Using Sequence Stratigraphy to Optimize Target Selection in Tight Sandstone Reservoirs of the Rockies (and Beyond)*

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Abstract

Sequence stratigraphy is not THE answer in optimizing the selection of horizontal targets in tight sandstone reservoirs. But it is an extremely useful, and oftentimes necessary, tool that should be used to assess potential reservoir intervals and improve geosteering.

Sequence stratigraphy can aid subsurface geologic interpretation and evaluation in numerous ways. It
(1) provides an increased understanding of depositional controls on reservoir vs. non-reservoir facies,
(2) promotes better well-log correlations,
(3) aids in reservoir prediction,
(4) offers a framework for data integration,
(5) guides sample collection from core,
(6) delivers better reservoir flow models and volumetric calculations,
(7) helps in choosing and staying within the target zone, and
(8) furnishes input for completion design.

This talk focuses on three aspects of optimizing target selection and horizontal drilling in tight sandstone reservoirs based on sequence stratigraphic concepts. First, the importance of establishing accurate correlations based on flooding surfaces and

parasequences when selecting a target and landing the wellbore is demonstrated for the Baxter and Parkman sandstones. Second, the significance of reservoir compartmentalization relative to reservoir modeling and economic evaluation in highstand vs. falling stage systems tracts is described for the Viking, Woodbine, Sussex, and Frontier-Turner systems. Finally, identifying different types of erosional surfaces and their impact on hydrocarbon production and the placement of laterals are highlighted for the Frontier-Turner and Three Forks-Bakken intervals.

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Acknowledgements

- Rob Diedrich & John McLeod, SM Energy
- Erik Kling, Kimmeridge Energy*

** previously with EOG Resources*

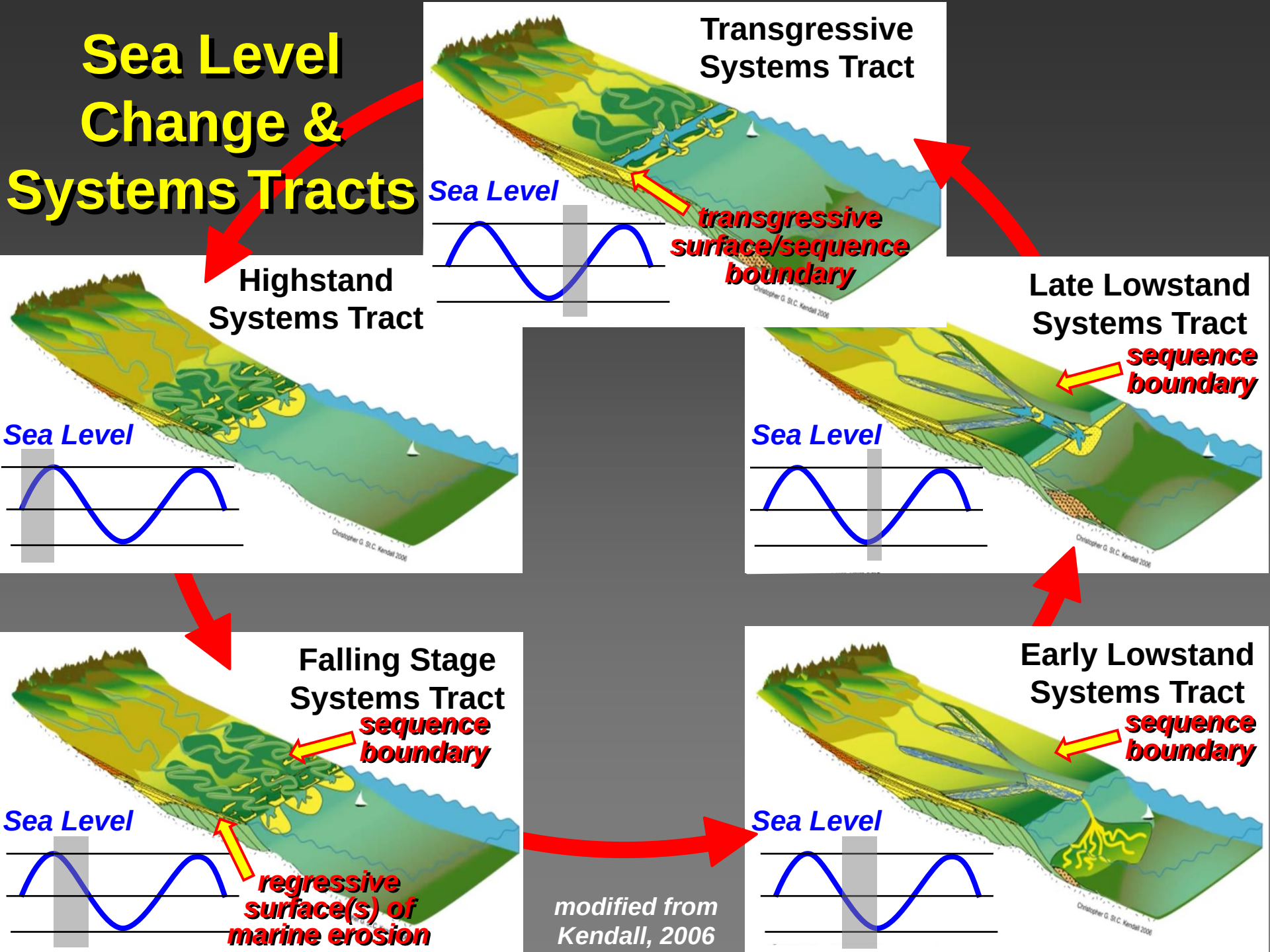
Sequence Stratigraphy

- provides another tool in your “tool box”
- promotes better well-log correlations
- offers context for depositional controls on reservoir vs. non-reservoir
- aids facies prediction (exploration)
- guides data collection from core
- provides framework for data integration
- delivers better reservoir flow models & volumetrics (compartmentalization)
- helps select & stay in horizontal target

Targeting Optimization

- parasequence (flooding surface) correlation
  - Parkman
  - Baxter
- HST vs. FSST & compartmentalization
  - Viking
  - Woodbine
  - Sussex
  - Frontier-Turner
- erosional surfaces & HC production
  - Frontier-Turner
  - Three Forks-Bakken

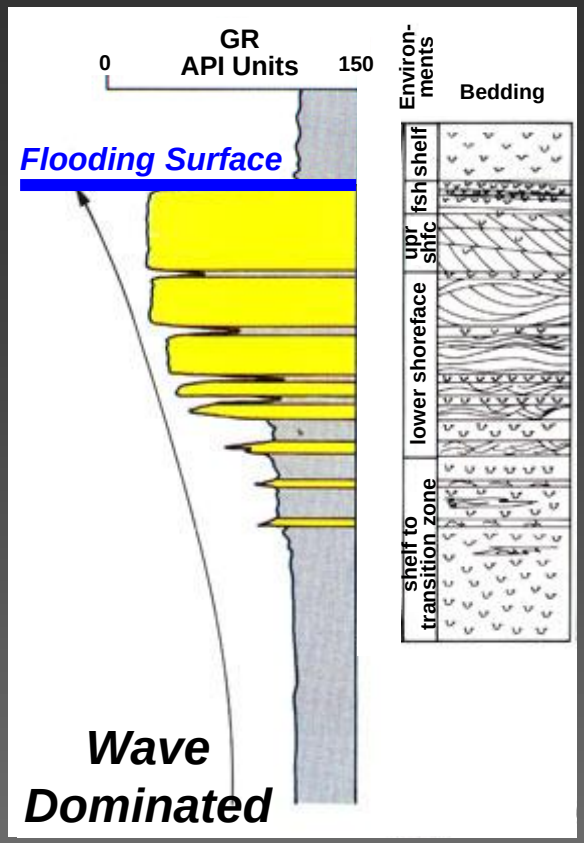
Sea Level Change & Systems Tracts

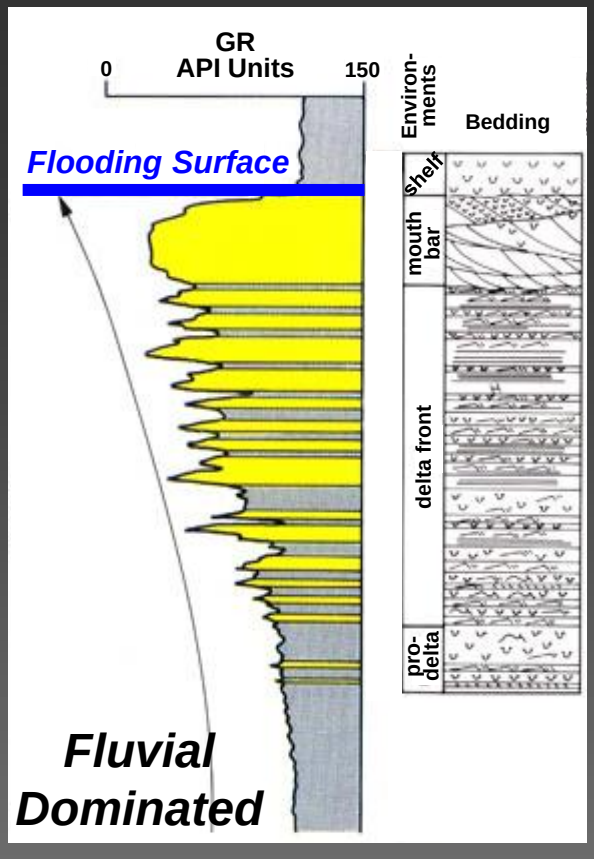


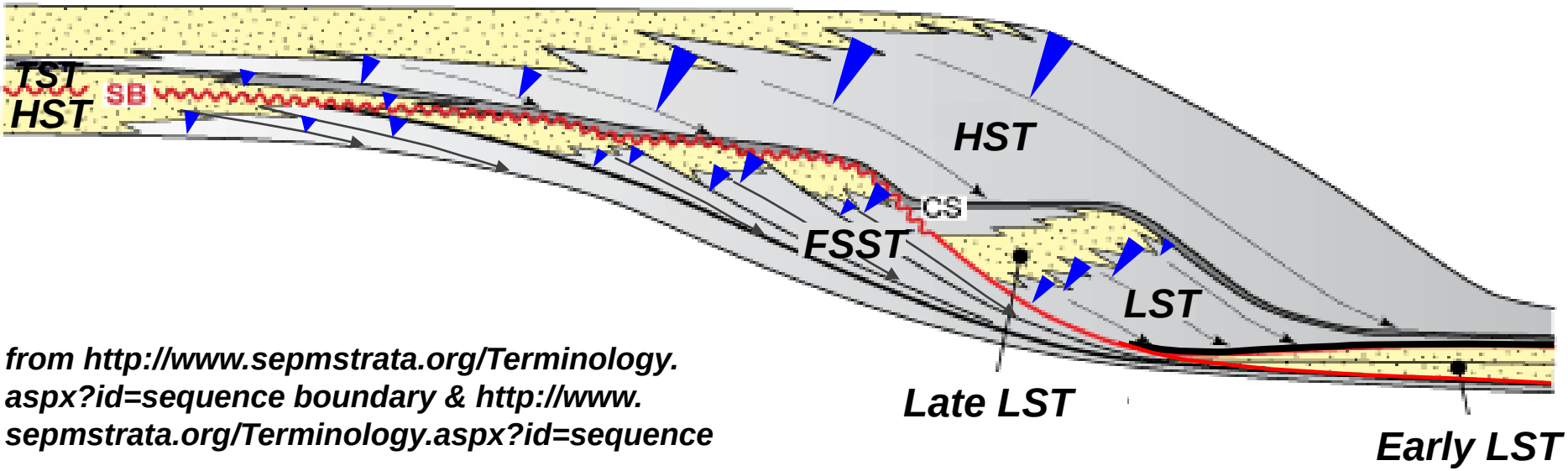
modified from Kendall, 2006

Parasequence = Fundamental Correlation Unit

modified from Van Wagoner et al., 1990







from http://www.sepmstrata.org/Terminology.aspx?id=sequence boundary & http://www.sepmstrata.org/Terminology.aspx?id=sequence

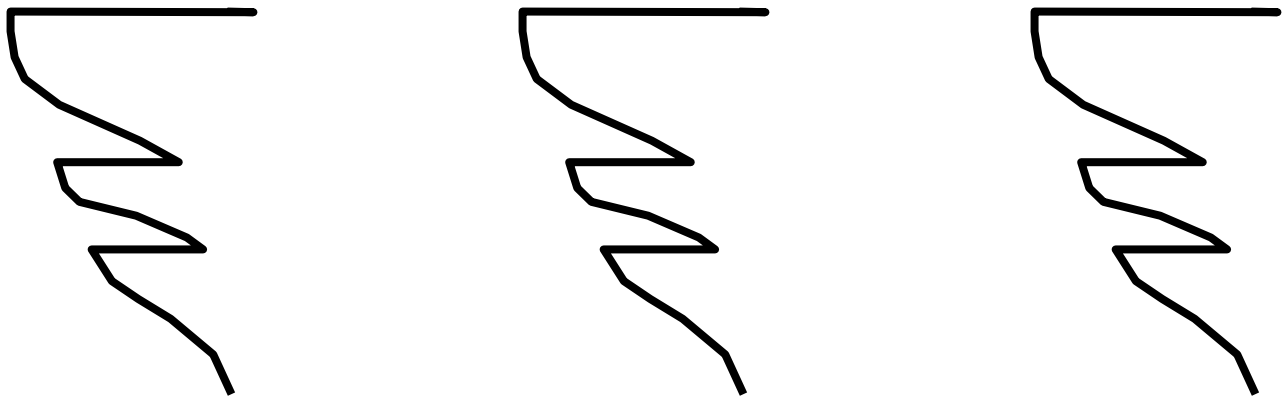
Targeting Optimization

- parasequence (flooding surface) correlation
  - Parkman
  - Baxter
- HST vs. FSST & compartmentalization
  - Viking
  - Woodbine
  - Sussex
  - Frontier-Turner
- erosional surfaces & HC production
  - Frontier-Turner
  - Three Forks-Bakken

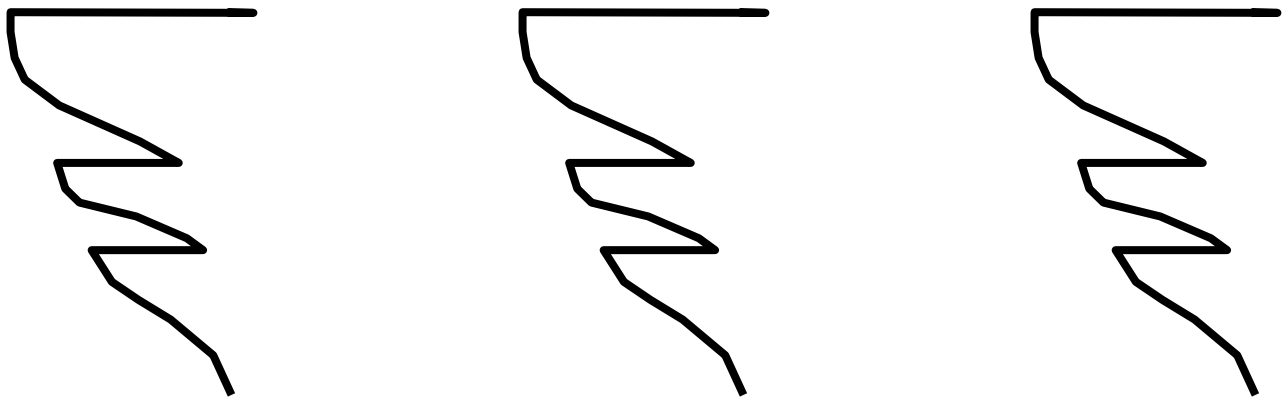
How Would You Correlate These Parasequences?

