Sheet-Like Fluvial Architecture on Regional Scales: Examples from the Cretaceous Western Interior Seaway of North America - The Case for Allogenic Control*

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Abstract

Extant sequence stratigraphic models for lowland/coastal plain fluvial successions emphasize vertical changes in stratal stacking patterns through a cycle of relative sea-level change. A common element to most models is a basal sequence boundary that has significant erosional relief and incised valleys. Not all lowland fluvial successions conform to this pattern, however, with many showing sequence boundaries of more planar cross-sectional geometry (ie., lacking significant valleys). Here, we draw attention to this under-appreciated stacking pattern by documenting the stratal architecture of three Upper Cretaceous formations, broadly of coastal plain origin, from the Henry Mountains of south-central Utah, USA.

The upper part of the Ferron Sandstone comprises a series of distributary channel sandstones and coastal floodbasin deposits. The channel bodies appear to be amalgamated laterally to form single- to locally multi-story channel complexes of 10's of km extent in a depositional strike orientation. Lateral extent of these composite bodies is at least an order of magnitude greater than the channel belt width predicted from paleohydraulic calculations or channel form dimensions. Accordingly, the stack of sheet-like channel complexes, separated by equally laterally extensive floodbasin intervals, may be interpreted as a series of sequences, forced by relative sea-level fluctuation. The overlying Muley Canyon Sandstone contains two intervals of tidally-influenced fluvial deposits enclosed by shoreface sandstones. Again, these intervals are of regional extent (>20 km) and sheet-like, with modest erosional relief (<10 m) on basal sequence boundaries. The most spectacular example of the sheet-like fluvial stacking pattern occurs in the overlying Masuk Formation, where several cycles of fluvial channel bodies and intervening coastal floodplain facies can be traced over >10 km as continuous sheets, again strongly suggesting an external forcing control on their cross-sectional geometry. The common factors among

these three formations are the prevalence of a sheet-like architecture to fluvial units, and their enclosing stratal intervals, the condensed and incomplete nature of sequences, and the lack of significant incisional relief at the base of sequences. These patterns suggest that fluvial channel complexes apparently lacking incised valley fills may in some cases nonetheless be records of external forcing and may be of great lateral extent.

Selected References

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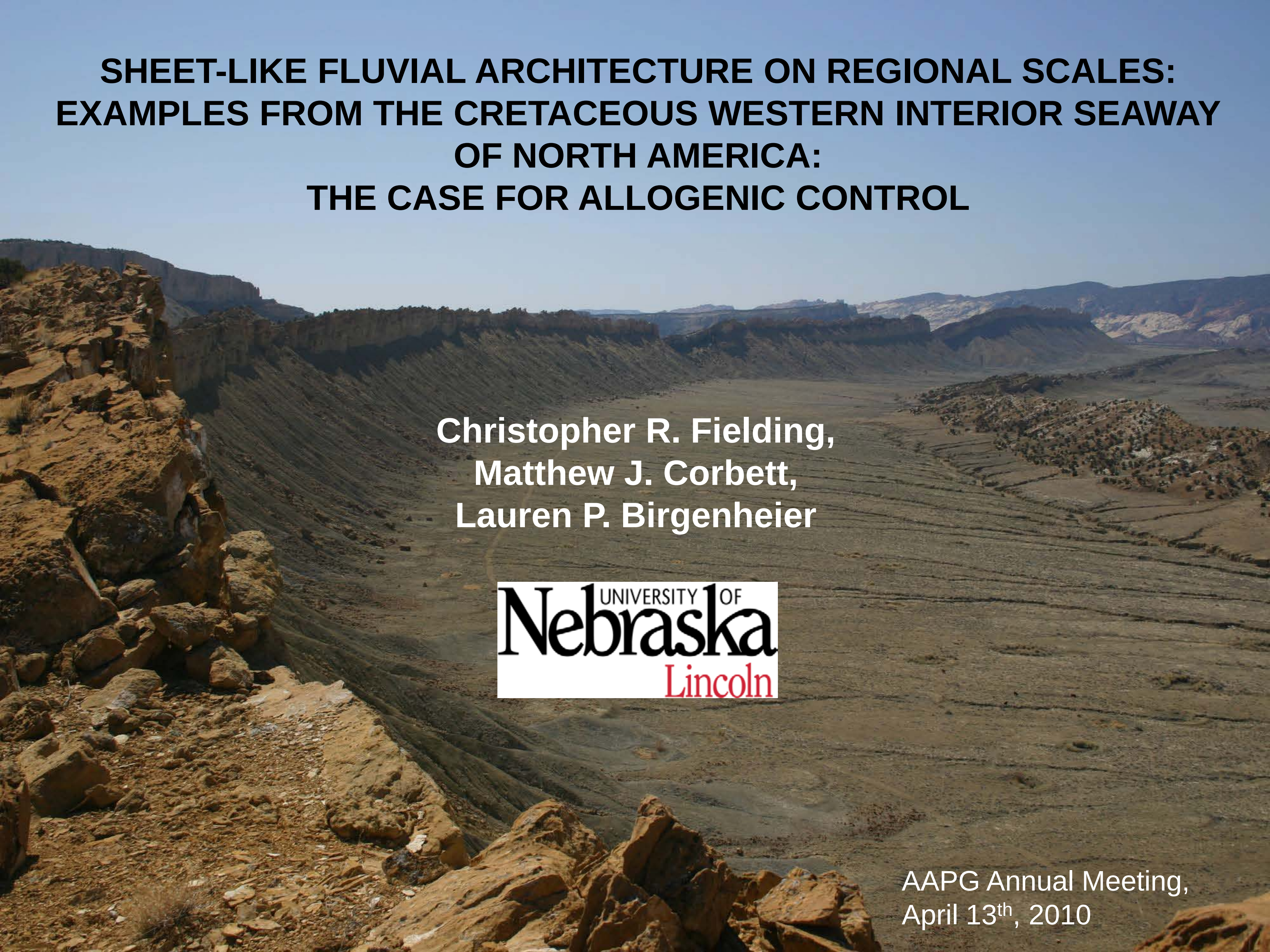

SHEET-LIKE FLUVIAL ARCHITECTURE ON REGIONAL SCALES: EXAMPLES FROM THE CRETACEOUS WESTERN INTERIOR SEAWAY OF NORTH AMERICA: THE CASE FOR ALLOGENIC CONTROL

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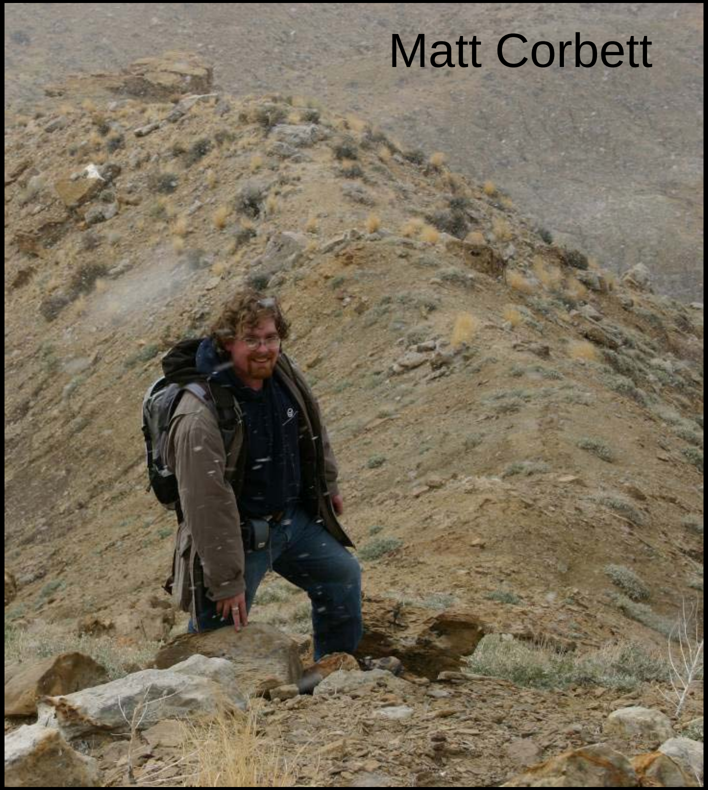
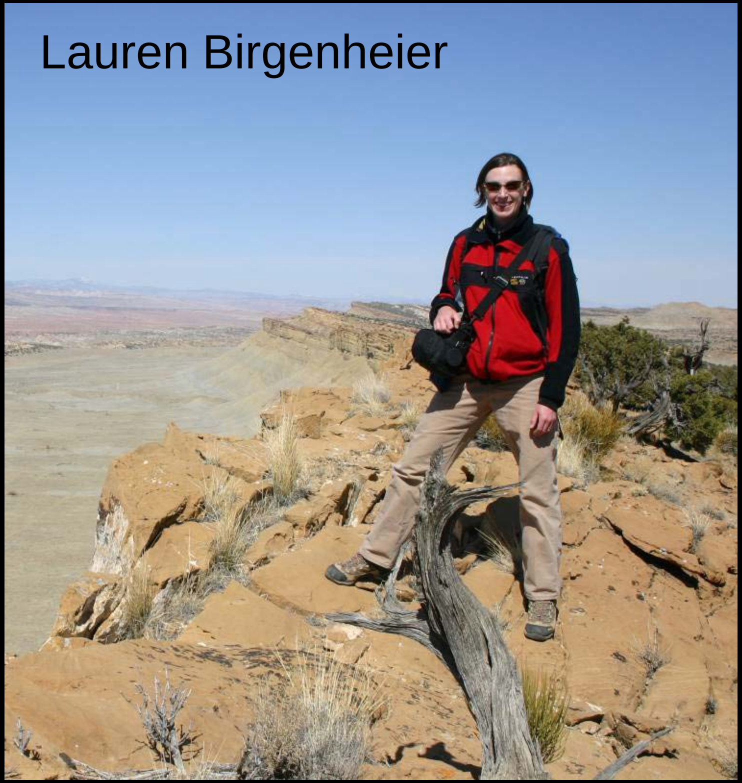
April 13th, 2010

