Anatomy of a Cretaceous Tide-Influenced Subaqueous Delta: The O'Brien Spring Member, Haystack Mountains Formation, S. Wyoming*

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Search and Discovery Article #50870 (2013)**
Posted October 18, 2013

*Adapted from oral presentation at AAPG Annual Convention and Exhibition, Pittsburgh, Pennsylvania, May 19-22, 2013

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Abstract

Shallow-marine sandstone bodies encased or semi-encased within marine shales, on the most distal fringes of the Campanian clastic wedges of the Cretaceous Western Interior Seaway have long been depositional enigmas. Here, we present an analysis of one of such sandstone bodies, the O'Brien Spring Member of the Haystack Mountains Formation (South-Central Wyoming) and suggest that its anatomy sheds light on the broader problem of the distal tips of the clastic wedges.

Based on outcrop facies, paleocurrent readings, and outcrop photography we interpret the O'Brien Spring Member as a large tide-dominated delta system because of its delta-scale clinoforms (30-50m), upward coarsening and thickening of beds within the clinoform sets, mudstone layers as dune toe-sets and extensive thin muds between rippled and cross stratified sandstone sets, bi-directional paleocurrents in places, and predominance of cross strata representing 2-D and 3-D dunes on the upper parts of the main delta body. The lobes of the O'Brien Spring system were entirely subaqueous, as evidenced by the lack of channels or any associated coastal-plain deposits.

The O'Brien Spring delta was supplied with sediments from a west-northwest source, as indicated by the eastward paleocurrents west of the study area. However, the delta system was re-aligned by southerly-oriented tidal currents within a lowstand-narrowed Western Interior Seaway, probably in a similar way (though on a smaller scale) as that which occurs in the modern Klang delta of Malaysia. It is also likely that the delta system prograded this far into the seaway during falling sea-level, argued from its regressive character, flattish shoreline trajectory, and non-association with any tail of coastal-plain deposits (it would seem to be subaqueously detached from the coeval shoreline). Modest sea-level falls (a few 10s of m) on a very flat alluvial-shelf landscape forced deltaic shorelines into the seaway by up to 150 km beyond the western highstand shorelines, thus creating a narrower seaway and likely enhancement of southerly-oriented tidal currents. This scenario of decreased basin water depth would also have built more irregular shorelines and enhanced basin-floor topography, both of which would have amplified the tidal processes. The falling-stage to lowstand O'Brien Spring clinoforms were possibly the outer segment of a double, larger scale clinoform, whose inner segment was the slightly older highstand, wave-dominated shorelines farther west.

References Cited

Blakey, R., 2011, Paleogeography and Geologic Evolution of North America, Late Cretaceous (75 Ma): Website accessed August 29, 2013. http://www2.nau.edu/rcb7/namK75.jpg

Mellere, D., and R. Steel, 1995, Variability of lowstand wedges and their distinction from forced-regressive wedges in the Mesaverde Group, southeast Wyoming: Geology, v. 23/9, p. 803-806.

Roehler, H.W., 1989, Surface-subsurface correlations of the Mesaverde Group and associated Upper Cretaceous formations, Rock Springs to Atlantic rim, southwest Wyoming: U.S. Geological Survey Miscellaneous Field Studies Map MF–2078.

Steel, R., P. Plink-Bjorklund, and J. Aschoff, 2011, Tidal deposits of the Campanian Western Interior Seaway, Wyoming, Utah, and Colorado: Search and Discovery Article #50474 (2011) (http://www.searchanddiscovery.com/documents/2011/50474steel/ndx_steel.pdf) (website accessed August 29, 2013).

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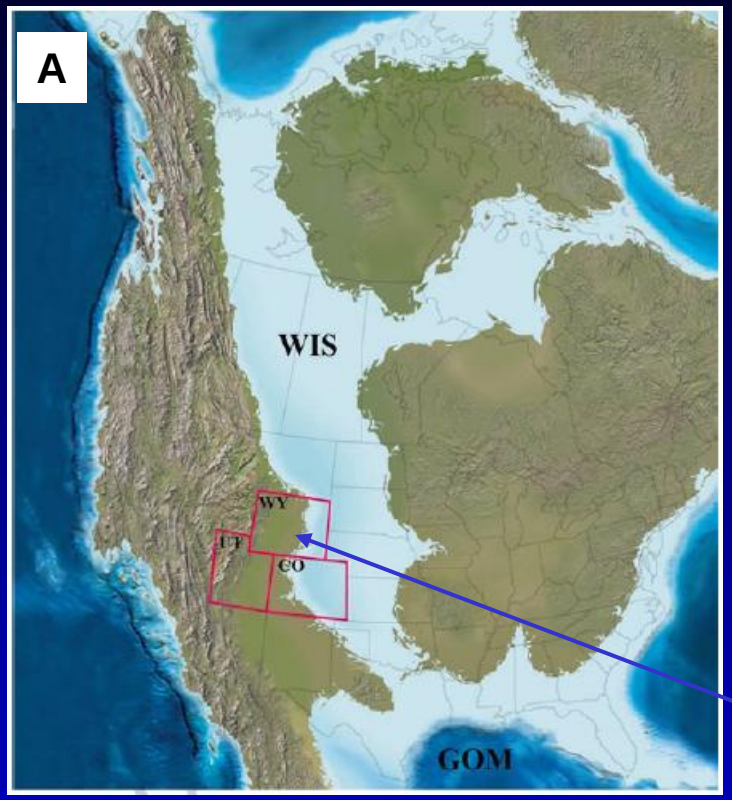
AAPG Annual Convention, May 2013