landward *basinward*

Layer Cake



Dipping Clinoforms



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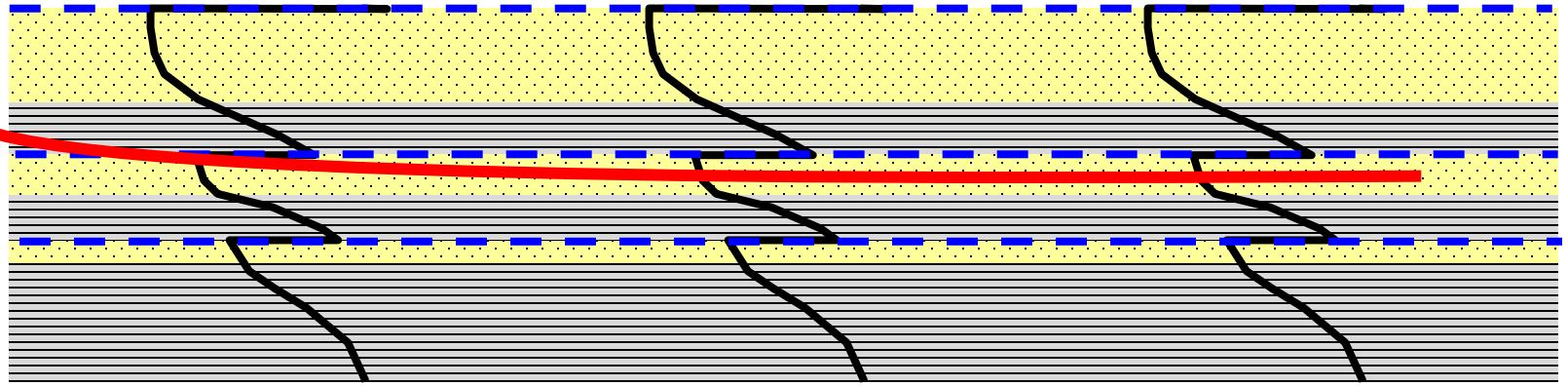
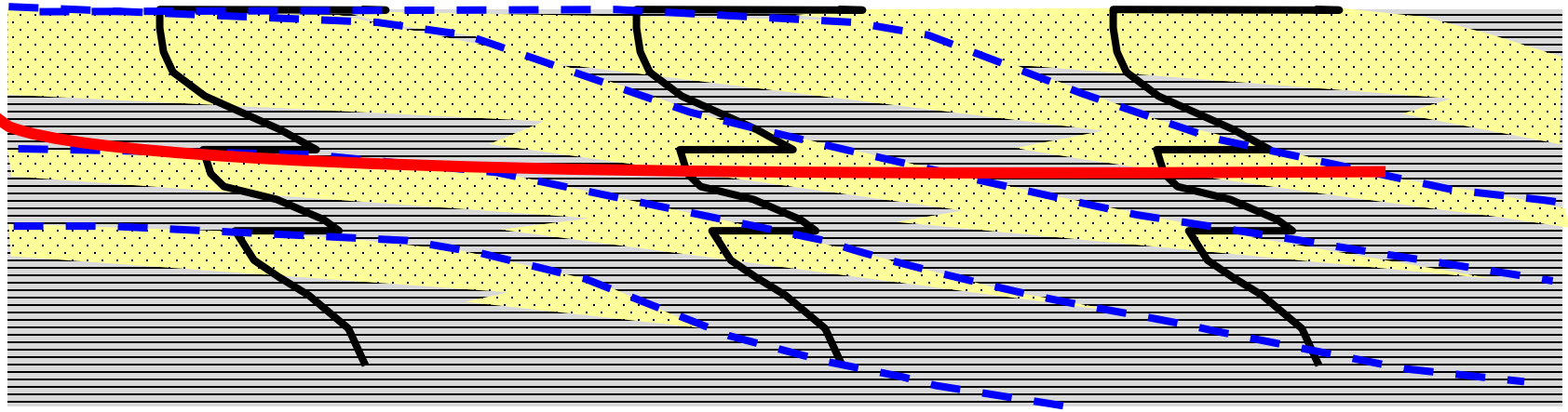
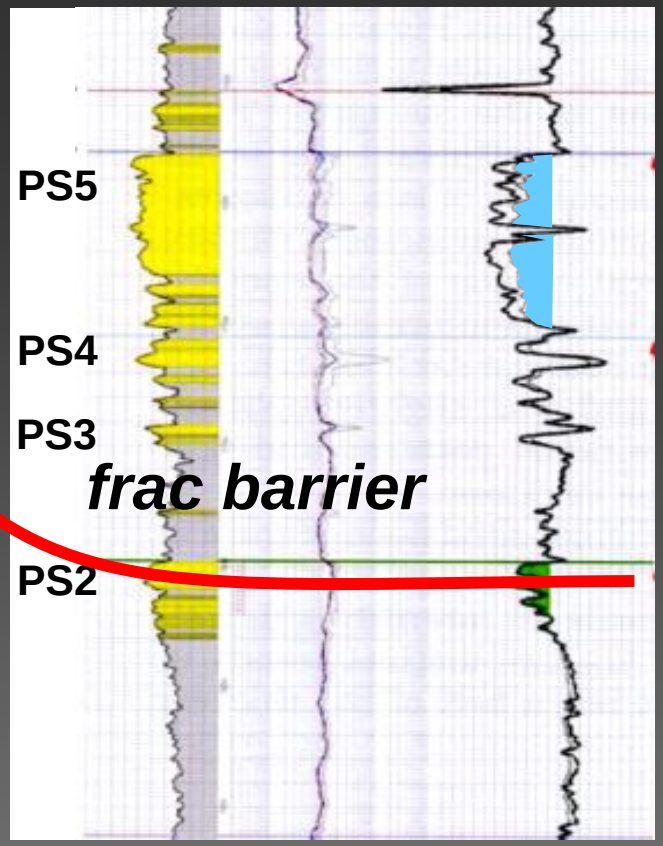


