The importance of water in aeolian systems; an example from the Sherwood Sandstone of the West Midlands

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FRG ERG

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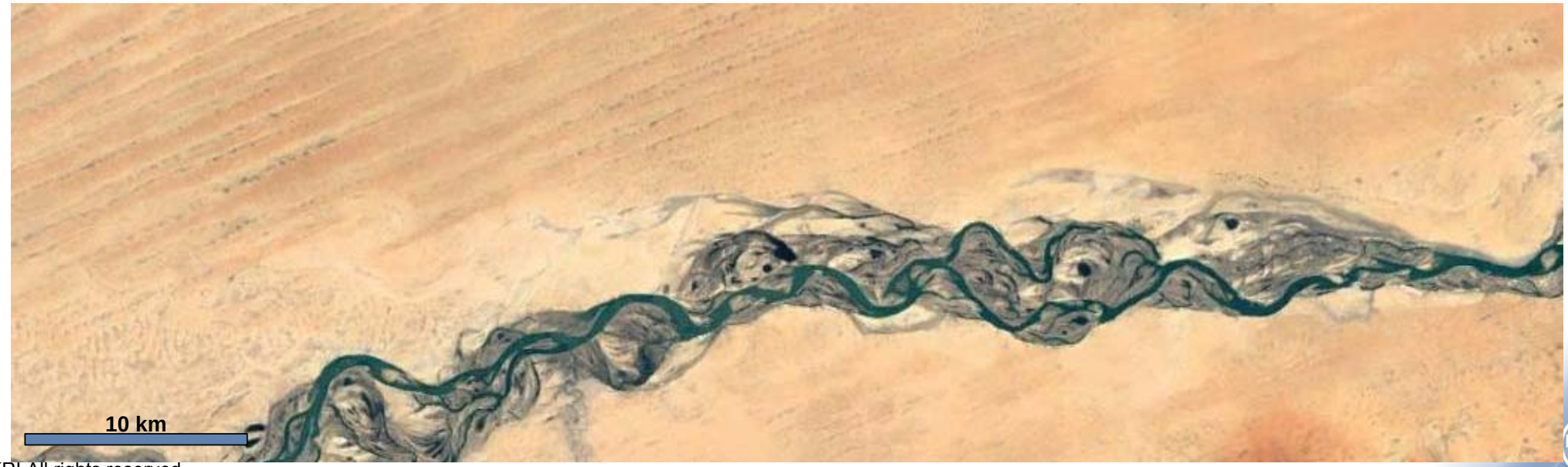
- Sherwood Sandstone
- Rationale
- Desert
- Building blocks; dunes & interdunes
- Size and scale
- Specific interaction types
- Sediment supply and capture
- Conclusions

Apologies……

Key messages

Within hot, arid aeolian systems (drylands):

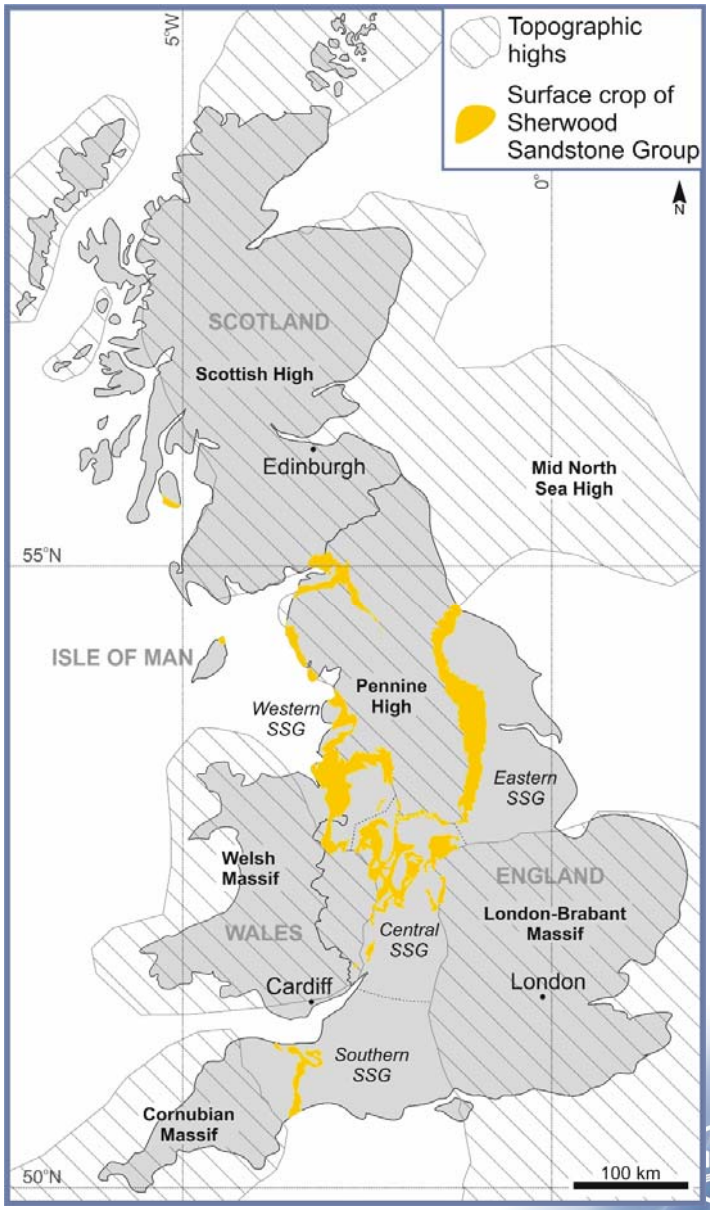
1. **The presence of water within aeolian systems creates heterogeneity that can impact the reservoir / aquifer quality**
2. **[*some*] Water within aeolian systems increases the preservation potential for aeolian lithofacies types (in general)**



Background

The Sherwood Sandstone Group (SSG)

- Triassic aged succession
- Predominately of fluvial affinity, except for western England (mixed aeolian & fluvial)
- Sand-rich unit with good (primary) permeability
- At rockhead for good portion of the Midlands, Lancashire and eastern margins of the Pennines
- Generally a ‘competent’ unit



Rationale

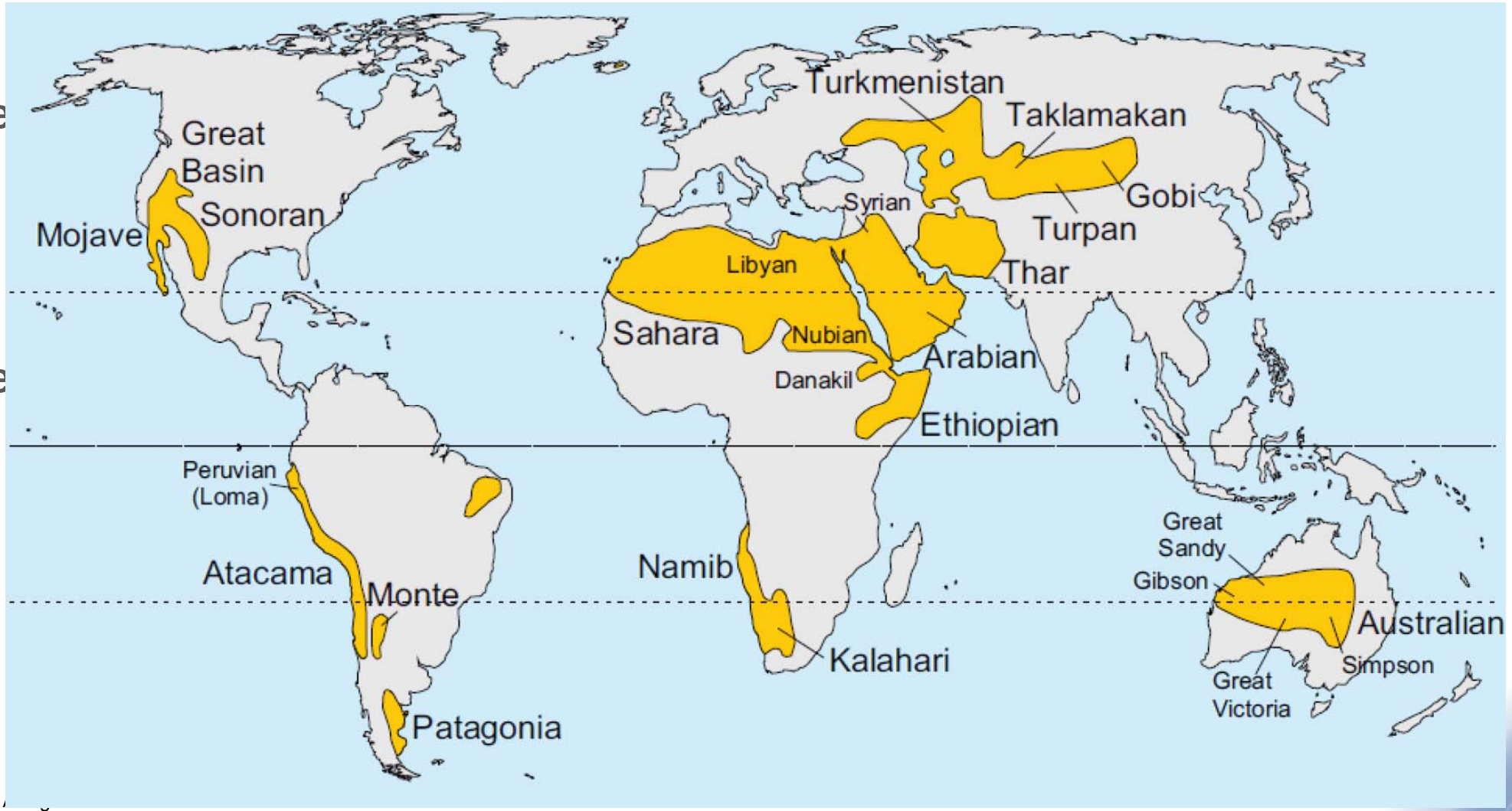
Sherwood Sandstone Group (SSG) has a host of (fluid flow) orientated applied considerations:

- Hydrocarbon producers in the East Irish Sea
  - Correlatives in the North Sea are also producing
- Designated a ‘principle’ aquifer
- Legacy of contamination
- Potential Carbon store

