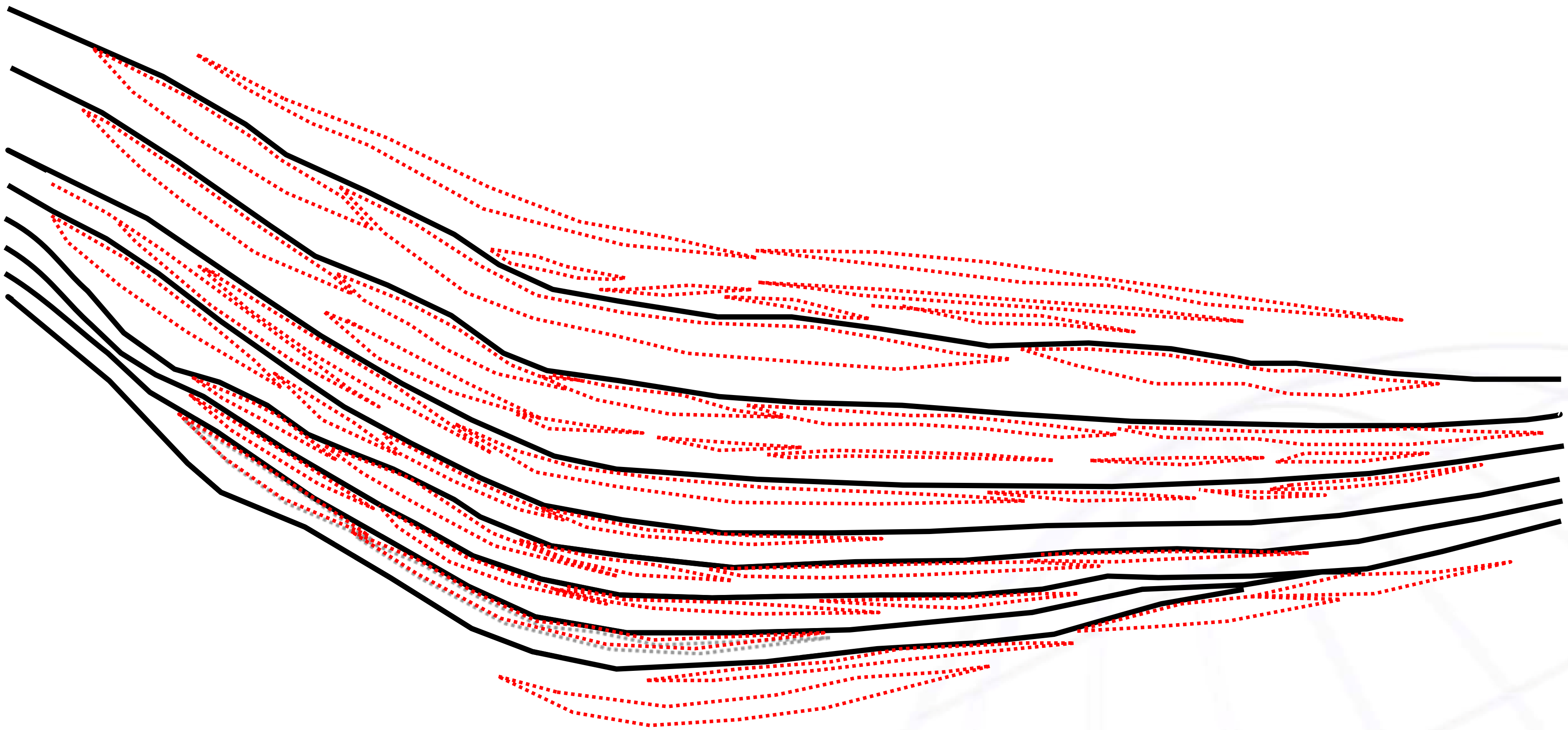
Major reservoir sand packages separated by capping shale intervals



