Channel and floodplain dynamics in the Cambrian Illinois Basin

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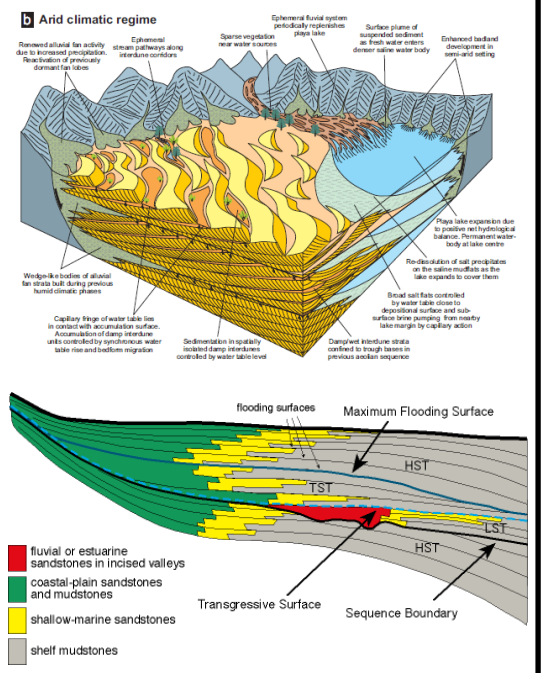
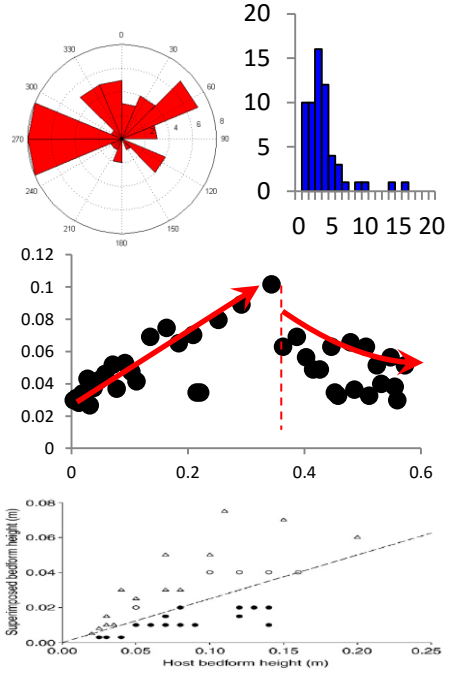
U.S. DEPARTMENT OF ENERGY | Office of Science

1-Conceptual models



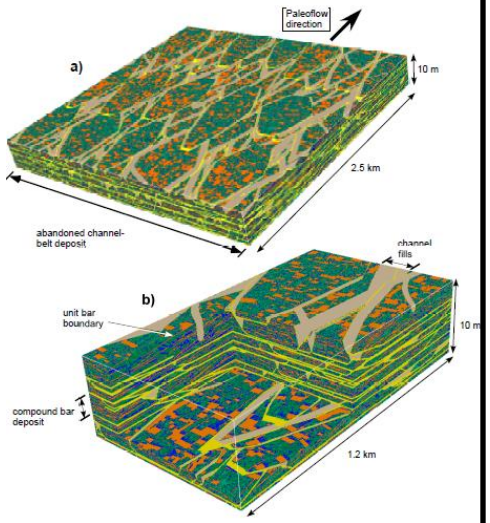
Papers: Webb, Monson, Reesink

2-Statistical characterisation



Papers: Pendleton, Ghose, Reesink, Freiburg

3-Geo-cellular models



Deliverables / products, now aimed at micro-seismicity

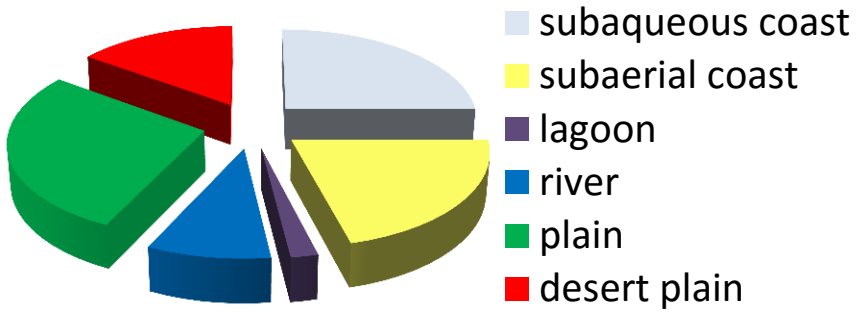
Geological Storage of CO2 - key questions :

- CO2 plume movement
- Position and movement of pressure front & microseismicity
- Geo-cellular models of petro-physical properties
- Characterisation of grain-scale heterogeneity

