Using 3D Facies Architecture and Ichnology Analysis to Evaluate Delta Asymmetry, Ferron Notom Delta, Capital Reef, Utah, USA*

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Abstract

Delta asymmetry forms where there is strong wave influence and net longshore transport. Morphology and facies of the updrift and the down drift sides of asymmetric deltas are predicted to be quite different, which is significant for exploration of hydrocarbons. Delta asymmetry has been widely recognized in modern systems. In the ancient record, however, there are only very few documented examples. Based on an integrated sedimentological and ichnological study, we document the 3D facies architecture within a single parasequence in the Cretaceous Ferron Notom Delta, Utah and provide the first well-documented example of delta asymmetry in the ancient record. Two discontinuity surfaces are recognized in the studied parasequence 6 (Ps6), which subdivided the parasequence into three bed sets, marked as Ps6-1 through Ps6-3. Ps6-3 consists predominately of river-dominated facies. Within Ps6-1 and Ps6-2, however, there is a clear along-strike facies transition from shoreface in the north, into much heterolithic river-dominated delta-front facies southeastward, and into wave/storm-reworked facies further southeastward. Ichnogenera correspondingly show distinct along-strike changes from robust and healthy archetypal Cruziana and Skolithos ichnofacies into a suite characterized by horizontal, morphologically simple, facies-crossing structures of the suppressed Skolithos and Cruziana ichnofacies. Further southeastward suites show higher abundance and diversity, reflecting the archetypal ichnofacies.

The overall facies distribution and paleogeography within the parasequence suggest delta asymmetry, with net longshore transport from north to south. The asymmetric delta consists of sandier shoreface in the updrift side and mixed riverine and wave/storm-reworked facies in the downdrift side, similar to many modern examples. However, in contrast to the recent delta asymmetry models, significant paralic, lagoonal, and bay-fill facies are not documented, because of both negative shoreline trajectory during delta progradation and transgressive erosion.

The field example documented here, coupled with the abundance of modern examples, indicates that delta asymmetry should be more common in the rock record than has been identified. Careful documentation of along-strike facies variation and involving regional stratigraphic and paleogeographic control are critical to separate asymmetric deltas from other wave-influenced depositional systems in the rock record.

References

Bhattacharya, J.P. and L. Giosan, 2003, Wave-influenced deltas; geomorphological implications for facies reconstruction: Sedimentology, v. 50/1, p. 187-210.

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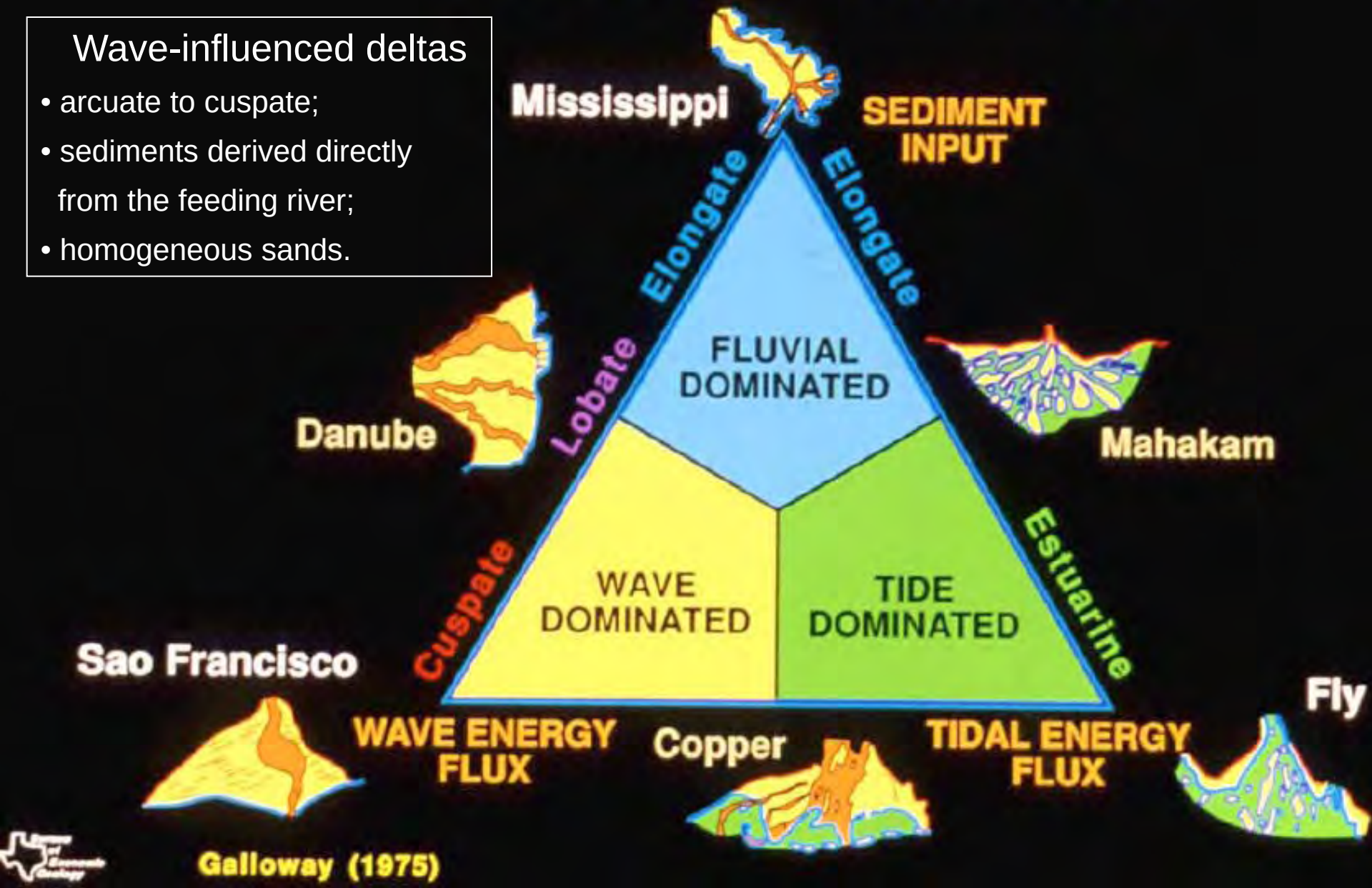
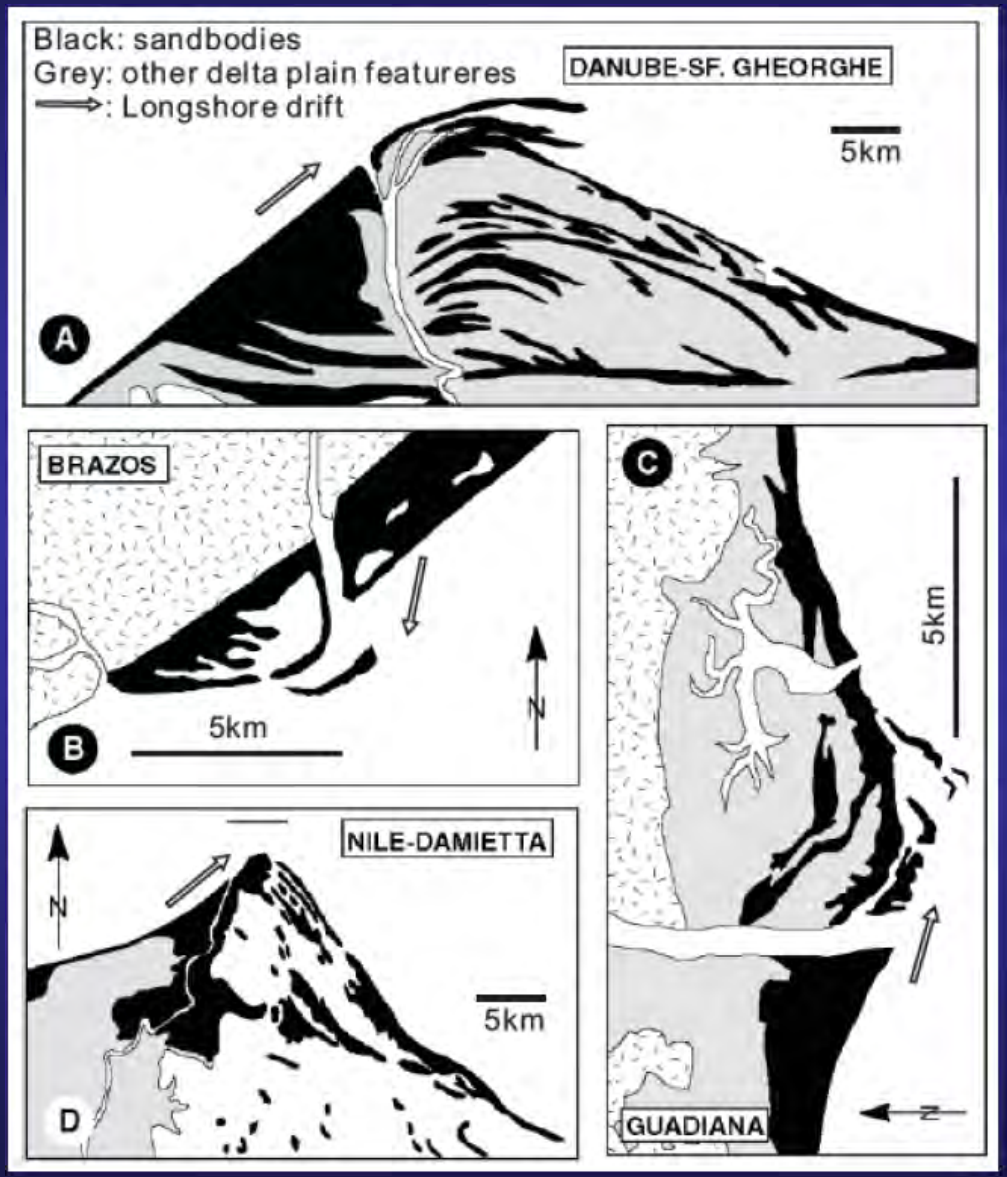
Early deltaic models

