Glacio-eustatic versus tectonic origin of high-frequency sequences in the mid-latitude Cretaceous foreland basins of North America.

McMaster University

Janok P. Bhattacharya

Susan Cunningham Research Chair in Geology

School of Geography and Earth Sciences

Quantitative Sedimentology Laboratories

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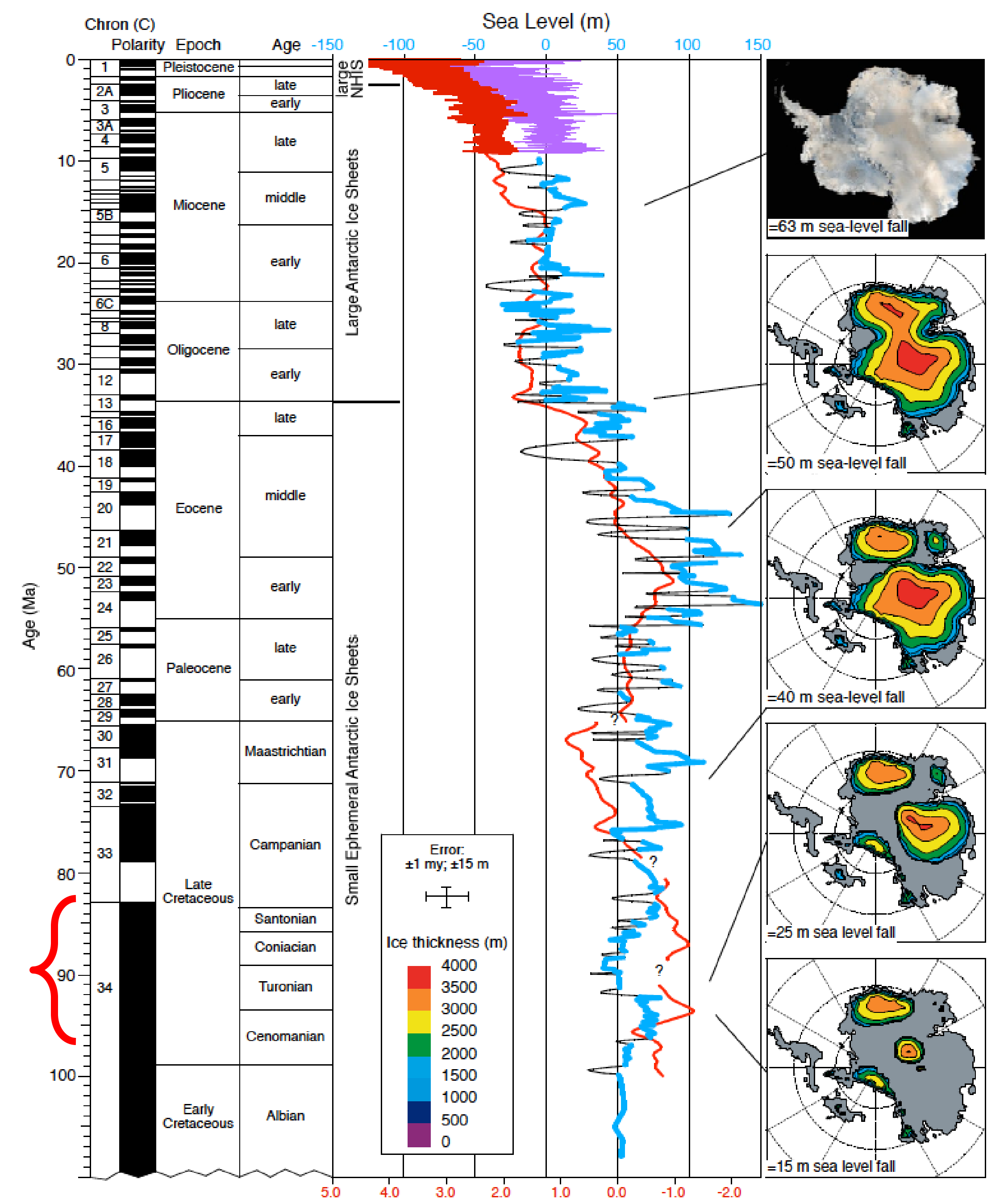
Outline

- Introduction
- Ferron Example (Eustatic)
- Wyoming Example (Tectonic)
- Conclusion

Glacioeustasy in the Greenhouse

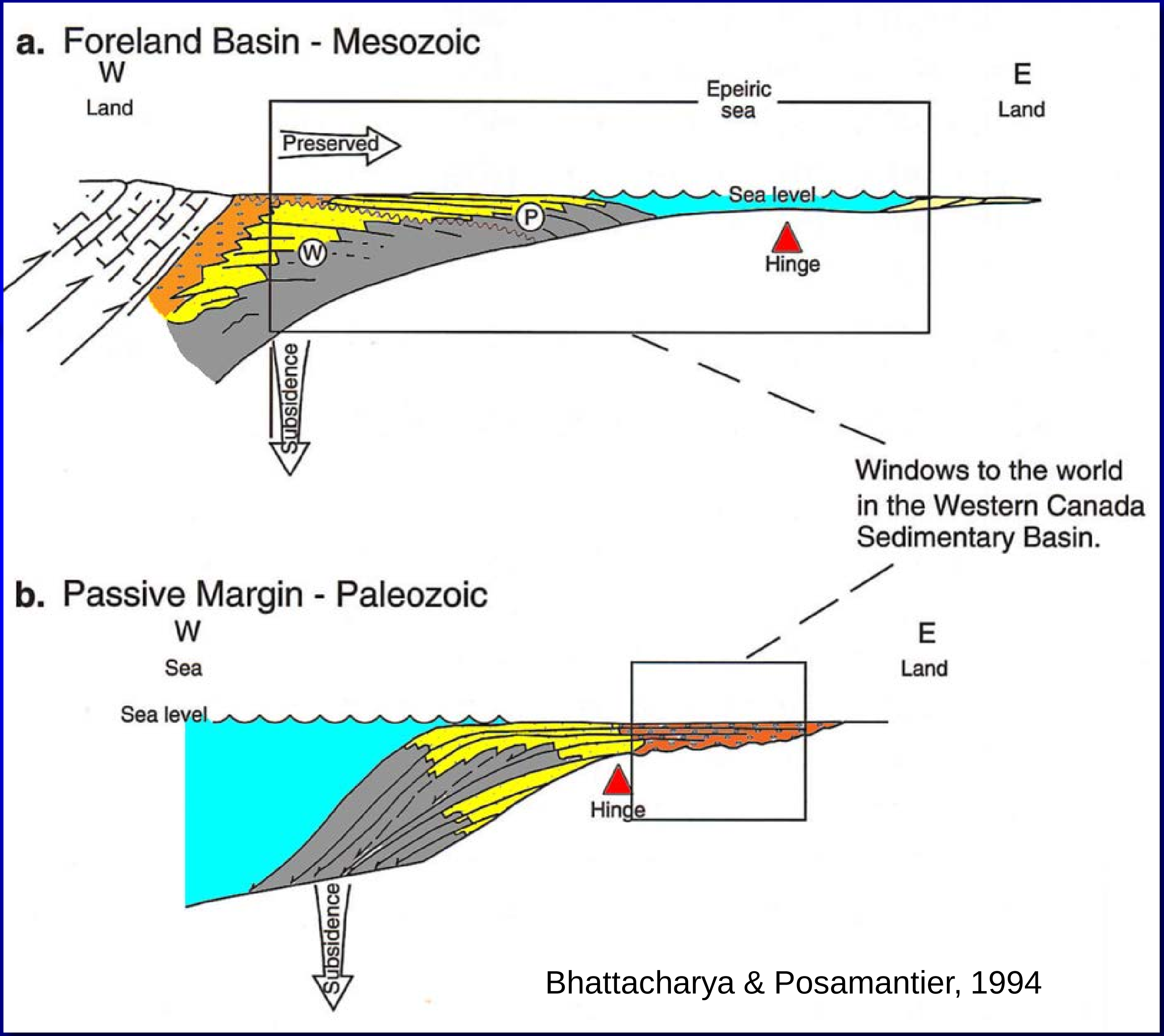
- Miller et al. (2008) suggest ephemeral Antarctic ice-sheets drove ± 25 m eustatic changes in the mid-Cretaceous Greenhouse.
- Key for developing astrochronological (Milankovitch) scale for Cretaceous.
- Debunks idea that earth was ever truly ice-free.



