Tidally-Influenced Sedimentation on a High-Latitude Cretaceous Coastal Plain: The Prince Creek Formation, North Slope, Alaska*

Peter P. Flaig[1], Paul J. McCarthy[2], and Anthony R. Fiorillo[3]

Search and Discovery Article #50365 (2010)
Posted December 17, 2010

*Adapted from oral presentation at AAPG International Conference and Exhibition, Calgary, Alberta, Canada, September 12-15, 2010

[1]Jackson School of Geosciences, Bureau of Economic Geology, University of Texas at Austin, Austin, TX (peter.flaig@beg.utexas.edu)
[2]Dept. of Geology and Geophysics, and Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK
[3]Museum of Nature and Science, Dallas, TX

Abstract

The late Cretaceous (Early Maastrichtian) Prince Creek Formation on Alaska's North Slope records deposition on a high-latitude coastal plain within tidally-influenced first-order meandering trunk channels, second-order meandering distributary channels, third-order fixed (anastomosed?) distributary channels and vegetated floodplains. Regionally restricted suspended-load meandering trunk channels (13-17 m thick) include a basal conglomerate, a medium-grained multi-storey sandbody lacking roots that fines-upward into inclined heterolithic stratification (IHS) and 3-4 m of finer organic-rich sediments. Meandering distributaries (2-6 m thick) composed of a singlestorey, fine-grained, rooted sandbody dominated by IHS and including abundant mud-filled channel plugs occur as laterally-extensive heterolithic sheets encased in organic-rich floodplain facies that appear lenticular along strike. Fixed (anastomosed?) distributary channels are composed of a fine-grained, single-storey, current rippled and rooted sandbody atop an arcuate erosive base with rare IHS and siltstone "wings" that extend laterally from the uppermost channelfill. Numerous fixed (anastomosed?) channels occupy tiers at the same stratigraphic level, with fixed channels incised into meandering distributaries or floodplain facies.

All channels are interbedded with drab-colored, organic-rich floodplain facies interpreted as the deposits of levees, splays, lakes, ponds, swamps, marshes, mires, paleosols, and ashfall. Spatial relationships between channel types, and between channels and floodplains indicate that most deposition took place adjacent to trunk channels on crevasse splay-complexes separated by organic-rich

Copyright © AAPG. Serial rights given by author. For all other rights contact author directly.

floodplain facies. The lateral migration of meandering distributaries driven by peat compaction and higher flow velocities and the vertical filling of fixed (anastomosed?) distributaries may have been contemporaneous. Alternatively fixed (anastomosed?) distributaries may record the initial or waning stages of flow during splay-complex formation or abandonment. IHS composed of rhythmically-repeating, coarse-to-fine couplets of current rippled sandstone/siltstone and mudstone is found within all channel-forms. The rhythmic and repetitive nature of IHS couplets together with relatively thick, muddy fine-grained members in the IHS suggest that flow within channels was likely influenced by tidal effects. Locally abundant jarosite lends credence to an interpretation of marine-influenced sedimentation.

References

Bird, K.J., 1987, North Slope oil and gas; the Barrow Arch paradox: SEPM Field Trip Guidebook, Pacific Section, v. 50, p. 41.

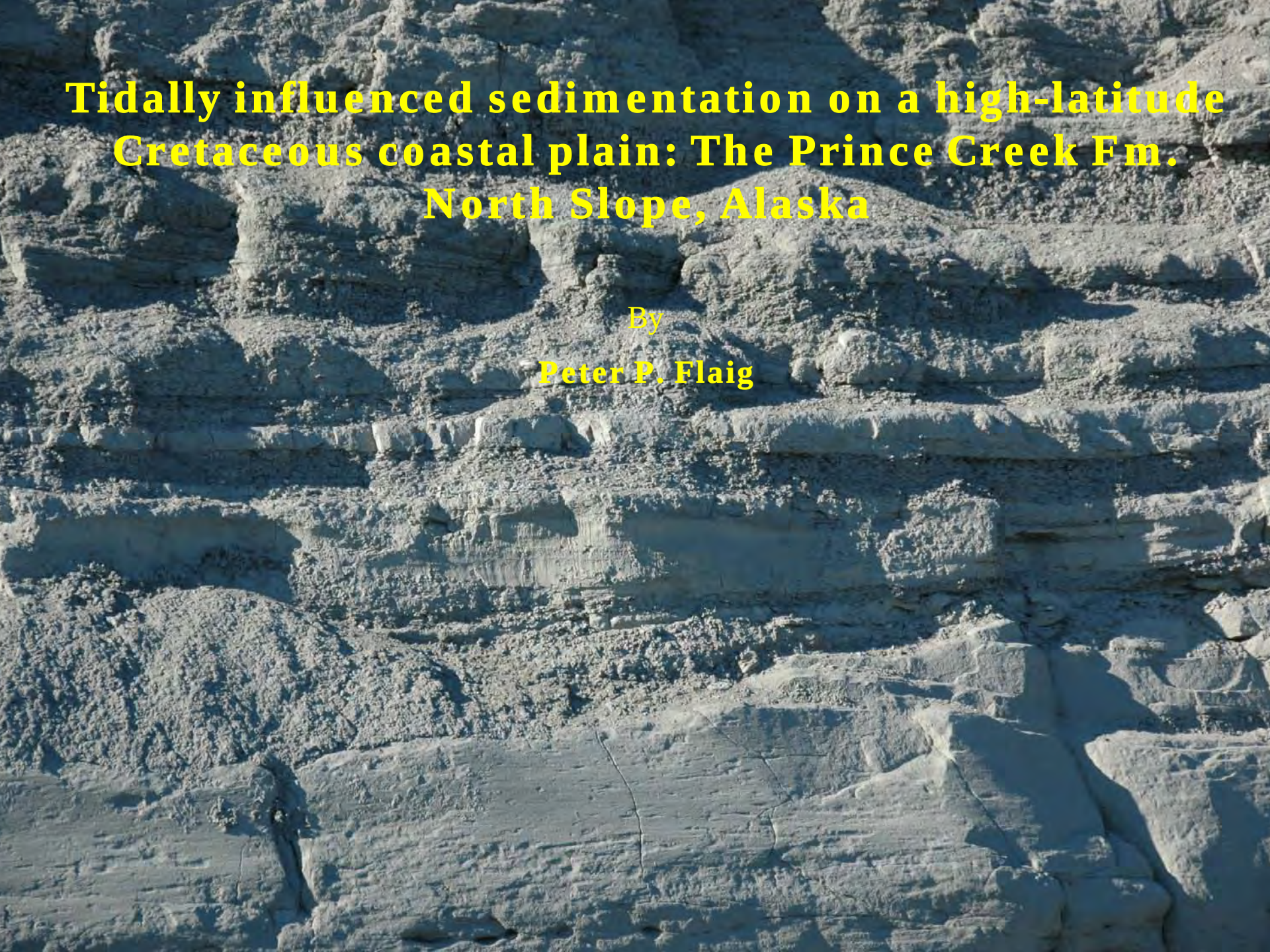
Bird, K.J. and C.M. Molenaar, 1992, The North Slope foreland basin, Alaska: AAPG Memoir, v. 55, p. 363-393.

Decker, D., J.E. Box, and R. Benson, 2009, Greenland ice sheet tidewater glacier front changes; seasonal and interannual changes 2000-2008: Association of American Geographers, Annual Meeting Abstracts, p. 149.

Fiorillo, A.R. and R. Gangloff, 2000, Theropod teeth from Prince Creek Formation (Cretaceous) of Northern Alaska, with speculations on Arctic dinosaur paleoecology: Arctic Science Conference, Program and Abstracts, v. 51, p. 87.

Garrity, C.P., D.W. Houseknecht, K.J. Bird, C.J. Potter, T.E. Moore, P.H. Nelson, and C.J. Schenk, 2005, USUS 2005 oil and gas resource assessment of the central North Slope, Alaska; play maps and results: USGS Open File Report #2005-1182,

Mull, C.G., D.W. Houseknecht, and K.J. Bird, 2003, Revised Cretaceous and Tertiary stratigraphic nomenclature in the Colville Basin, northern Alaska: USGS Professional Paper 1673, version 1.0. http://pubs.usgs.gov/pp/p1673/index.html

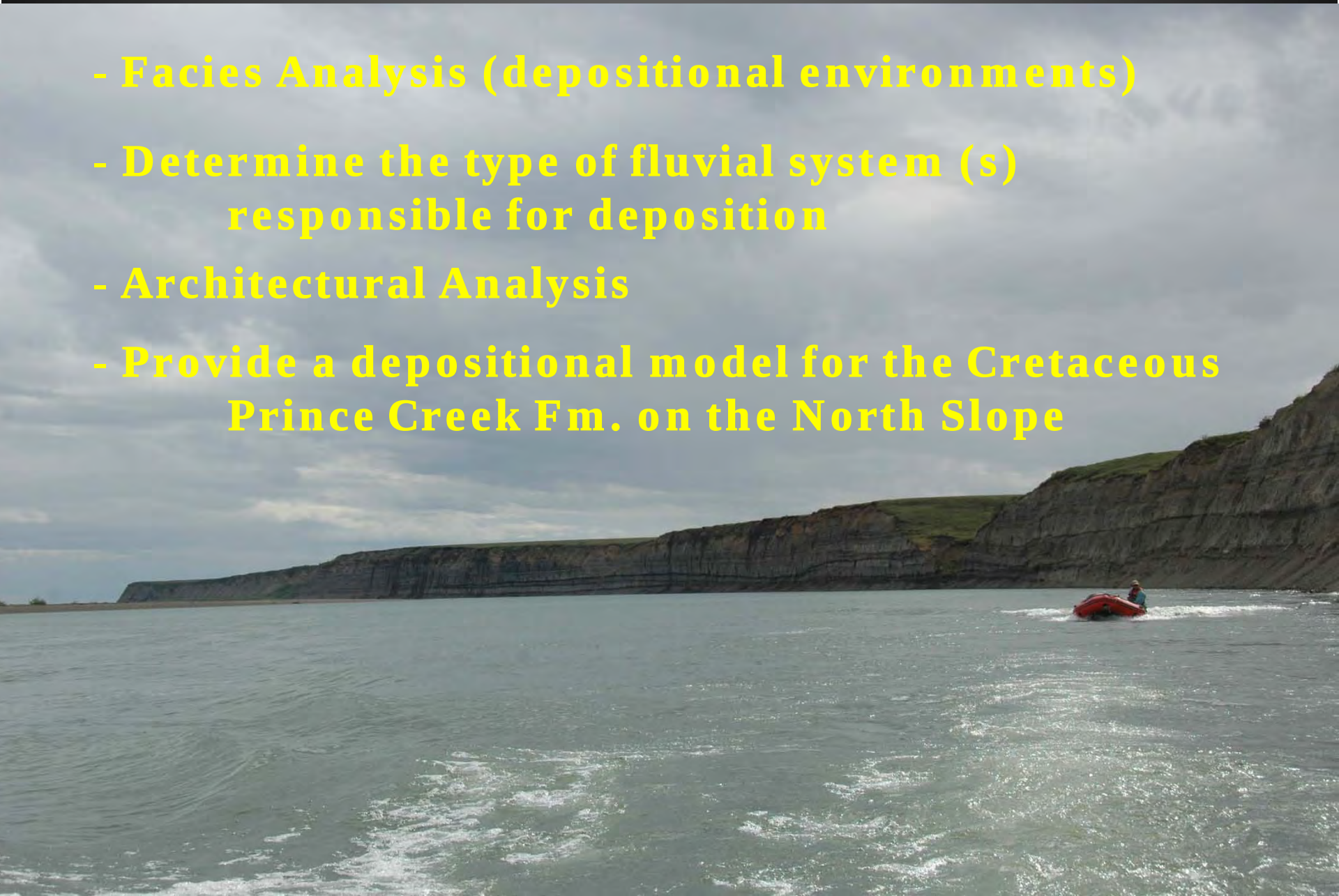


Tidally influenced sedimentation on a high-latitude Cretaceous coastal plain: The Prince Creek Fm. North Slope, Alaska