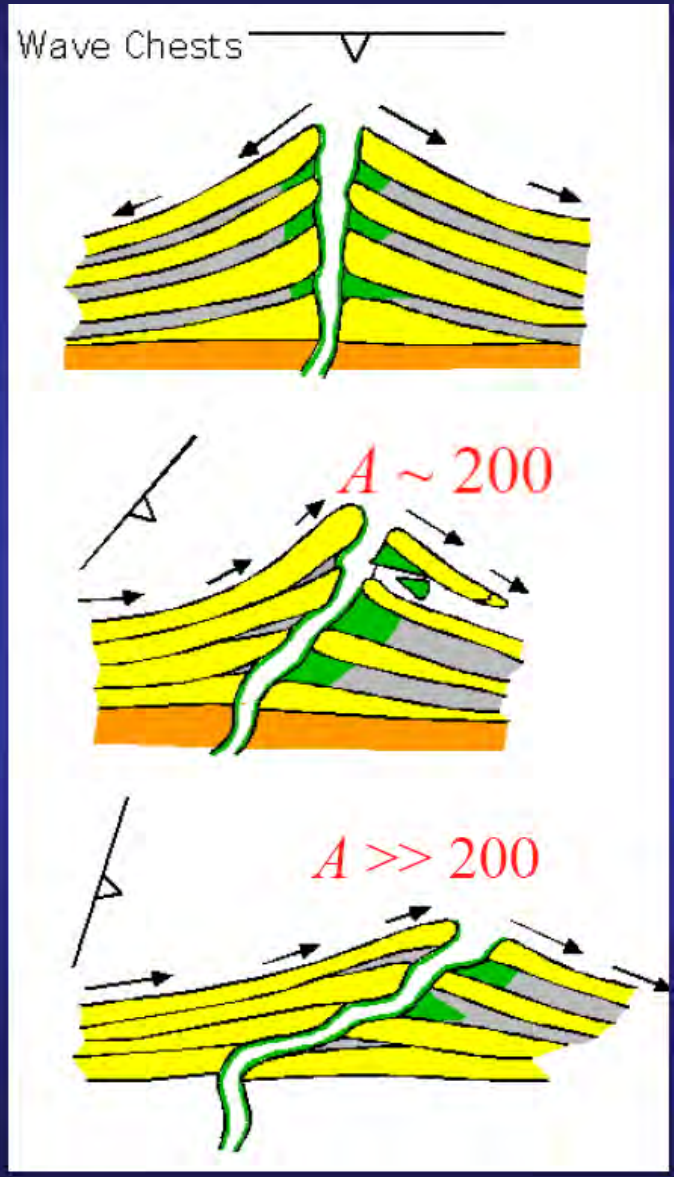
Wave-influenced deltas

- arcuate to cuspate;
- sediments derived directly from the feeding river;
- homogeneous sands.



Delta asymmetry: models



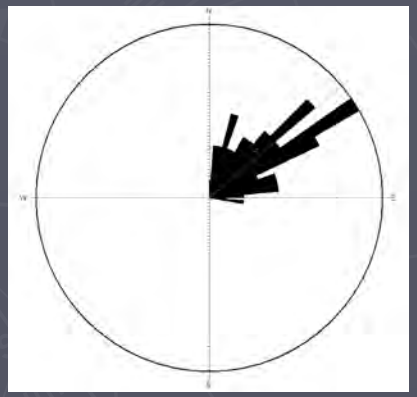


(Bhattacharya and Giosan, 2003)