Dipping Clinoforms

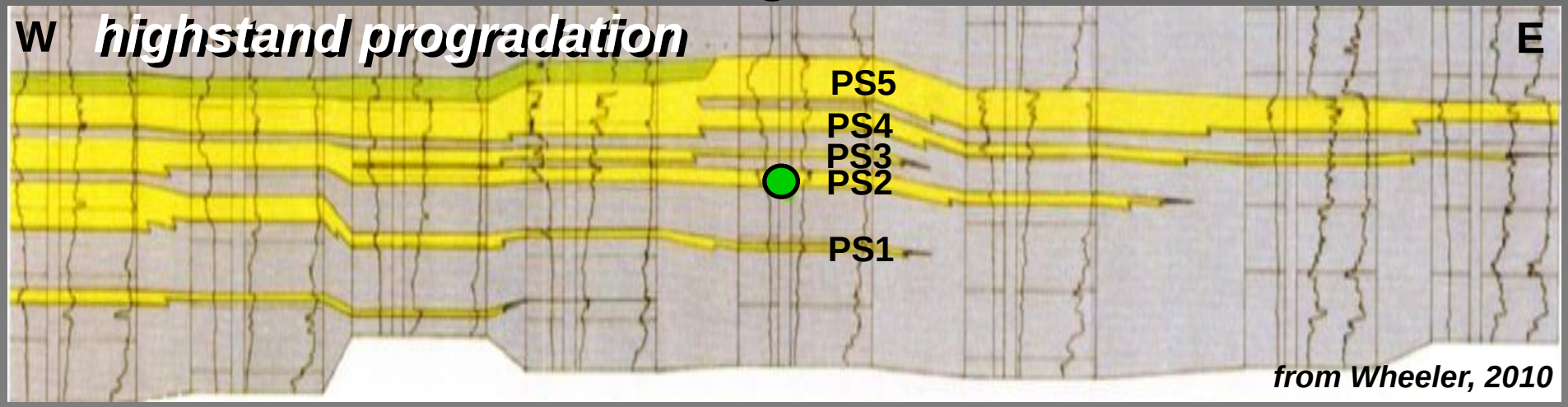


Parkman Targeting



Savegeton Fld

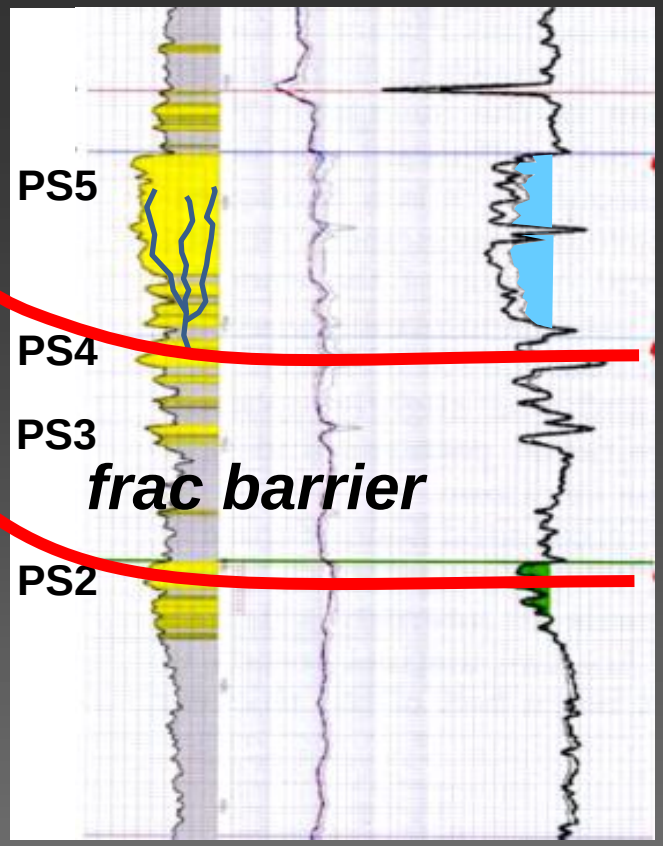
House Creek Fld



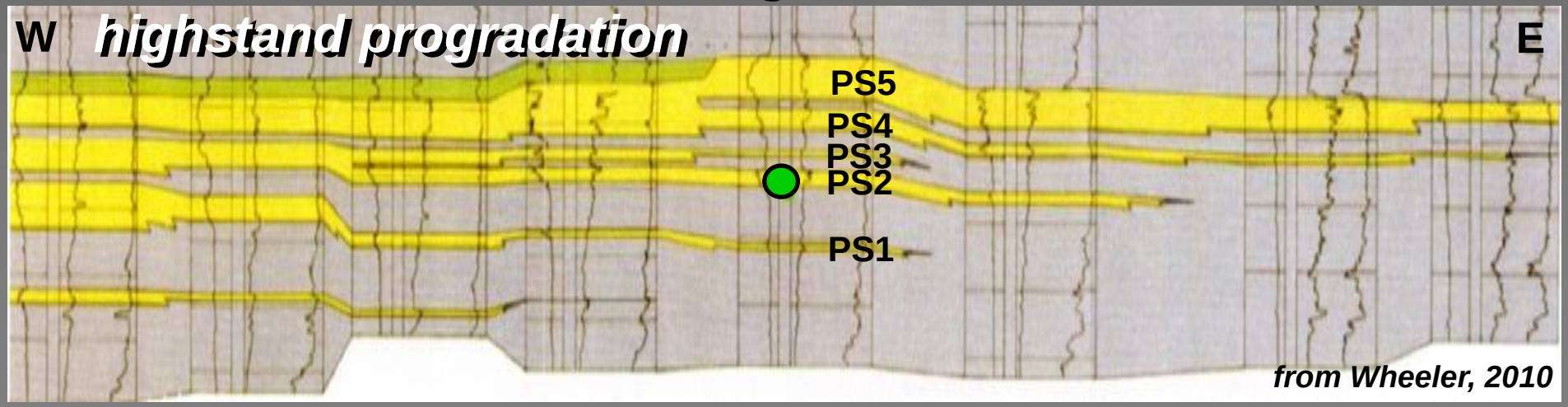
from Wheeler, 2010

Parkman Targeting

Savegeton Fld



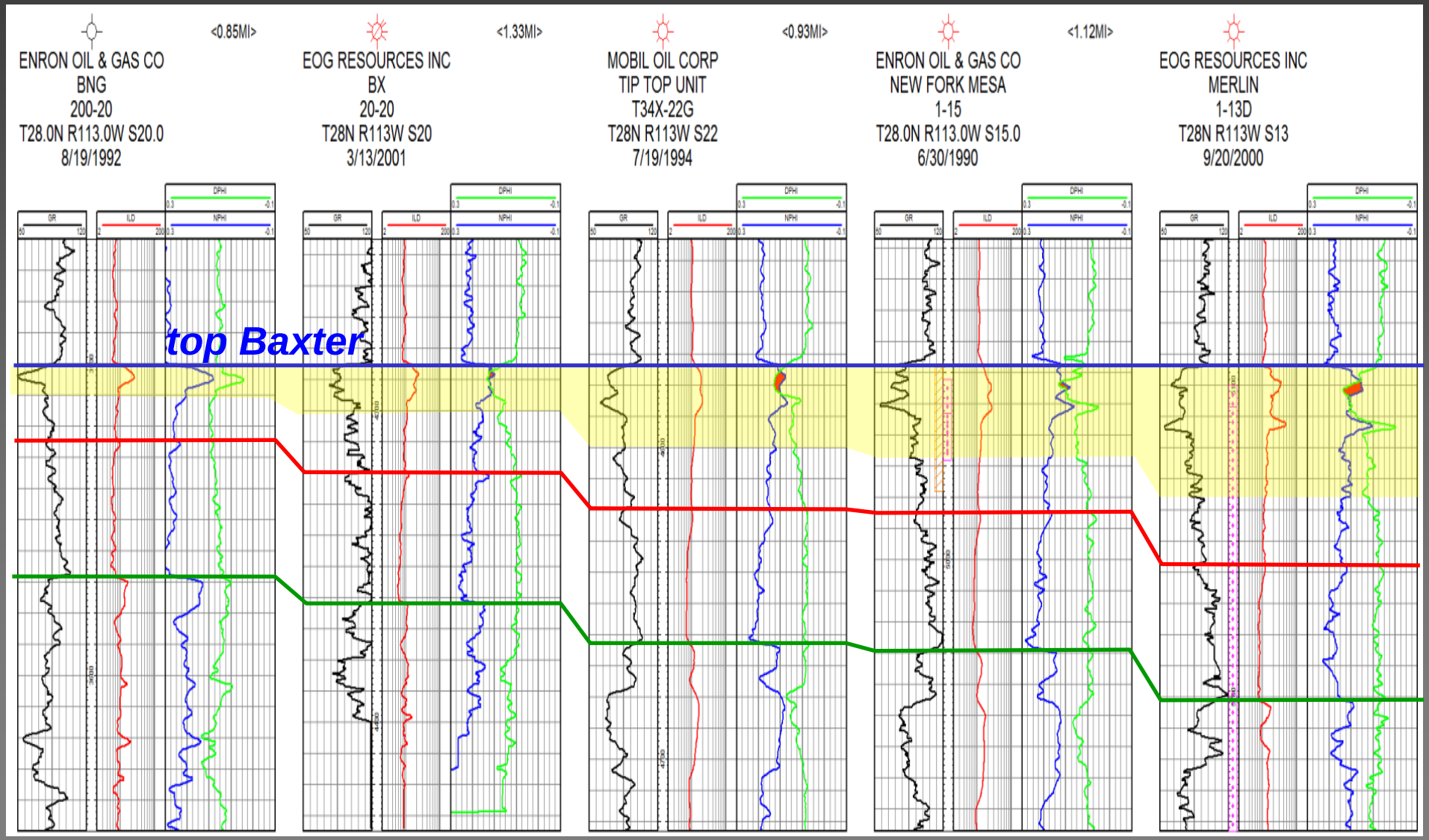
House Creek Fld



from Wheeler, 2010

Baxter Compartmentalization

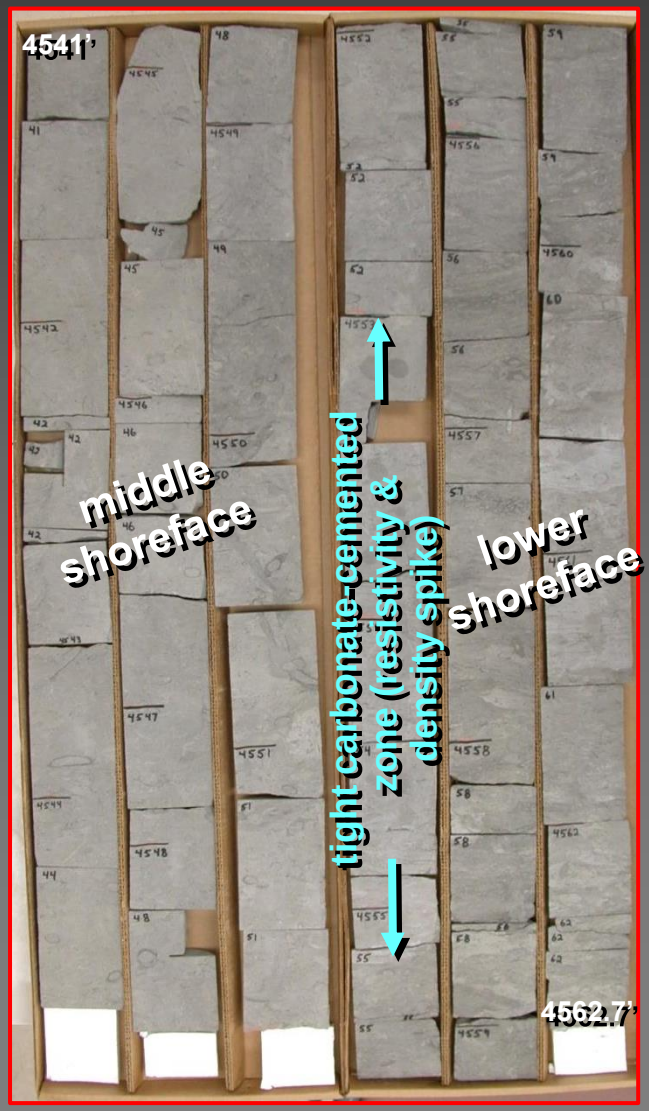
landward *basinward*

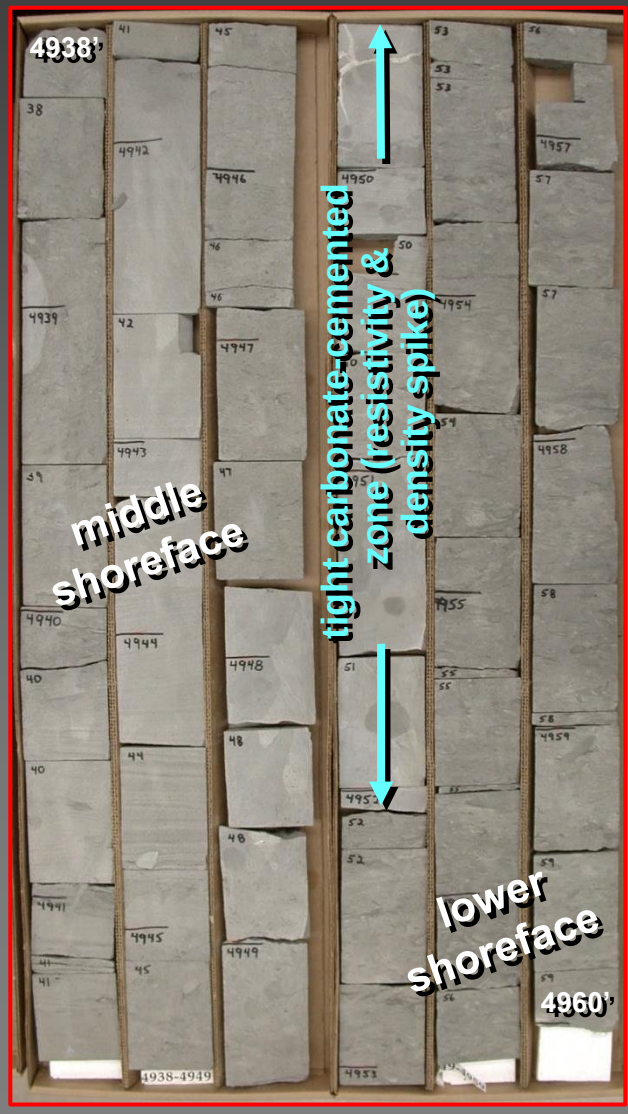


Baxter Core Observations

"normal" parasequence capped by flooding surface

tight flooding surface between parasequences





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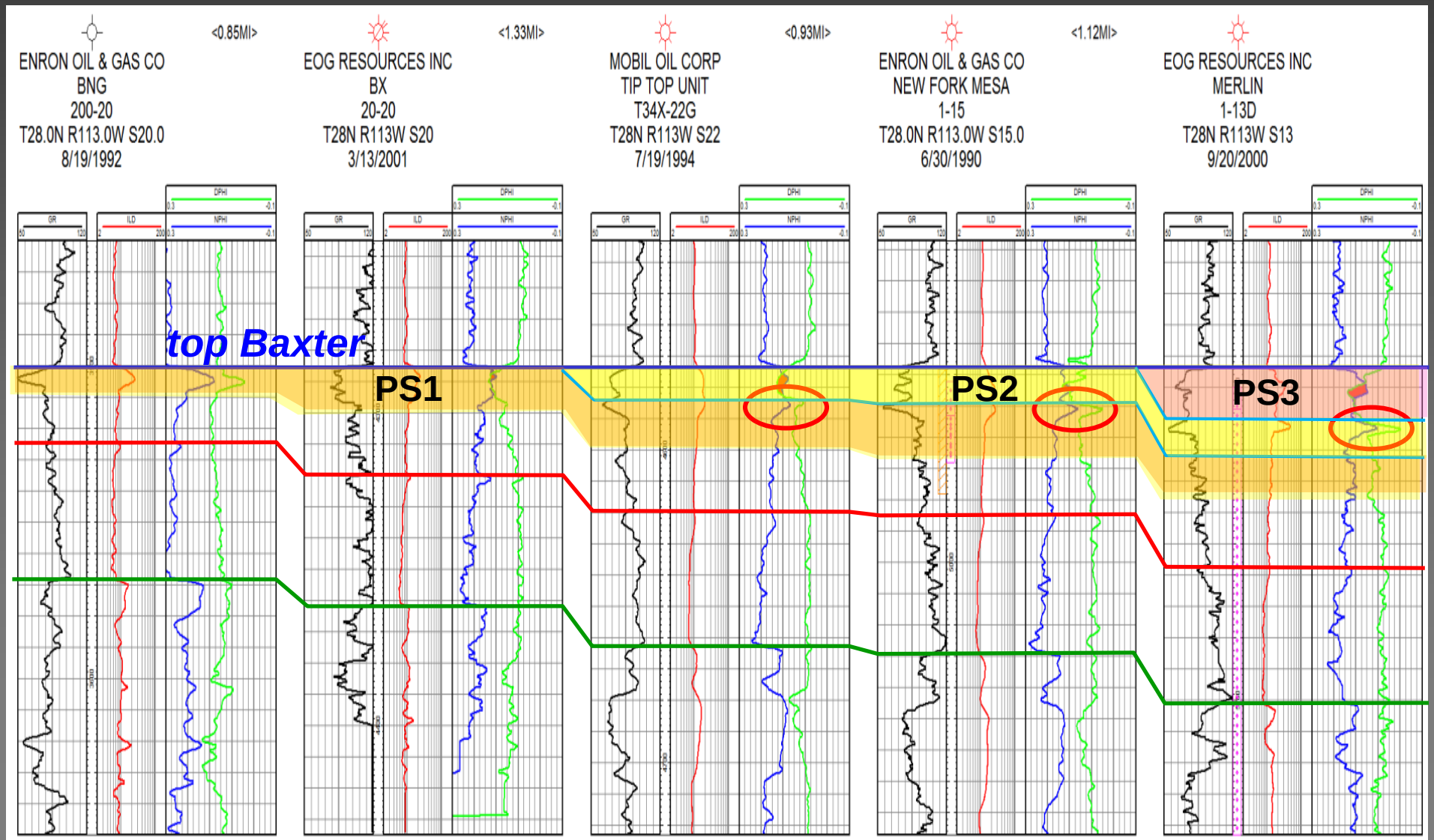
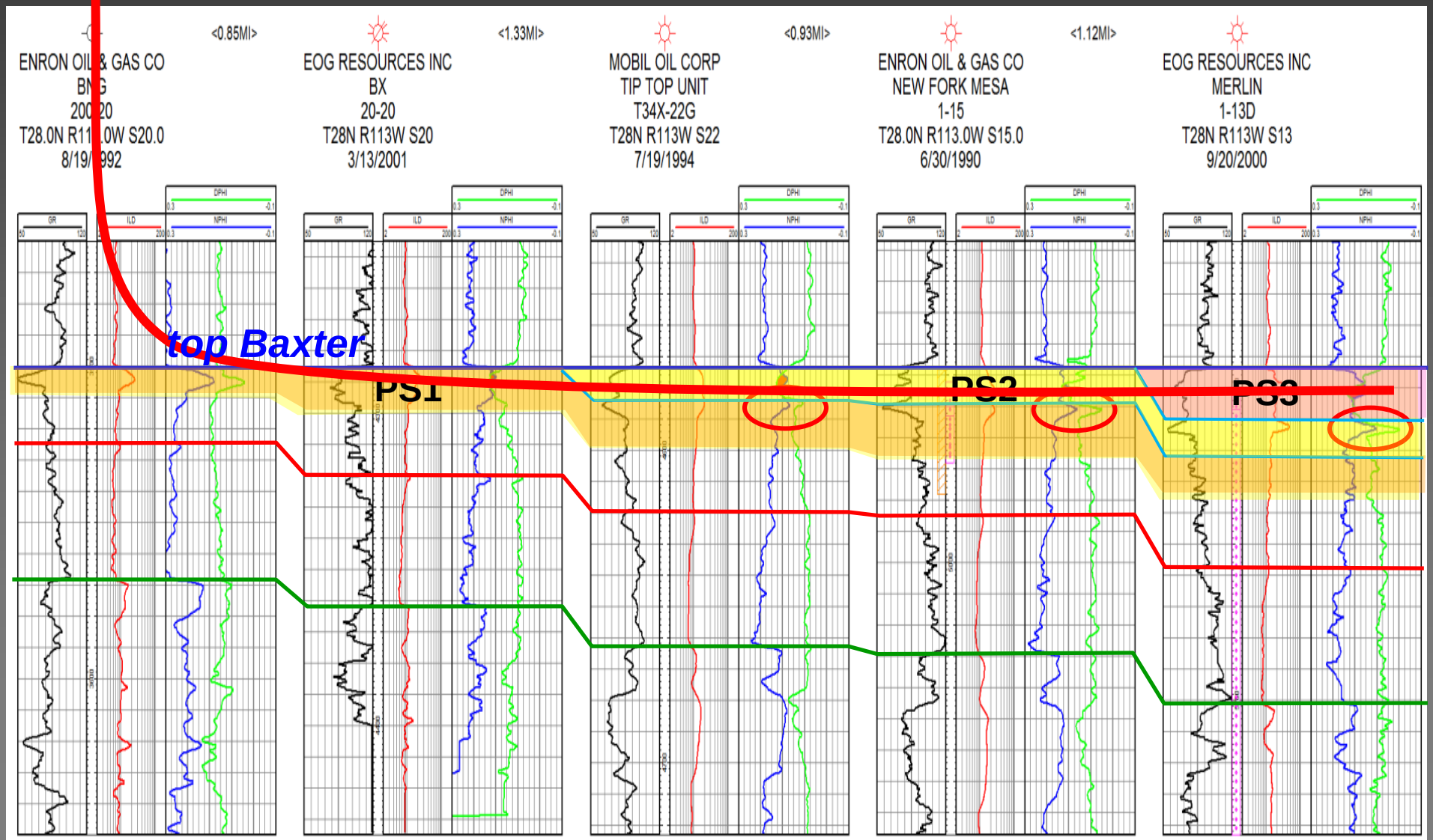
landward *basinward*