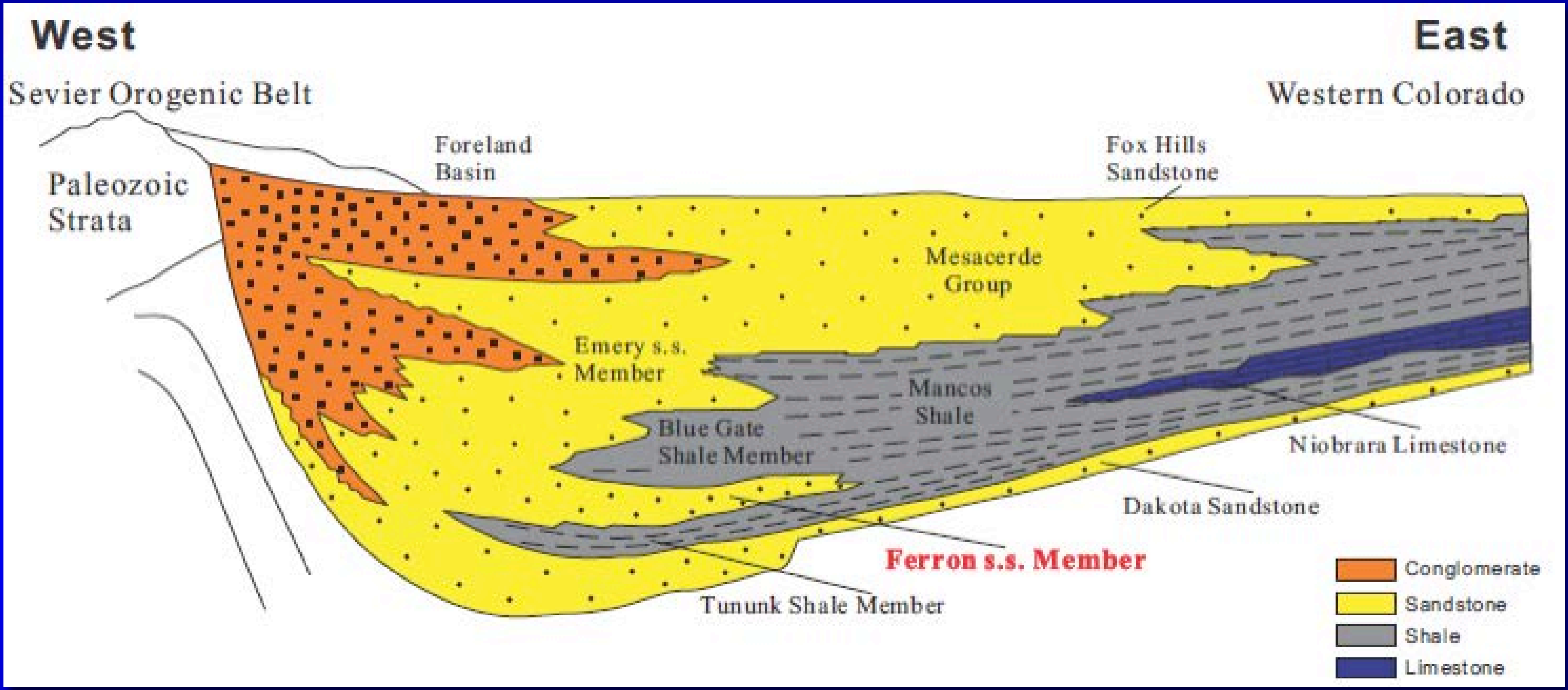
Miller at al, 2008

Passive sensitivity to glacioeustasy

- **Foreland basins very sensitive to tectonics BUT typically better exposed.**
  - **Much high-resolution sequence stratigraphy done here!**
- **Passive margins are hard to uplift.**
- **Analysis of degradational lapout indicates eustatic falls.**
  - **Mostly seismic analysis (resolution may preclude observation of highest frequency sequences)**



Ferron Example



Armstrong, 1968

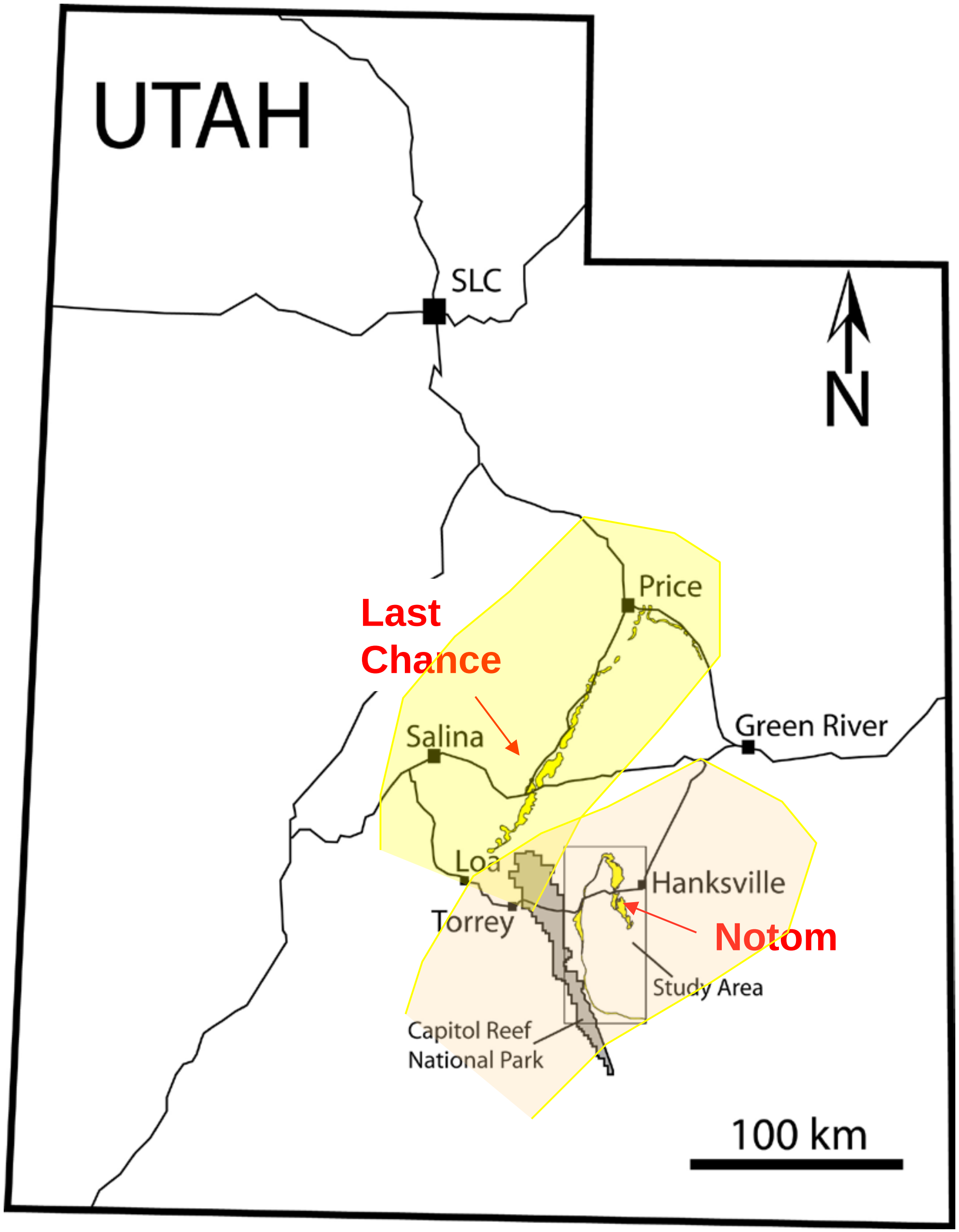
Regional cross section

Ferron Example

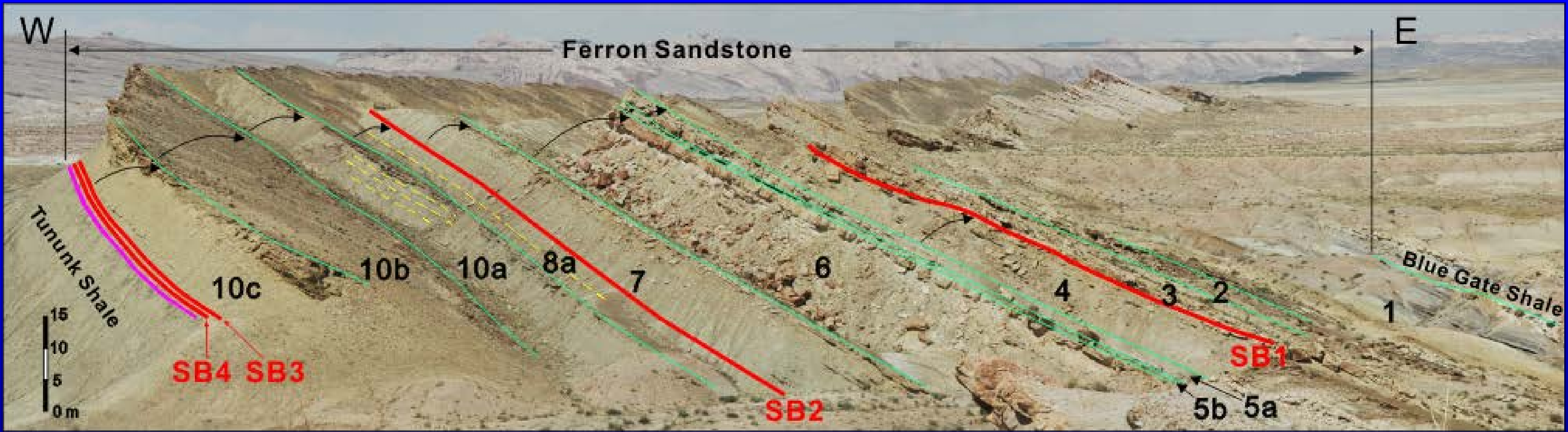
- Foreland basin
- Small, high-relief drainage basins.
- Ramp Margin
- “Greenhousish”