Saughall Massie BH, Wirral

Chester Formation, Nott's Castle

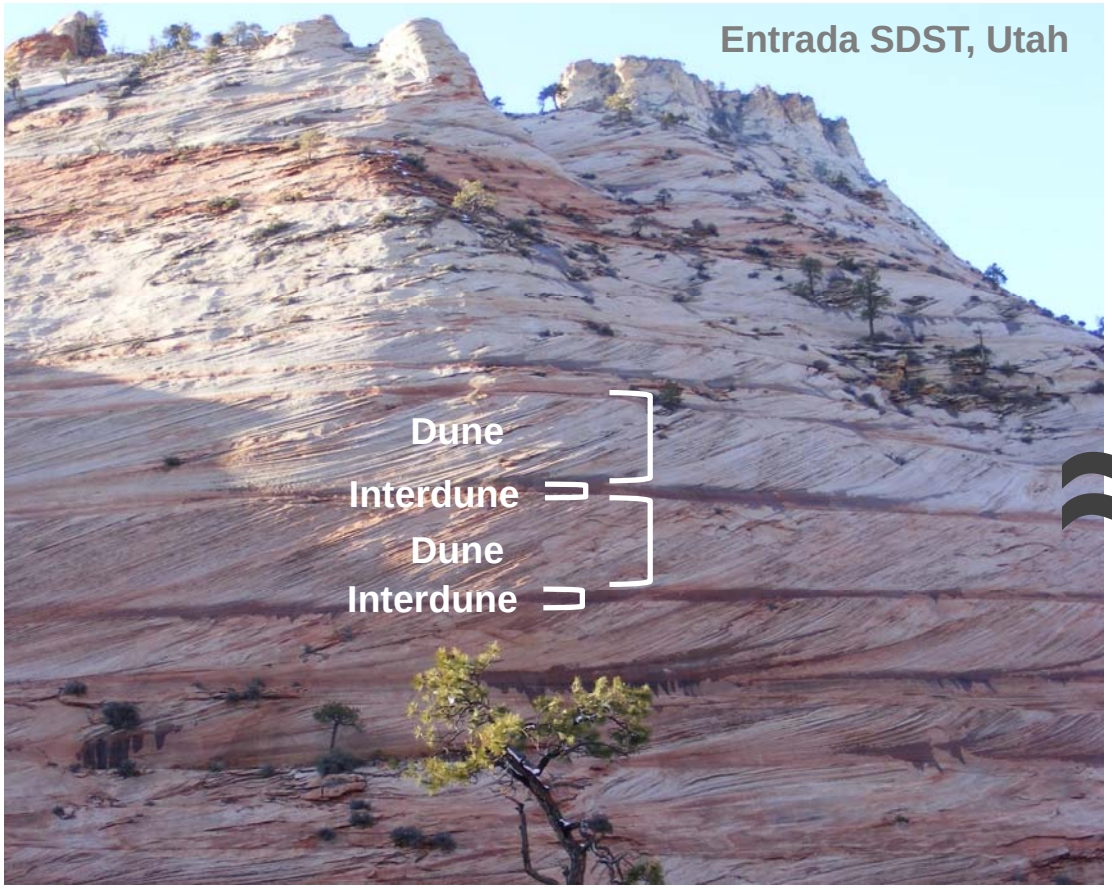
Deserts – Aeolian systems



Deserts – Aeolian systems

- Represent an environmental ‘end member’ that is quick to respond to climatic fluctuations
- Cover a significant part of the land surface
- Still relatively poorly understood

Deserts – Modern & Ancient



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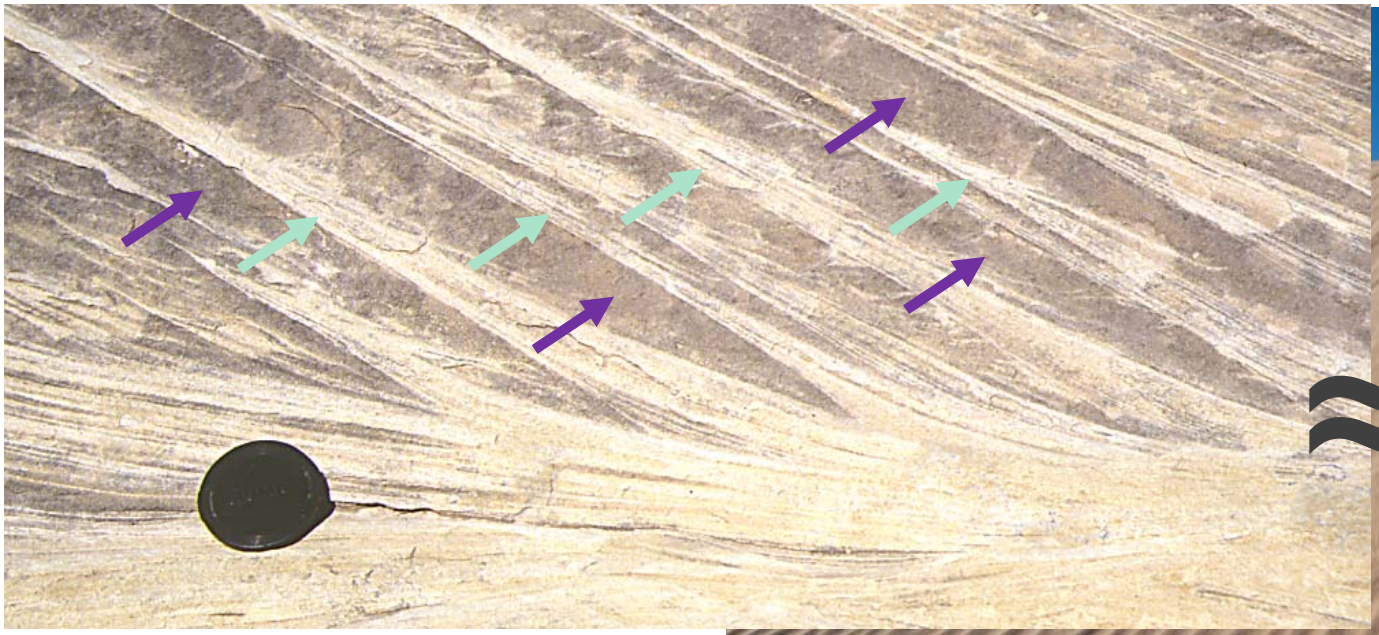
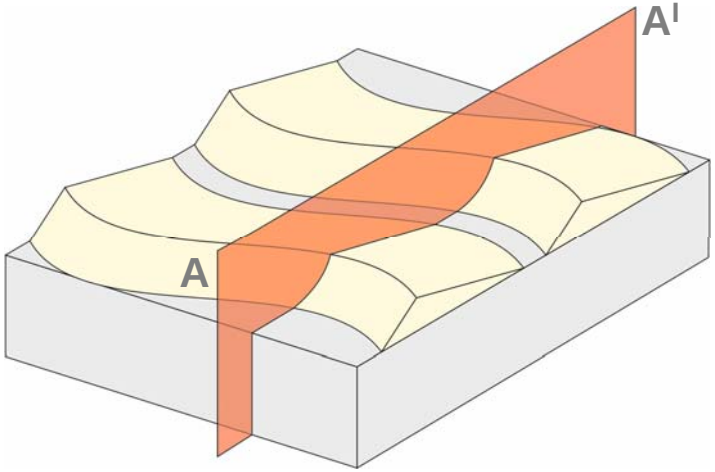
Navajo Sandstone, Zion National Park - Utah