Baxter Compartmentalization



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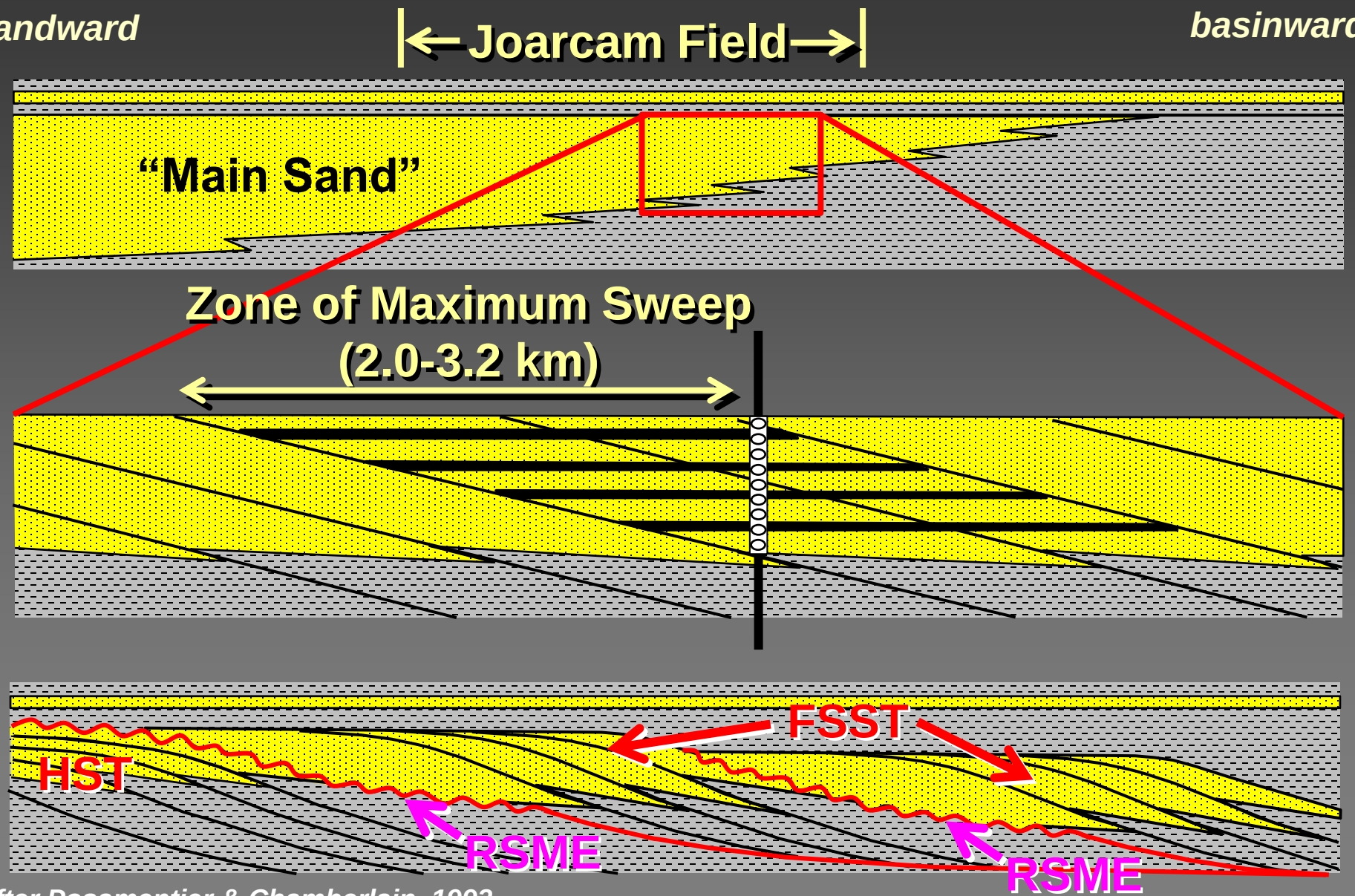
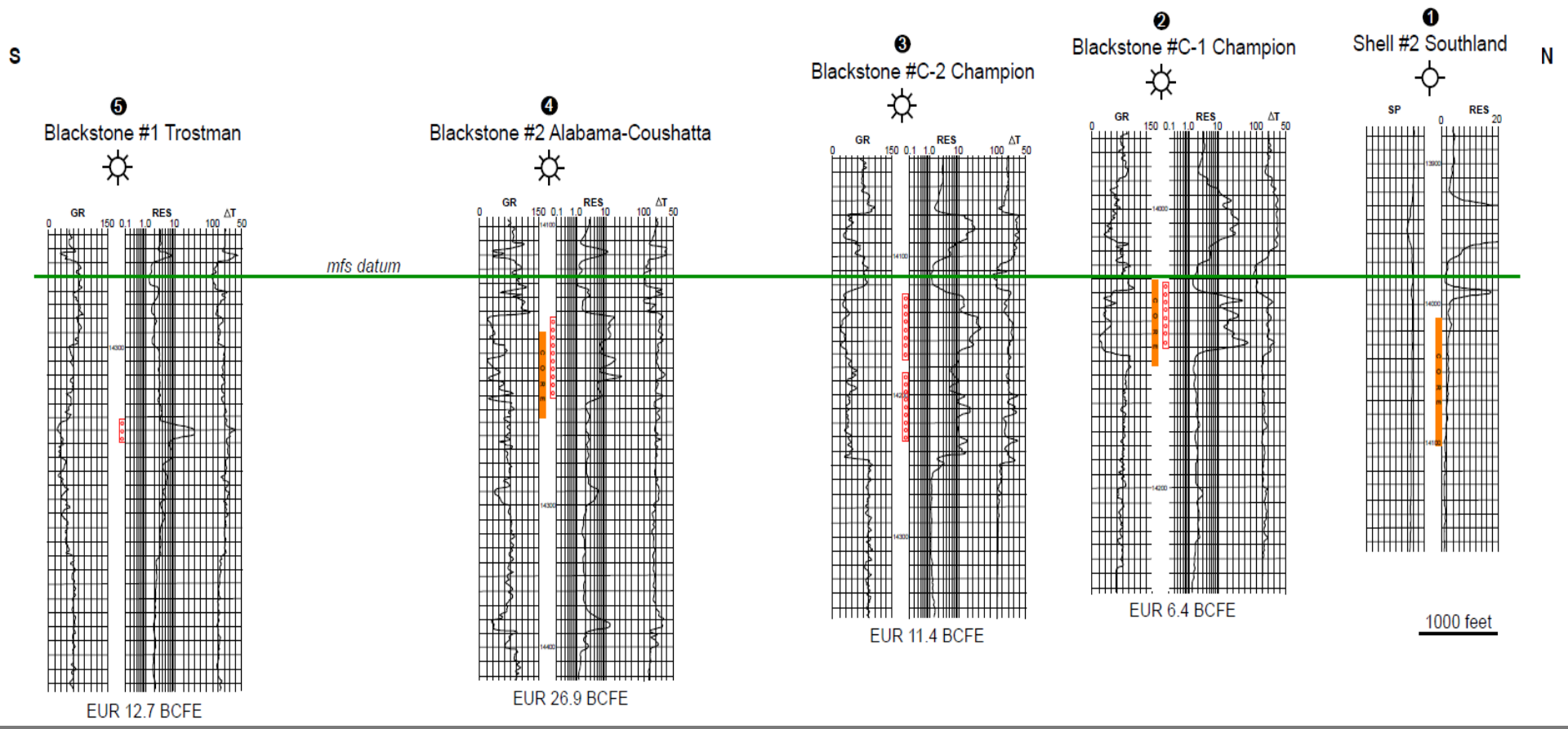
Viking Ss Compartmentalization



after Posamentier & Chamberlain, 1993

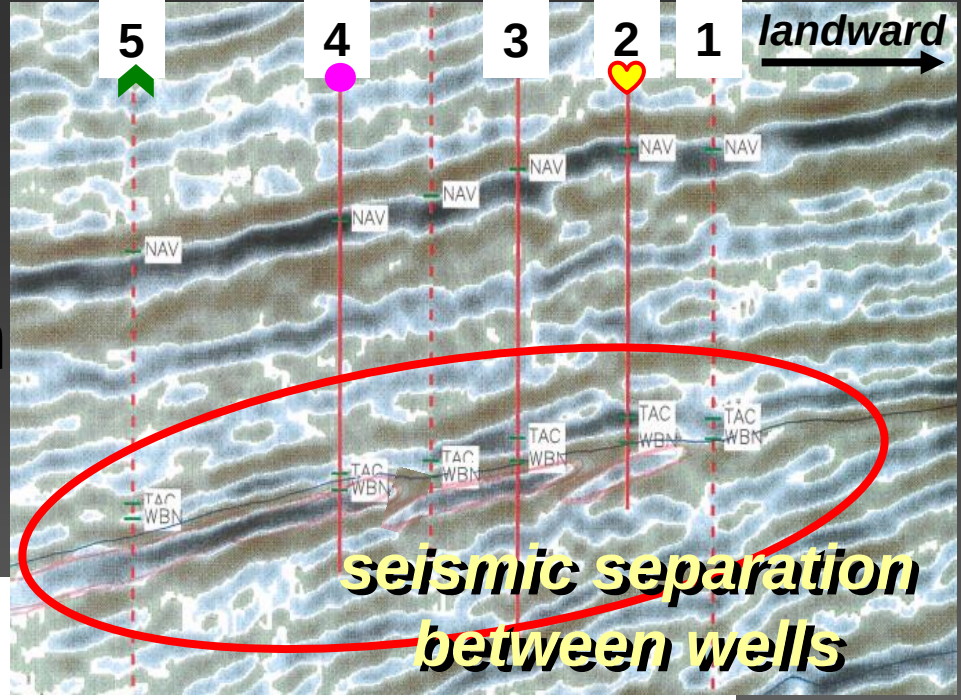
Woodbine (Double A Wells Field)
Falling Stage Systems Tract

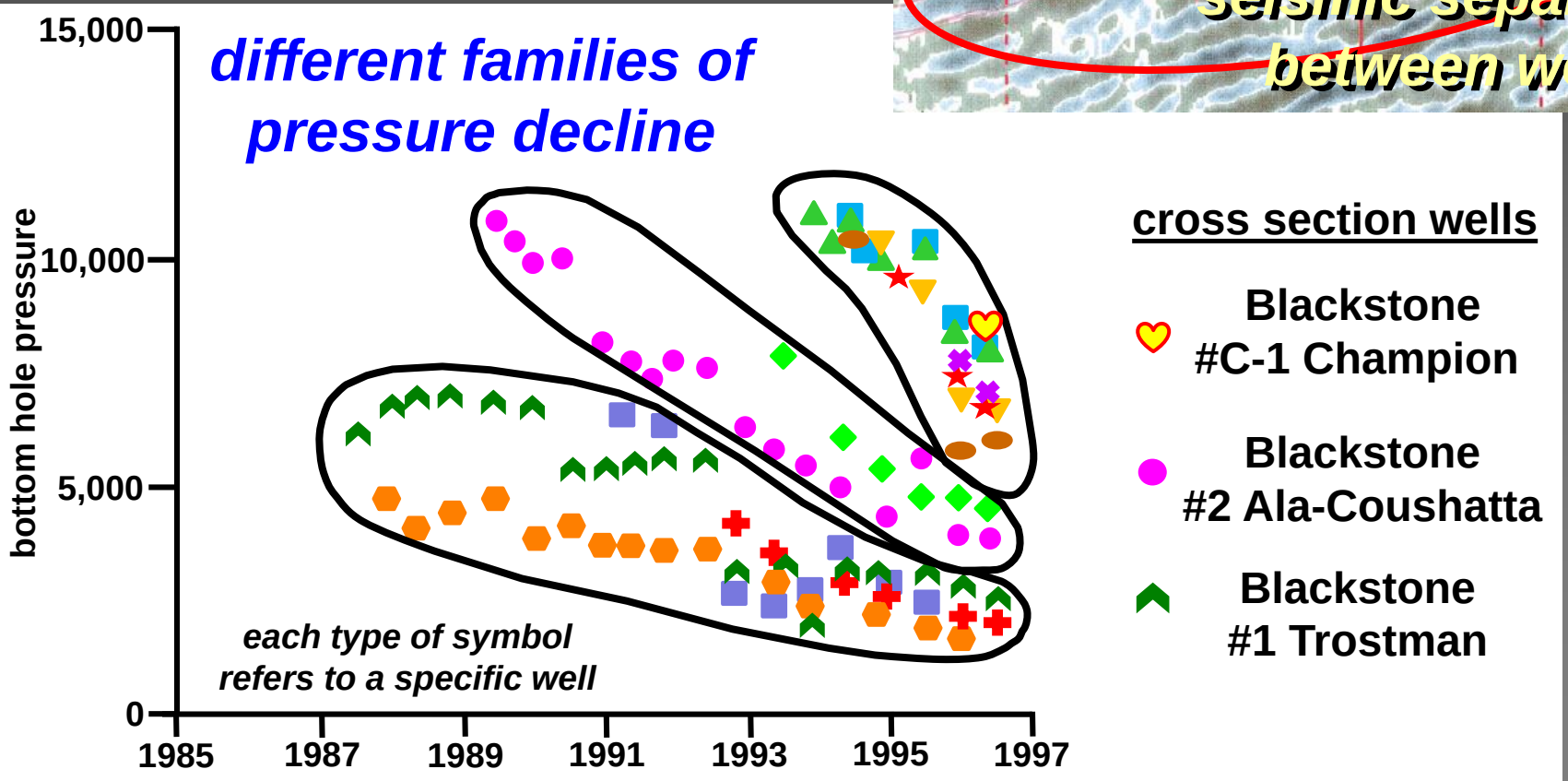
basinward *landward*



- lose sandstones landward
- sharp-based deltaic sandstones
- variable thicknesses along dip

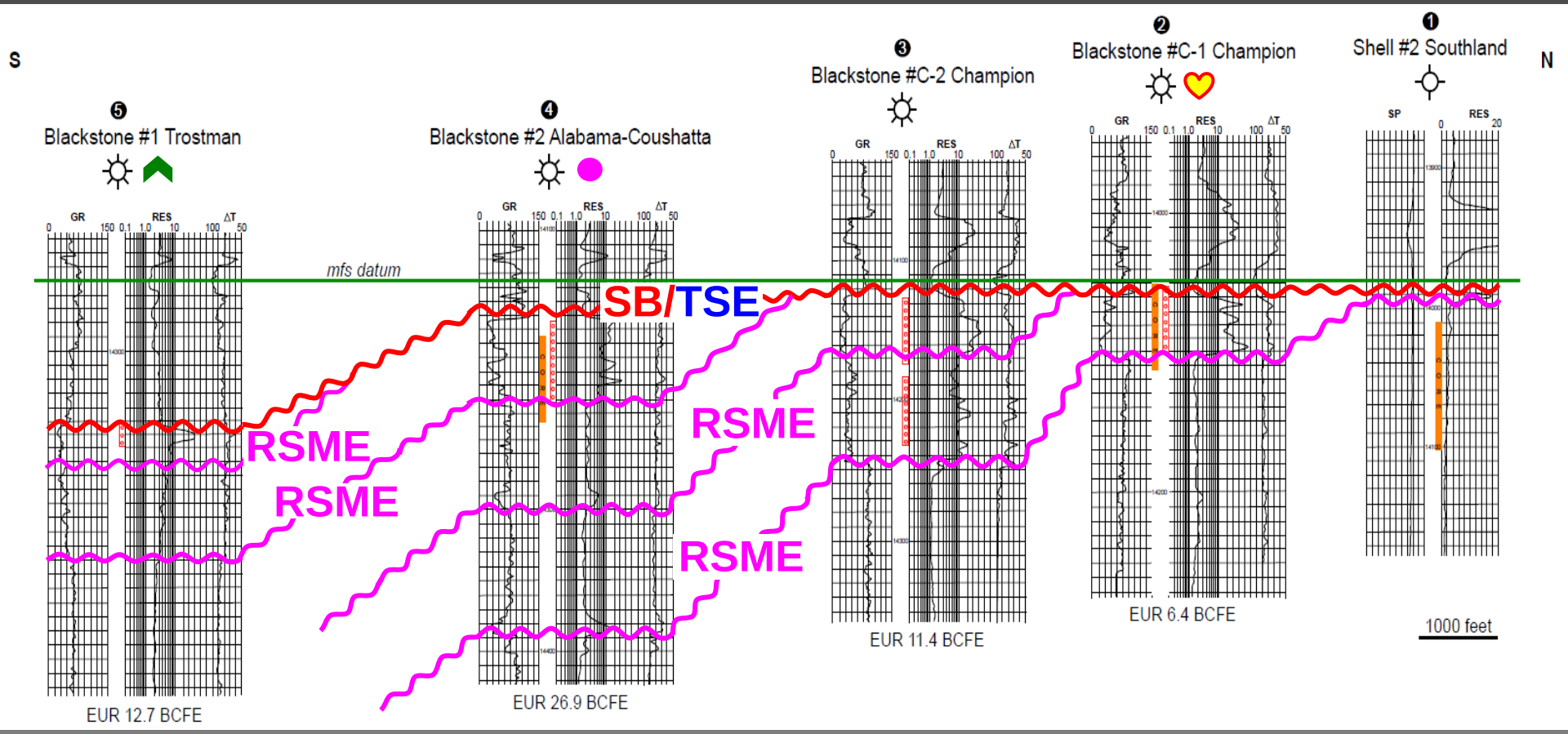
Woodbine (Double A Wells Field) Compartmentalization