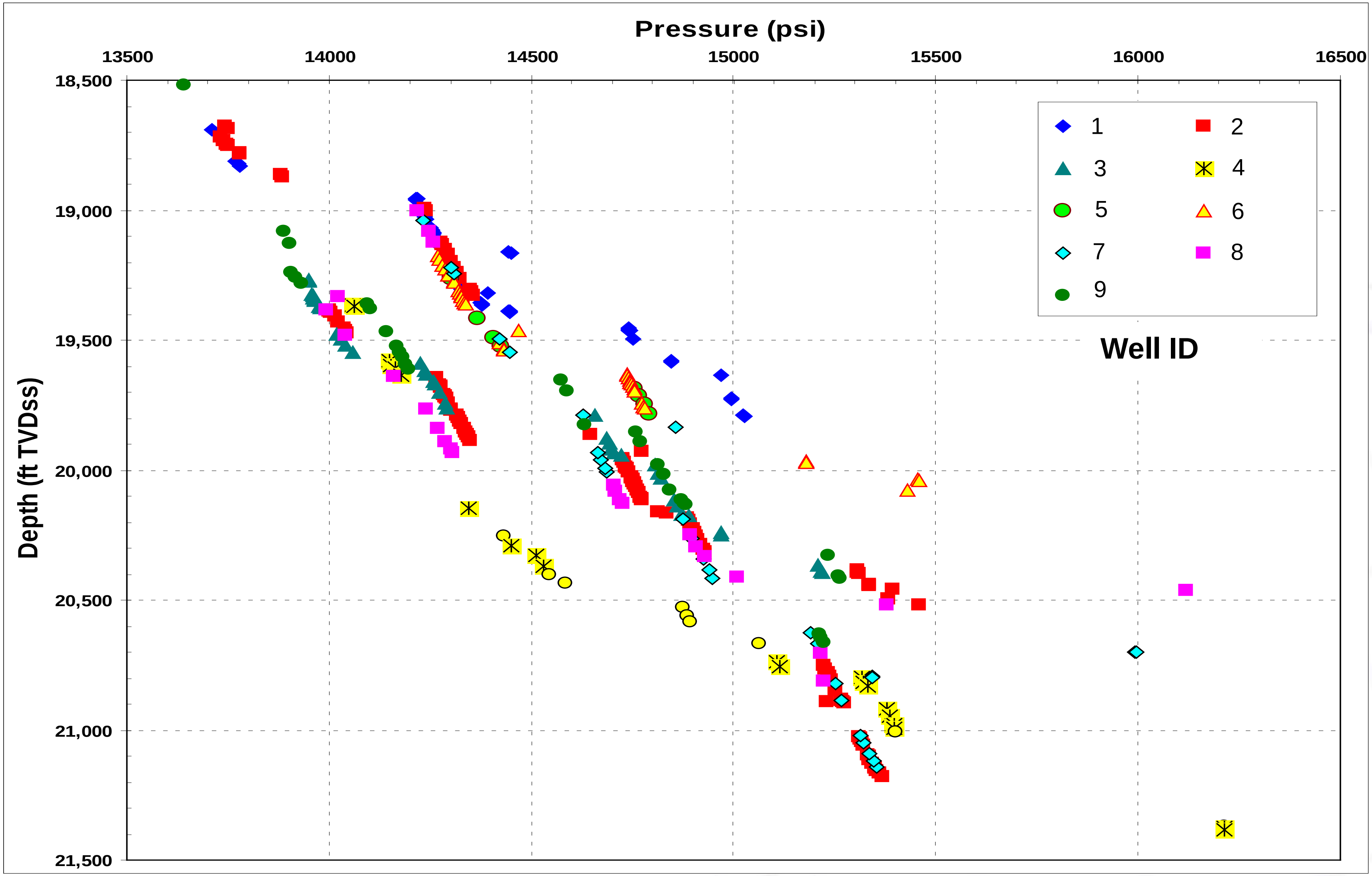
Deep Water Turbidite Deposition Process