Ferron Sandstone Outcrops

- Superb exposures near Capitol Reef, Utah

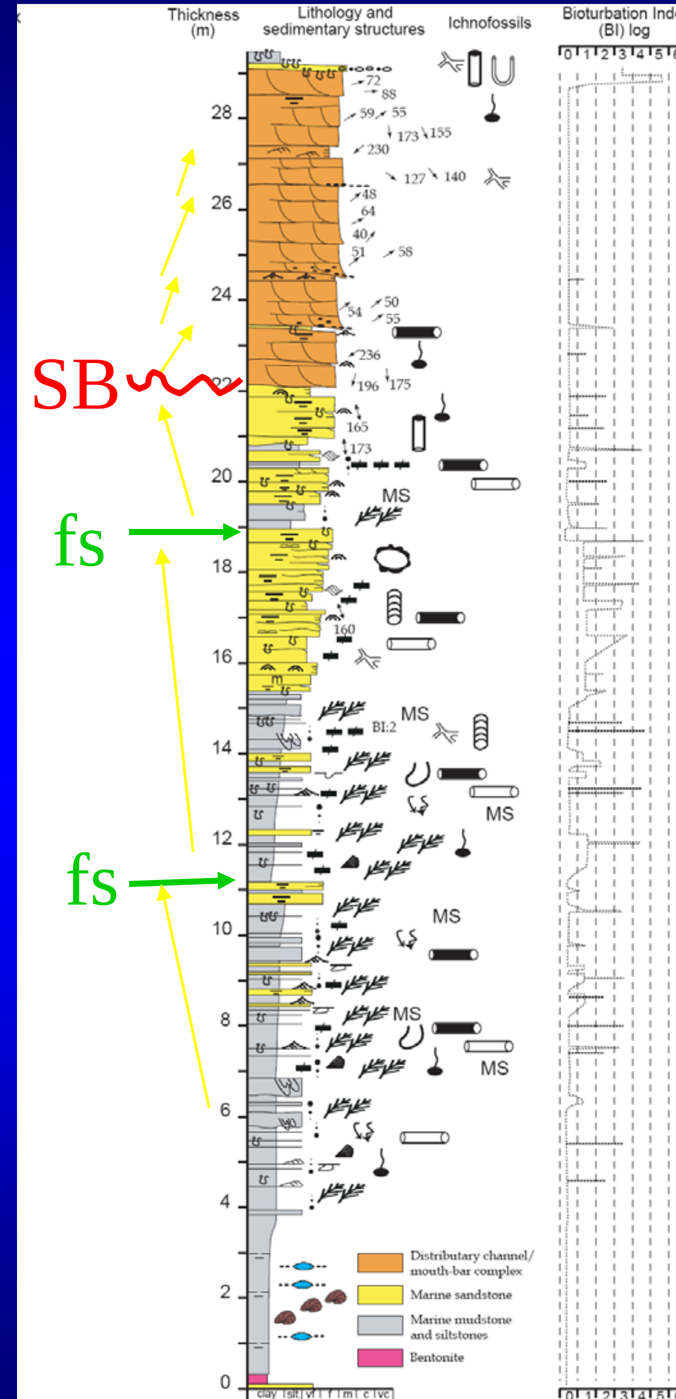


Caineville Reef, Utah

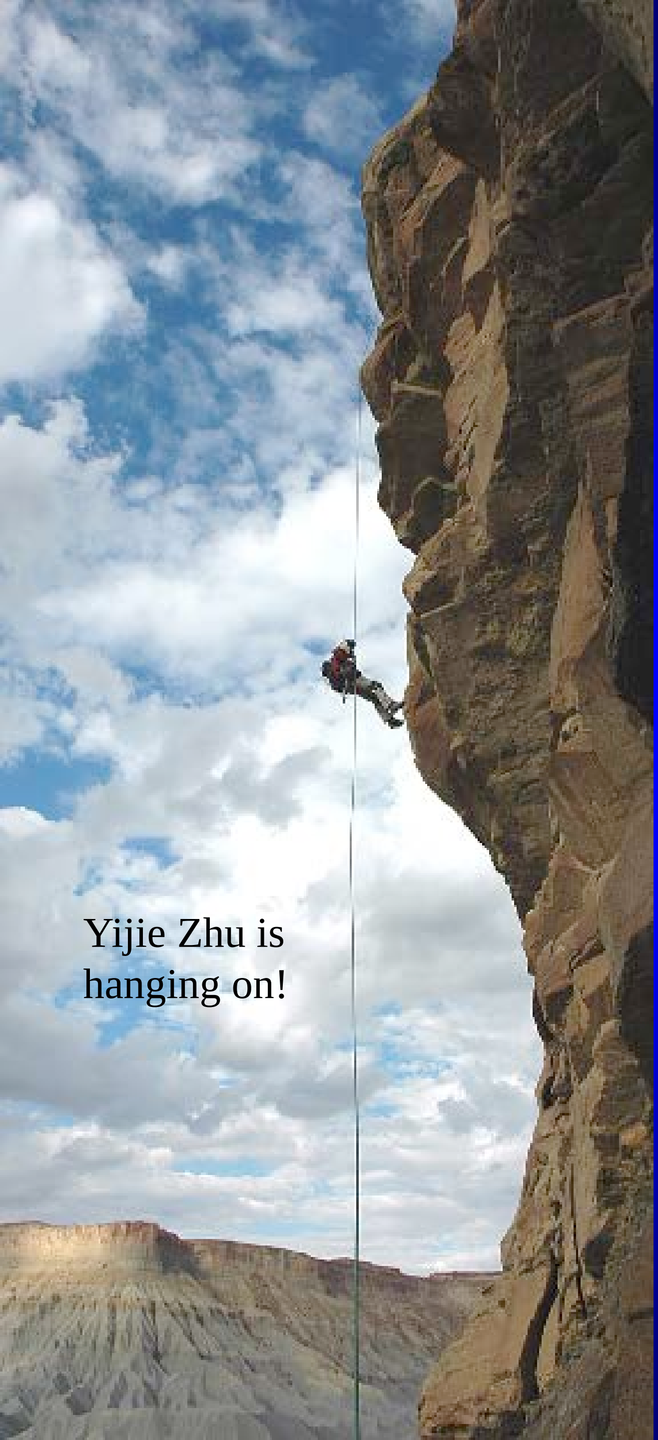


- 20º-30º structural tilt of the outcrops enable walking on hogsback ridges to trace key surfaces and sandstone bodies.

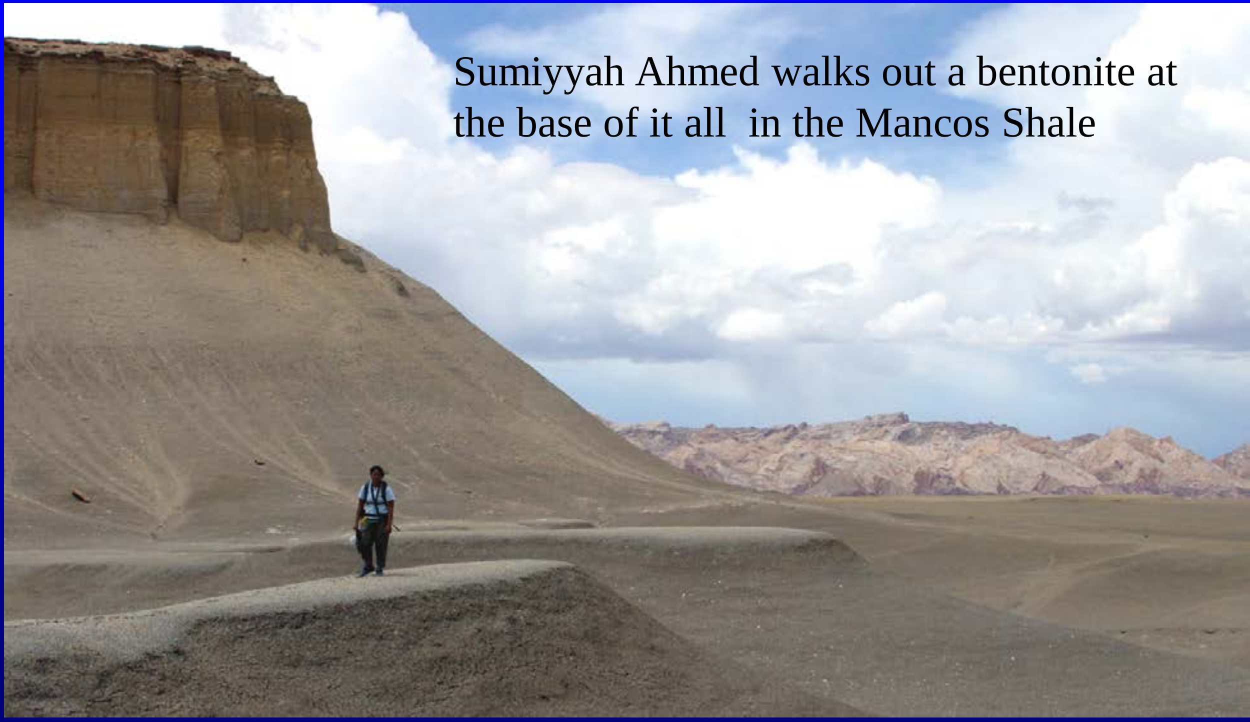
Measuring Sections



I'll take the high road!

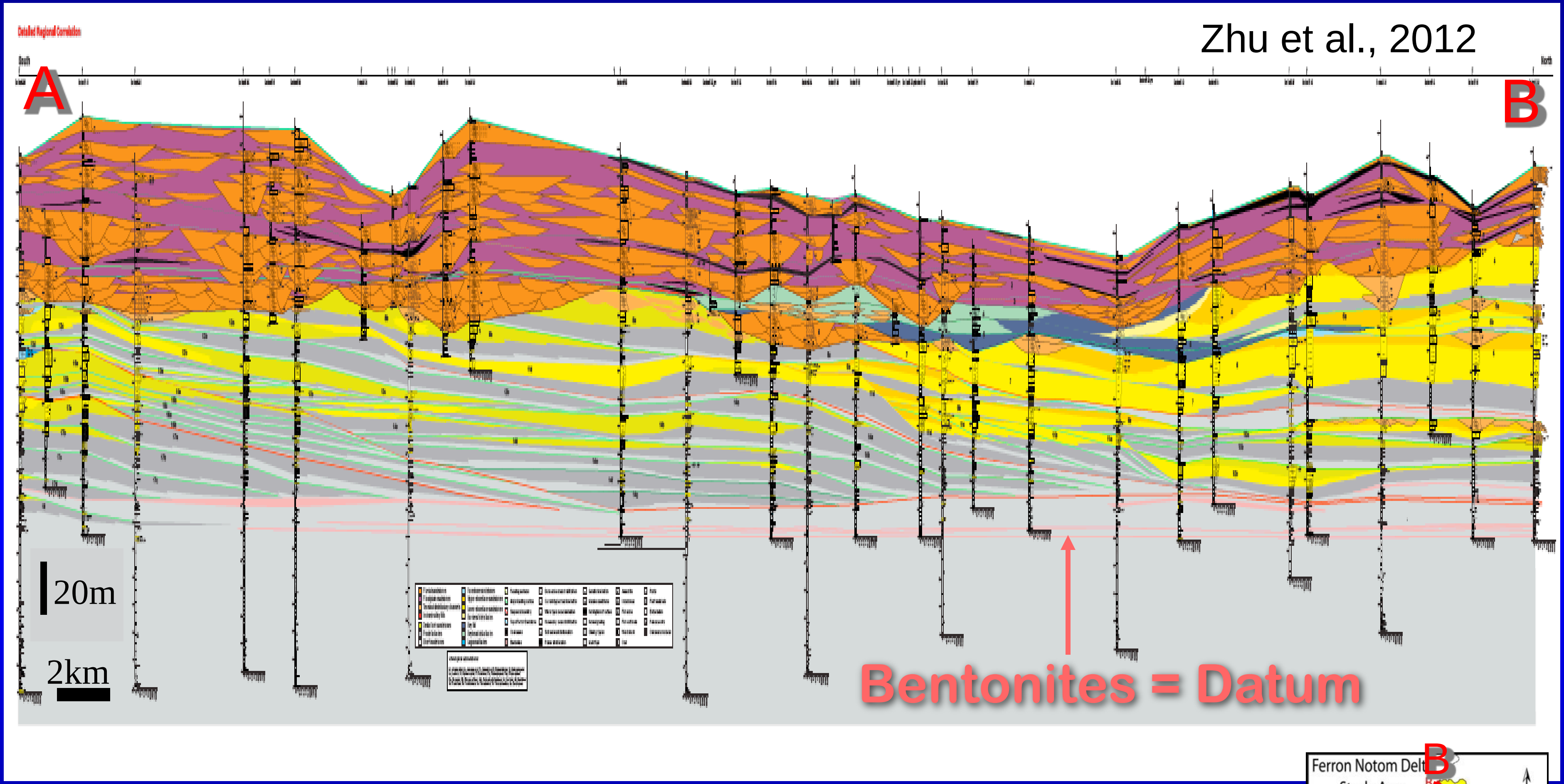


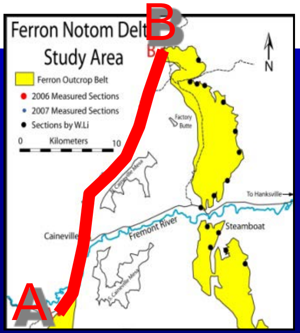
Yijie Zhu is hanging on!



