

Windy Landscapes

Aeolian Forms and Dynamics

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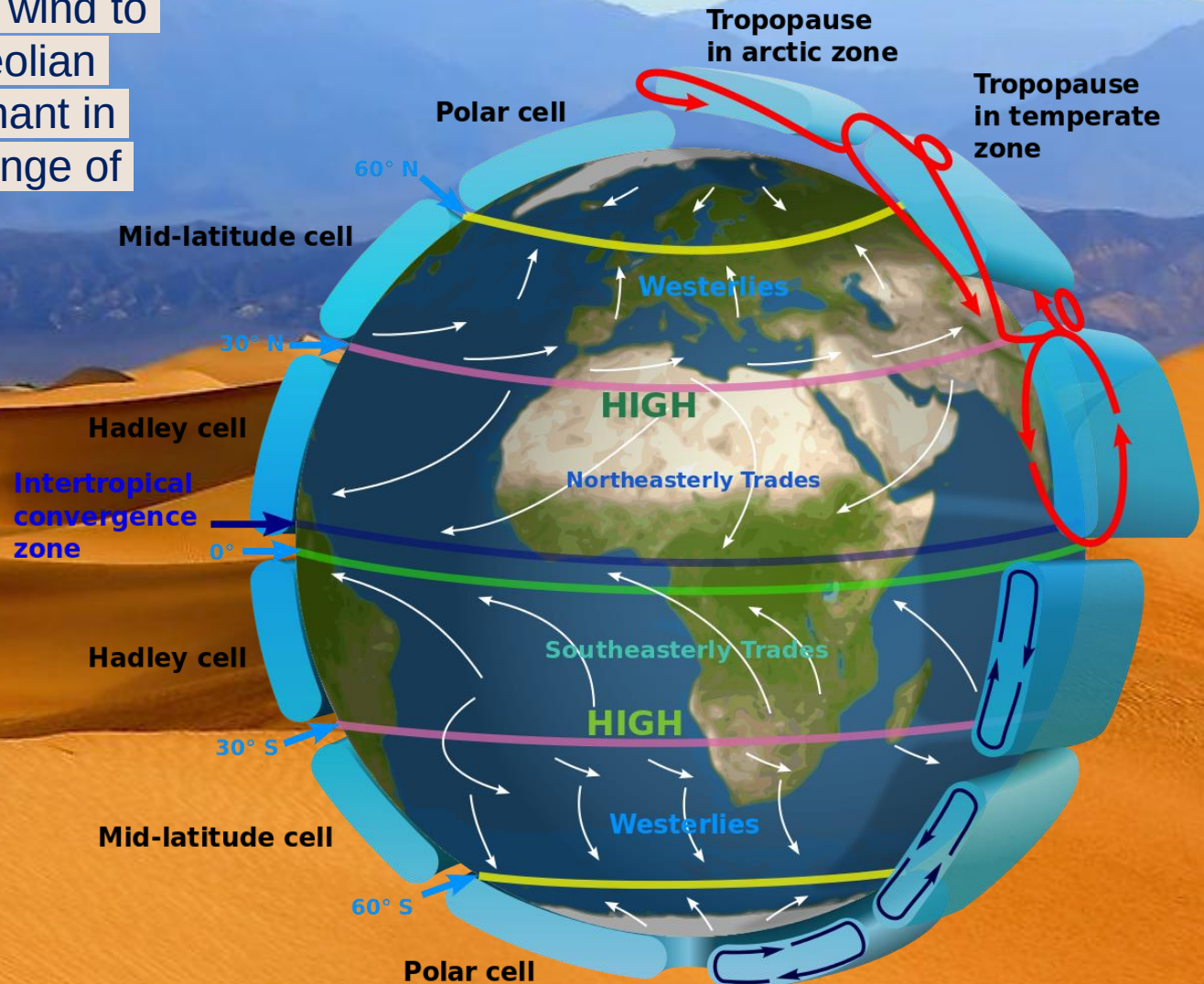
Aeolian relating to or arising from the action of the wind.

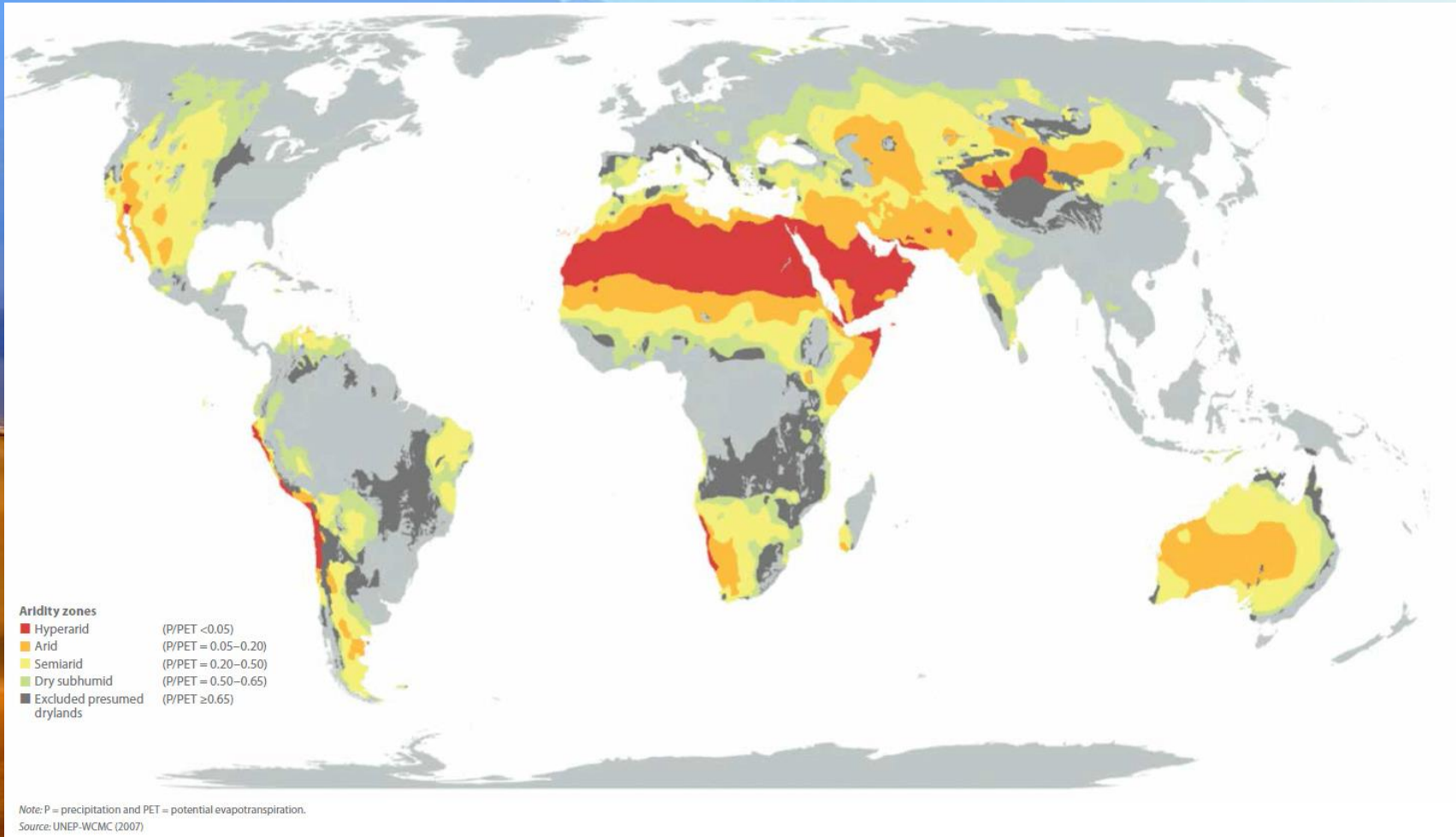
A dune is a mound of sand formed by the wind, usually along the beach or in a desert. Dunes form when wind blows sand into a sheltered area behind an obstacle. Dunes grow as grains of sand accumulate.

[Dune \(nationalgeographic.org\)](https://nationalgeographic.org)

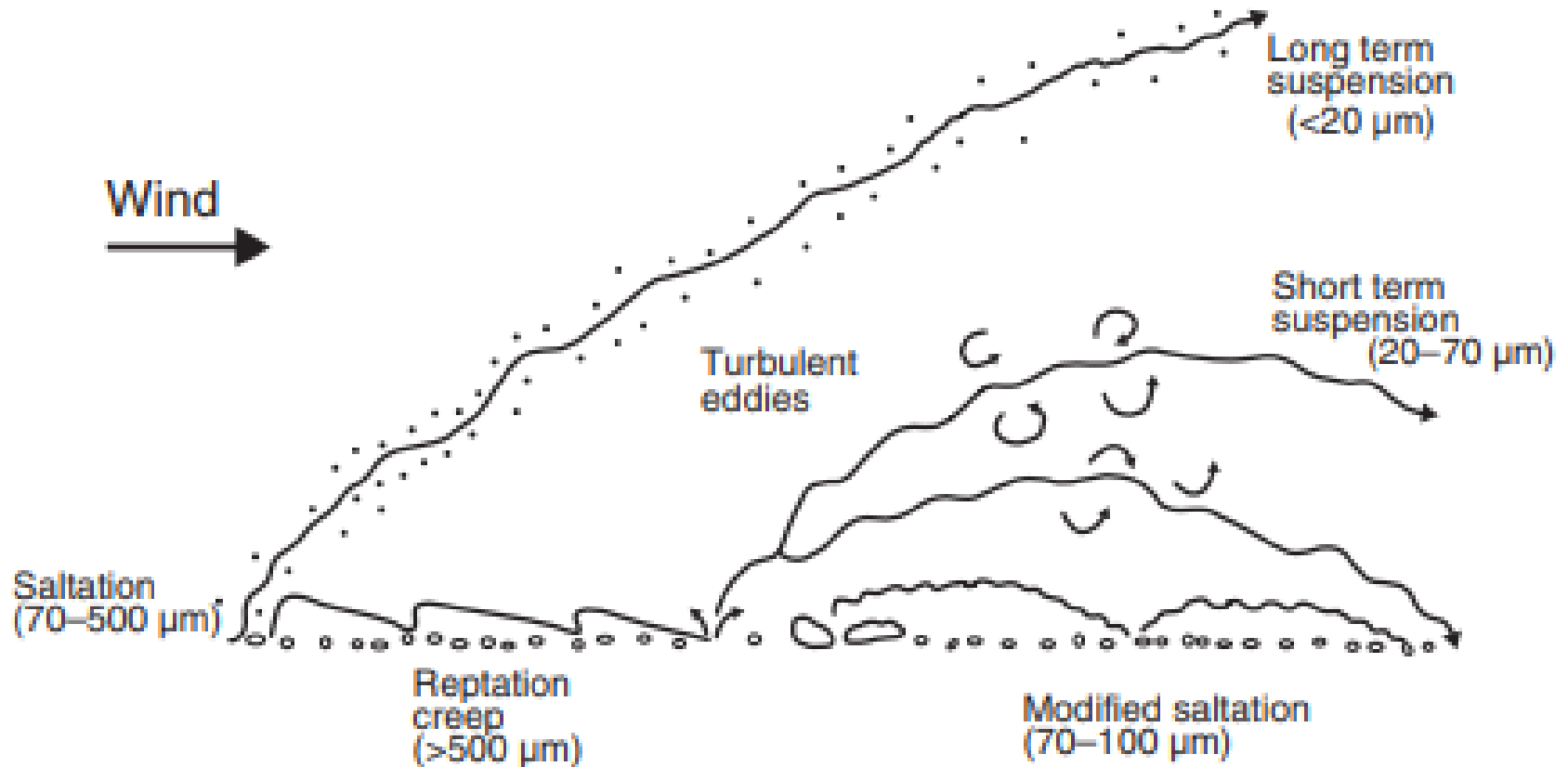
Understanding the aeolian system...

The whole of the surface of the globe is affected by the wind to varying degrees, but aeolian deposits are only dominant in a relatively restricted range of settings.





Arid and hyper-arid regions make up approximately 20% of Earth's surface and are arranged in two latitudinal zones around 30°N and S of equator, as a result of dry air associated with the descending arm of a Hadley Cell.