By

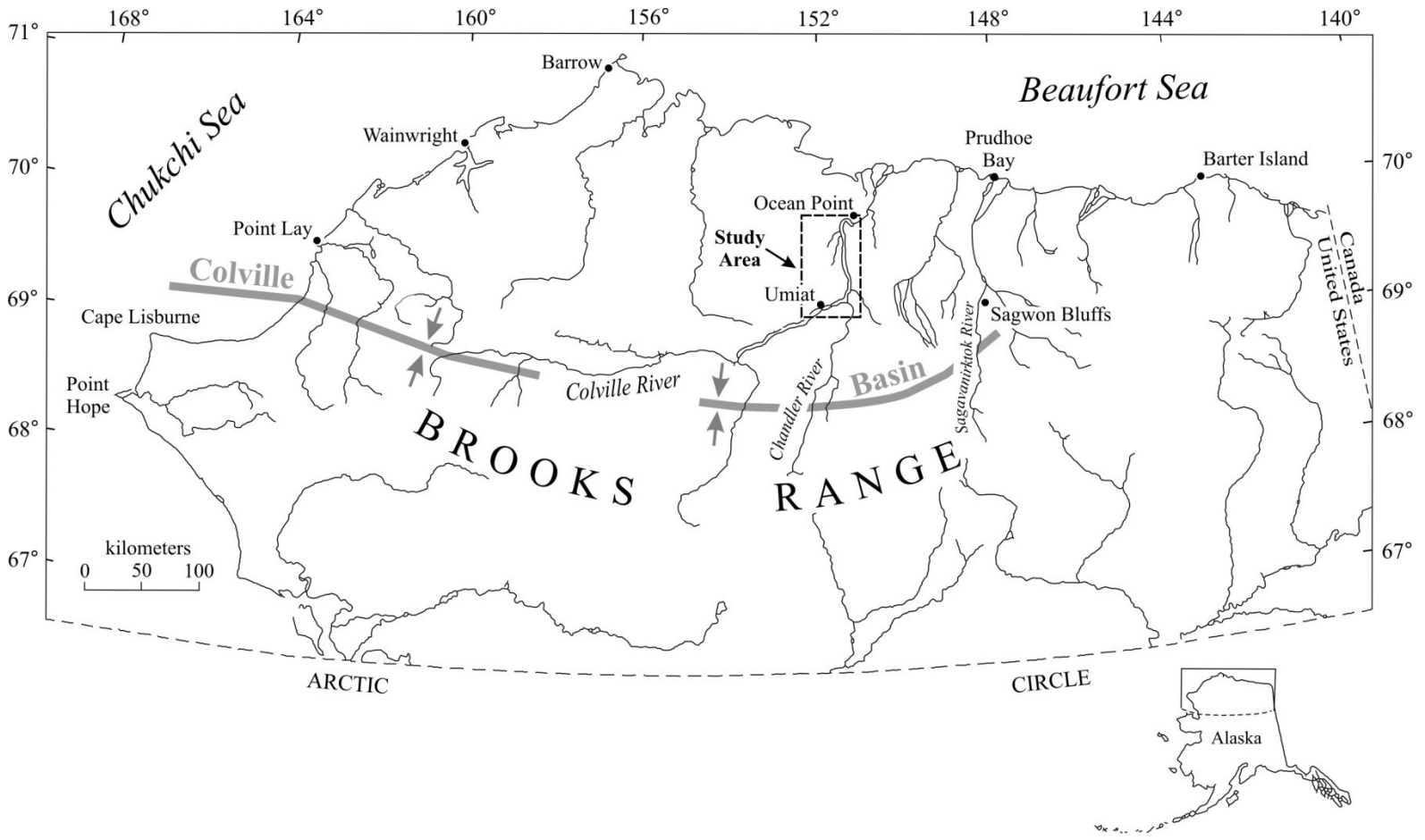
Peter P. Flaig

Purpose of this talk



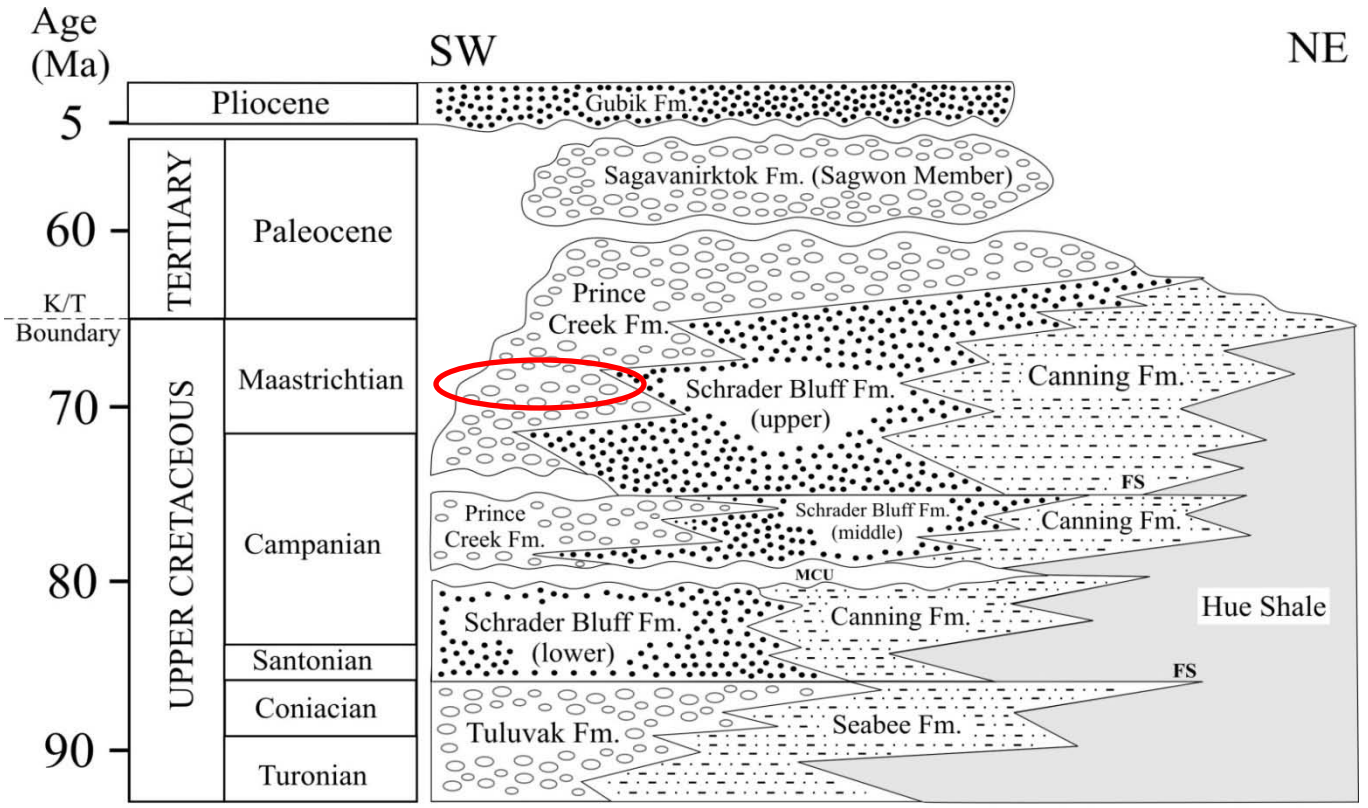
- Facies Analysis (depositional environments)
- Determine the type of fluvial system (s) responsible for deposition
- Architectural Analysis
- Provide a depositional model for the Cretaceous Prince Creek Fm. on the North Slope

Location:



Modified from Fiorillo and Gangloff (2000)

Regional Stratigraphy:



Prince Creek Formation records deposition in a foreland basin on a high-latitude coastal plain

Modified from Mull et al. (2003), Garrity et al. (2005), Decker et al. (2009)

Colville Basin...Why Important?

- Preserves a high-latitude dinosaur ecosystem
- Surface expression of subsurface reservoirs

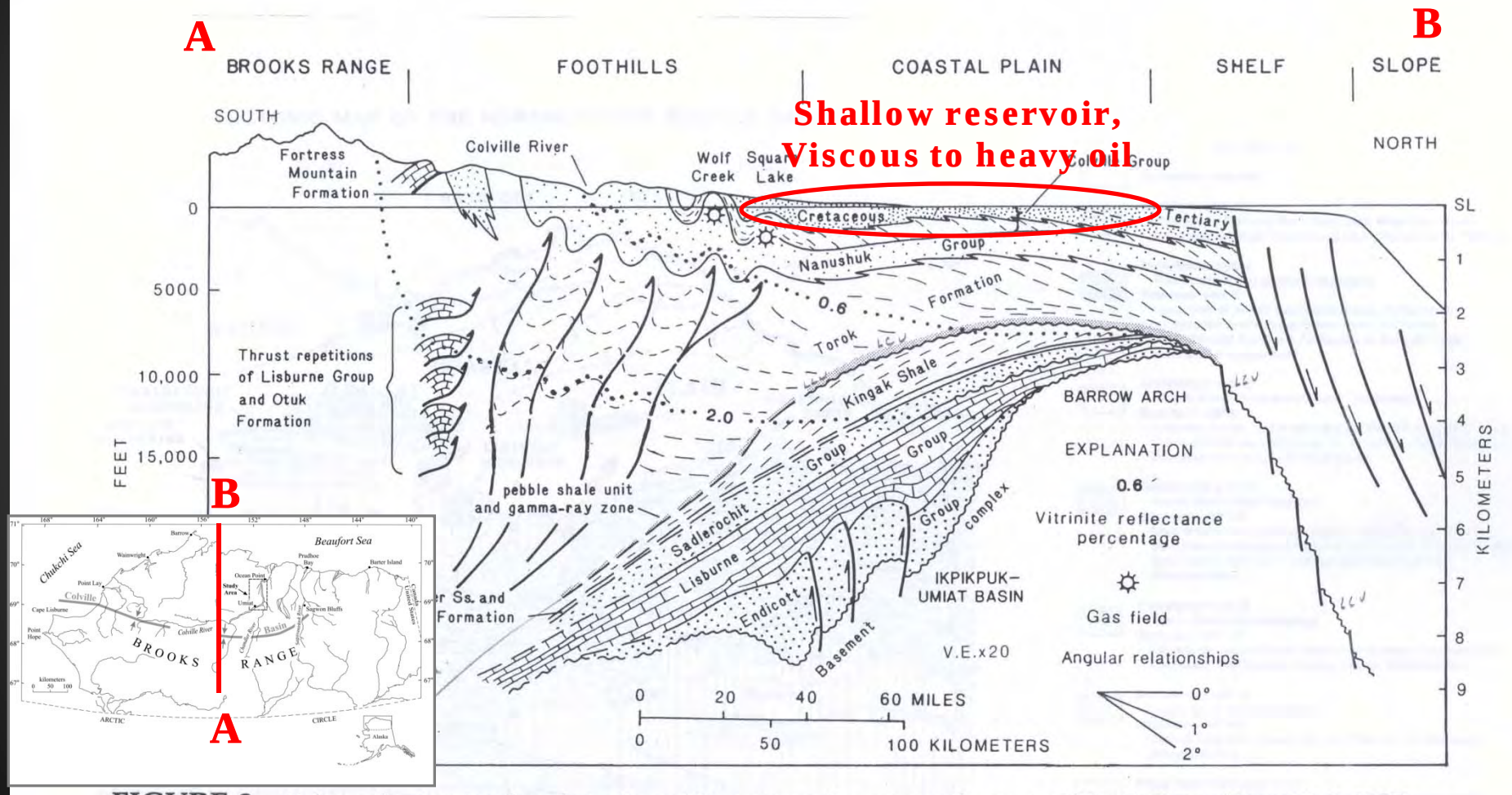
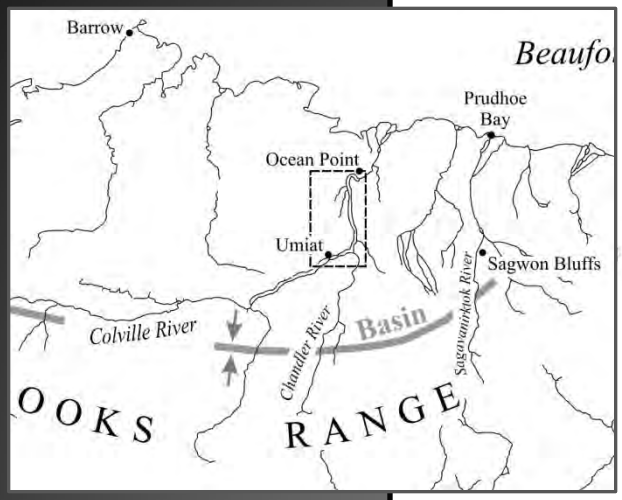


FIGURE 3. Schematic structural and stratigraphic cross section across the central North Slope (from Bird, 1987). Shaded zone between Torok Formation and Kingak Shale is the pebble shale unit and gamma-ray zone. See Figure 2 for location of section.