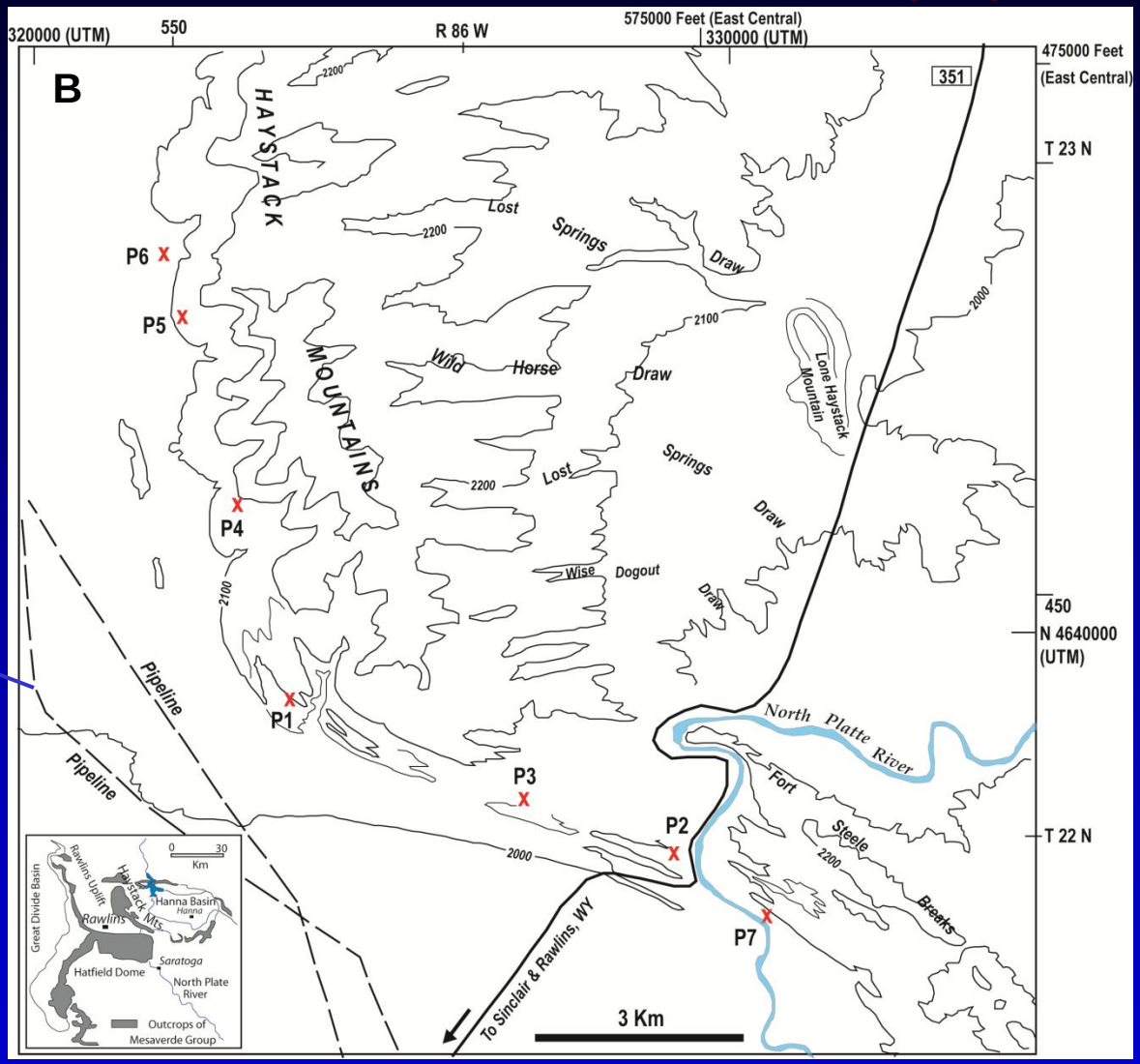
OUTLINE

- ✓INTRODUCTION: - Location of the Study Area
  - Regional Stratigraphy Campanian
- ✓DELTA CLINOFORMS: O' Brien Spring Member
- ✓DELTAIC SUCCESSION: O' Brien Spring Member
- ✓FACIES ASSOCIATIONS
- ✓DEPOSITIONAL GEOMETRY & MODEL
- ✓CONCLUSIONS

Location of the Study Area



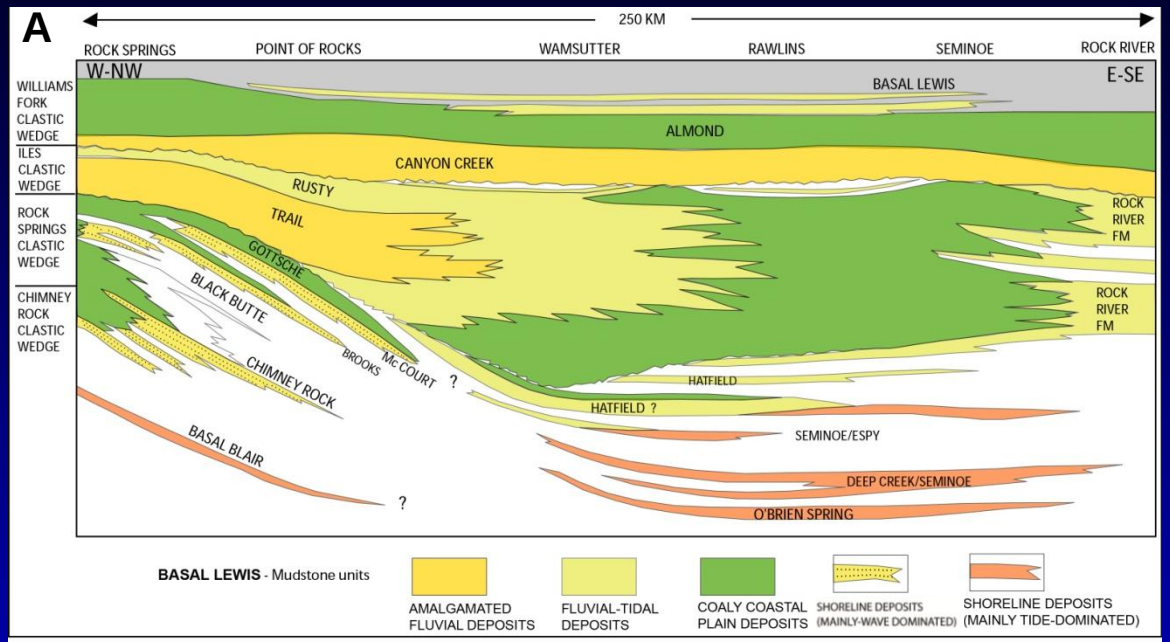
A. Western Interior Seaway (USA) at 75 Ma with Utah, Colorado, & Wyoming highlighted (from Blakey, NAU Geology).



B. Study area along the Haystack Mountains, showing the location of the measured outcrop sections in the O'Brien Spring Member. Inset map shows the location of the Haystack Mountains area in relation to Mesaverde outcrops .