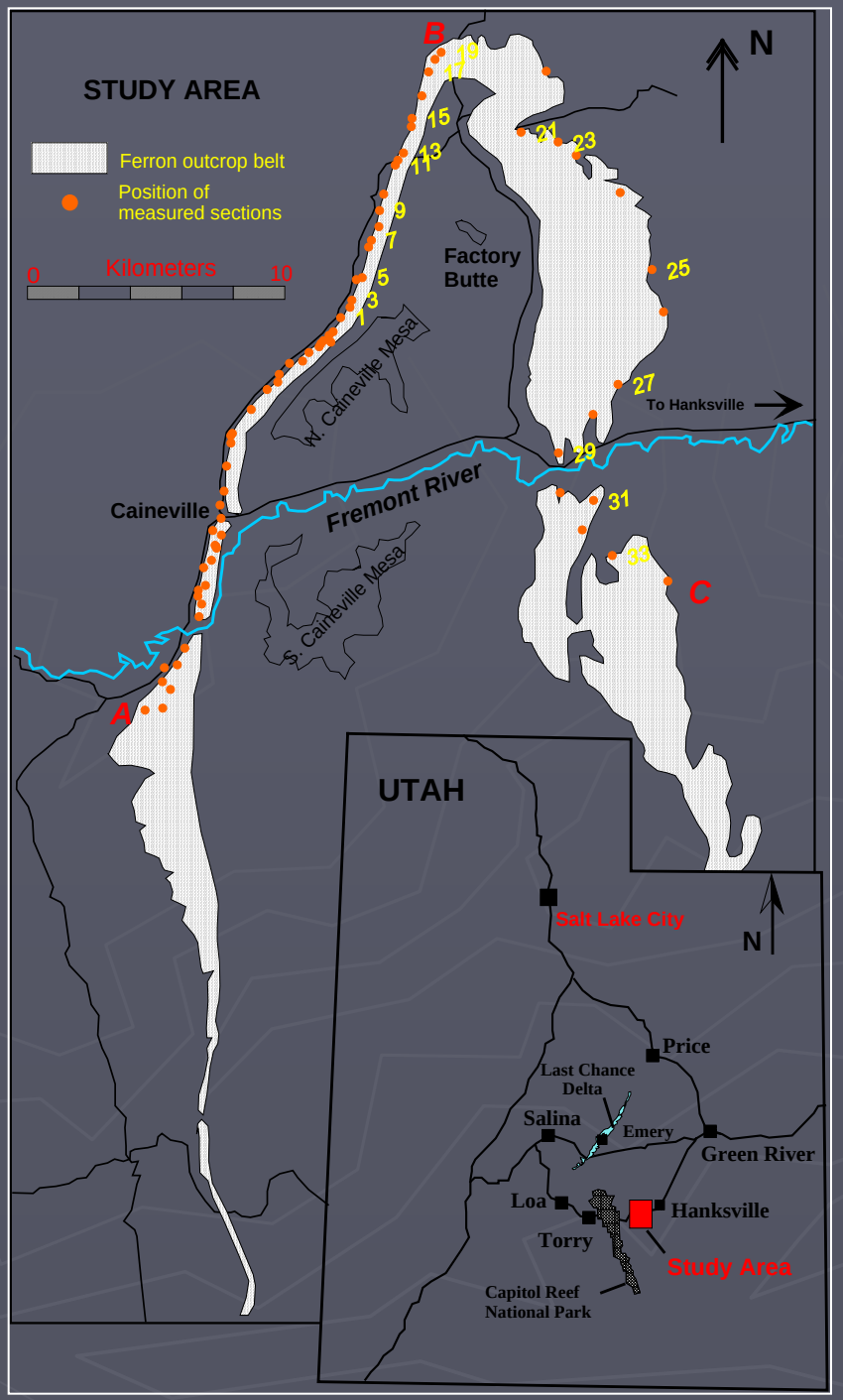
Study area and data set

- 73 sections total
- 34 to cover the studied parasequence

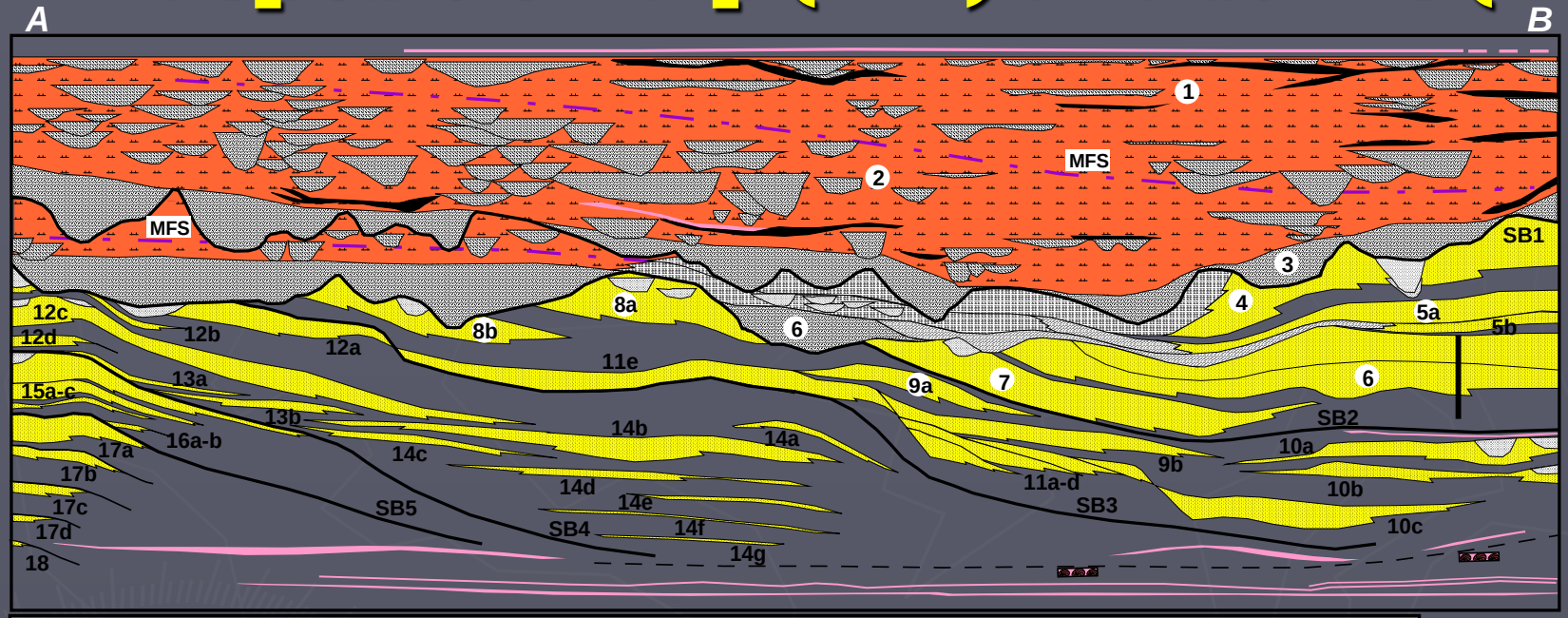
Regional paleocurrent



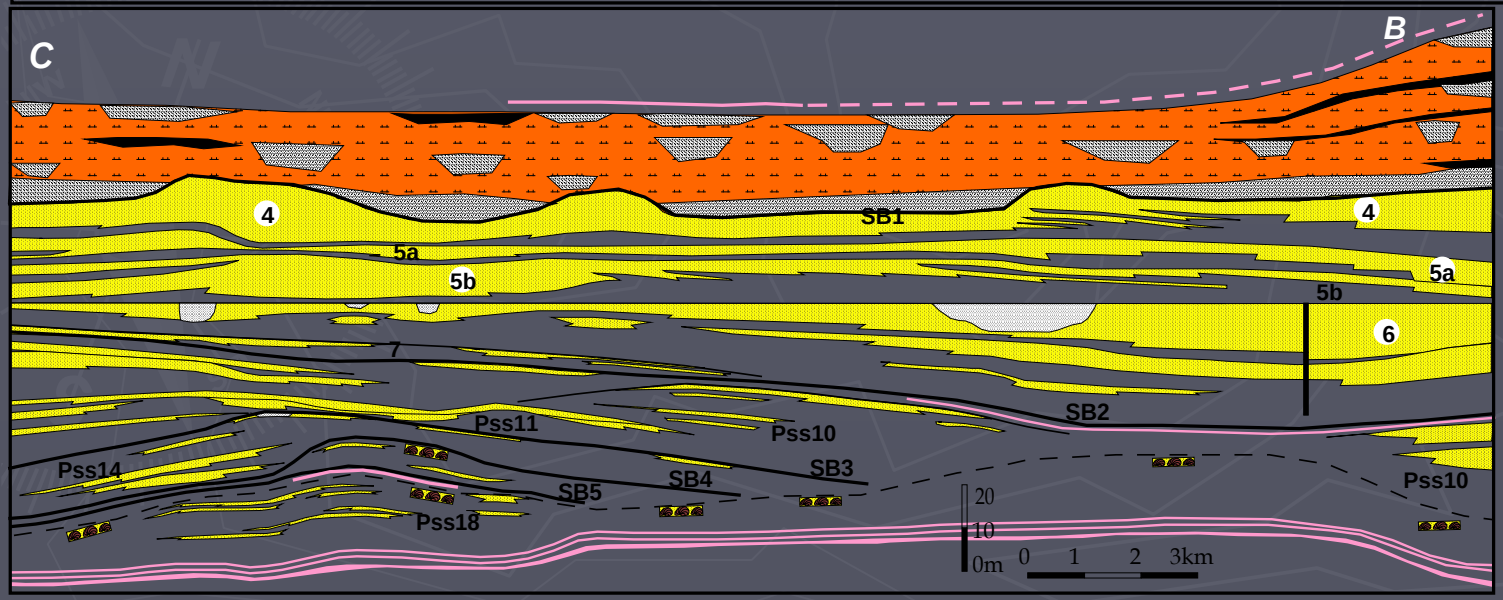
Measurements: N=123
mean: 50°

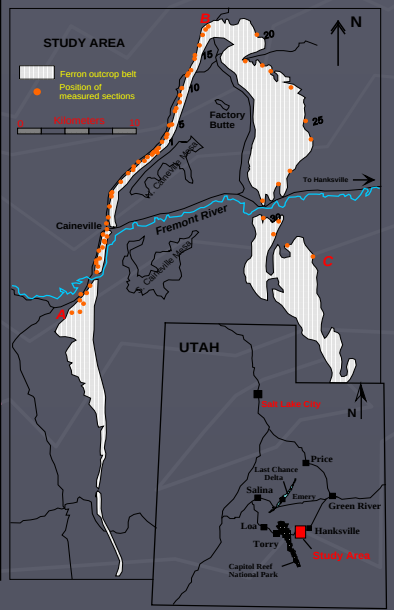


Sequence stratigraphy: deposition dip (A-B) and strike (B-C)