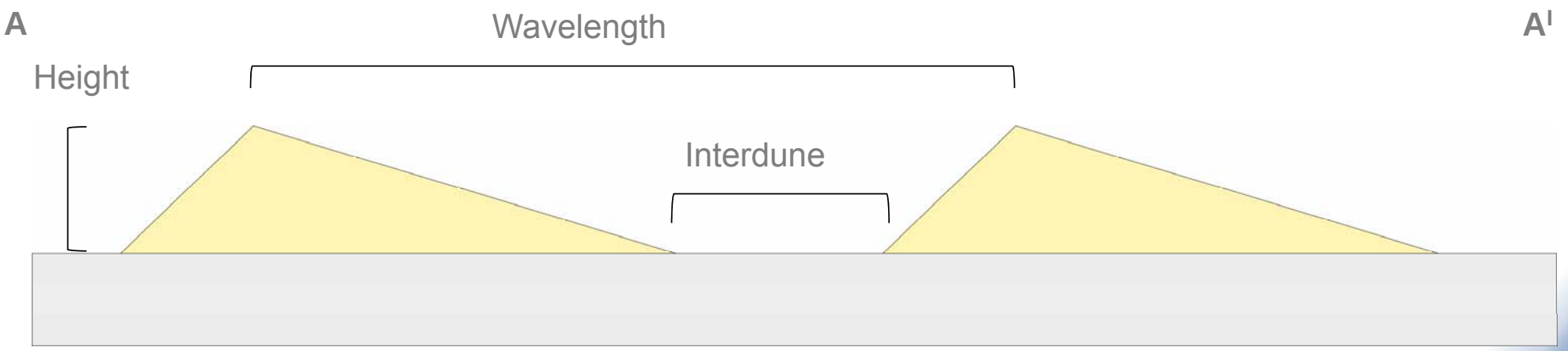
Deserts – Aeolian systems



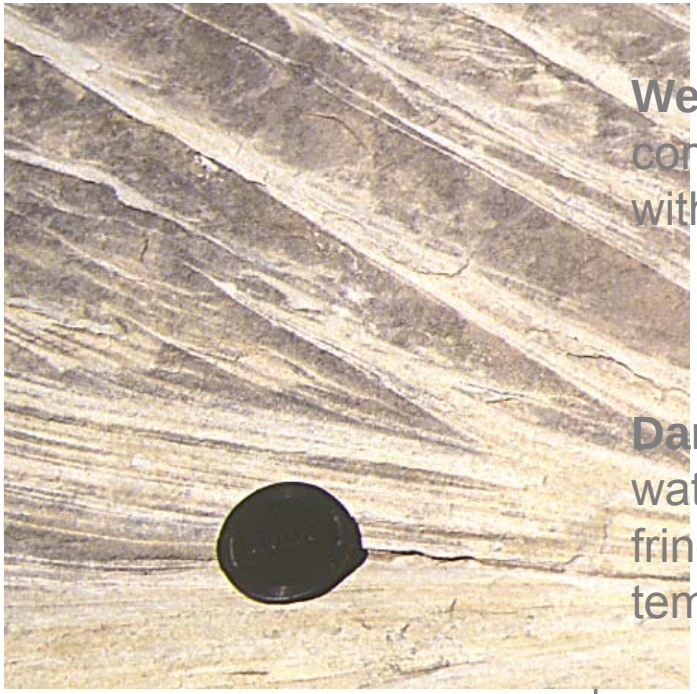
The basics – sand dunes

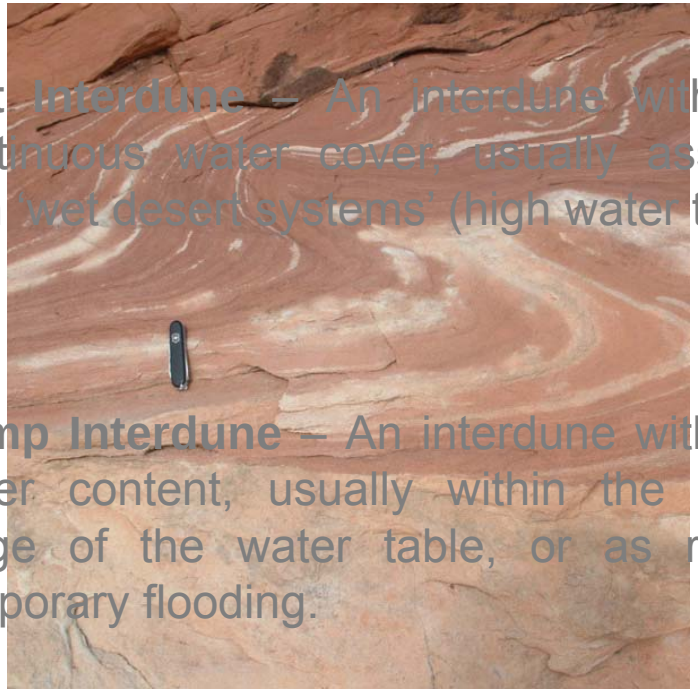



Sand Dunes National Park, Colorado



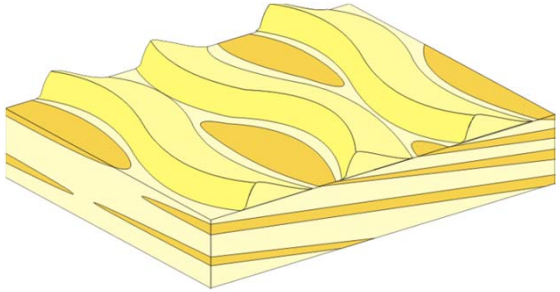
Interdune





Wet Interdune – An interdune with nearly continuous water cover, usually associated with 'wet desert systems' (high water table).

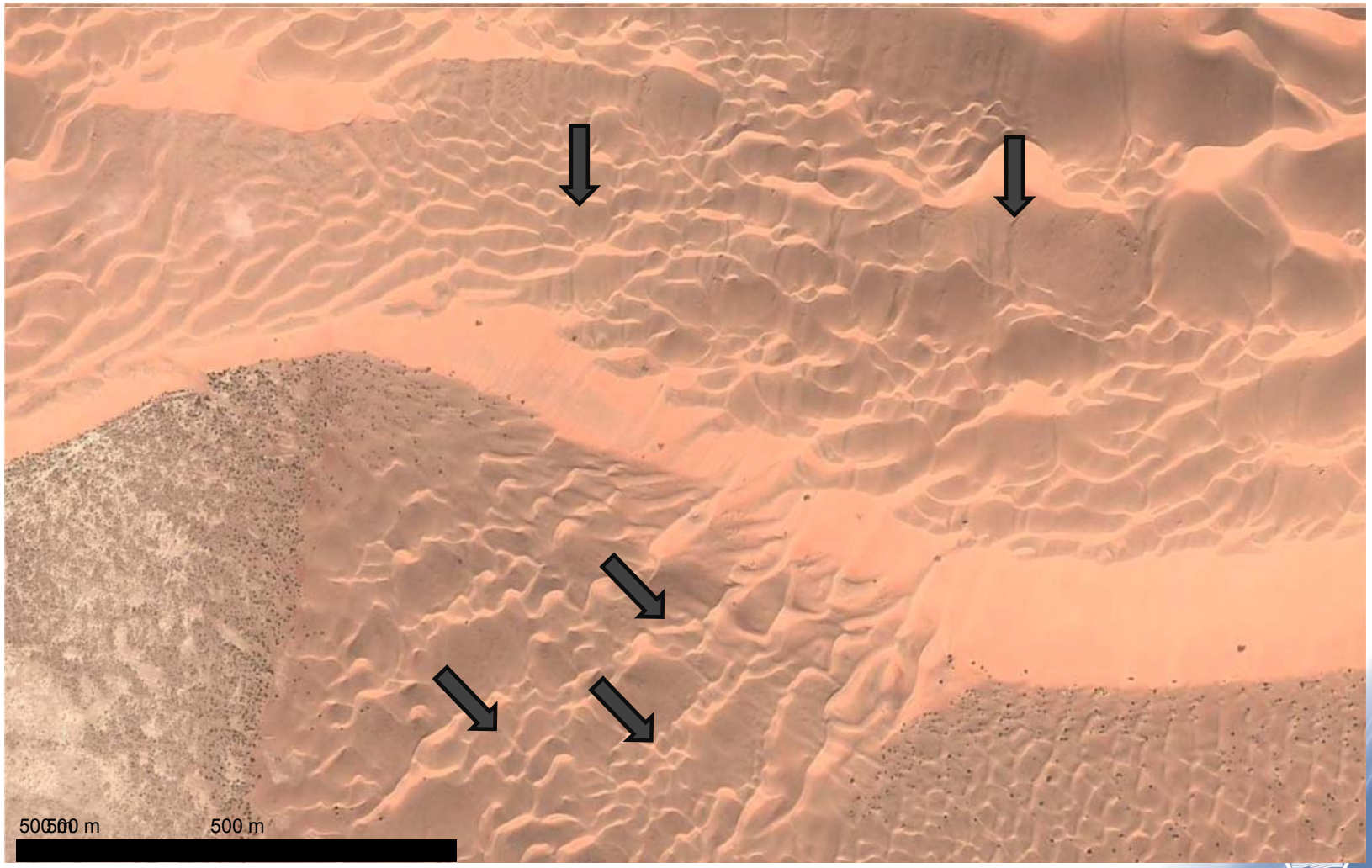
Damp Interdune – An interdune with a high water content, usually within the capillary fringe of the water table, or as result of temporary flooding.



Dry Interdune – An interdune with no evidence of the presence of water.

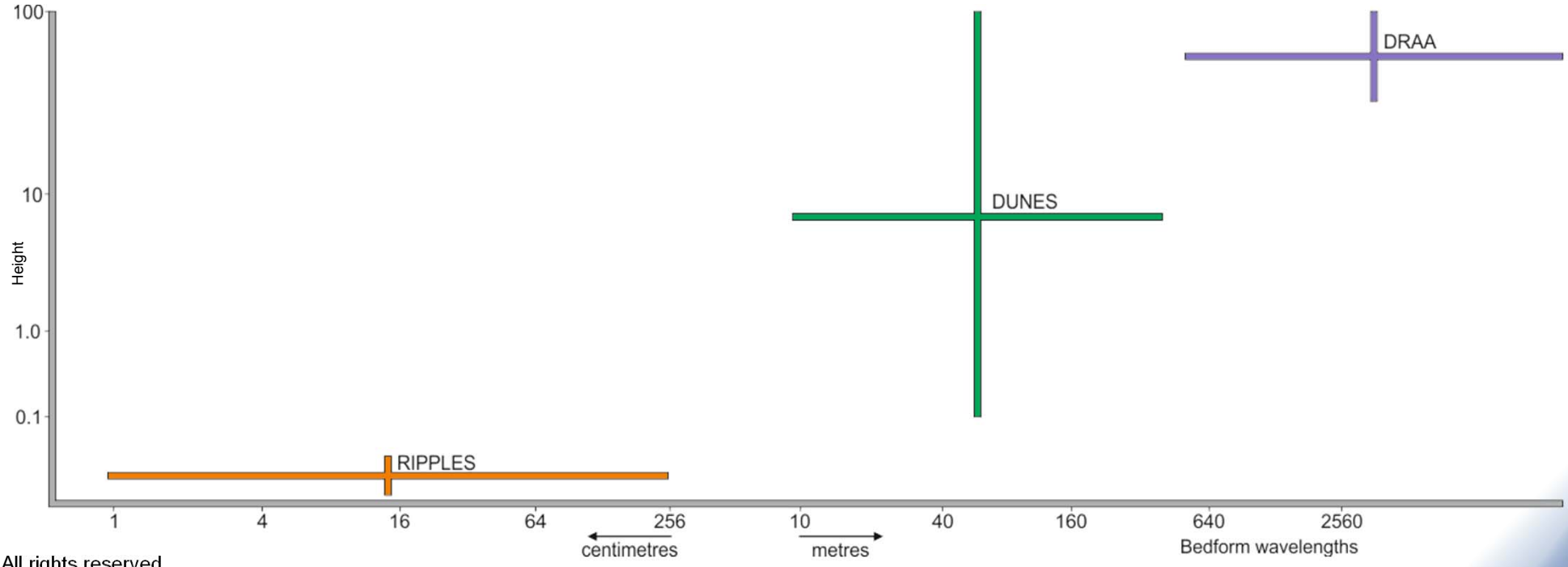
The building blocks….