70 m interval of 2.5 km deep core

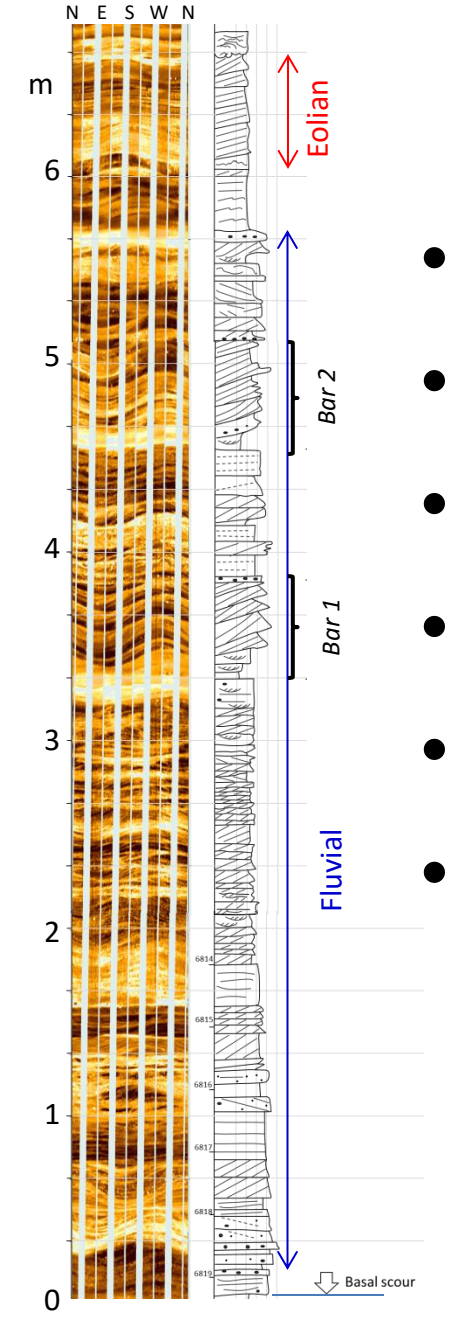
Multiple environments:

- Desert dunes
- Splay deposits
- **Planar crinkly strata**
- **Fluvial channel**
- Lagoon – fine grained
- Shallow marine / foreshore
- Low-angle eolian deposits
- Shoreline, rounded sediment

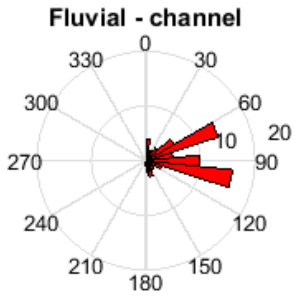


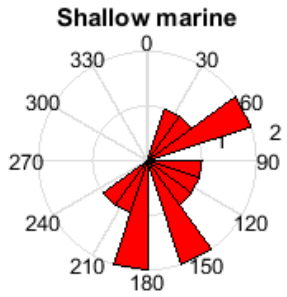
Roughly a clock-wise development

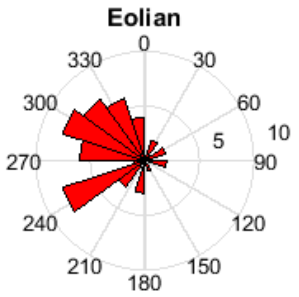
River channel



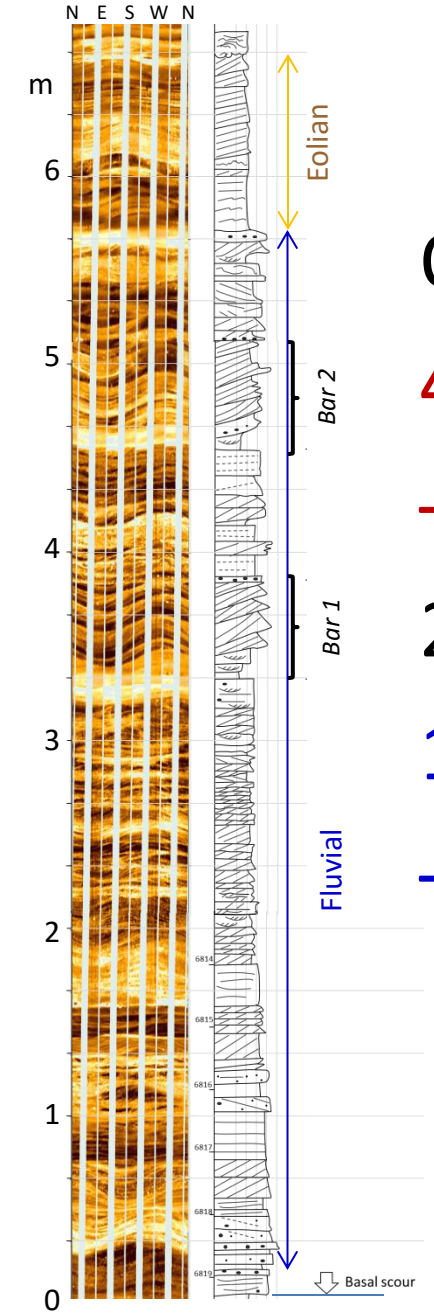
- Coarse base, 5 units, 3 fining upward
- Mostly dune sets, some ripple sets
- No distinct vertical thinning of sets
- 2 angle-of-repose bars on top
- Marine/coastal deposits below
- Planar strata & eolian dune deposit on top