TEAM HENRY





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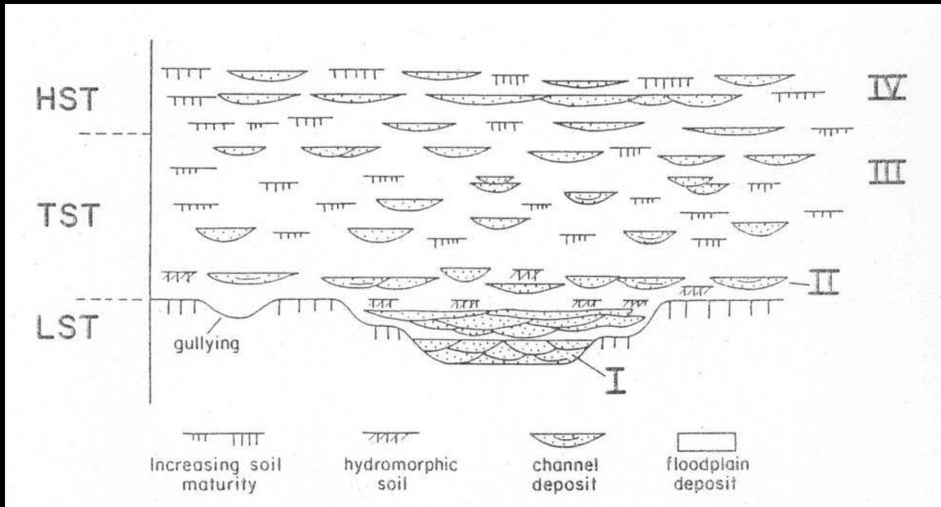
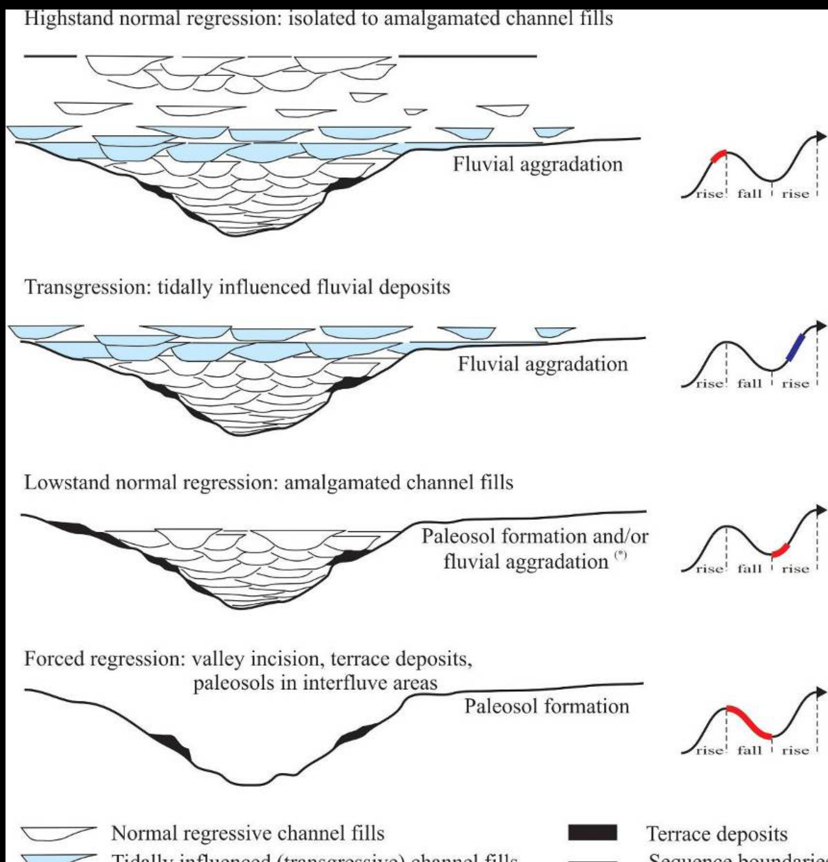
OUTLINE OF TALK

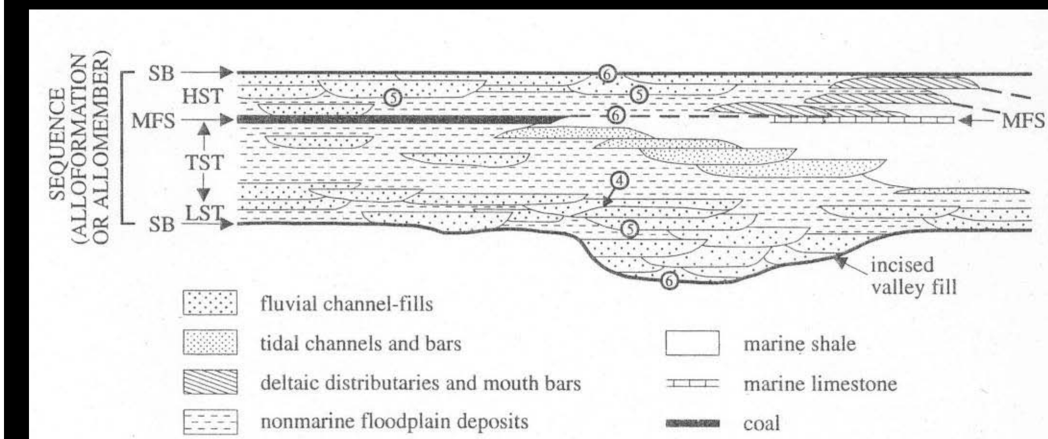
1. REVIEW OF STRATIGRAPHIC MODELS FOR FLUVIAL SUCCESSIONS,
2. REGIONAL SETTING OF STUDY AREA – HENRY MOUNTAINS, UTAH,
3. FACIES & STACKING PATTERNS – FERRON SANDSTONE,
4. FACIES & STACKING PATTERNS – MULEY CANYON SANDSTONE,
5. FACIES & STACKING PATTERNS – MASUK FORMATION,
6. SYNTHESIS – SHEET-LIKE FLUVIAL ARCHITECTURE
7. CONCLUSIONS



SEQUENCE STRATIGRAPHIC MODELS FOR LOWLAND ALLUVIAL SUCCESSIONS

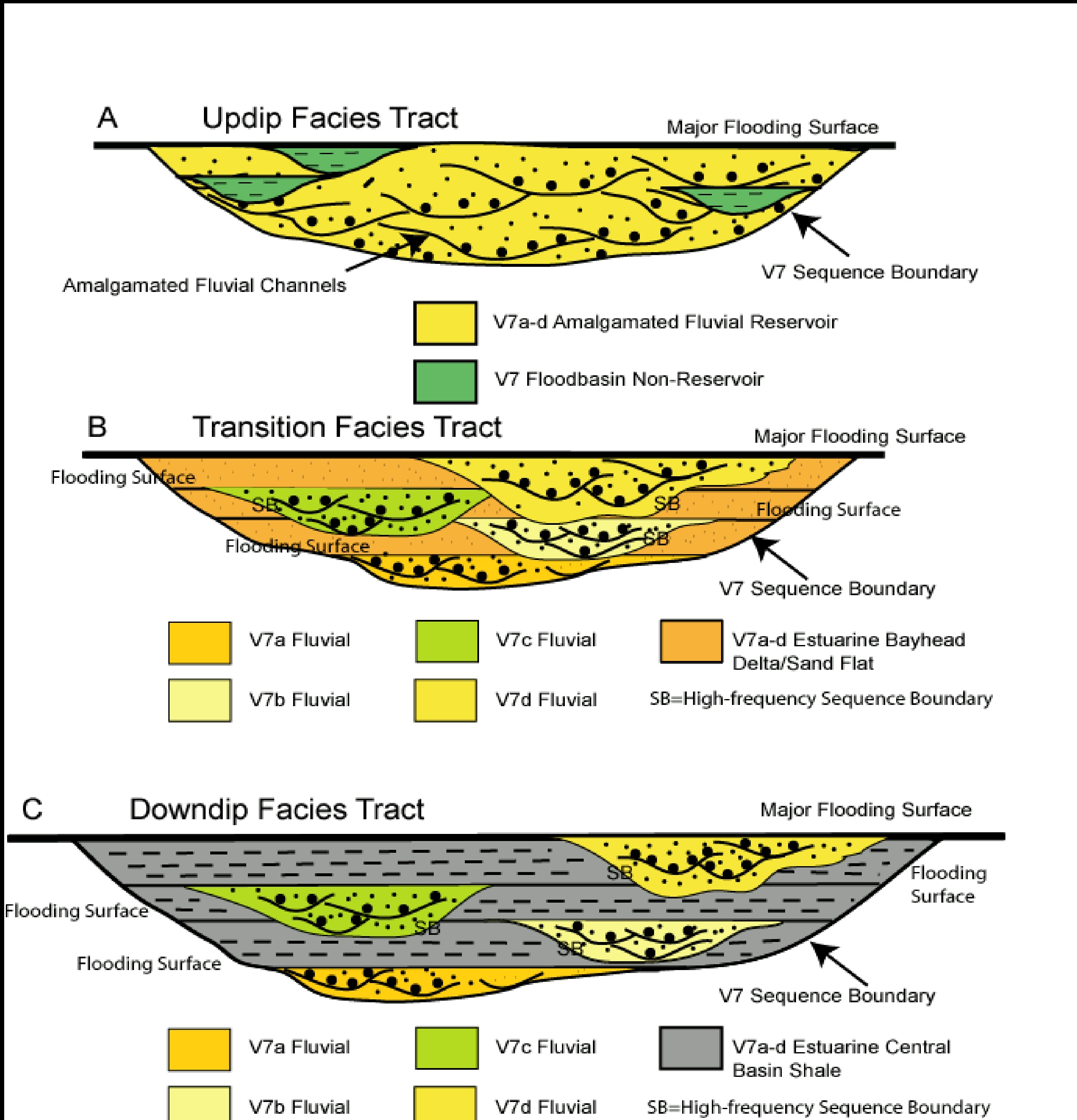
(from Wright & Marriott, 1993, Sed. Geo., 86, 203-210)