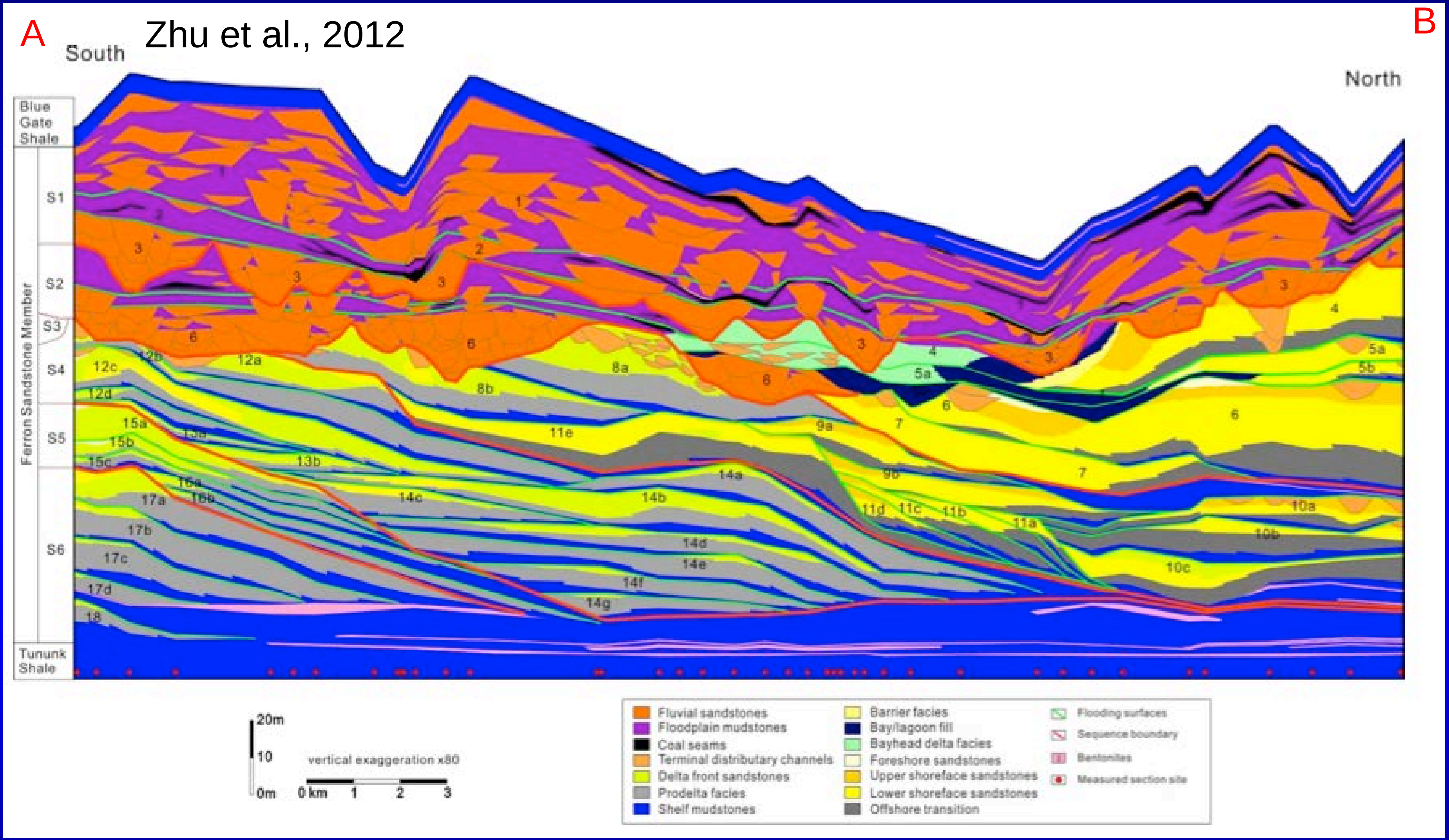
Sumiyyah Ahmed walks out a bentonite at the base of it all in the Mancos Shale

Outcrop Correlation Panel



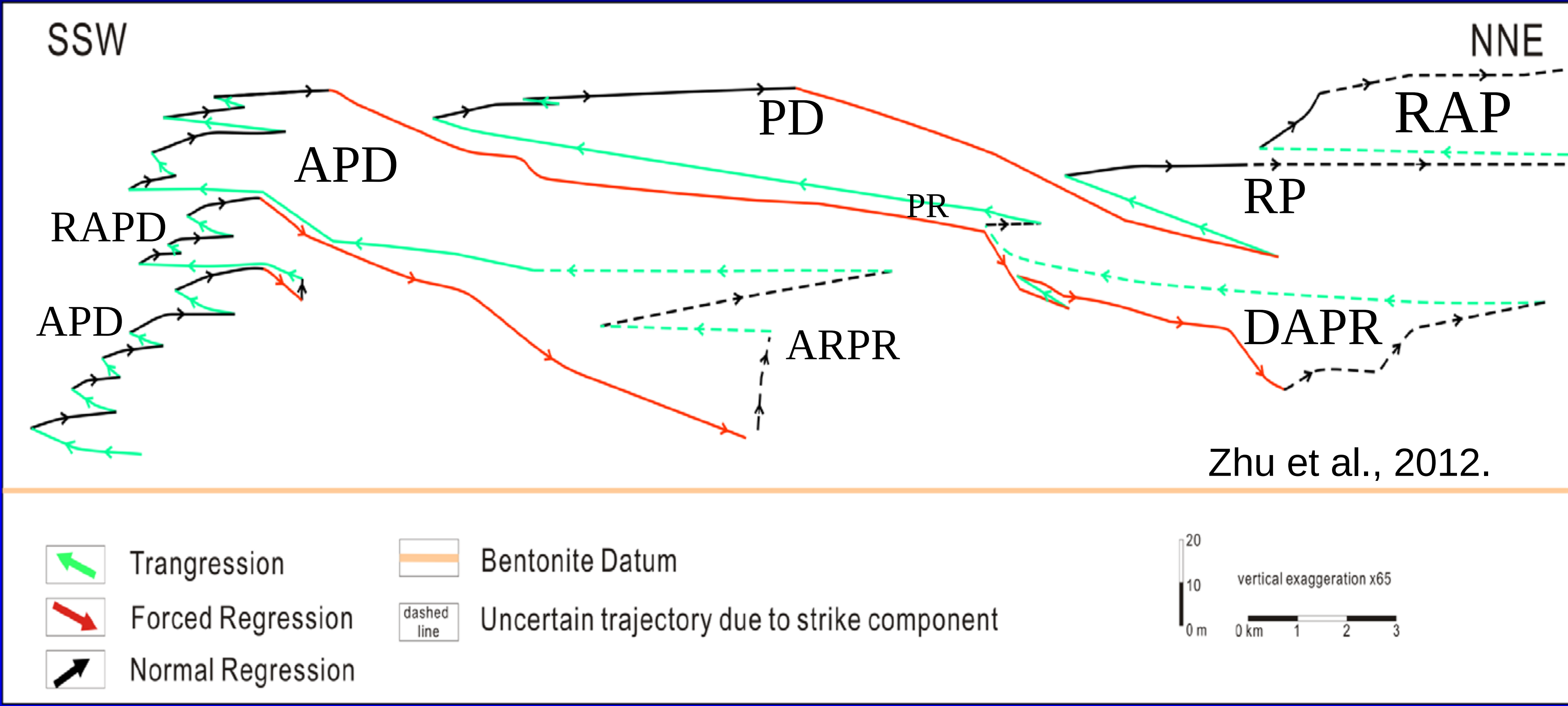


Ferron Sandstone Dip Sequence Stratigraphy



- 43 Parasequences, 18 Parasequence Sets, 6 Sequences
- Well-developed parasequence stacking patterns define systems tracts and allow shoreline trajectory analysis.