River channel



Quantifying formative bedforms:

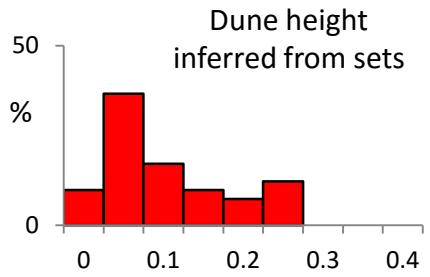
41 dune sets, mean 0.05 m

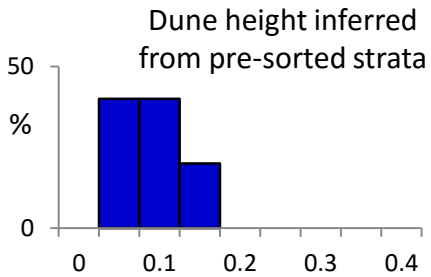
– indicates 0.12-0.21 m high dunes

2 bar sets 0.43 & 0.48 m

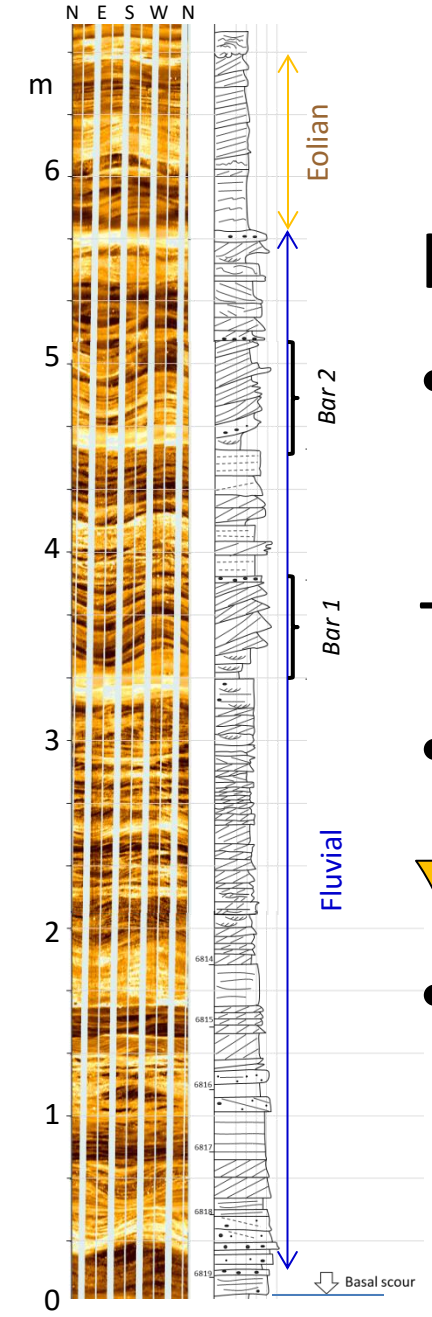
10 pre-sorted cross strata in the bar sets

– indicates 0.08-0.16 m high dunes (H/L=0.1)





Reesink & Bridge, 2007-2009-2011; Reesink et al. 2015; Nicholas et al, 2015



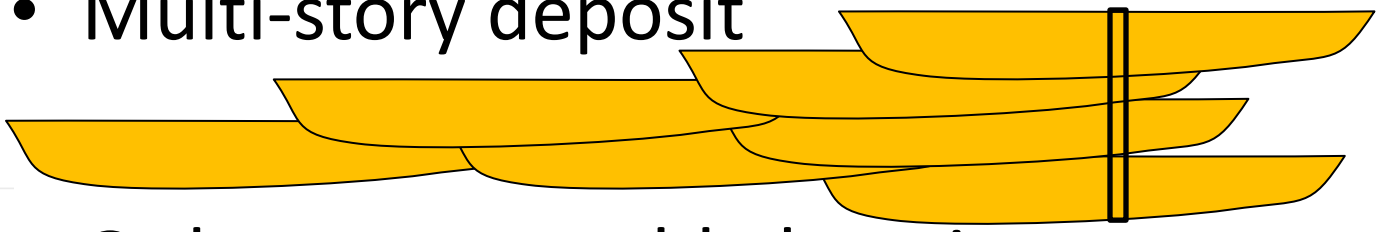
River channel

Interpreted dunes and bars indicate:

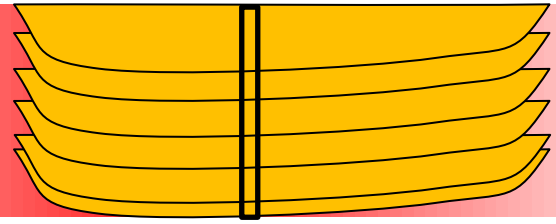
- Channel depth >0.5 m & 2-3 m deep

Total channel deposits = 6 m

- Multi-story deposit

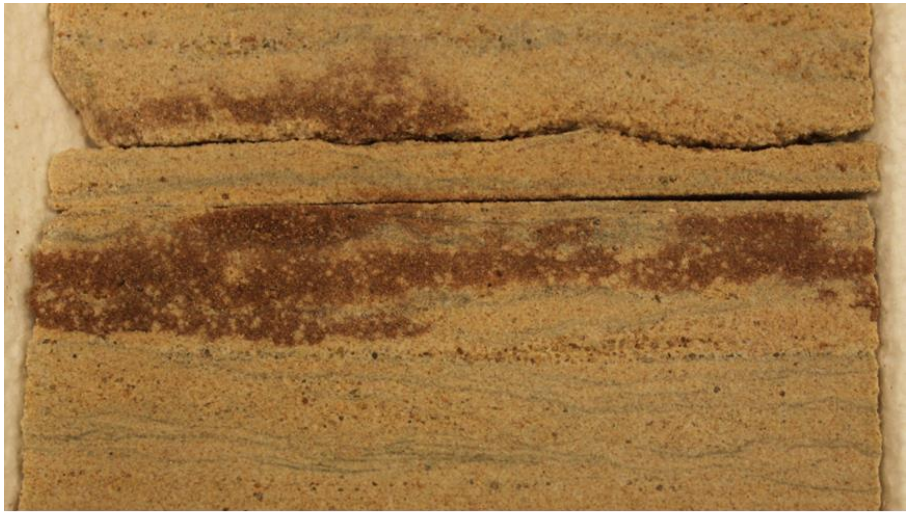


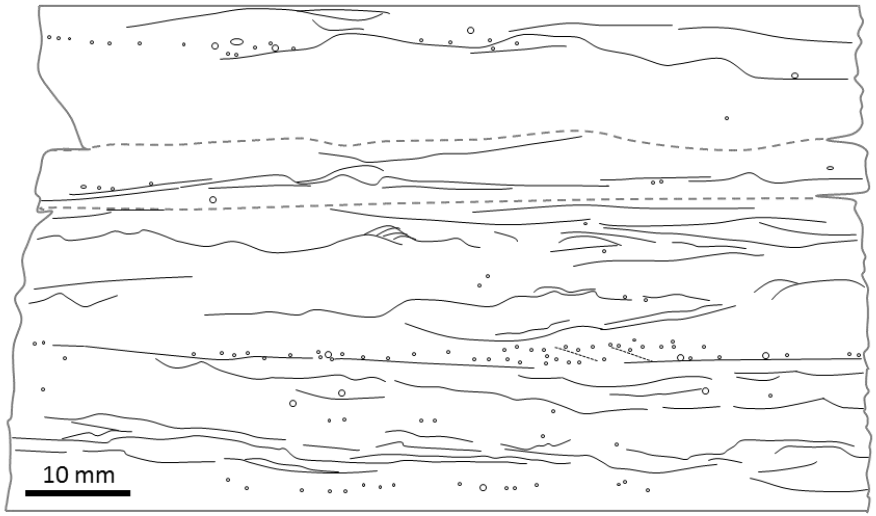
- Or long-term stable location



What else?