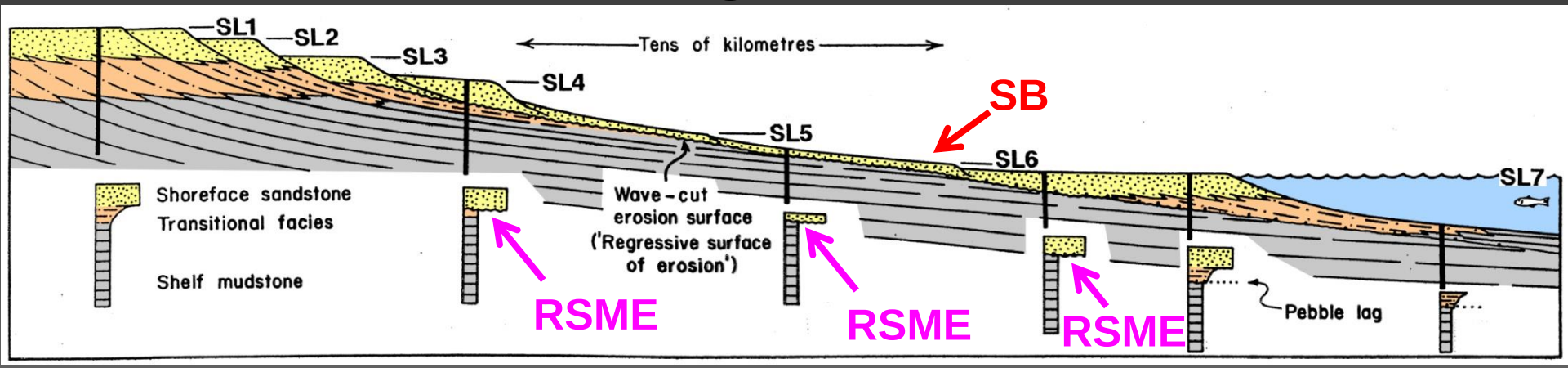
Woodbine (Double A Wells Field) Falling Stage Systems Tract