Shoreline Trajectory and Accommodation Successions

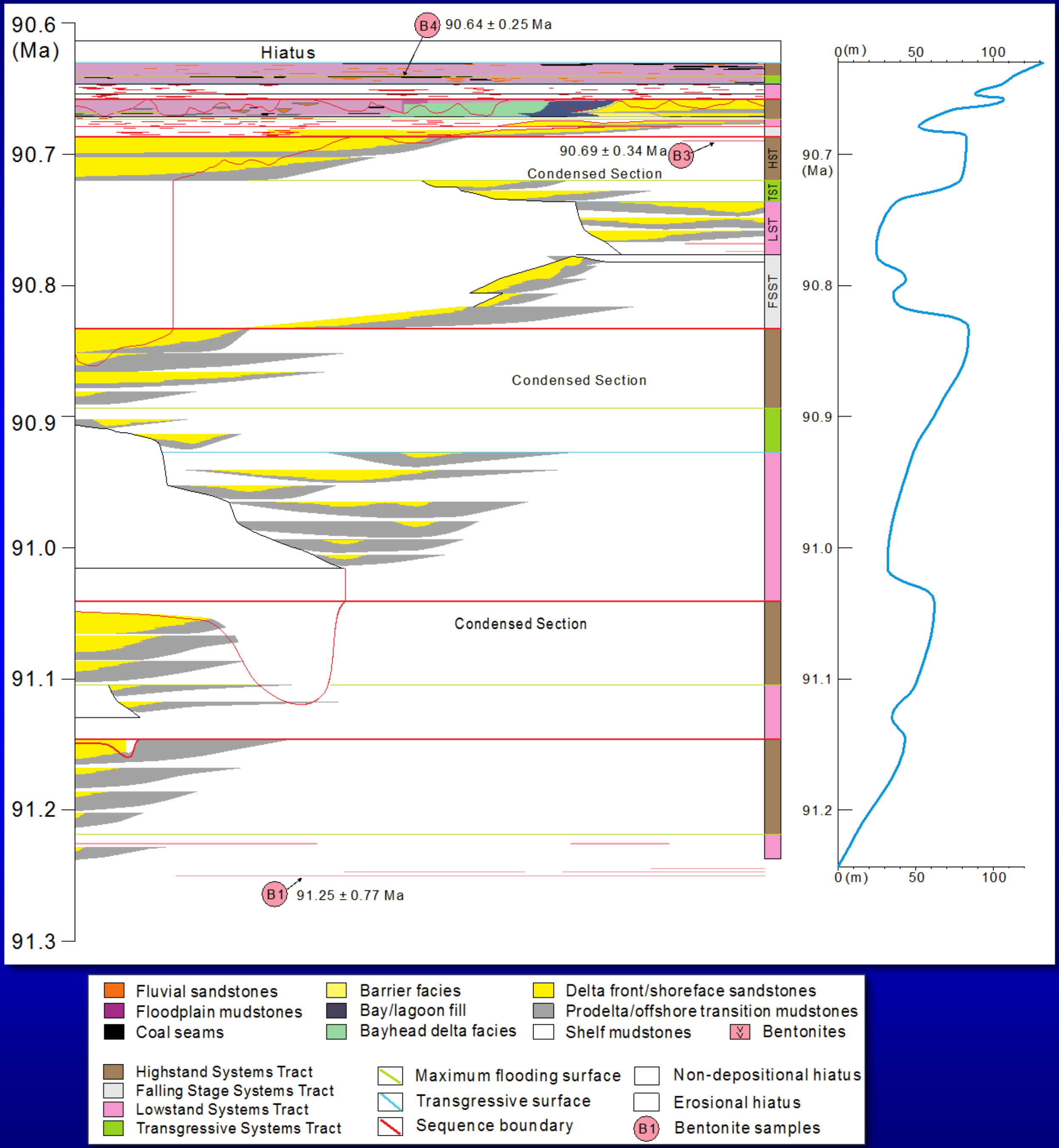


- **Evidence for 10s to 50 m drops of relative sea-level, assuming horizontal datum**
- **High frequency sequences, could be eustatic?**
- **Stacking Patterns**

  A - Aggradational, P - Progradational, D- Degradational, R - retrogradational

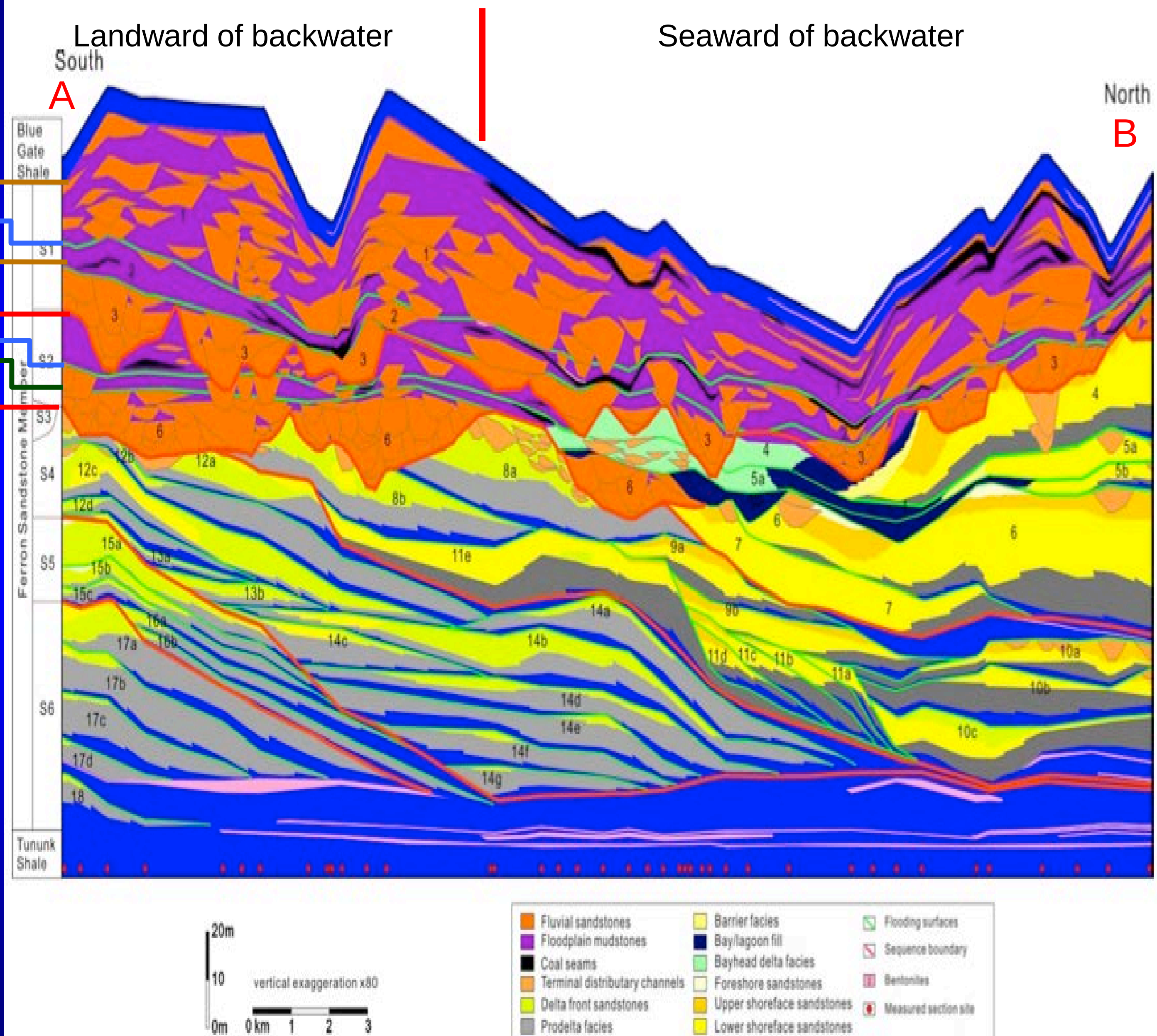
Ferron Wheeler Diagram

- Bentonite dates show entire delta complex is deposited in about 620Ka
- Ferron contains 6 100Ka, Milankovitch-frequency sequences.
- Some of these 100Ka sequences are composite.
  - Evidence for 20 Ka sequences



Facies Change in a Non-Marine Sequence

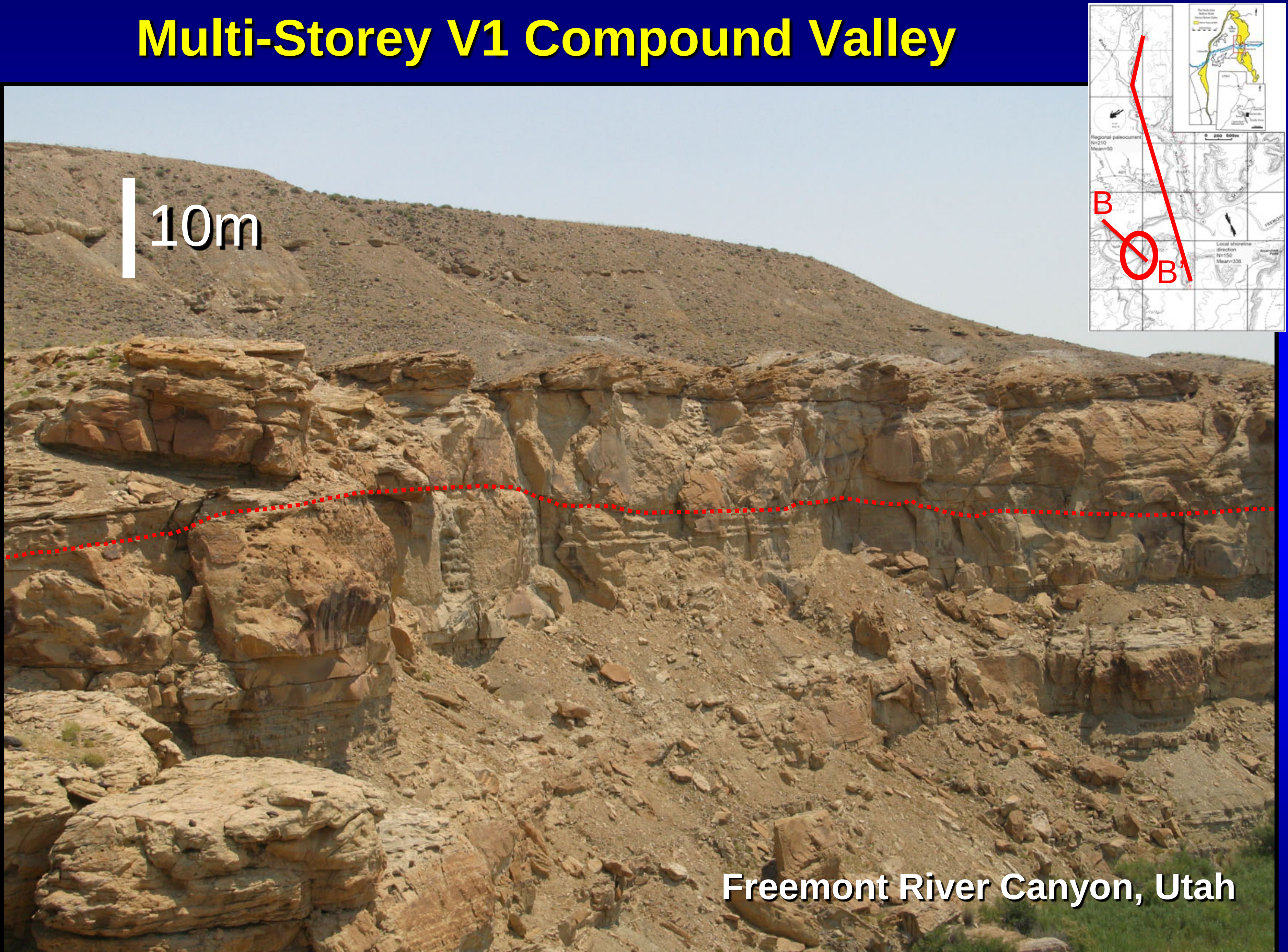
HST
TST
LST SB confined
HST
TST
LST SB confined