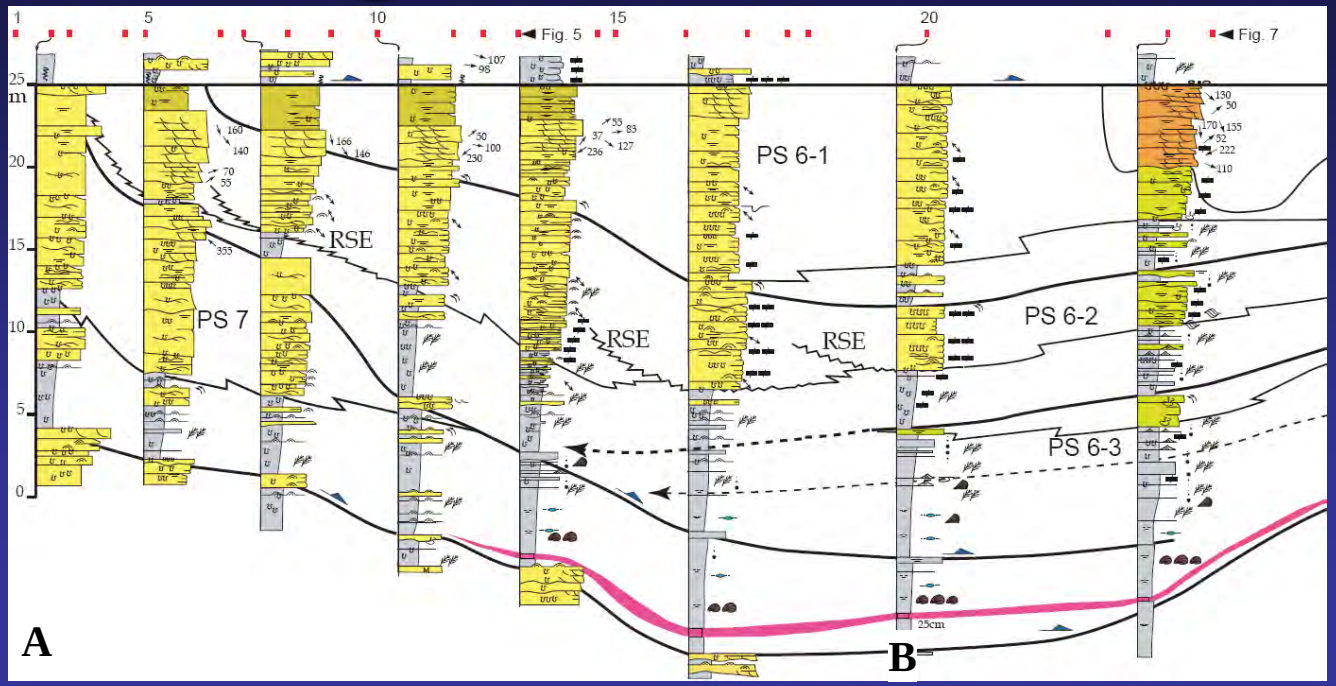


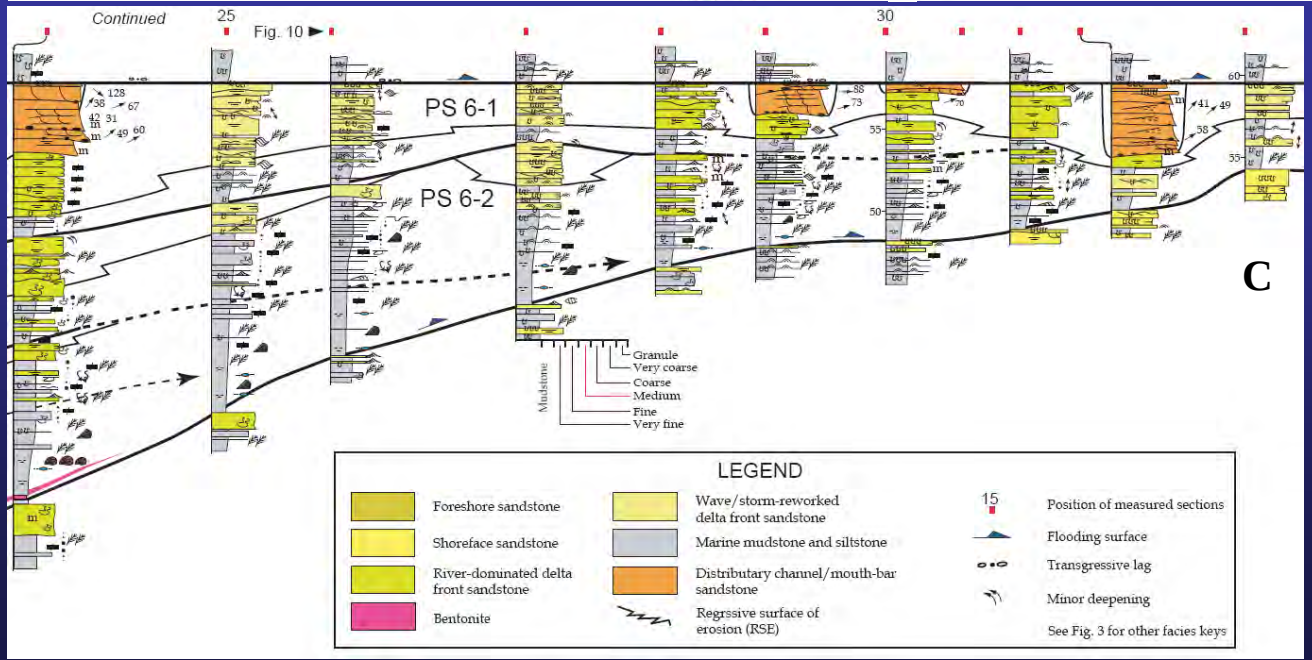
Regional paleocurrent





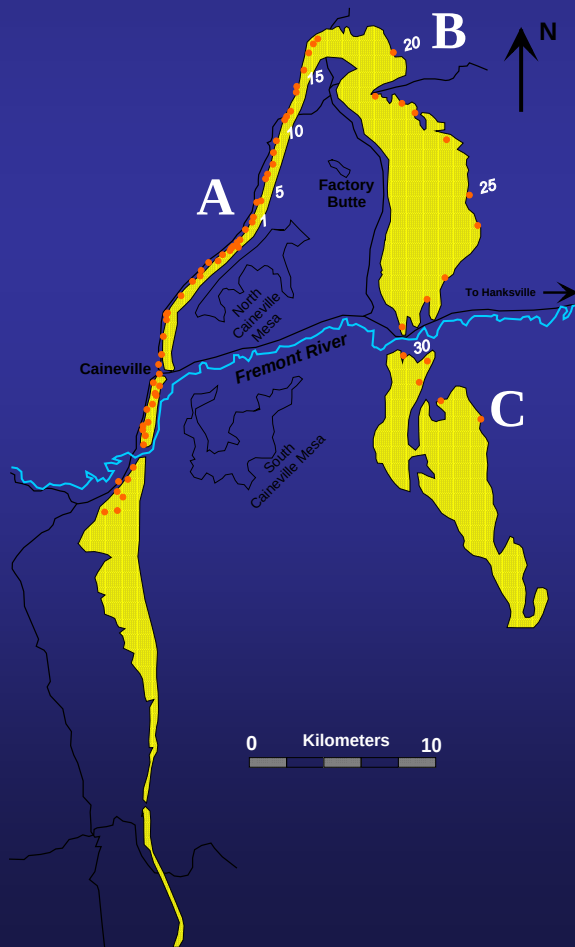
Along-strike facies transition: Ps 6





Four major facies types

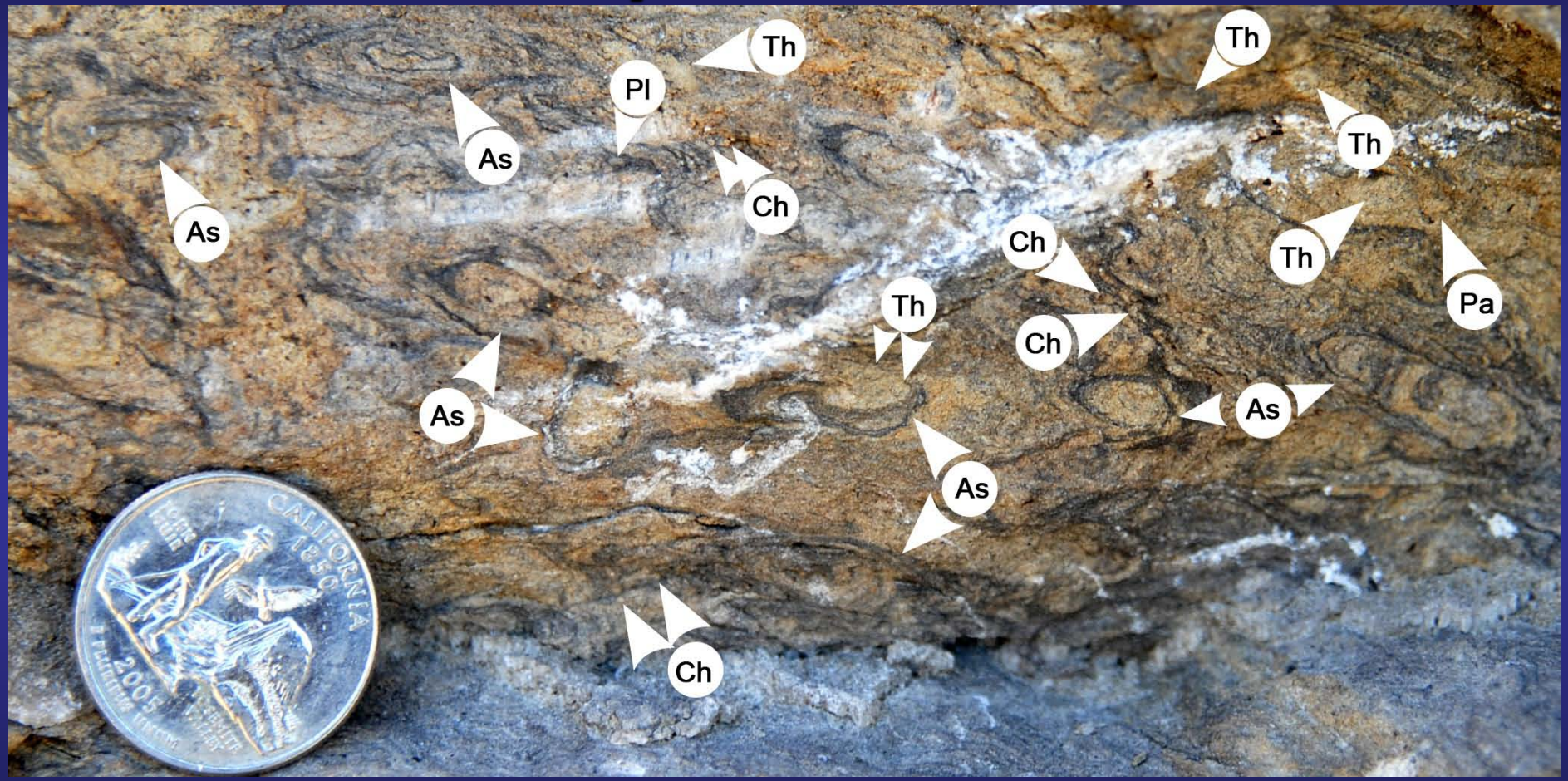
- FAC1: shoreface
- FAC2: active delta front
- FAC3: reworked delta front
- FAC4: channel/Mouth bar



Shoreface facies: upper shoreface (USF) /foreshore (FS)

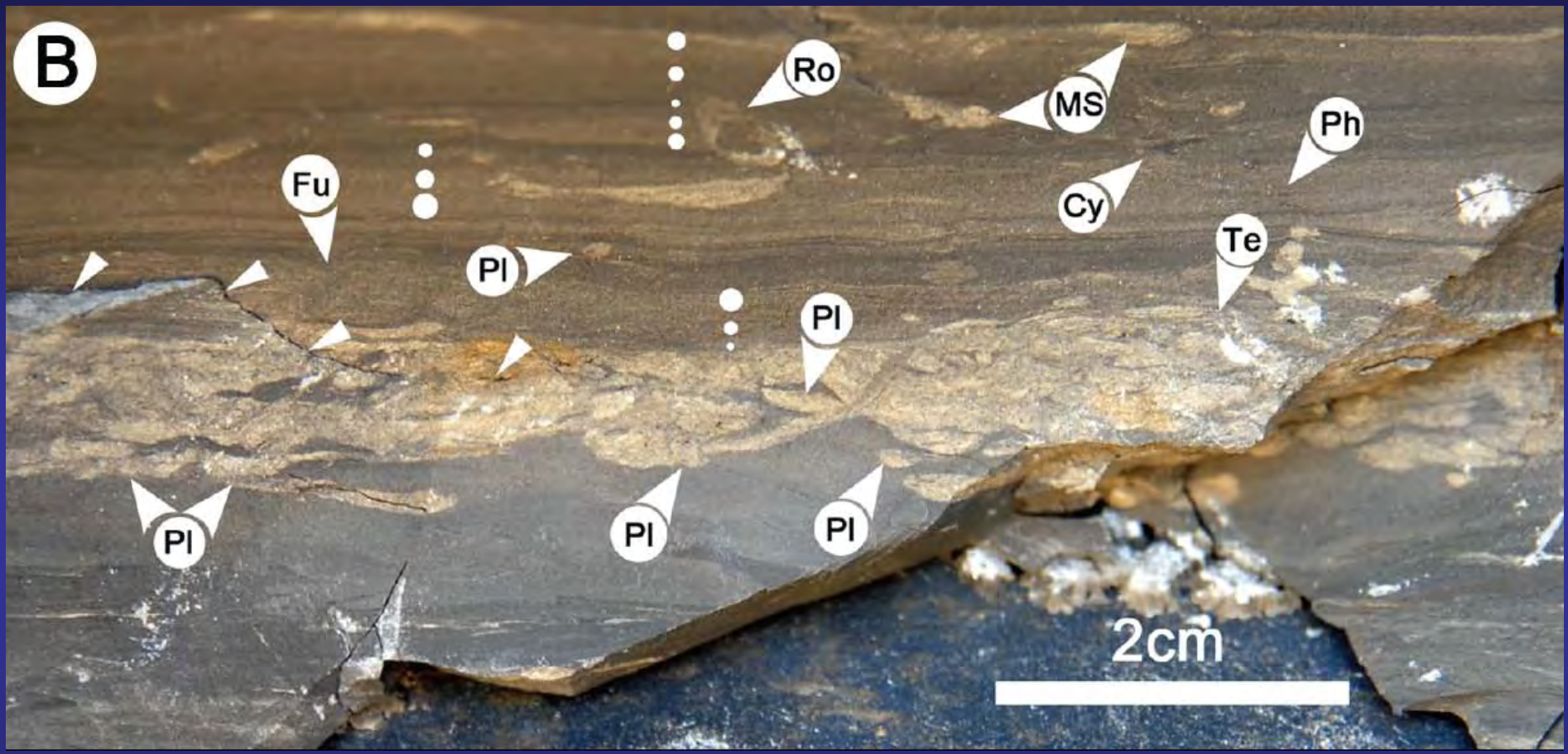
Typical storm wave-induced structures

Robust & healthy expression of the *Cruziana* ichnofacies in lower shoreface muddy sandstones



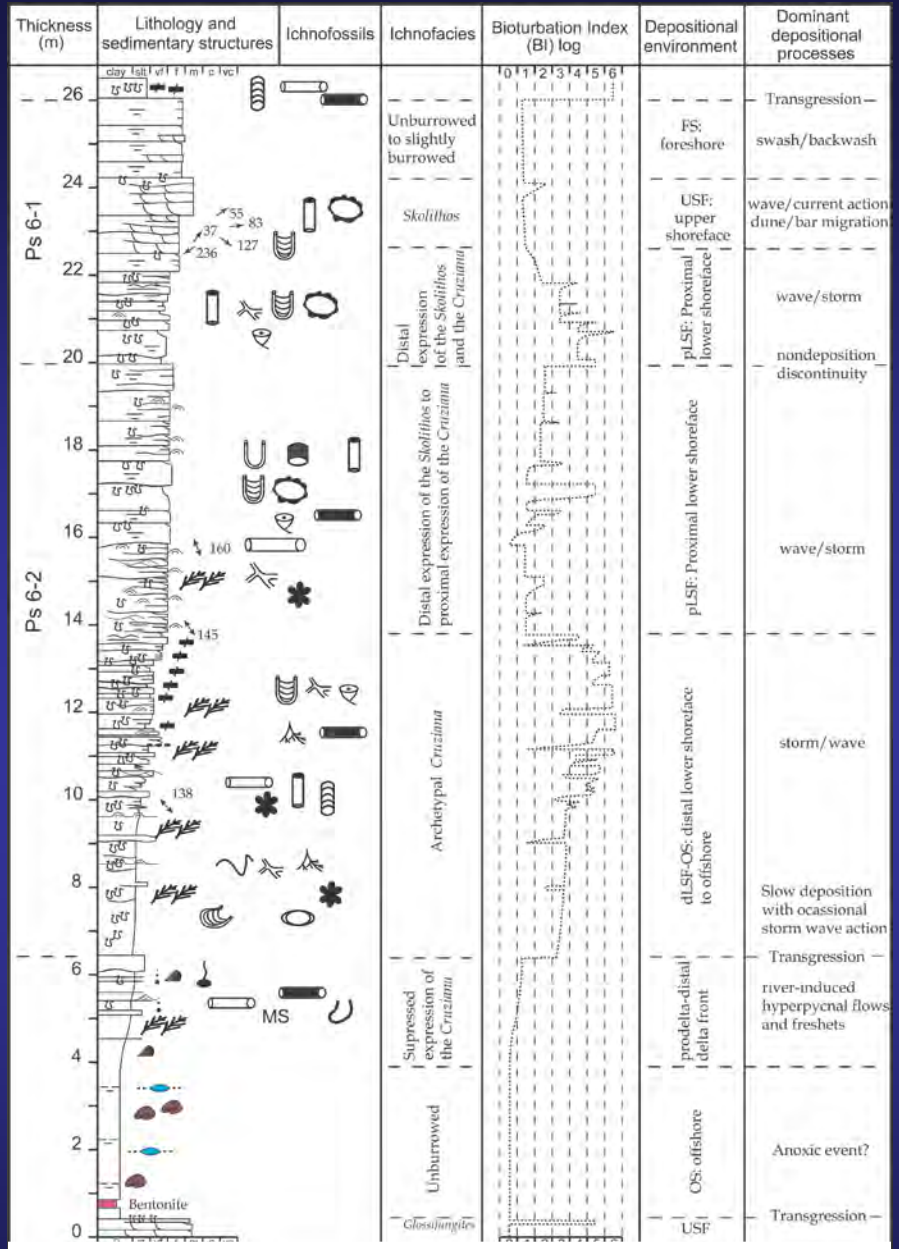
Asterosoma (As), *Thalassinoides* (Th), *Chondrites* (Ch), *Planolites* (Pl) and *Palaeophycus* (Pa)