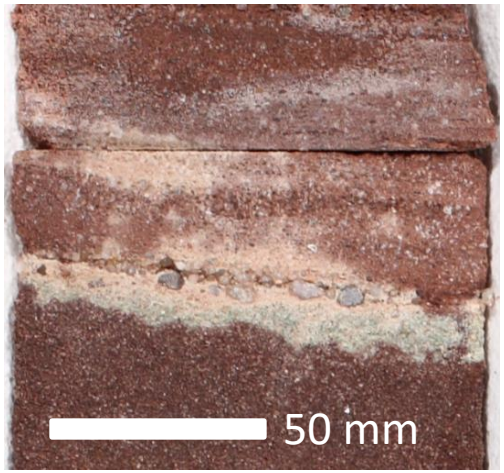
Planar crinkly strata

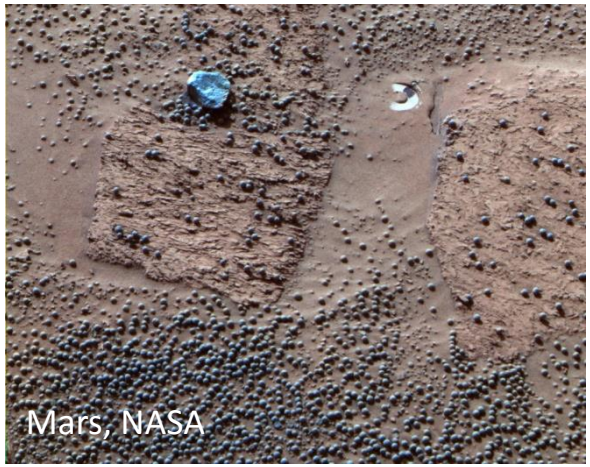


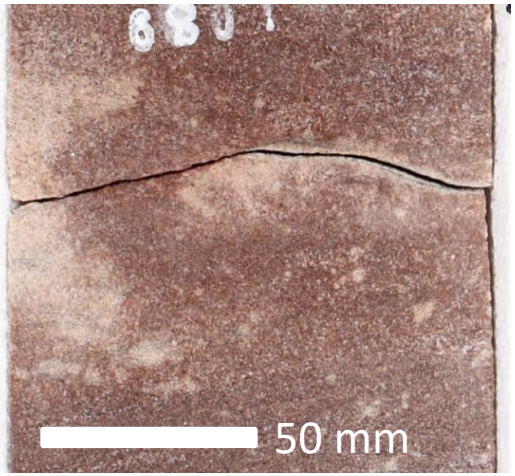


Mostly fine and medium sand

Deflation lags & ripple strata







Interpretation

- Traces of biofilms (wet, likely sticky surface)
- Adhesion structures (pseudo cross strata)
- Eolian ripples; coarse sand & granule lags

A wet plain, dominated by eolian activity?

