Signature of Climate Control in Early Eocene Fluvial Channel Systems*

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Abstract

Here we document climate control signature in lower Eocene fluvial-lacustrine succession of the Uinta Basin, Utah, USA. A distinct feature of the lower Eocene river deposits is that in many stratigraphic intervals; the river channels are filled with sandstones with dominantly gradational plane-parallel or climbing-ripple lamination, convex-up low angle bedforms, with only a minor (5-10%) cross stratification that in most cases is the most common feature of sandy river deposits. These sandstones are organized into simple, thick, dominantly downstream accreting barforms, based by significant erosion surfaces. All these features indicate very high deposition rates, generally not expected in rivers, but rather in environments of rapid accumulation like deltaic mouth bars or deepwater turbidite fans. Moreover, these channels are large (up to tens of meters deep), and vertically as well as laterally amalgamated. The lateral and vertical channel amalgamation demonstrates high frequency of avulsions. Stratigraphic intervals with such river channels coincide with peaks of negative carbon 13 excursions, interpreted as peaks of early Eocene transient global warming events or hyperthermals. Other stratigraphic intervals are associated with initial negative and final positive shifts of the overall negative carbon 13 excursions, interpreted as onset and offset of the hyperthermals. These intervals coincide with stratigraphic sections of thick floodplain mudstones encasing small (up to a few meters deep), laterally partially amalgamated channels with infills that indicate high deposition rates, similar to the channels described above. However, these channels are small and indicate low peak discharge. Moreover, the thick floodplain mudstones indicate high fine-grained sediment production and storage. Yet other stratigraphic intervals exhibit more “normal” river deposition with migration of dunes, organized into complex downstream, lateral- and upstream-migrating barforms. Such rivers indicate significantly lower deposition rates, as well as notably more stable water supply. We show that the combination of high-erosion and high-deposition rates is characteristic for climate-controlled river systems, and it suggests that this Greenhouse world fluvial succession displays climate controls that produce a distinct stratigraphic record and a distinct type of fluvial reservoirs.

References

Castle, J.W., 1990, Sedimentation in Eocene Lake Uinta (Lower Green River Formation), northeastern Uinta Basin, Utah, *in* B.J. Katz, (ed.) Lacustrine basin exploration – case studies and modern analogs: AAPG Memoir 50, p. 243-264.

Taylor, A.W., 2002, Sedimentology, facies architecture, and reservoir characterization of lacustrine rocks, Eocene Green River and Colton Formation, Uinta Basin, Utah: M.S. Thesis, Utah State University, Logan, Utah, 137 p.

Website

Geographic Guide, North American image: Web site accessed 12 June 2012. http://www.geographicguide.com/north-america-image.htm

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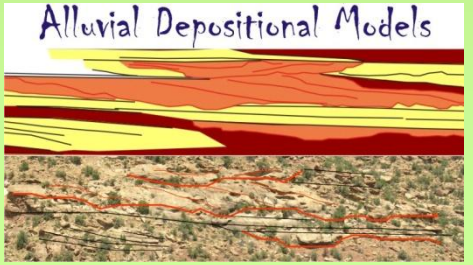


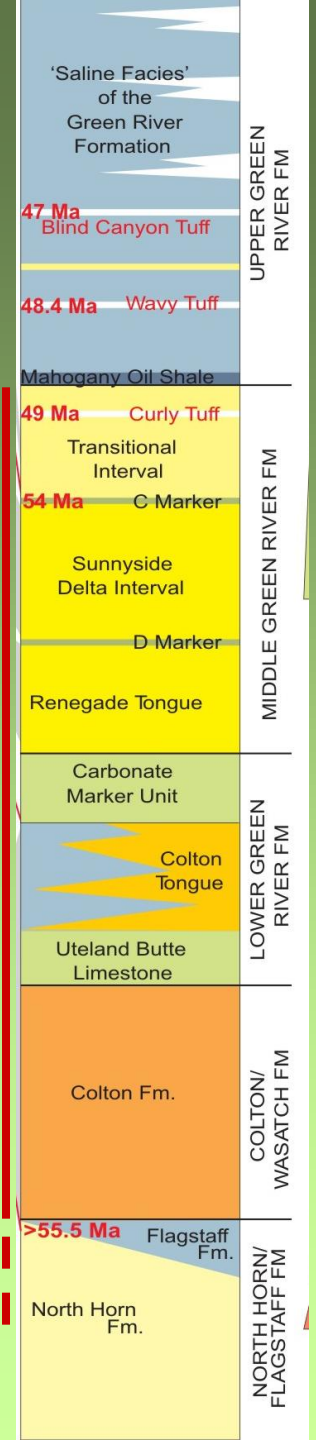
FOCUS:

- Nature of fluvial channels
  - Detailed sedimentology/stratigraphy
  - Stable carbon isotope analyses
  - Paleosol analyses
  - Continental trace fossil analyses
- The controls on deposition
- Especially the effects of climate seasonality

DATASET:
Lower Eocene Wasatch and Lower-Middle Green River Fm., Uinta Basin, UT

Satellite image of North America from
http://www.geographicguide.com/north-america-image.htm

Map based on
Castle (1990) and Taylor (2002).



"Strange" channel fills?

Sedimentary structures:

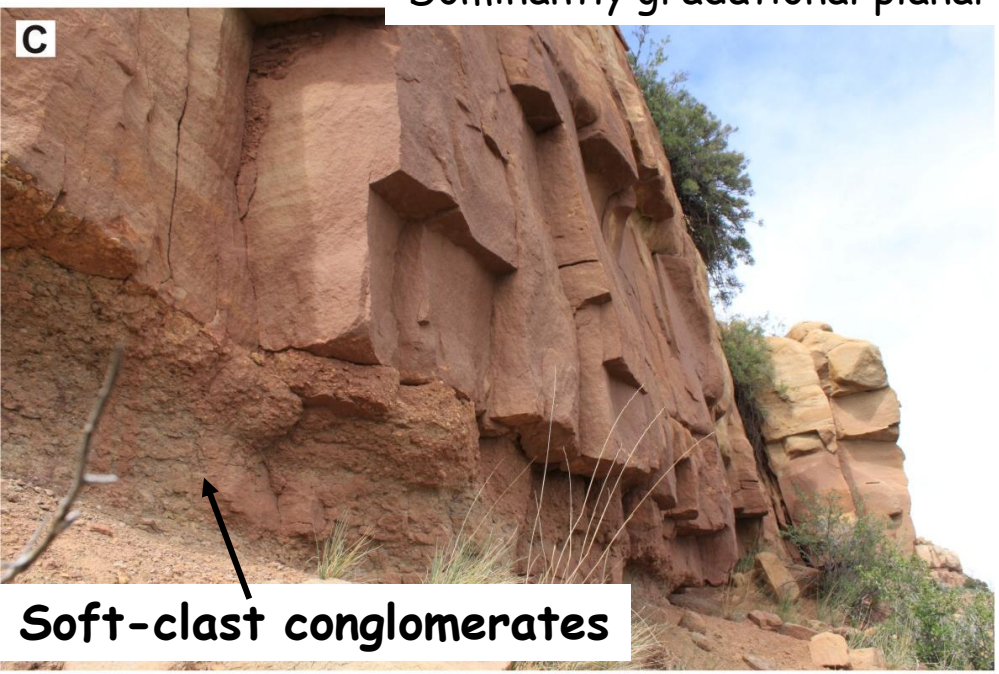
- Dominantly gradational planar-laminated sandstones

"Strange" channel fills?