- Bedforms at a variety of scales and shapes
- Spaces between the bedforms – interdunes
- *‘Bulk-scale’ – the relationship of multiple dunes in a ‘train’*
- *Variations from the dune centre to fringe*



Bedforms

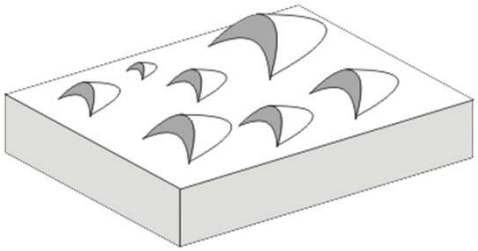
- No sub-aqueous equivalent to aeolian draas.
- *So large you can't see them!*



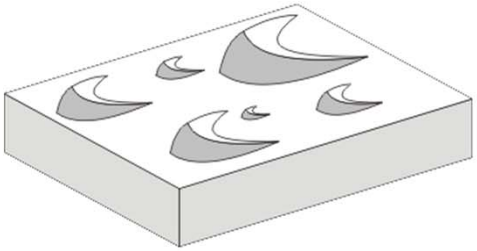

>30 m
Etjo Frm, Namibia
source; Mountney, 2006

Bedforms

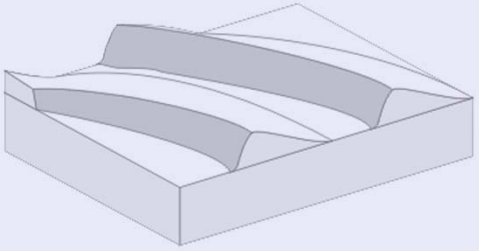
Barchan



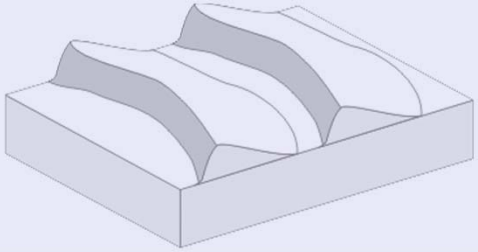
Parabolic

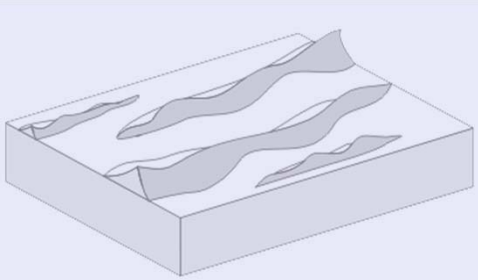


Oblique

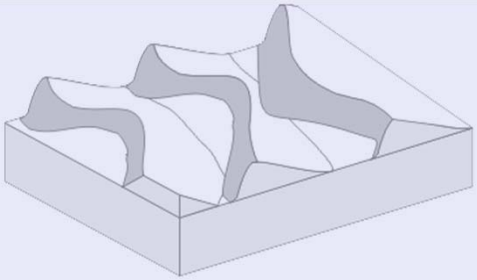


Transverse

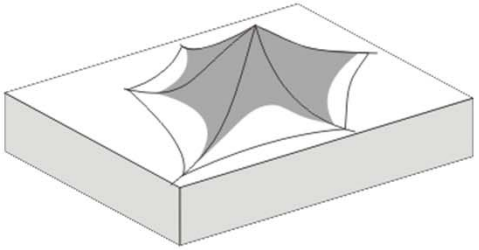




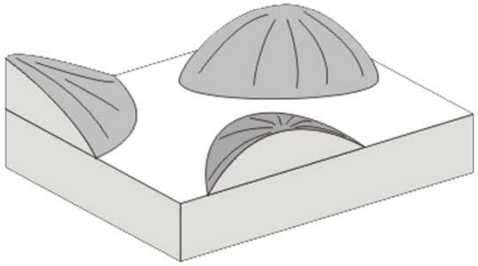
Linear (seif)



Barchanoid



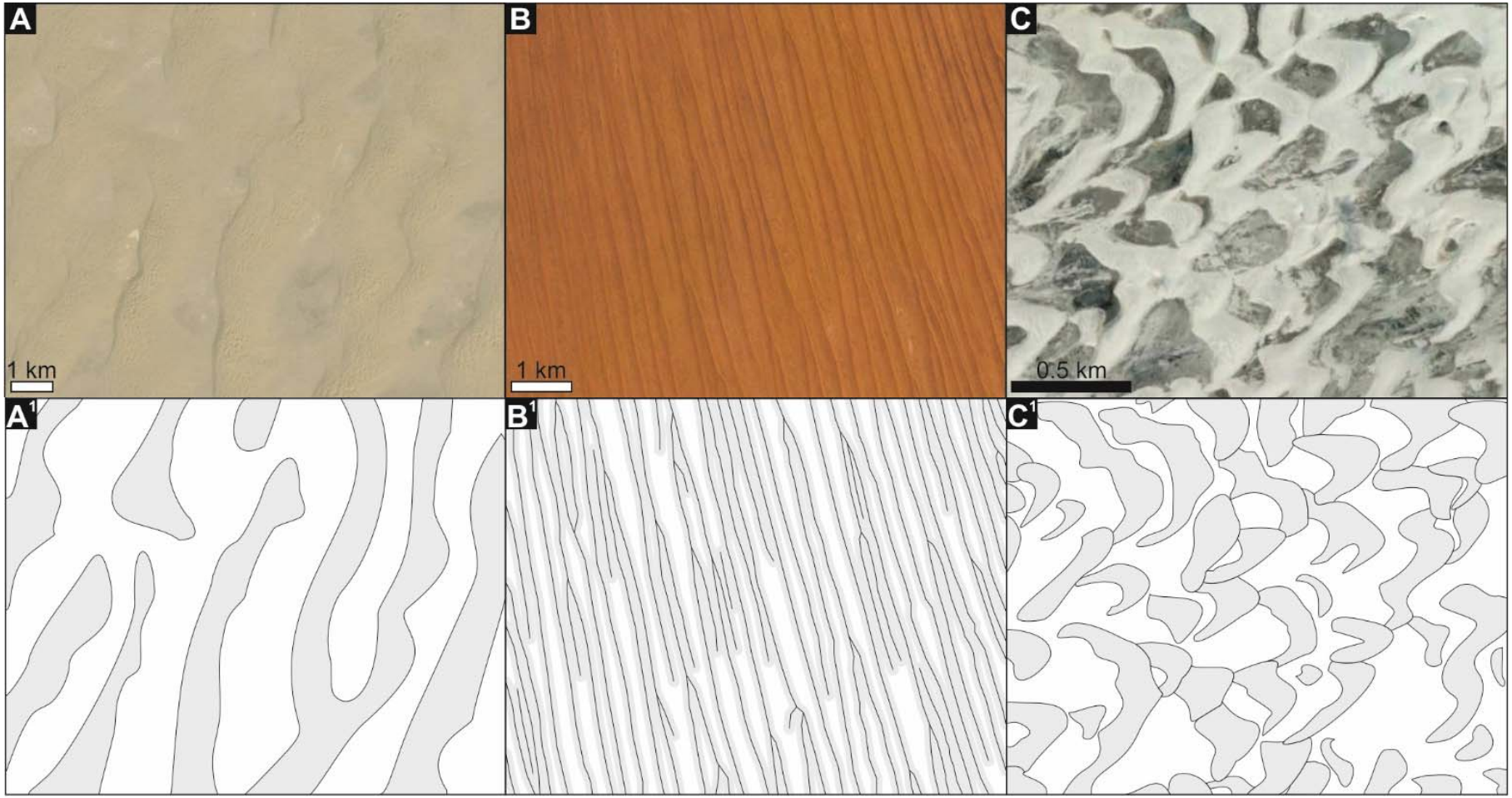
Star



Dome

Sand dune geometries

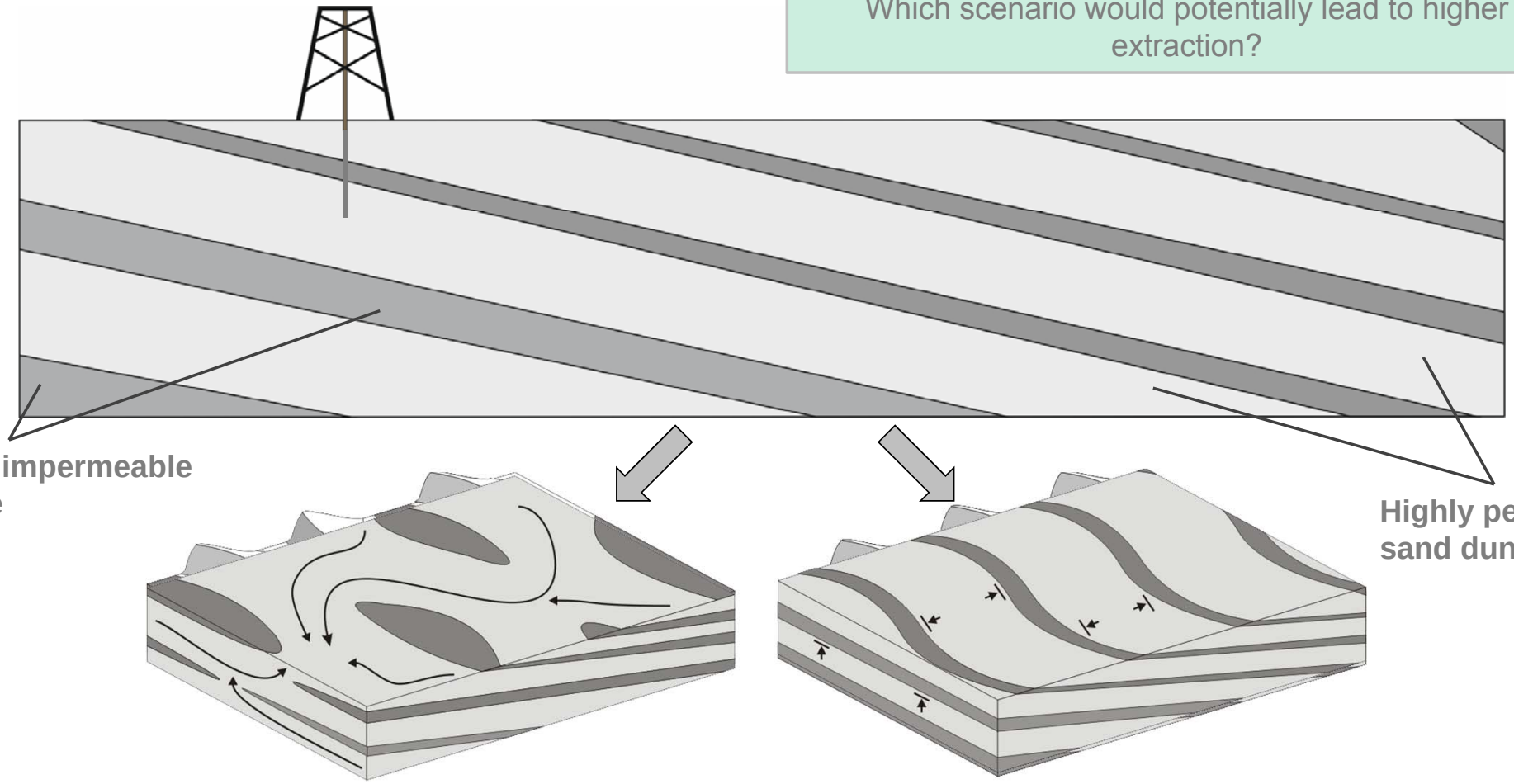
- But why does the potential source of water make any difference?



a) Taklamakan desert, China
b) Simpson desert, Australia
c) Lençóis Maranhenses, Brasil

Bedforms – dune trains

Which scenario would potentially lead to higher extraction?