basinward *landward*

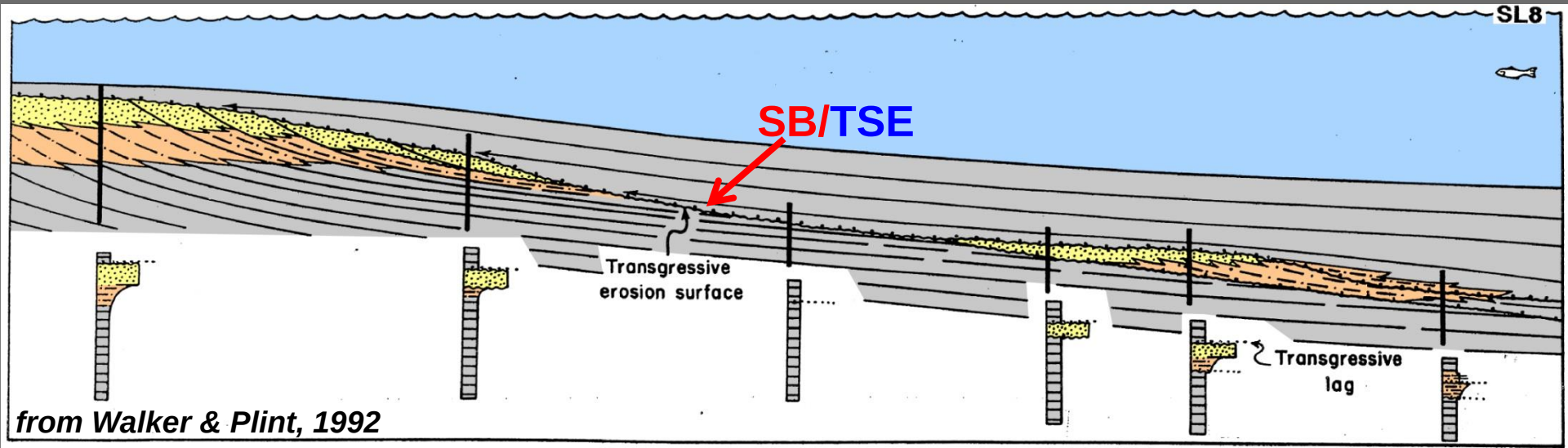


Reworking of Falling Stage Shorelines

Falling Sea Level



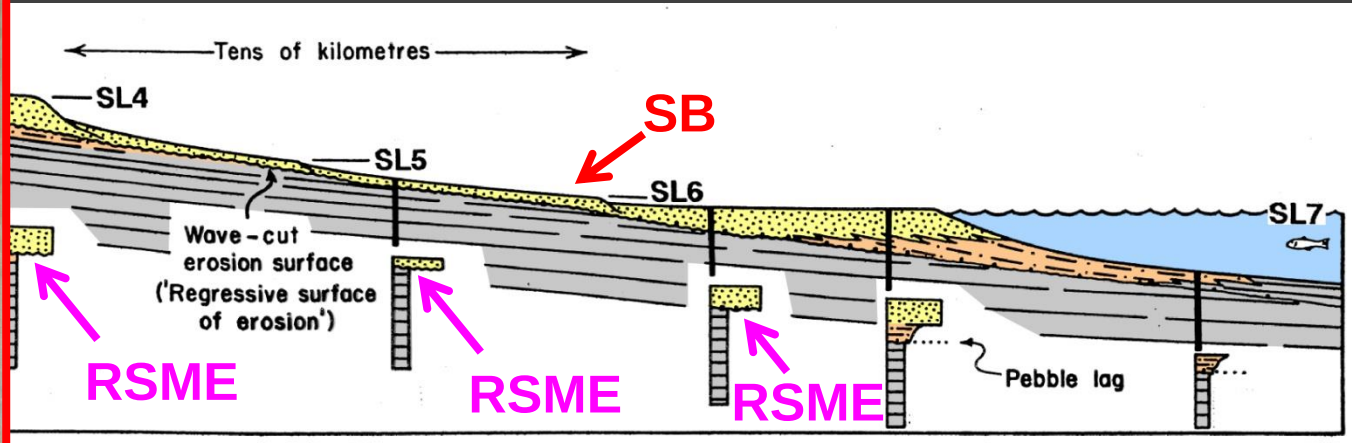
Transgressive Removal & Reworking



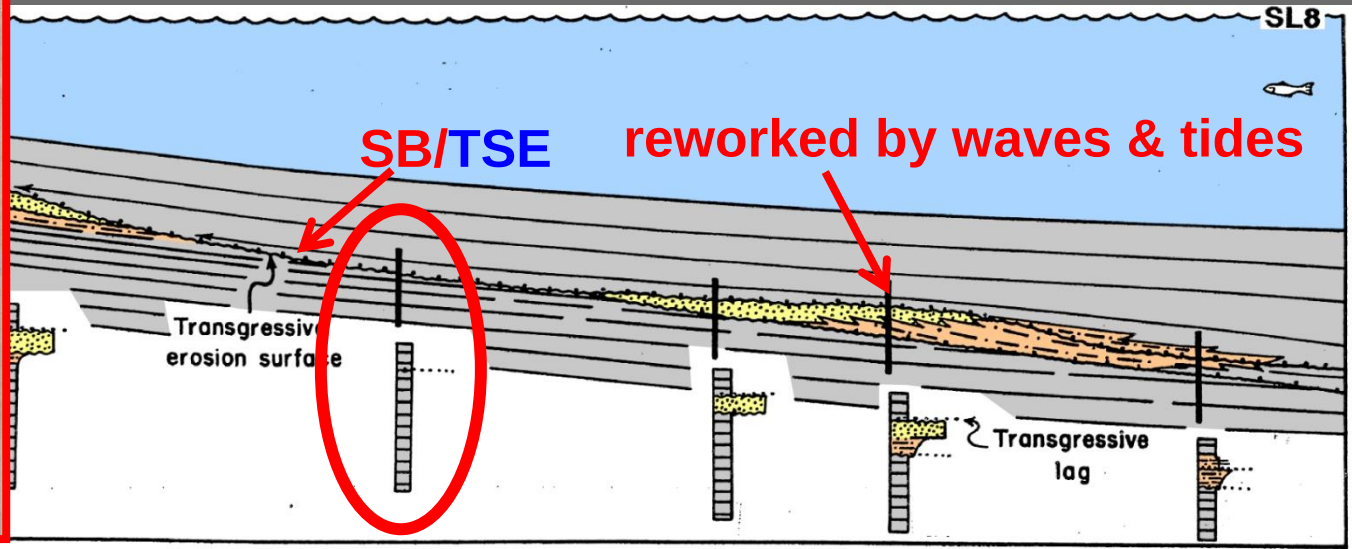
from Walker & Plint, 1992

Reworking of Falling Stage Shorelines

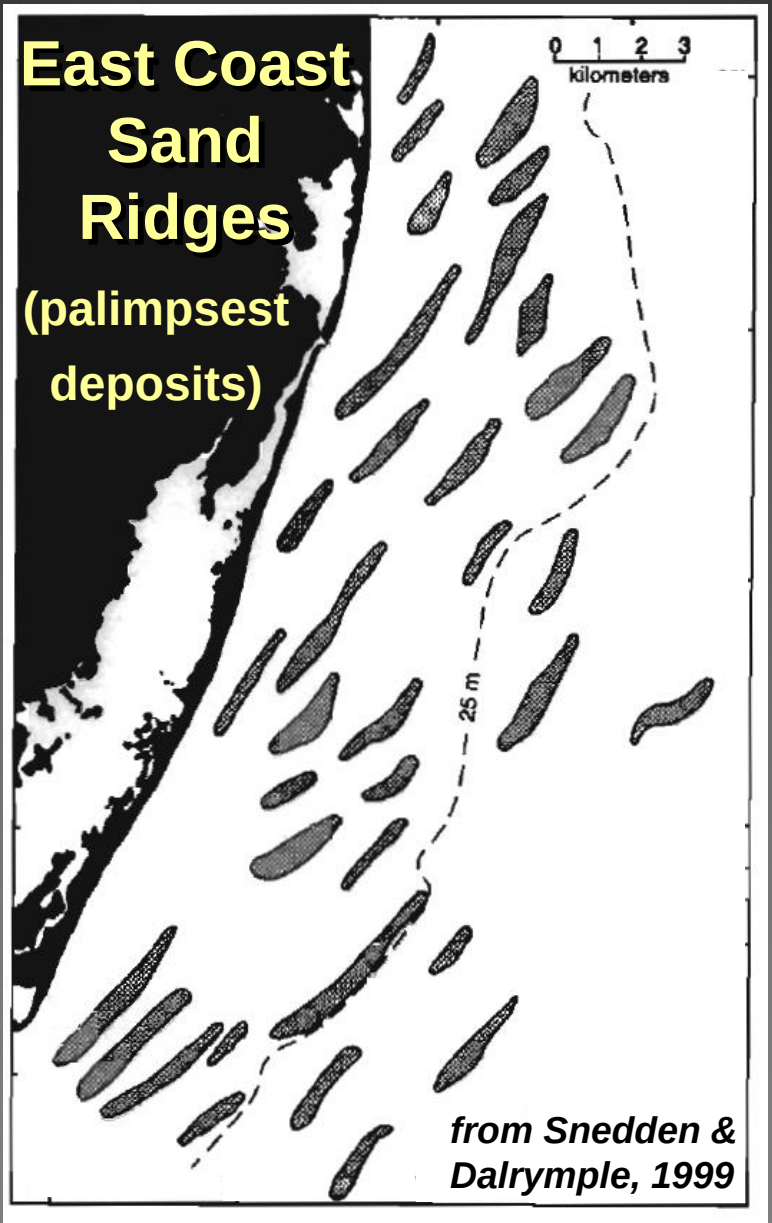
Falling Sea Level

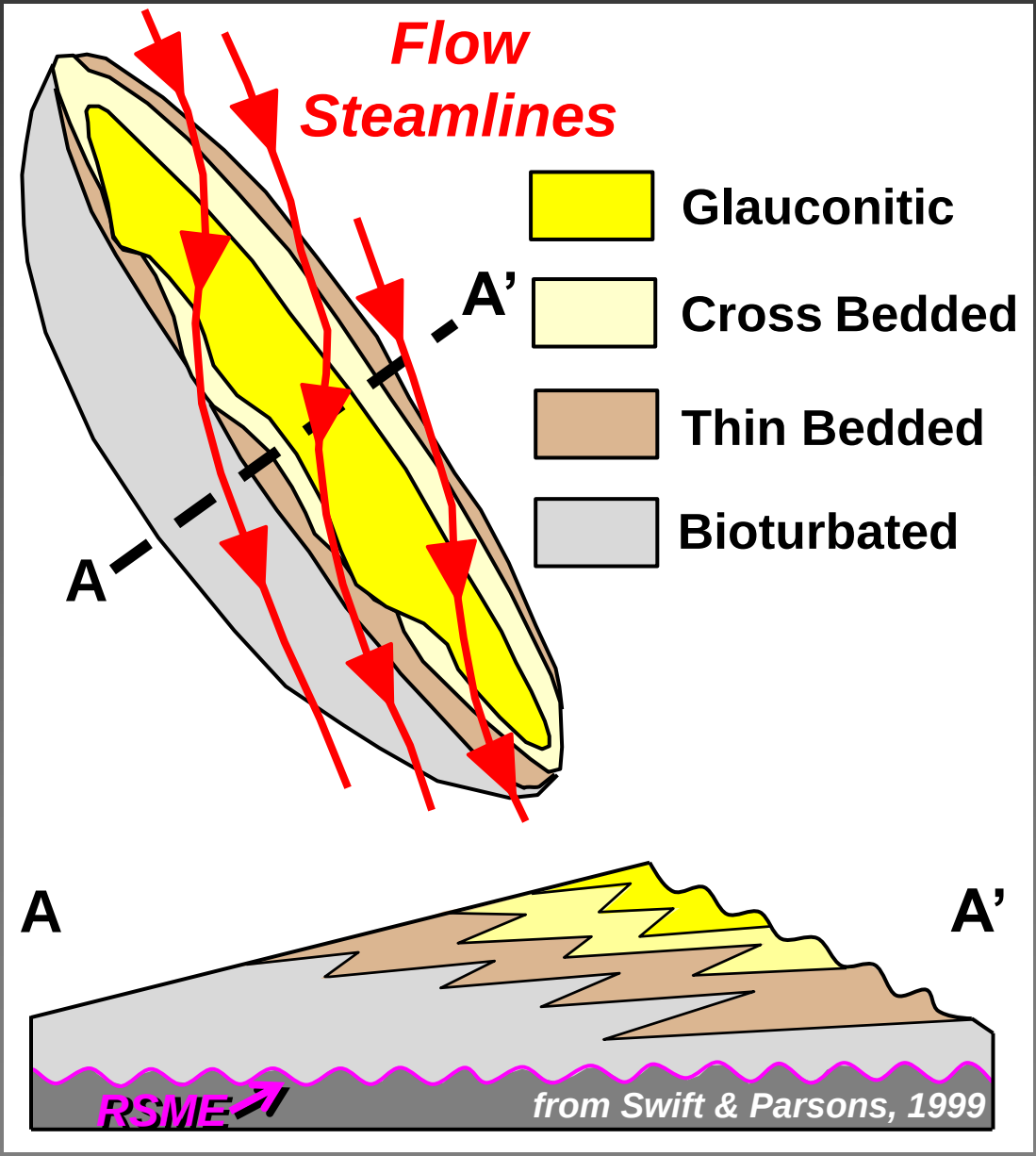


gressive Removal & Reworking

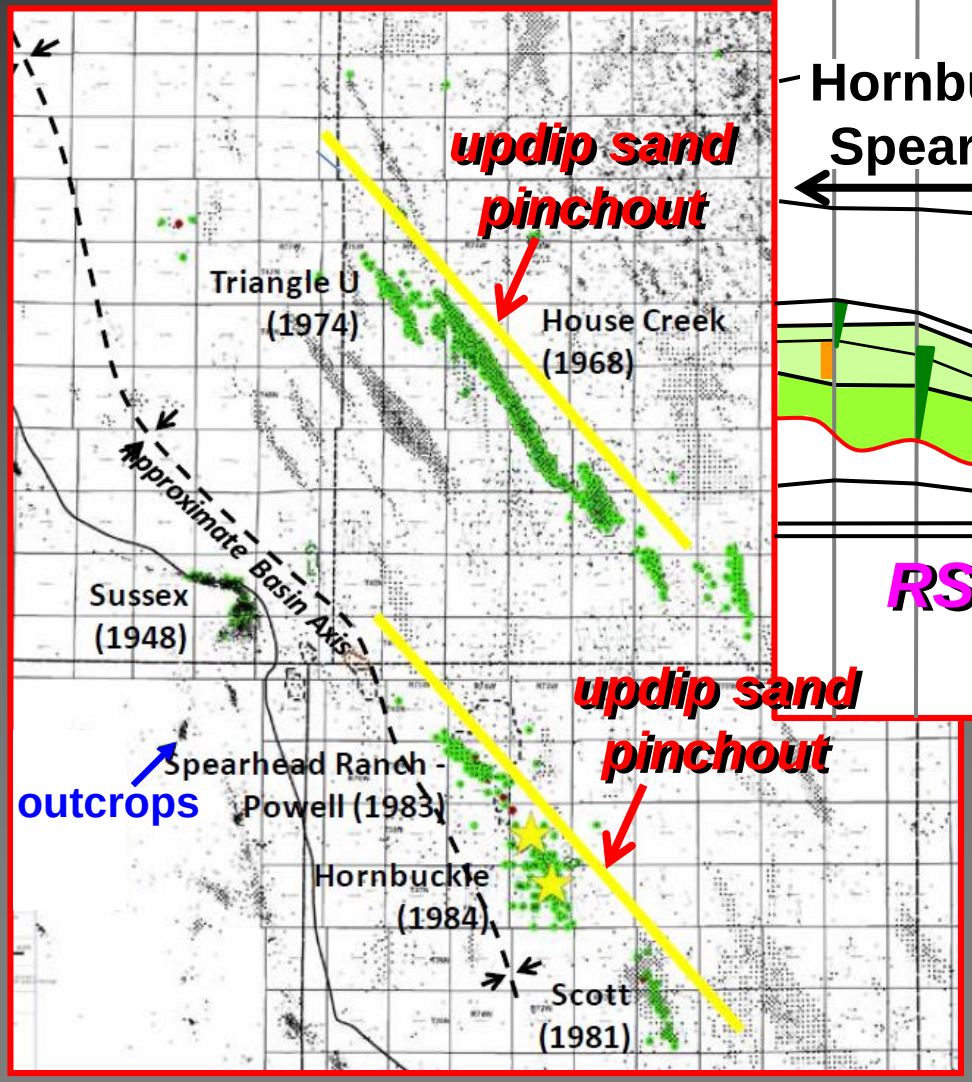


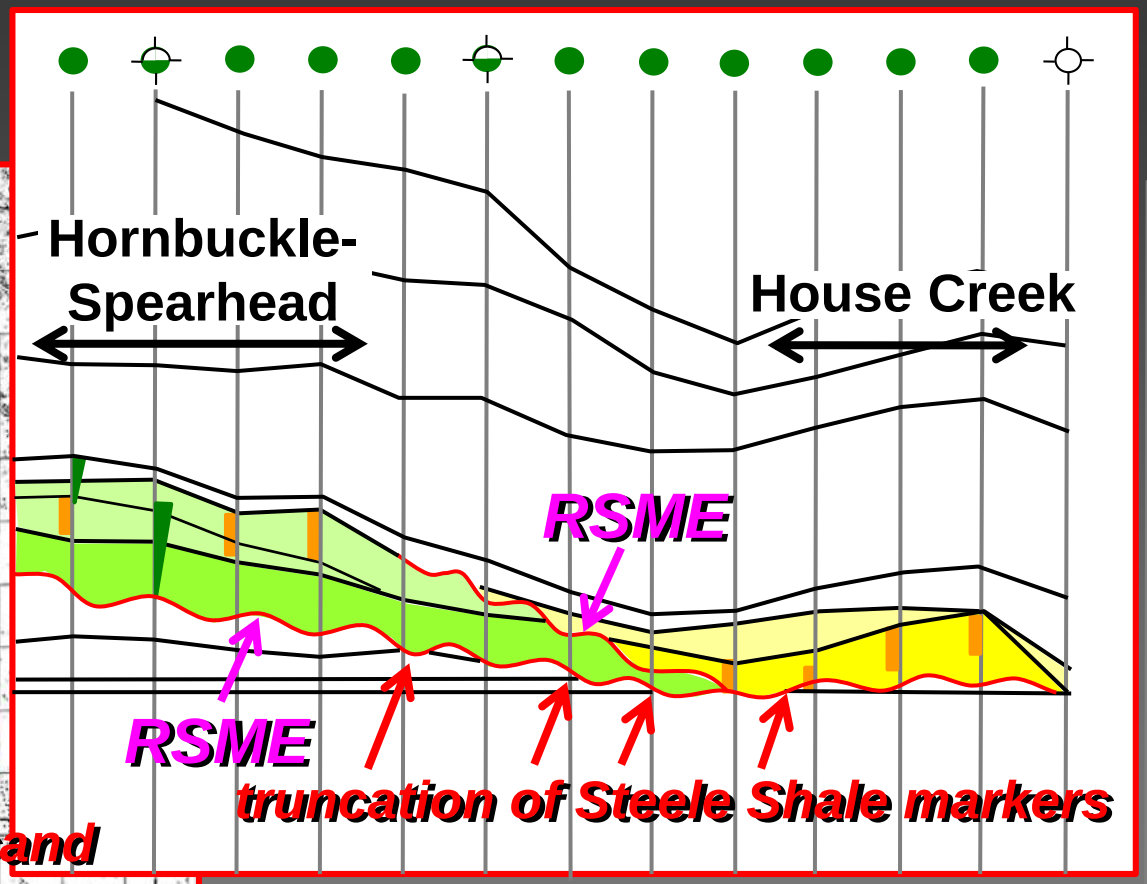
Facies Variation In Reworked FSST





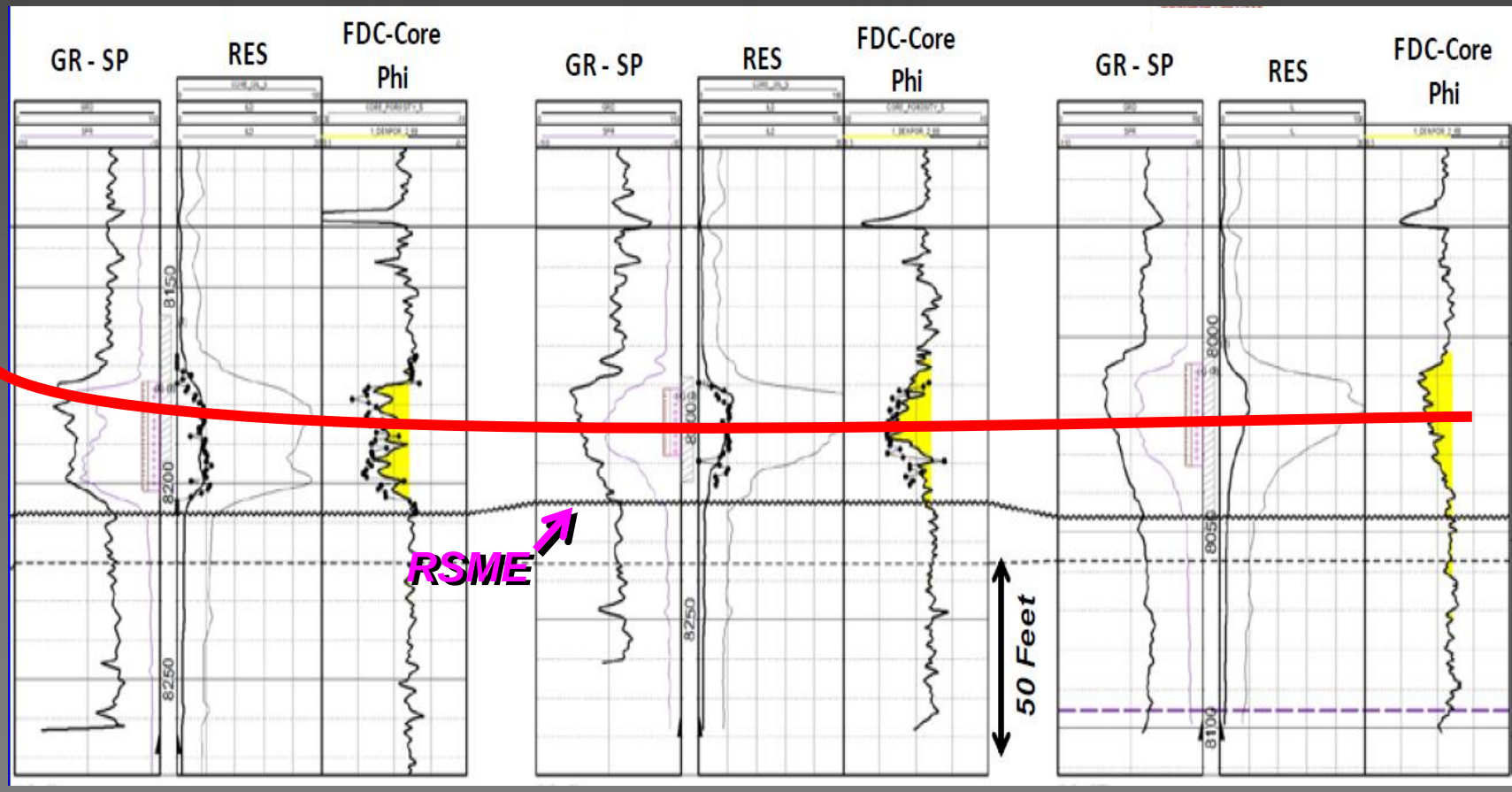
Sussex Falling Stage Systems Tract





after Bottjer et al., 2015

Sussex (House Creek Fld) Facies Variation



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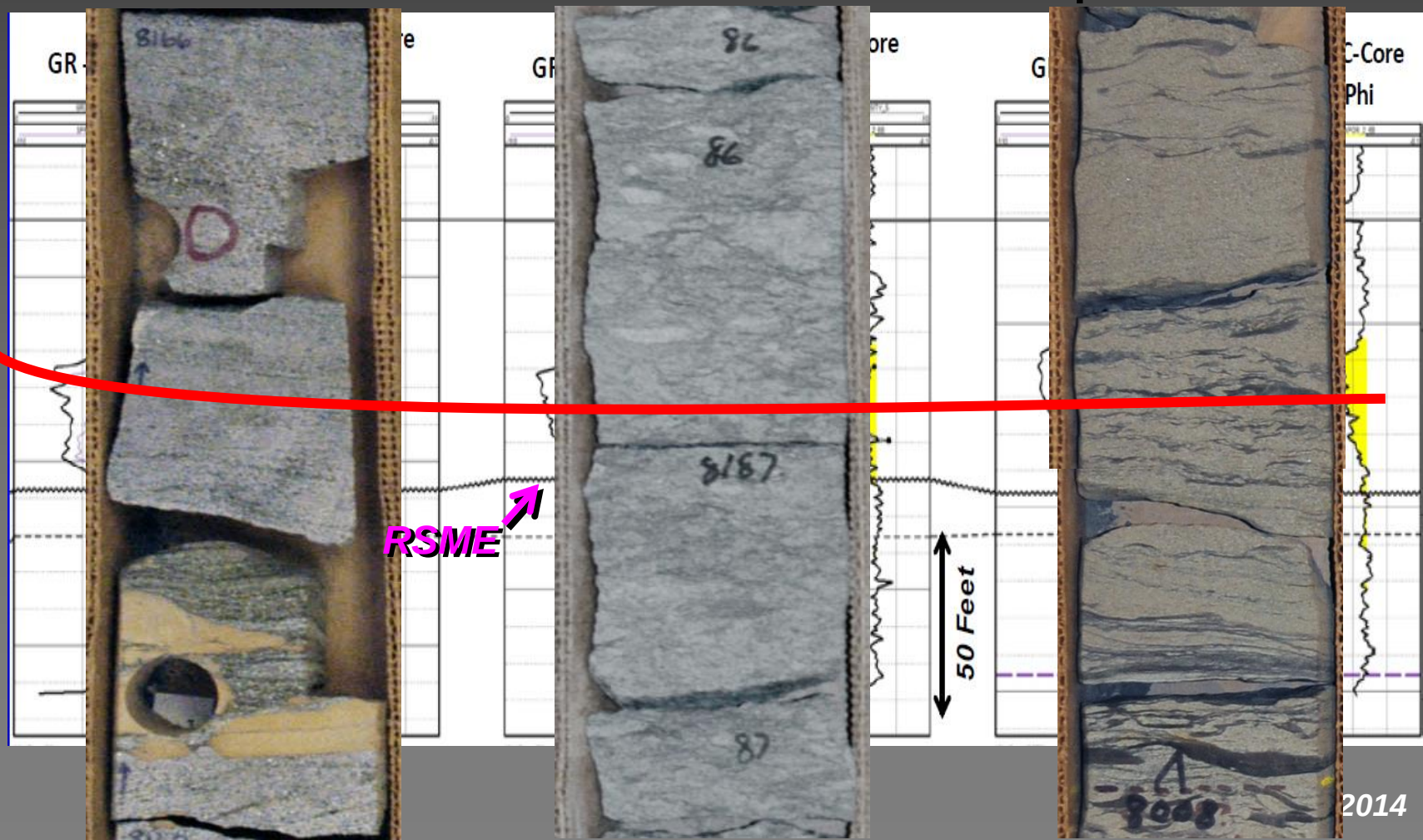
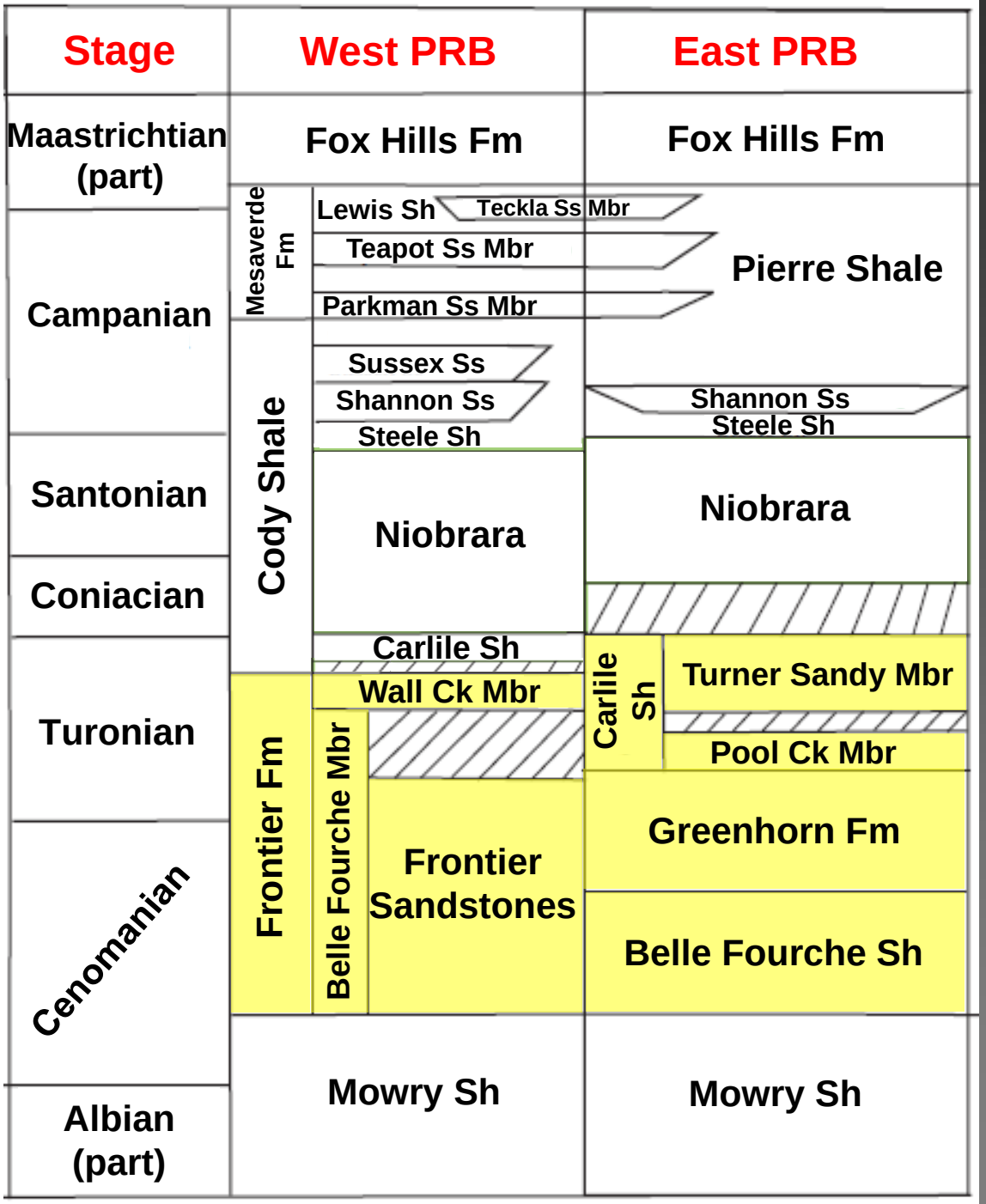