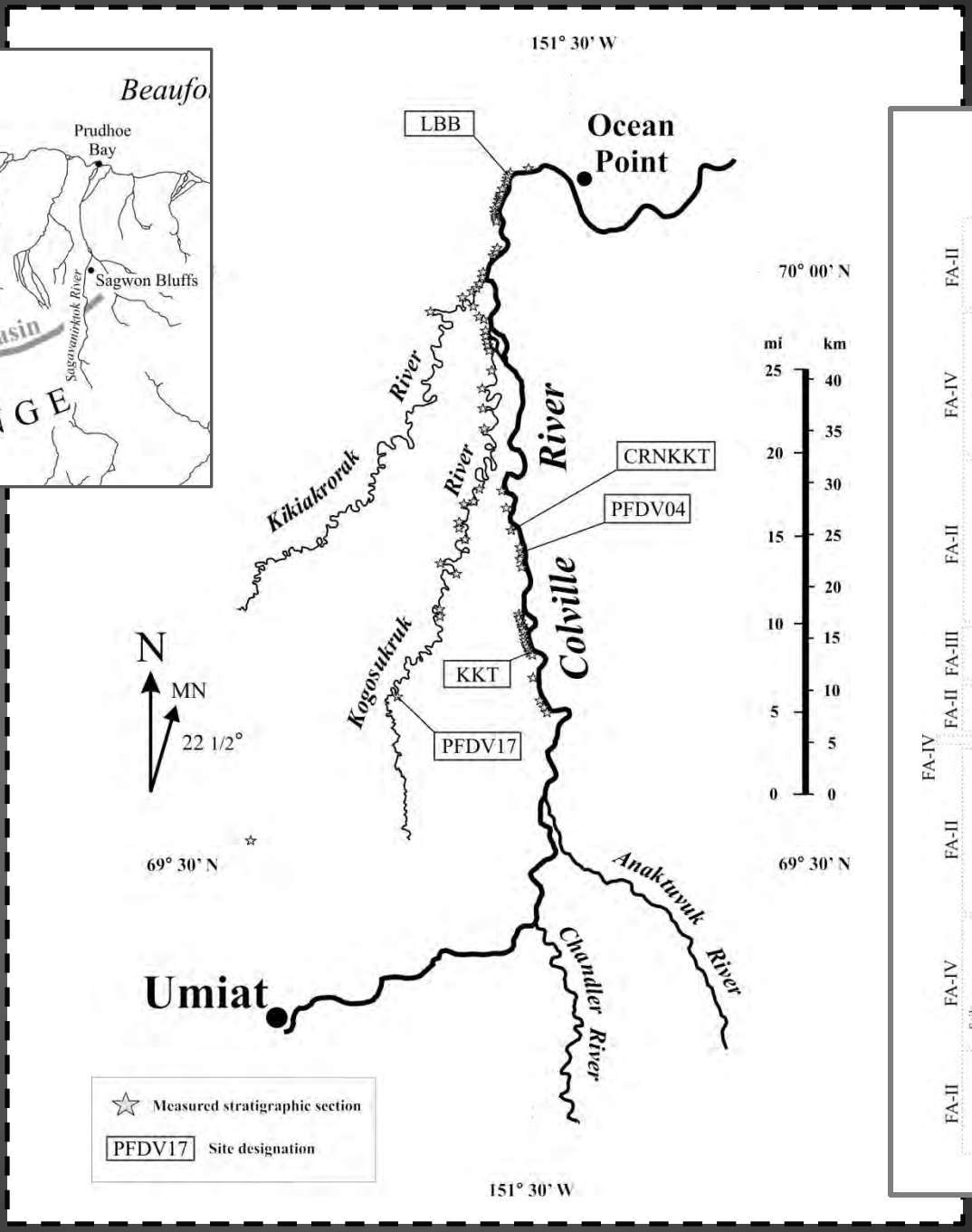
BIRD & MOLENAAR, 1992

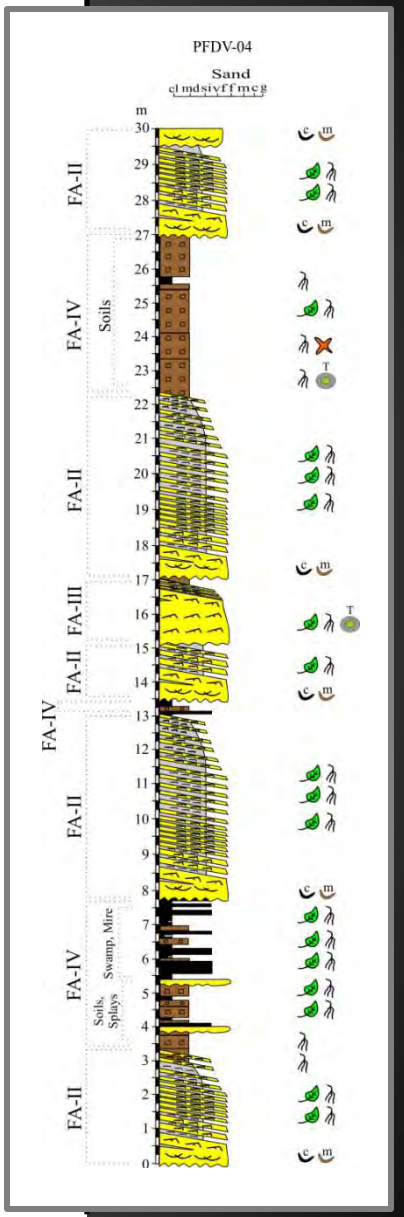


Study Area

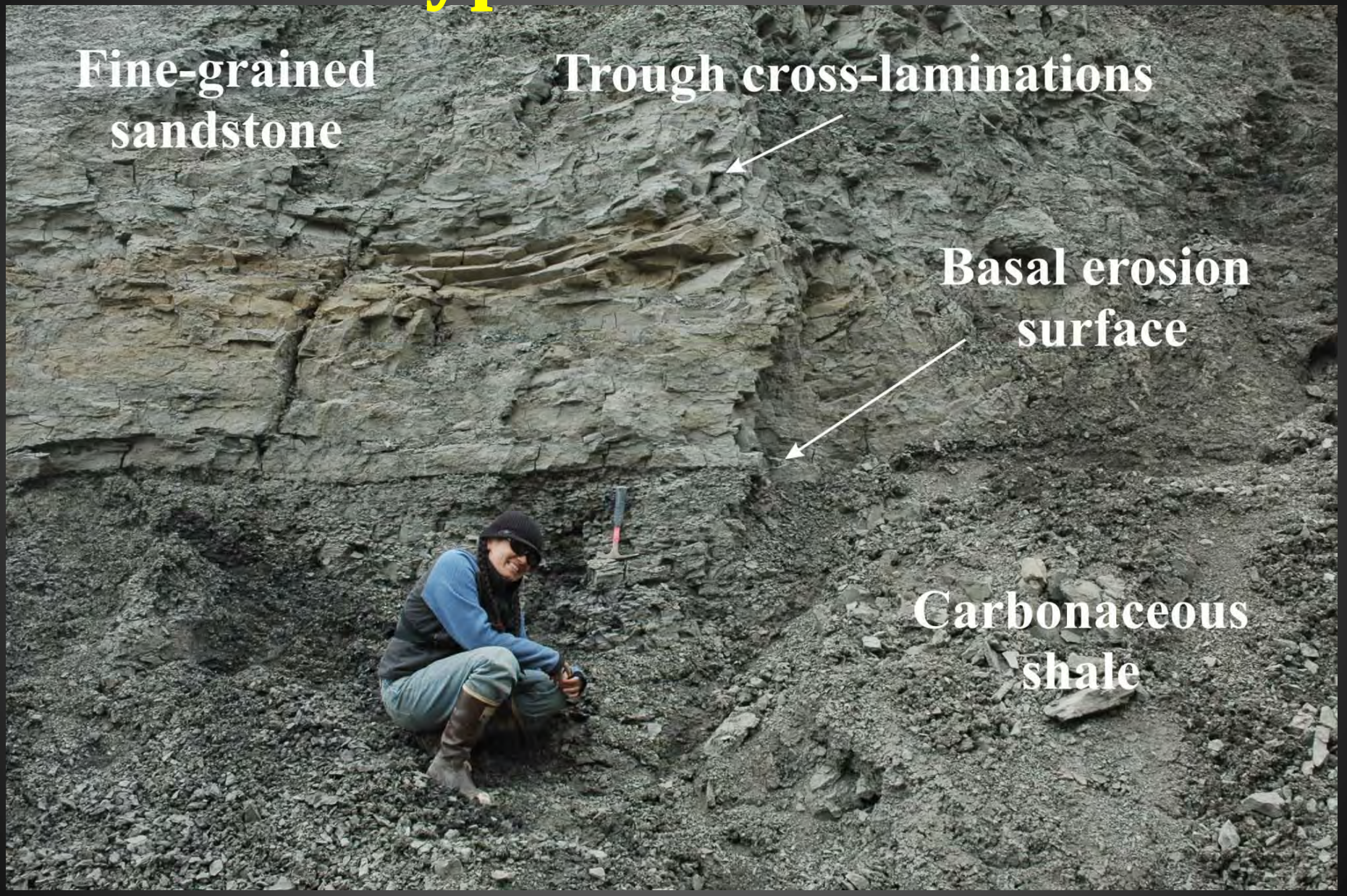
75 measured stratigraphic sections

Grain-size, lithology, contacts, sed. structures, flora, fauna

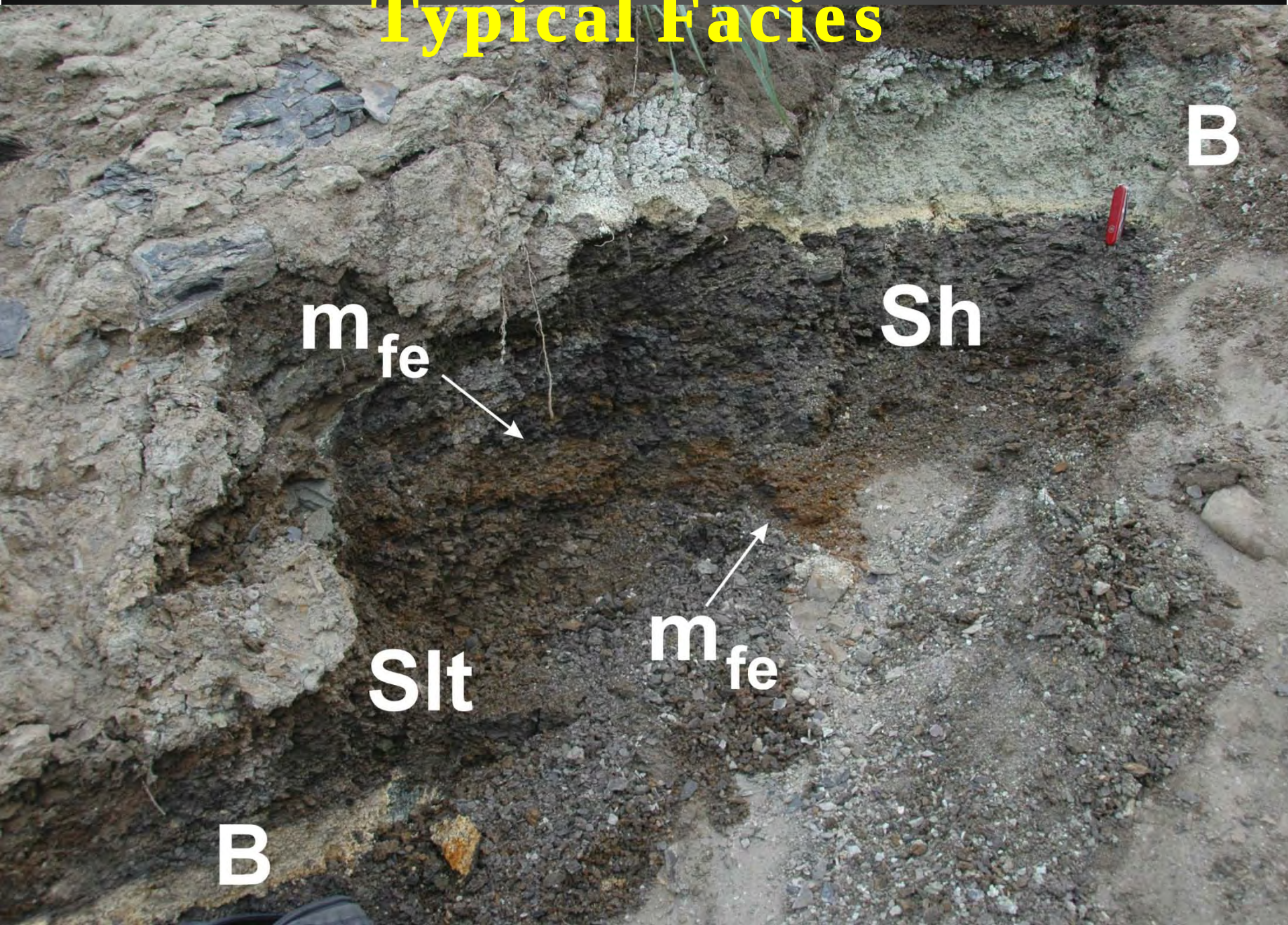




Typical Facies

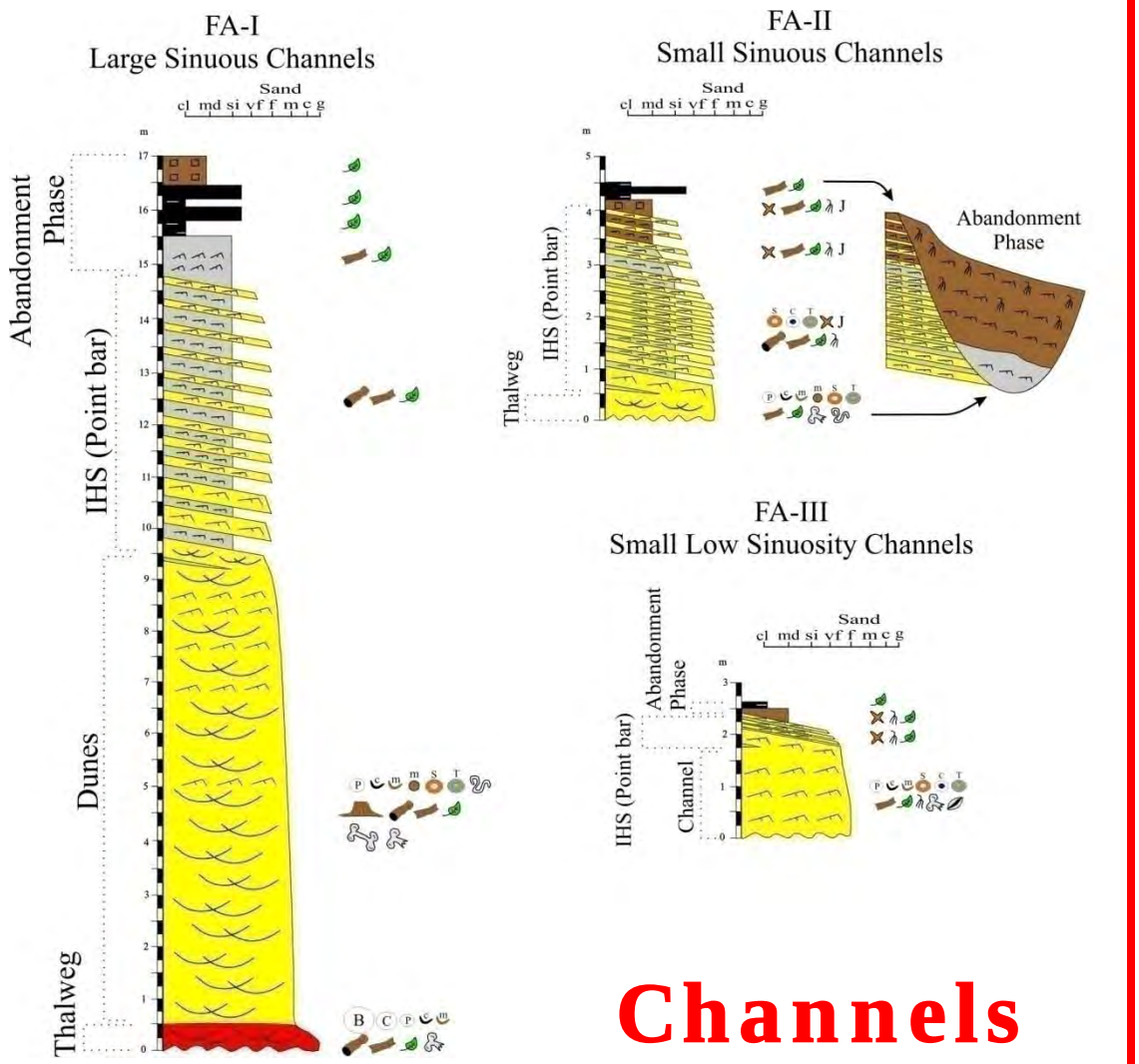


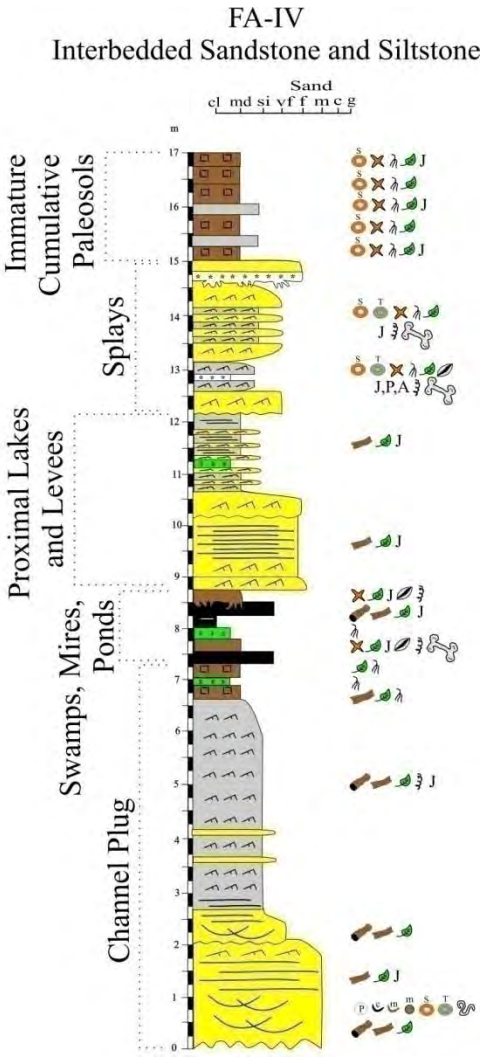
Typical Facies



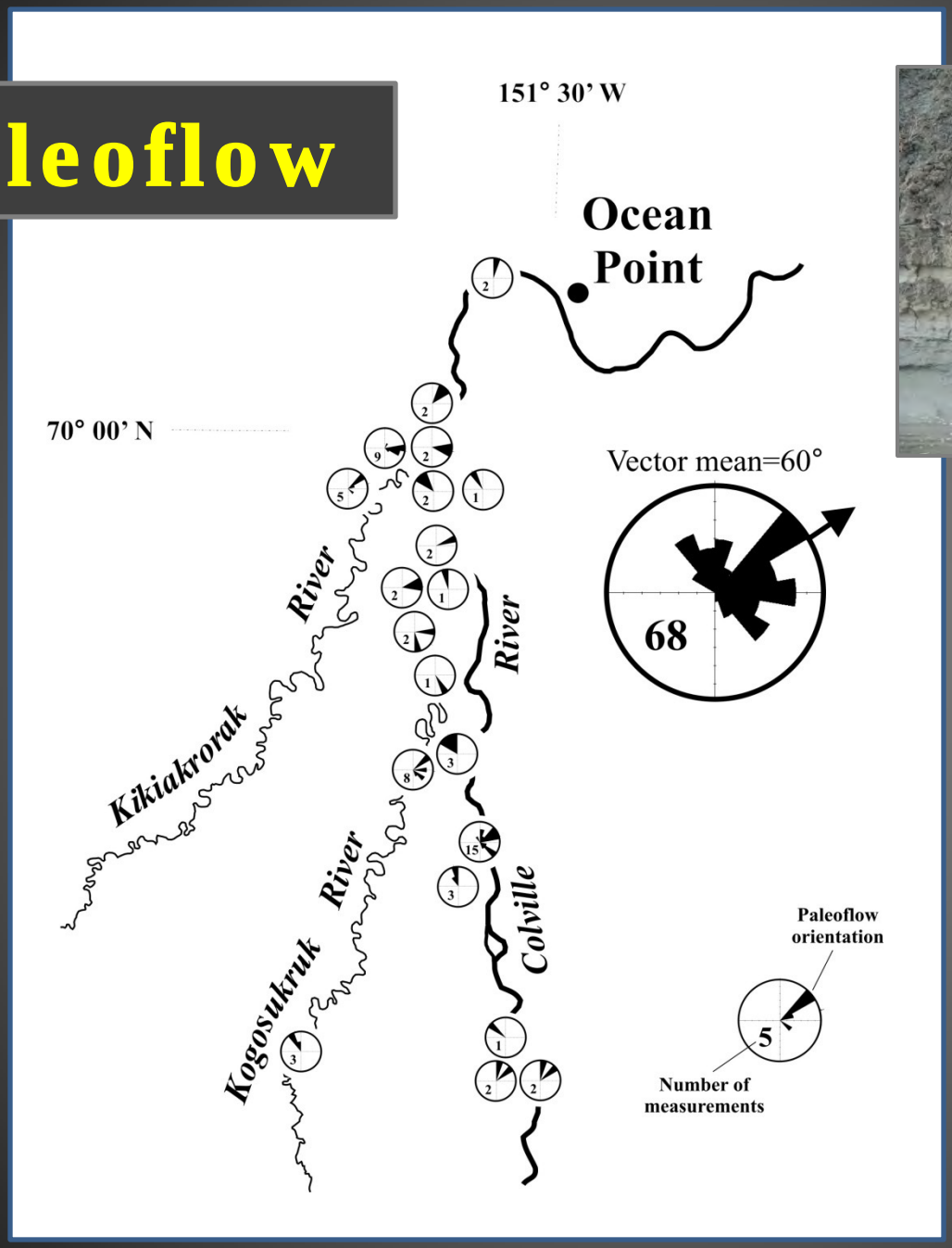