River-dominated delta front



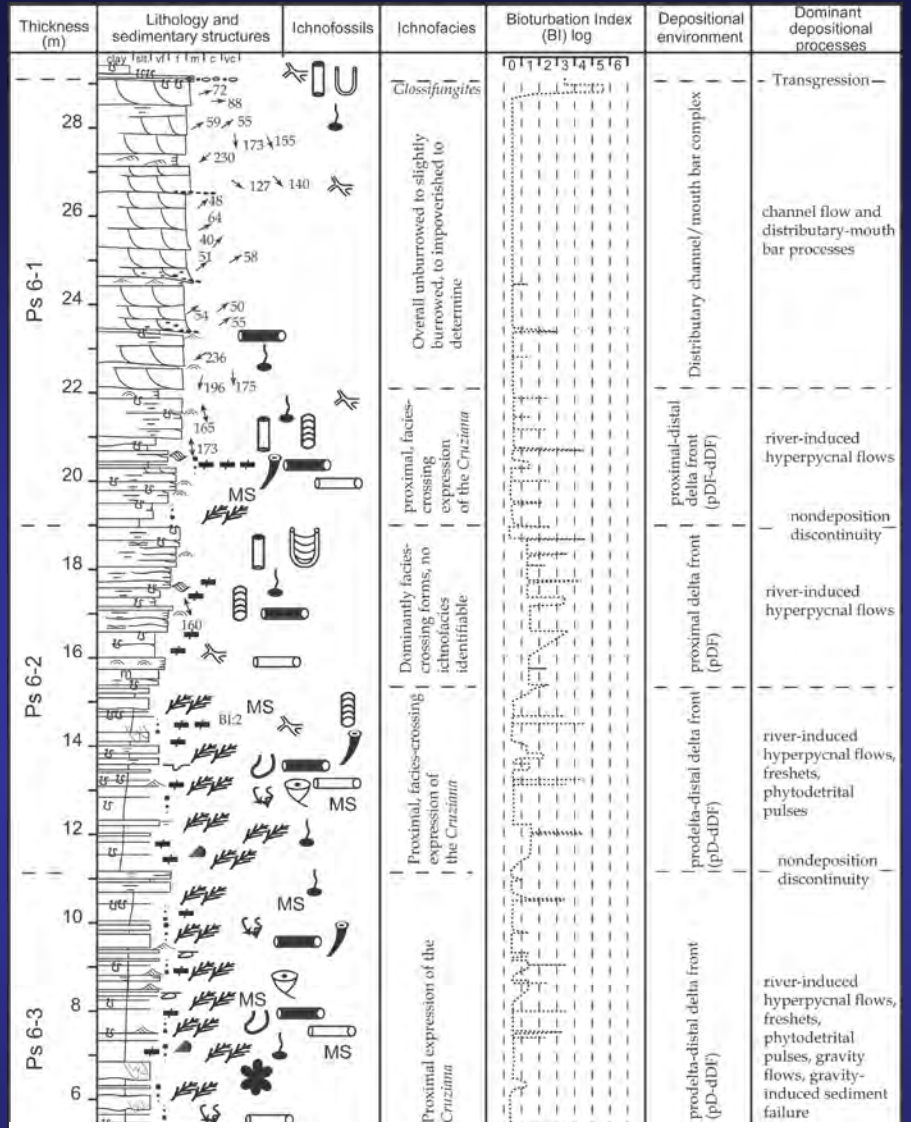
Planolites (Pl), Teichichnus (Te), Phycosiphon (Ph), fugichnia (Fu), Rosselia (Ro) and "mantle and swirl" structures (MS).

- Ichnogenera: low diversity and abundance;
- Overall low bioturbation, with high spikes;
- MS structures, sediment-swimming of organism in soupy substrata;
- Erosional truncation indicates emplacement of hyperpycnal flows.



Strongly wave-influenced Shoreface

- Typical storm wave-induced structures;
- Diverse, healthy, and robust ichnogenera.

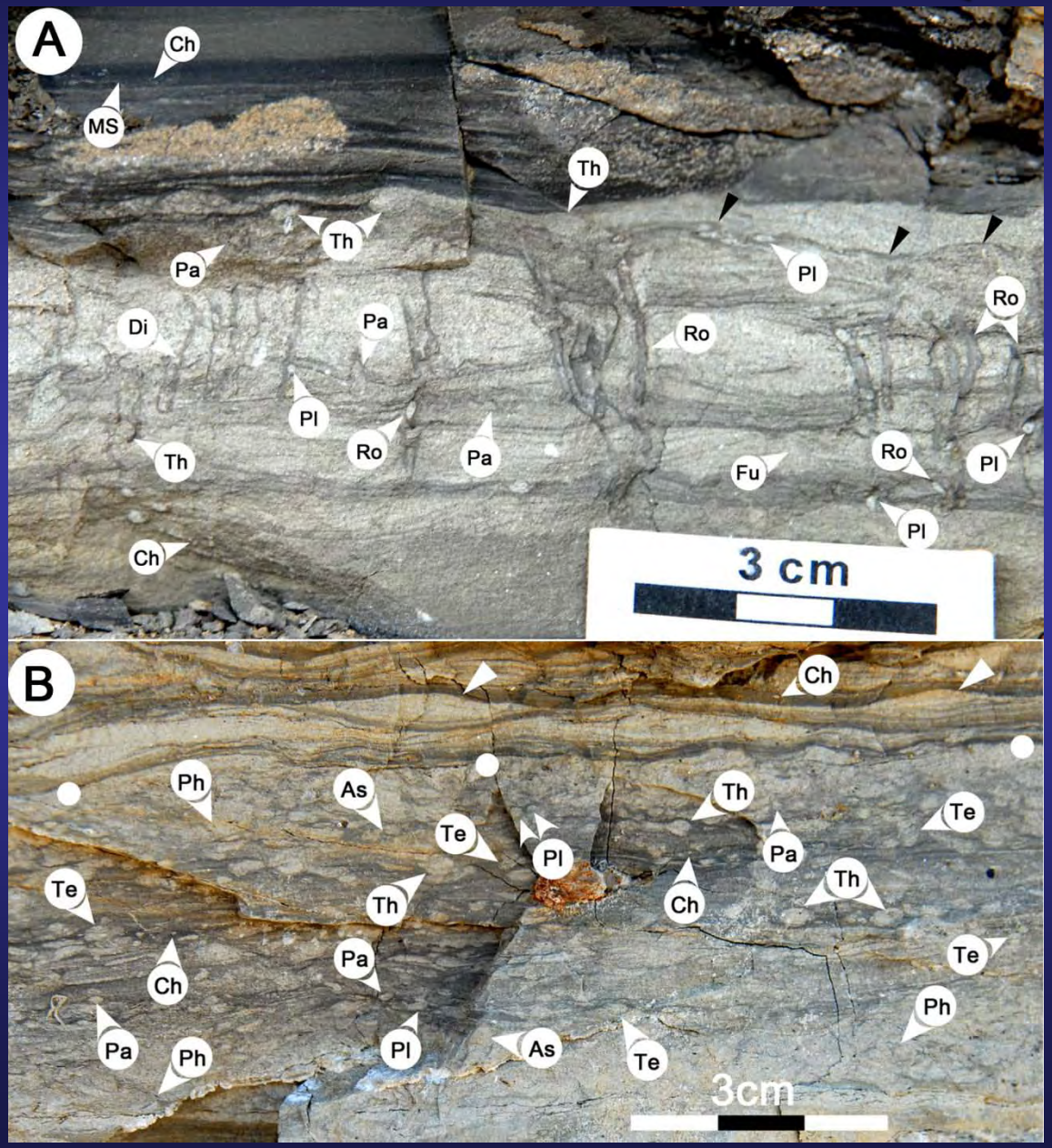


Strongly River-influenced delta front

- Muddier and heterolithic, typical unidirectional flow induced structures;
- Low diverse suppressed ichnogenera;
- Dominated by facies-crossing, morphological-simples ichnological structures

wave-rework delta front, planar/wavy bedding

Ichnogenera in wave-reworked distal delta front (dDF)



(A)

Thalassinoides **(Th),**

Diplocraterion **(Di),**

Planolites **(Pl),**

Chondrites (Ch) **,**

Palaeophycus **(Pa),**

Rosselia (Ro) **,**

Fugichnia (Fu)

"mantle and swirl" structures (MS).

a low-diversity, proximal expression of the *Cruziana* ichnofacies

(B)