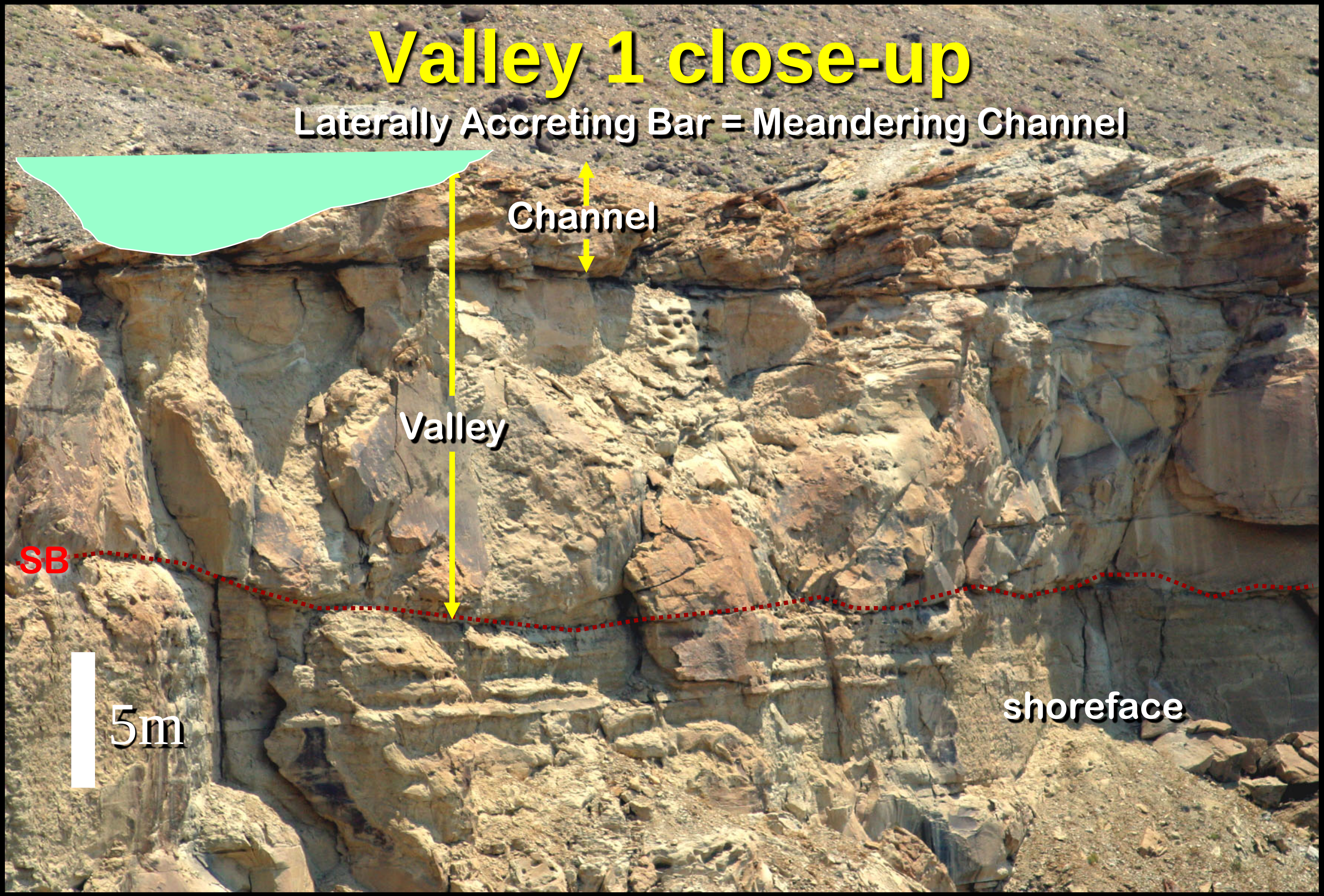


Zhu et al., 2012

Systematic changes in Fluvial stacking styles associated with different systems tracts

Multi-Storey V1 Compound Valley



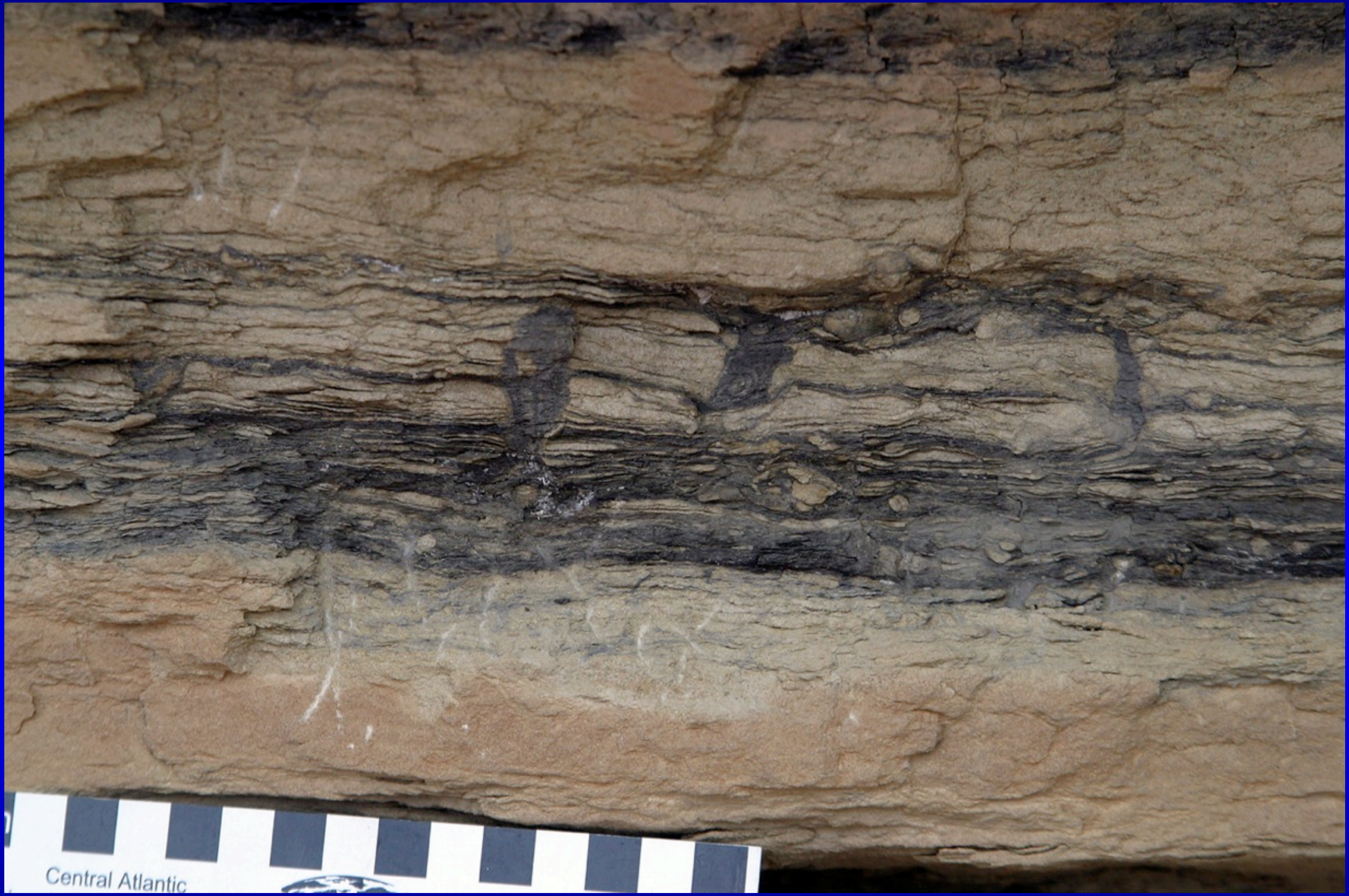

Valley 1 close-up
Laterally Accreting Bar = Meandering Channel
Channel
Valley
SB
5m
shoreface

Channel fills locally conglomeratic

Note: No granules, pebbles, or cobbles are found anywhere in any of the shoreline or delta front parasequences, only in the fluvial facies.