The aeolian sediment transport system can be subdivided into two classes based on grain size characteristics. That is: (a) material of sand size (>50 μm); and (b) silt- and clay-sized particles (< 50 μm) and dust

[Aeolian Sediment Transport | SpringerLink](#)

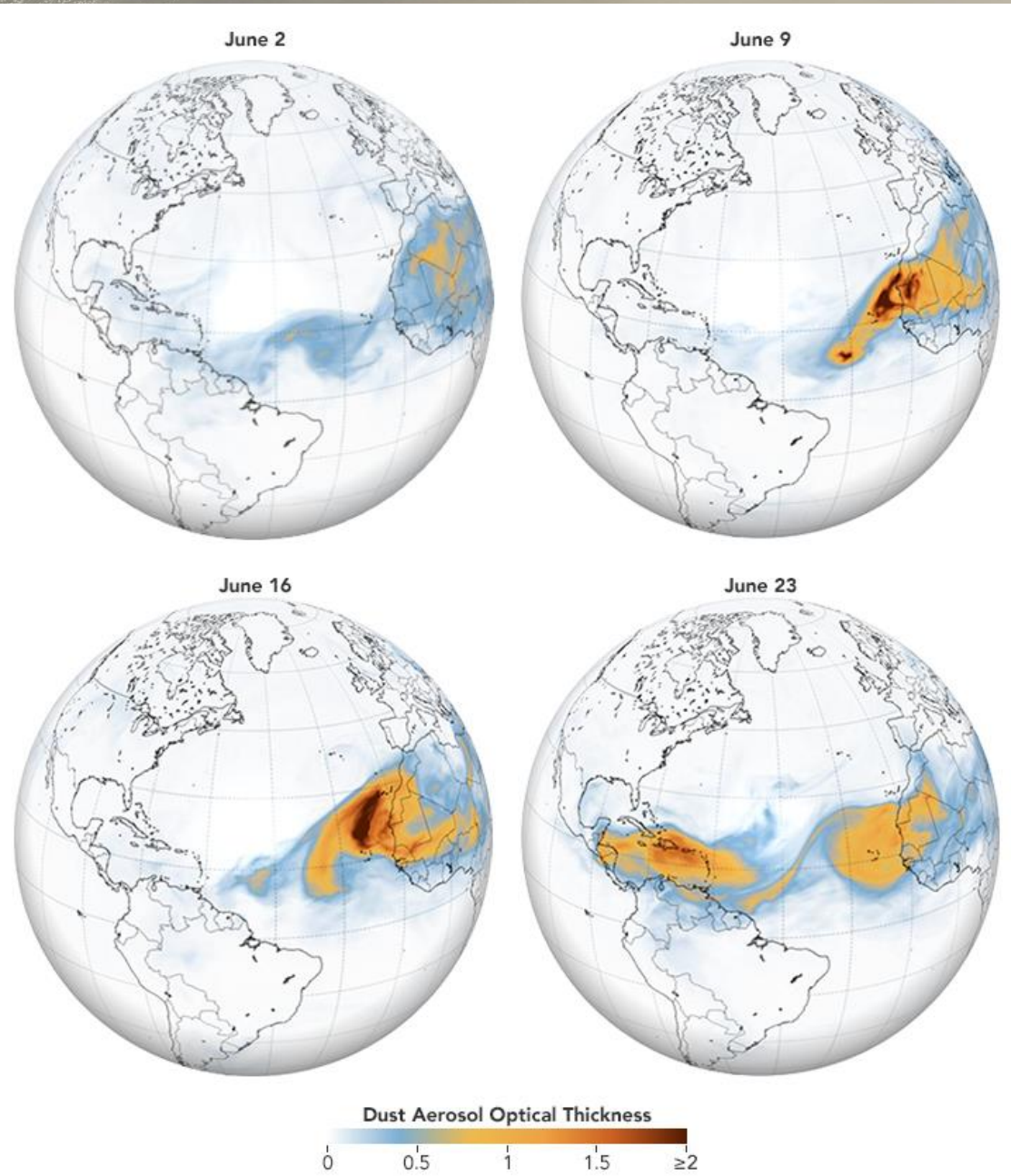
Understanding the aeolian system...

[Saharan Dust Blows Toward Europe](https://www.nasa.gov)
([nasa.gov](https://www.nasa.gov))



Long term suspension from aerial images (Cabo Verde)

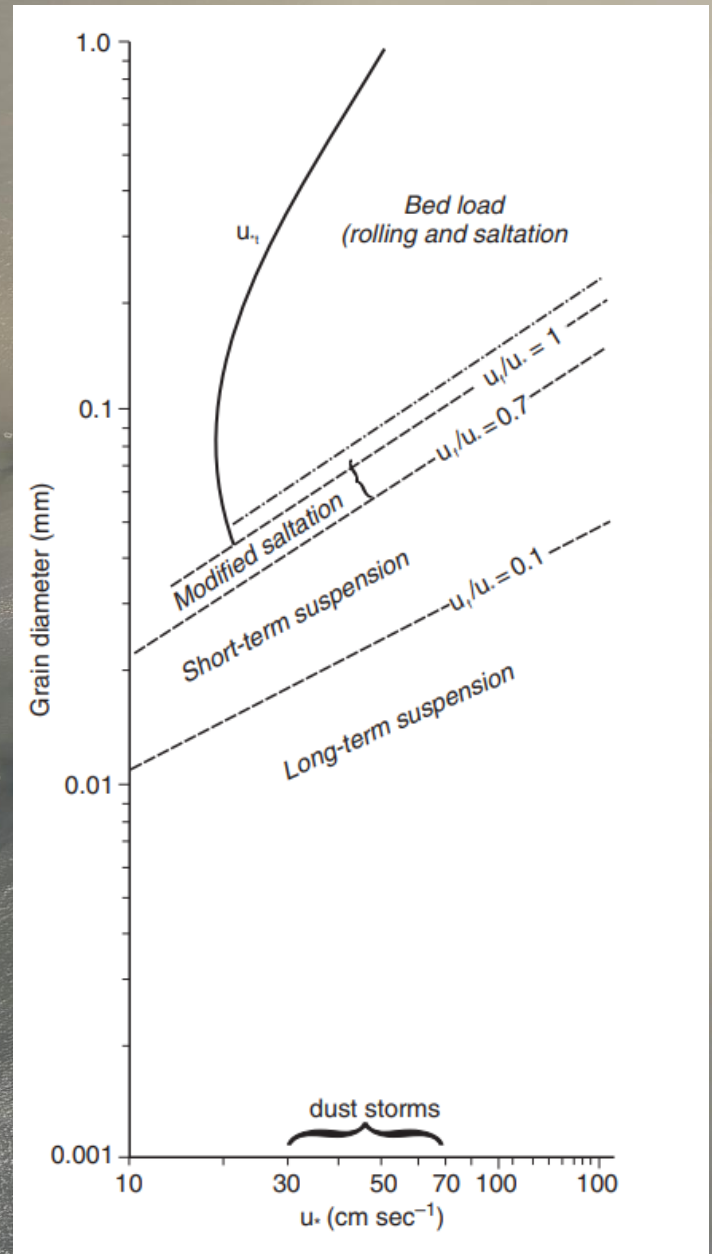
[A Dust Plume to Remember \(nasa.gov\)](https://www.nasa.gov)



Saharan dust transport

Modes of transport for quartz spheres of different diameters at different wind shear velocities (After Tsoar and Pye 1987)

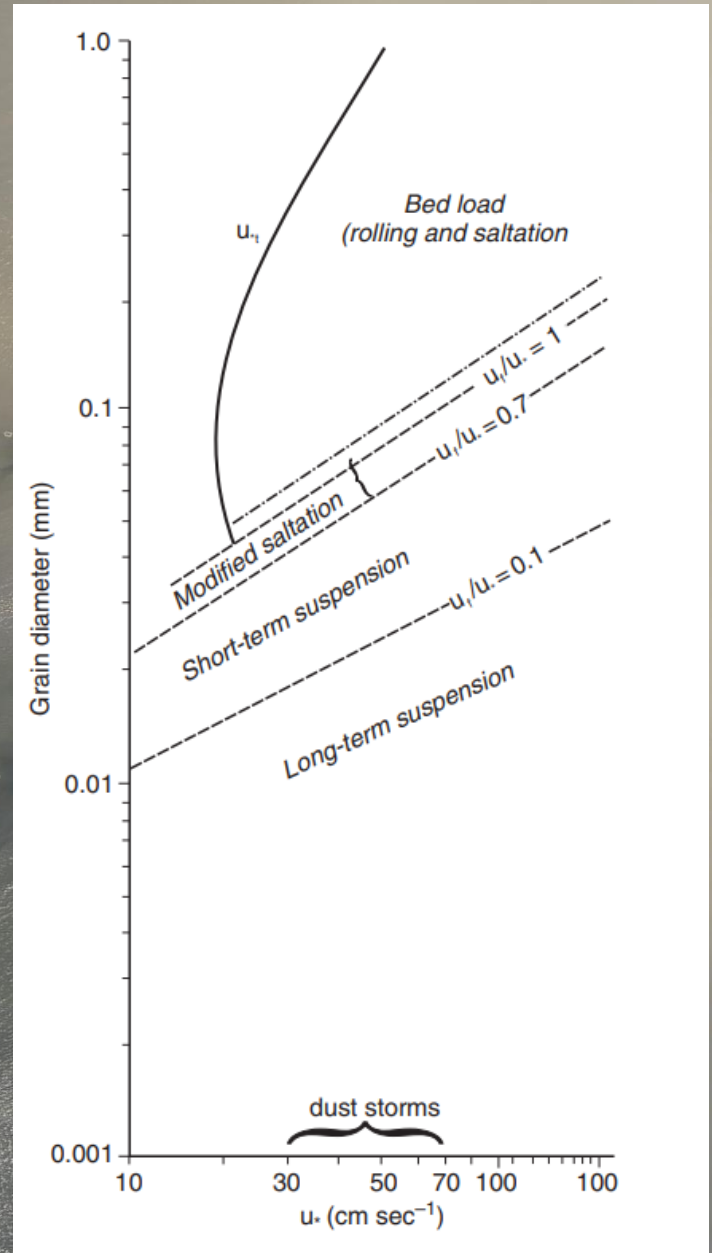
[Aeolian Sediment Transport | SpringerLink](#)



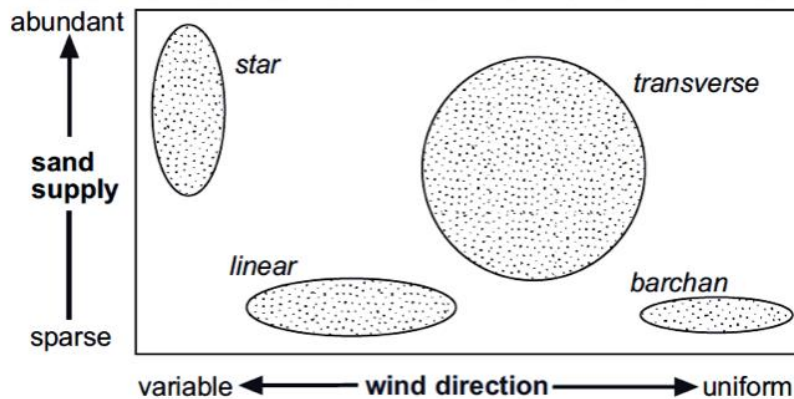
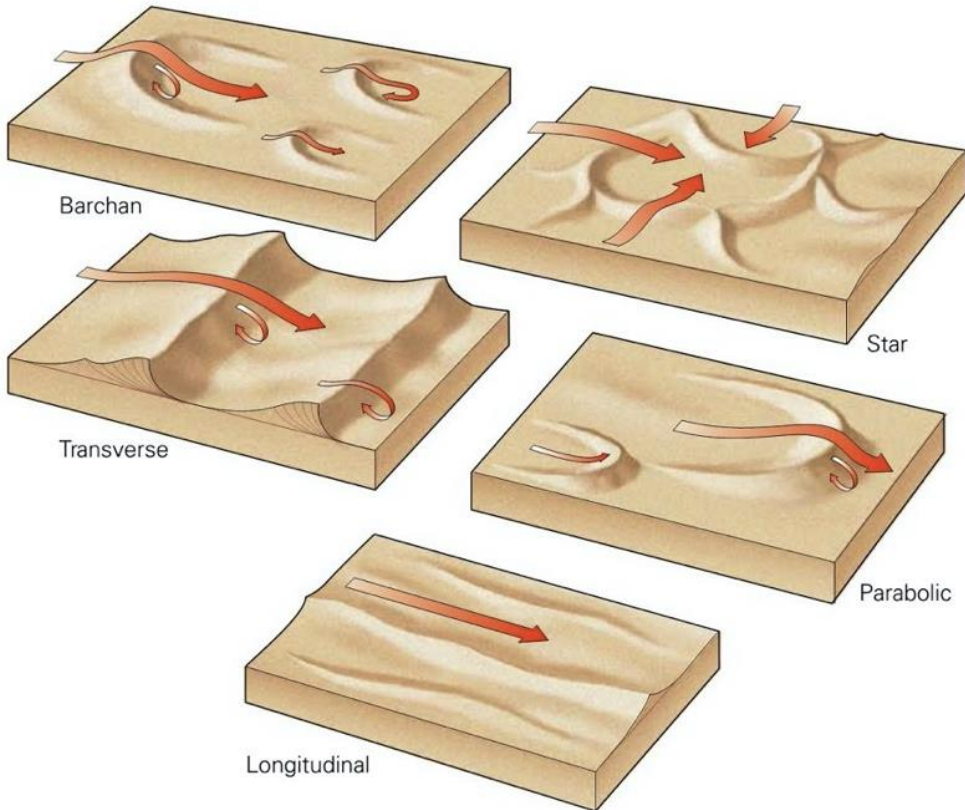
What about dune form?