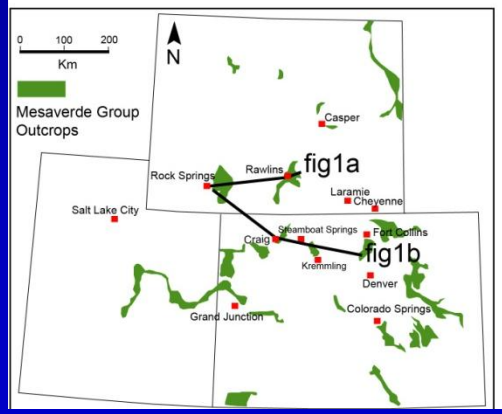
Regional Stratigraphy Campanian

WIS Lowstand Deltas, South Wyoming

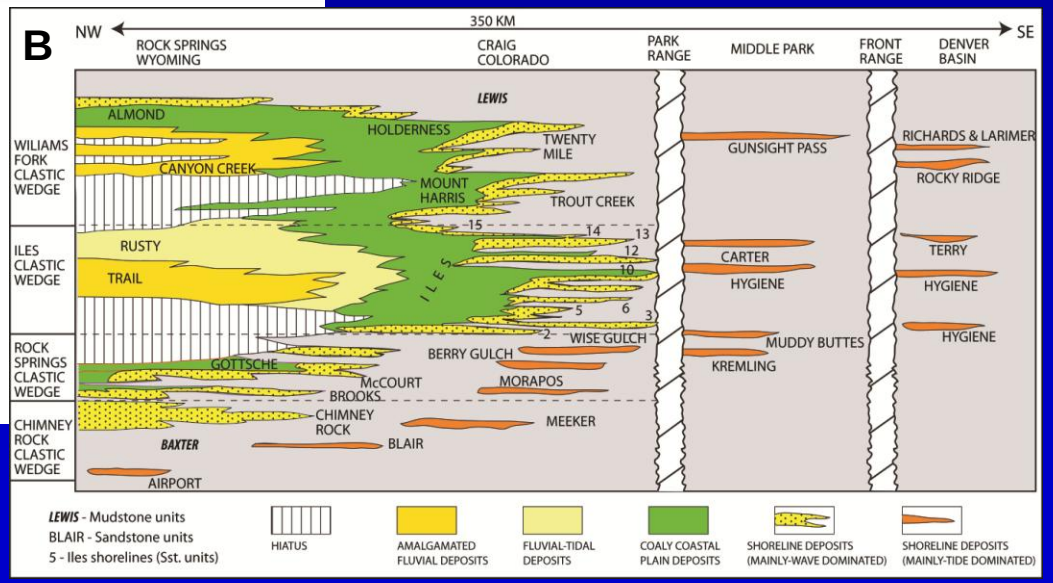


A) Transect from Rock Springs to Rock River in Wyoming, showing four large clastic wedges that built out from the active Sevier Fold-and Thrust Belt in Wyoming (modified from Roehler, 1989).

Highstack Mountains Fm.

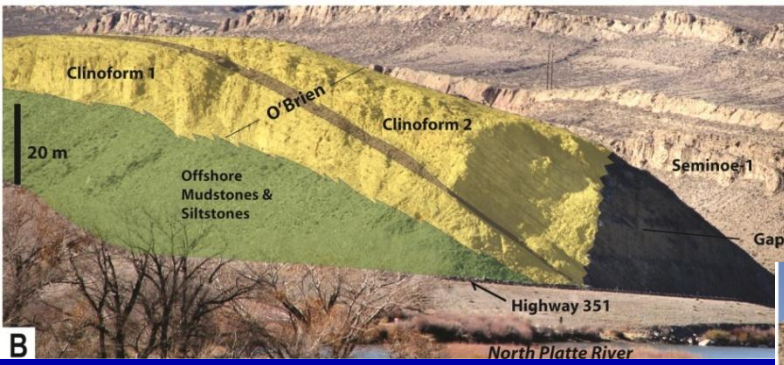


B) Transect S Wyoming to N Colorado, showing four large clastic wedges that built out from the active Sevier Fold-and Thrust Belt in Wyoming and Colorado sectors (Steel et al, 2011).