Planolites **(Pl),**

Palaeophycus **(Pa),**

Thalassinoides **(Th),**

Teichichnus **(Te),**

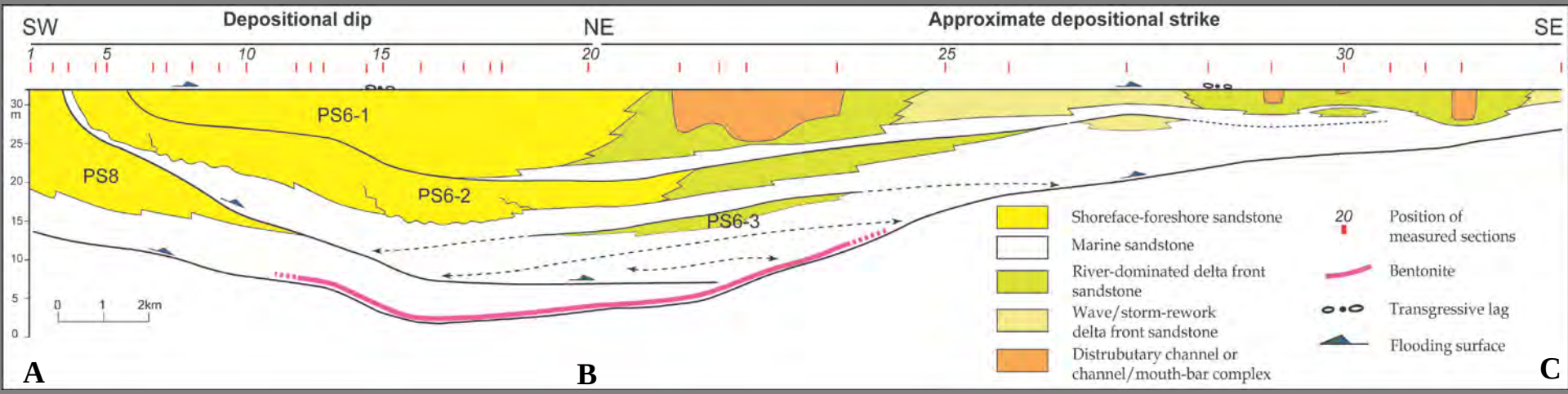
Rosselia (Ro) **,**

Phycosiphon **(Ph),**

Chondrites **(Ch)**

a more healthy expression of the *Cruziana* ichnofacies

Along-strike facies transition



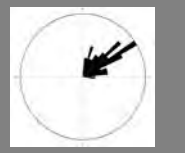
Four major facies types

FAC1: shoreface

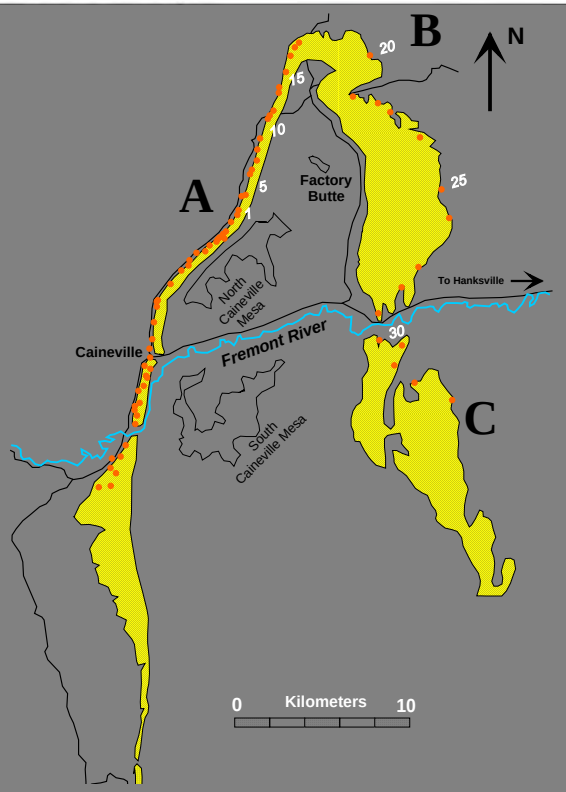
FAC2: active delta front

FAC3: wave-reworked delta front

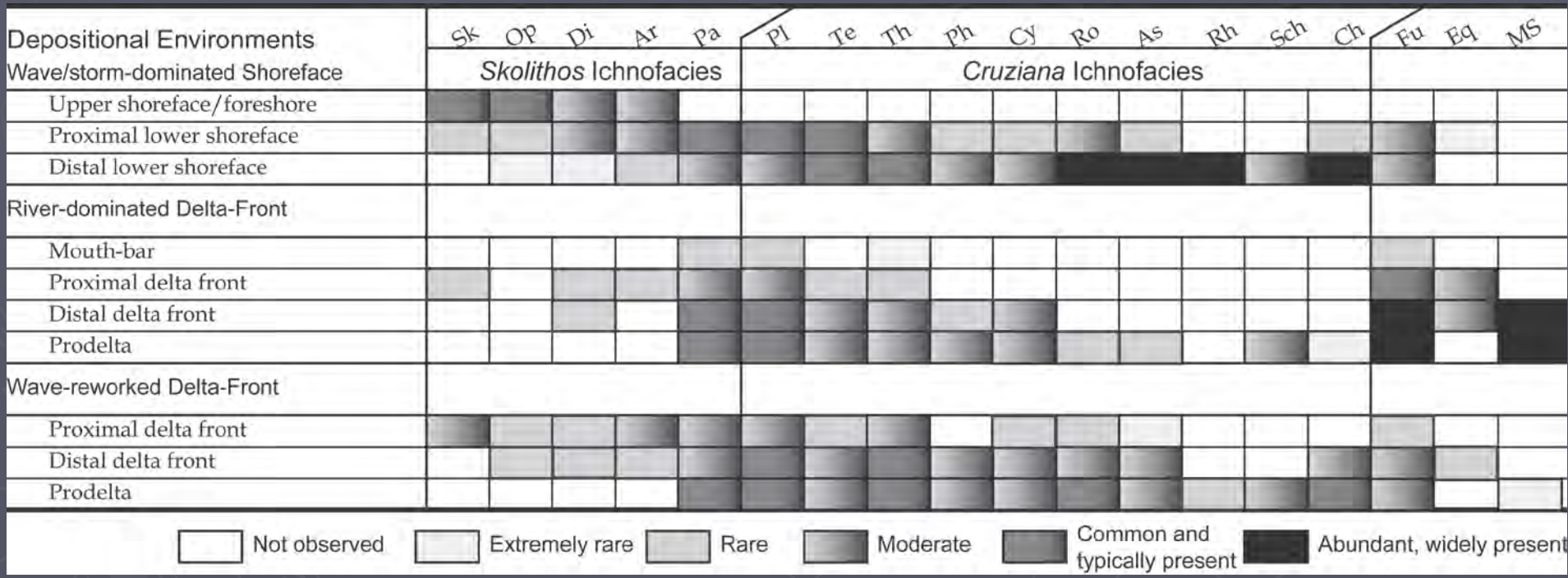
FAC4: distributary/mouth bars