Typical Facies

Facies Associations





Paleoflow

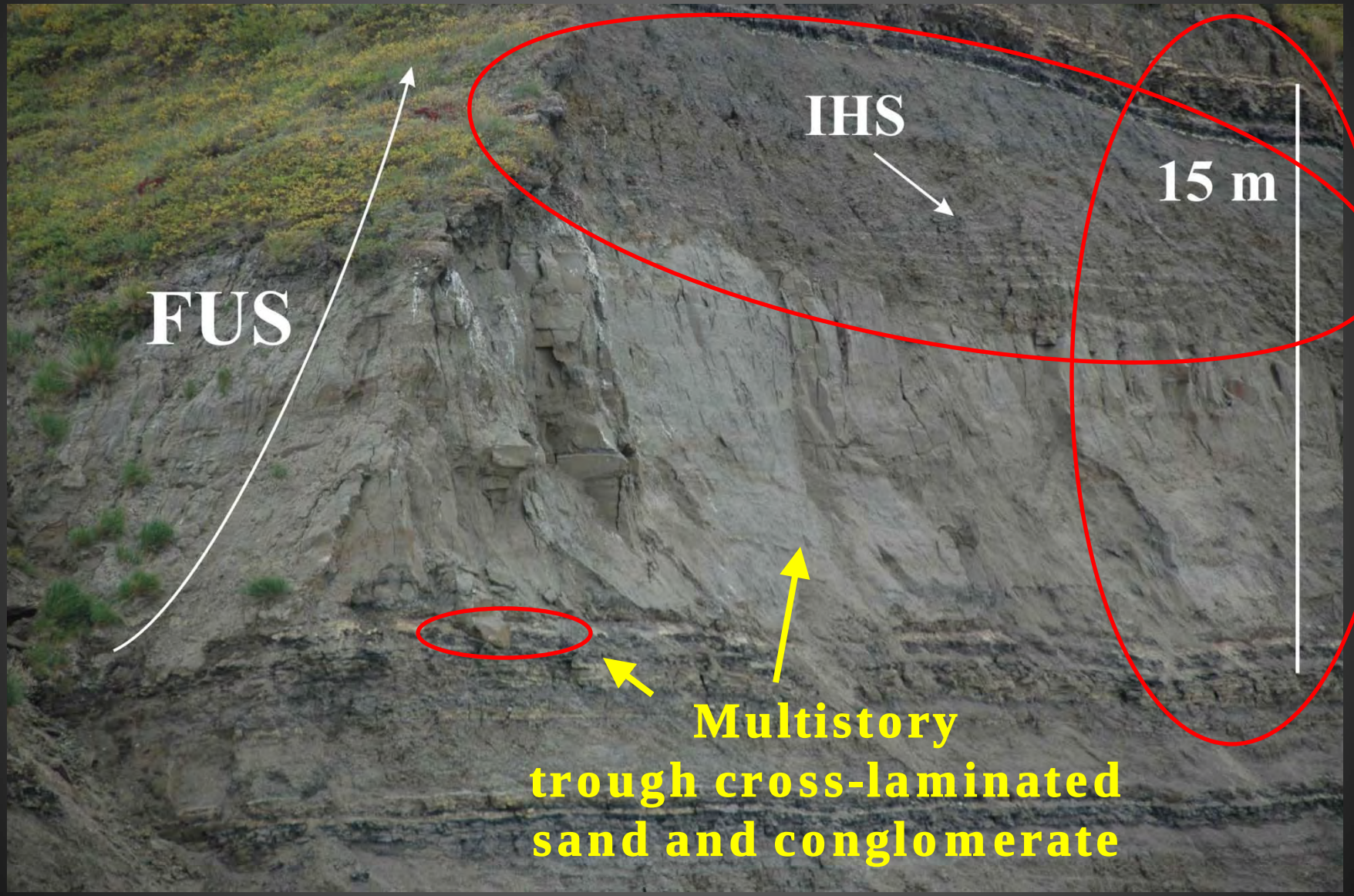


Axial flow recorded from trough cross-laminations

(consistent with previous work)

Channels
3 channel-forms...

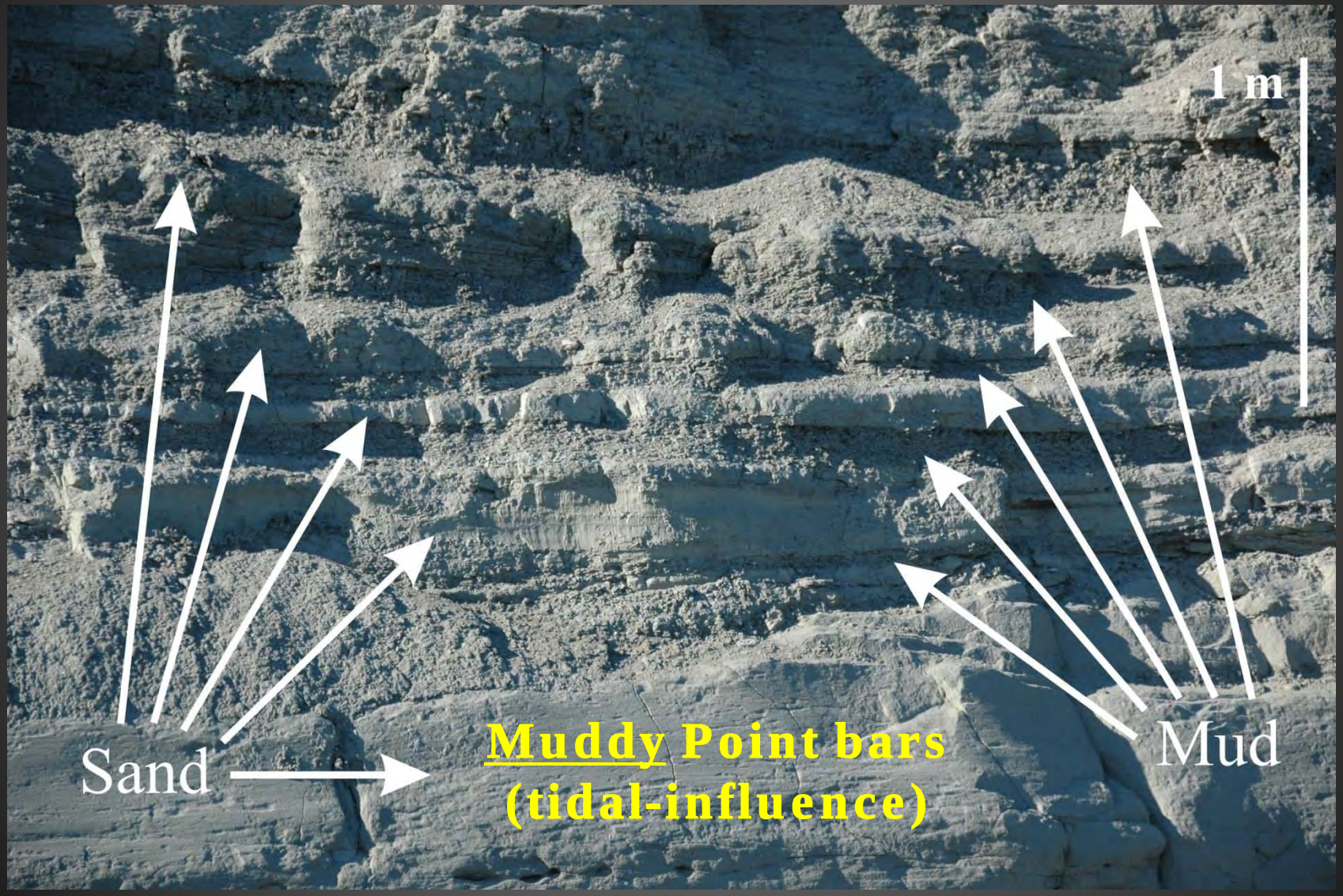
Large Sinuous Channels (FA-I)

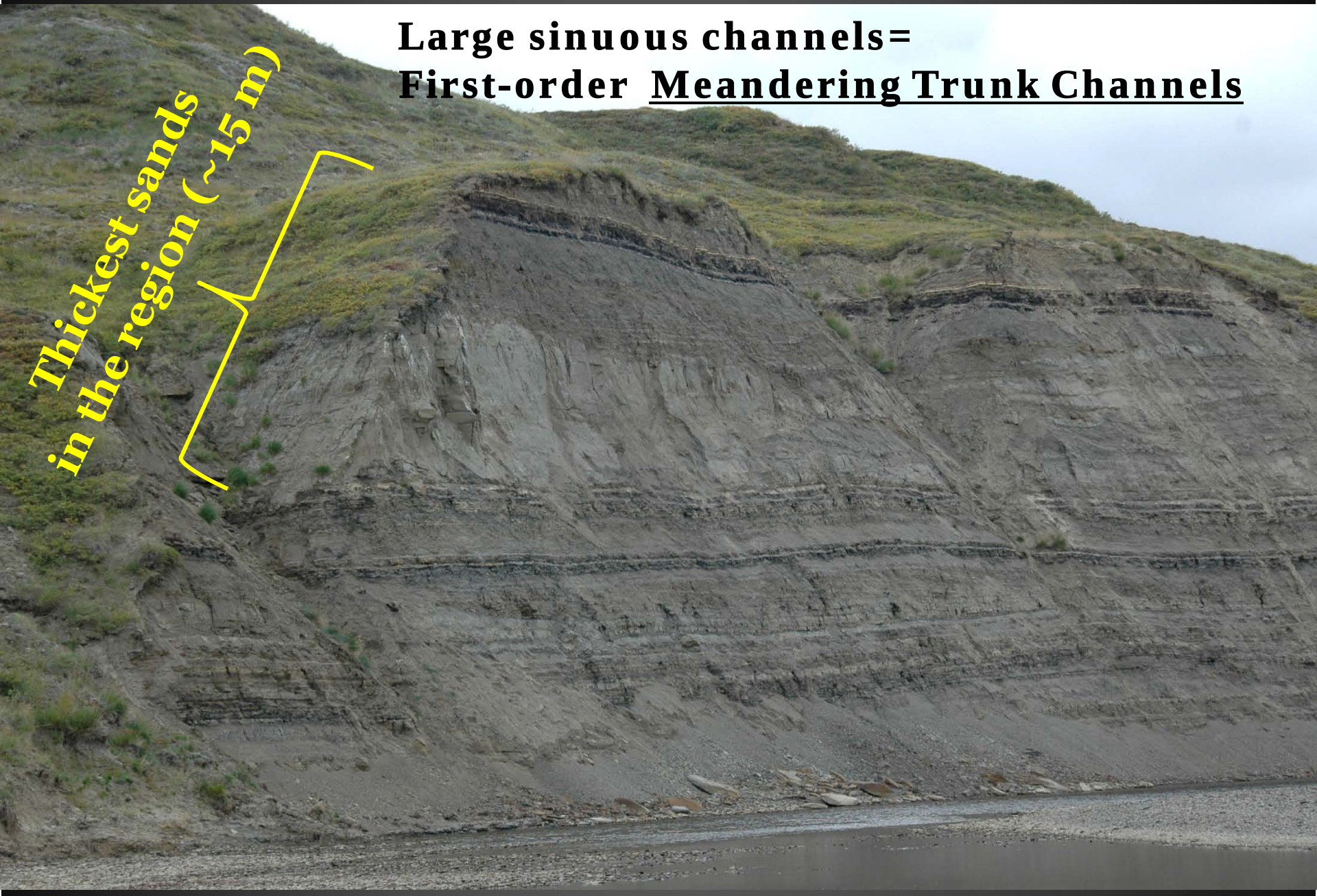


Only Channels with Gravels/Boulders

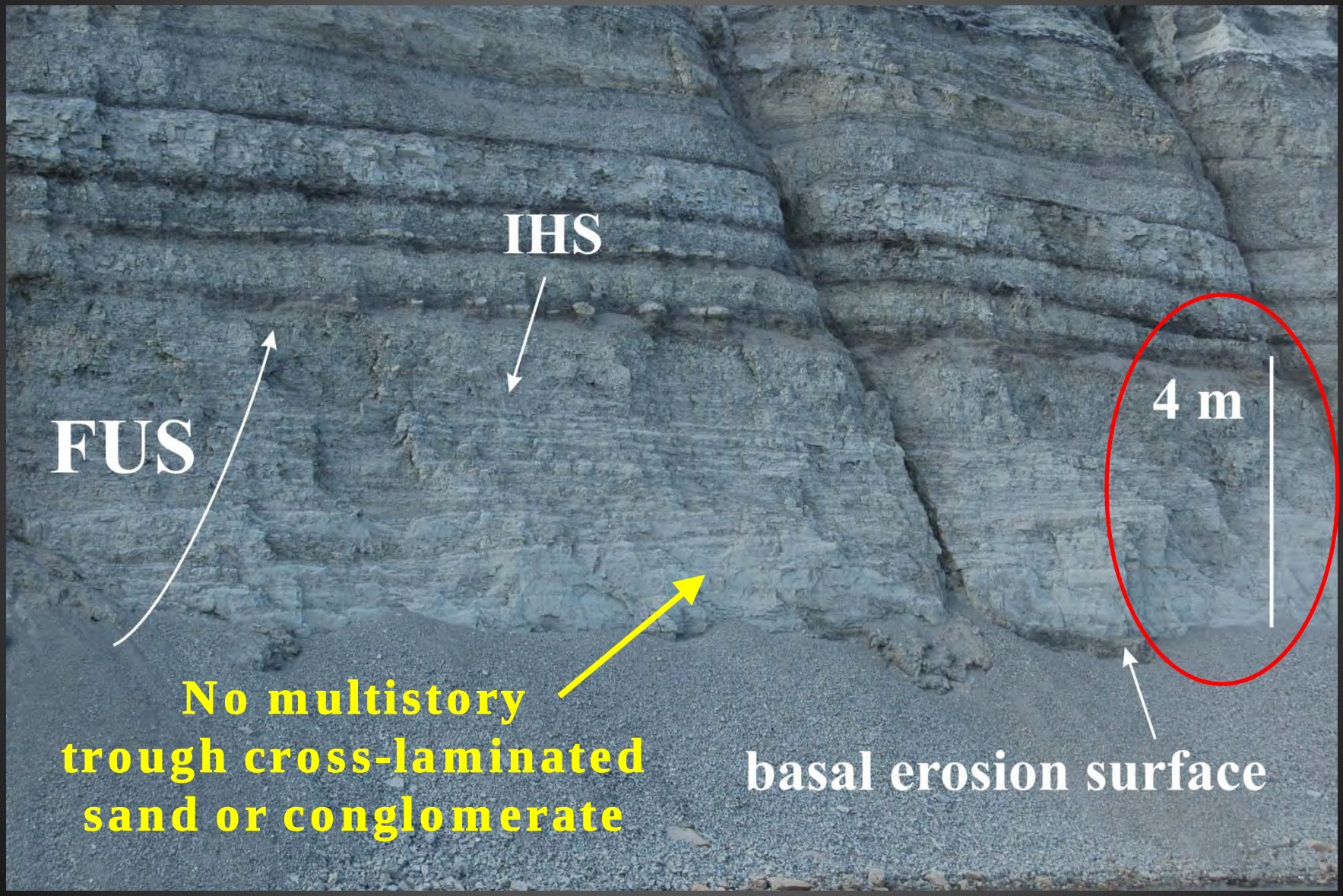
…some clasts are the size a football
…important why?…this is extremely rare