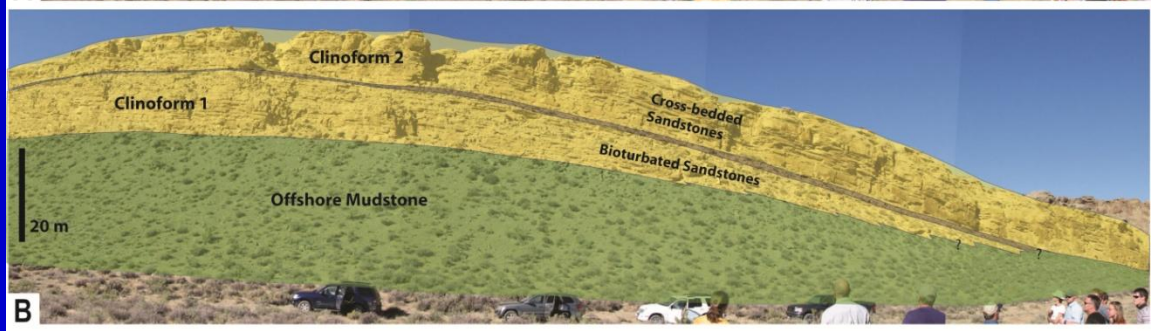


Deltaic Clinoforms

WIS Lowstand Deltas, South Wyoming

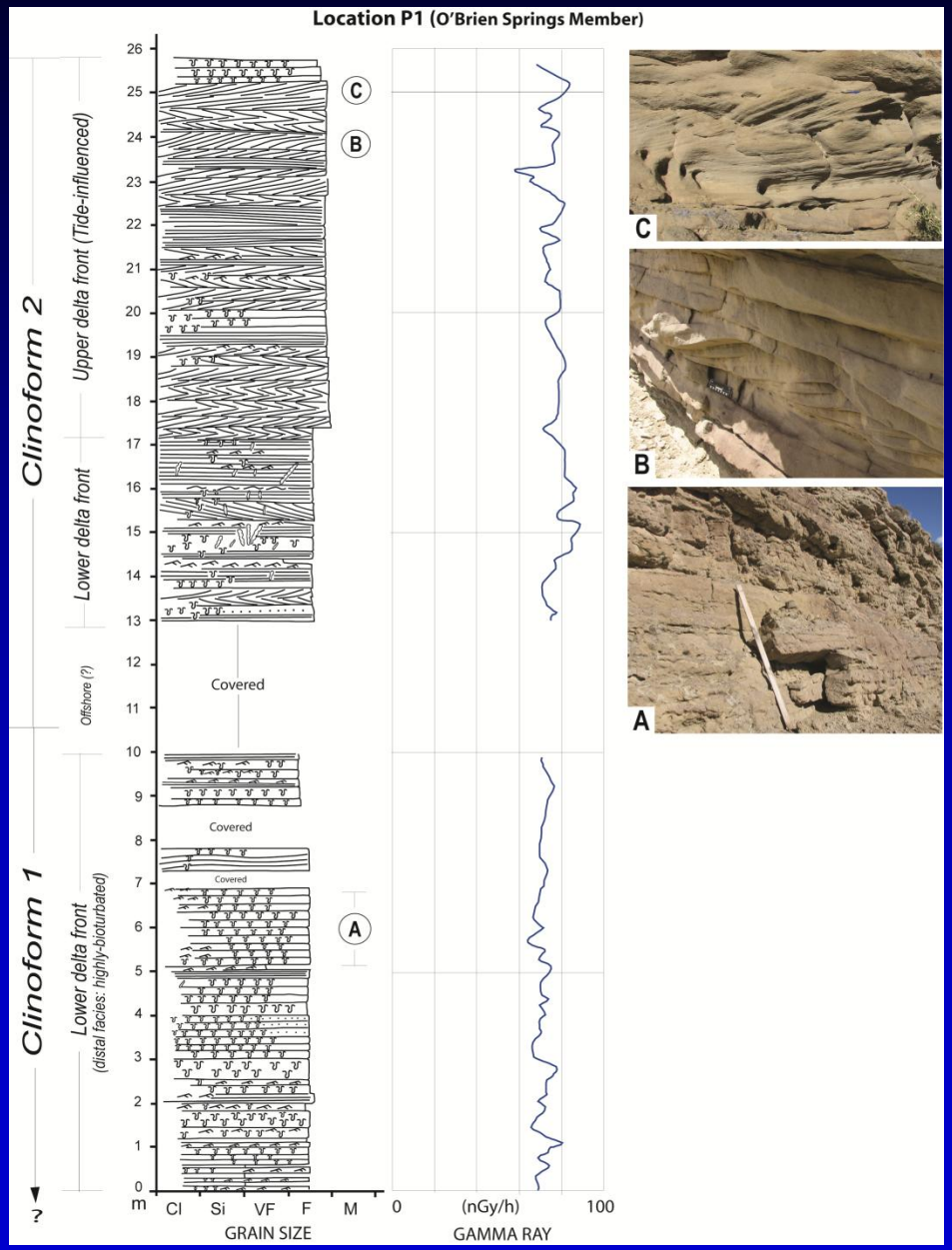


Clinoformed geometries O'Brien Spring Member at location P2 (A uninterpreted, B with interpretation).



Clinoformed geometries O'Brien Spring Member at location P1 (A uninterpreted, B with interpretation). Clinoform 1 seen in its distal part (bioturbated sandstones). Clinoform 2 contains more proximal facies (cross-bedded sandstones) .