(from Miall, 1996, “The Geology of Fluvial Deposits, Springer-Verlag)

(from Catuneanu, 2006, after Shanley & McCabe, 1994, AAPGBull., 78, 544-568)



Emphasis on Incised Valley-Fills in many stratigraphic case studies

- some invoke multiple cycles of RSL change within a single valley fill.

Example from Upper Carboniferous Morrow Group, Kansas, USA.

(Diagram from Bowen & Weimer, 2003, AAPG Bull., 87, 781-815)

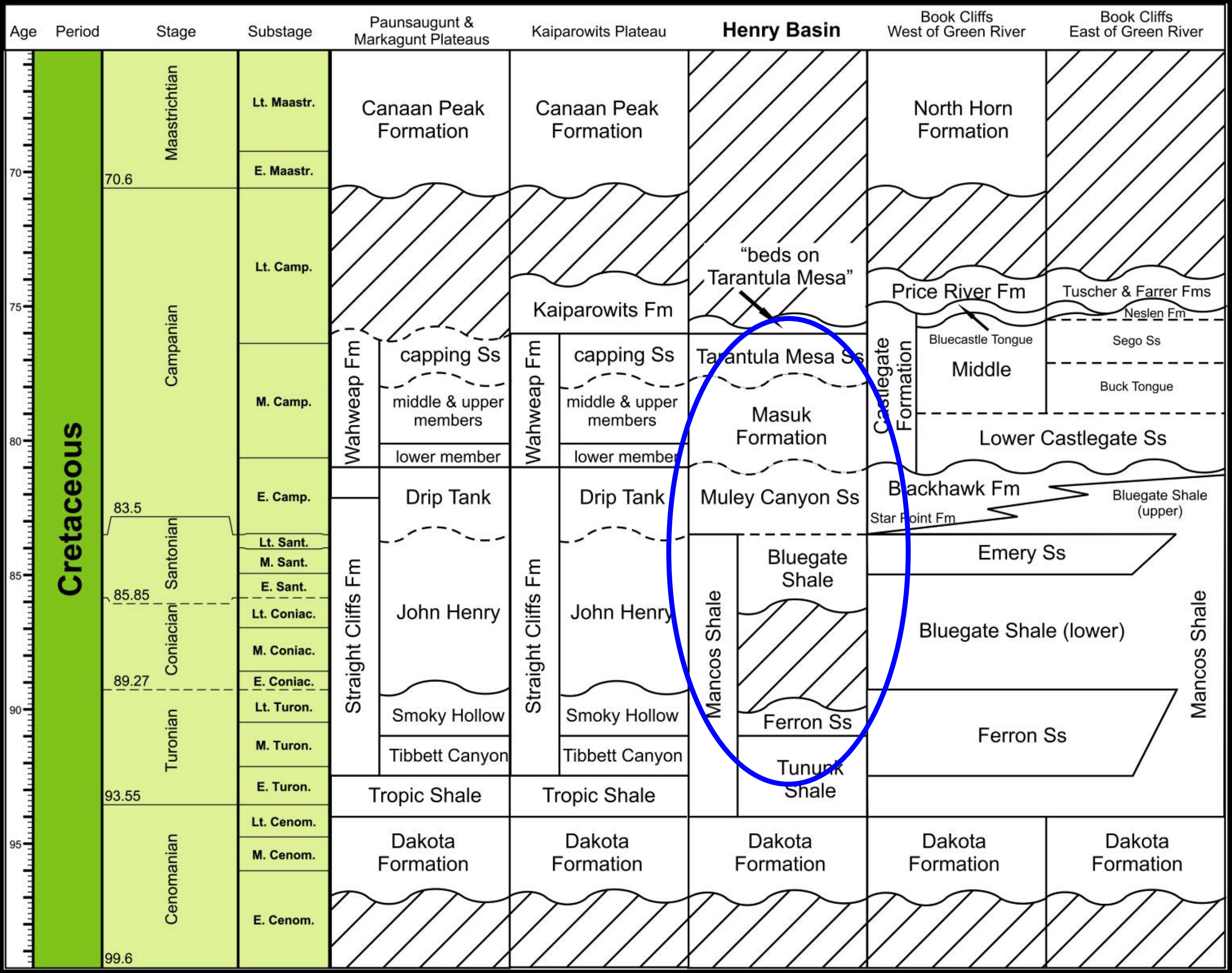
WE WILL HEREIN SHOW EXAMPLES OF CRETACEOUS FORMATIONS FROM UTAH THAT PRESERVE

A SHEET-LIKE CROSS-SECTIONAL ARCHITECTURE, WITH NO SIGNIFICANT INCISED VALLEY FILLS.

THESE SUCCESSIONS ARE OF LOWLAND, COASTAL PLAIN ORIGIN, DISPLAY EVIDENCE FOR MULTIPLE CYCLES OF RELATIVE SEA-LEVEL FLUCTUATION,

BUT SHOW ESSENTIALLY PLANAR BASAL EROSION SURFACES AT THE BASES OF CYCLES, WITH LITTLE OR NO EVIDENCE FOR VALLEY INCISION IN A PALAEOFLOW-PERPENDICULAR ORIENTATION.

CRETACEOUS STRATIGRAPHY OF SOUTHEAST UTAH



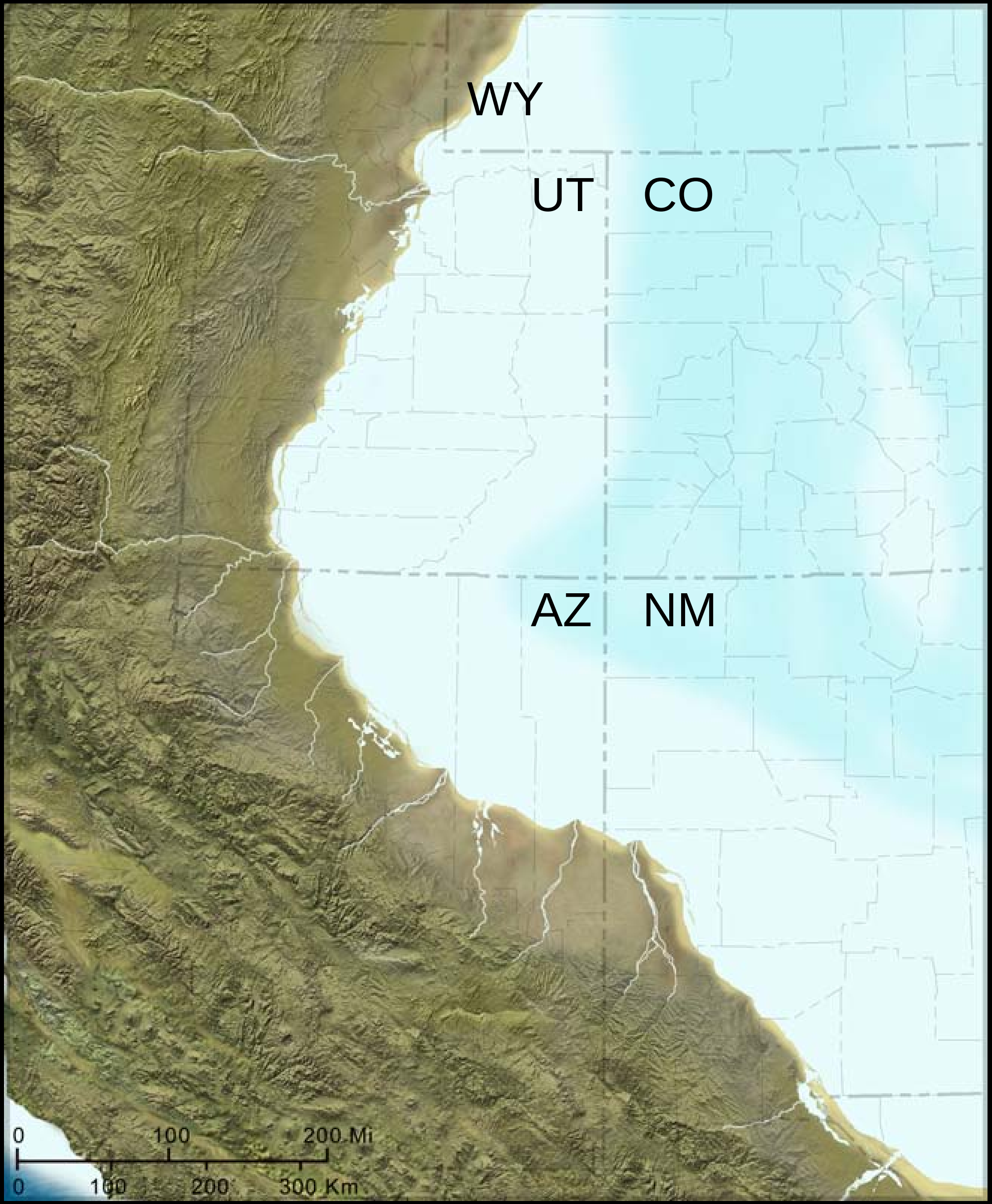
(Diagram from Fielding et al., in press, UGA Field Guidebook, 39)