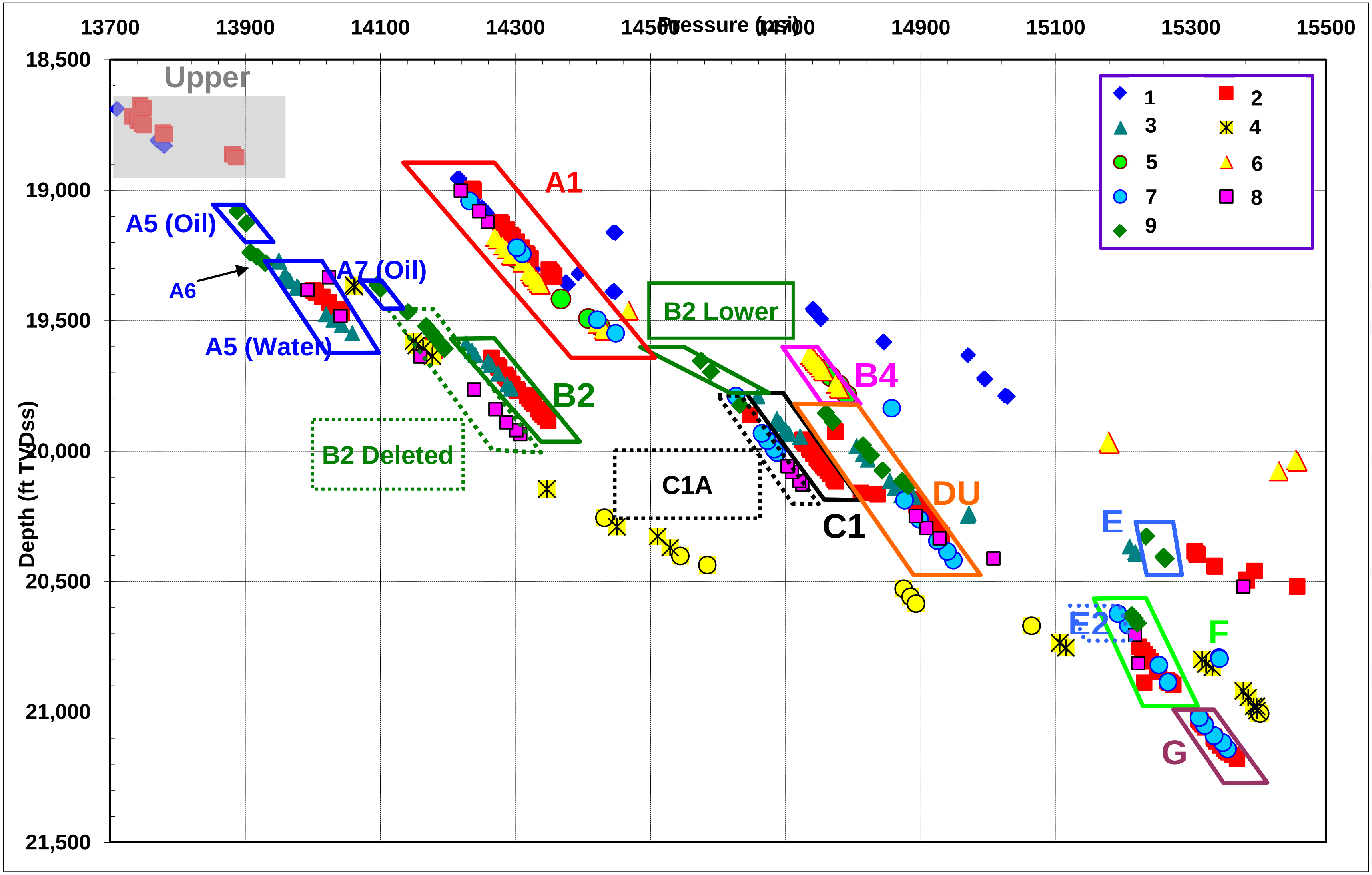
Deep Water Turbidite Deposition Process