Deltaic Succession O'Brien Spring



C) Planar cross-bedding towards the top of the O'Brien Spring Member

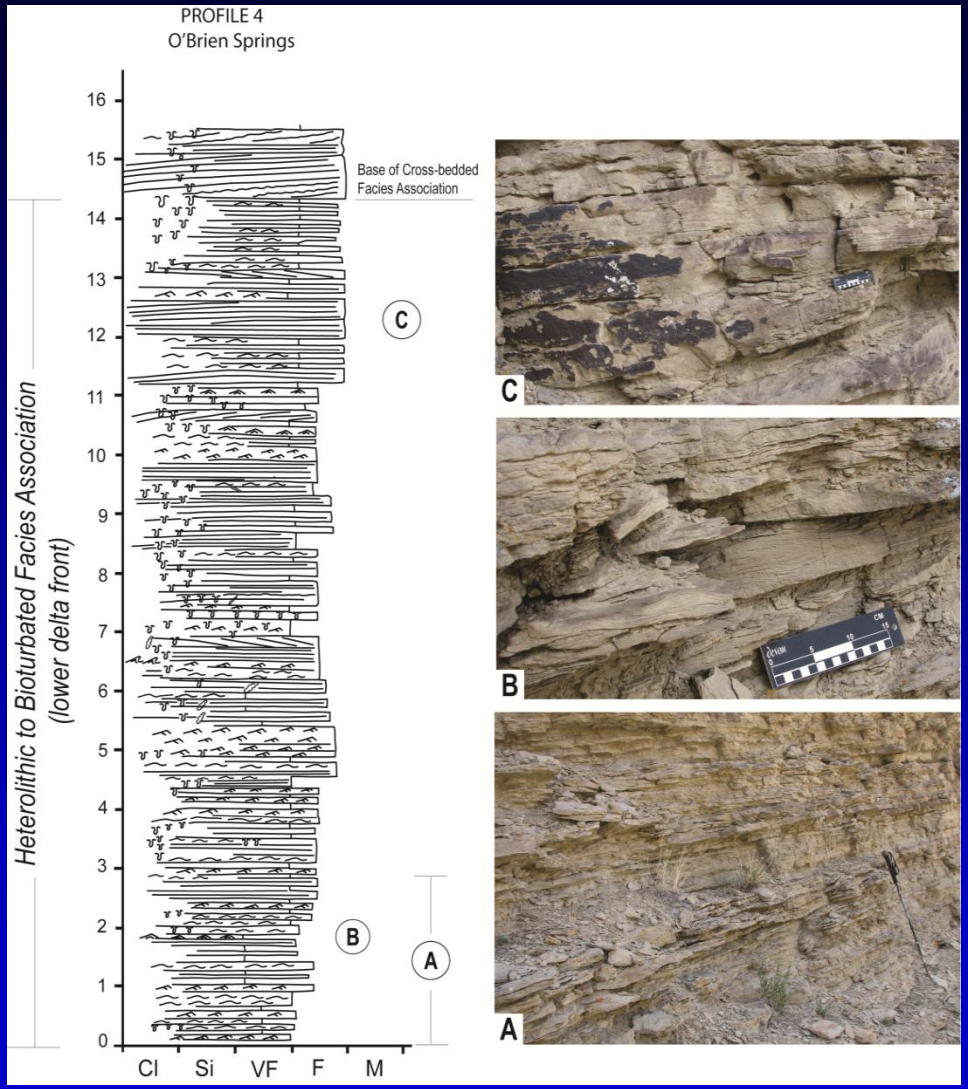
B) Sigmoidal cross-bedding

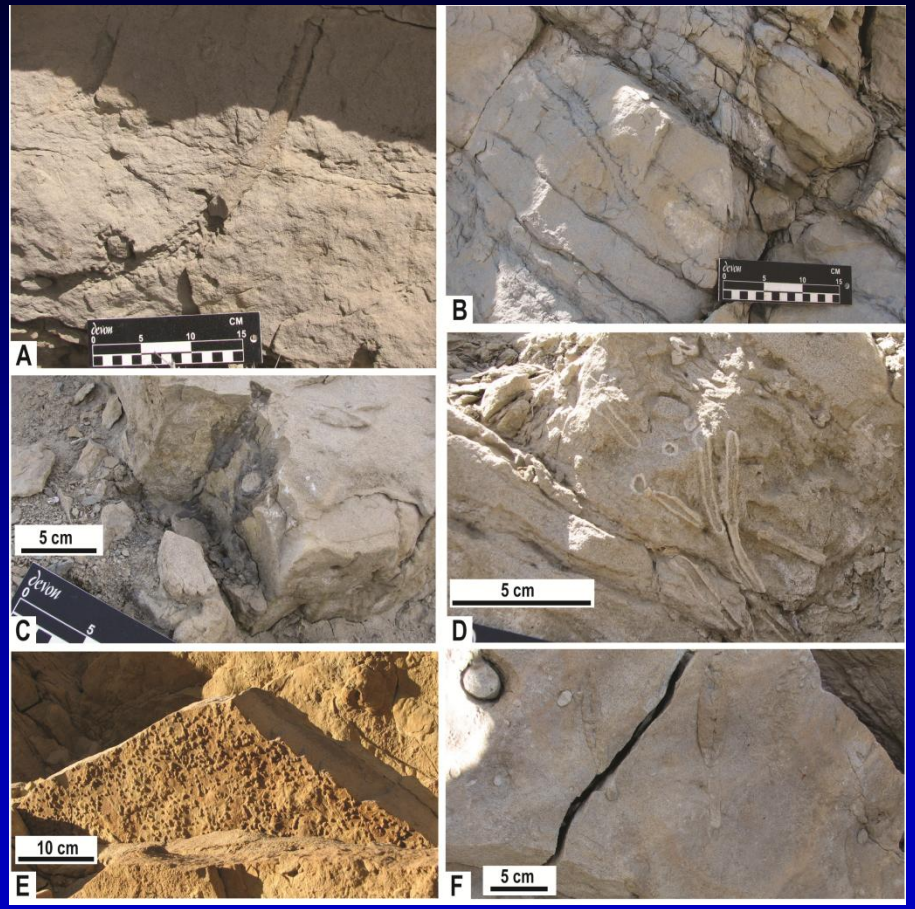
A) Bioturbated bedsets within the lower delta front

Deltaic succession O'Brien Spring Member at Location P1, showing some characteristic features. The section below this profile is weathered and covered (composed of 20 feet of muddy shelf deposits).

Facies Associations

WIS Lowstand Deltas, South Wyoming





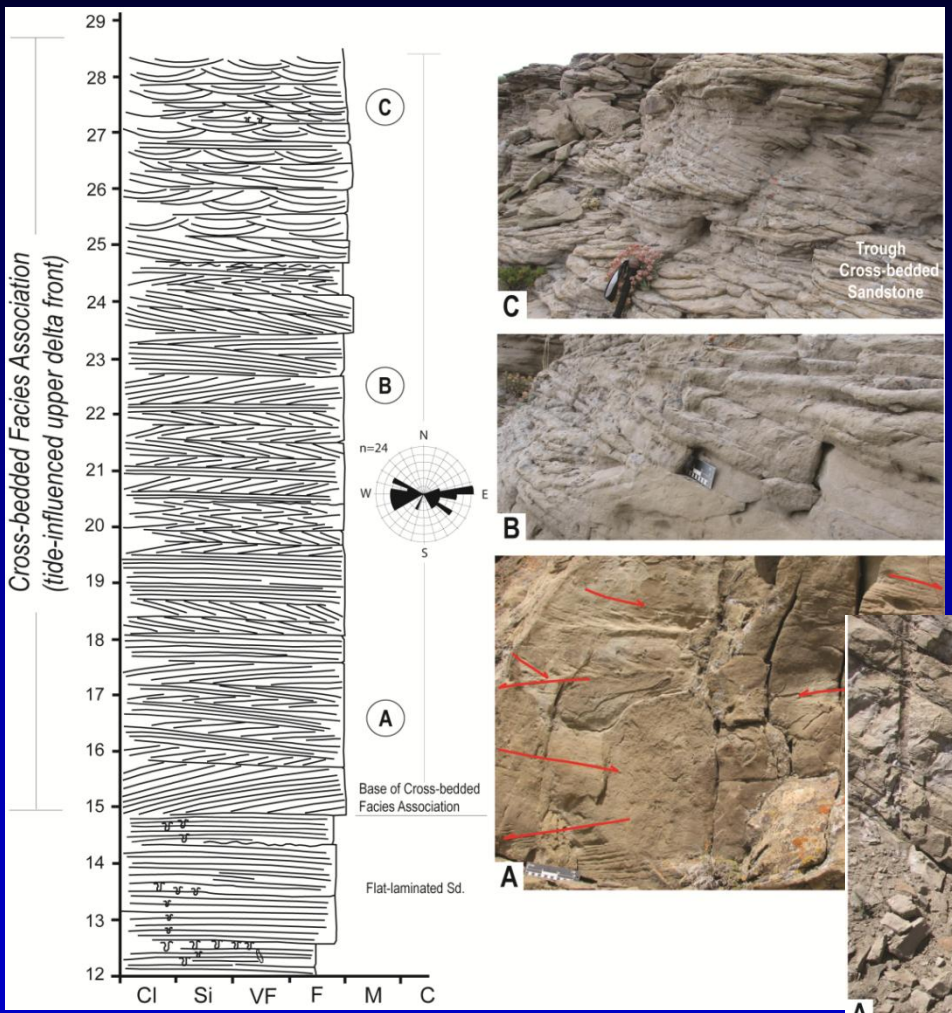
Trace fossils from this association: A) *Ophiomorpha*. B) *Ophiomorpha Nodosa*. C) *Asterosoma*. D) *Terebellina*. E) *Chondrites*, F) *Rosselia*. This ichnofossil suite reflects shallow-marine conditions.

Heterolithic to Bioturbated Facies Association, at Location P4. (A) Heterolithic facies at the bottom of the succession. (B) Wave ripple lamination. (C) Swaley-like features.