2014

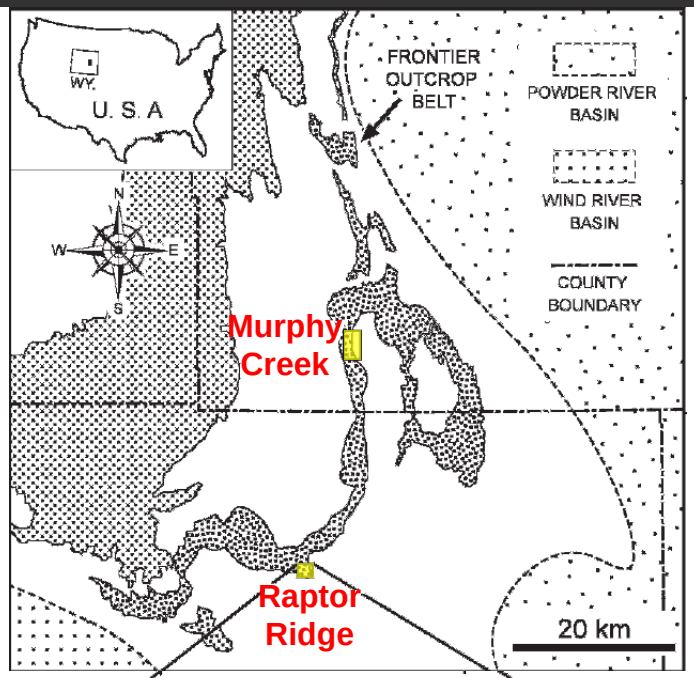
Frontier-Wall Creek/Turner Stratigraphy

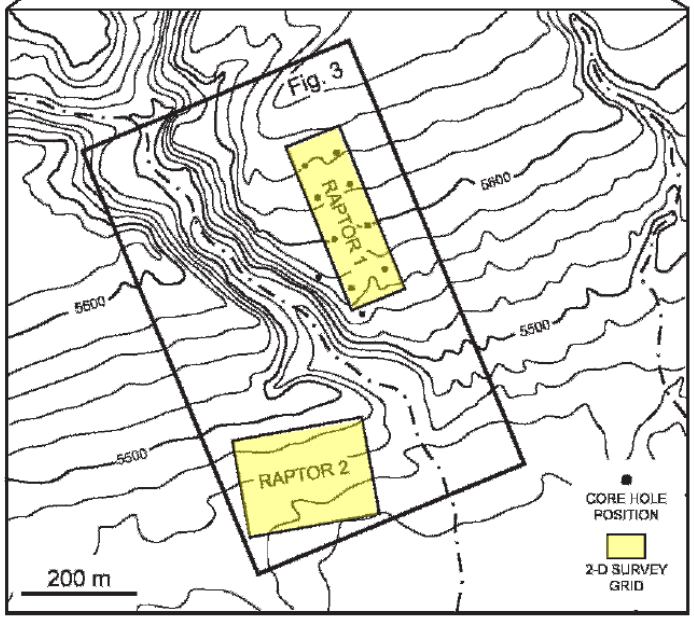


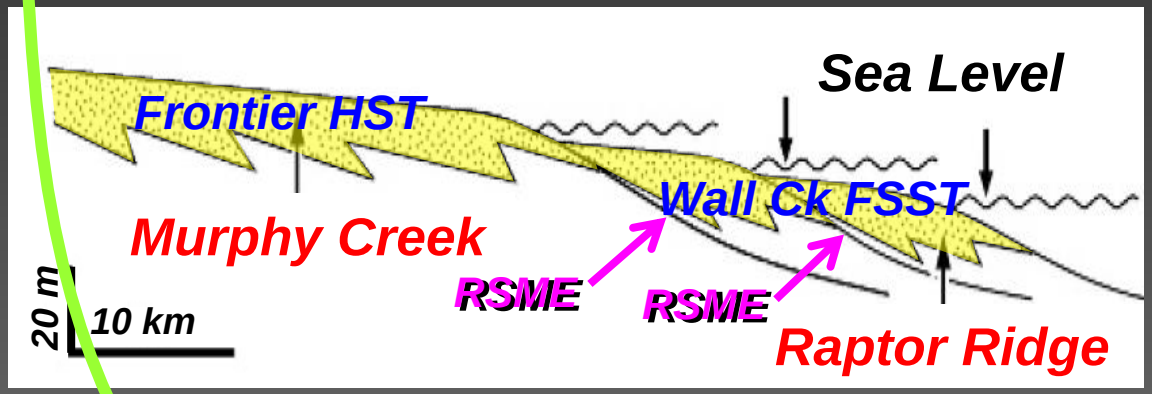
modified from Anna, 2009

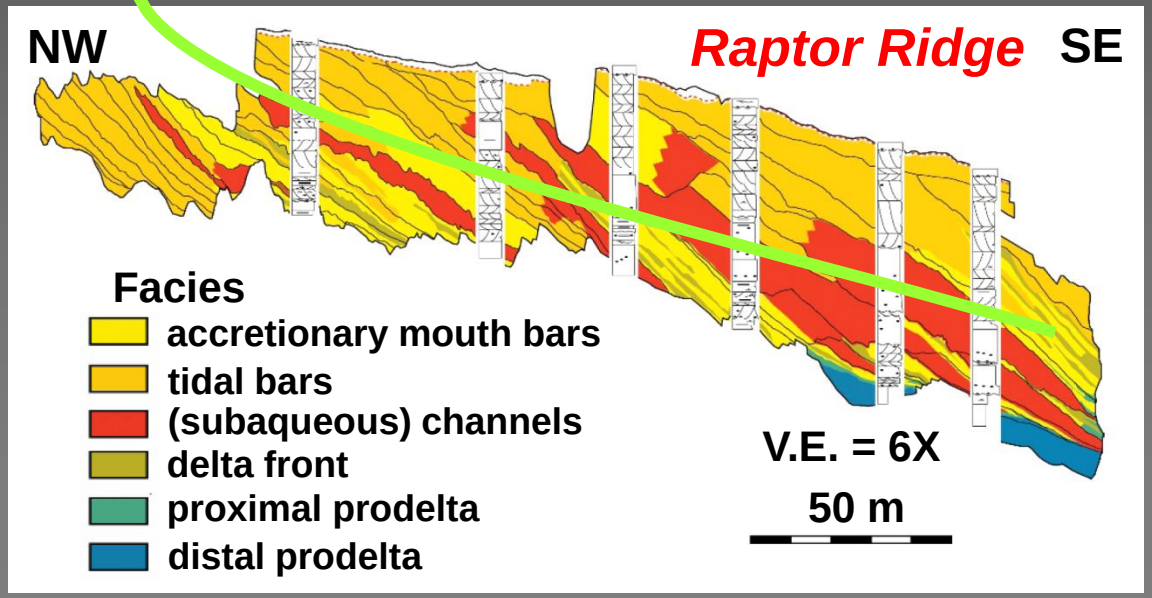
Wall Creek Member (Turner)

Frontier-Wall Creek/ Turner Outcrops









from Lee et al., 2007

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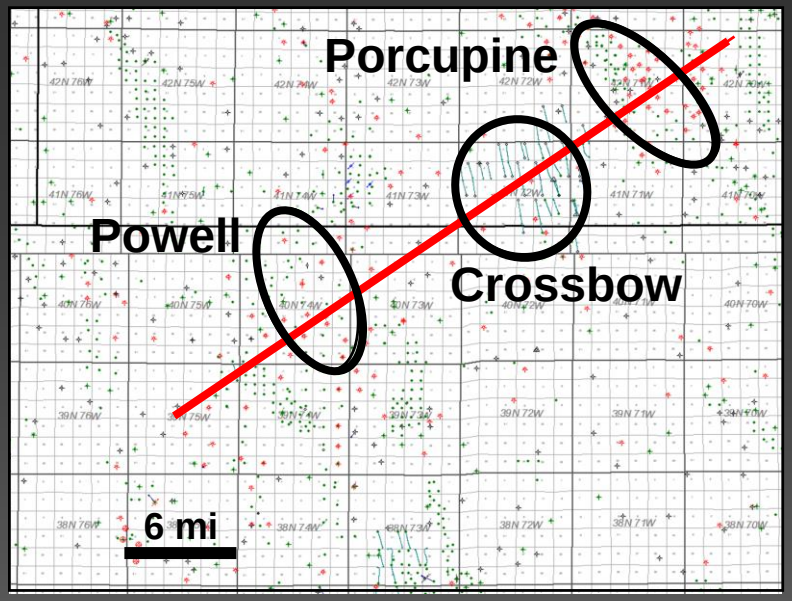
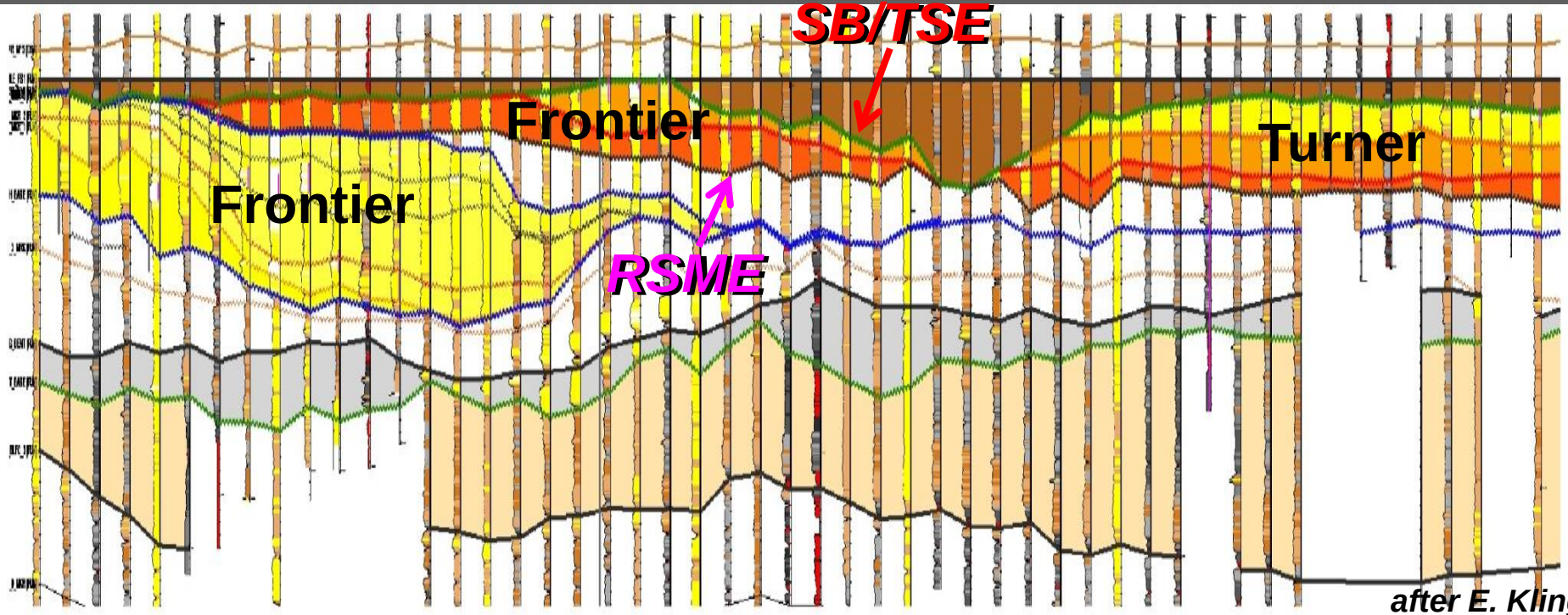
Frontier-Turner Correlations & Erosion