Modes of transport for quartz spheres of different diameters at different wind shear velocities (After Tsoar and Pye 1987)

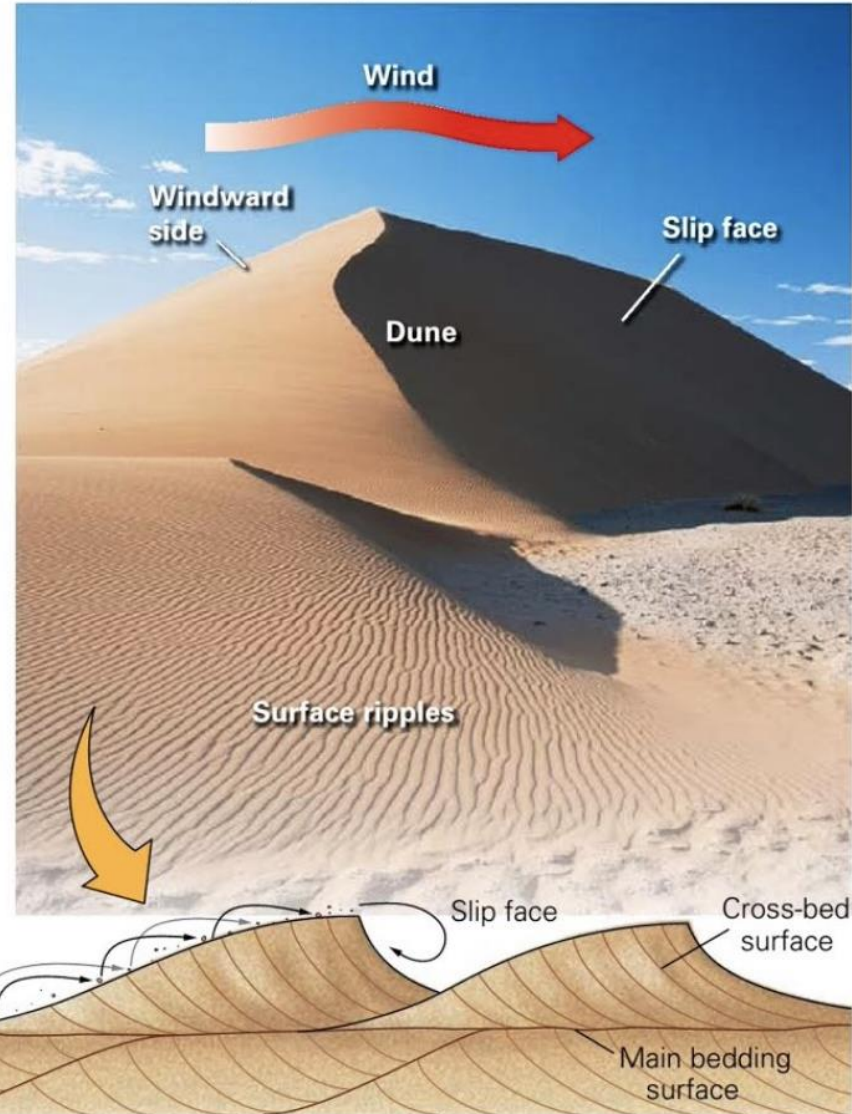
[Aeolian Sediment Transport | SpringerLink](#)



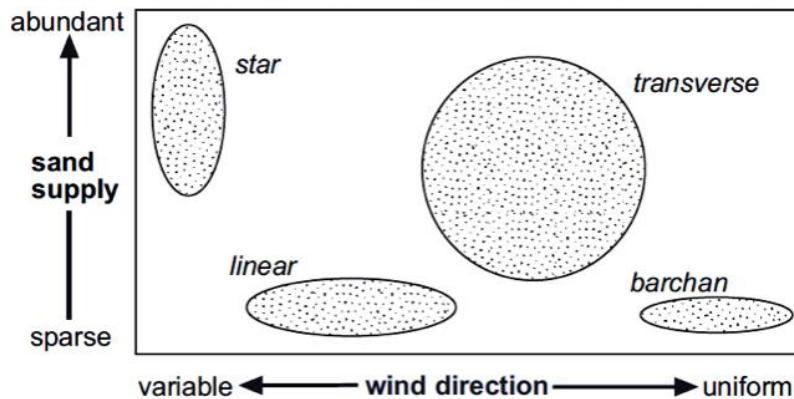
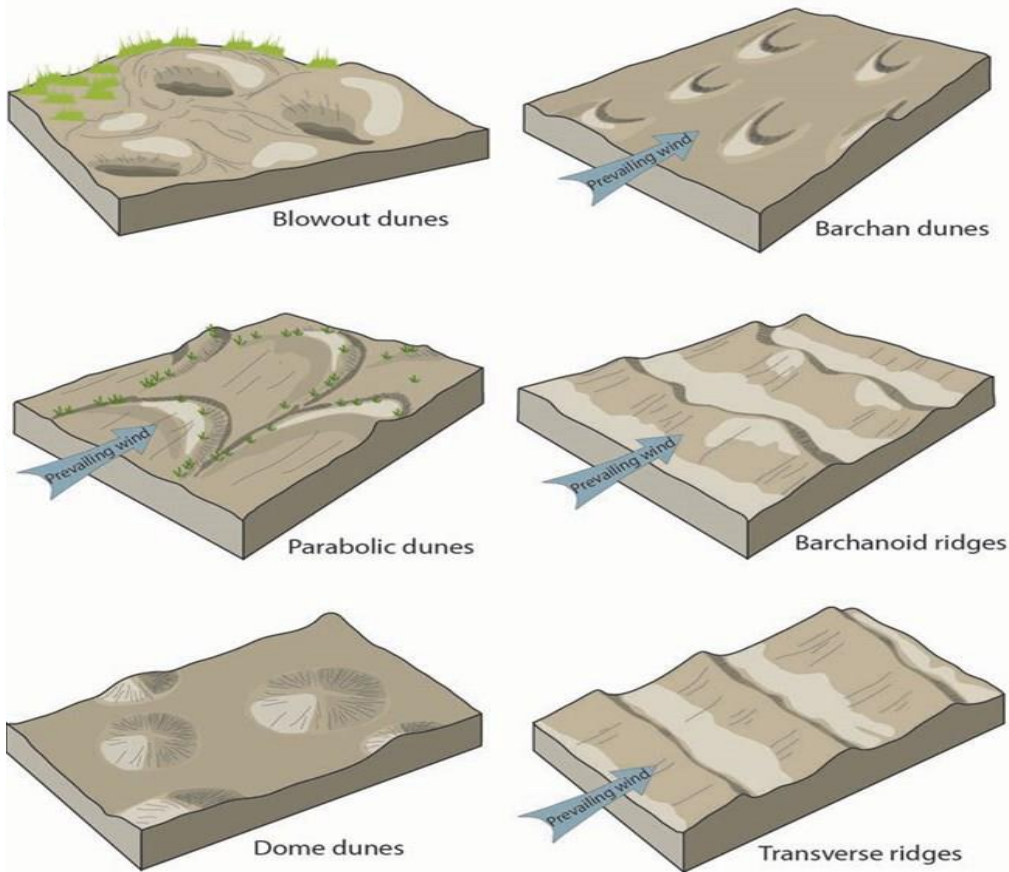
(a) The various kinds of sand dunes. Shapes depend on the sand supply and the wind character.



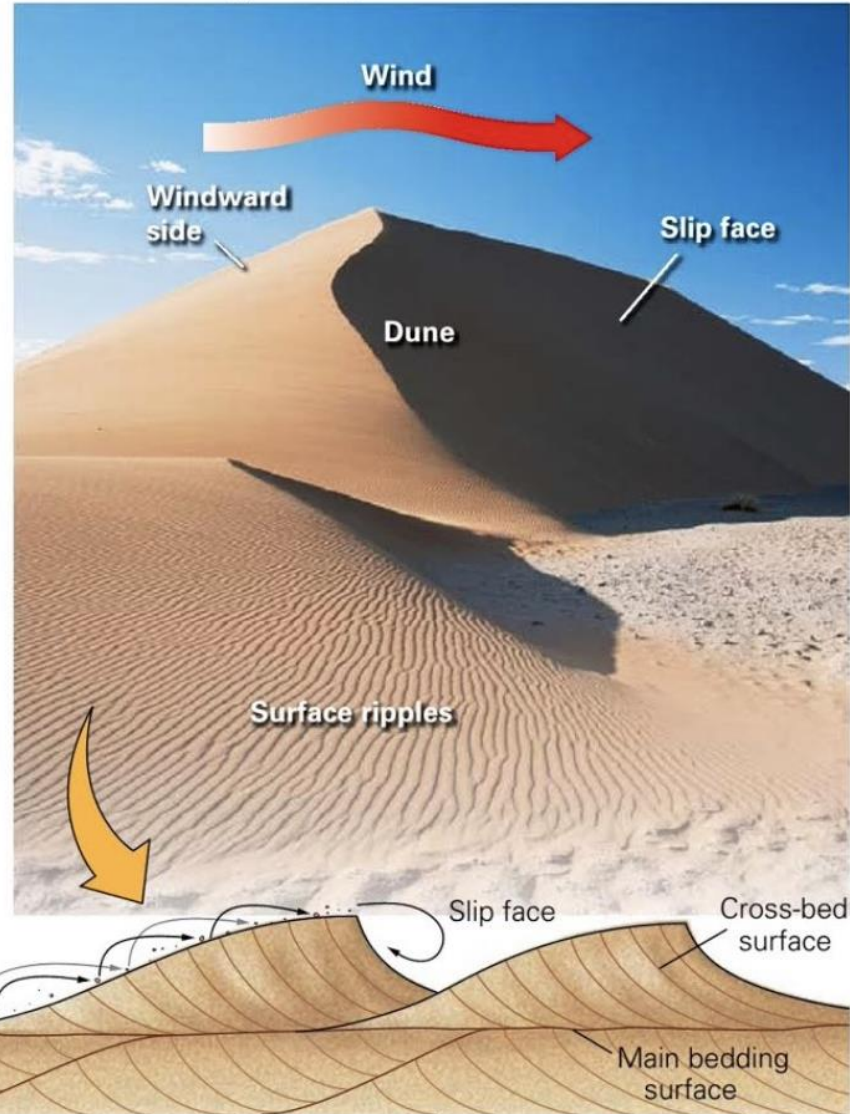
(b) The shape of a sand dune depends on the wind direction. Small ripples may form on the dune surface.



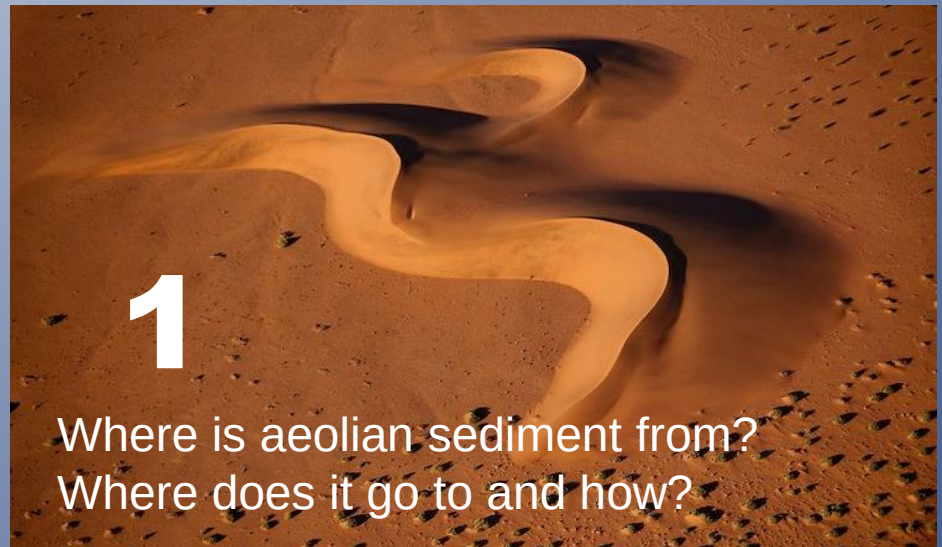
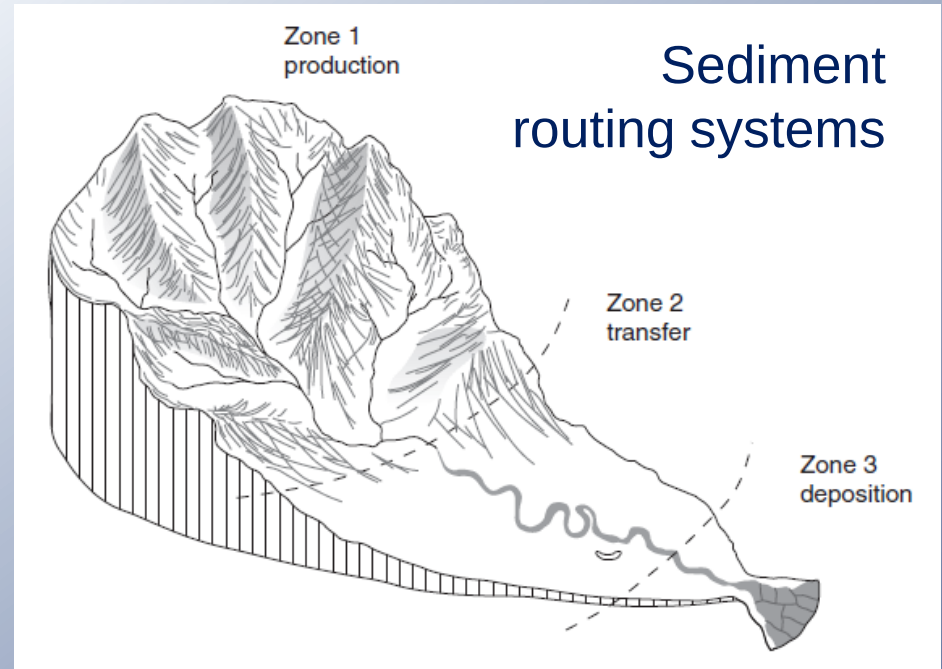
(c) Cross bedding inside a dune. Note that a cross bed is a buried slip face.

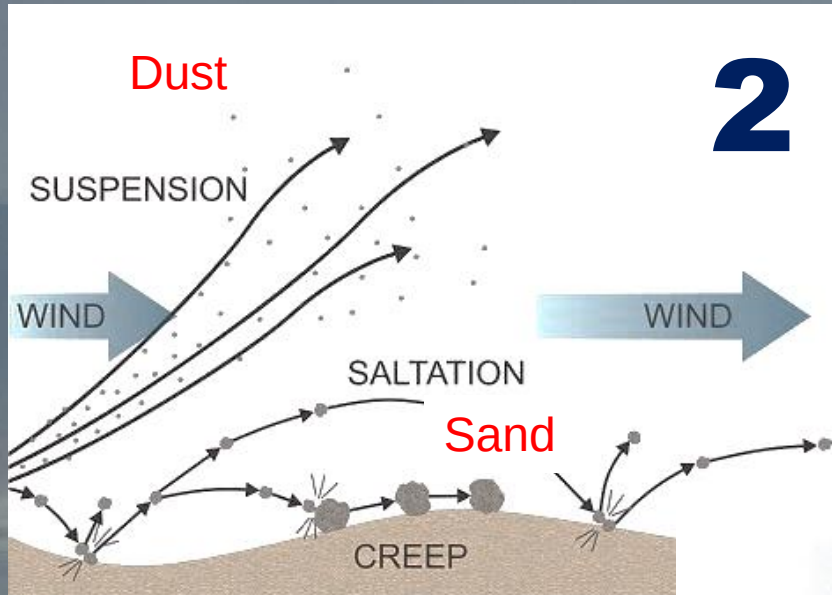


(b) The shape of a sand dune depends on the wind direction. Small ripples may form on the dune surface.