STUDY BASED ON EXAMINATION OF LATERALLY CONTINUOUS CLIFF EXPOSURES,

North-south elongate,
i.e., parallel to depositional strike

View north from SW of Spring Canyon

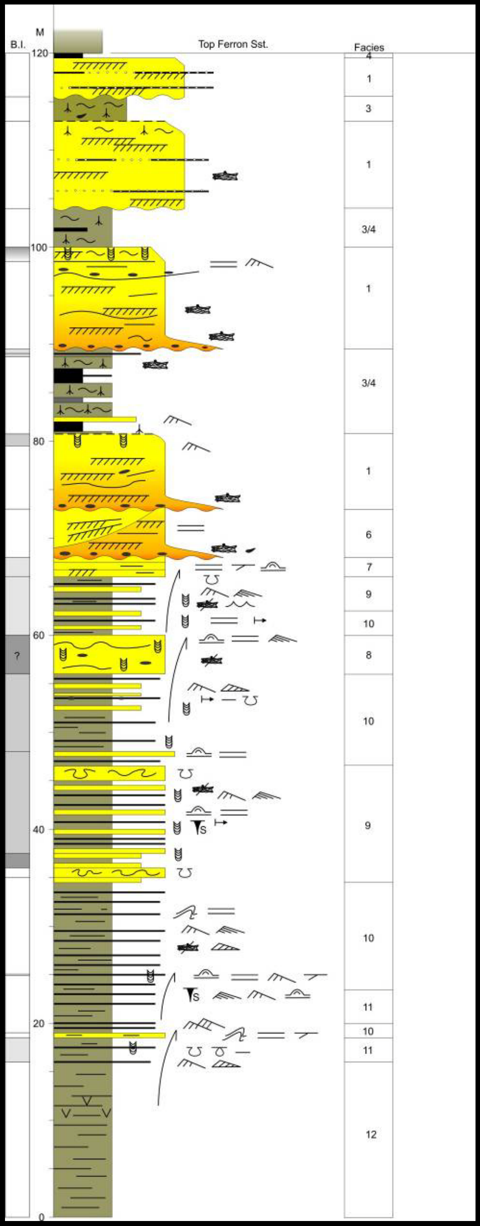
CENOMANIAN-TURONIAN PALEOGEOGRAPHY OF THE COLORADO PLATEAU
BY RON BLAKEY



CONTINENTAL DRAINAGE DISPERSED SEDIMENT EASTWARD INTO THE WESTERN INTERIOR SEAWAY BASIN.

http://jan.ucc.nau.edu/~rcb7/ColoPlatCret_Tropic.jpg

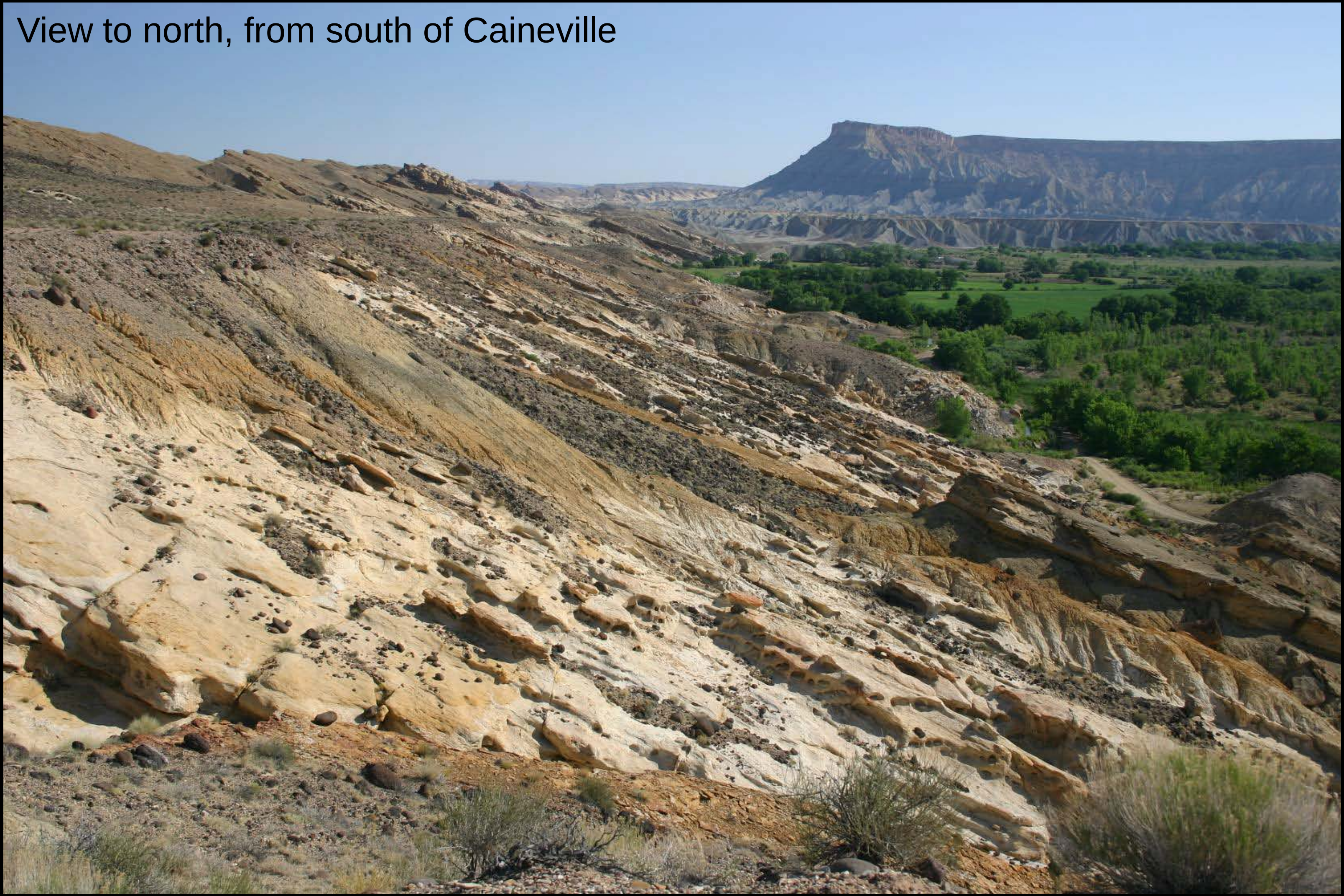
1. FERRON SANDSTONE MEMBER OF MANCOS SHALE



Upper member: series of sharply-based cross-bedded sandstone bodies and interbedded root-penetrated mudrocks/fine-grained sandstones, interpreted as coastal plain channel and overbank deposits.

Lower member: series of crudely coarsening-upward units <10-15 m thick, interpreted as progradational deltaic packages.

EXCELLENT EXPOSURE ON DISSECTED DIP SLOPES IS CONTINUOUS OVER SEVERAL KM, IN A DIRECTION PARALLEL TO DEPOSITIONAL STRIKE.



CHANNEL BODIES ARE STACKED IN A MANNER THAT PRODUCES MULTI-LATERAL (LOCALLY MULTI-STOREY) LITHOSOMES

SANDSTONE BODIES CAN BE TRACED CONTINUOUSLY OVER SEVERAL KM – CROSS-SECTIONAL WIDTH IS SIGNIFICANTLY GREATER THAN CHANNEL BELT WIDTH PREDICTED FROM CROSS-SET THICKNESSES OR CHANNEL FORM DIMENSIONS.