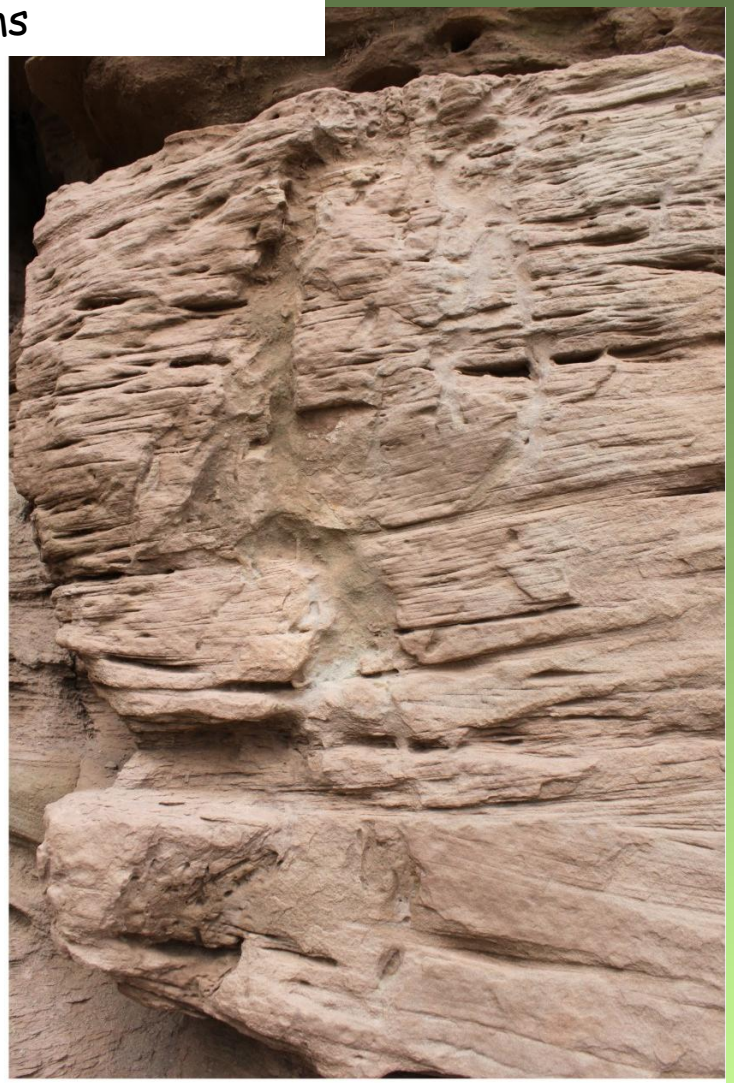
Sedimentary structures:

- Dominantly gradational planar-laminated sandstones
- +aggradational convex-up low-angle bedforms
- +climbing ripples
- +structureless sandstones
- +soft-clast conglomerates
- +minor cross-stratification (5-10% of observed volume)

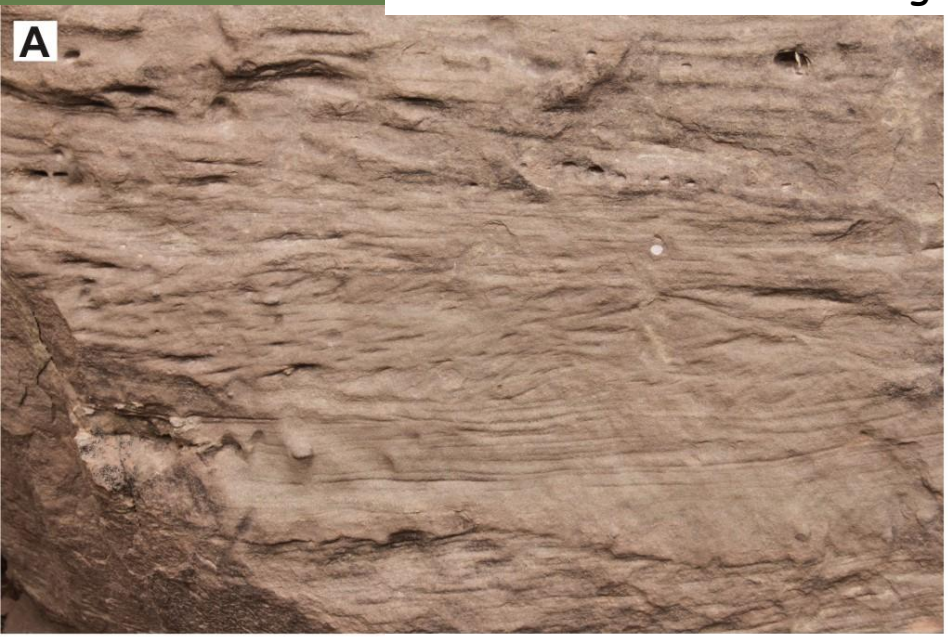
Dominantly gradational planar-laminated sandstones