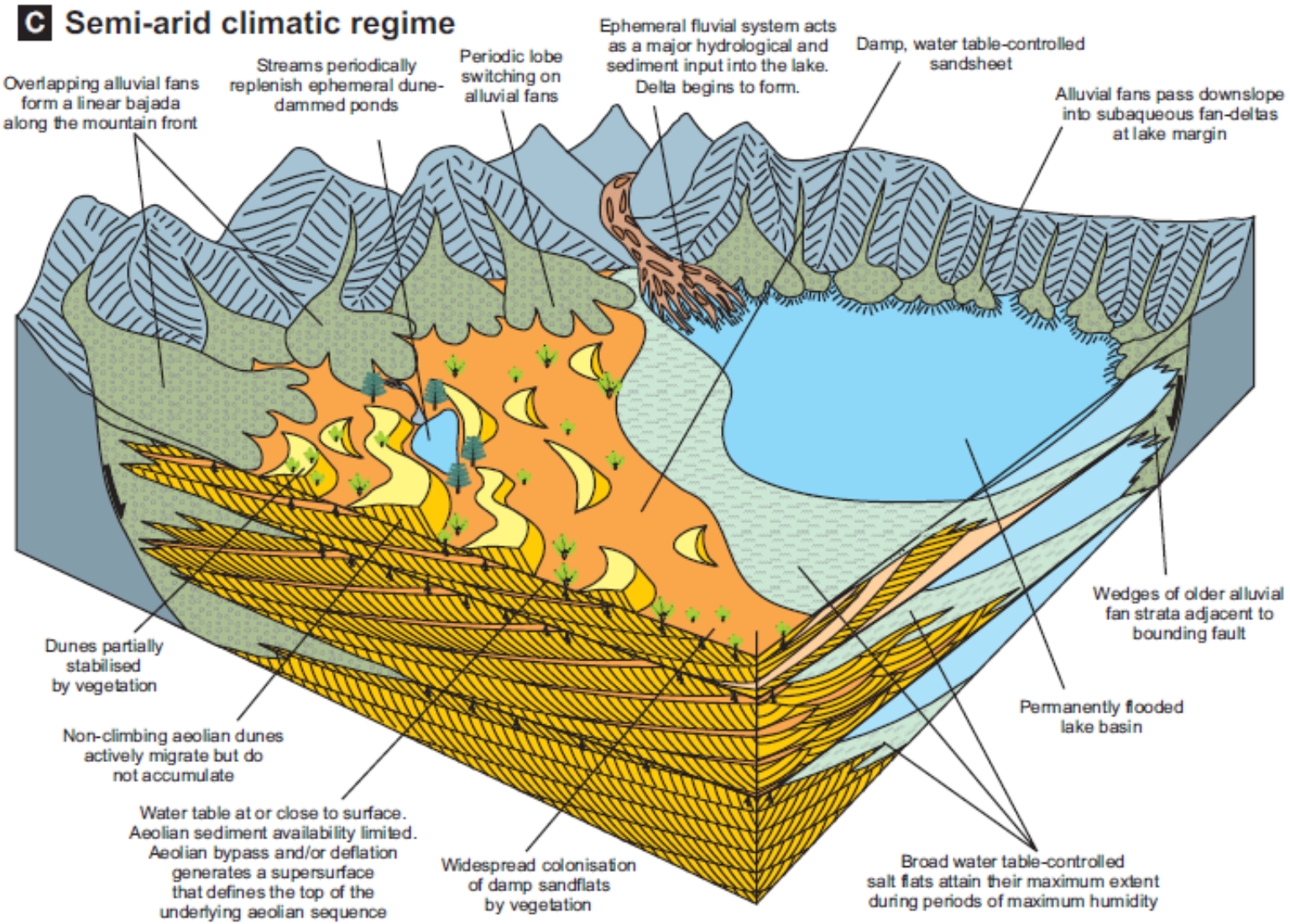
- No perfect modern analogue exists…

Zandmotor
The Netherlands

Sandur coastal plain
Iceland

Lençóis Maranhenses N.P.
Brazil

Groundwater control on basin fill

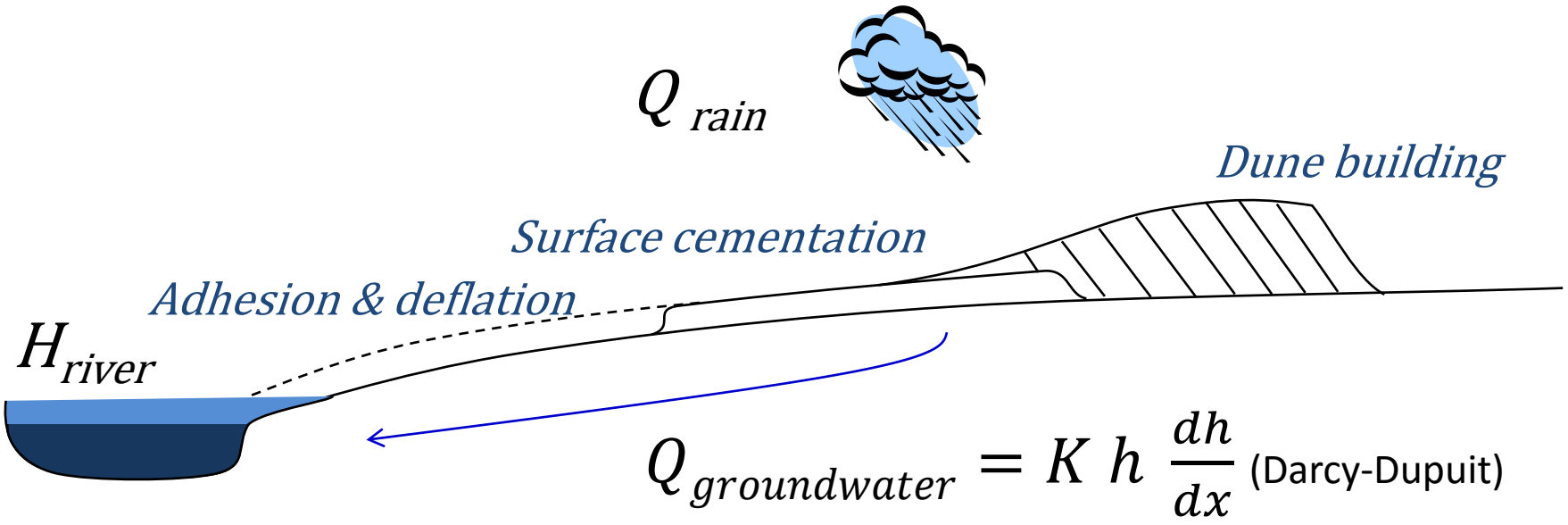


From Mountney, 2004

Numerical experiment

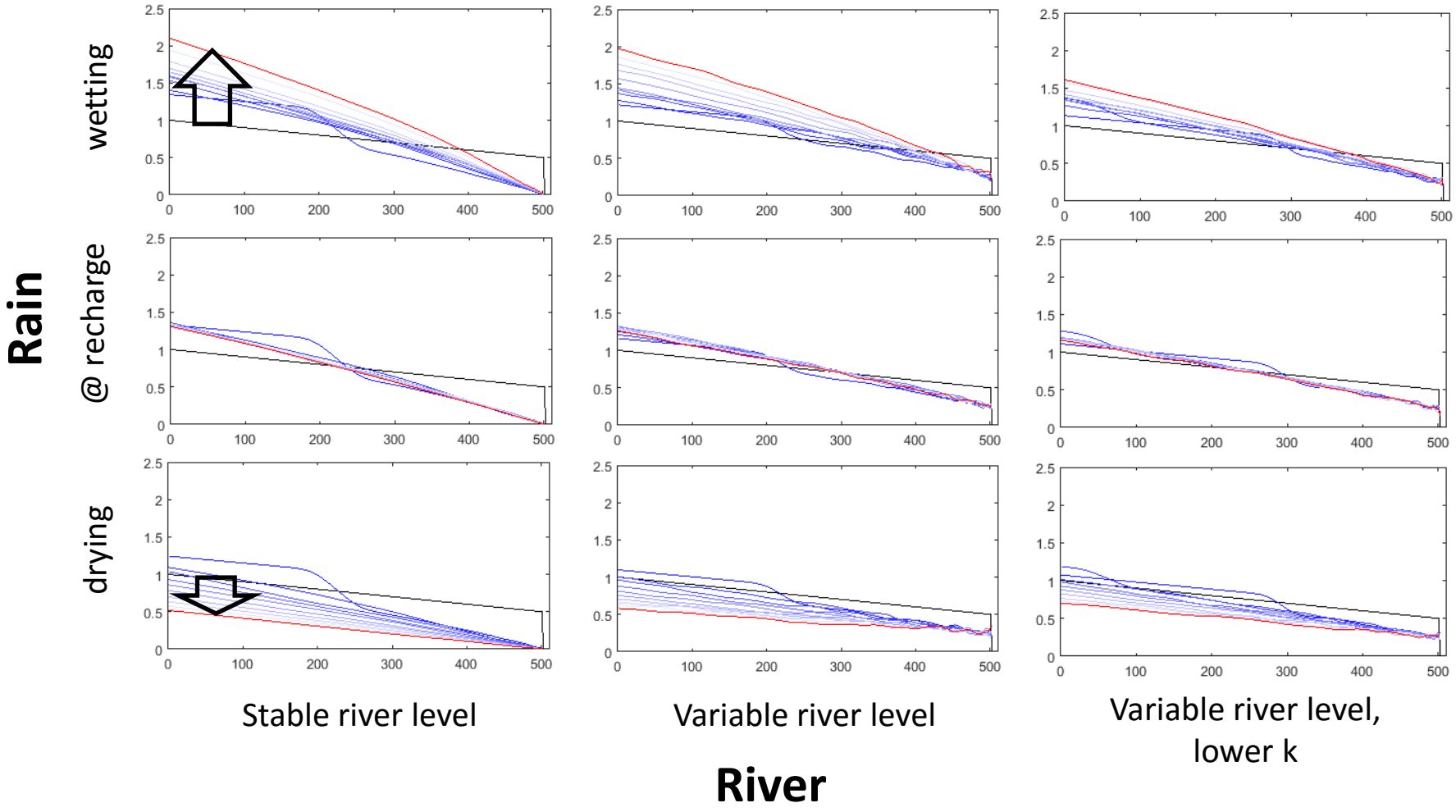
Which self-organising (flood)plain processes?