PART OF A NORTH-SOUTH CROSS-SECTION SHOWING CORRELATION OF CHANNEL BODIES IN UPPER MEMBER OF FERRON SANDSTONE

15 km OF CONTINUOUS EXPOSURE SHOWN

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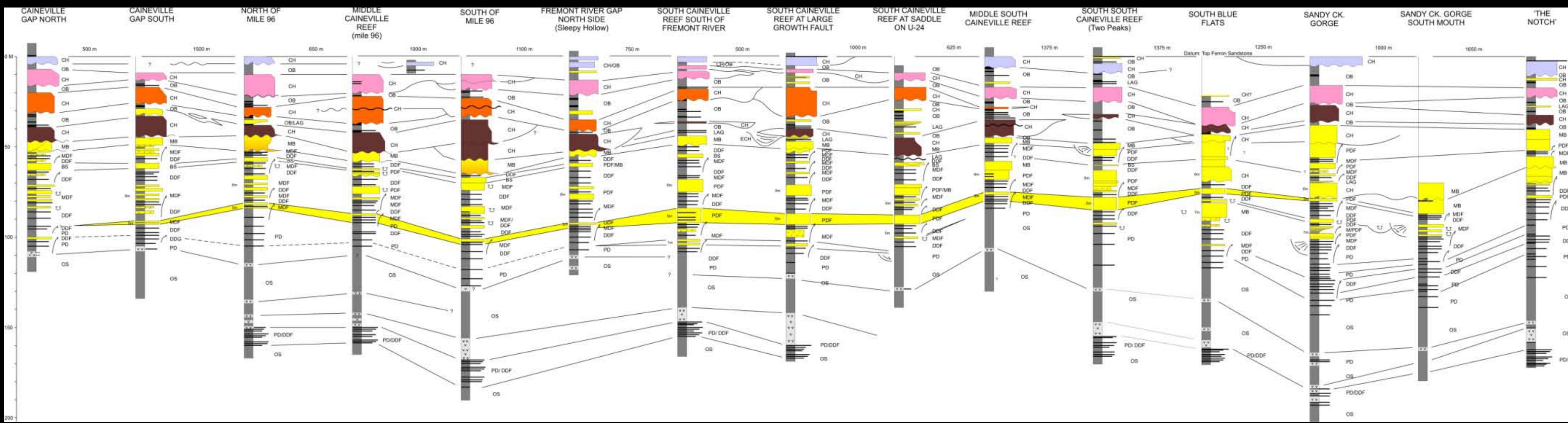
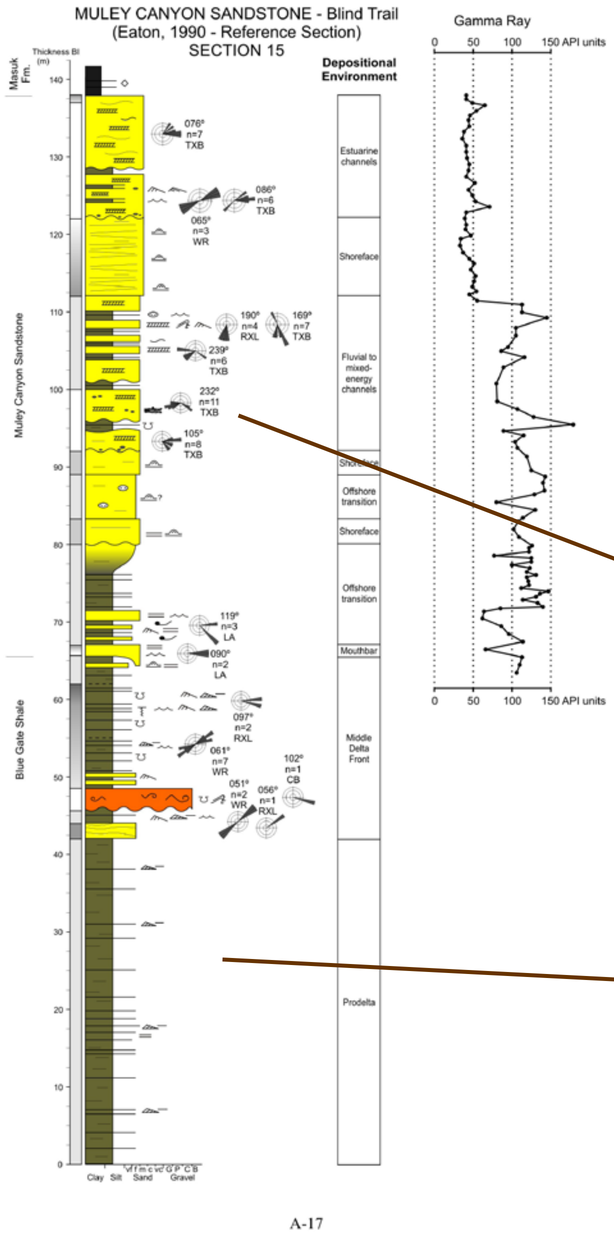


Gray-blue: Channel Complex 4
Pink: Channel Complex 3
Orange: Channel Complex 2
Brown: Channel Complex 1

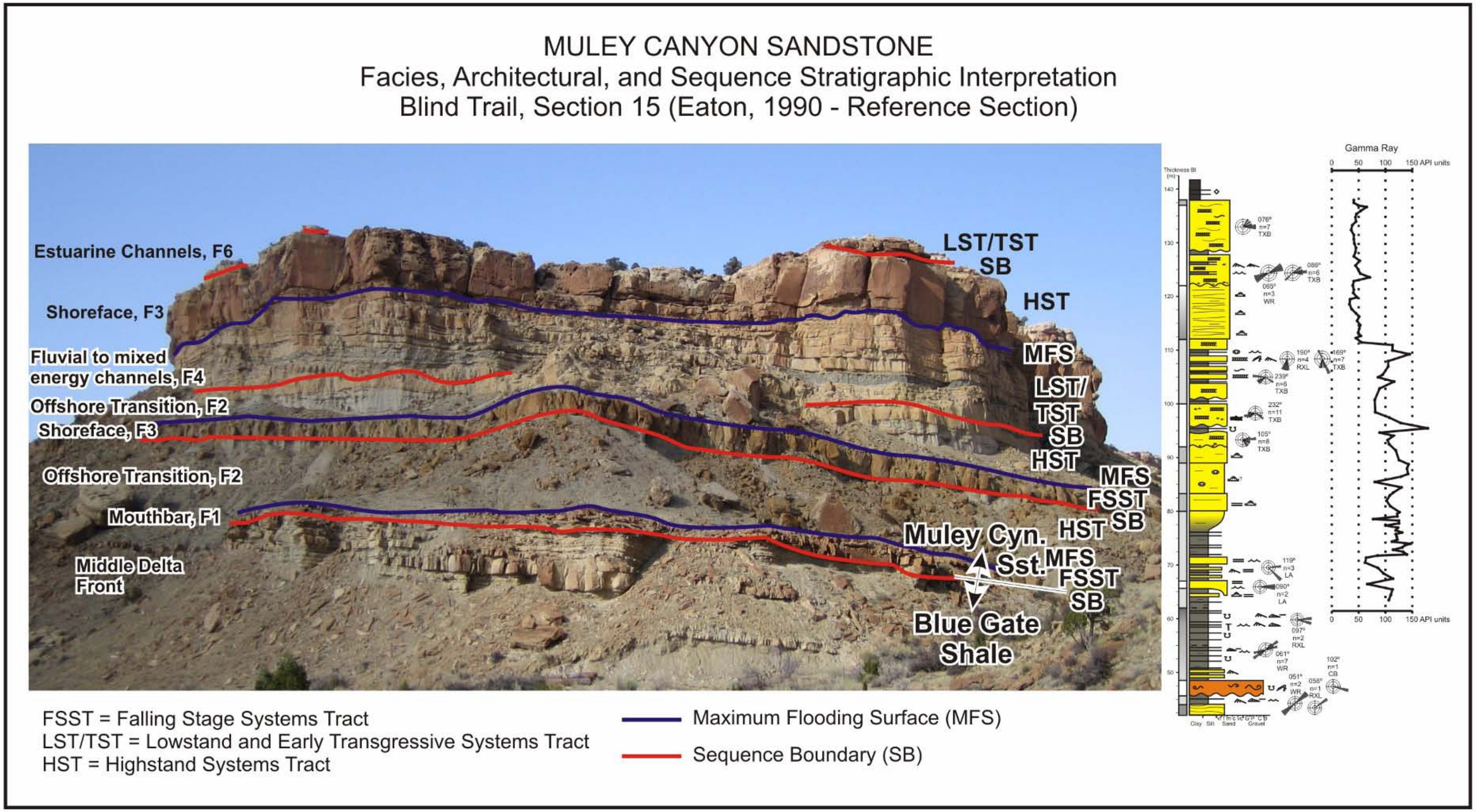
Yellow: Significant Delta Front Sandstone Bodies (lower member)

2. MULEY CANYON SANDSTONE

- Forms the main cliff line in the photograph,
- Overlies the thick Blue Gate Shale,
- Previously thought to be deltaic in origin.



ANNOTATED PHOTOGRAPH OF REFERENCE SECTION AT BLIND TRAIL, SHOWING DIVISION OF M.C.S. INTO ALTERNATING SHOREFACE AND FLUVIAL UNITS.