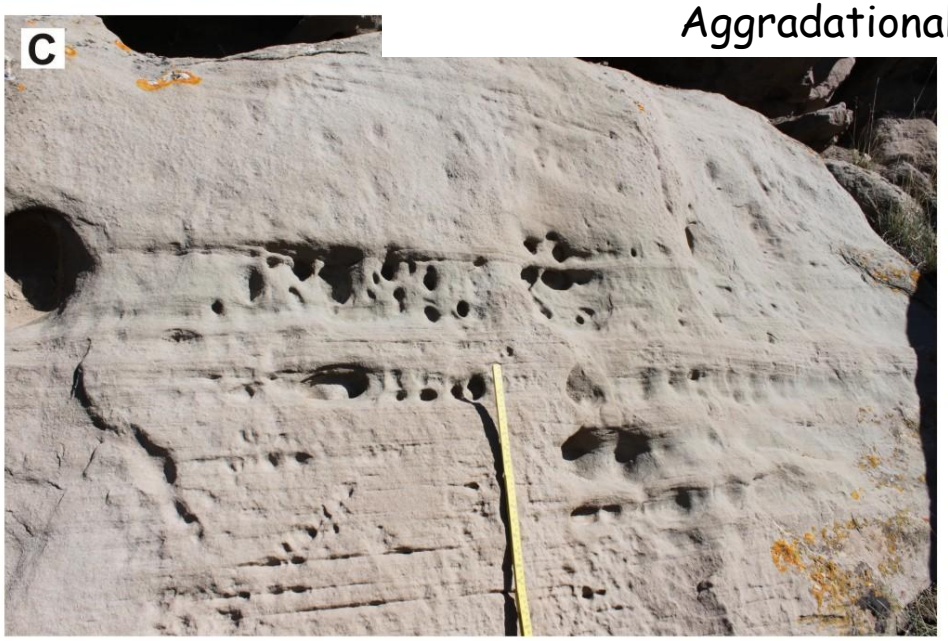
Aggradational bedforms



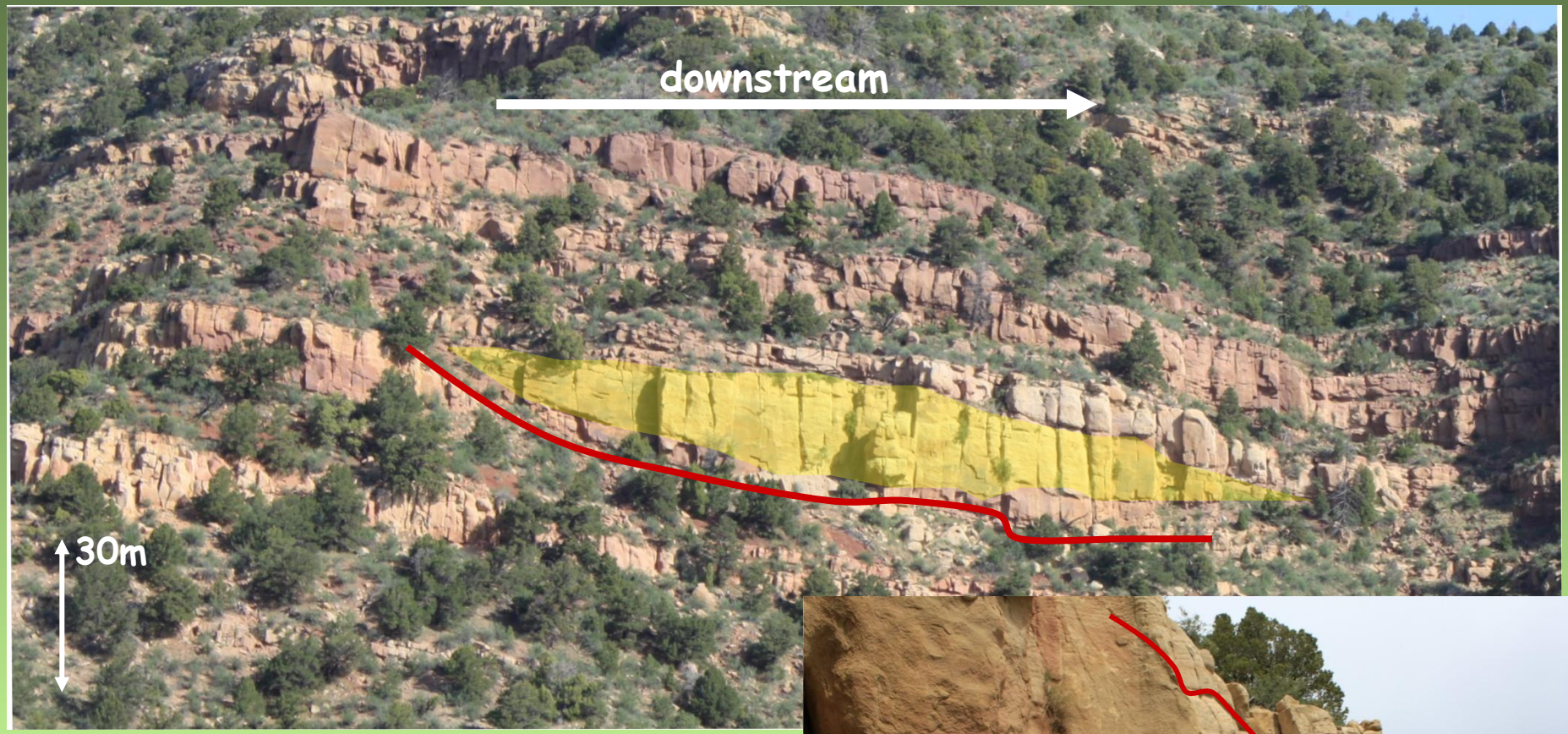
Climbing ripples



Aggradational bedforms



"Strange" channel fills?



Geometry:

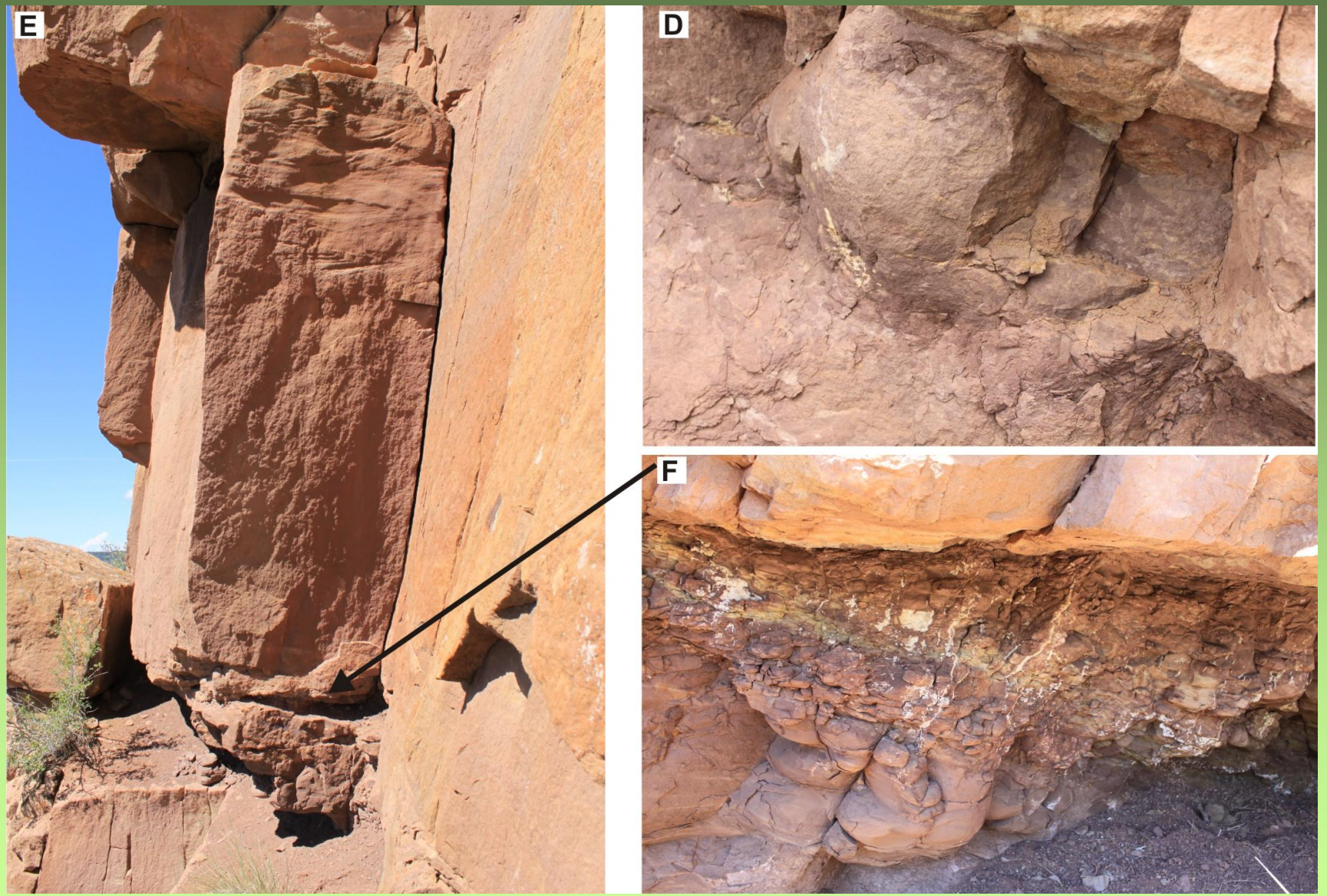
- erosion depth several to 10s of meters
- multiple internal erosion surfaces
- thick, convex-up low-angle barforms with dominantly downstream accretion sets
  + some lateral and upstream accretion

"Strange" channel fills?

Bioturbation:

- Biturbation within channels on bar surfaces

"Strange" channel fills?



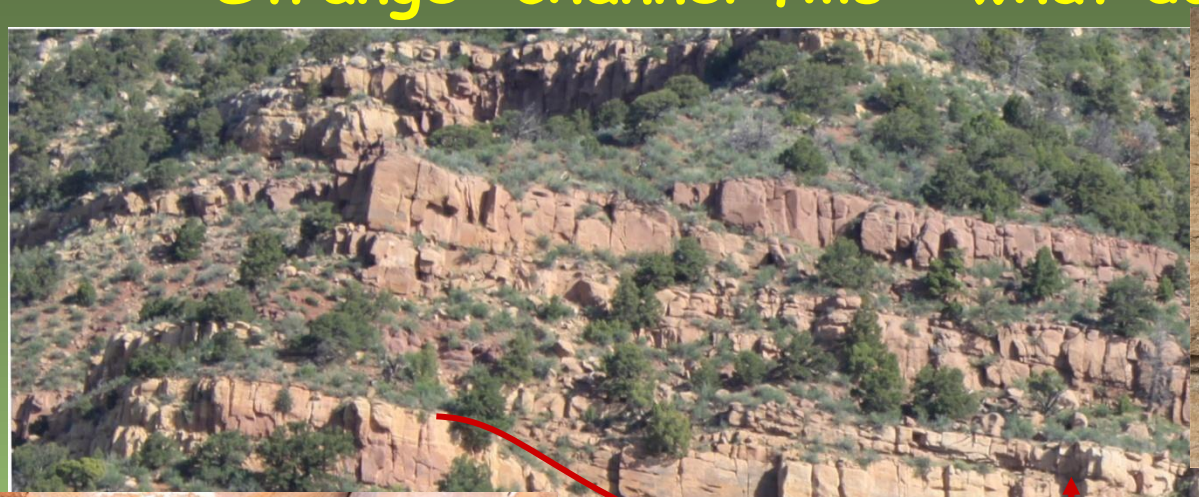
Bioturbation and palaeosols:

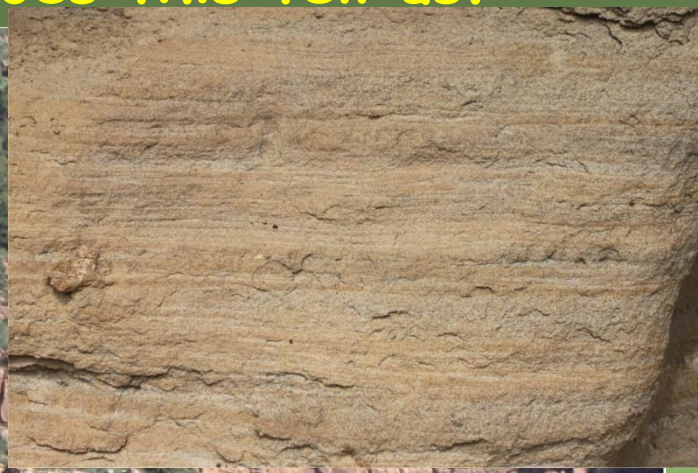
- Palaeosols within channels on bar surfaces

Architecture:

- Laterally and vertically amalgamated

"Strange" channel fills – what does this tell us?