Interpretation: *Lower portion of tide-influenced (or river-tide interaction) delta front*

Facies Associations

WIS Lowstand Deltas, South Wyoming



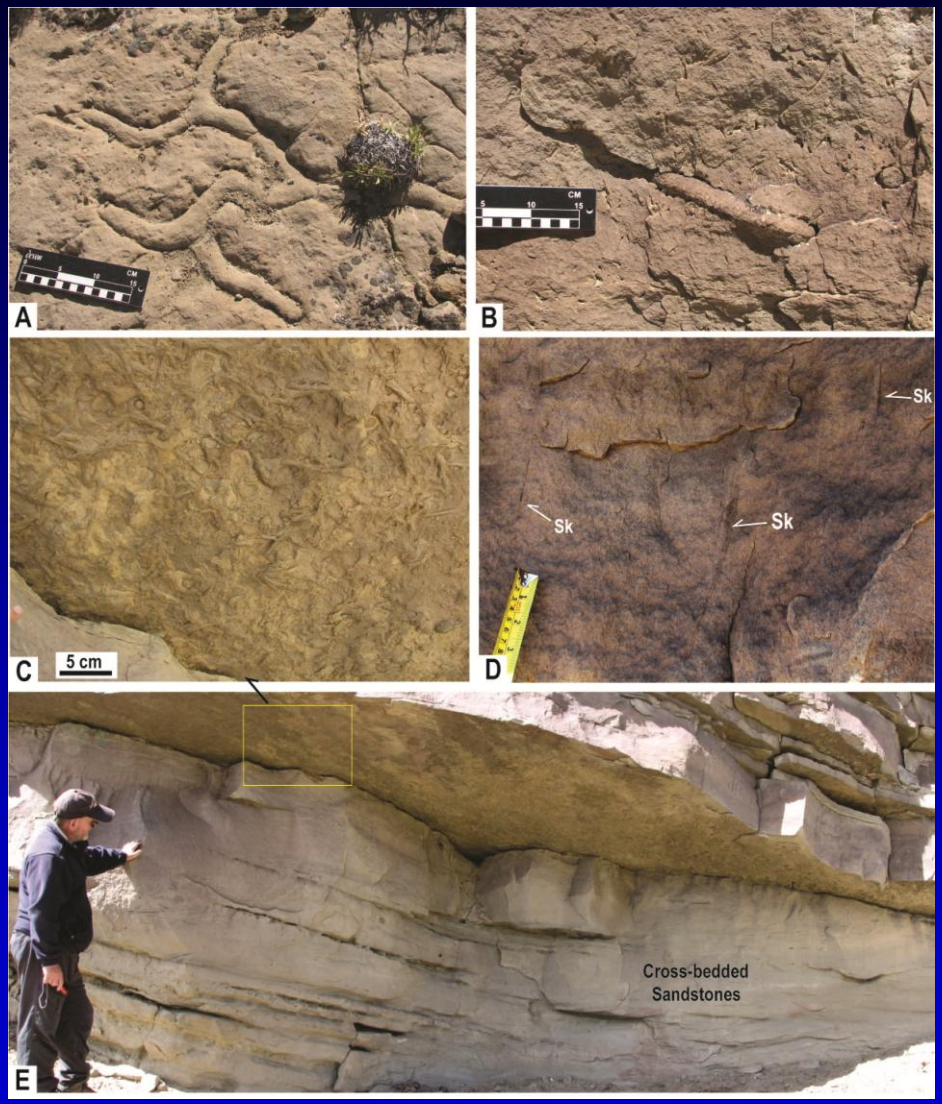
Cross-Stratified Facies Association, location P5. A) Bidirectional cross-bedding, highlighted by red arrows; B) Tangential cross-bedding; C) Trough cross-bedding towards top of profile.

***Interpretation:* Succession of 2D & 3D tidal dunes deposited within the upper portion of a tide-influenced delta front**

A) Stacked cross-bedded sandstone sets capped by siltstone/mudstone drapes, loc. P2. B) Cross-bedded sandstone sets showing double mud drapes from loc. P2. C) Bi-directional cross-bedded sandstone sets without mud drapes, loc. P1.

Facies Associations

WIS Lowstand Deltas, South Wyoming



Trace fossils from this association: A) *Thalassinoides*. B) *Ophiomorpha*. C) Intense bioturbation. D) *Skolitos*. E) Cross-bedded sandstone beds capped by an intensely bioturbated layer

Cross-Stratified Facies Association

Bidirectional cross-strata from Location P5.

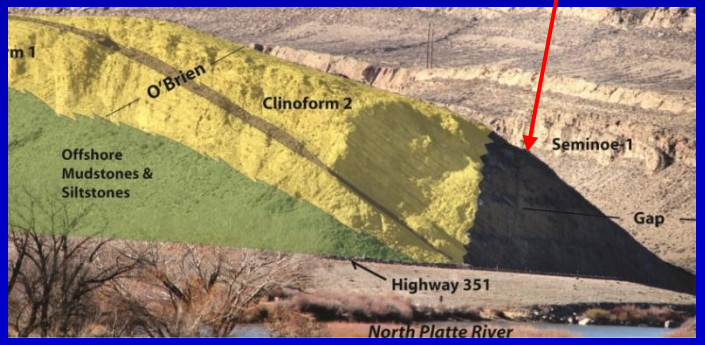
Large dunes within a sandstone wedge, loc. P7 (stick as scale about 1 m). Dunes are oriented to the south.