(c) Cross bedding inside a dune. Note that a cross bed is a buried slip face.

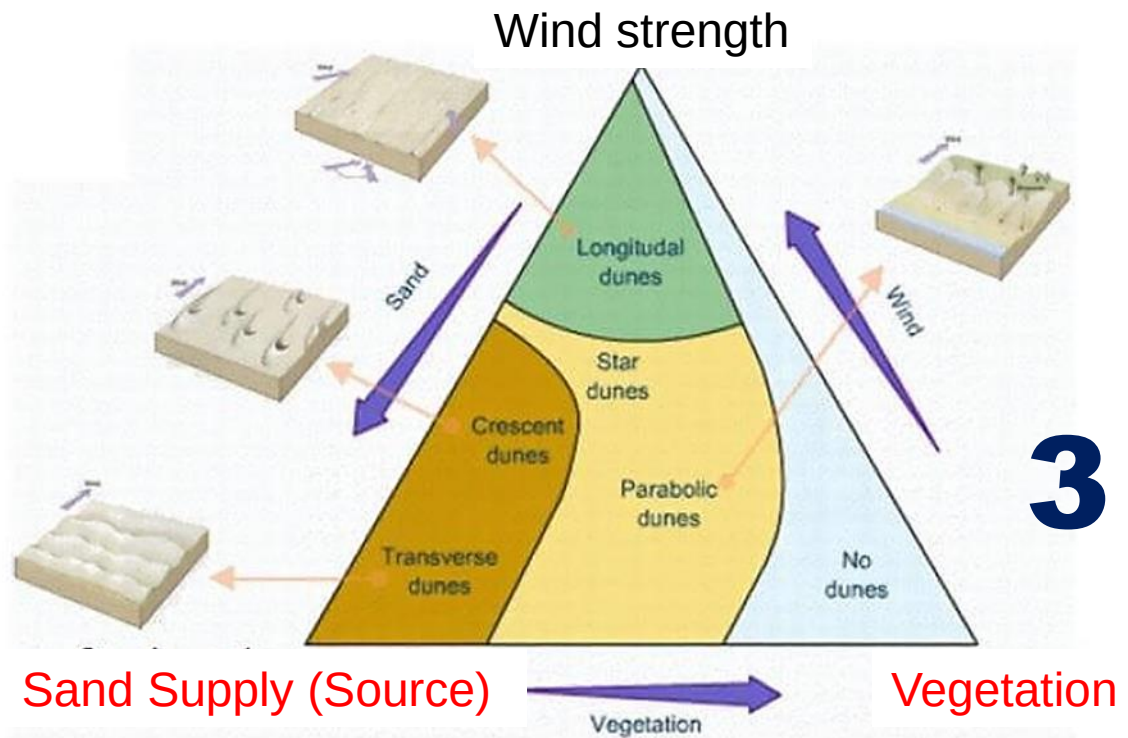




How does wind transport sediment?

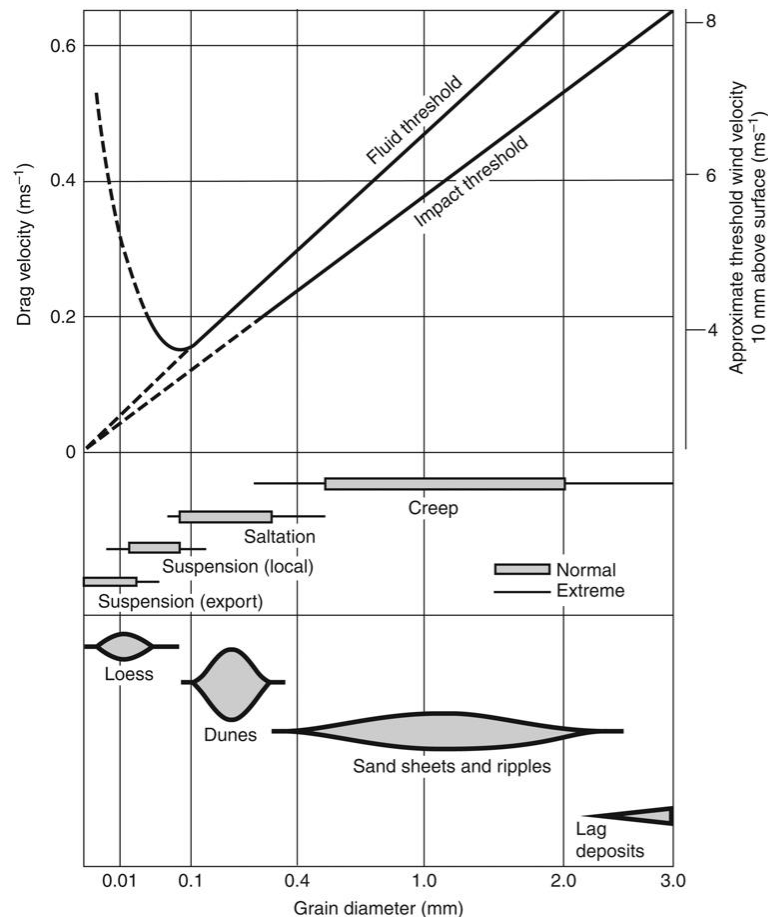
[How Are Sand Dunes Formed?](https://www.youtube.com/watch?v=...)
([youtube.com](https://www.youtube.com/watch?v=...)) (8mins)

Which landforms does this create, and what controls their formation?

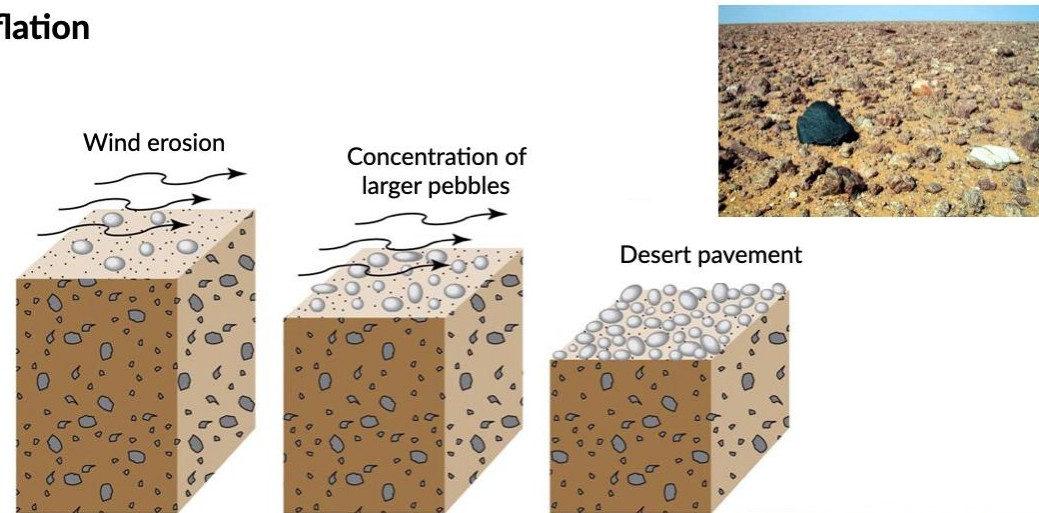


1.Deflation which is related to small particles eroded from the landscape by wind over time, leaving larger particles behind to form a desert pavement (ground surface lowers);

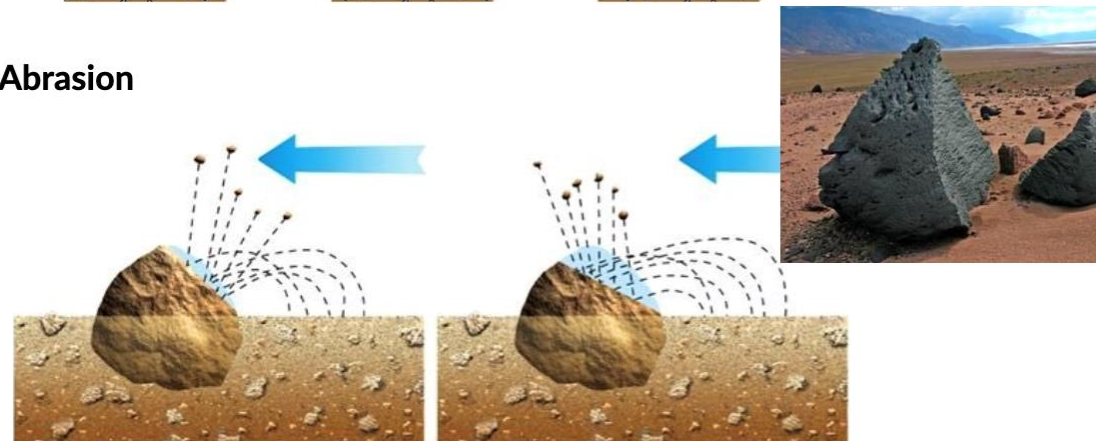
2.Abrasion where particles carried by the wind blast larger features in the landscape, abrading their surface and wearing away the rock.



Deflation



Abrasion



- Sand sources for aeolian transport

- Abrasion by saltating grains (aeolian erosion)

Yardangs

- **Sand sources** for aeolian transport

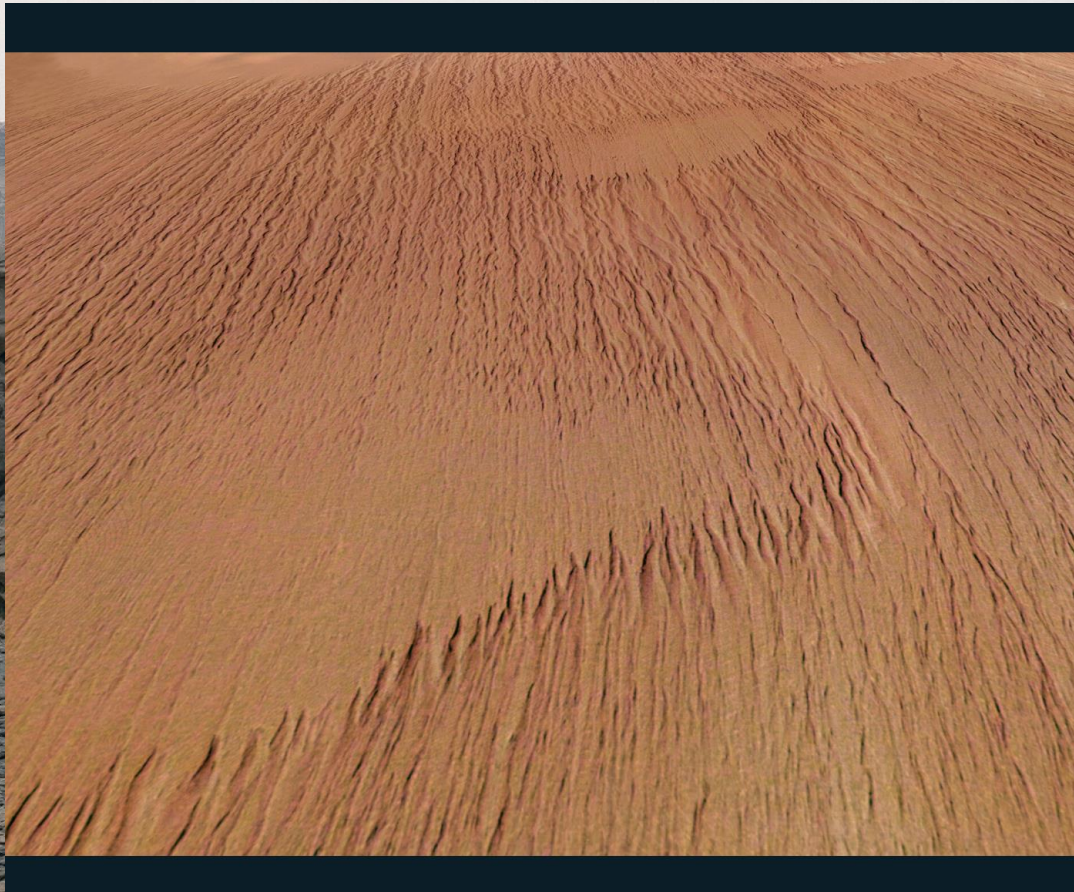
Yardangs are portions of rock that have been sandblasted into long, skinny ridges by saltating (or bouncing) sand particles blowing in the wind.



- Abrasion by saltating grains (aeolian erosion)

Yardang formation – Wadi Rum,
Jordan
AKA Arrakis in Dune

Yardangs are portions of rock that have been sandblasted into long, skinny ridges by saltating (or bouncing) sand particles blowing in the wind.