Interpretation:

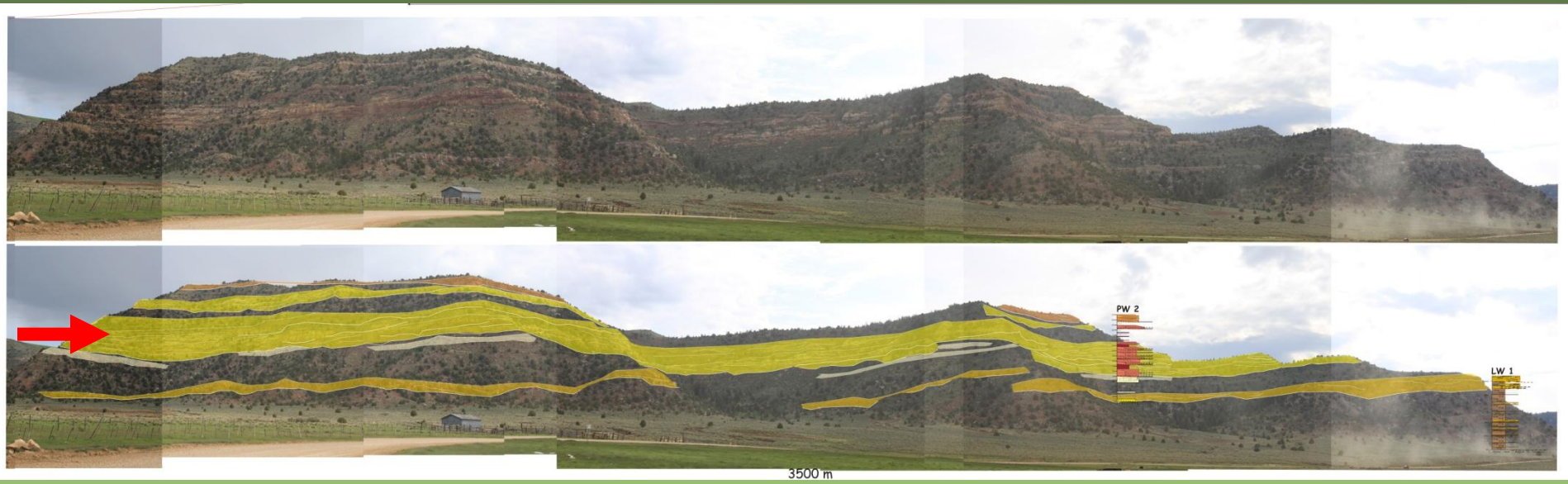
- Intense erosion
- Extremely high deposition rates
- Sustained pauses in deposition
- High avulsion rates

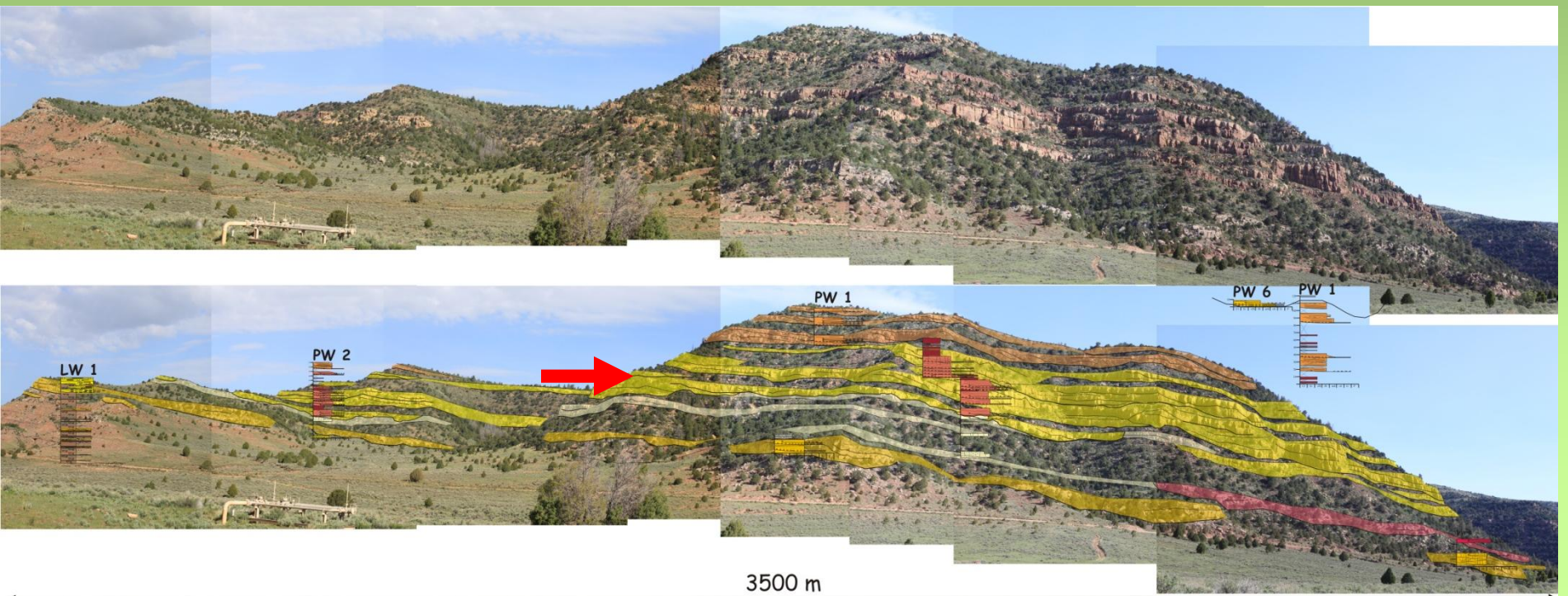
CONCLUSION 1:

- High deposition rates – high sediment load
- Deep erosion - extremely high water discharge
- = Intense seasonal precipitation
- Sustained pauses in deposition – river beds dry
- = Sustained aridity (droughts)

➔ Intense seasonality (monsoon)

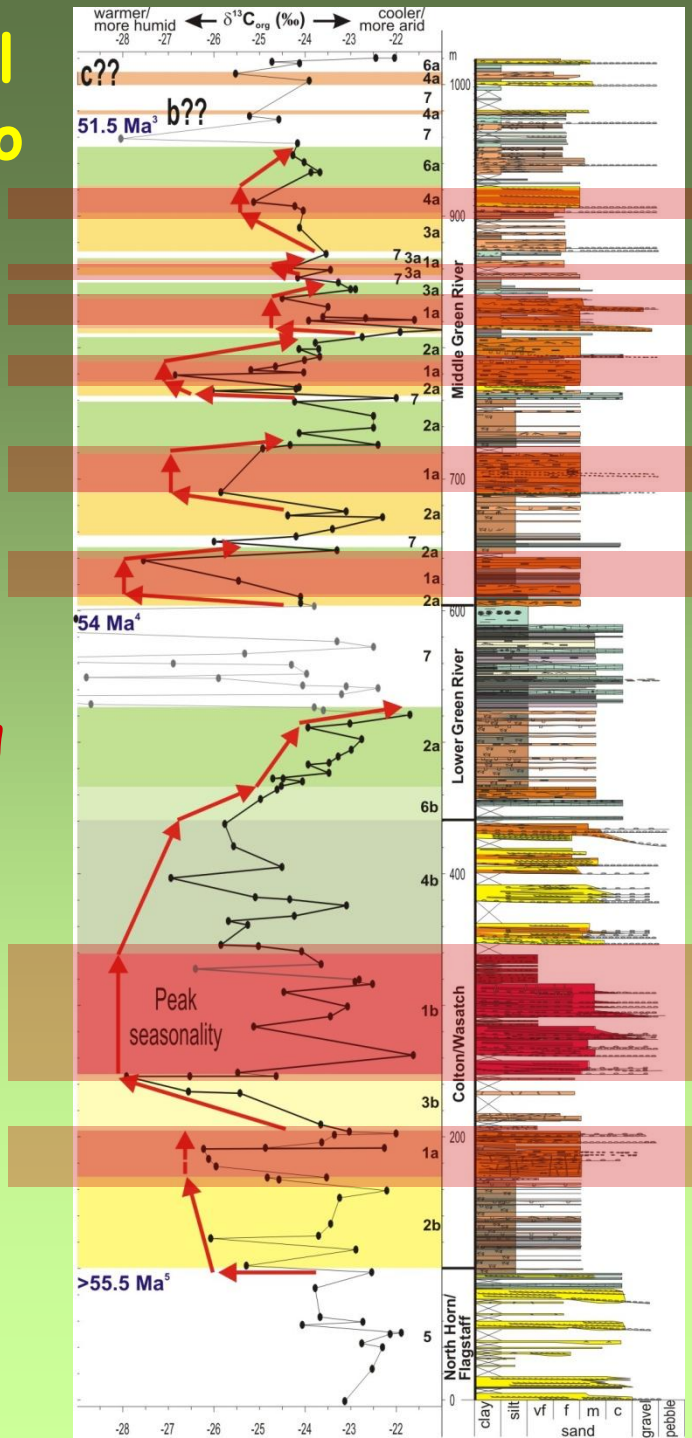
Such channel belts are continuous = stratigraphic changes