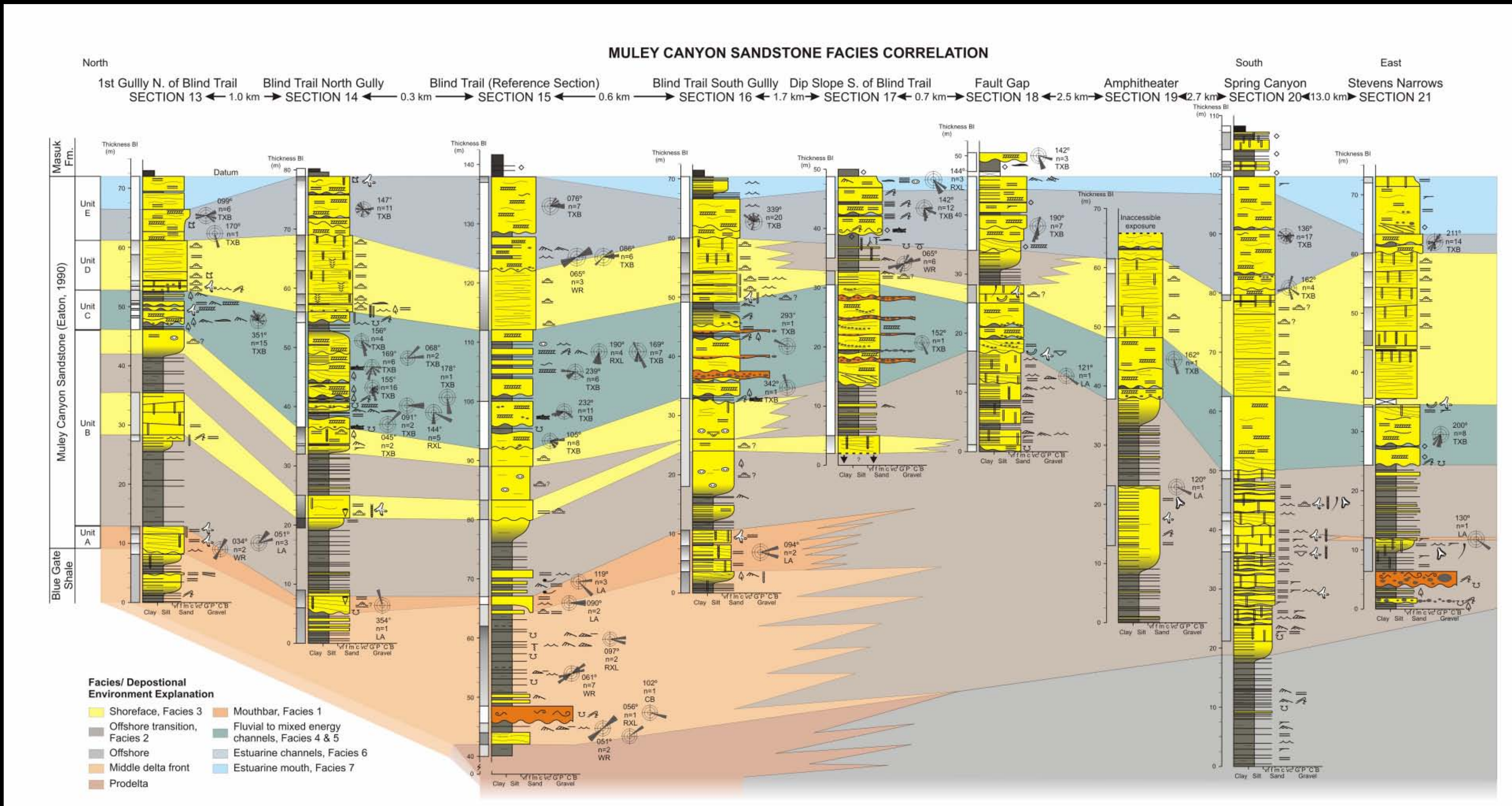
(Diagram from Birgenheier et al., 2009, UGS OFR 557)

MULEY CANYON SANDSTONE AT BLIND TRAIL

Topmost shoreface unit

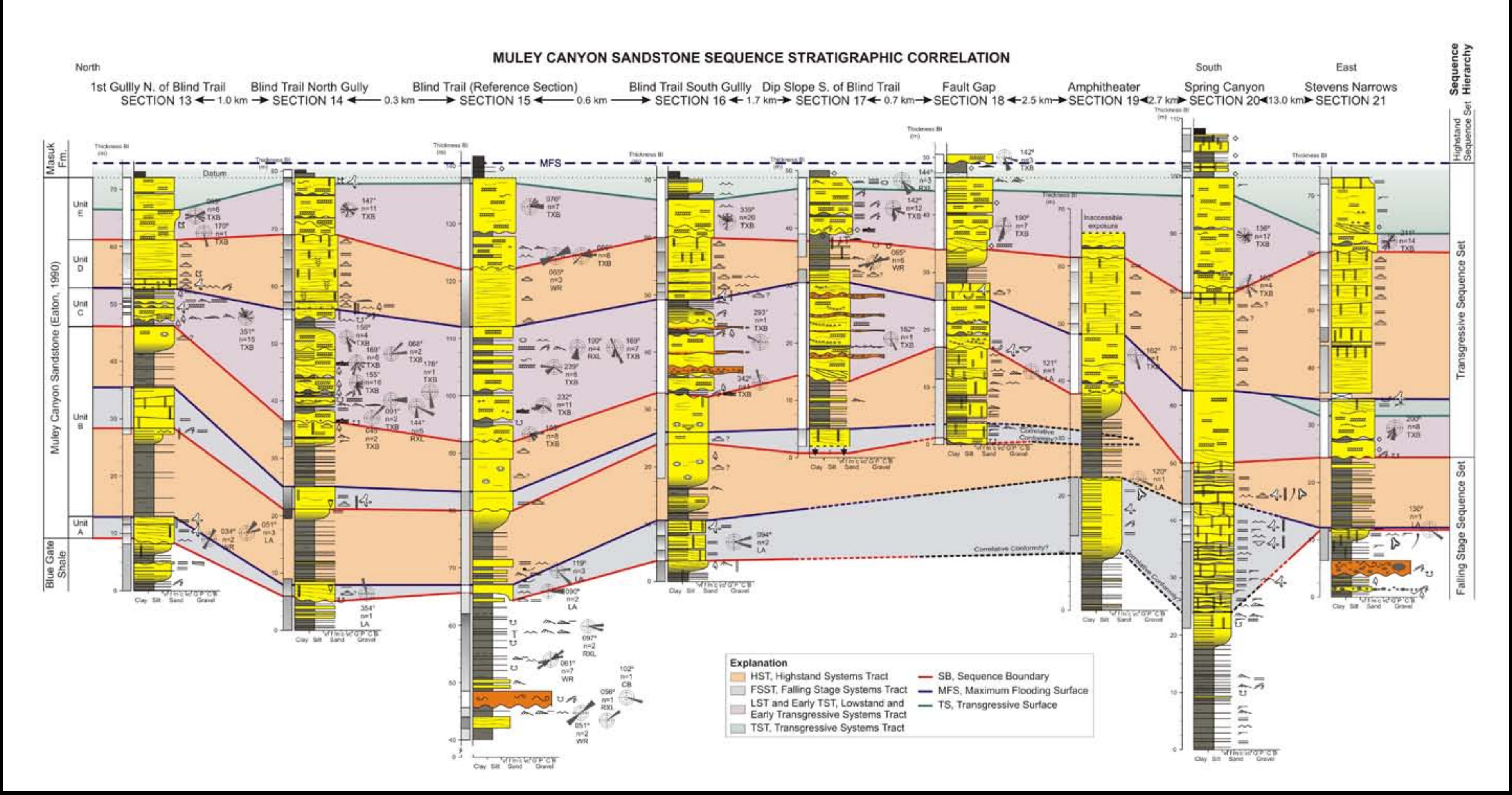
Lower channel unit

A FACIES CORRELATION OF THE M.C.S. OVER ~10 km NORTH TO SOUTH, SHOWING LATERAL CONTINUITY OF SUB-UNITS



(Diagram from Birgenheier et al., 2009, UGS OFR 557)

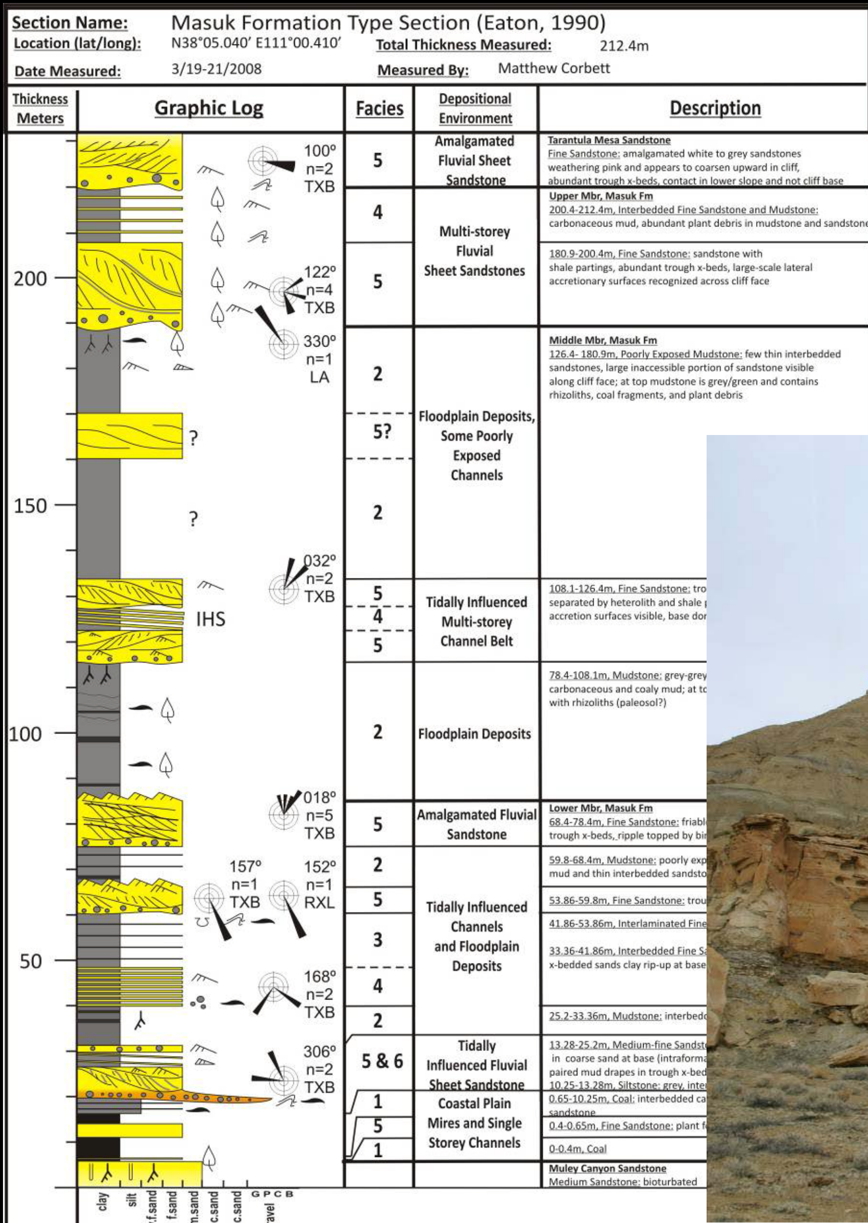
SAME CROSS-SECTION AS PREVIOUS SLIDE, WITH SEQUENCE STRATIGRAPHIC INTERPRETATION