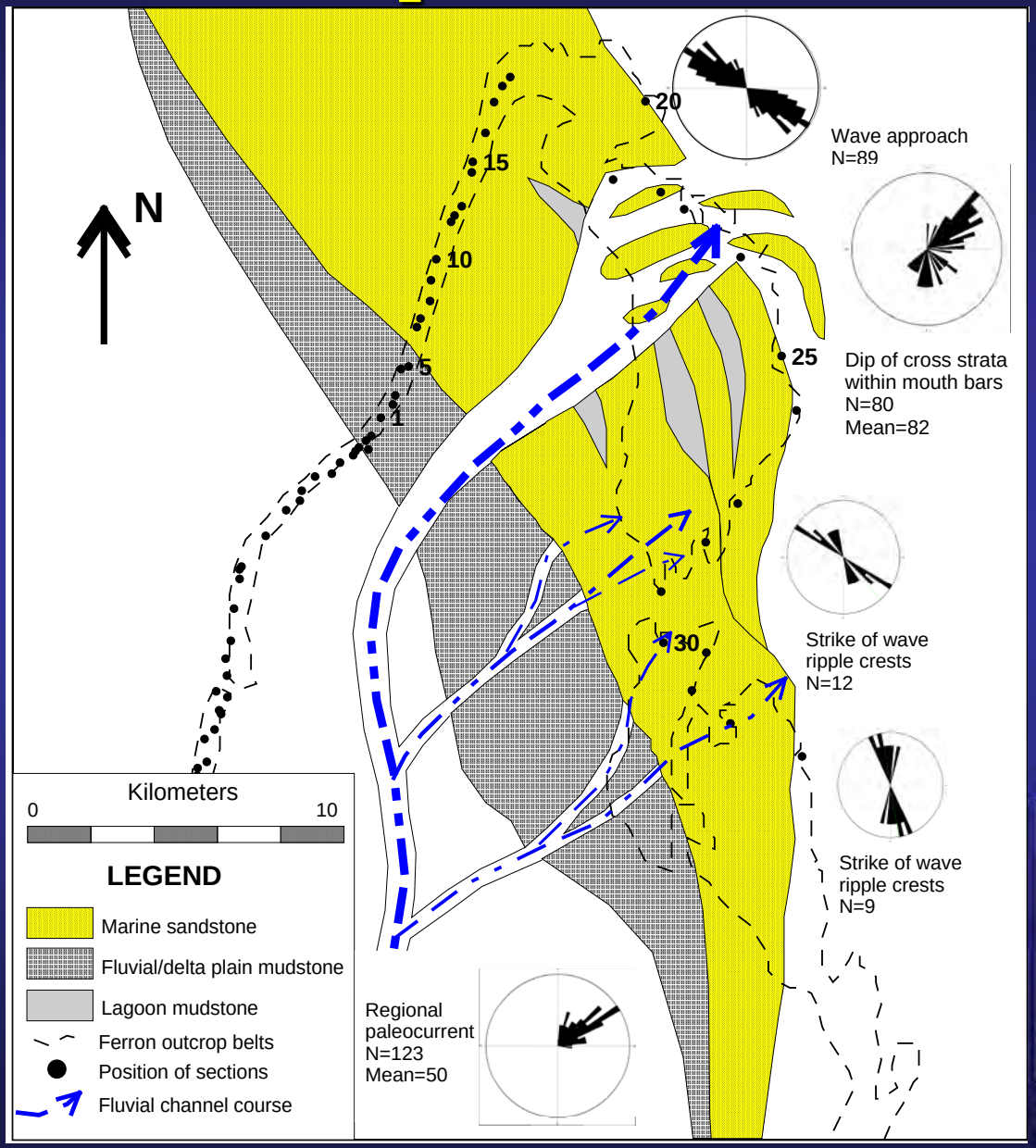
Regional paleocurrent

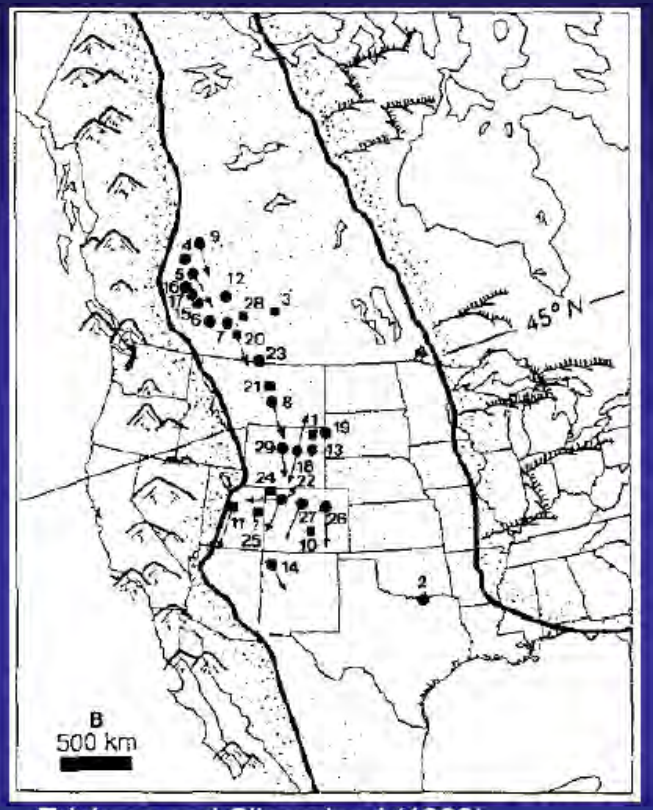


Ichnological response to different physico-chemical processes



Paleogeographic reconstruction and comparison with modern examples

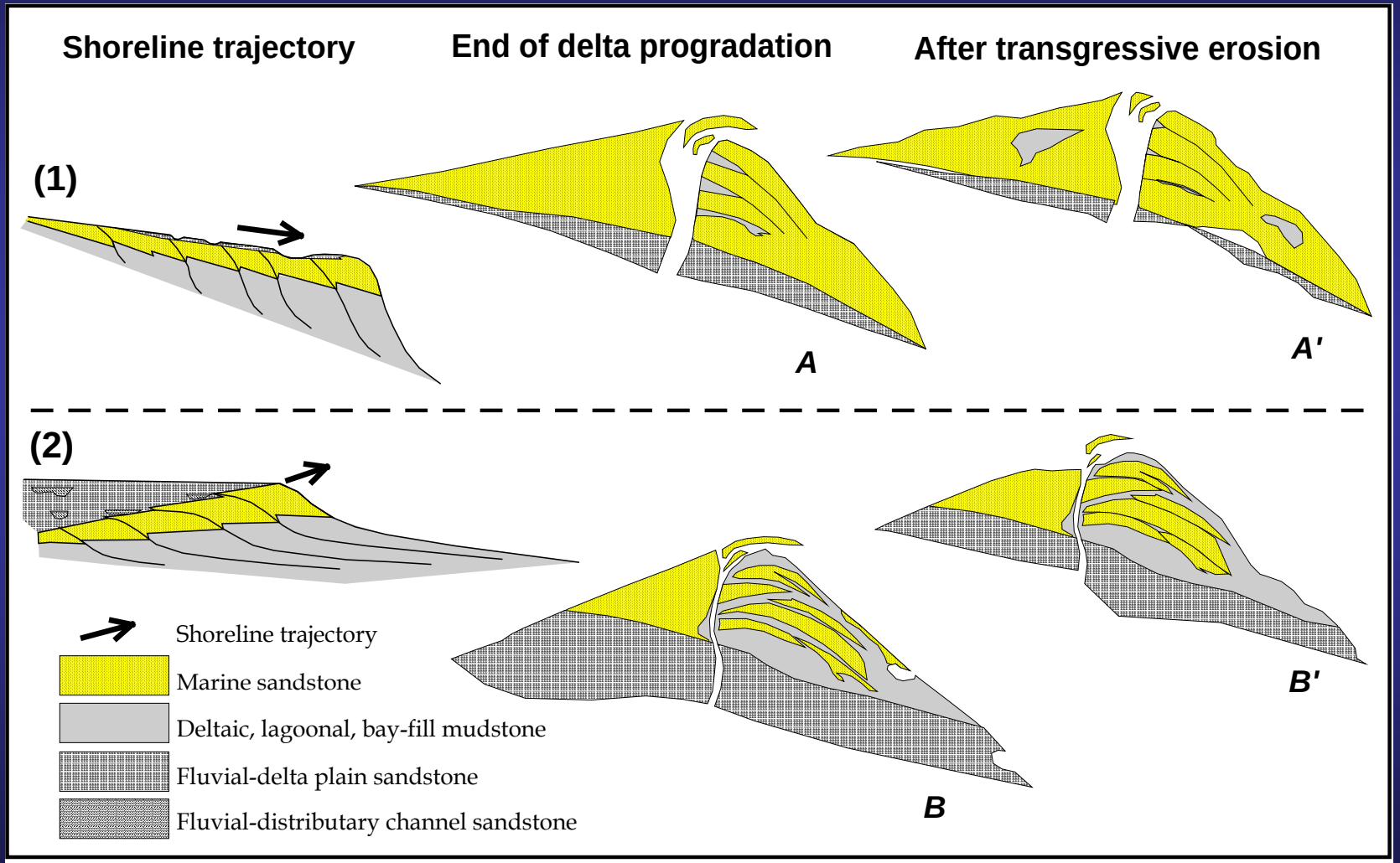




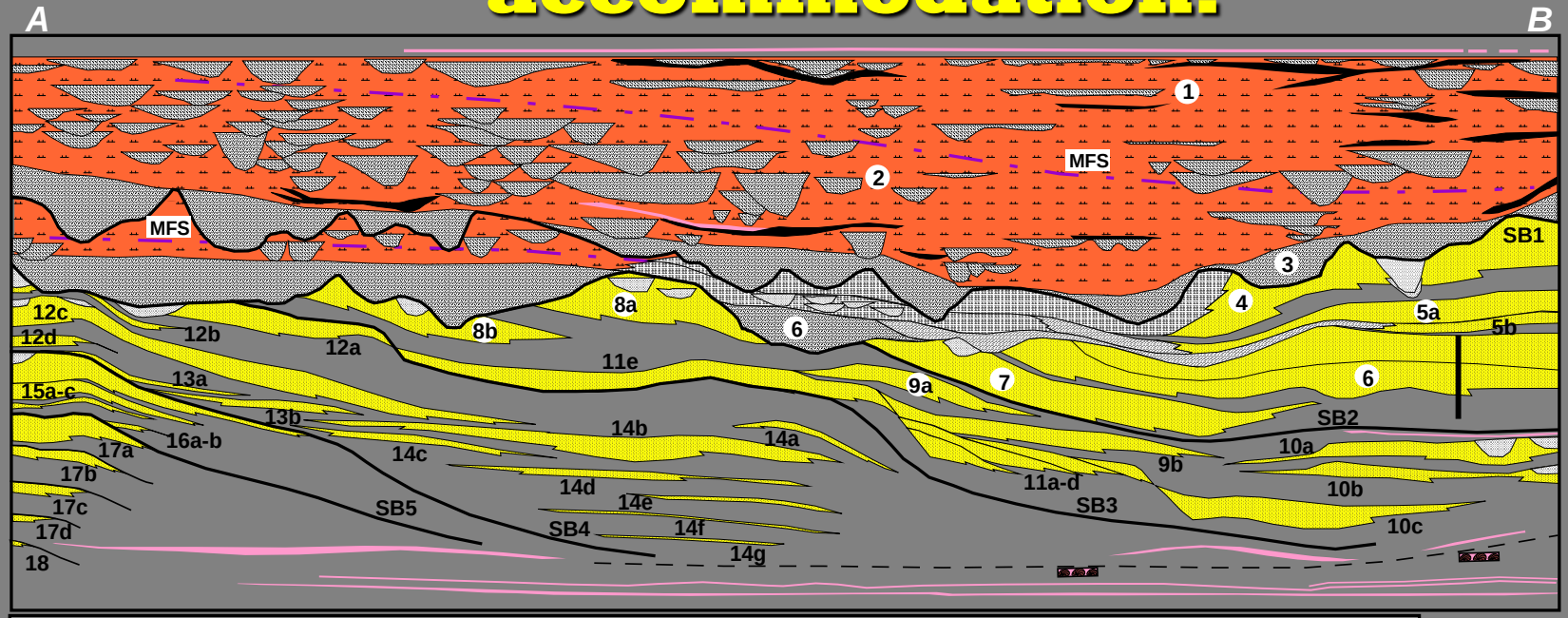
Ericksen and Slingerland (1990)

Sf. Gheorghe lobe, Danube delta, (Bhattacharya and Giosan, 2003)

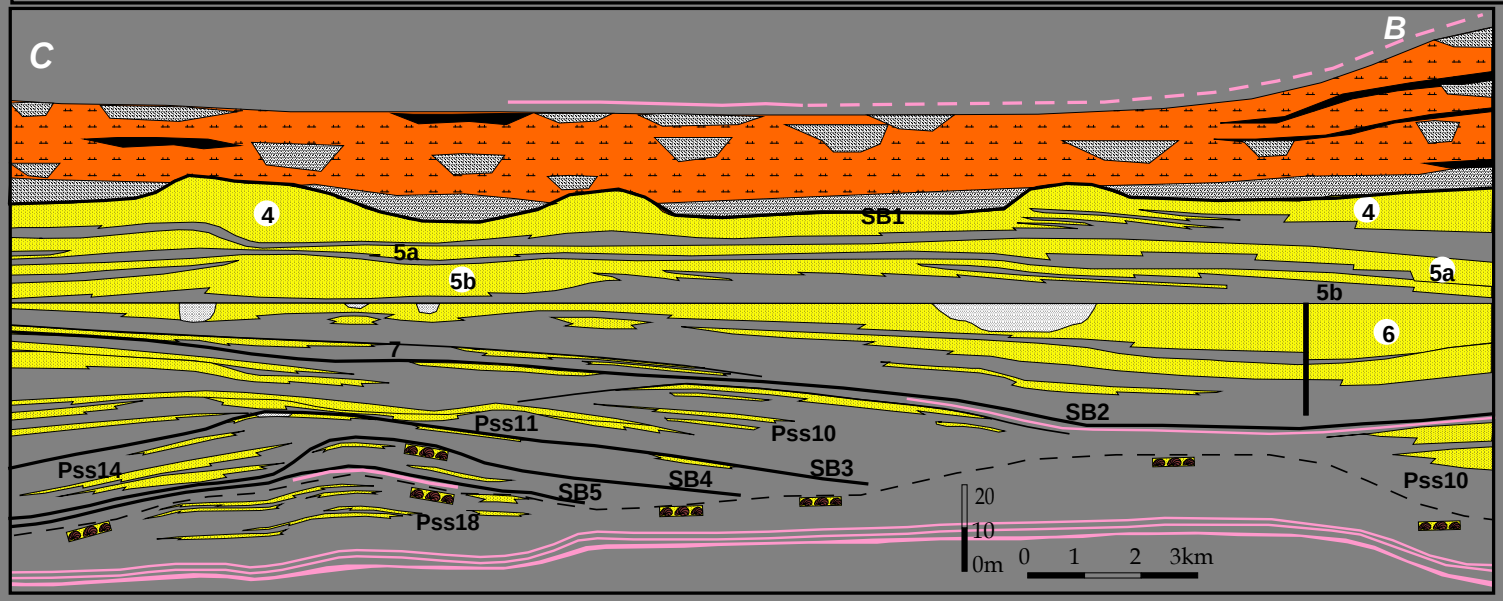
Facies of asymmetric deltas as a function of shoreline trajectory