Inclined Heterolithic Stratification (IHS)




Large sinuous channels=
First-order Meandering Trunk Channels
Thickest sands
in the region (~15 m)

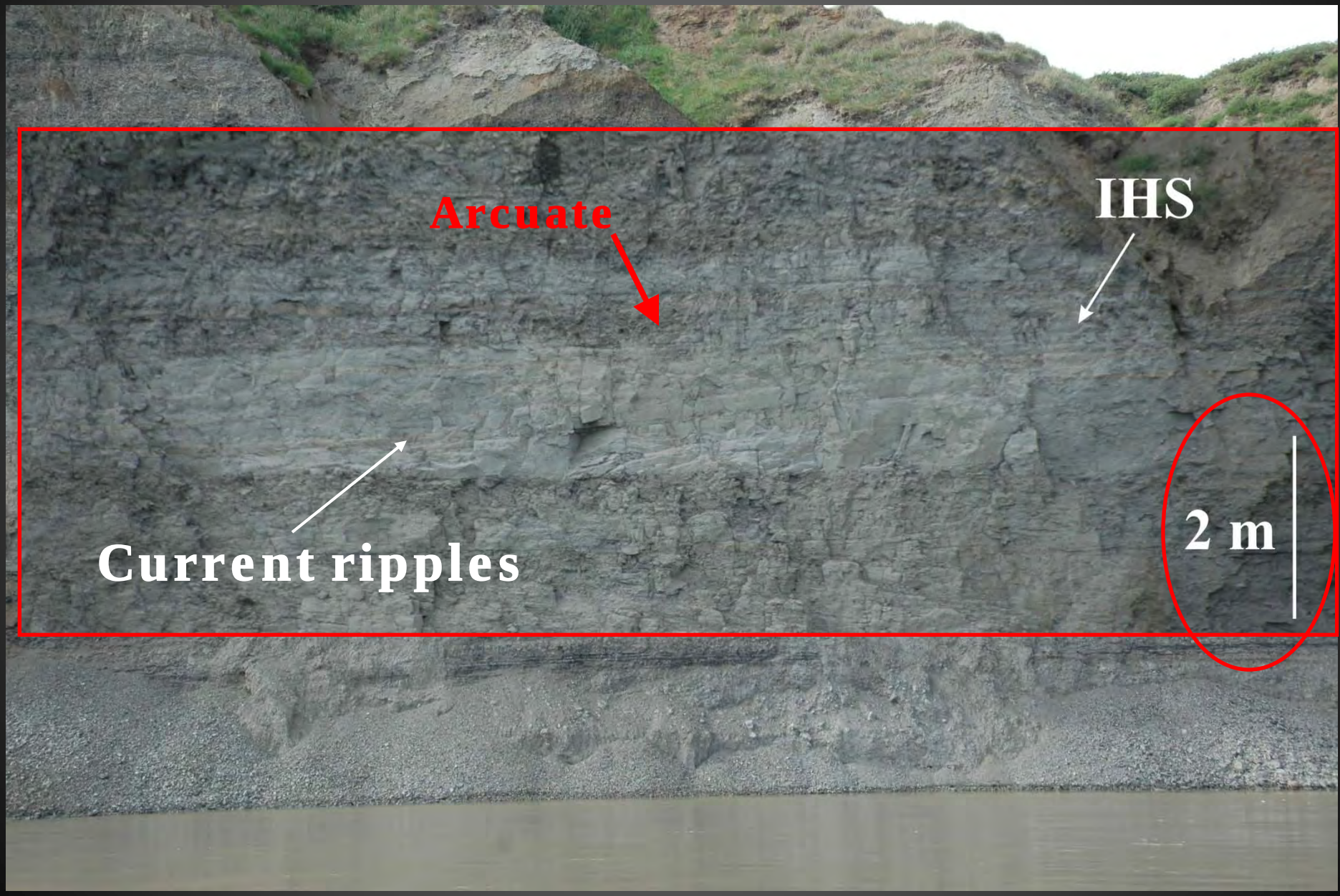
Small Sinuous Channels (FA-II)



- Fine grained sand and silt
- Alternating sand & mud (couplets)
- Carbonaceous roots throughout
- Small sinuous channels=
  Meandering second-order distributary channels

Opposing apparent dips

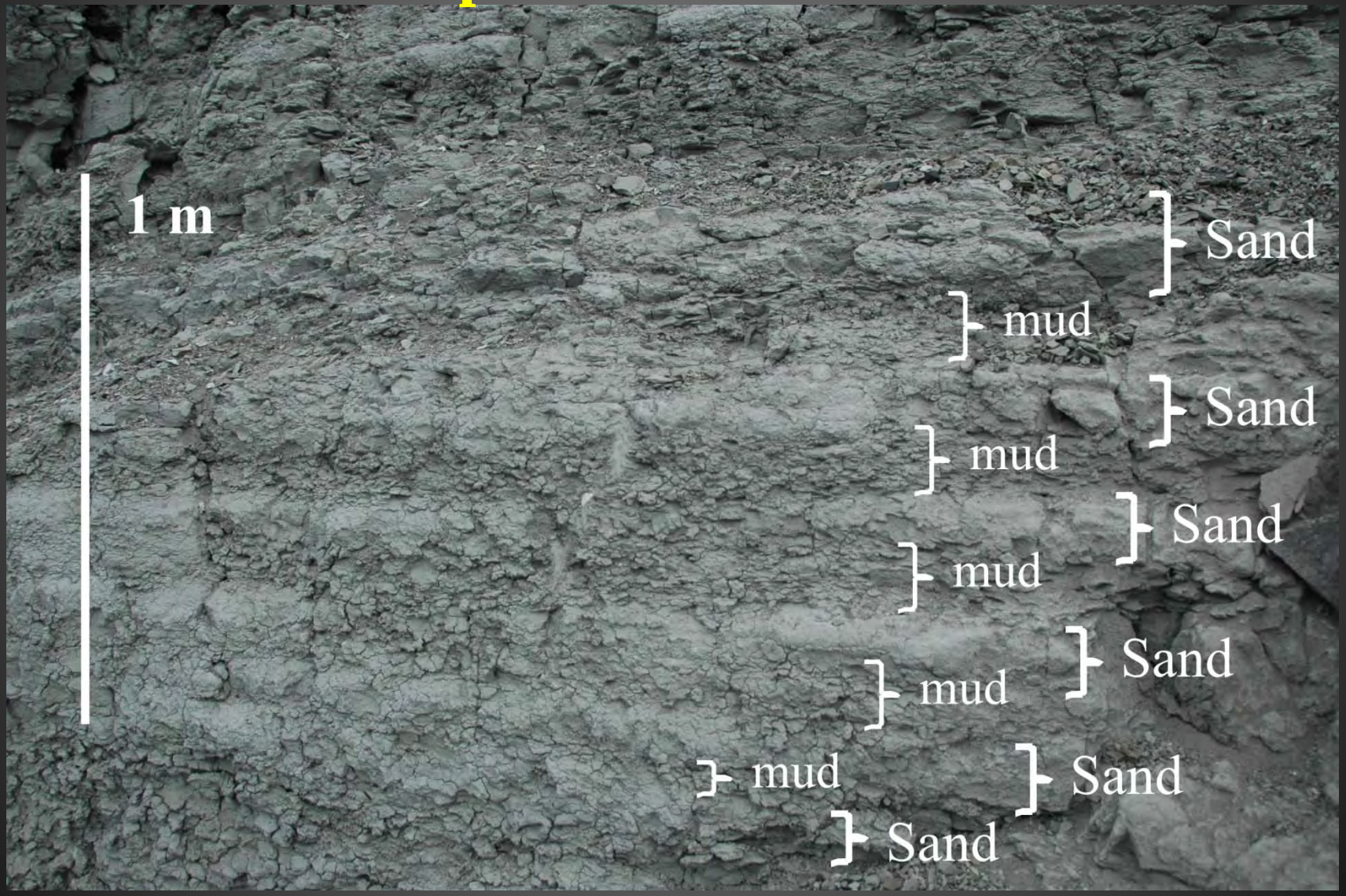
Small Low Sinuosity Channels (FA-III)



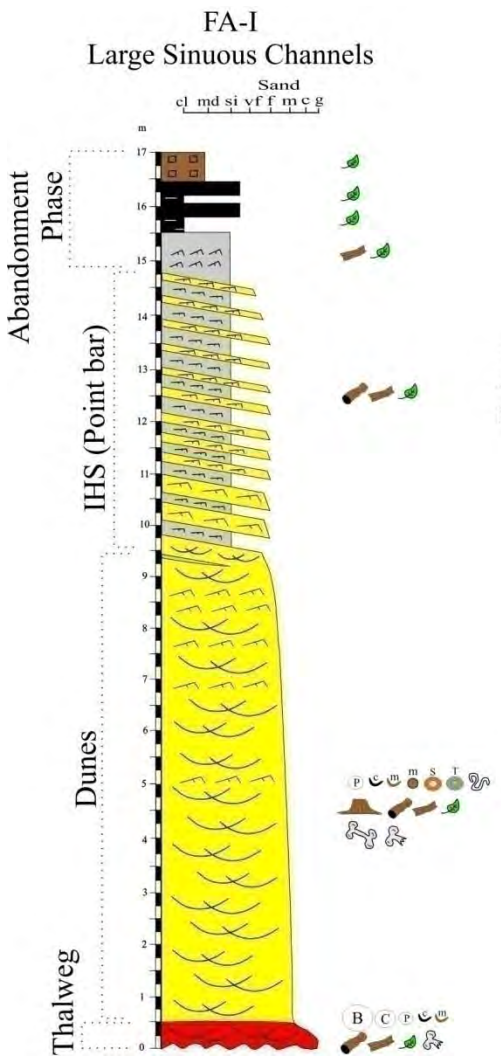
Small low-sinuosity channels=
Third order fixed (anastomosed?) distributaries

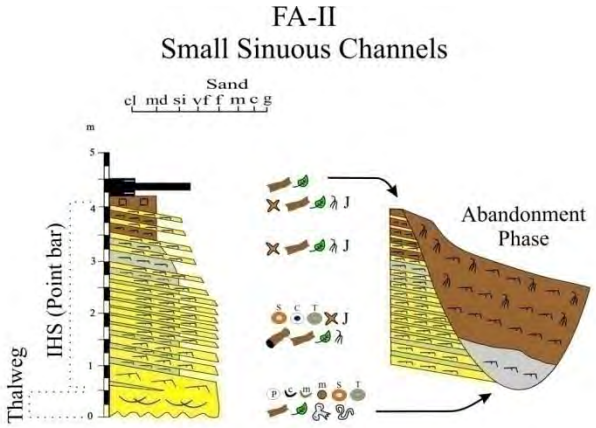
"Classic" ribbon channel body with "wings"

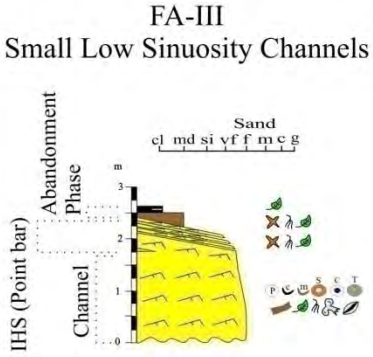
All Channels have rhythmically-repeating sand/mud couplets = Tidal Influence