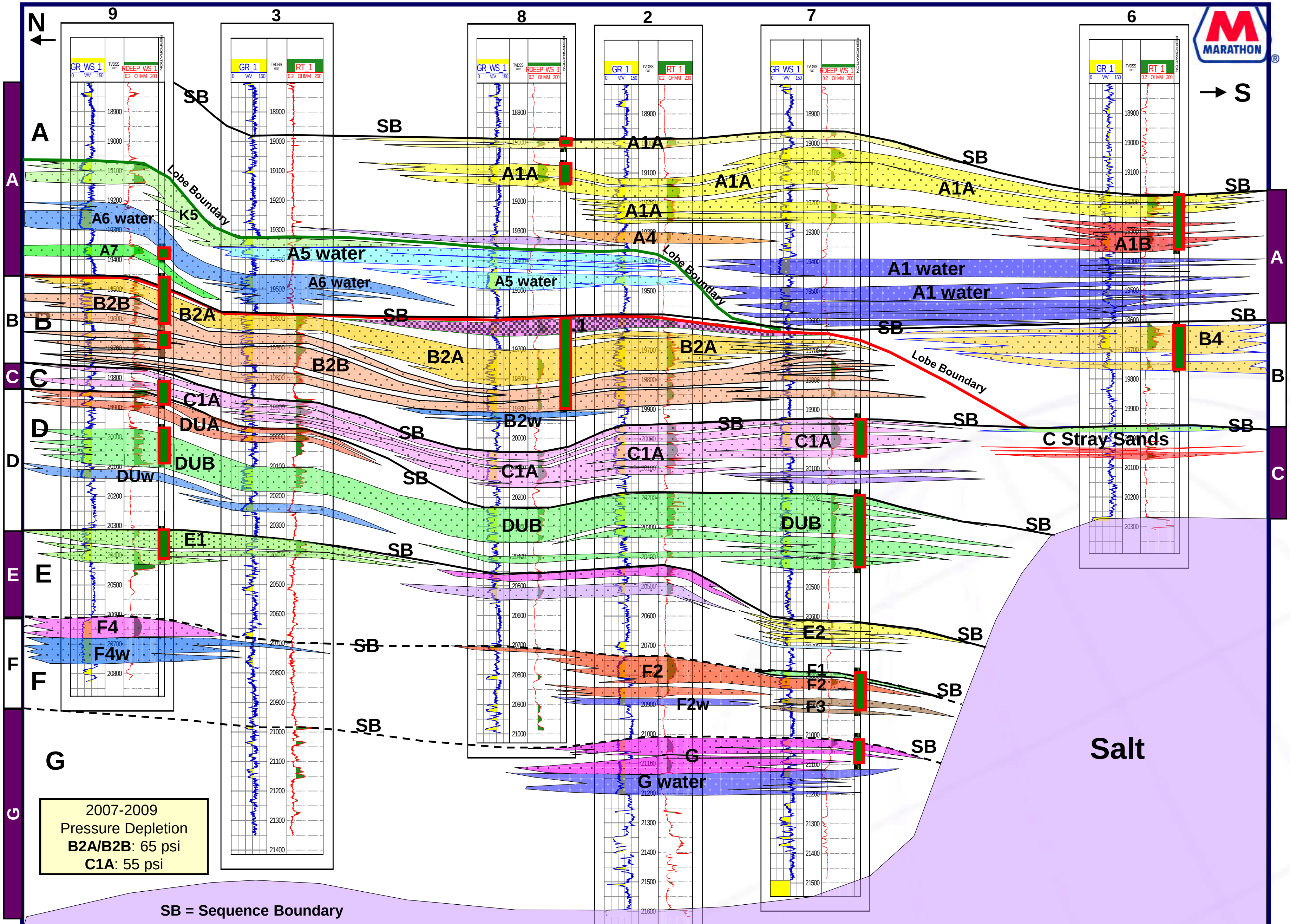
Post-Drill Pressure Trends with Stratigraphic Zonation