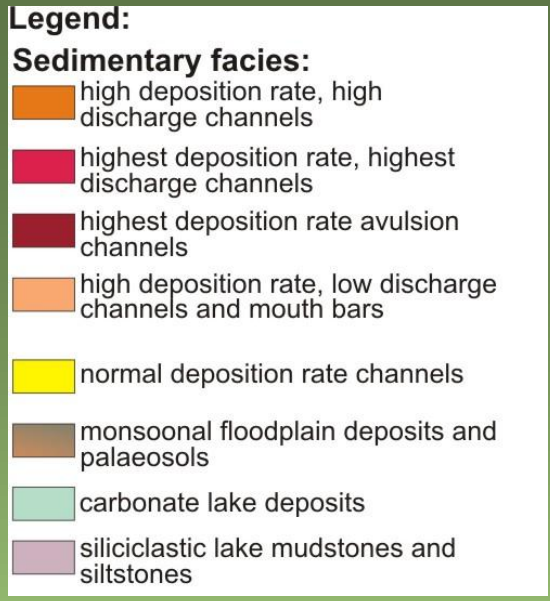




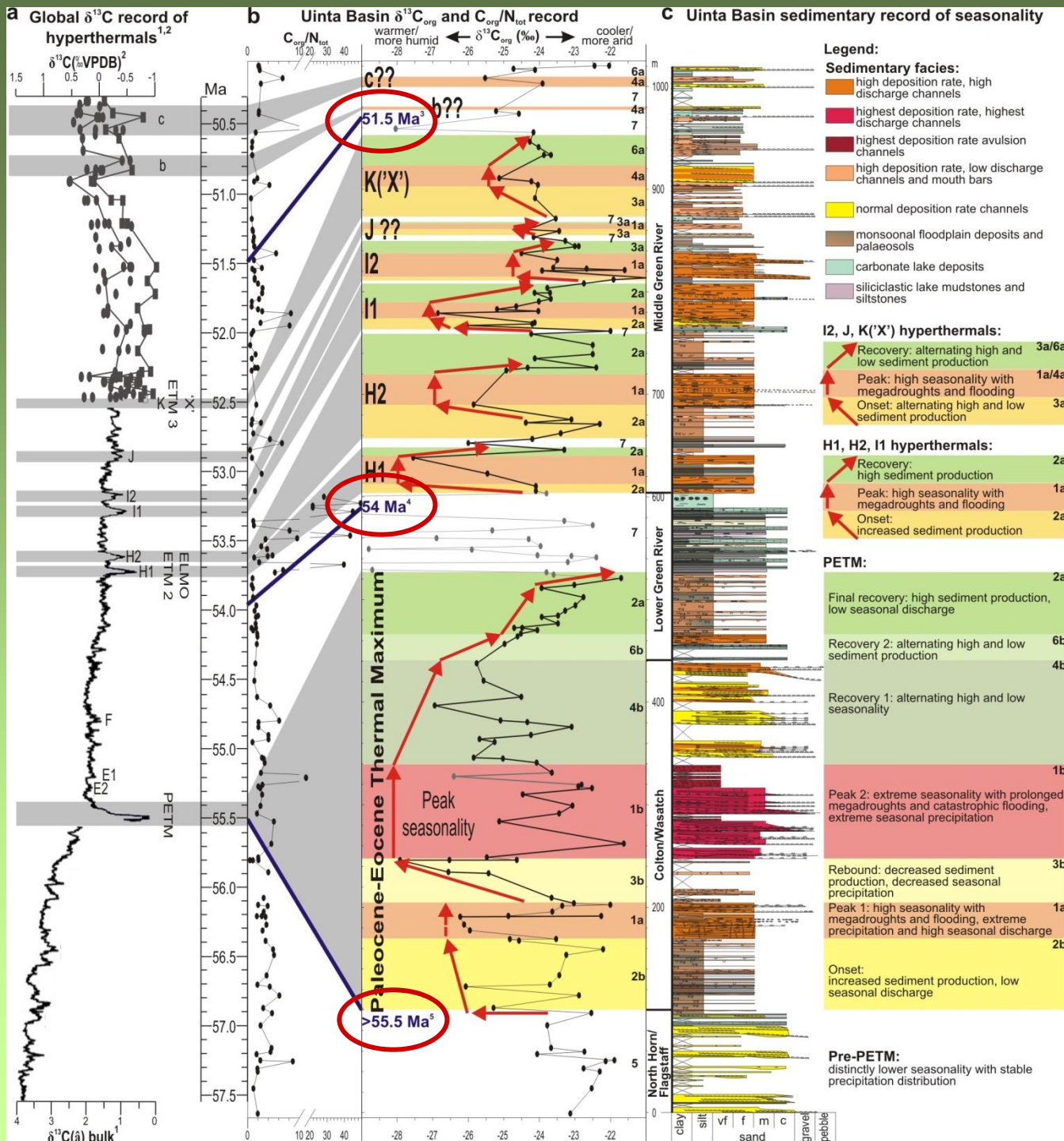
"Strange" channel fills correspond to negative $\delta^{13}C$ excursions

Deposition during transient global warming events?