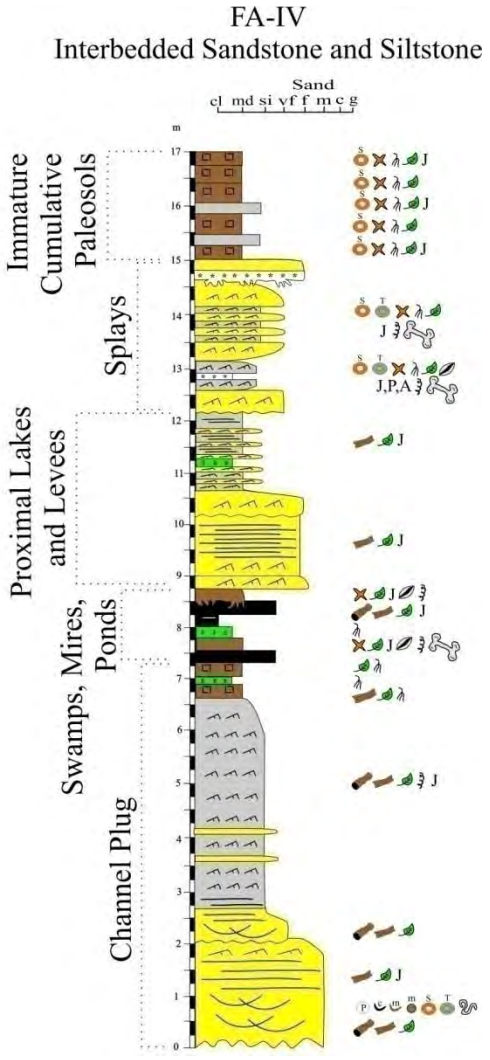


Facies Associations



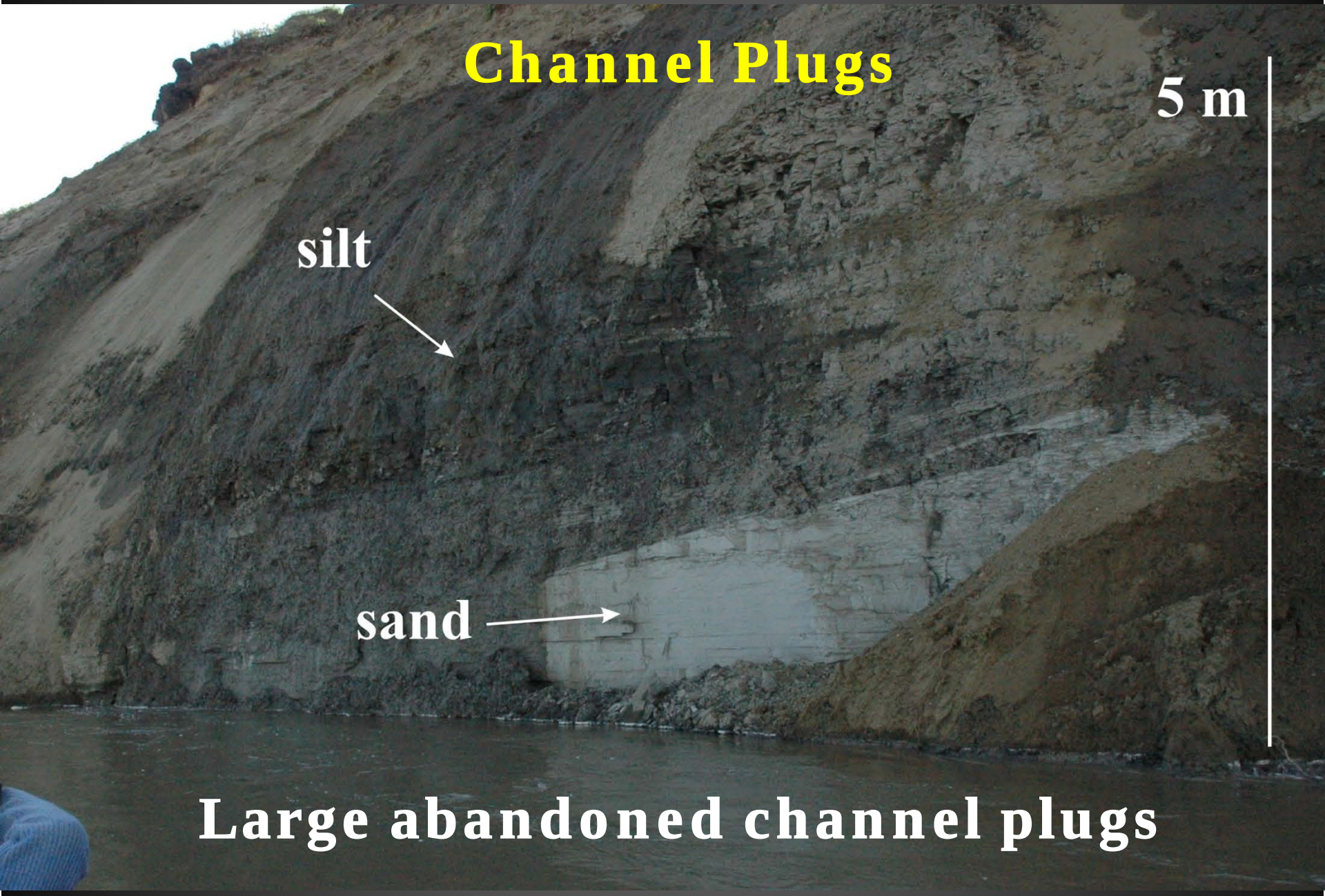






Floodplains

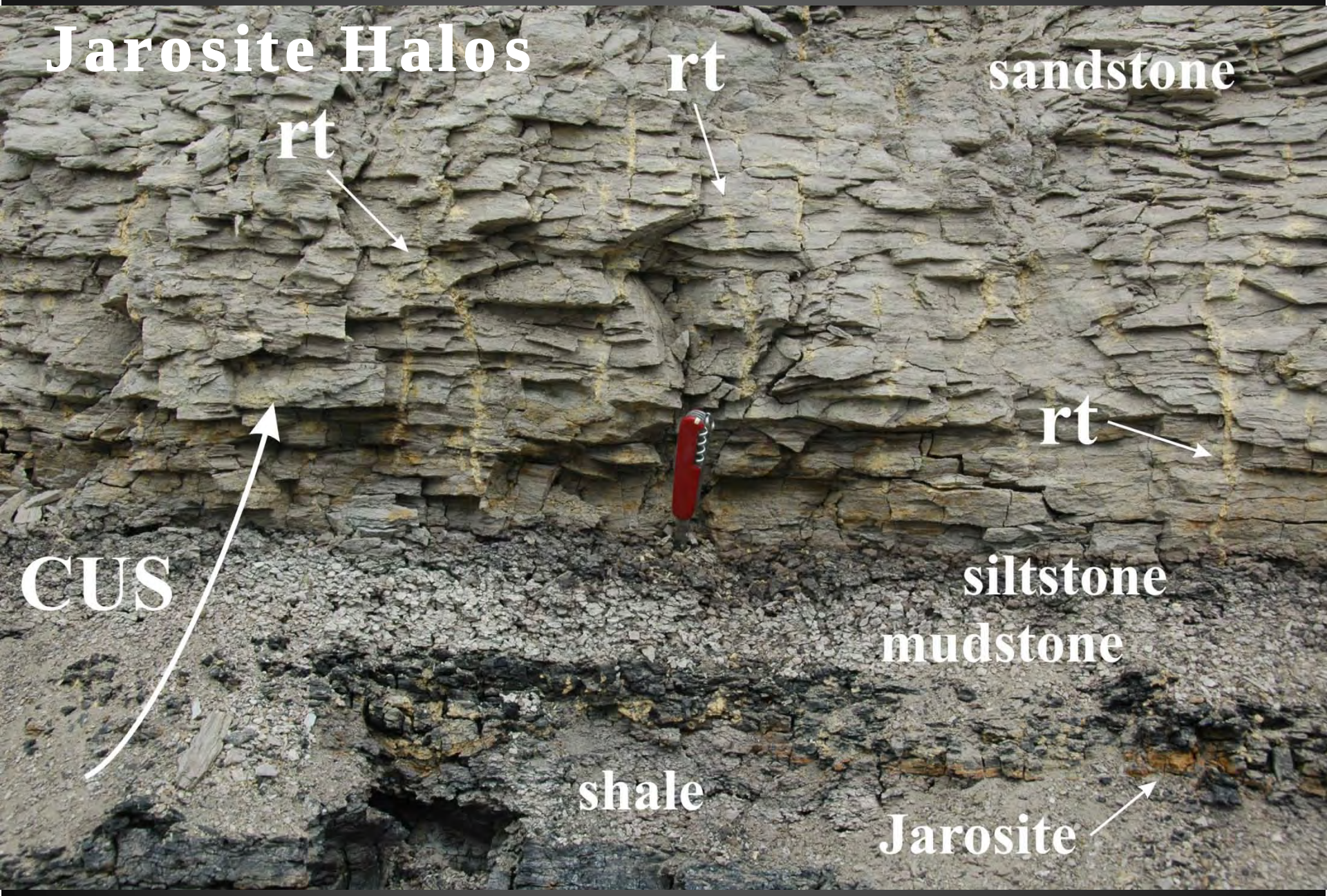
Levees


Channel Plugs
5 m
silt
sand
Large abandoned channel plugs

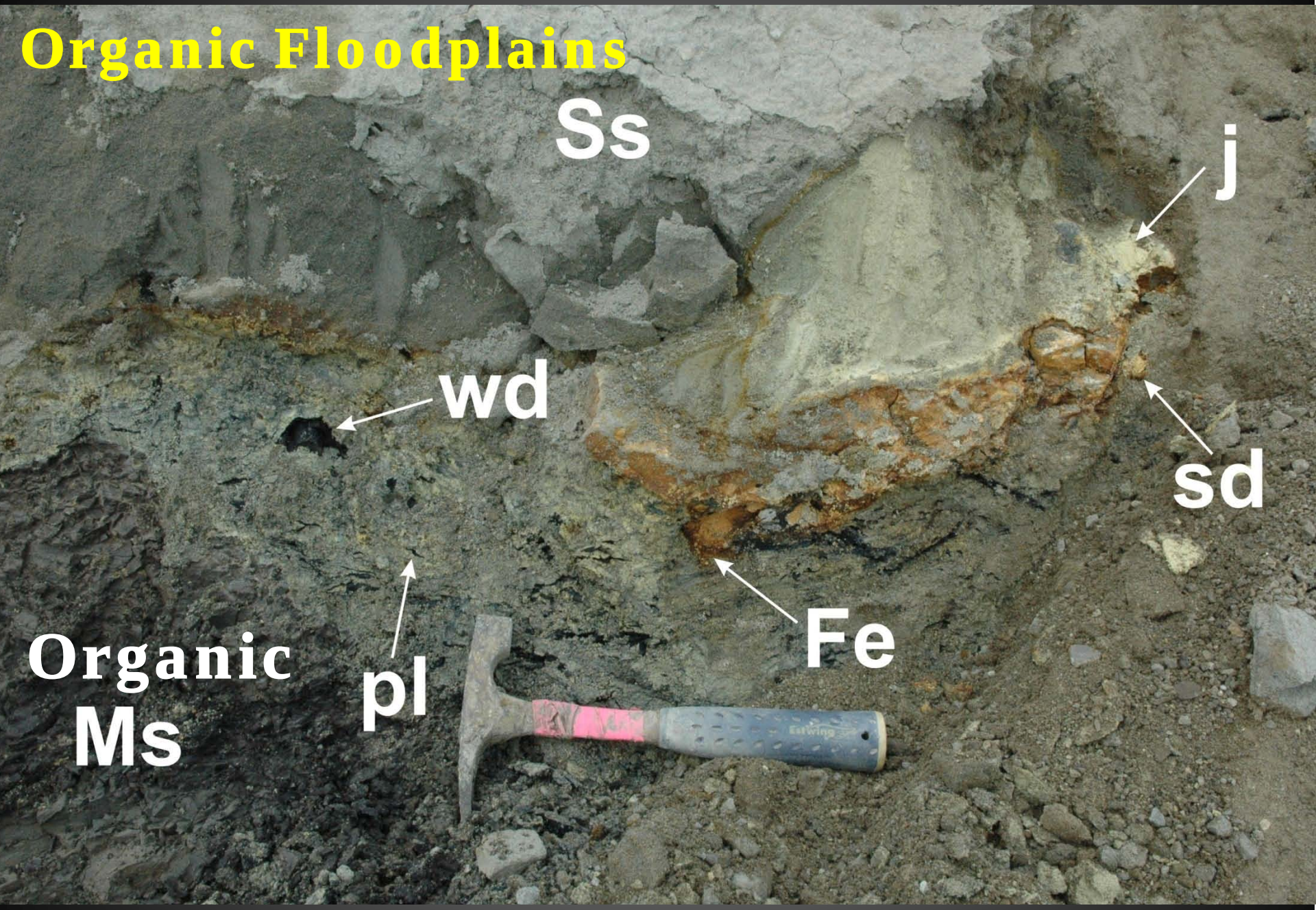
Small Floodplain Lakes

Clams & Gastropods
Nucula aff *N. percrassa* Conrad
High-dominance, low-diversity,
Brackish/Estuarine (pers. comm. Robert Blodgett)

Small-scale Crevasse Splays

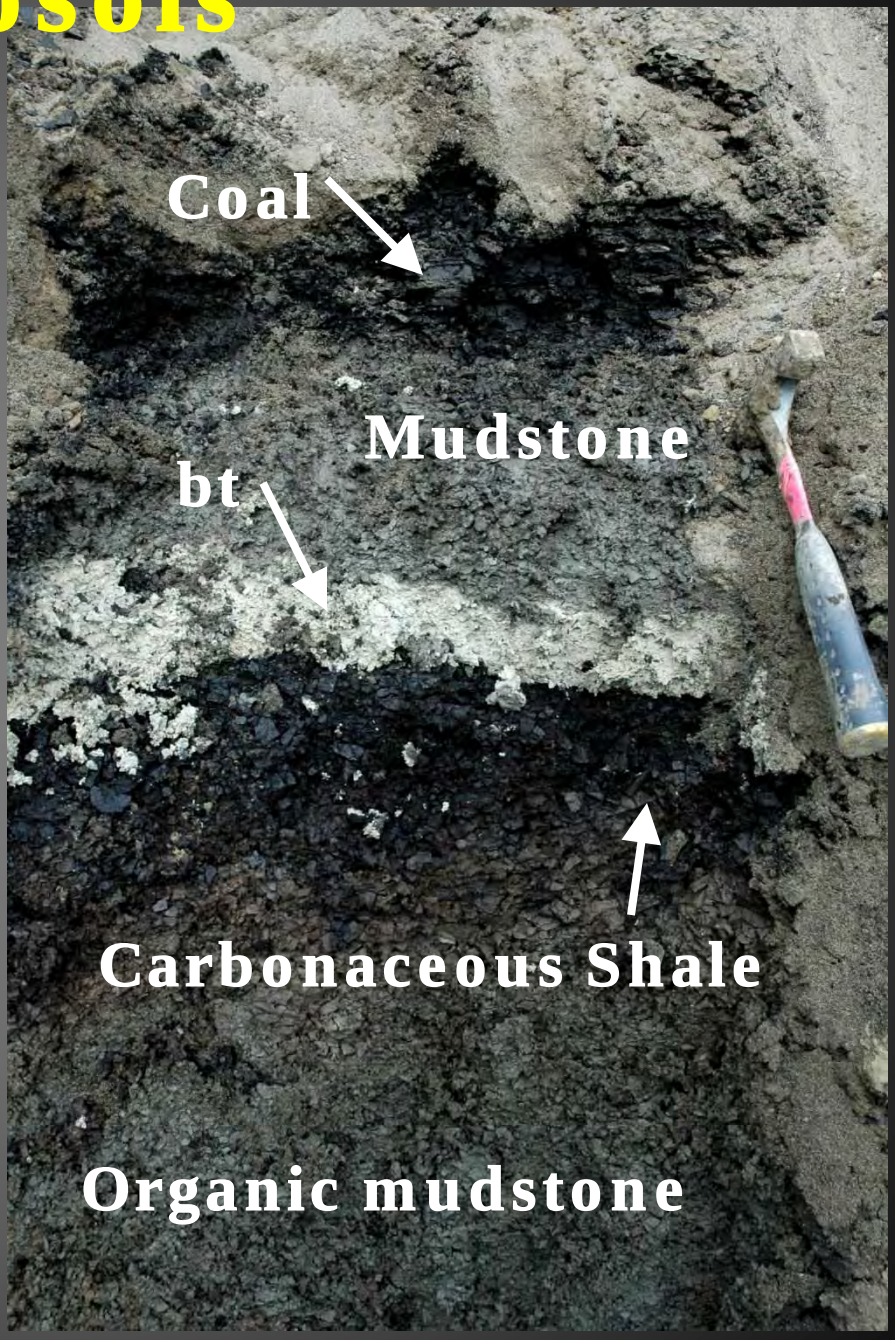


Dinosaur Bone

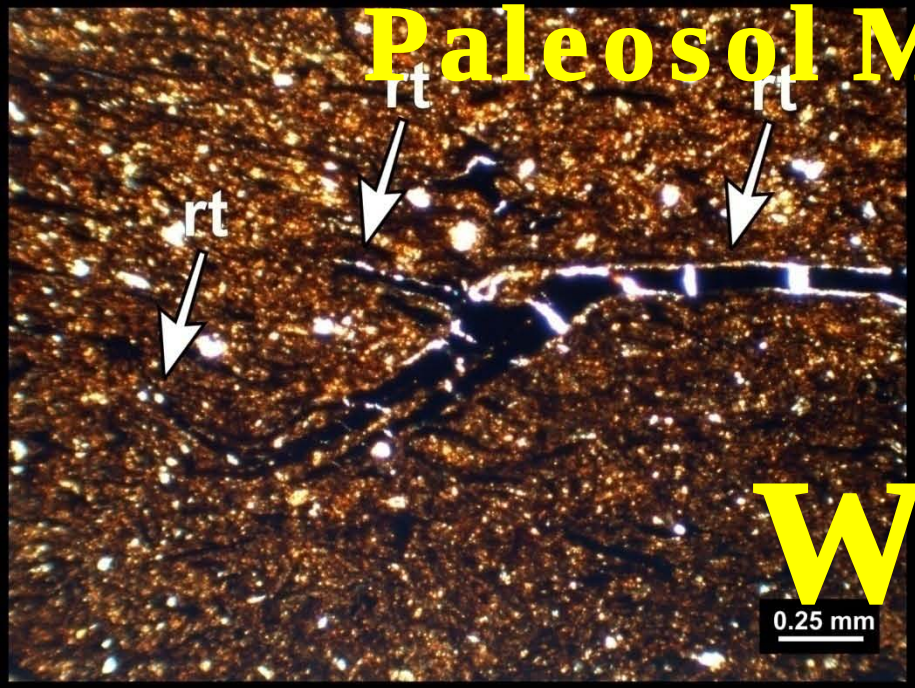

Organic Floodplains
Ss
j
wd
sd
Fe
pl
Organic
Ms

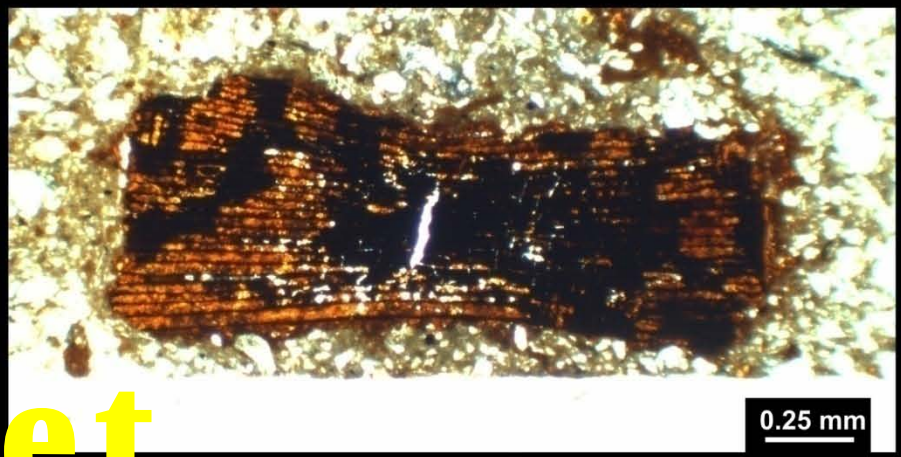
Paleosols

Weakly developed cumulative to compound soils
Carbonaceous Shale
Sandy siltstone
Mudstone