SCIENCE & EXPLORATION

'Yardangs' on the surface of Mars

12/07/2004 1240 VIEWS 6 LIKES 239525 ID

LIKE

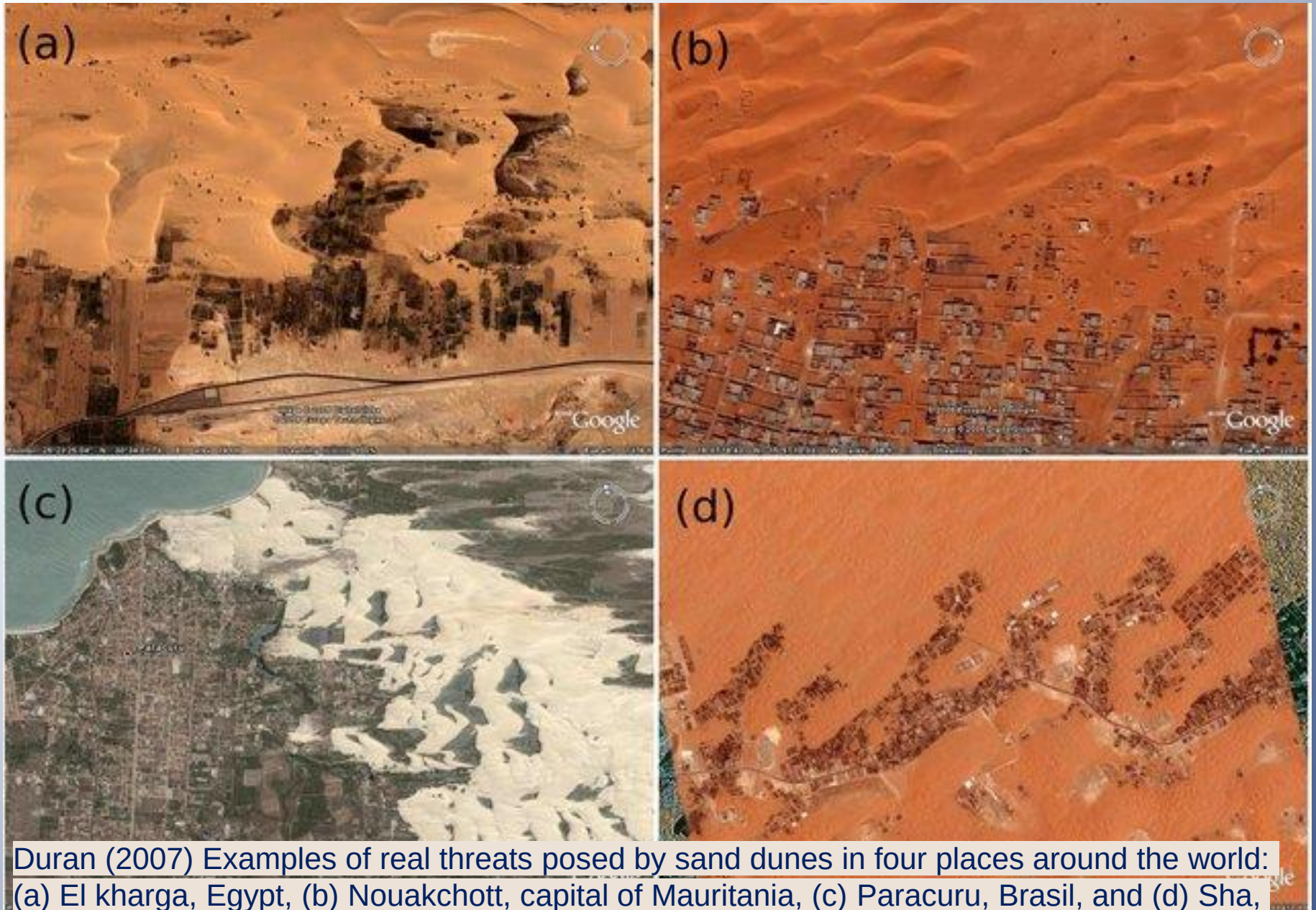
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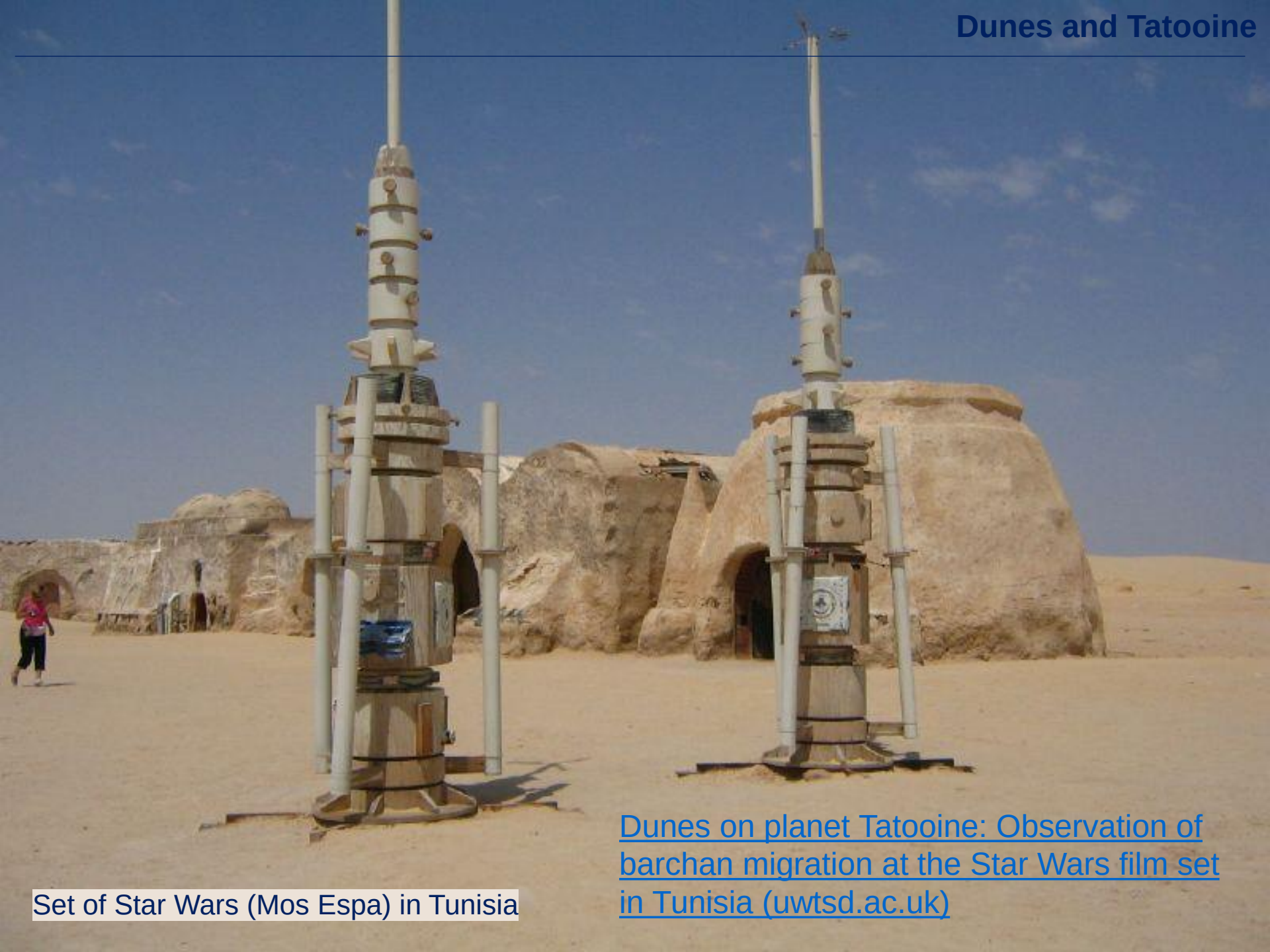
DETAILS

RELATED

These images of 'yardangs', features sculpted by wind-blown sand seen here near Olympus Mons on Mars, were obtained by the High Resolution Stereo Camera (HRSC) on board the ESA Mars Express spacecraft.



Duran (2007) Examples of real threats posed by sand dunes in four places around the world: (a) El kharga, Egypt, (b) Nouakchott, capital of Mauritania, (c) Paracuru, Brasil, and (d) Sha, United Arab Emirates.



Set of Star Wars (Mos Espa) in Tunisia

[Dunes on planet Tatooine: Observation of barchan migration at the Star Wars film set in Tunisia \(uwtsd.ac.uk\)](http://uwtsd.ac.uk)

What about now?

[Star Wars: Mos Espa - Google Maps](#)



Set of Star Wars (Mos Espa) in Tunisia

[Dunes on planet Tatooine: Observation of barchan migration at the Star Wars film set in Tunisia \(uwtsd.ac.uk\)](#)

Where does the sand originate from?

- **Sand sources** for aeolian transport



- Fluvial processes often play a key role in presorting and concentrating weathering products

removal of solid particles by wind

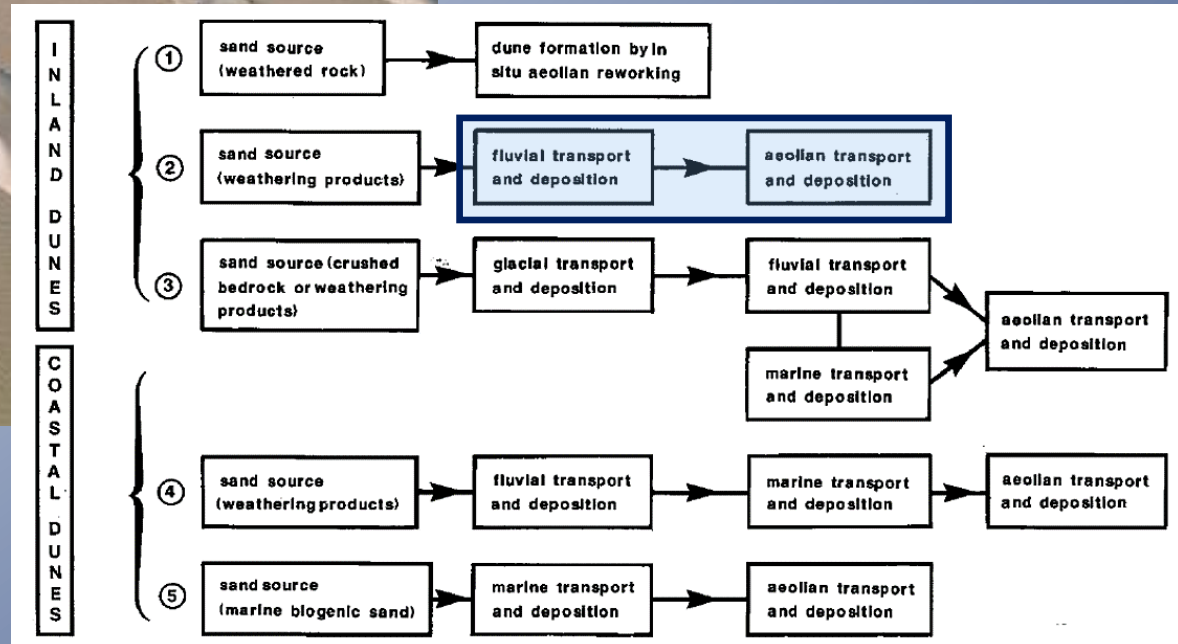
- **Deflation** of exposed **fluvial** and **lacustrine** sediments /