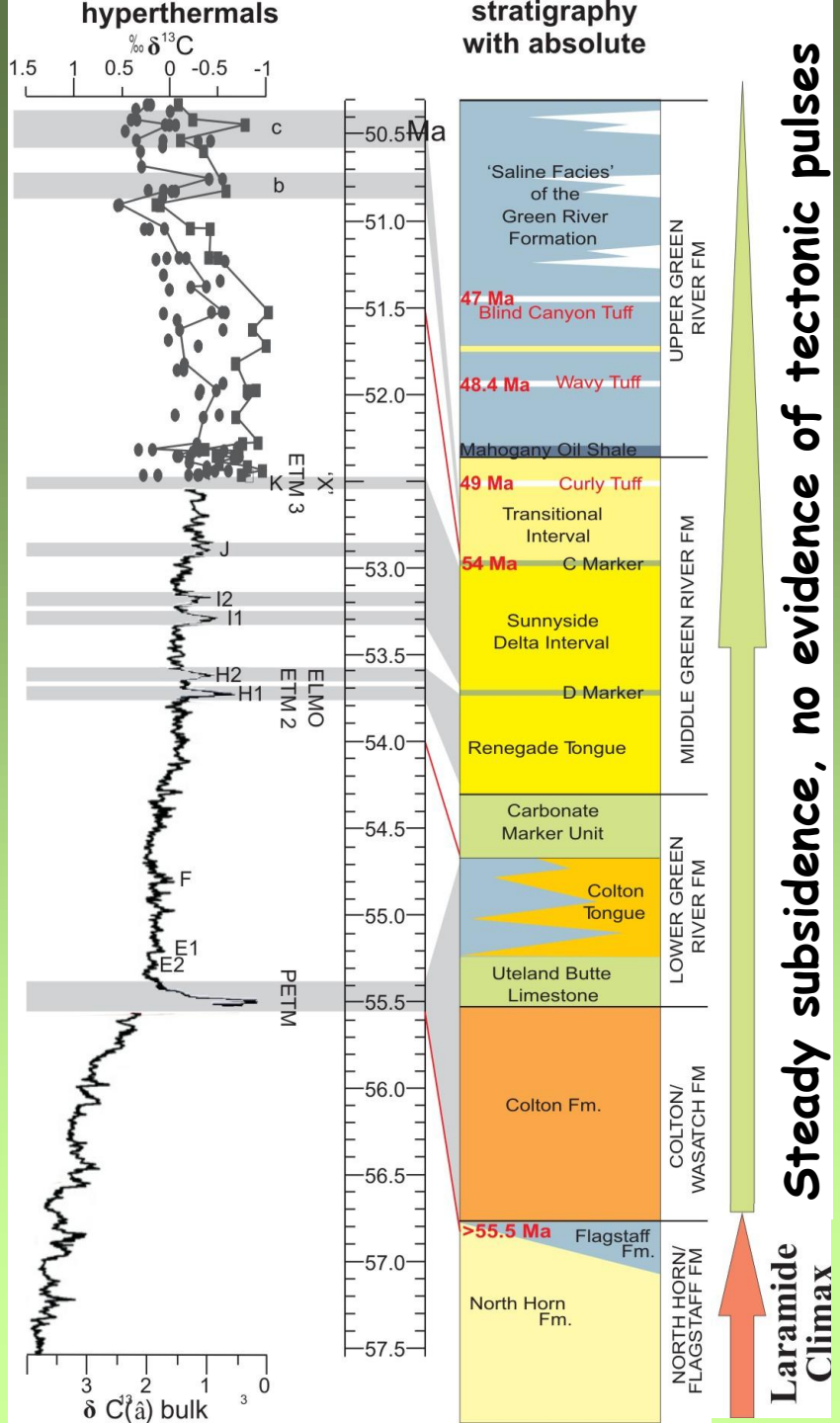




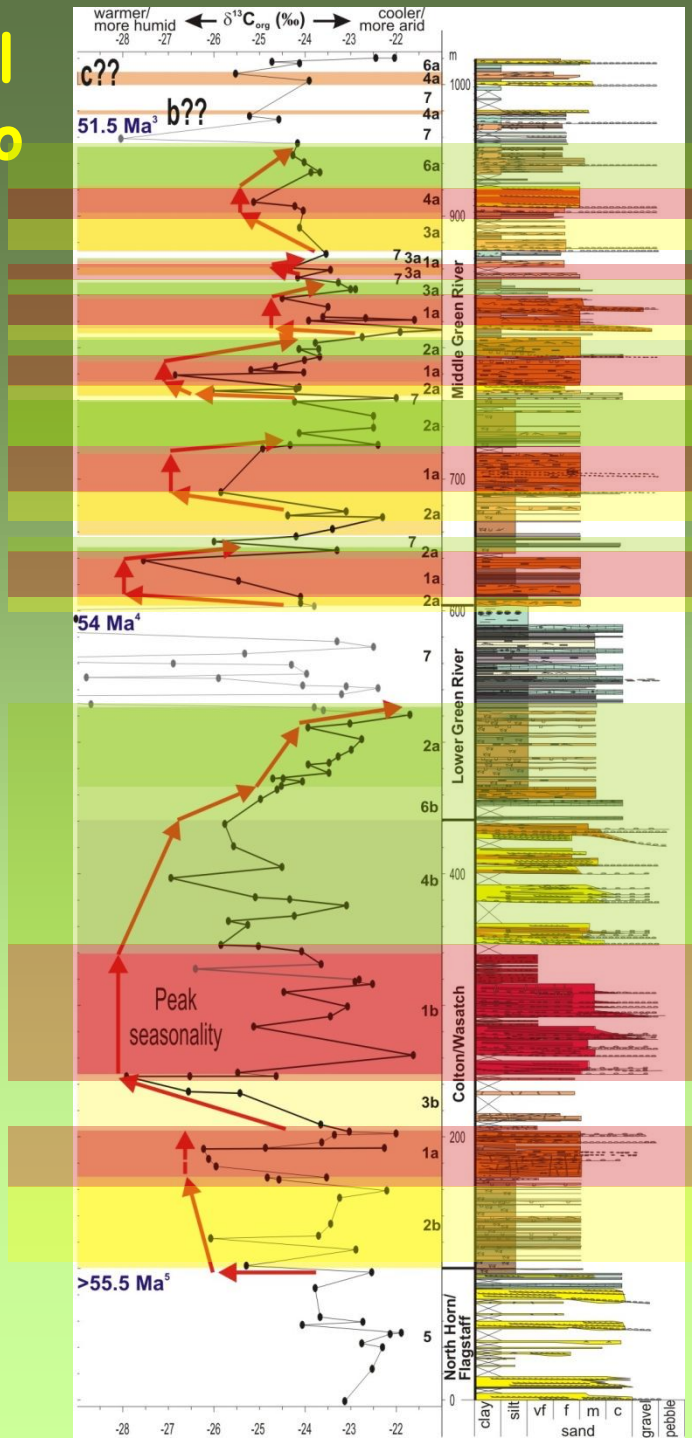
Correlate with global data on Early Eocene hyperthermals

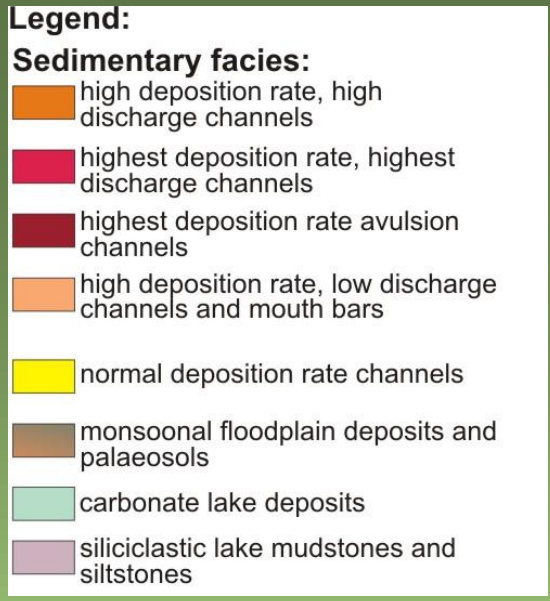


Possible tectonic controls?



"Strange" channel fills correspond to negative $\delta^{13}C$ excursions





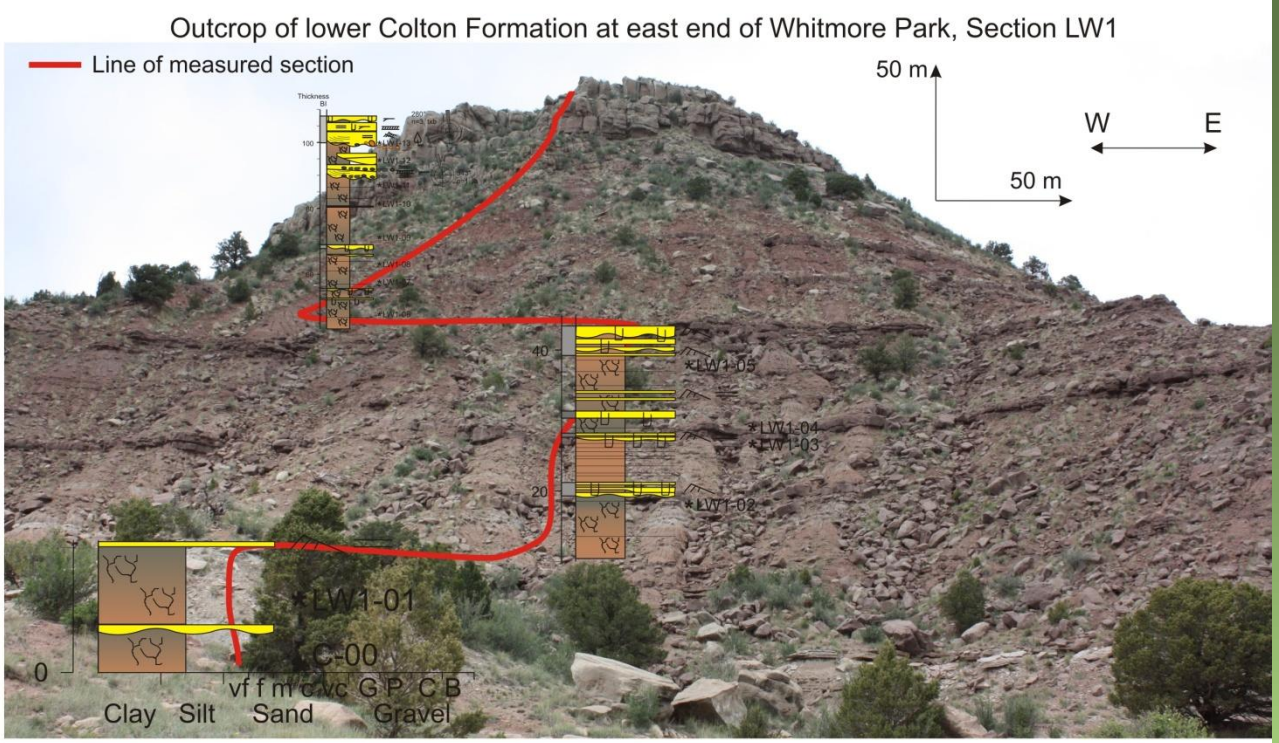
Channels in Onset/offset intervals?