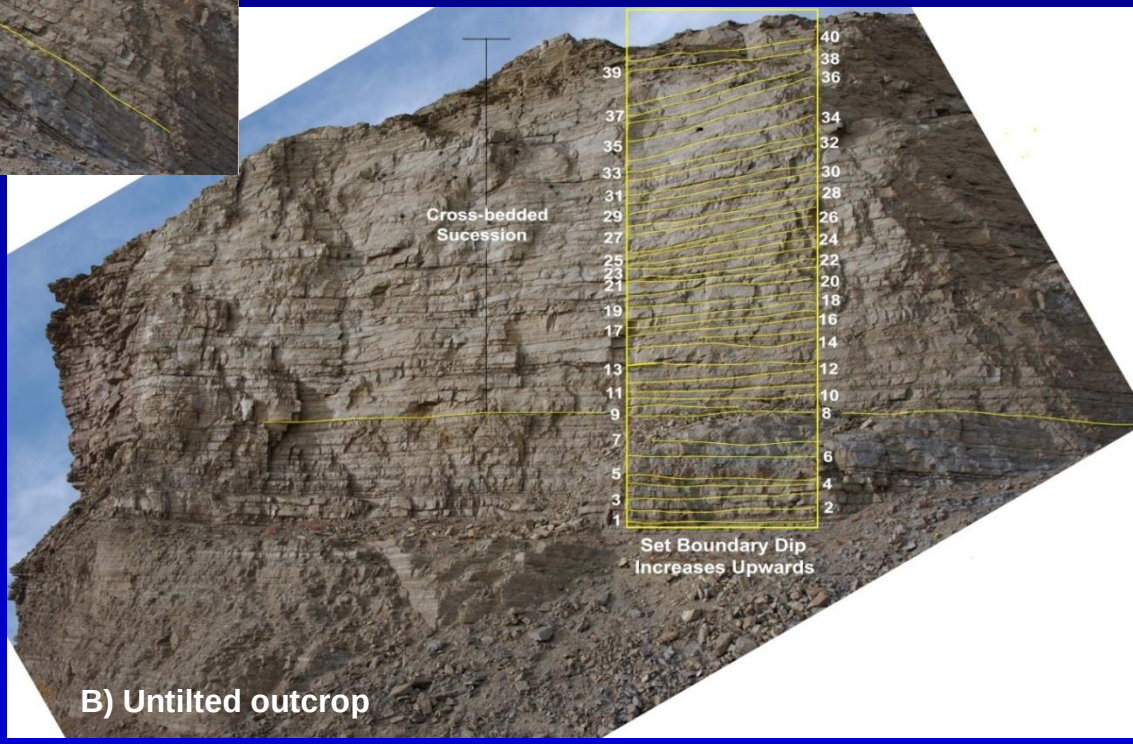
Facies Associations

WIS Lowstand Deltas, South Wyoming

Cross-Stratified Facies Association

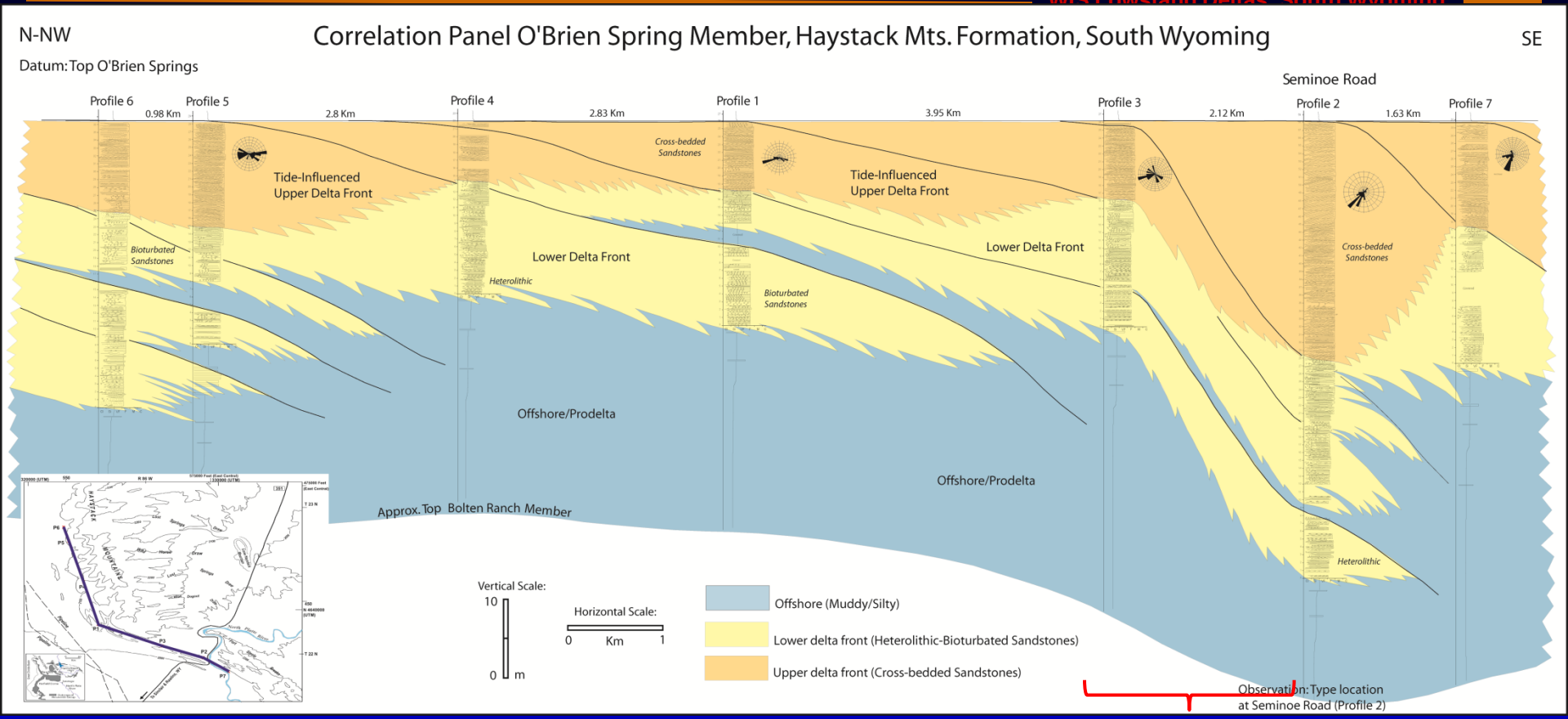
A view of location P2, showing an upward increase in the dip of the sandstone sets within the cross-bedded facies association. Outcrop face is oriented N-S with bed-sets oriented towards south-southeast.