Highly in impermeable interdune

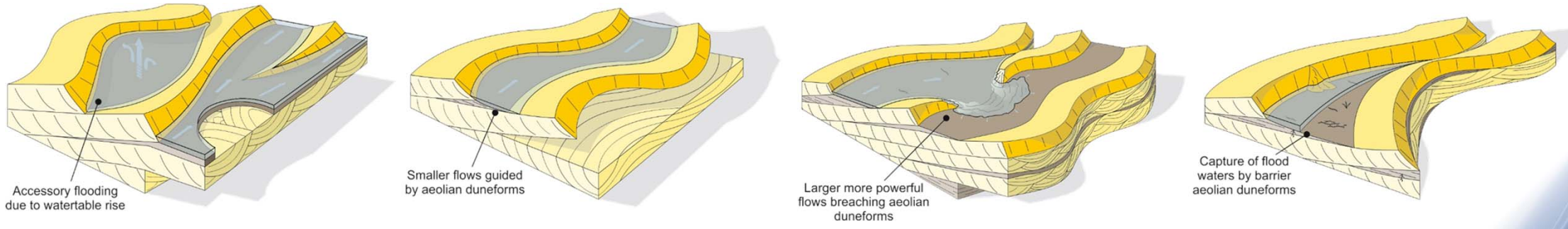
Highly permeable sand dune

Interdunes generally have lower poro-perm than sand dune elements. In instances where the interdunes non-aeolian facies types they **can act as barriers to flow**.

Hilbre Island, Wirral

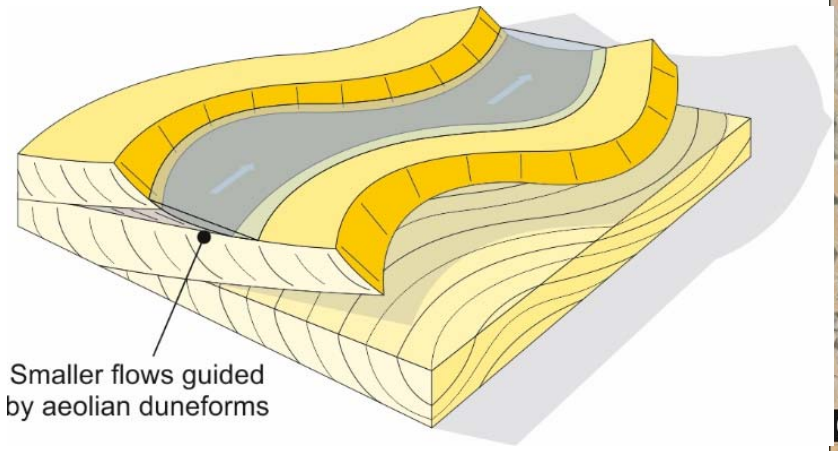
Types of flooding in deserts

- The type and scale of flooding in arid dunefields is broadly a function of:
  - The geometry of individual sand dunes
  - Spacing and geometry assemblage of the ‘dune train’
  - Height of the watertable
  - The source, volume and frequency water
- Flooding within dunefields occurs as four distinct



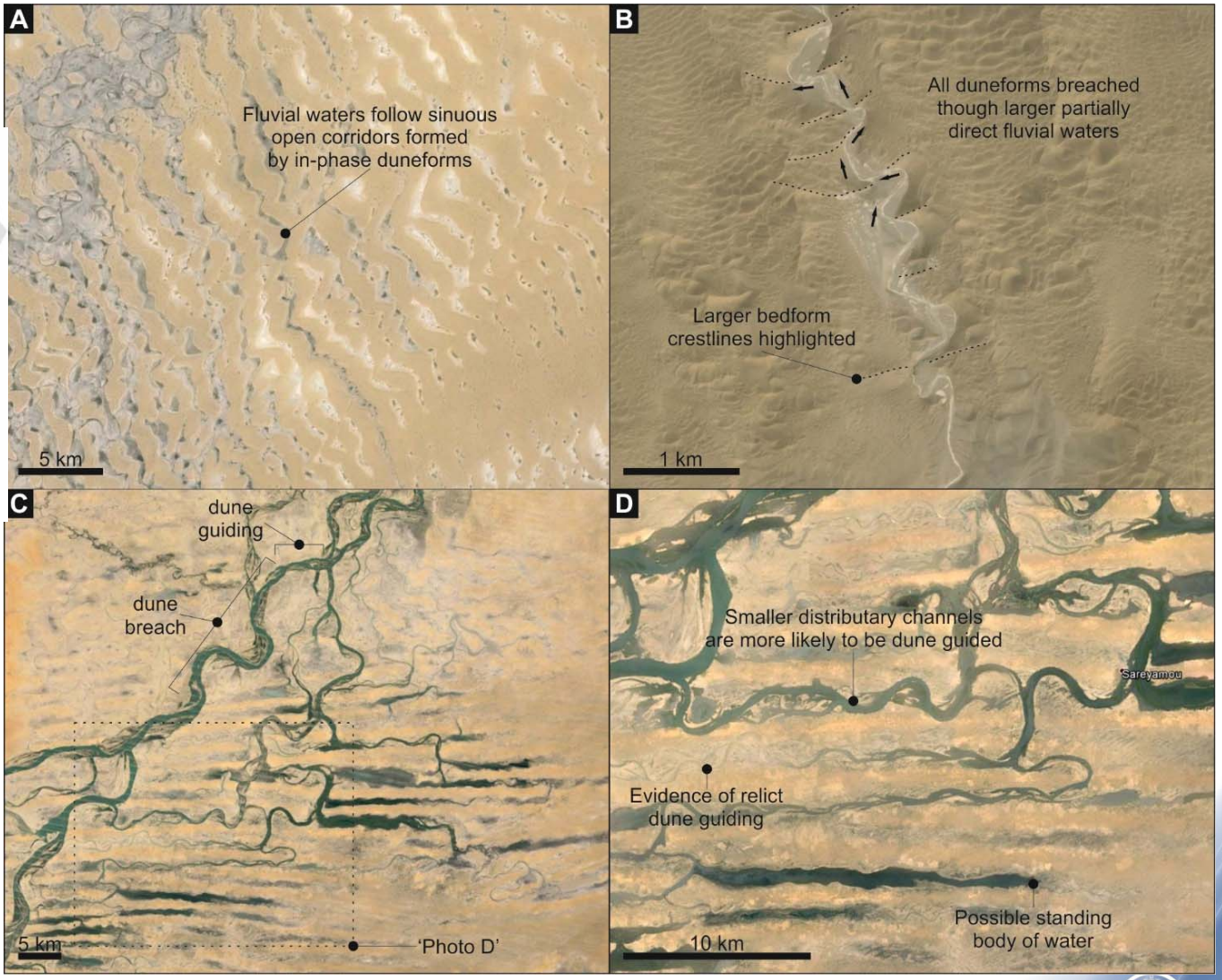
Left to right: accessory flooding, dune guiding, dune breach, dune damming

Flooding in deserts



Input of fluvial sediments – destruction of some aeolian facies types.

Incursions limited to open aeolian interdune corridors.

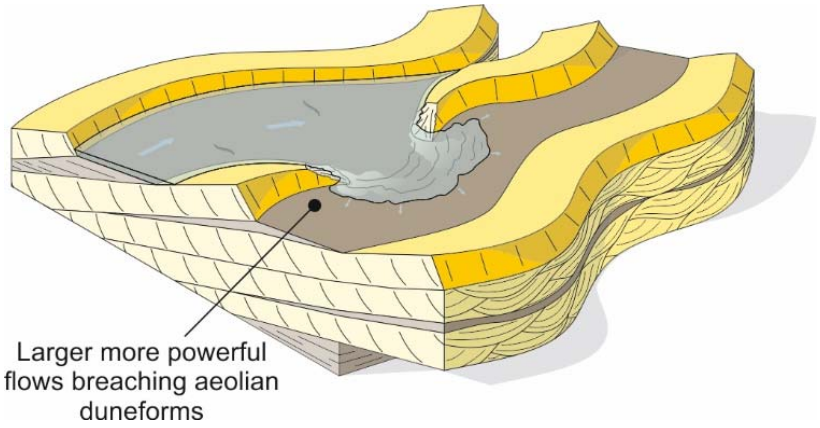


A) Northwest of Lake Chad, Chad, B) Southwest Taklimakan Desert, China, C & D) Central Tombouctou Region, Mali.