NOTE SHEET-LIKE ARCHITECTURE OF COMPONENT UNITS

(Diagram from Birgenheier et al., 2009, UGS OFR 557)

3. MASUK FORMATION

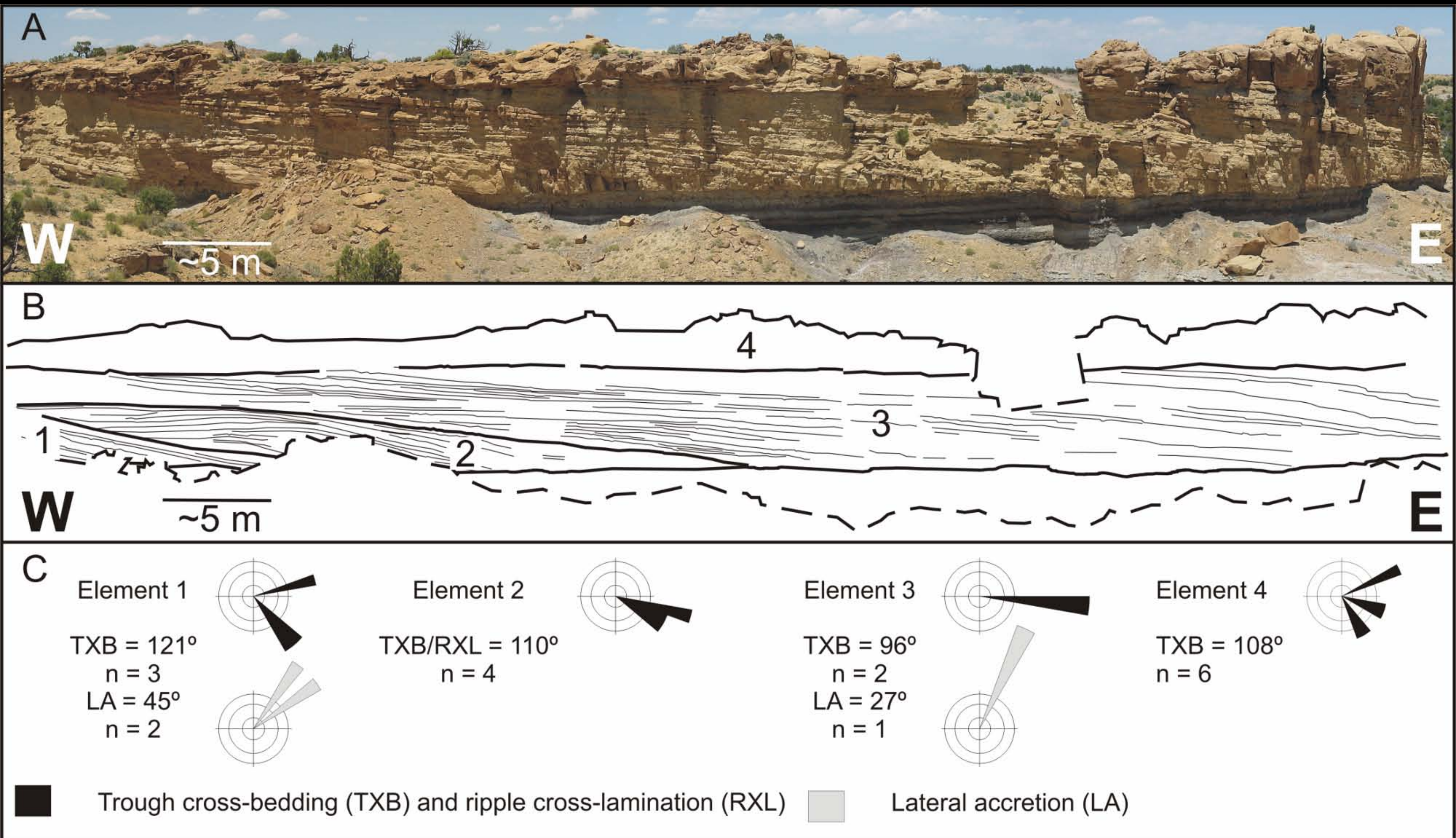


- Stratigraphically highest unit examined,
- Overlies Muley Canyon Sandstone,
- Broadly interpreted as of coastal plain origin.

Eaton's (1990) type section of the Masuk Formation at Blind Trail.

MANY MASUK FM CHANNEL BODIES SHOW COMPLEX INTERNAL ARCHITECTURE WITH COMMON HETEROLITHIC STOREYS

EXAMPLE OF A MULTI-STOREY BODY FROM THE LOWER MEMBER

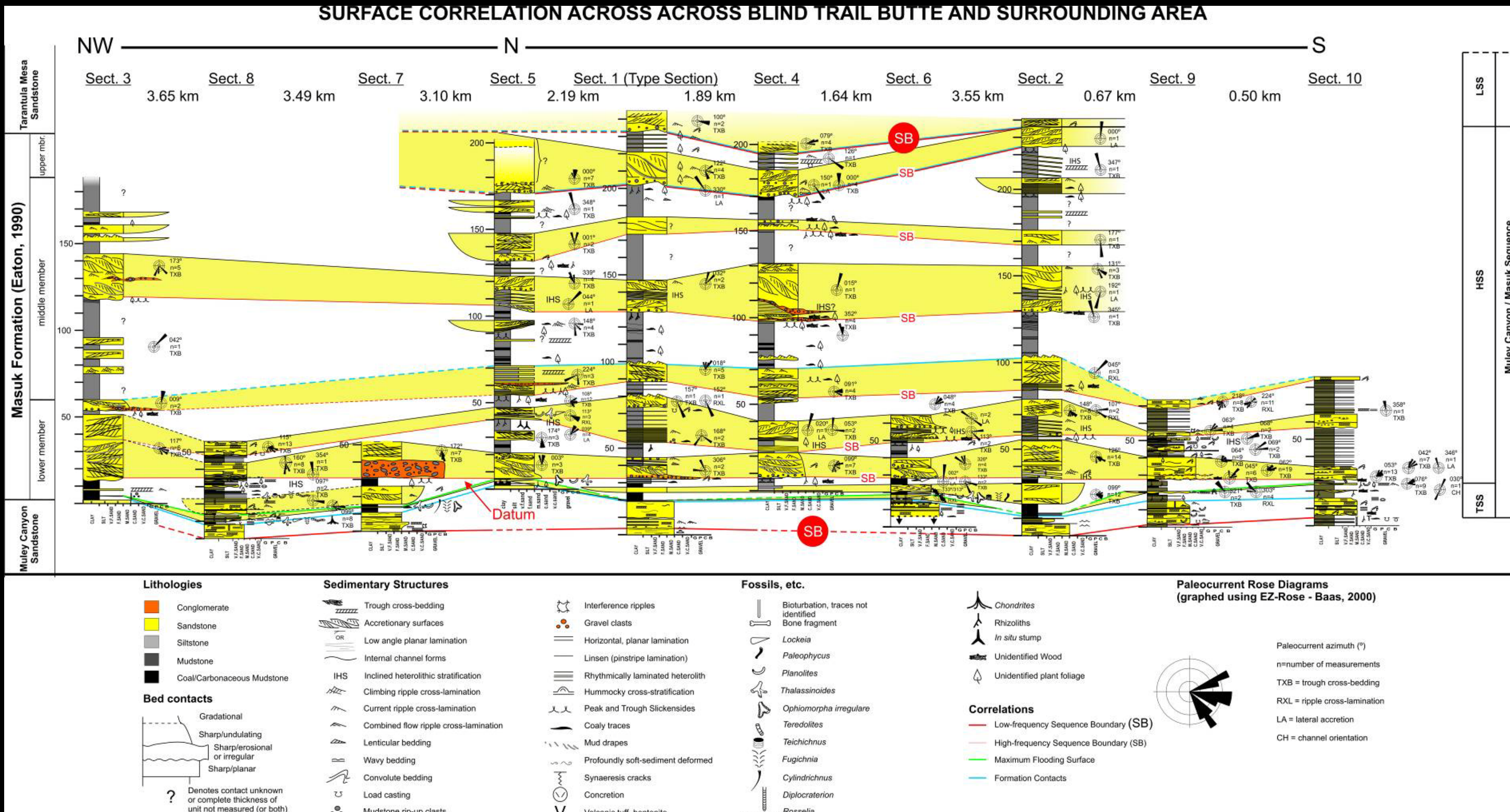


(Diagram from Corbett et al., submitted, J.S.R.)