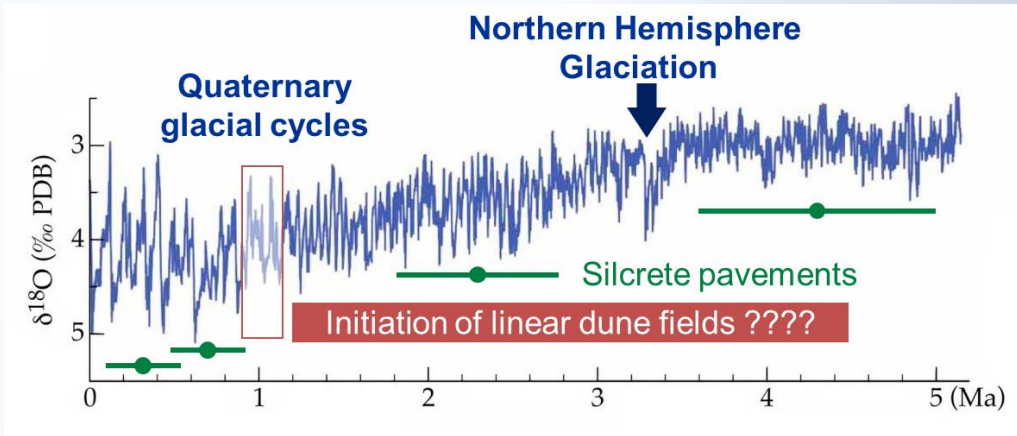
1

2

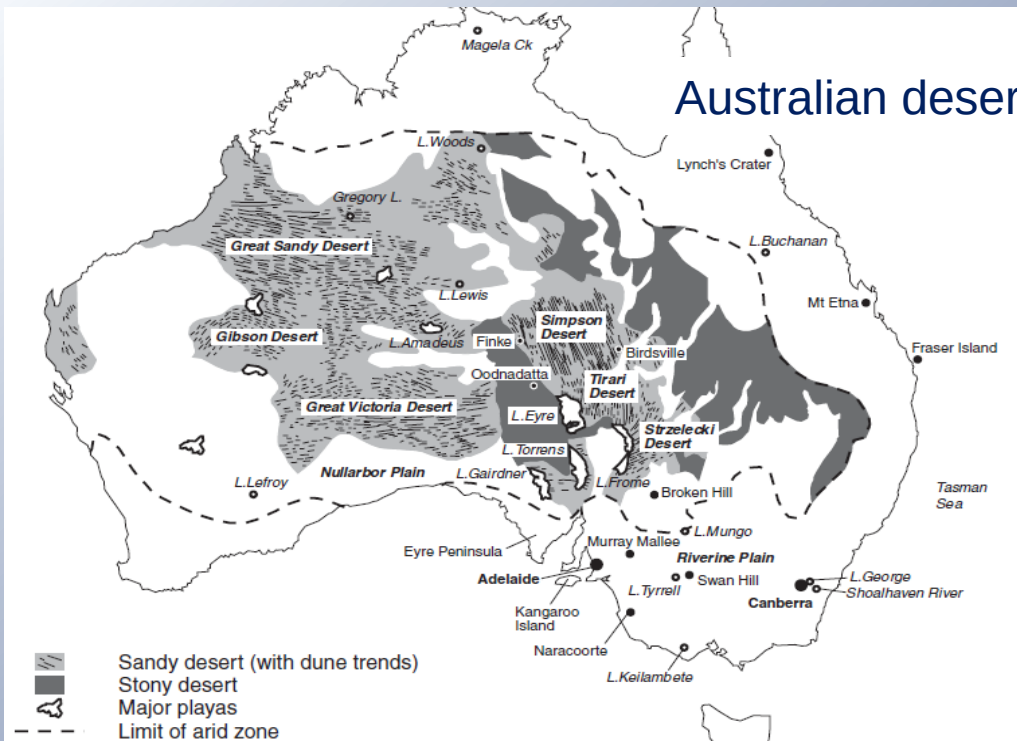
3

Sandy regolith
formed by weathering
in arid climates



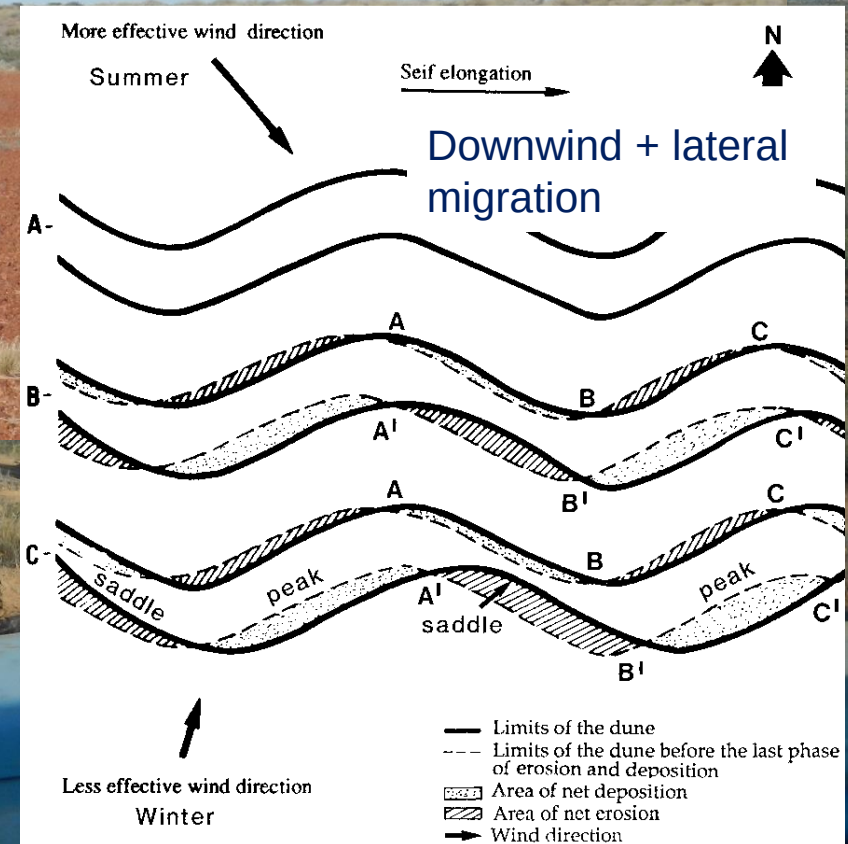
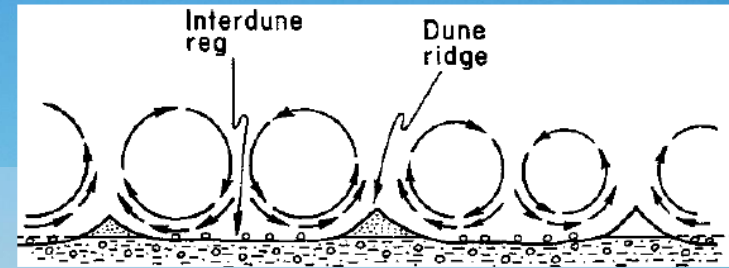


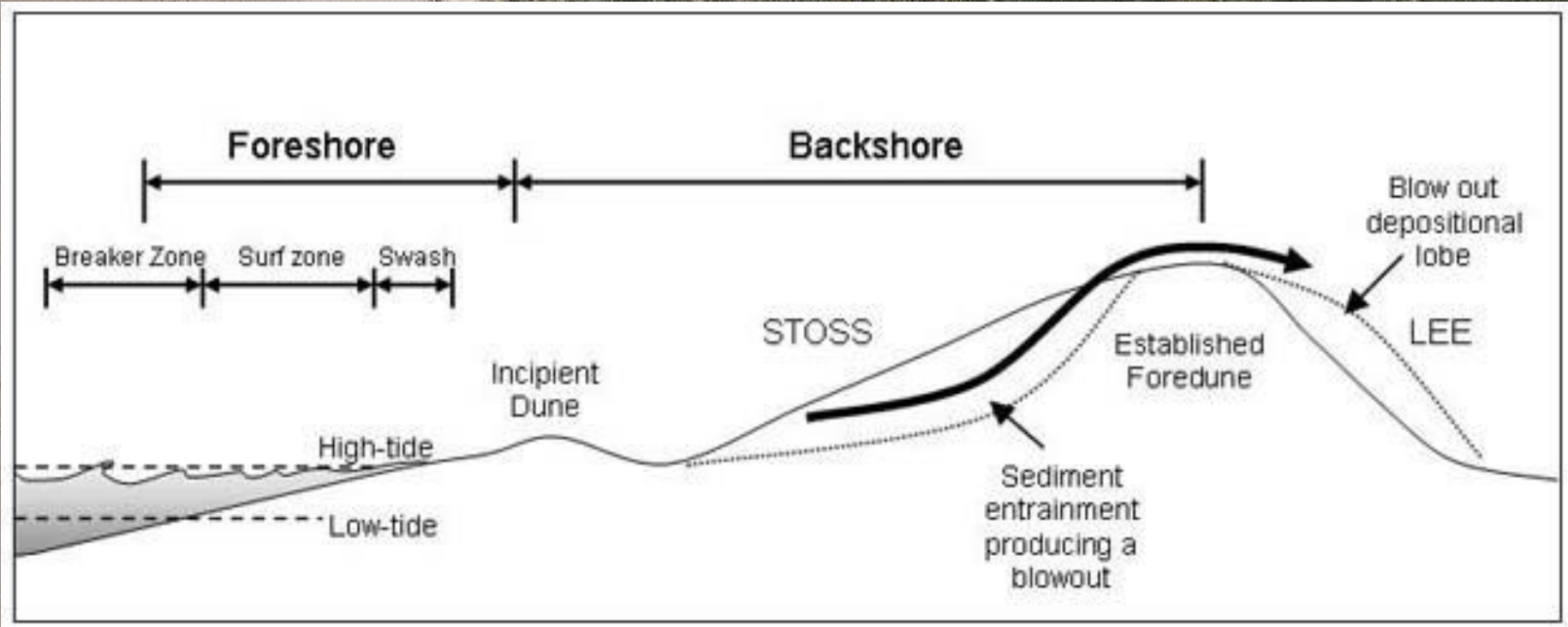
Transport-limited and humid



Weathering-limited and dry

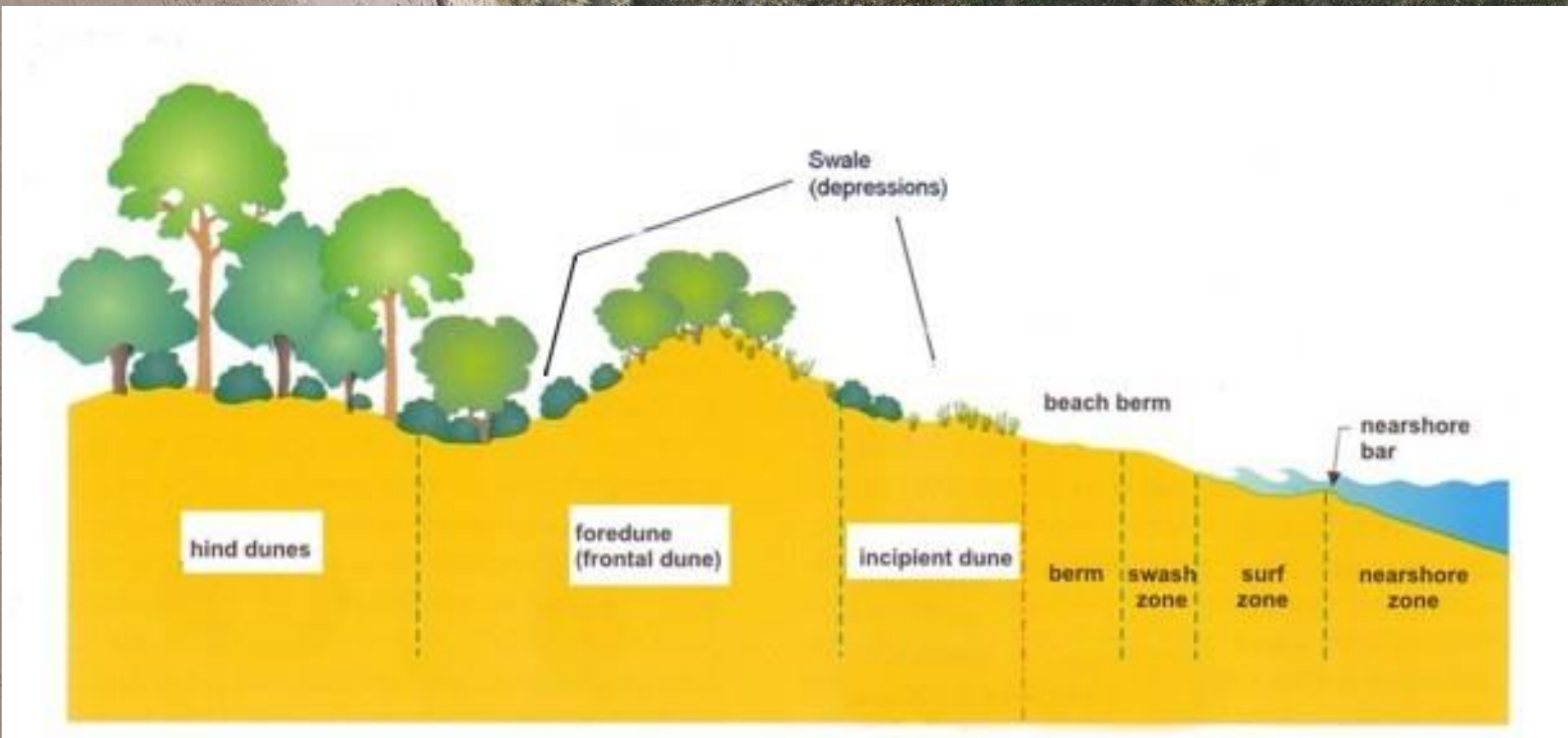
- Linear Dune Formation ? Alignment with dominant wind direction?
 - ... roller vortices with helicoidal flow sweep sand from interdune areas to dunes ?
 - correlation between the occurrence of linear dunes and directional wind variability
 - studies of internal sedimentary structures
 - experiments in flumes
 - numerical simulations
 - detailed process studies on linear dunes





[Formation of Sand Dunes - Shape Your Coastal Landscape \(dunedoctors.com\)](http://dunedoctors.com)

[Coastal Dunes: Geomorphology | Learn Science at Scitable \(nature.com\)](http://nature.com)



The Geomorphological zones of a coastal dune system

[Formation of Sand Dunes - Shape Your Coastal Landscape \(dunedoctors.com\)](http://dunedoctors.com)

[Coastal Dunes: Geomorphology | Learn Science at Scitable \(nature.com\)](http://nature.com)

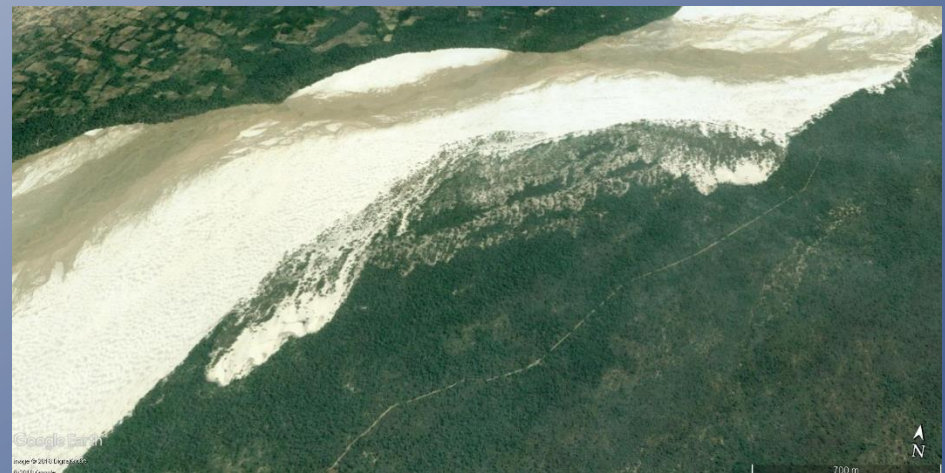
- Source-bordering dune = **SBD**

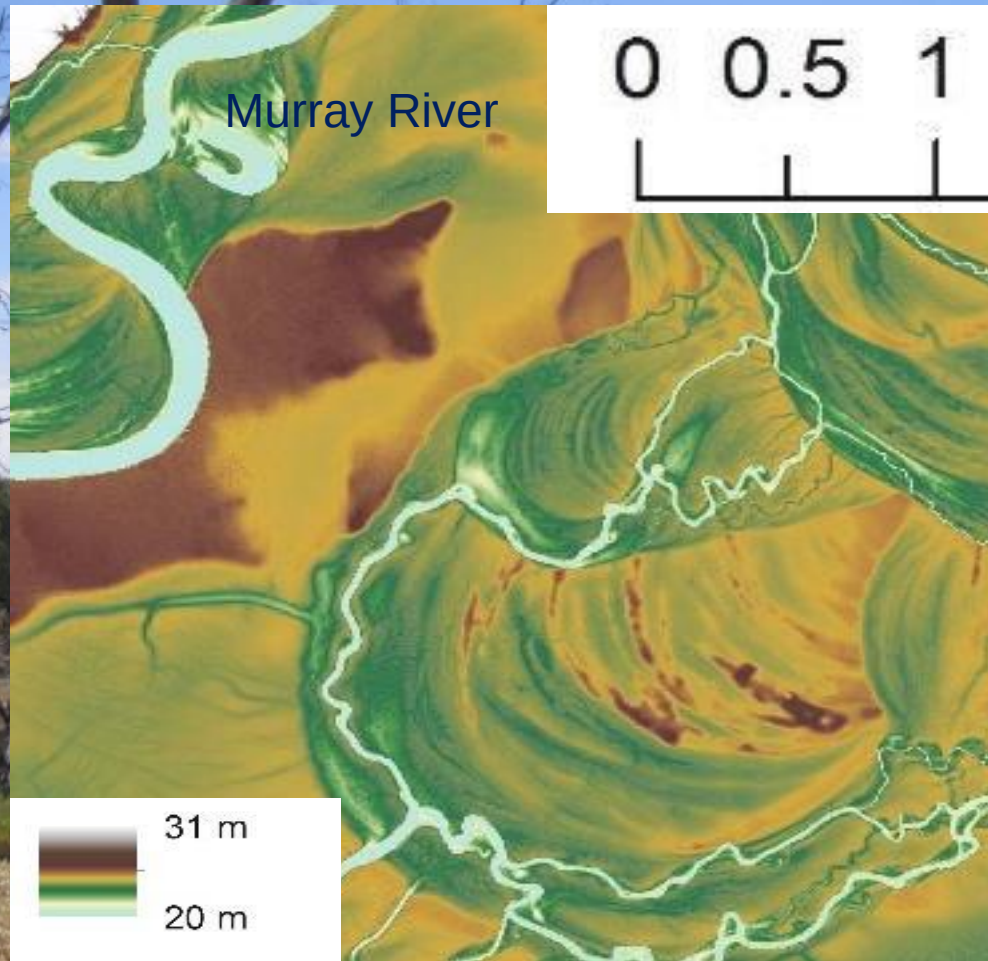
The term SBD generally describes a dune closely bordering the leeside of its sediment source (Page et al 2001)...