Post-Drill Pressure Trends with Stratigraphic Zonation

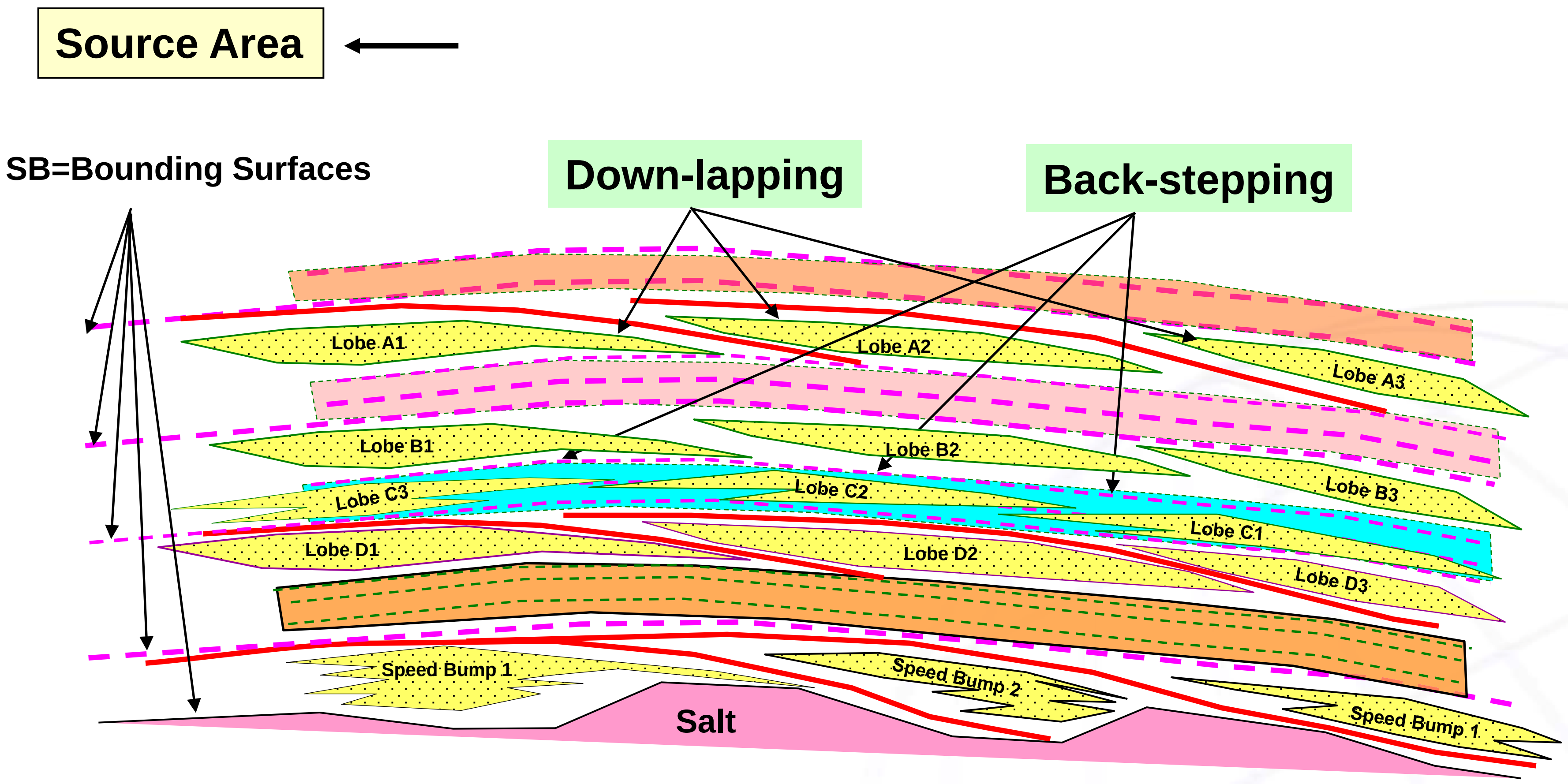


Conceptual Reservoir Connectivity Model



Working model as of 9/9/09

Depositional Process: A Quick Thought



Summary Remarks

- **Presented a conceptual, *ad hoc* model for deepwater depositional processes**

- **A GOM field development case study consistent with the model**
  - **Reservoir connectivity**
  - **Field development / completion scenarios**

- **General sequence stratigraphy concepts can be applied to deepwater reservoir modeling**
  - **Stacking patterns determined by relative sea-level fluctuation and sediment input**

- **Deepwater basin (including mini-basins) deposition can be attributed to two processes:**
  - **Basinward downlapping during falling period (forced-regression)**
  - **Landward “backstepping” during rising stage (transgression)**

- **Integrating well logs, cores, paleo, geochem, seismic (amplitude & AI volumes), pressure and other reservoir property data is the key for success**