PHOTOMOSAIC OF TYPE SECTION BUTTE, EAST FACE, SHOWING LATERAL CONTINUITY OF MEMBERS AND COMPONENT CHANNEL BODIES

VIEW FROM TOP OF TYPE SECTION BUTTE LOOKING SOUTH – NOTE LATERAL CONTINUITY OF CHANNEL BODIES OVER MANY KM.

SEQUENCE STRATIGRAPHIC INTERPRETATION OF THE MASUK FORMATION IN THE VICINITY OF THE TYPE SECTION AT BLIND TRAIL



(Diagram from Corbett et al., submitted, J.S.R.)

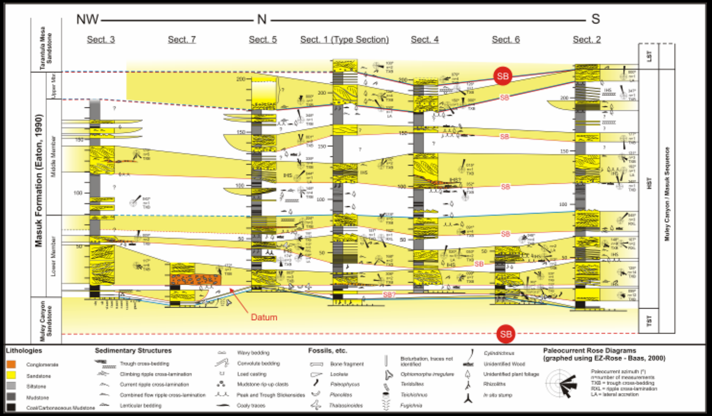
EACH OF THE THREE FORMATIONS IS CHARACTERISED BY PRESERVATION OF THIN, INCOMPLETE SEQUENCES WITH SHEET-LIKE CROSS-SECTIONAL ARCHITECTURE IN A DEPOSITIONAL STRIKE ORIENTATION.

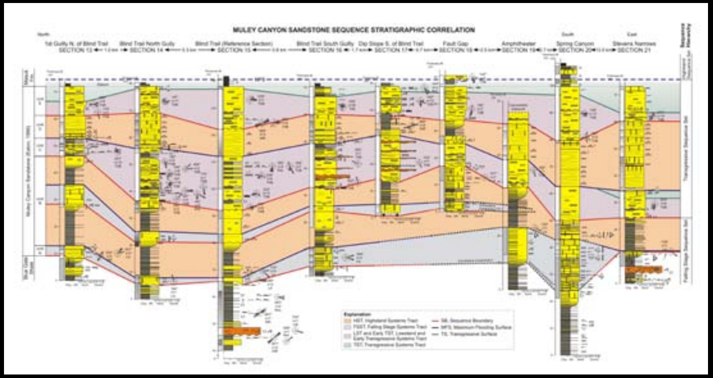
THE BASE OF EACH SEQUENCE IS CLEARLY EROSIONAL, BUT NO SUBSTANTIAL VALLEY FORMS ARE EVIDENT.

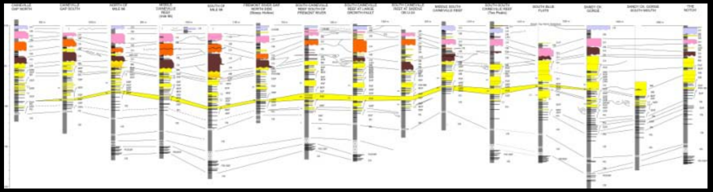
THIS IMPLIES AN EROSIONAL REGIME THAT PRODUCED PENEPLAINS DURING SEA-LEVEL DRAWDOWN RATHER THAN VALLEYS AND INTERFLUVES.

IT IS ENTIRELY POSSIBLE THAT THIS STYLE DOMINATES THE CRETACEOUS OF THE W.I.S.

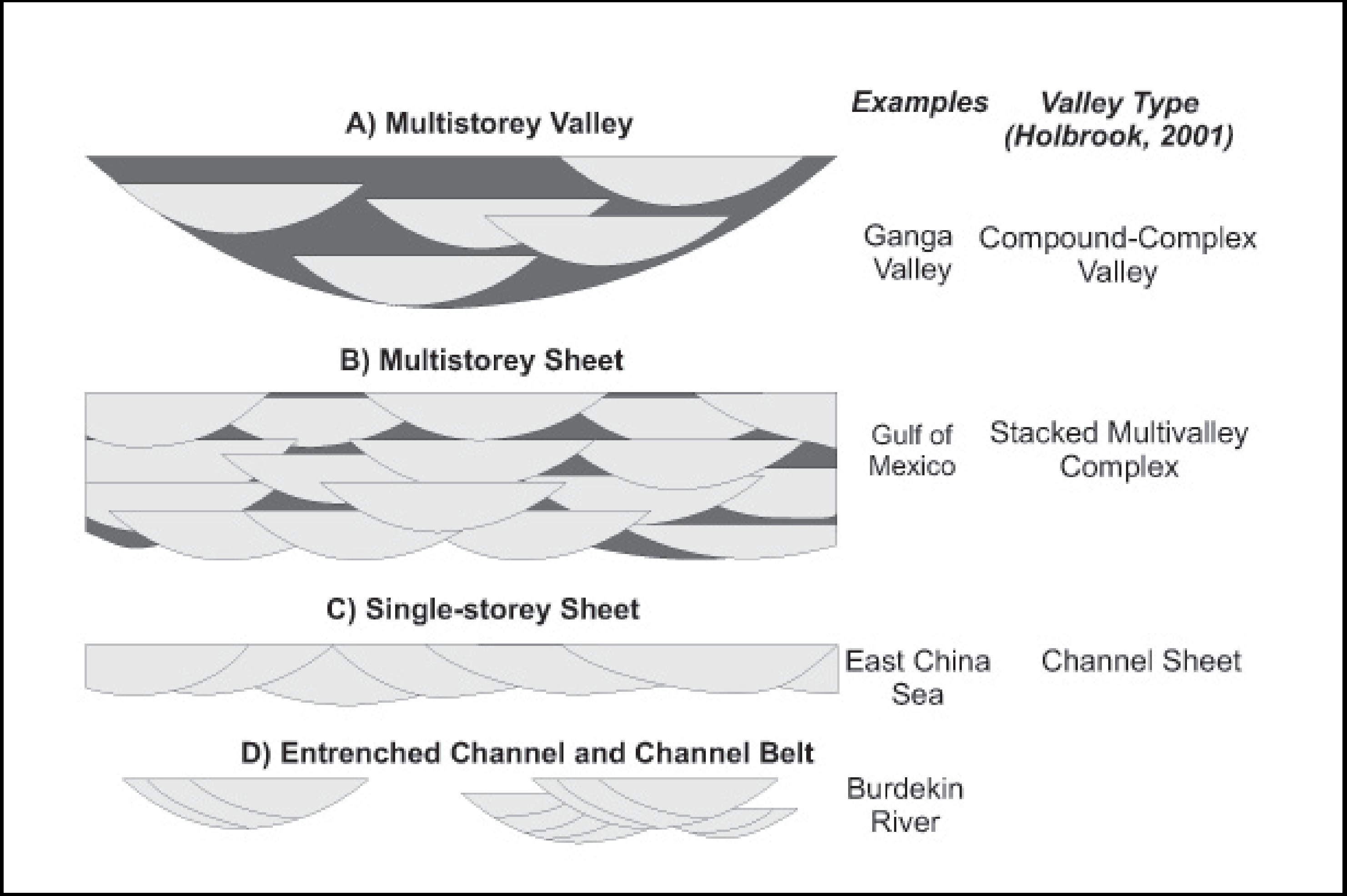
WHY? – GREENHOUSE CLIMATE REGIME??







BROADENING THE CLASSIFICATION OF FLUVIAL CHANNEL LITHOSOMES



(Diagram from Gibling et al., in press, SEPM Spec. Publ. “River to Rock Record”)

CONCLUSIONS

- THE FERRON SANDSTONE, MULEY CANYON SANDSTONE AND MASUK FORMATION ALL PRESERVE EROSIONALLY-BASED FLUVIAL BODIES THAT ARE LATERALLY EXTENSIVE IN A DEPOSITIONAL STRIKE ORIENTATION OVER TENS OF KM,

- THESE BODIES DEFINE ALLOGENICALLY FORCED SEQUENCES, FORMED DURING CYCLES OF RELATIVE SEA-LEVEL FLUCTUATION,

- NO EVIDENCE OF SIGNIFICANT VALLEY INCISION WAS FOUND IN ANY OF THE THREE FORMATIONS, RATHER, A SHEET-LIKE ARCHITECTURE DOMINATES THE SUCCESSION,

- SEA-LEVEL DRAWDOWN IN THE K.W.I.S. WAS EVIDENTLY SUCH THAT VALLEY INCISION WAS UNCOMMON – POSSIBLY DUE TO MODEST MAGNITUDES (<15 m) AND SLOW RATES OF RSL CHANGE.

- INVOKING SHEET-LIKE GEOMETRY FOR CRETACEOUS FLUVIAL SSTS IN THE K.W.I.S. HAS MAJOR IMPLICATIONS FOR UNDERSTANDING SEQUENCE GENESIS, STRATAL ARCHITECTURE, AND RESERVOIR POTENTIAL.


THANK YOU FOR YOUR INTEREST