1. Coastal foredunes
2. Lunette
3. Riverine

... but more specifically is has been applied to sand dunes downwind of sand bed **ivers** (Page 1971, Bullard and McTainsh 2003); no formation definition

1. lee-source dune (Melton 1940)
2. source-bordering lee dune (Stone 1967)
3. source-bordering ramparts (Wopfner & Twidale 1988)
4. riverine dune (Ivester and Leigh 2003)
5. stream-side dune (Wasson 1983a)

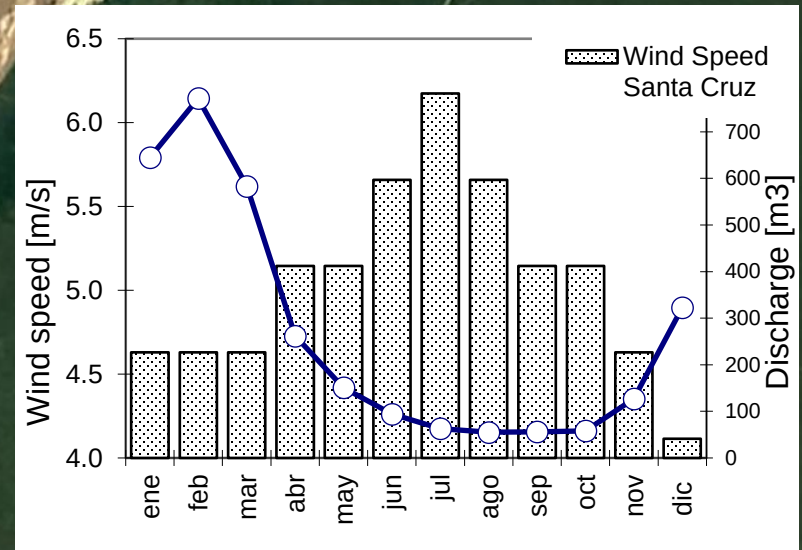


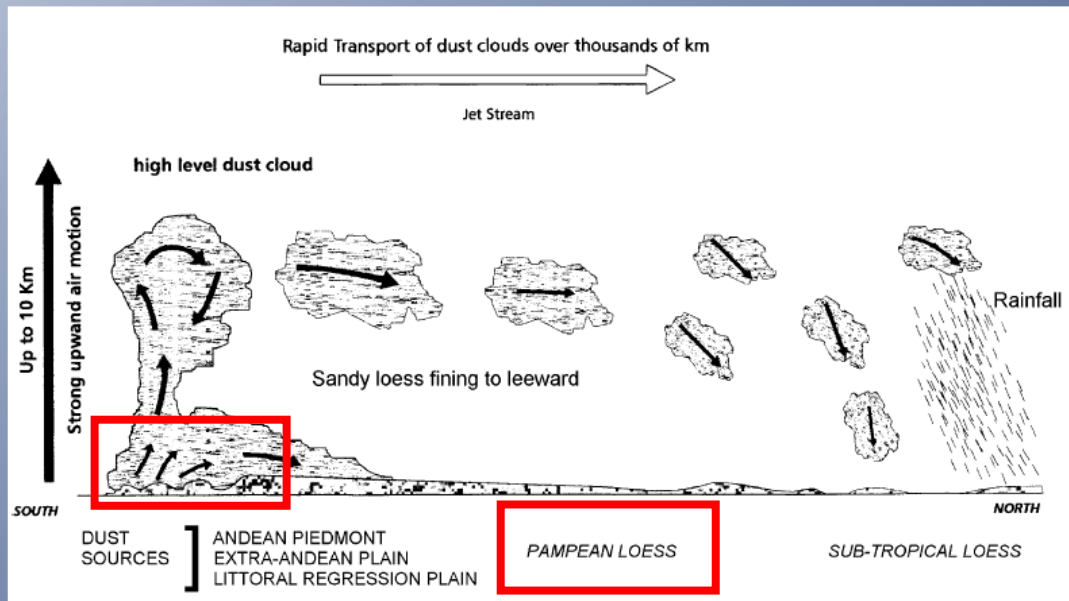
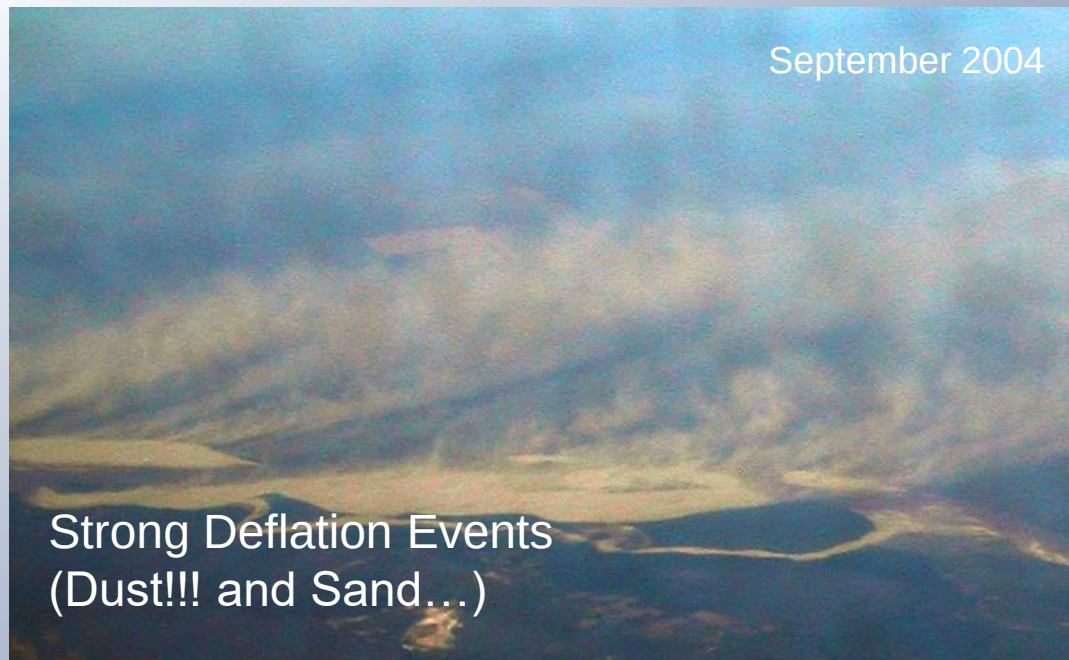
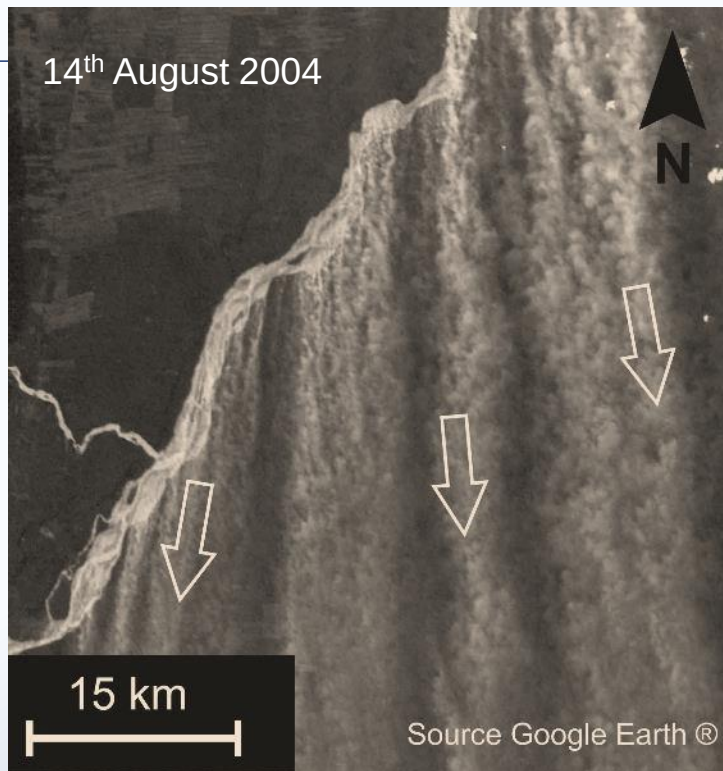


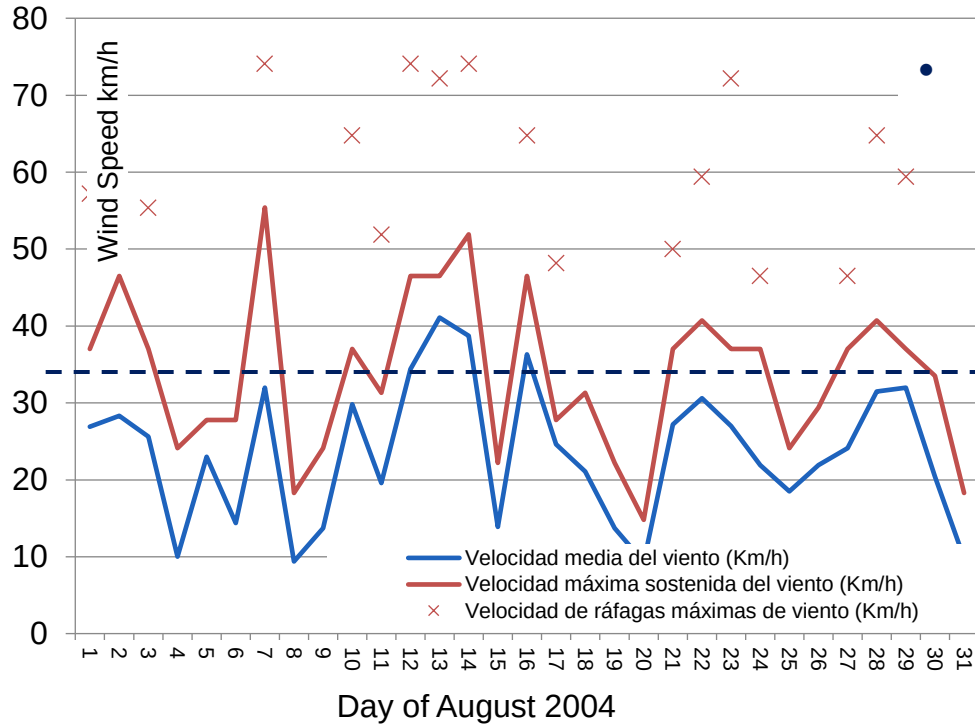
- Persistent **seasonality**, with renewed **sediment supply during flood events** and subsequent **drying of river bed required for deflation** (Bullard and McTainsh 2003)...
- SBD activity may also be controlled by **density of bank vegetation** (Williams et al 1991)
- **Lack of modern analogue** studies complicates the development of models on processes and controls of initial SBD formation (Maroulis et al 2007).

- Unidirectional Wind Regime + Seasonal Contrast in Discharge and Wind Speed !