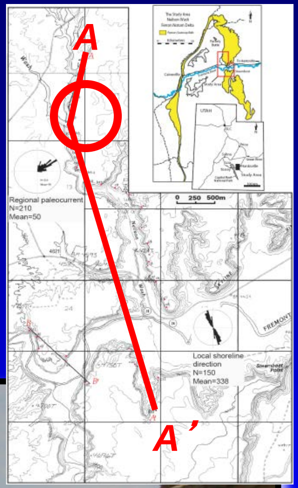
Cross beds

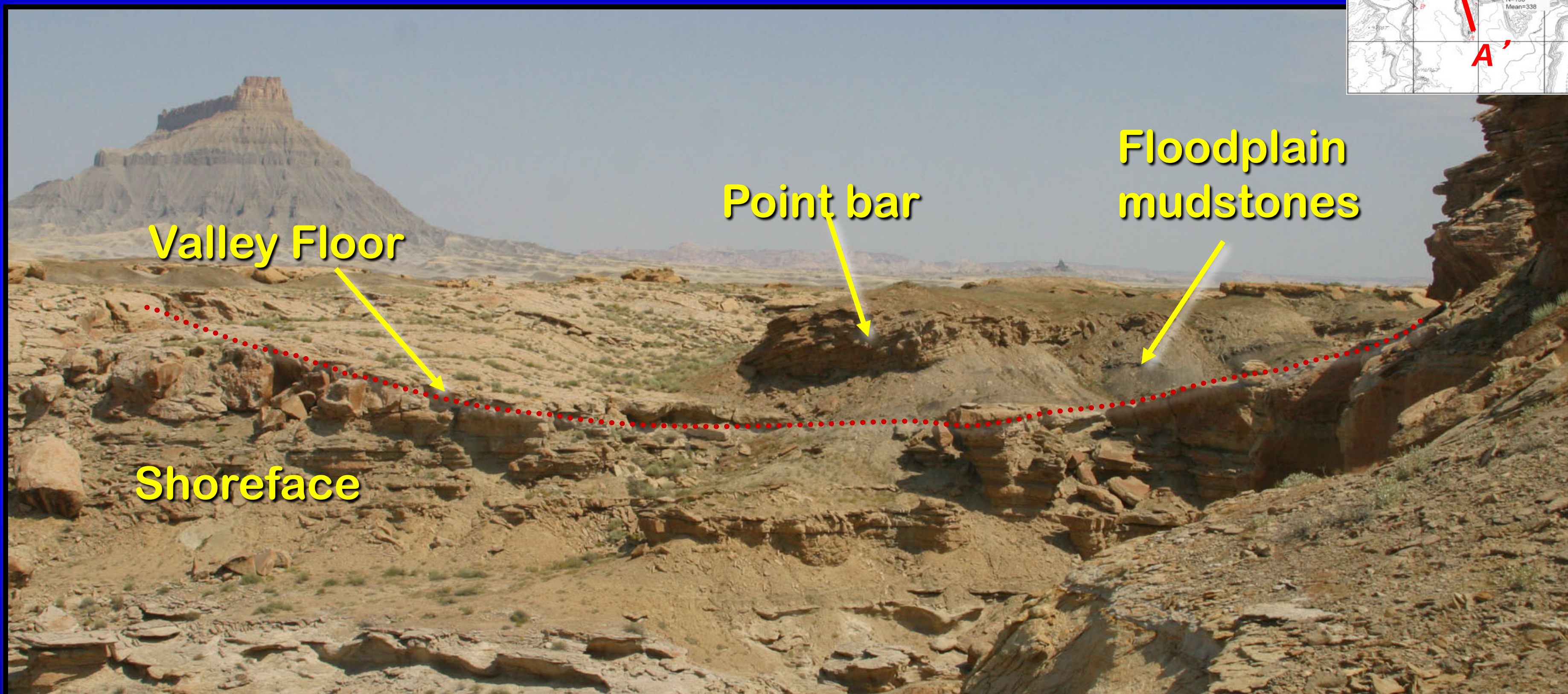
Upper valley fill is estuarine



Burrowed heterolithics indicate brackish water, estuarine conditions and must be within the bayline.

Exhumed Ferron Paleo-Valley





Laterally migrating bar overlies floodplain mudstone, contained within larger erosional feature (valley).

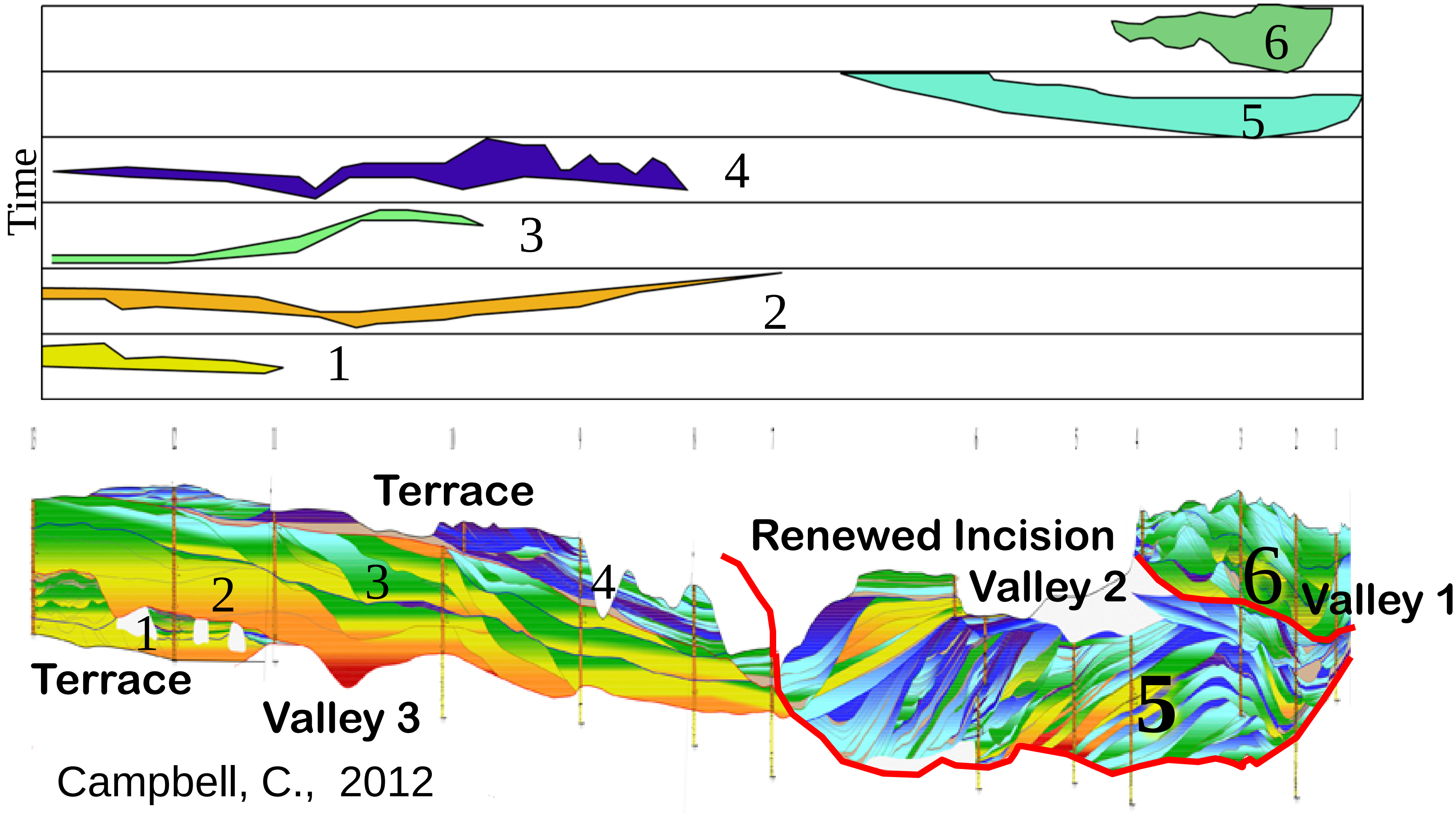
Exh

Dinosaurs!


10 CM
SVP


cm
Central Atlantic
Conjugate Margins Conference
Halifax 2008
www.conjugatemargins.com

Relative Wheeler Diagram



Campbell, C., 2012

Compound Valley in sequence 1 shows 3 cut and fill episodes, 25 m relief in < 100,000 years!

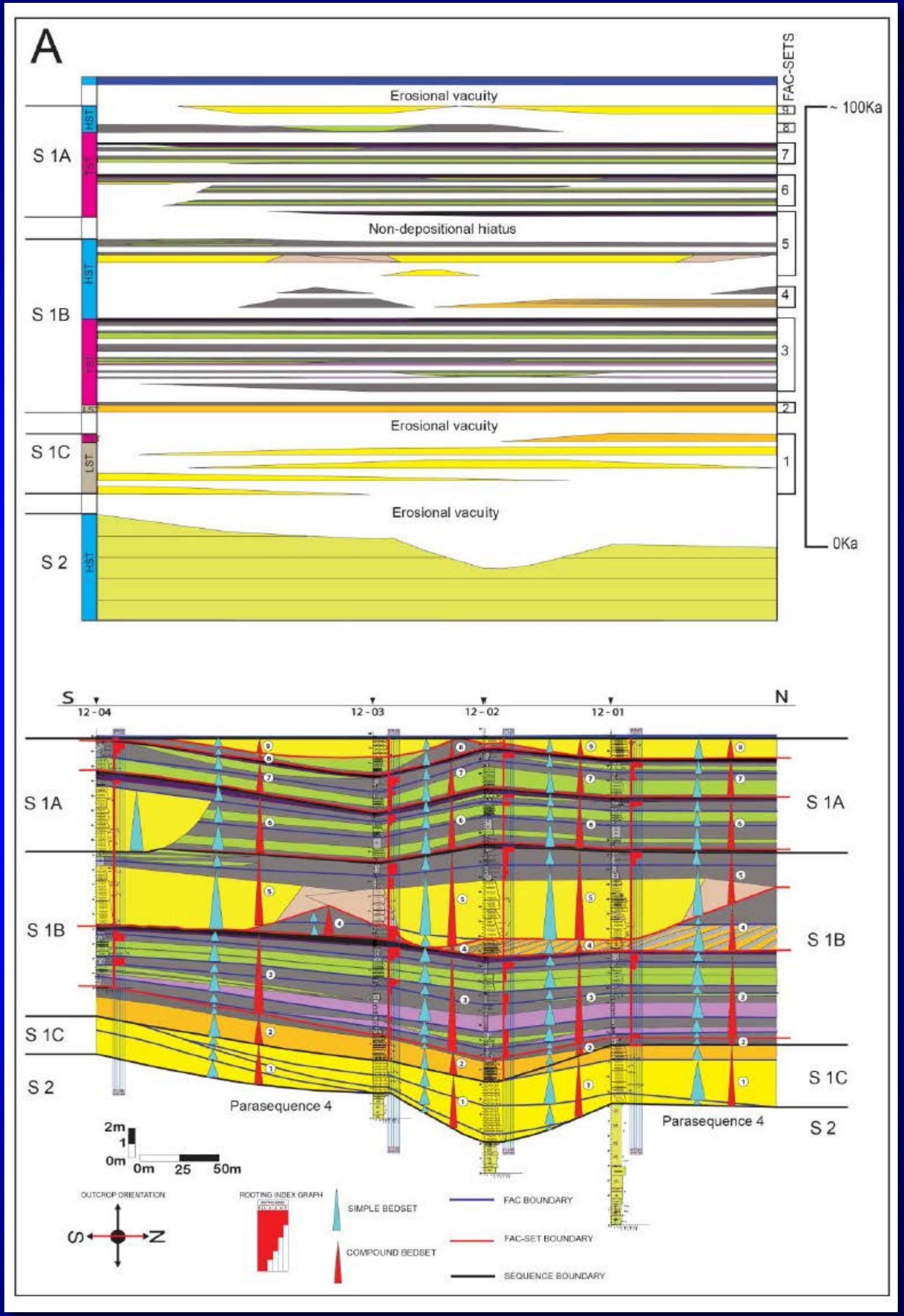
"Highstand" Fluvial Deposits in upper sequence 1 overlying incised valley

In-situ fossilized tree trunk preserved in floodplain lake facies

- Mudstone dominated.
- Multiple pedostratigraphic cycles.