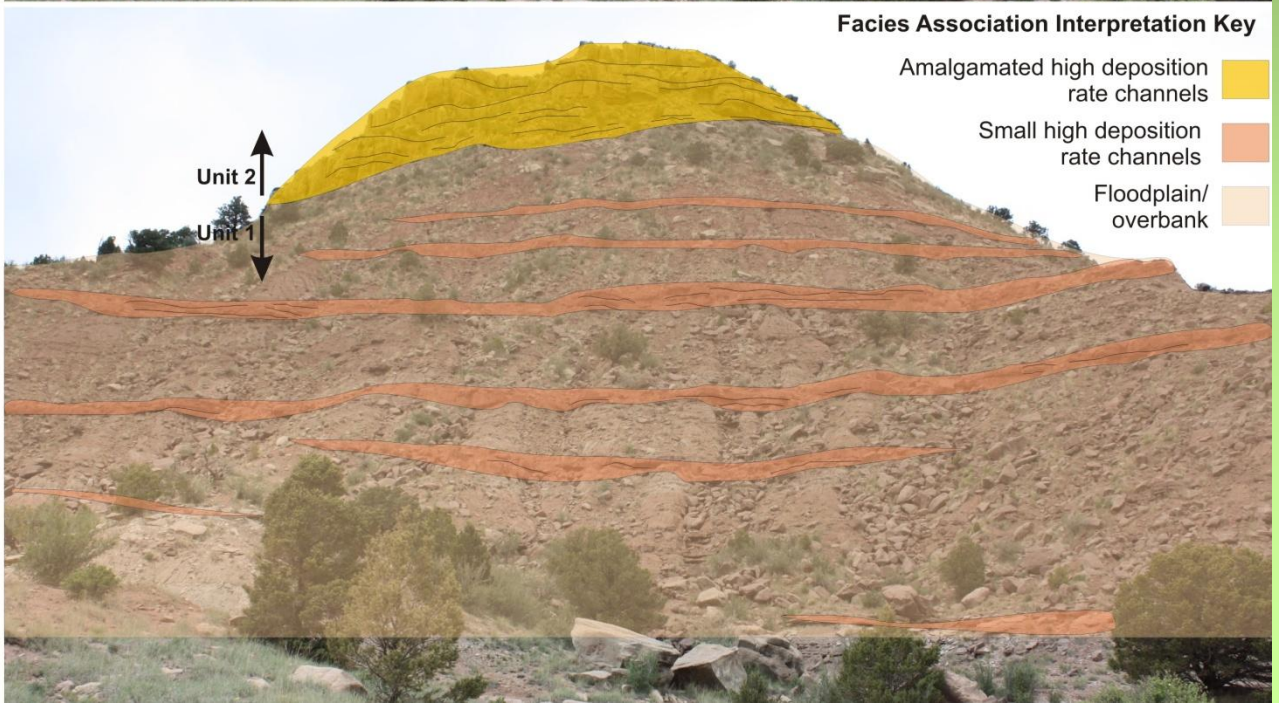
Onset/offset

- Small channels
- Gradational planar laminations; climbing ripples

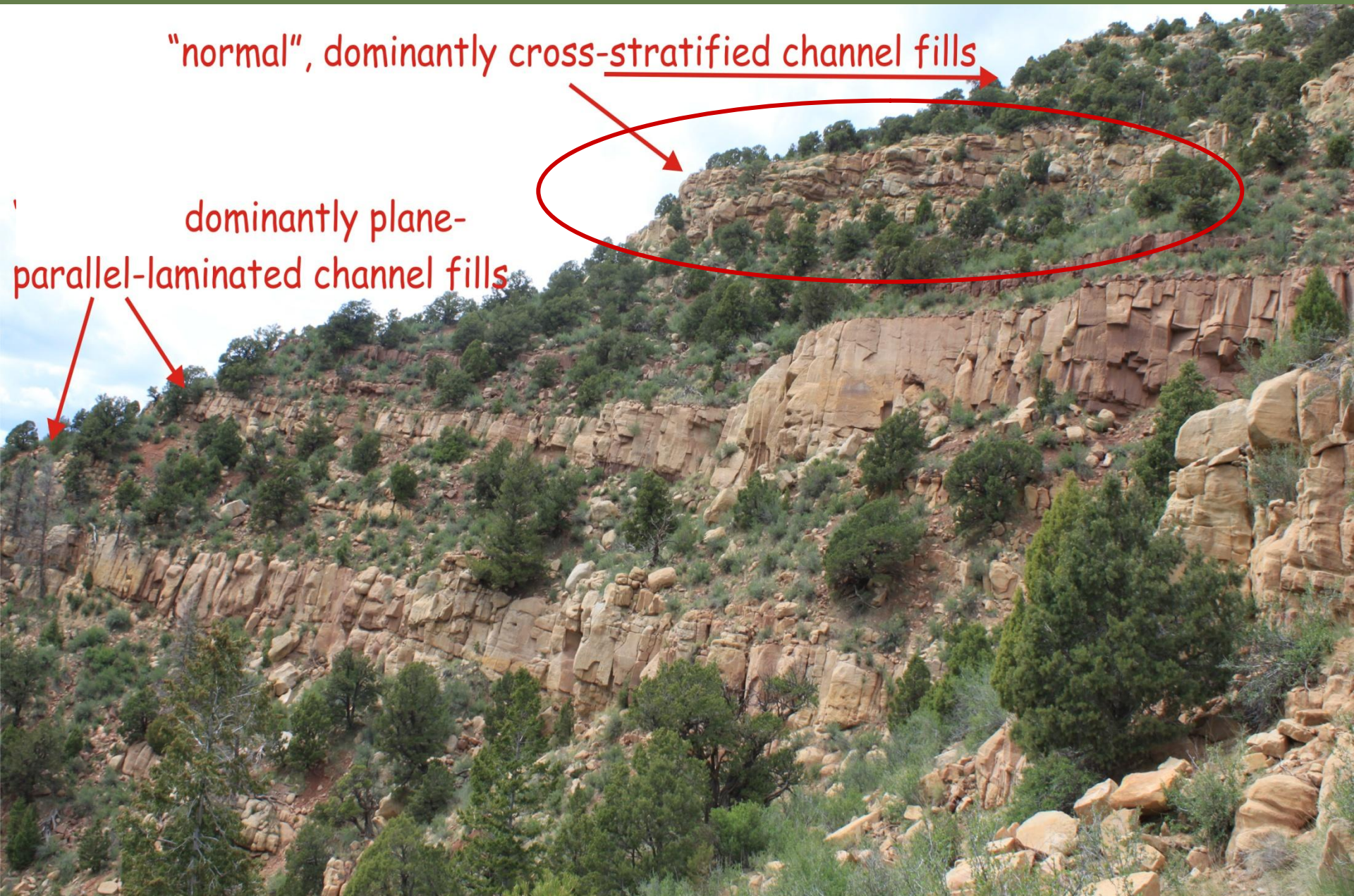
- Simple barforms
- Laterally relatively amalgamated
- Vertically distinct
- Encased in floodplain fines

Seasonal climate, Low-seasonal discharge





"Normal" channel fills



"Normal" channel fills

Geometry:

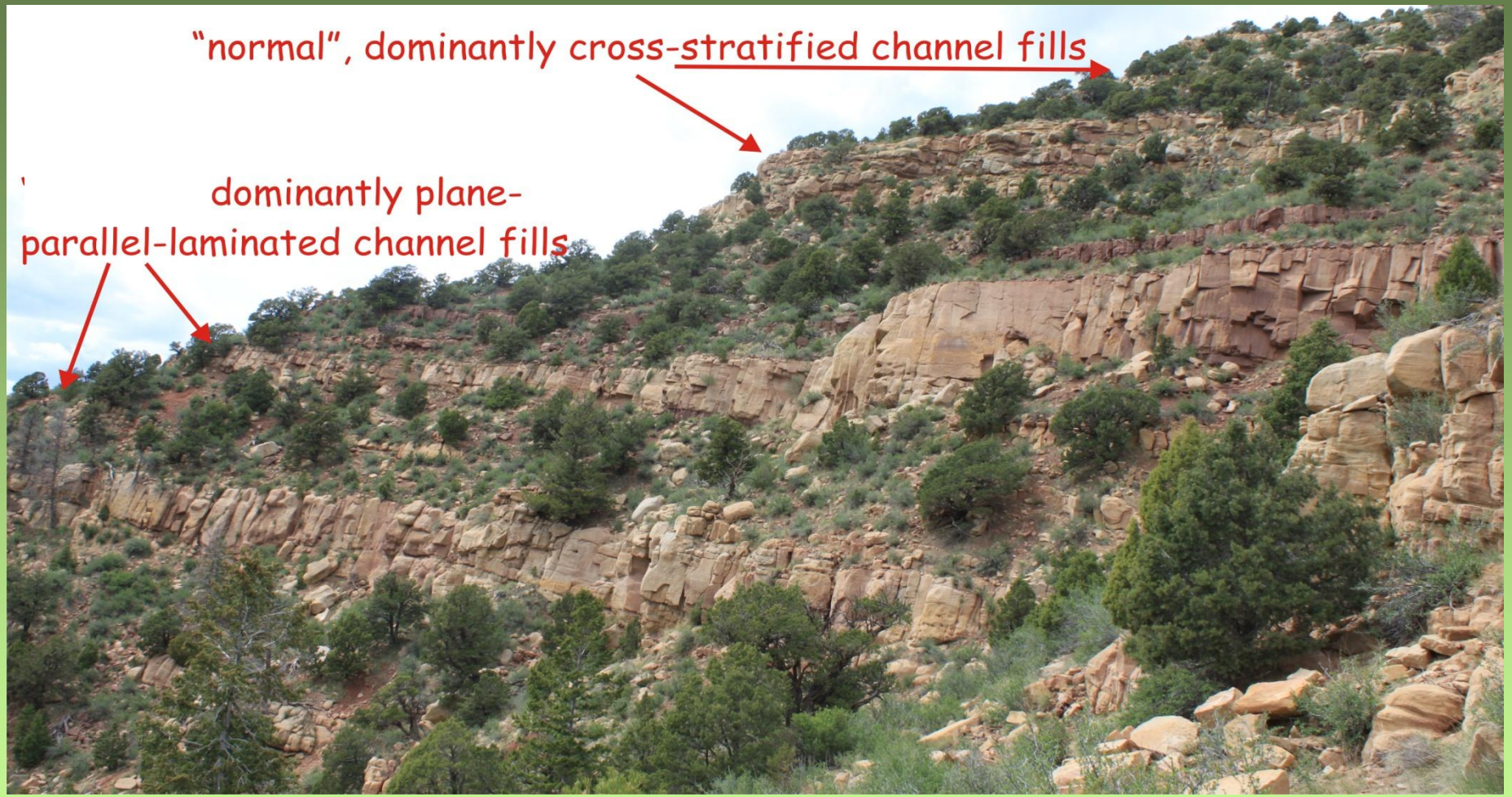
- complex, thin, lateral, downstream and upstream accretion sets

Sedimentary structures:

- dominantly cross-stratified sandstones
- +plane-parallel-laminated sandstone
- +ripple-laminated sandstones

Planar-laminated sandstone

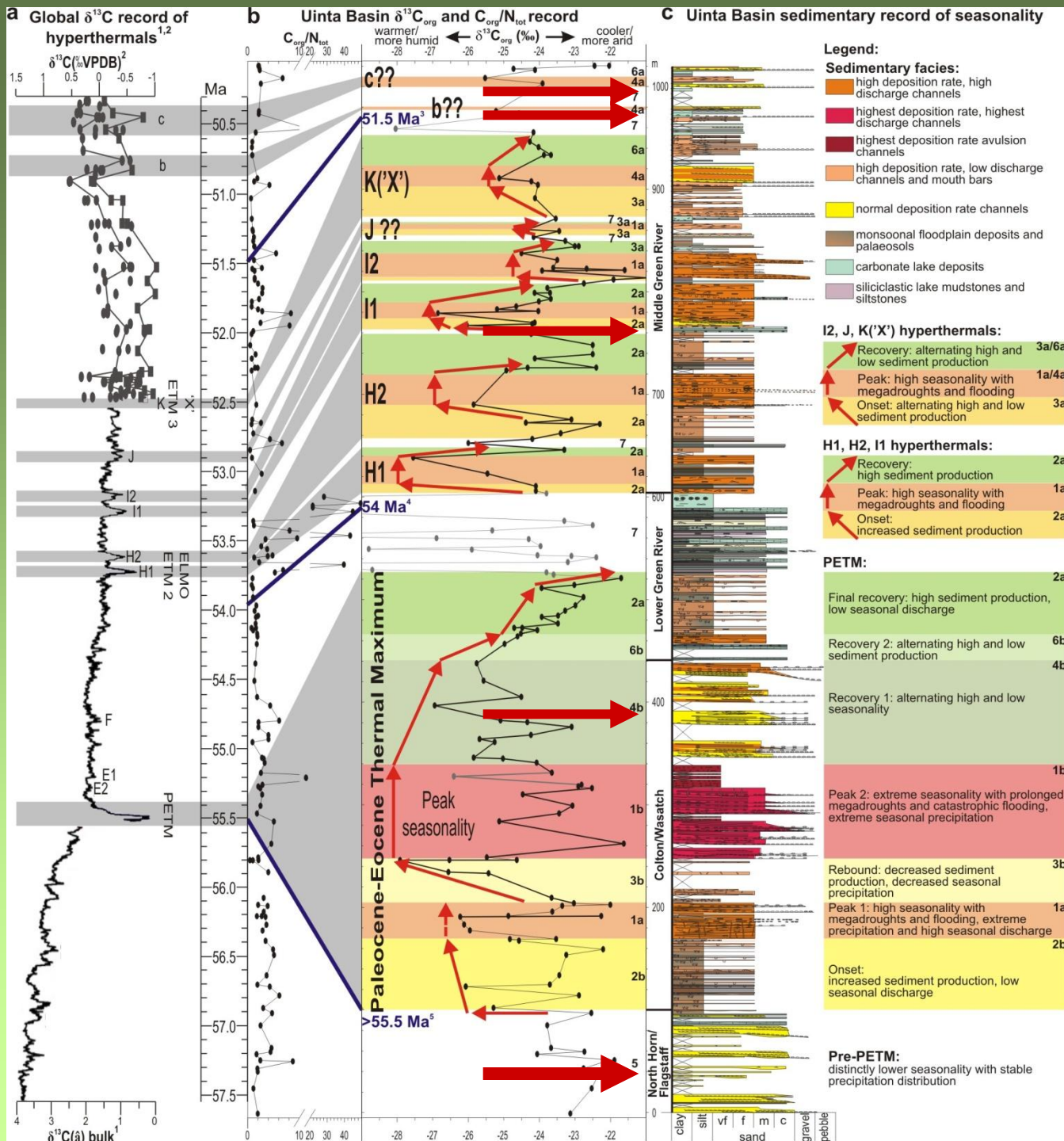
"Normal" channel fills



Interpretation:

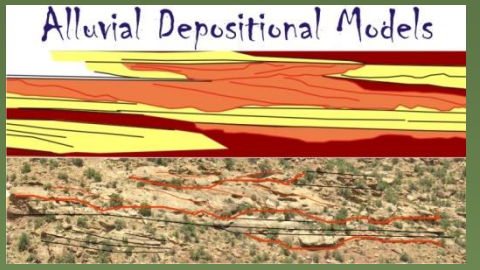
- Lower erosion rates
- Lower deposition rates
- More steady water supply

"Normal" channel fills correspond to non-hyperthermal conditions, Onset/offset of the youngest hyperthermals, offset of the PETM



CONCLUSION 2:

- Fluvial channel fills clearly reflect climate seasonality, as well as peak-discharge changes
- High-erosion rates combined with high-deposition rates – a characteristic feature of climate (high-seasonal discharge) controlled fluvial channels
- However: occur only in rivers with mountainous hinterland – need high-sediment supply & high runoff



QUESTIONS?