Depositional Geometry

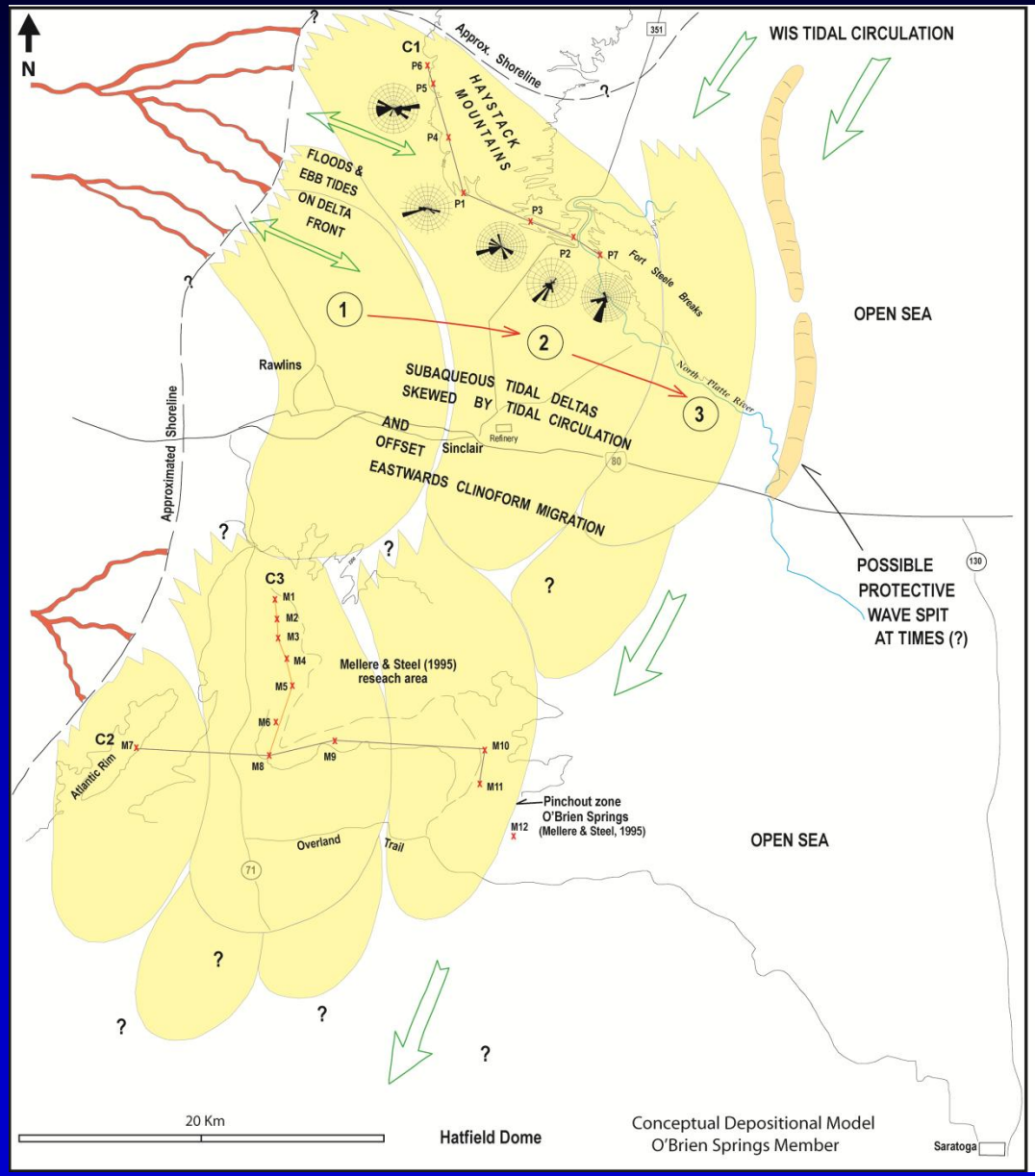
WIS Lowstand Deltas, South Wyoming

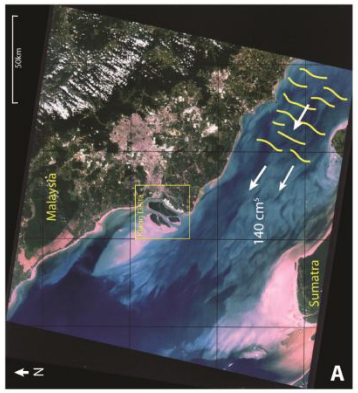


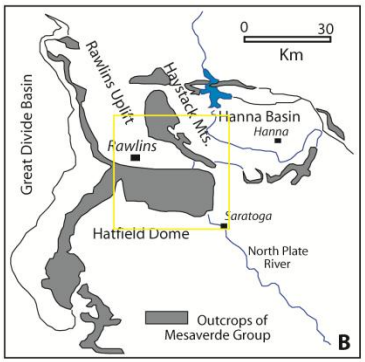
Correlation Panel: O'Brien Spring Member along a 14-Km stretch in the Haystack Mountains area (Wyoming). The O' Brien Spring is composed of a series of deltaic clinoforms, migrating initially towards the east-southeast but later skewed to the south by north-south directed tidal currents within the narrowed Western Interior Seaway.

Depositional Model

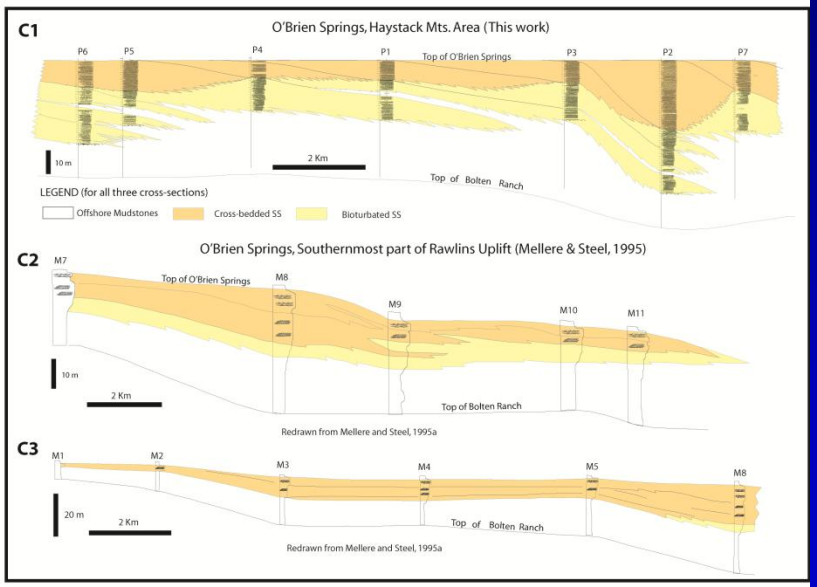
WIS Lowstand Deltas, South Wyoming







Satellite photo Klang delta, Malaysia



Conceptual depositional model: O'Brien Spring Member including Mellere and Steel (1995a) area of study. Tidal deltas were skewed and reworked by north-south-oriented tidal currents from the seaway (analogous to Klang delta in Malaysia)

Conclusions

✓The O'Brien Spring Member corresponds to a subaqueous tide-dominated delta system developed during sea-level lowstand. The strong tidal influence is emphasized by the 10s of m thick dune succession on the delta front.

✓The O'Brien Spring Member is interpreted as delta lobes because of their upward coarsening character and clear clinoform geometry.

✓WIS shorelines possibly changed from updip wave domination to downdip tidal-current enhancement (regional scale 100-200km) due to embaying of shorelines, narrowing of the seaway and enhancing seabed relief during fall of sea level.

✓Semi-isolated tidal sandbodies, occurring at the regressive maxima of multiple tongues within larger Sevier clastic wedges, could possibly be the subaqueous parts of compound shelf clinoforms skewed southwards in the seaway by strong N-S tidal currents.

Acknowledgements

Univ. of Texas at Austin, Jackson School of Geosciences

John A. & Katherine G. JACKSON SCHOOL OF GEOSCIENCES

Riomar Consortium
(2005-2008)

ConocoPhillips, BP, Statoil,
BHP Billitton, Shell, Woodside.