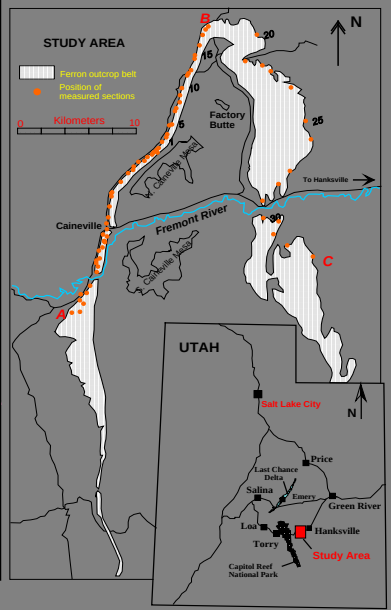


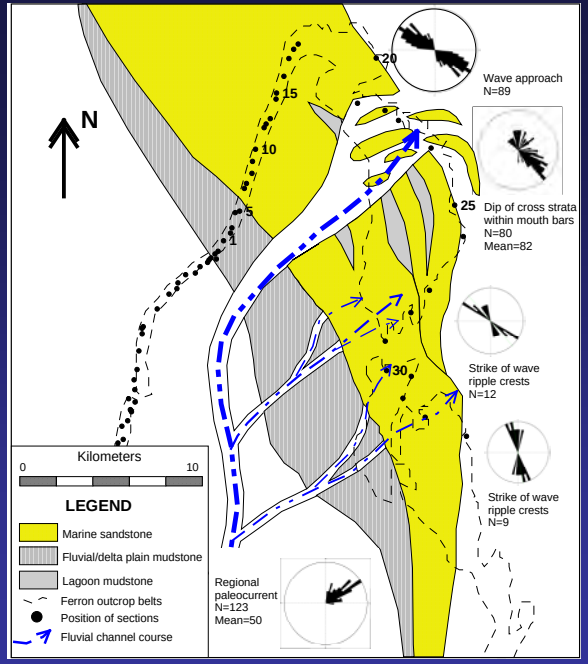
Progradation of PS6 under minimal accommodation!



Regional paleocurrent





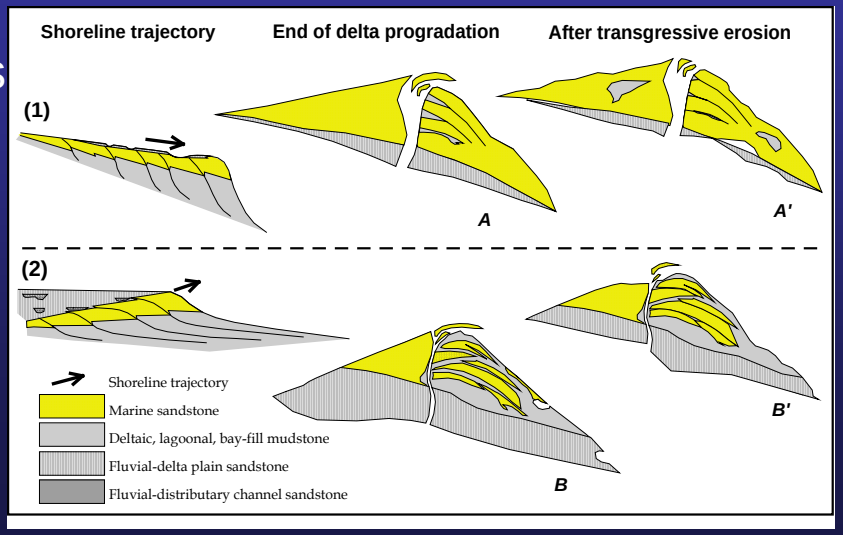


Conclusions

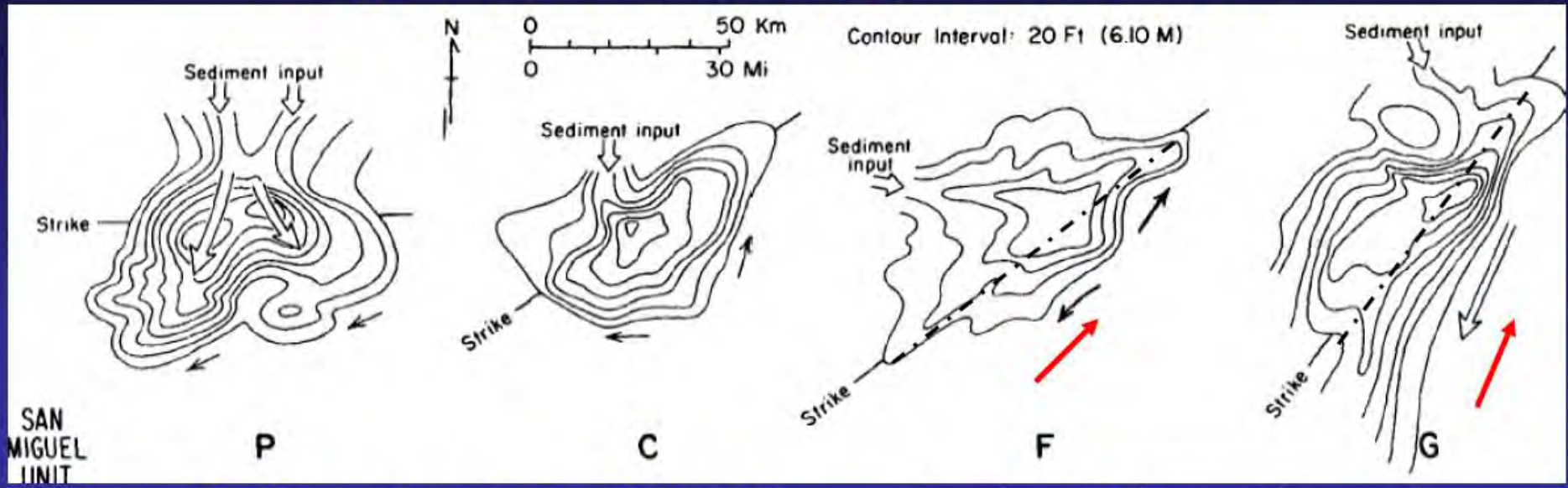
1. The studied parasequence 6 (PS6) shows delta asymmetry. The asymmetric delta is fed both by the trunk river flowing NE and by longshore transport from the NNW to the SSE.

2. Ichnogenera shows distinct along-strike changes in response to physico-chemical process in the asymmetric delta, and ichnological analysis is effective to identify river influences.

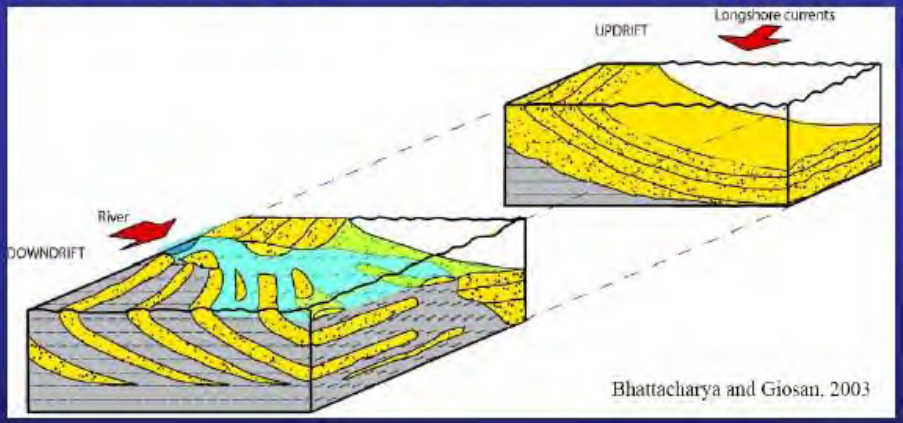
3. Using the asymmetric delta models in the ancient record should incorporate regional stratigraphy and paleoshoreline activity, both of which could control the overall deltaic facies.



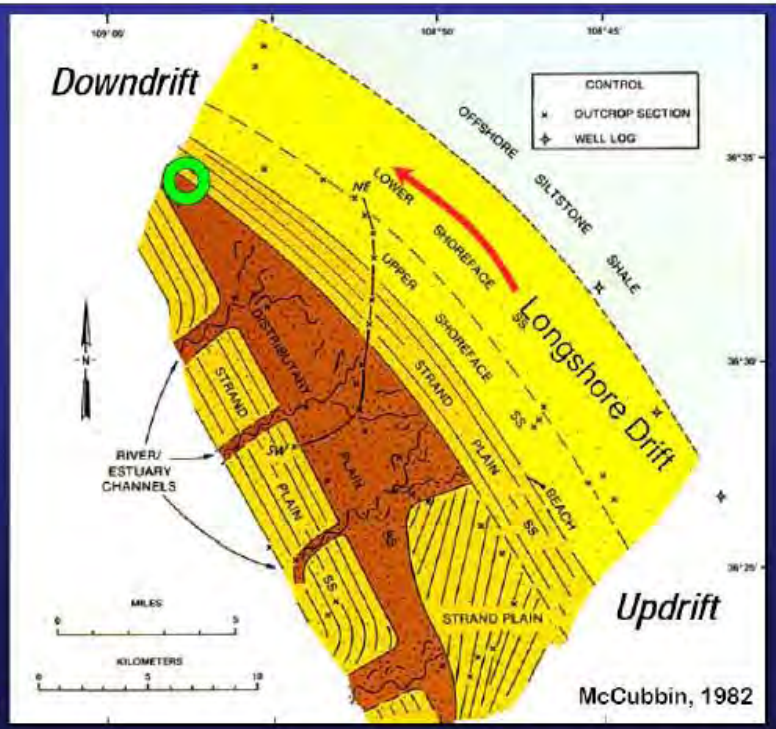
Exploration significance



(Upper Cretaceous, Miguel Formation, Maverick Basin, South TX, Weise, 1980)



- Clean sands updrift
  - Potentially sharp-based shoreface deposits.
- Heterolithic facies downdrift
  - May include river and wave successions



Gallup Sandstone, NM

Thanks for your support and attention

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Jul. 23, 2007, Hanksville, UT

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Comments & Questions are welcomed!

Jun. 17, 2007, Hanksville, UT

Jun. 10, 2008,ANP, UT