Frogsmouth Quarry, Cheshire

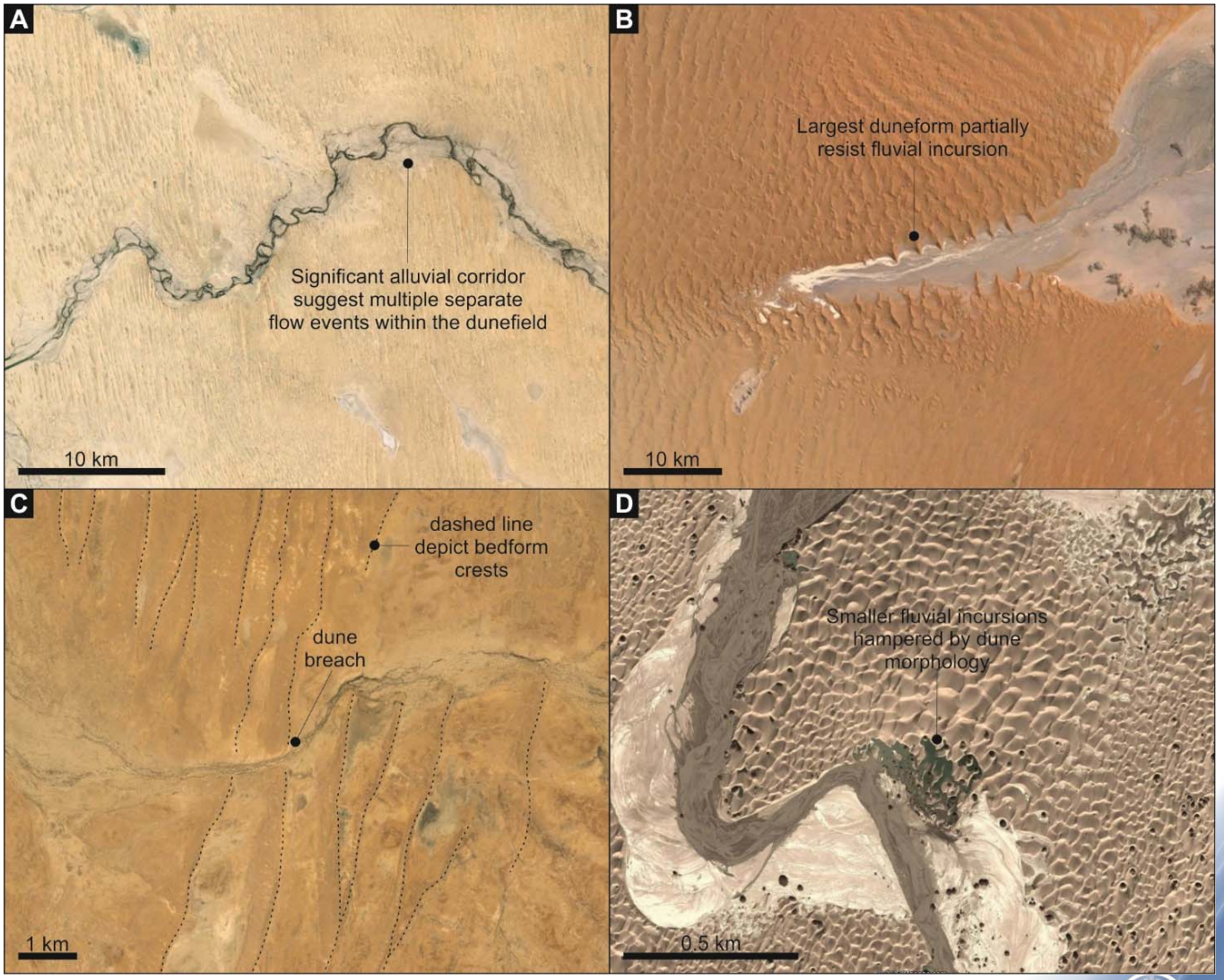
Cedar Mesa Sandstone, Utah

Flooding in deserts



Input of fluvial sediments – destruction of lots of aeolian facies types.

Incursions penetrating large parts of the system; some of the largest bedforms able to act as baffles.

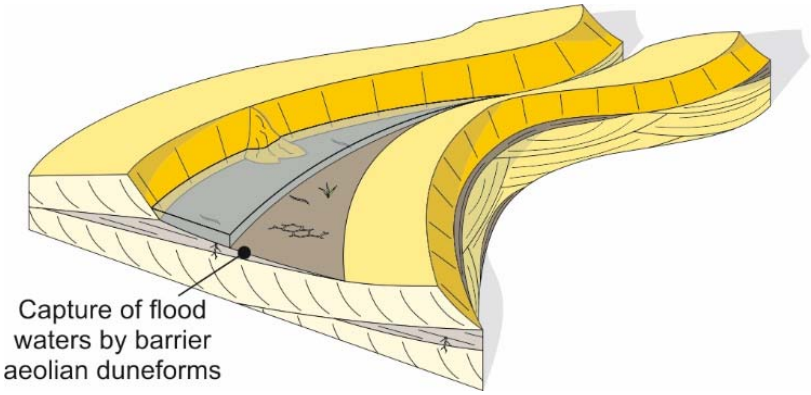


A) North Lake Eyre, South Australia B) Namib Desert, Namibia, C) Lake Harry, South Australia, D) South Taklimakan Desert, China.

Thurstaston Common, Wirral

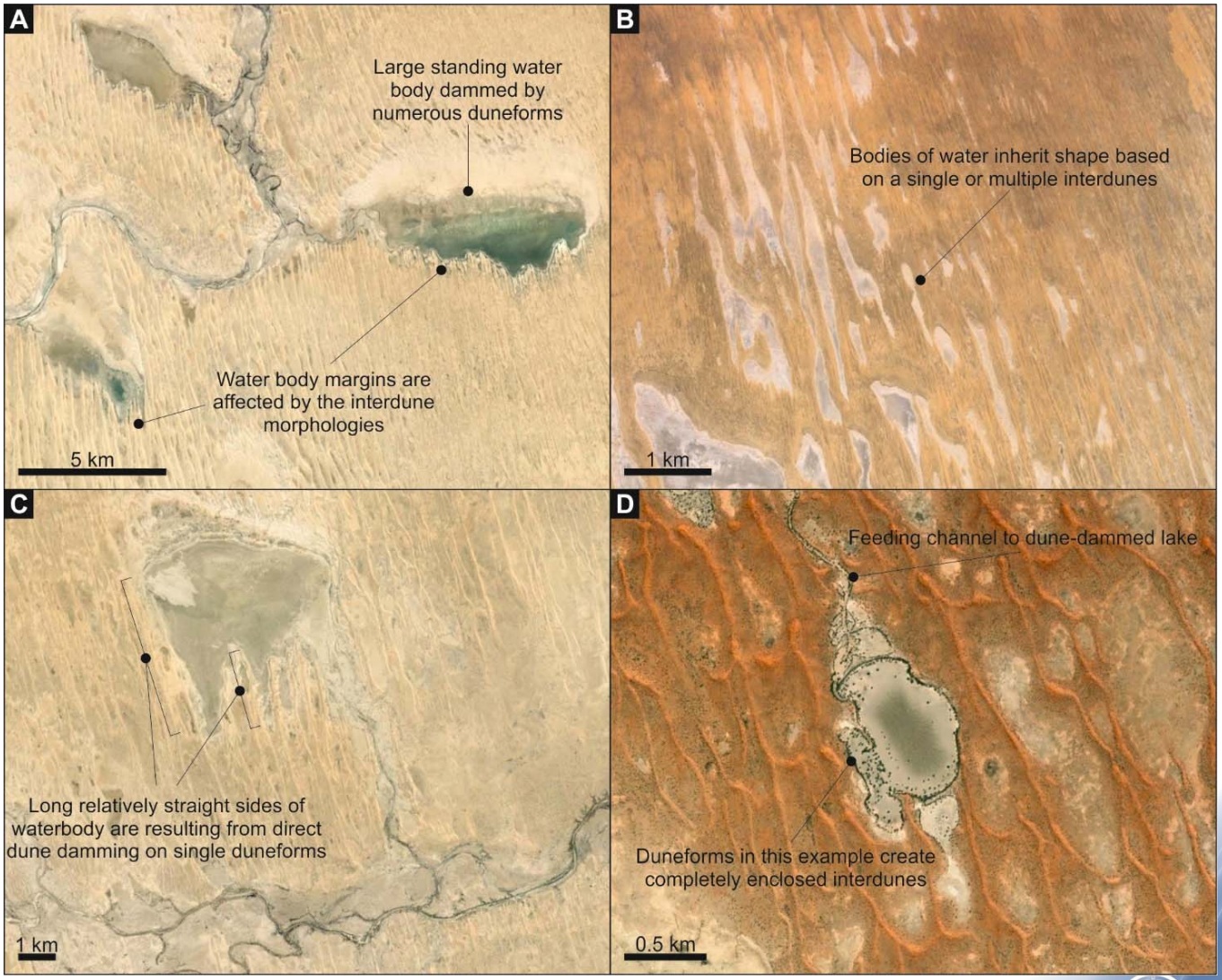
Runcorn Hill, Cheshire

Flooding in deserts



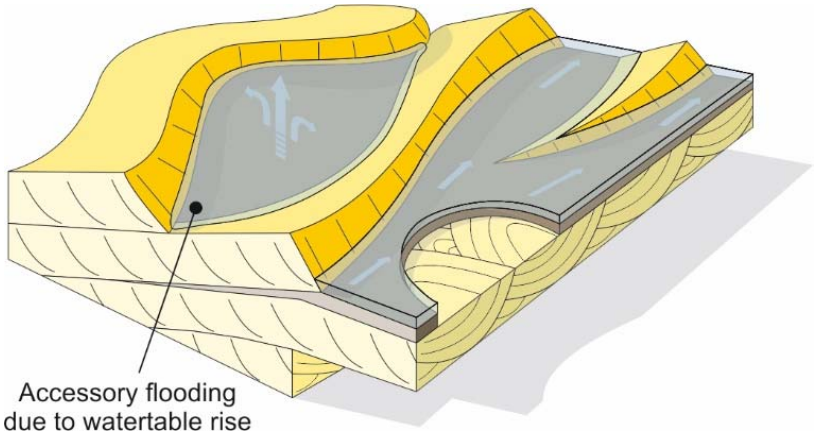
Input of fluvial sediments – destruction of some aeolian facies types.