Coal
Mudstone
bt
Carbonaceous Shale
Organic mudstone

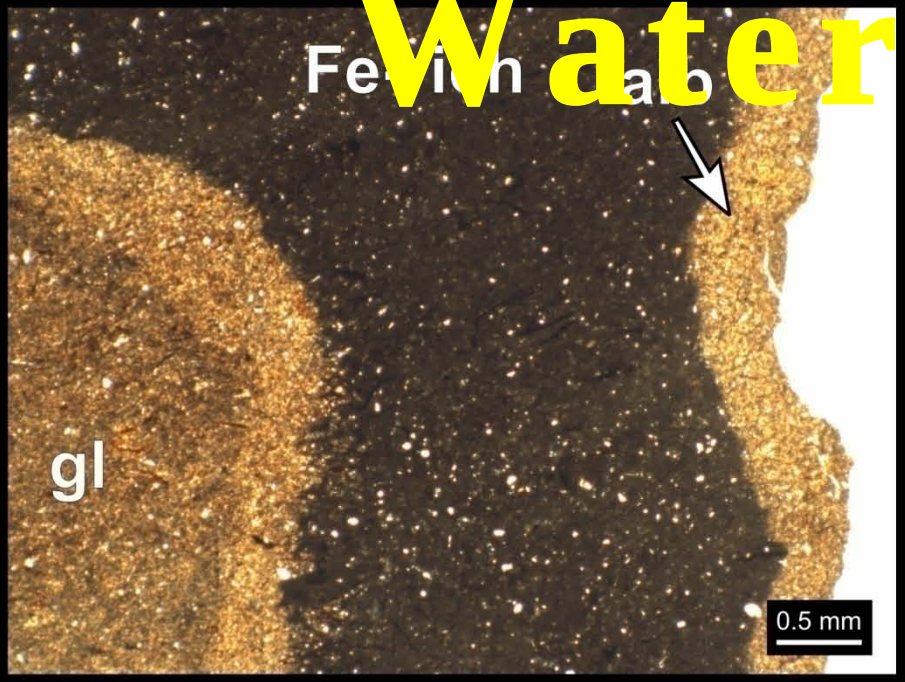
Paleosol Microfacies

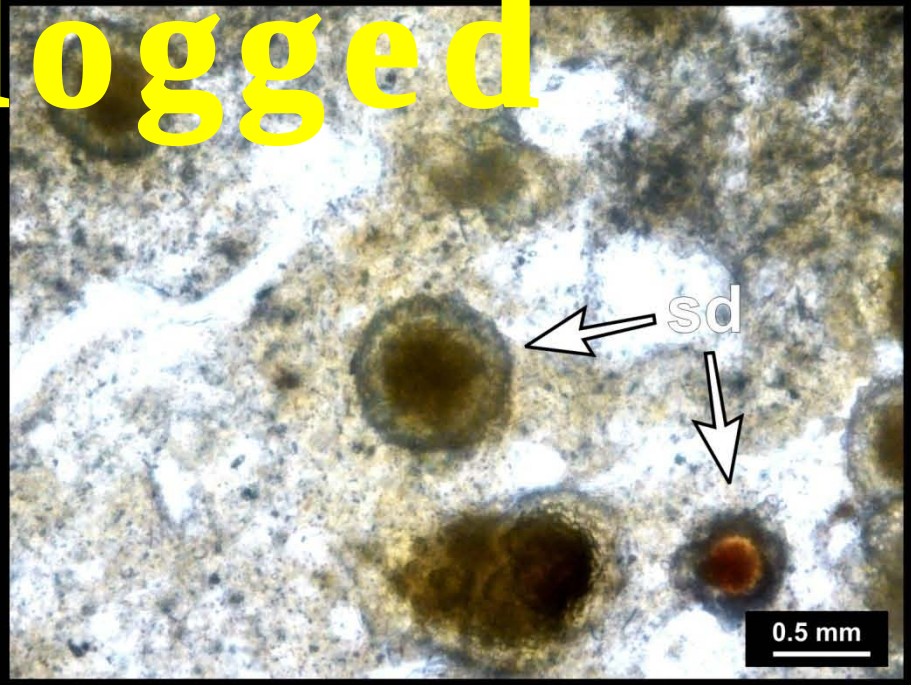




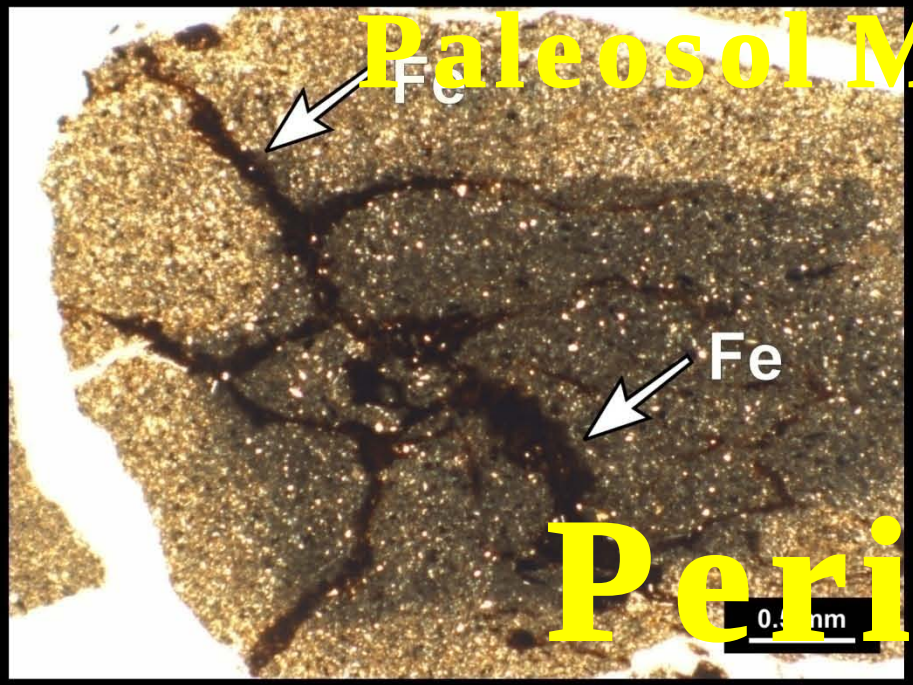
Wet

Waterlogged



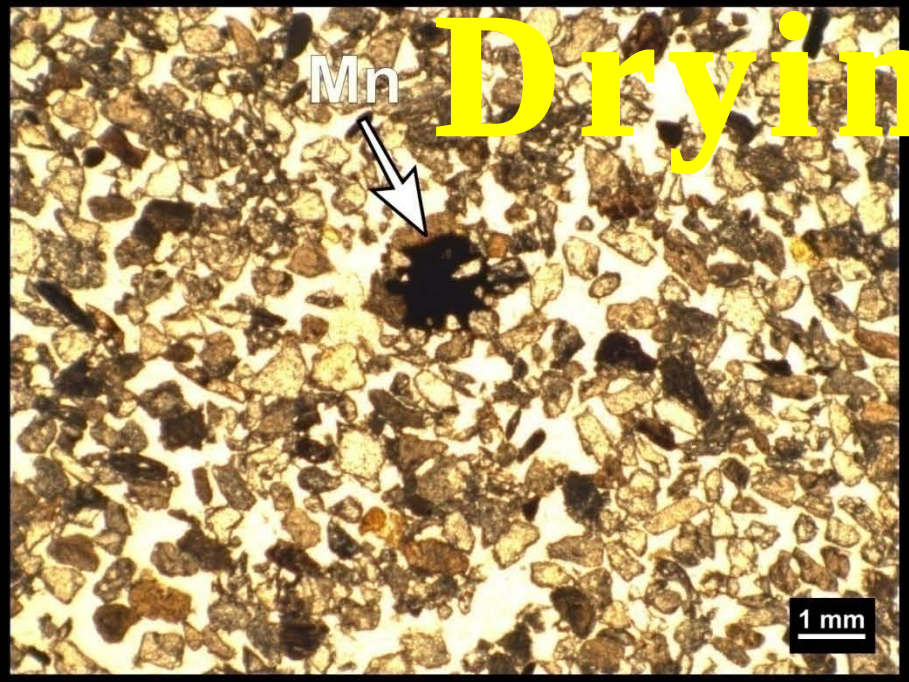


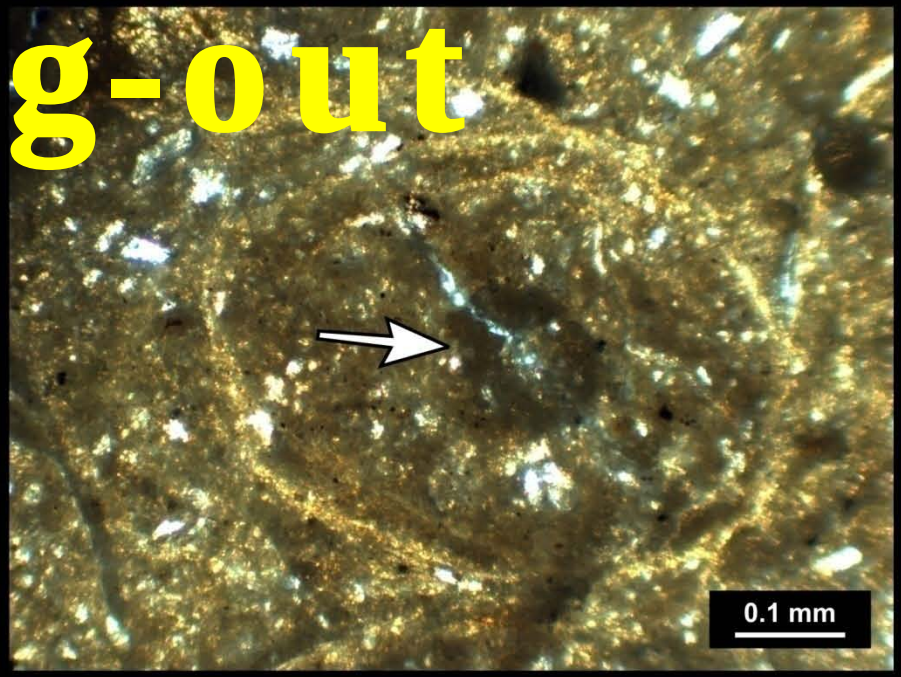
Paleosol Microfacies



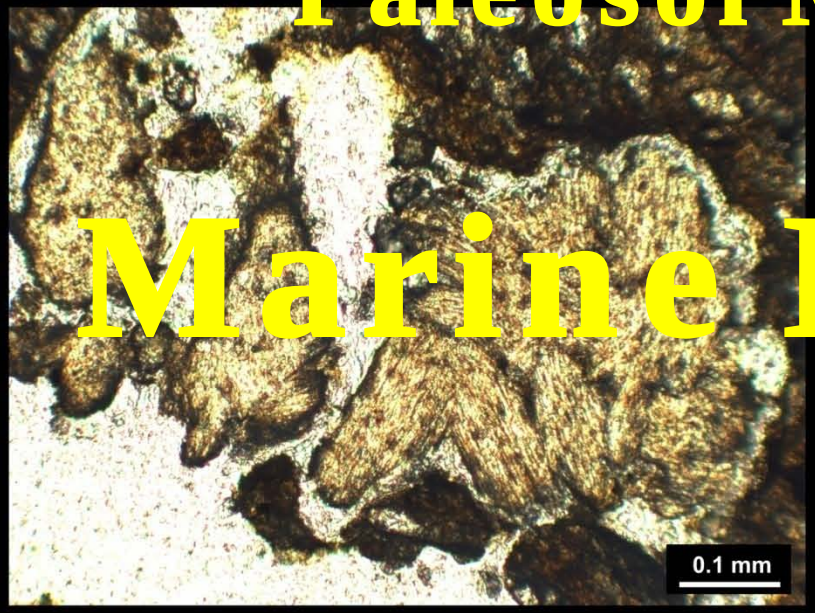
Periodic

Drying-out

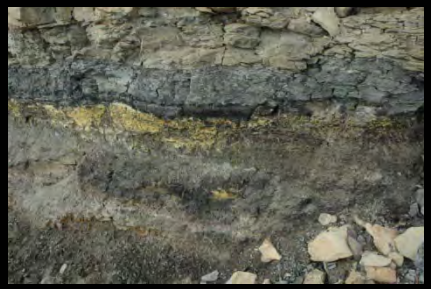




Paleosol Microfacies



Marine Influence



Clastic Influx

Comparison with Modern Soils

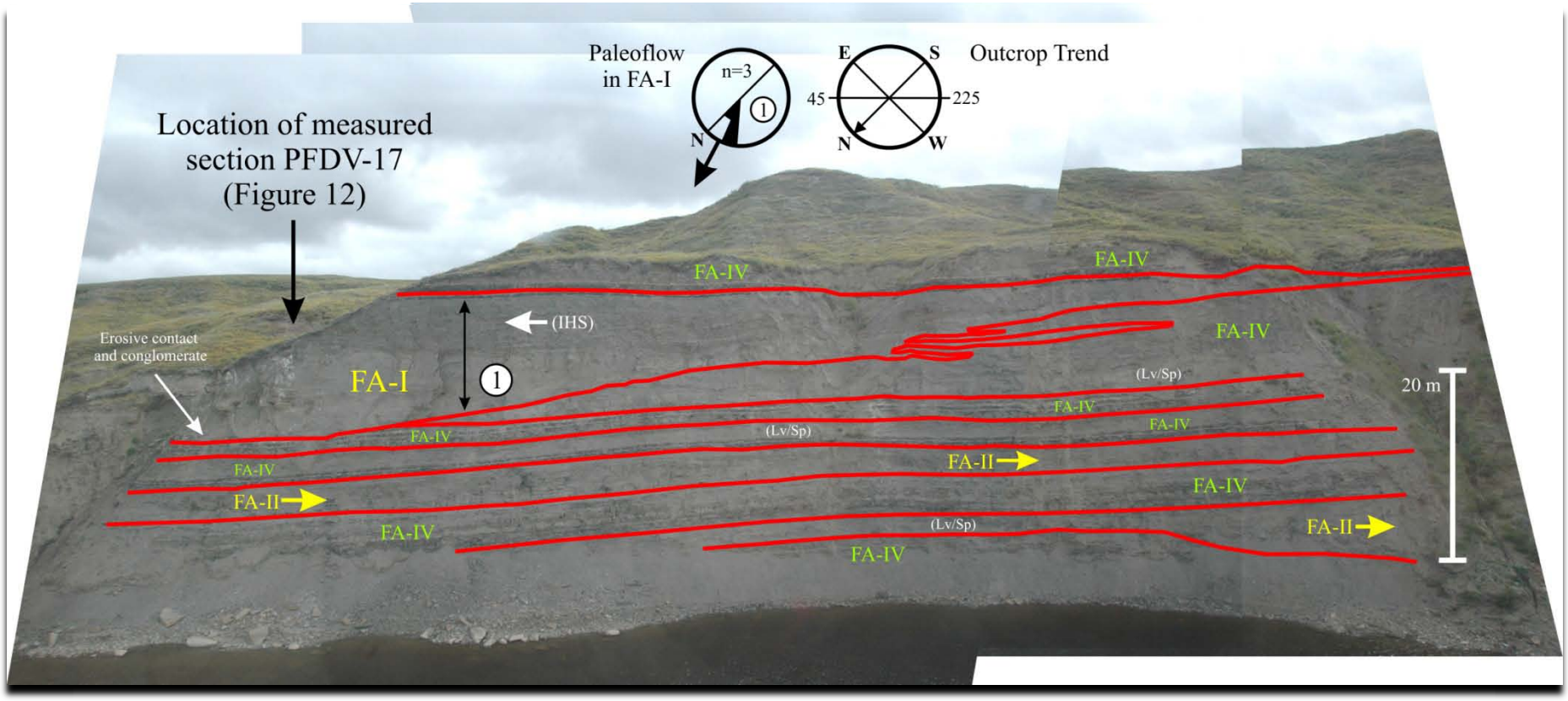
Jarosite mottling in acid sulphate soil (Mitch Tulau)