- Groundwater → deflation vs adhesion
- Sediment balance between “plain deposits” and desert dunes



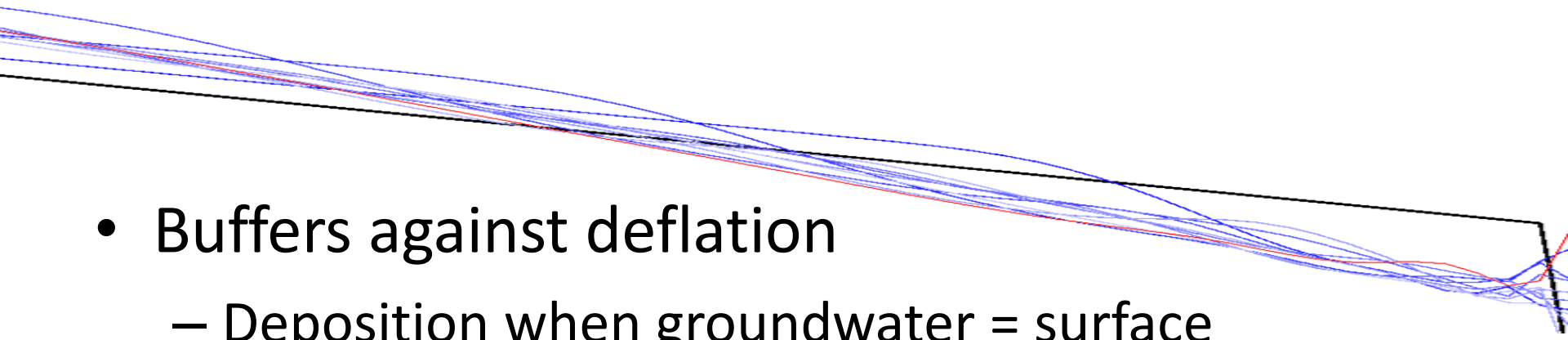
Numerical experiment

Controls: Rain & Rivers - The rest is self-organising?



Great questions & implications

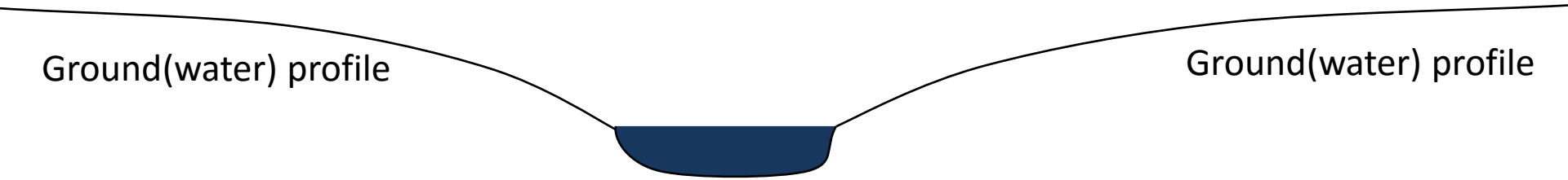
- Predicting palaeo-surface topography
  - River may incite groundwater-surface waves
  - Rain & conductivity control length and amplitude of groundwater surface waves



- Buffers against deflation
  - Deposition when groundwater = surface
  - Erosion only above ‘capillary fringe’
  - Granule lags & cementation by biofilms…

Landscape and Climate

- Pre-vegetation Earth: aeolian processes in all types of climates
- Sediment supply to floodplain not *a priori* linked to river channel…



- Topography controls '*avulsion threshold*'
  - multi-story / stable channel observed…
- Groundwater = climate + sea level (river profile)