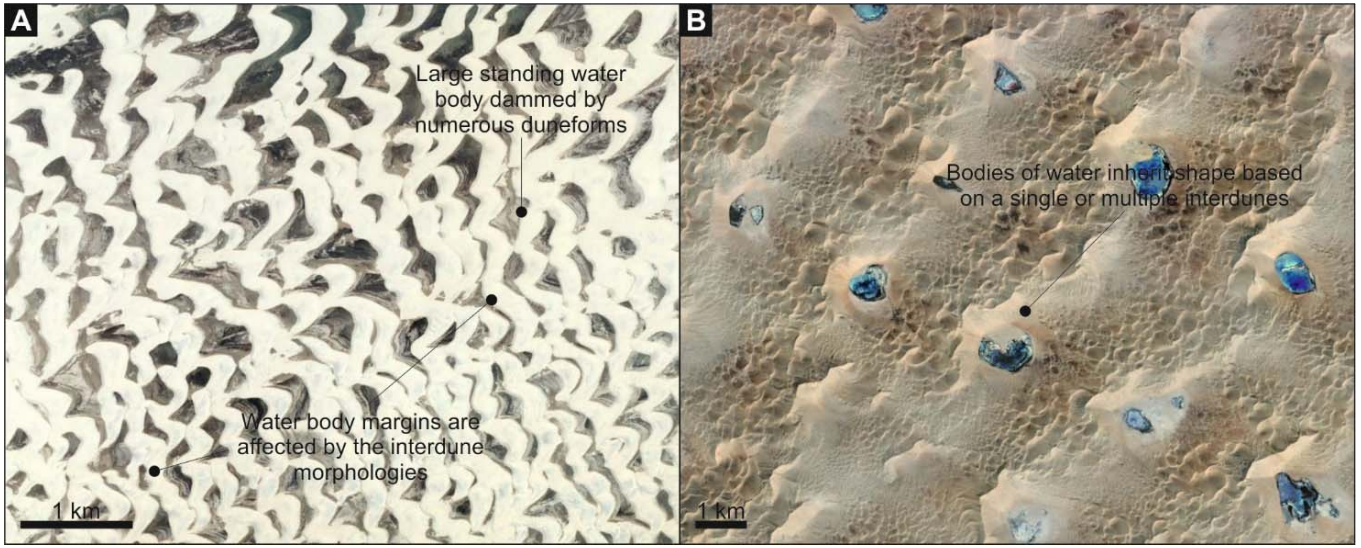
Incursions limited at first to open aeolian interdune corridors, before becoming trapped in interdune depressions.



A) Lake Eyre, South Australia, B) Simpson Desert Conservation Park, South Australia, C) Lake Pathraootara - South Australia, D) Northeast Lake Eyre, South Australia.

Flooding in deserts



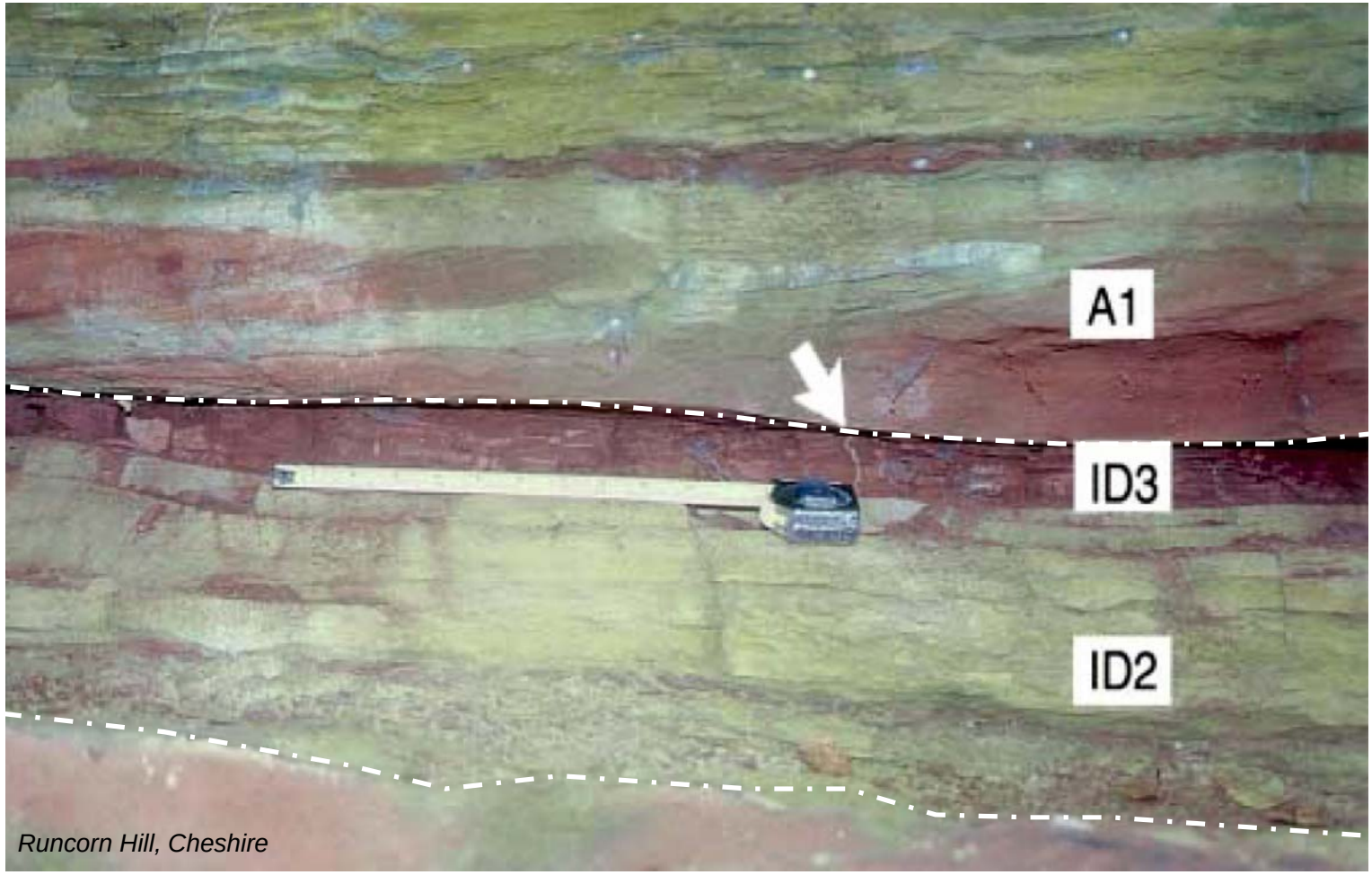


A) Lençóis Maranhenses, Brazil, B) South Gobi Desert, Mongolia

- Significant reworking of original aeolian sediment (no additional sediment input). Hampers bedform migration and can cause bedform destruction.
- Can only feasibly occur in instances where aeolian interdunes are completely enclosed.
- Prolonged periods of standing water can promote colonisation by plants or the precipitation of evaporitic minerals.

WOJ1

Flooding in deserts



Runcorn Hill, Cheshire

Sand dune

Wet interdune

Damp interdune

Sand dune

Slide 33

WOJ1 Wakefield, Oliver J.W., 11/08/2018

Helsby Hill, Cheshire

Helsby Hill, Cheshire

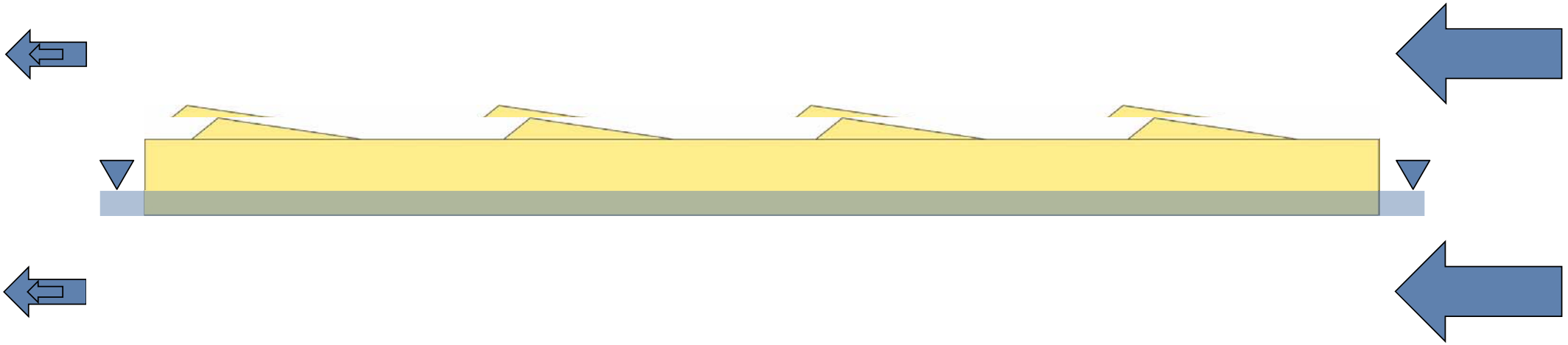
Sediment supply

- Aeolian systems transport enormous volumes of sediment across significant distances and require constant sediment supply to maintain an equilibrium between the carrying capacity of the wind and the sediment supply rate and volume
- The wind is highly discriminating when entraining sediment, the additional cohesive forces like the addition of small amounts of water often raise the entrainment energy for clasts beyond the limits of wind transport
- This makes the level of the watertable highly important for the preservation of aeolian sediments