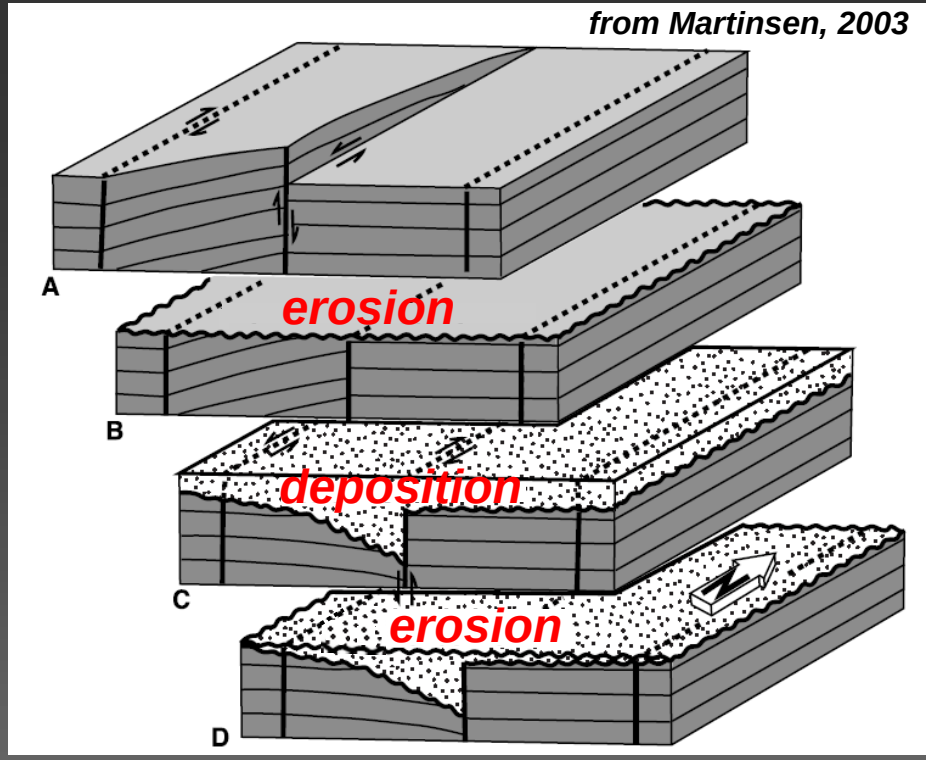


SW Avery/Finley/Powell Crossbow/Porcupine NE



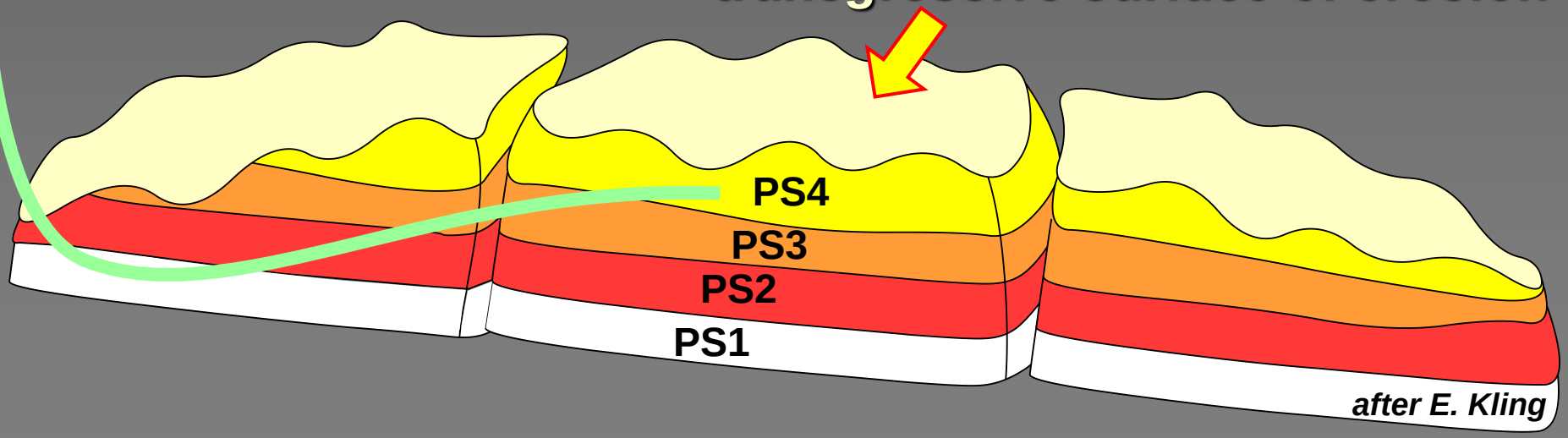
after E. Kling

Turner Erosional Modification

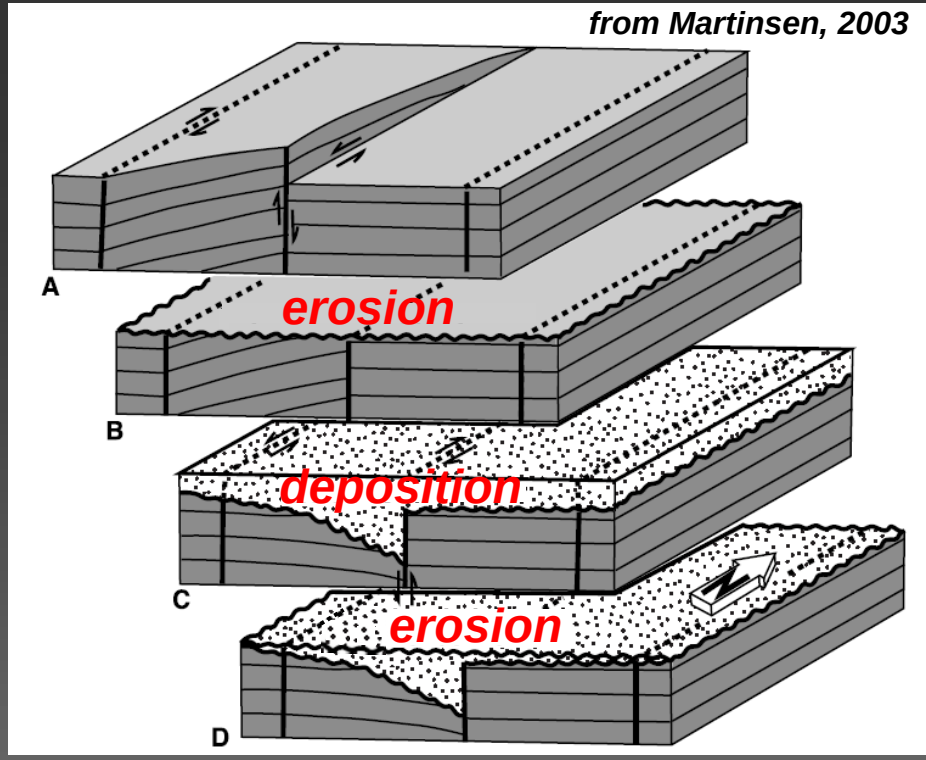


Mary's Draw/
Crossbow/
Porcupine area

merged sequence boundary &
transgressive surface of erosion

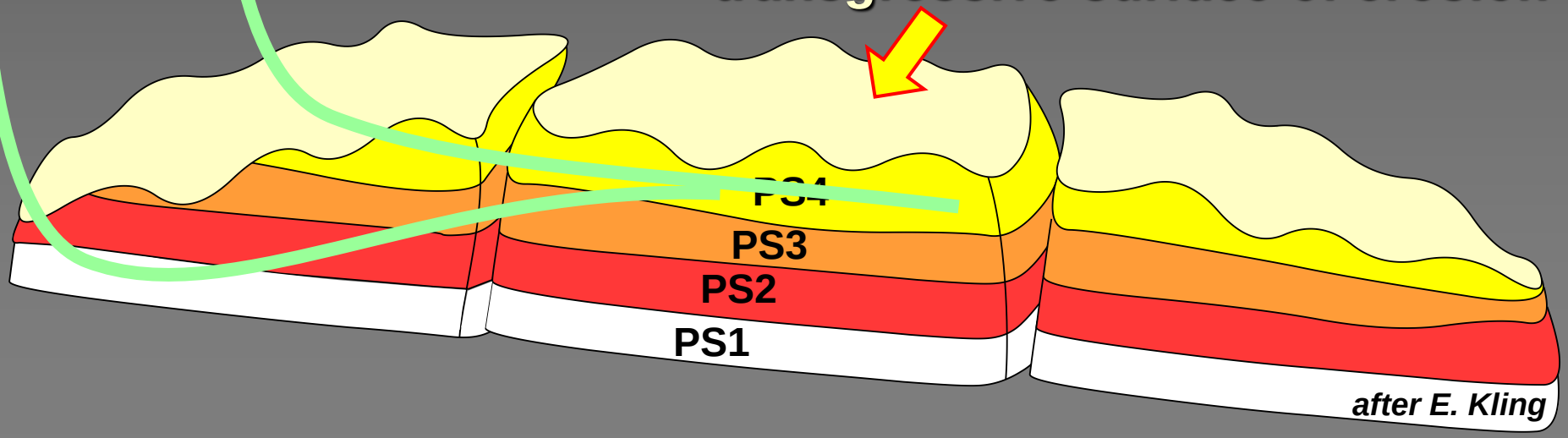


Turner Erosional Modification

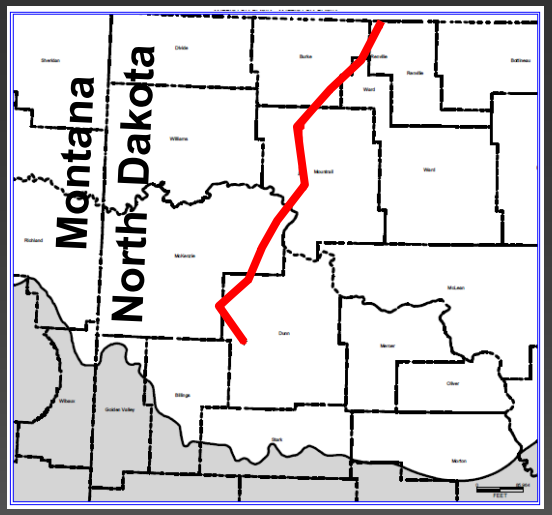


Mary's Draw/
Crossbow/
Porcupine area

merged sequence boundary &
transgressive surface of erosion



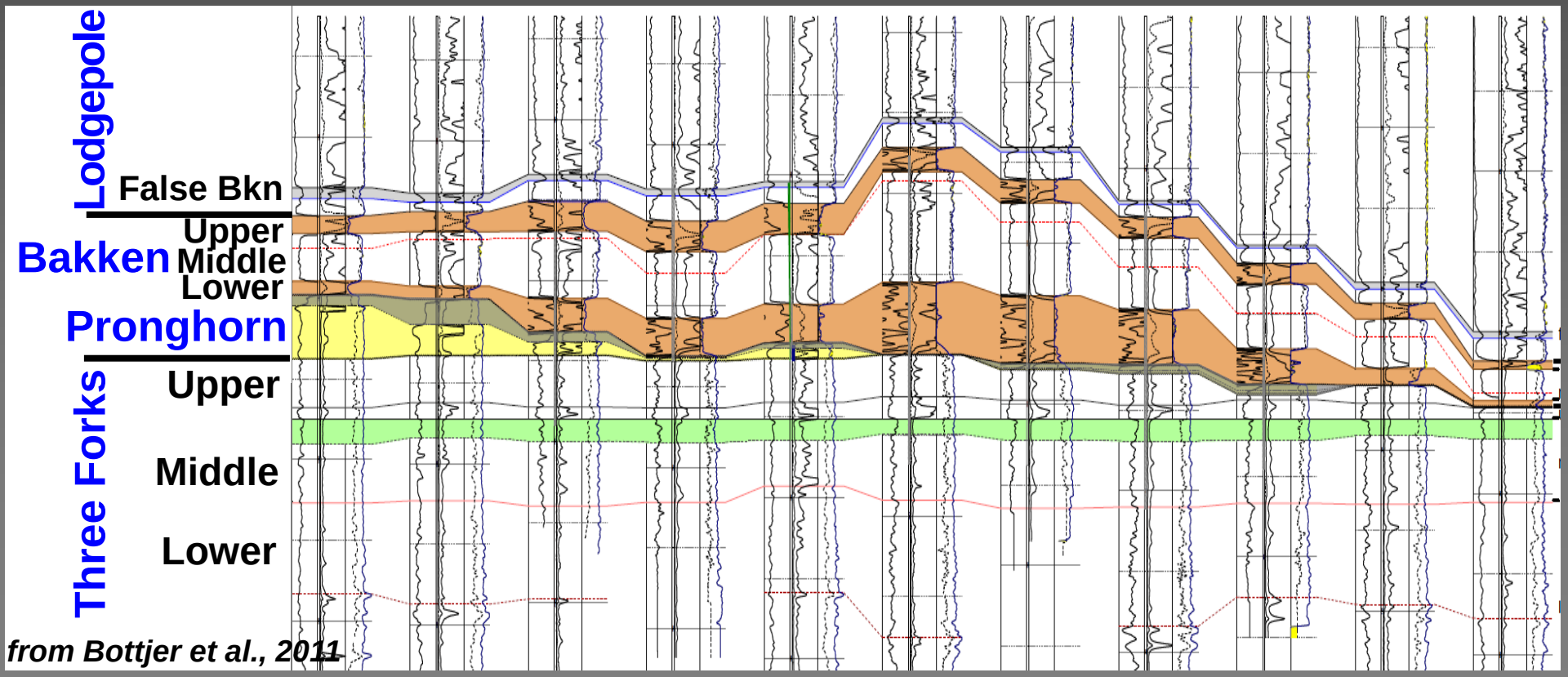
Three Forks Optimization



Antelope Field

SW

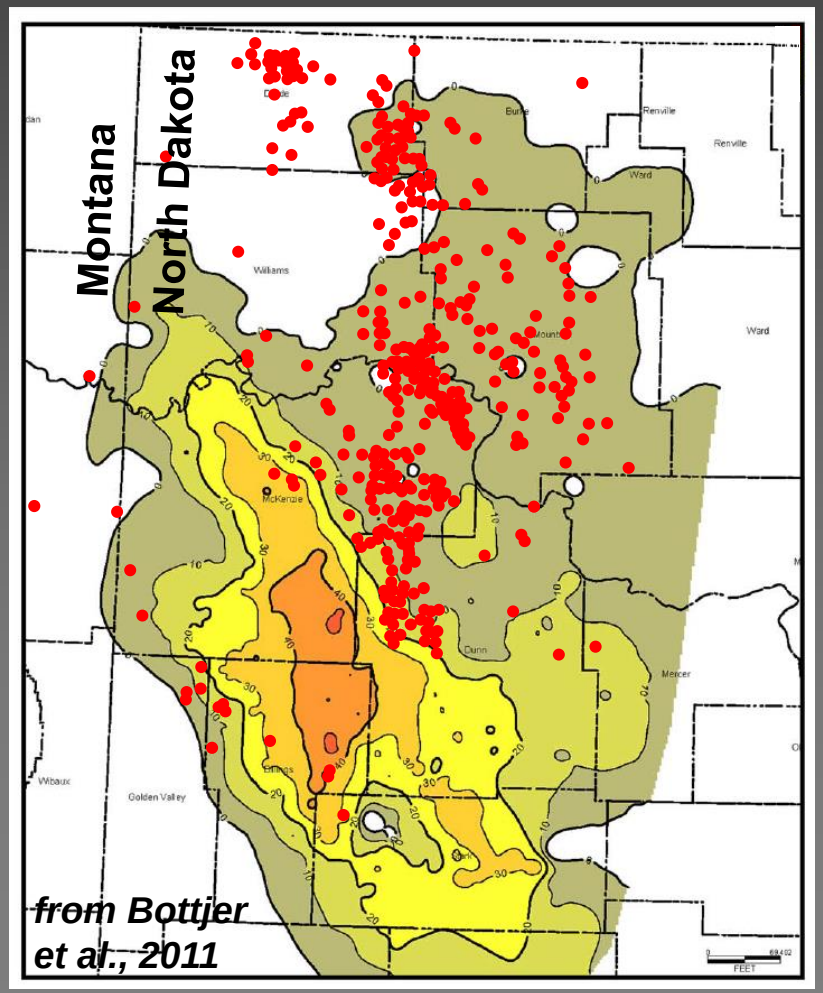
NE



from Bottjer et al., 2011

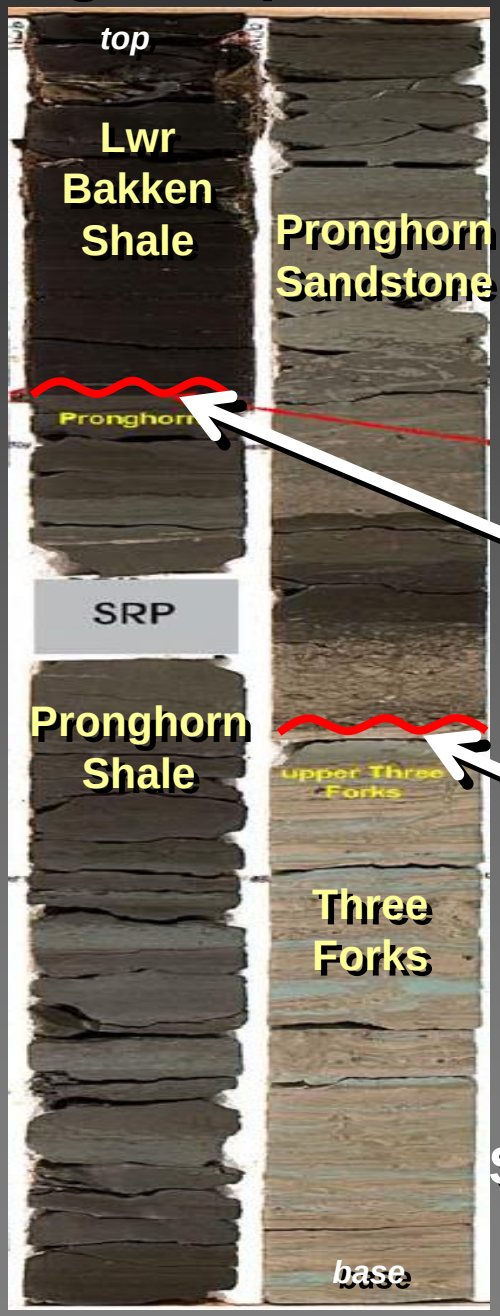
Unconformities & Targeting

Pronghorn Isopach & Three Forks Production



from Bottjer et al., 2011

Pronghorn present (SW)



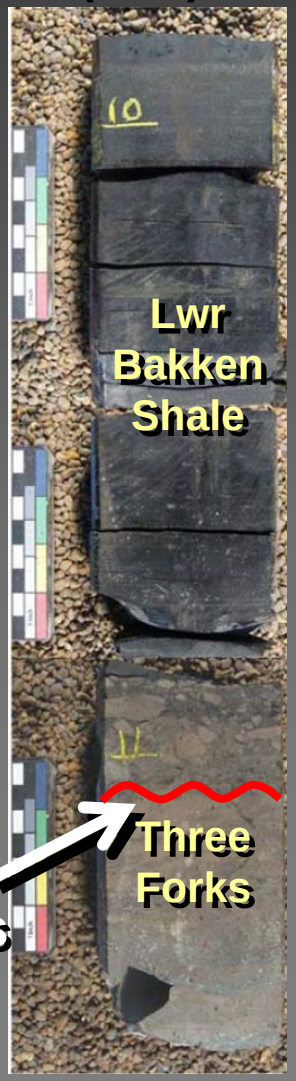
merged SB & TSE

merged SB & TSE

merged SBs & TSEs

from Bottjer et al., 2011

Pronghorn missing (NE)



Conclusions: Sequence Stratigraphy & Horizontal Targeting

- not “THE” answer, but a useful (necessary?) tool
- increased understanding of depositional controls on reservoir vs. non-reservoir
- framework for data selection and integration
- better correlation and mapping of targets
- aids reservoir modeling & economic evaluation (compartmentalization)
- helps with selection of & staying in best zone