Conclusions

- The Cambrian Illinois rivers were likely surrounded by floodplains on which deposition was controlled by Rain, Groundwater & Wind

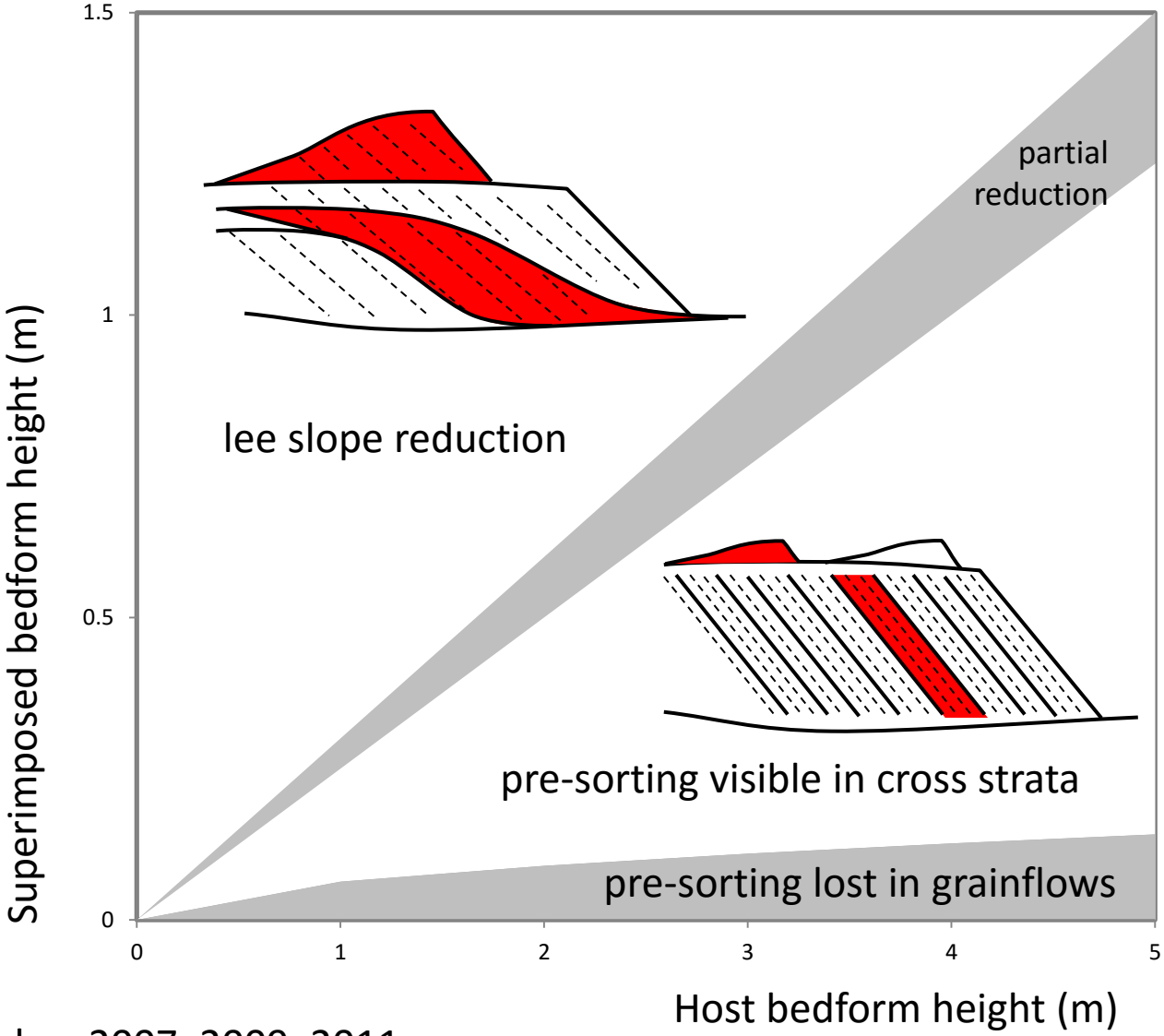
- River banks may be more erodible, but ‘autonomous’ floodplains place the river channels in a different landscape context (effect on avulsion frequency?)

- Such an aeolian-fluvial system is unlike anything that exists today: need to know about processes!

Acknowledgements

The data were collected on behalf of the CSCO2 project - Department of Energy

Pre-sorting & reactivation surfaces



Reesink & Bridge, 2007, 2009, 2011

Pre-vegetation river systems

Central Standard Time – Chicago, USA

11:00-11:15 Jim Best – University of Illinois, USA

11:15-12:00 Darrel Long – Laurentian University, Canada

12:00-12:15 Phil Fralick – Lakehead University, Canada

12:15-12:30 Renato Almeida – University of São Paulo, Brazil

13:15-13:30 Mauricio G.M. Santos – UFABC, Brazil

13:30-13:45 Alessandro Ielpi – Laurentian University, Canada

13:45-14:00 Arnold Jan Reesink – University of Illinois, USA & University of Southampton, UK

14:00-14:45 James Syvitski – University of Colorado, Boulder, USA

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