Nonmarine High-frequency Sequences

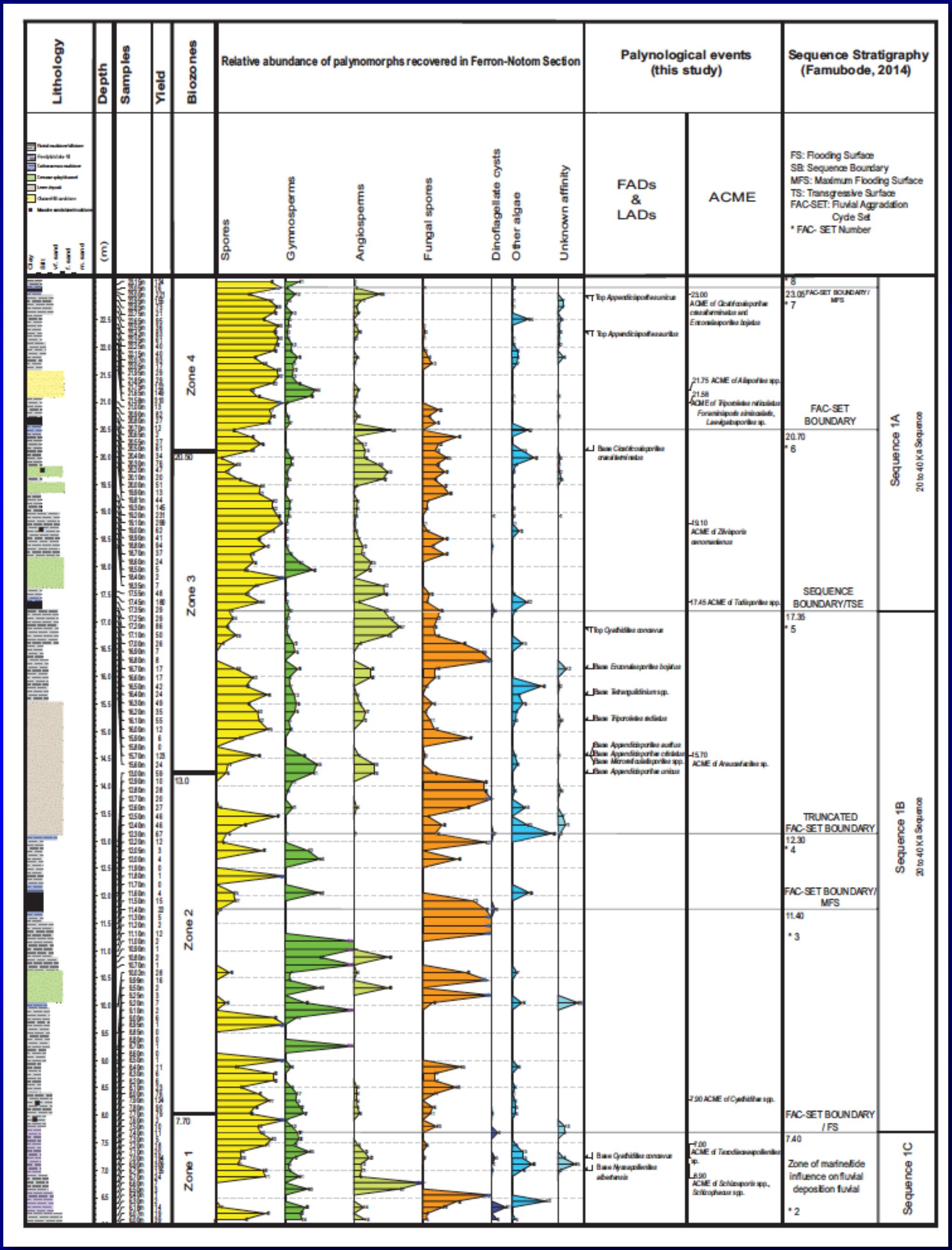
- > 21 FACS in 100 Ka
- 9 FAC sets
- 3 High-frequency Sequences
  - < 30 Ka duration



Famubode et al., 2015

Nonmarine High-frequency Sequences

- Palynology analysis shows marine dinocysts at maximum flooding surfaces.
- Indicate ever-wet conditions.



Akuyz et al., 2015

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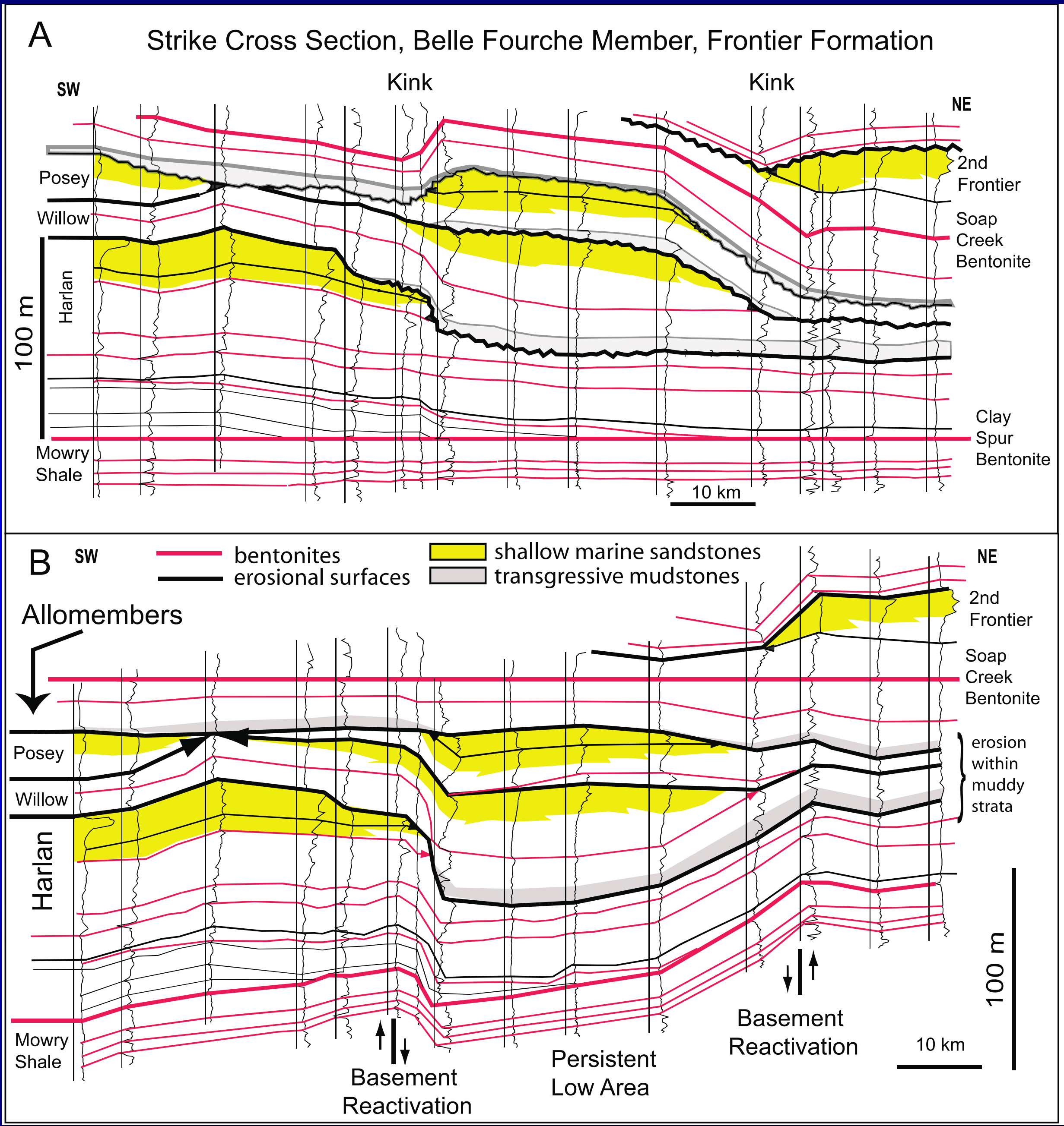
Contrast: Tectono-sequences, Wyoming

- Position of unconformities is stationary reflecting reactivated faults.
  - Subtle *Angular Unconformities* versus *Eustatic Disconformities*
- Sequences are ~ 400 Ka in duration.
- Need more bentonite dates!



Vakarelov et al., 2006; Bhattacharya 2011

Conclusion

- Reasonable evidence for ~25 m Milankovitch-frequency eustatic sequences in the Turonian
- Locally convoluted with similar physical-scale, sub-million year tectonic sequences with same "frequency" as eccentricity cycles.
- Tectonic unconformities are positionally stationary
  - Located above reactivated basement lineaments.
- Eustatic disconformities migrate with shoreline.
  - Lack angular discordance and shift position.
- *Caveat:* shoreline facies easily track sea-level but also may miss cycles at disconformities.
  - Careful work in Ferron shows multiple cycles in compound incised valleys and in paleosols.
- Critical need for additional high-precision chronometry and more precise geodynamic models to asses tectonic component.