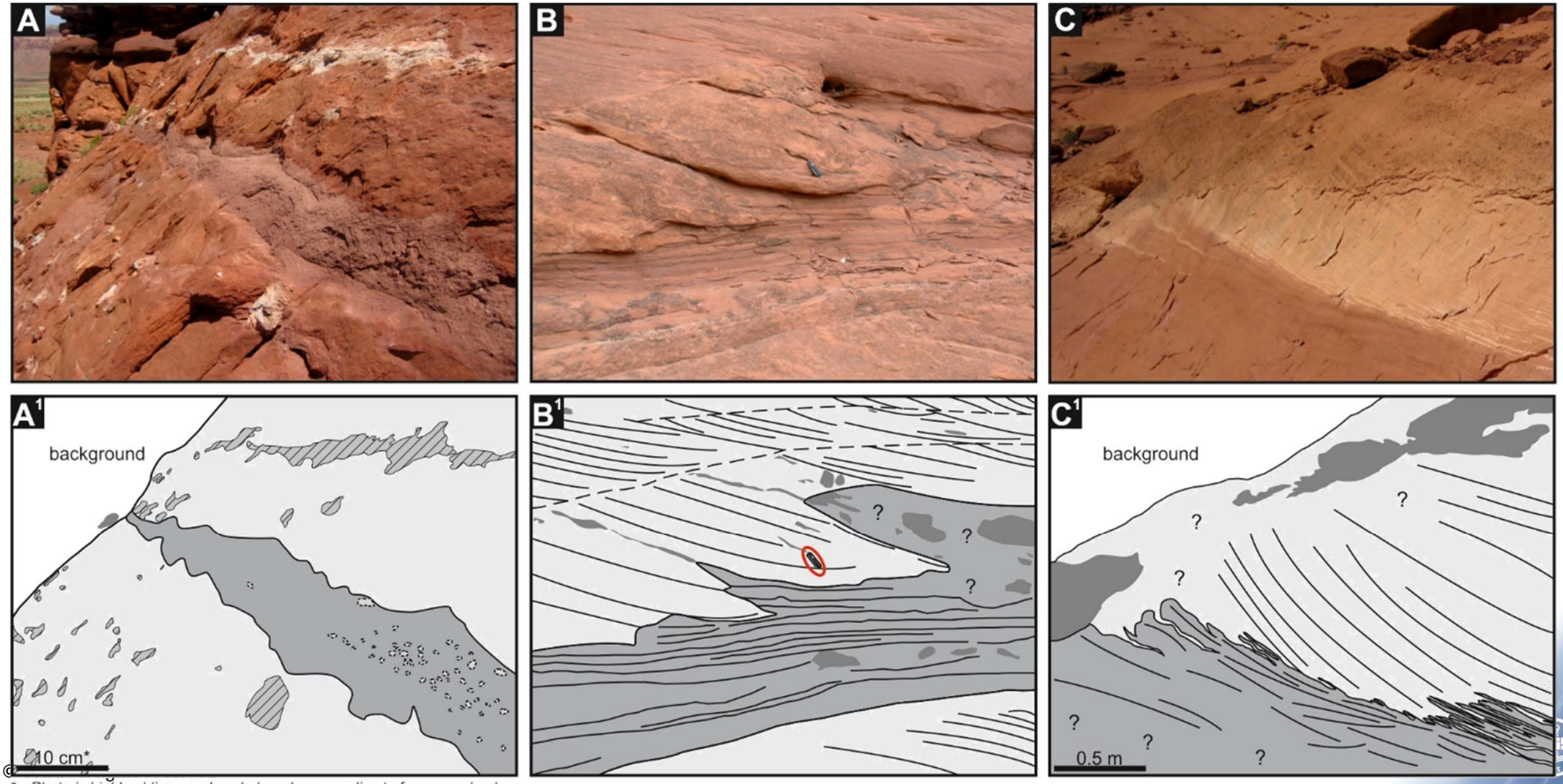
Sediment supply

Sediment stored within the system

+ + +

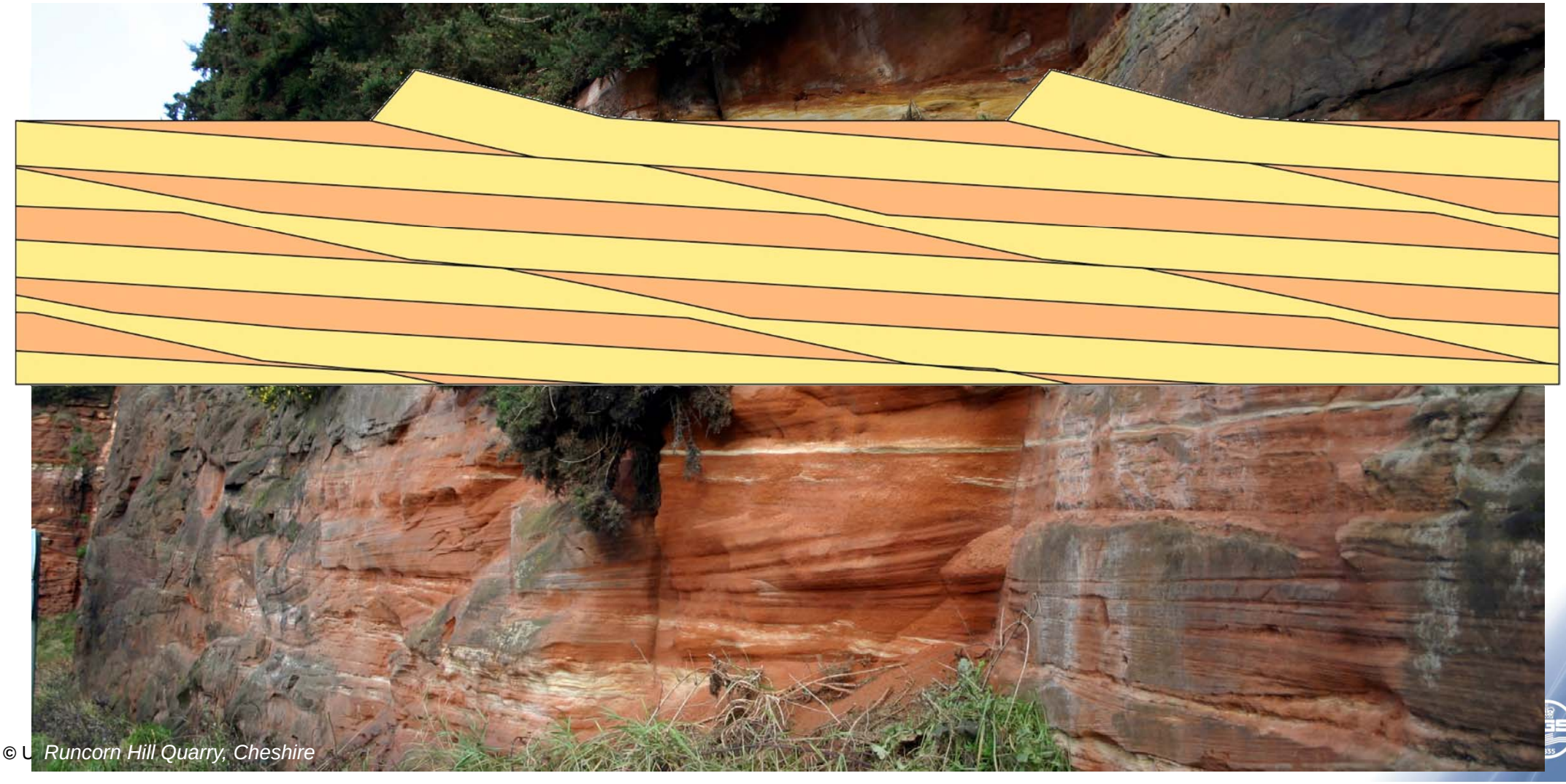


Coeval growth



* - Photo is highly oblique and scale bar shown applies to foreground only

Wet aeolian system

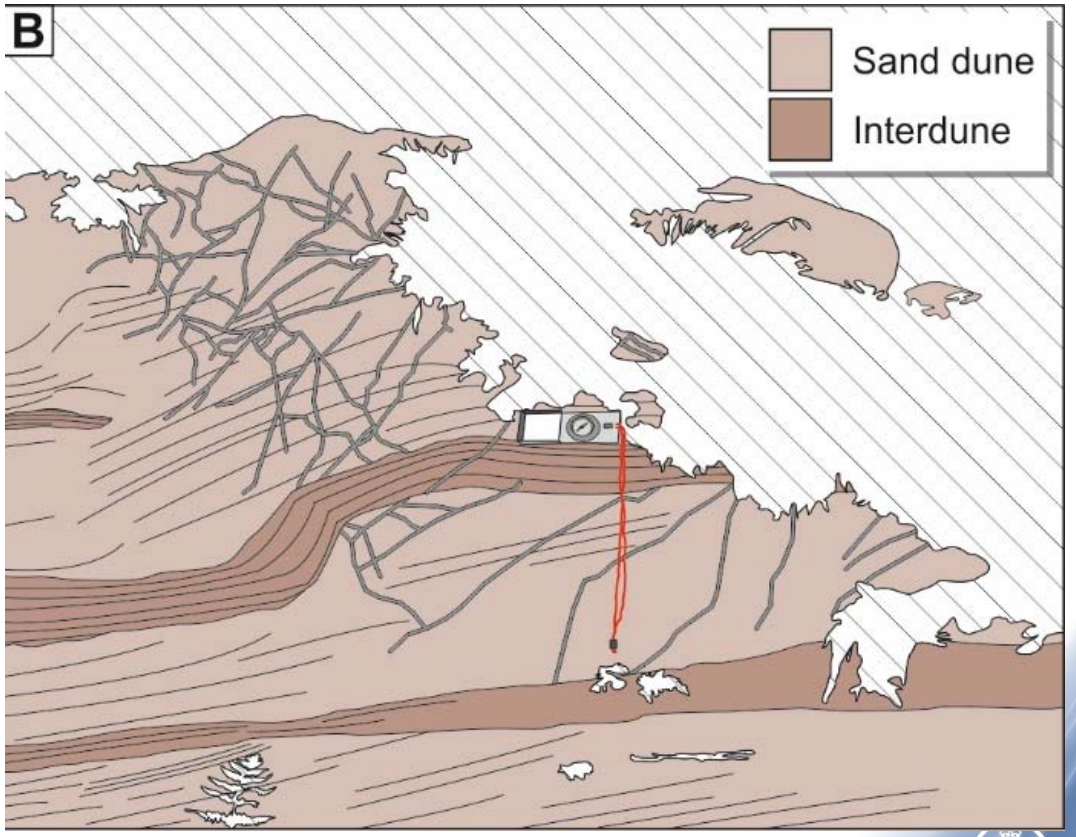


Runcorn Hill Quarry, Cheshire

Cedar Mesa Sandstone, Canyonlands National Park - Utah

Architectural heterogeneity

- Could poor reservoir / aquifer (quality) interdunes be helpful?



Conclusions

1. Aeolian [dunefield] systems are composed of two architectural element types; sand dunes and interdunes
   - Though this doesn't necessarily make them simple to understand

2. The presence of water can lead to significant architectural complexity
   - Impacting reservoir and aquifer quality

3. Water can act as preserving agent by increasing the entrain energy required for wind transport
   - Effectively increasing in-system storage capacity


Questions??