Estuarine soil in Australia

Modern Inceptisols/Entisols/Potential Acid Sulphate Soils

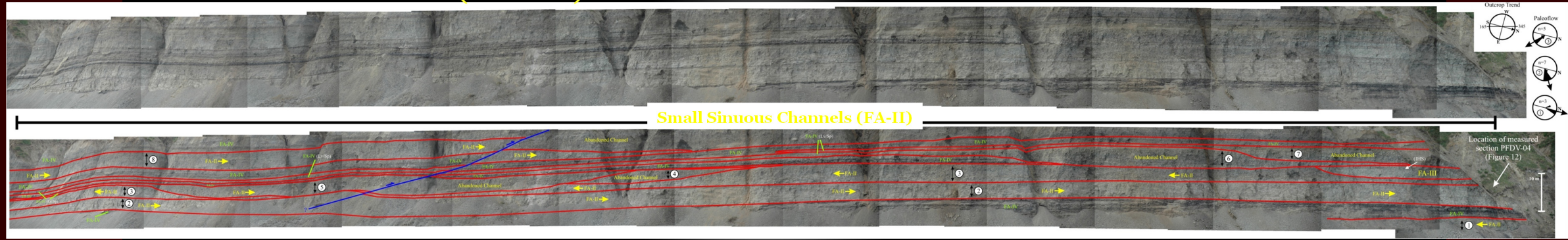
Alluvial Architecture

Large Sinuous Channels (FA-I)



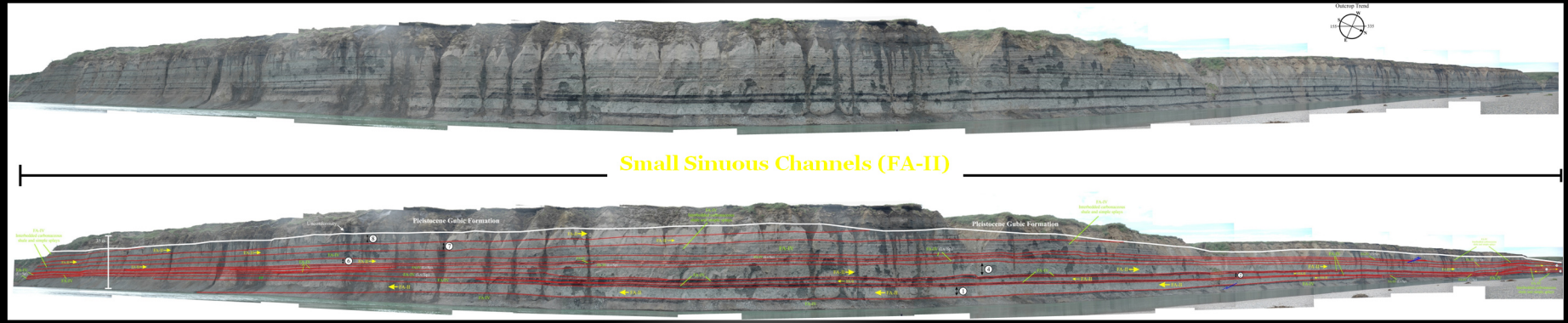
Rare and regionally-restricted

Small Sinuous Channels (FA-II)



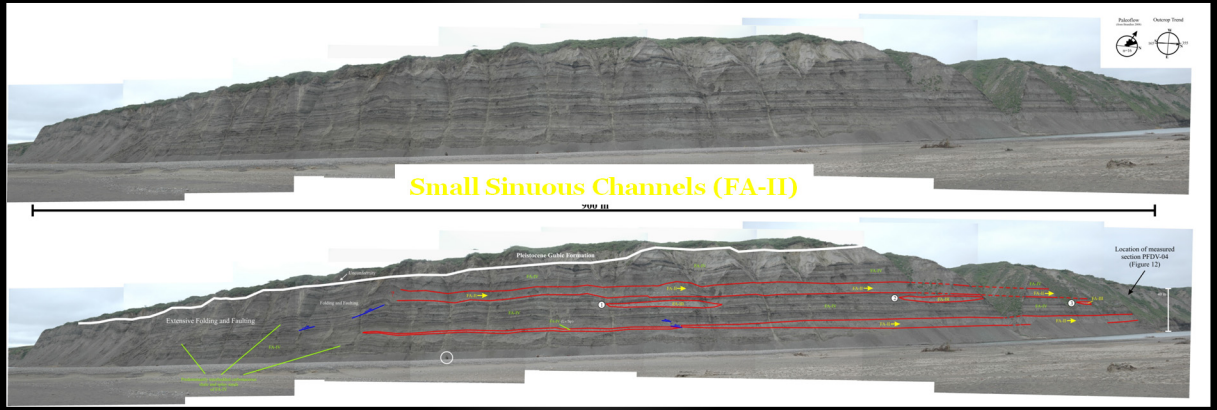
Most common channel-form

Small Sinuous Channels (FA-II)



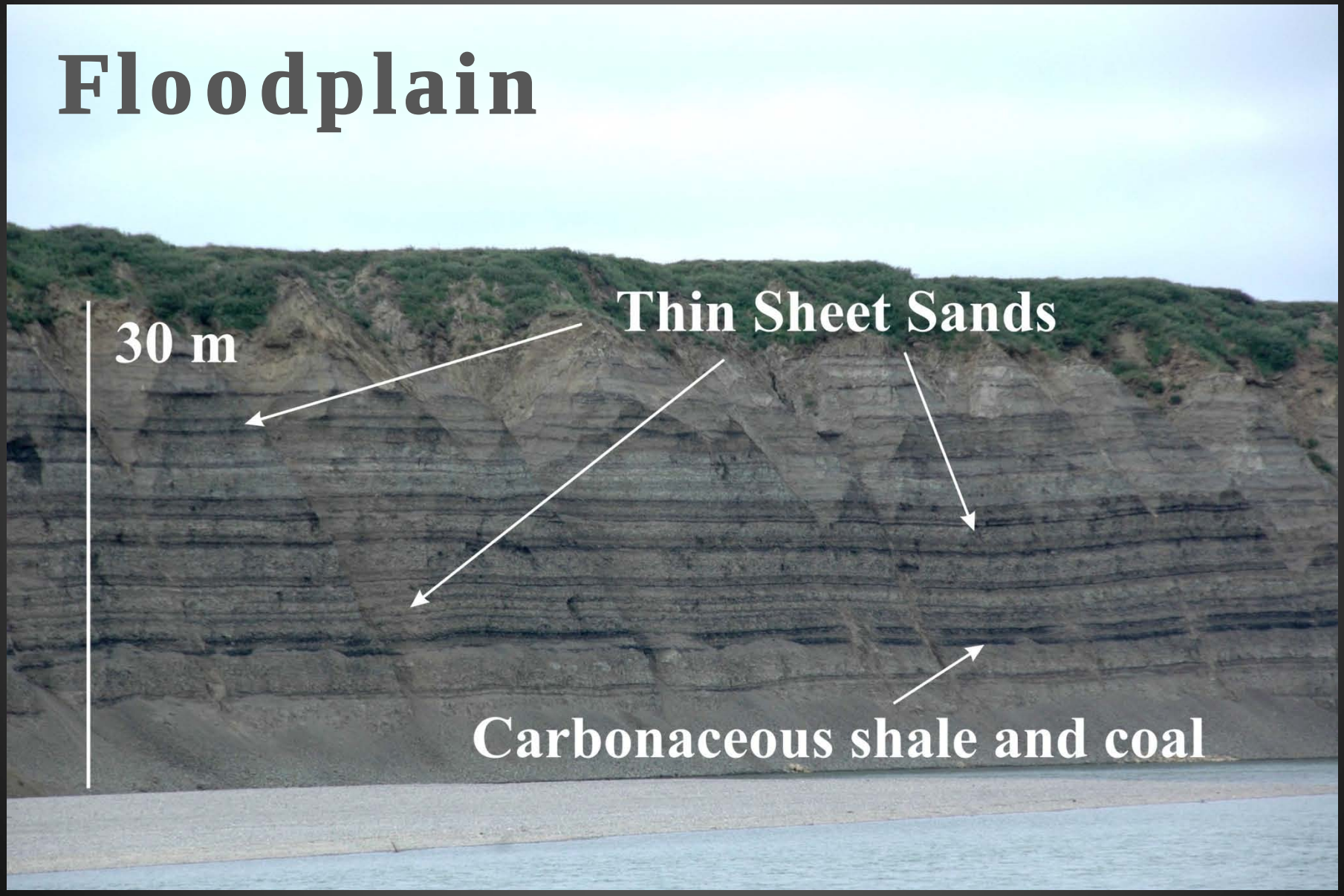
Deposits appear lenticular along strike

Small Low Sinuosity Channels (FA-III)



Incise into meandering distributaries or floodplains

Interbedded Sandstone, Siltstone, Mudstone (FA-IV)

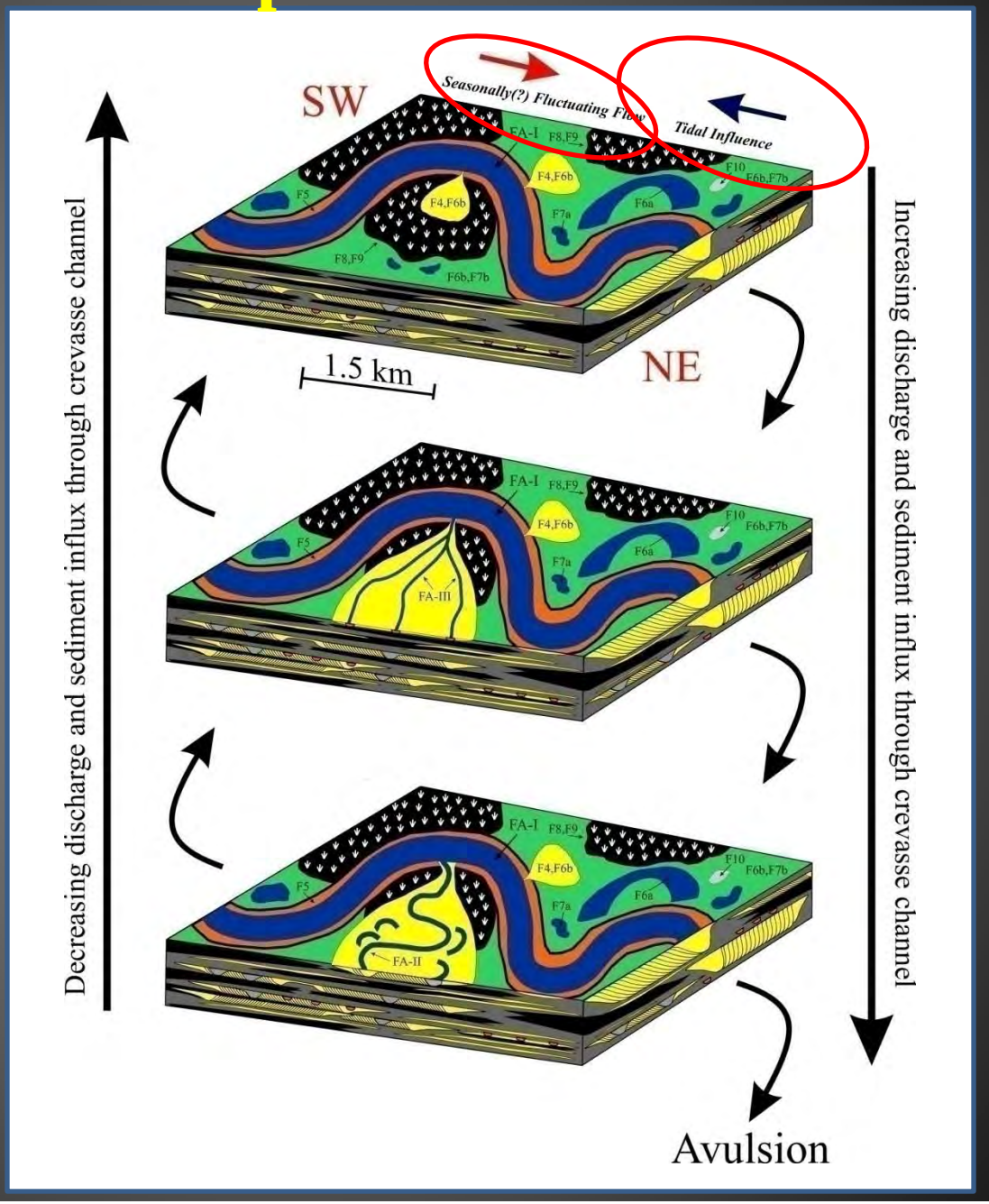


Depositional Model

Trunk Channels

Distributary Channels on Crevasse Splay Complexes

Organic-rich floodplains



Conclusions:

- Channels
  - Larger first-order meandering trunk channels (rare)
  - Smaller second-order meandering distributary channels
  - Small third-order anastomosed(?) distributary channels
- IHS (rhythmically-repeating sand/mud couplets) in channels suggest tidal influence on system (abundant jarosite, pyrite, and brackish-water fauna also indicate proximity to marine waters)
- Floodplain Depositional Environments:
  - Small-scale crevasse splays
  - Levees
  - Lakes, ponds, swamps, ashfall deposits
  - Paleosols

Conclusions: Paleosols and Pollen

-Paleosols:

- Weakly-developed, cumulative to compound soils
- Frequent influx of material into soils
- Predominantly waterlogged
- Drying-out of parts of the floodplain
- Marine influence
- Similar to modern Entisols, Inceptisols, and Potential Acid Sulphate soils

- Depositional Model

-Meandering trunk channels with distributary channels forming crevasse-splay complexes that alternate with organic floodplain facies

Thank You !

Three Field Seasons
30+ individuals
Logistical Support

NSF grants:
OPP-0425636 to Paul McCarthy
OPP-424594 to Anthony Fiorillo
Also David LePain, Paul Layer

The Geist Fund at the University of Alaska Museum of the North

The Alaska Geological Society

The Geological Society of America

The Evolving Earth Foundation

The University of Alaska Graduate School Fellowship Program

British Petroleum

Dolores van der Kolk