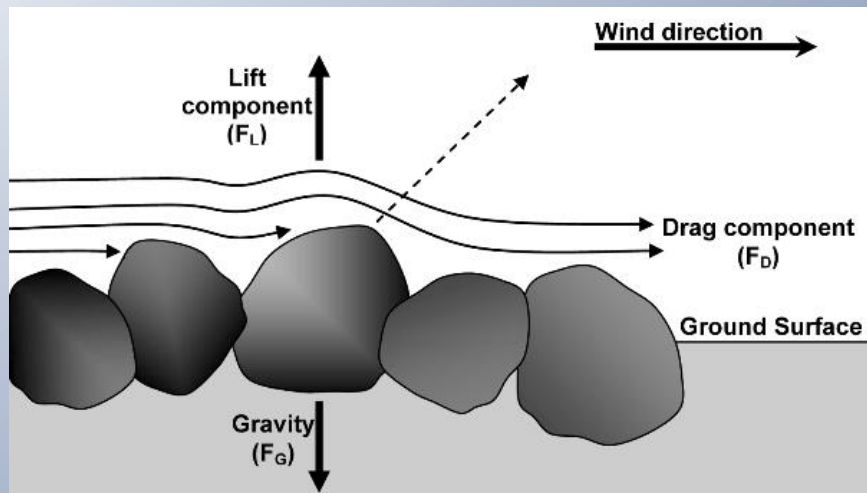
Grande / Guapay
River (Bolivia)



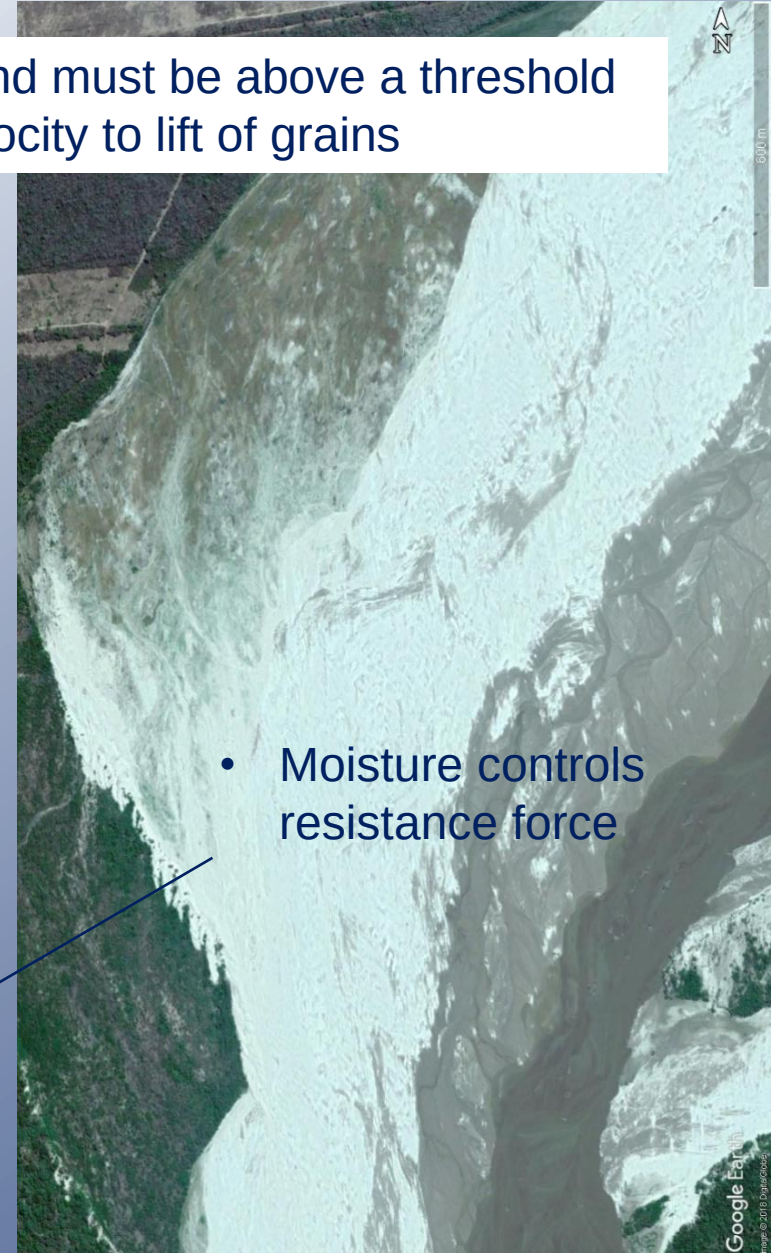


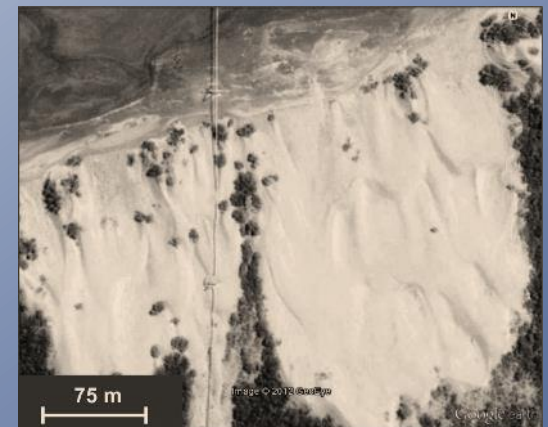
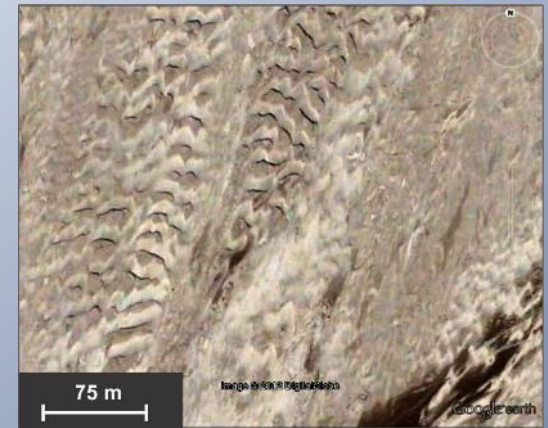


- Wind must be above a threshold velocity to lift of grains



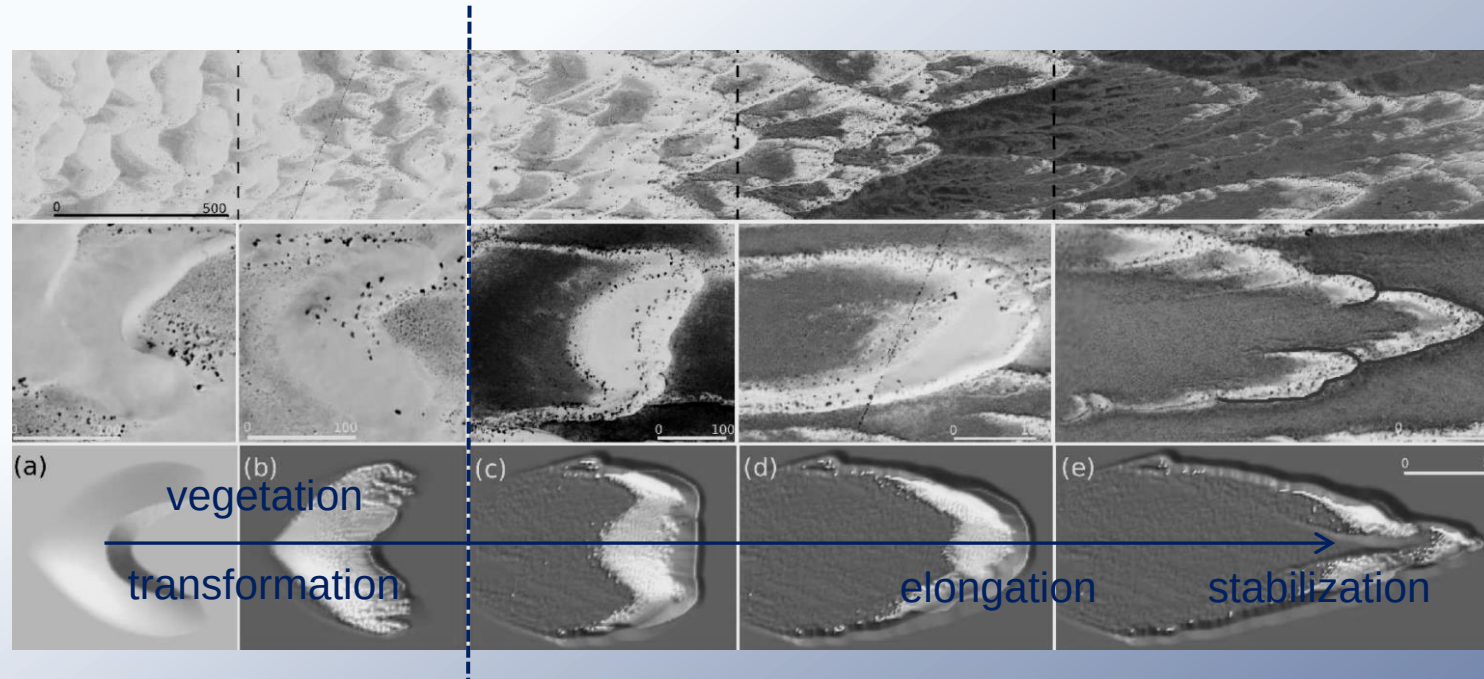
- Moisture controls resistance force





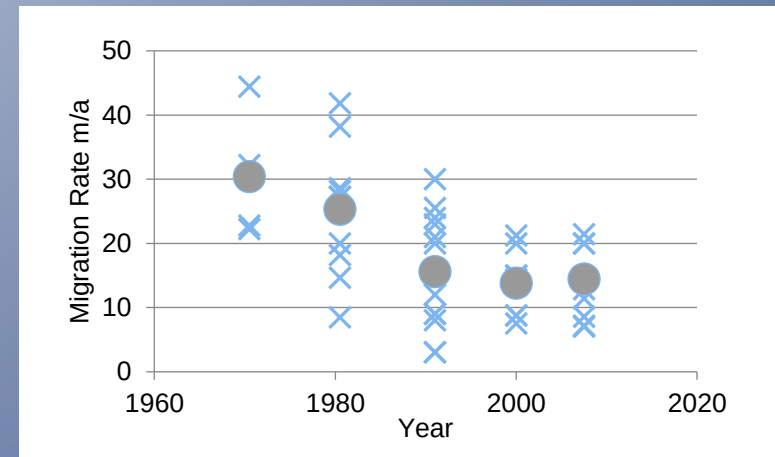
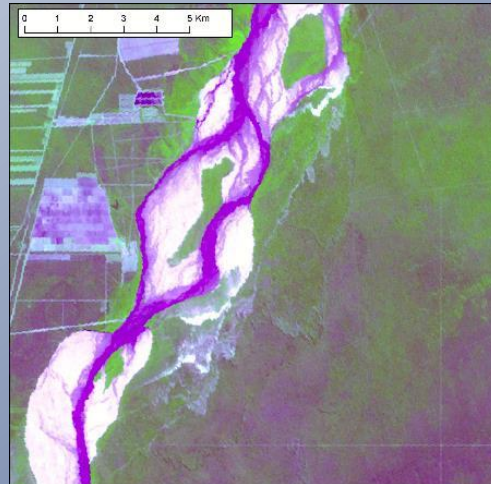
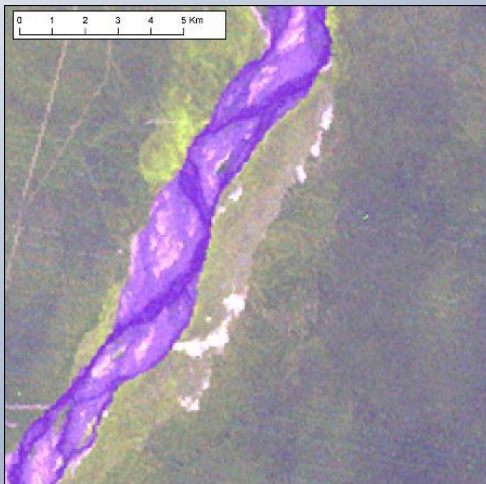
- **From Source to Border – sequential development (Short-term dynamics)**

Source



Border

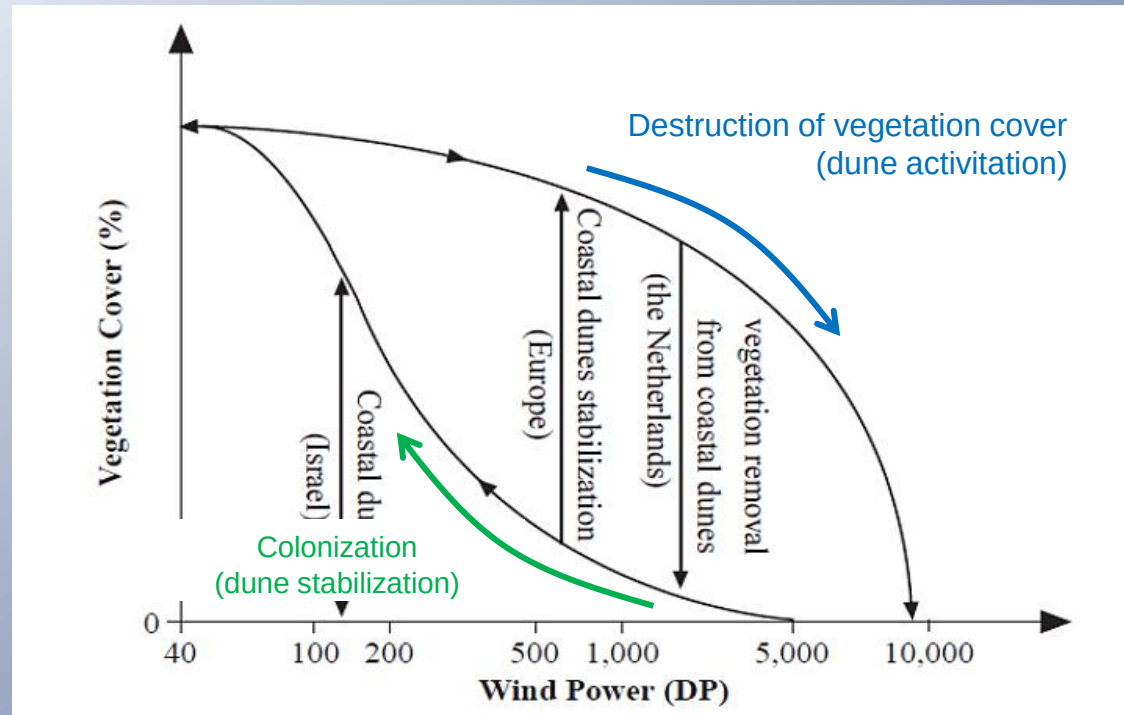
- Migration Rates are initially extremely high, then decline over time (dune gets stabilized)



- Sand Supply or wind (distance) vs vegetation



- Sandy ecosystems are not controlled by water (rainfall) but by wind power
- Wind erosion the main limiting factor for vegetation



- Once vegetated, a much higher wind stress is needed to destroy the vegetation and re-activate the dunes
- Hysteresis – threshold and non-linear behaviour



climbing dunes

3

falling dunes

4

- Arid environment – absence of vegetation

2

proximal dune fields

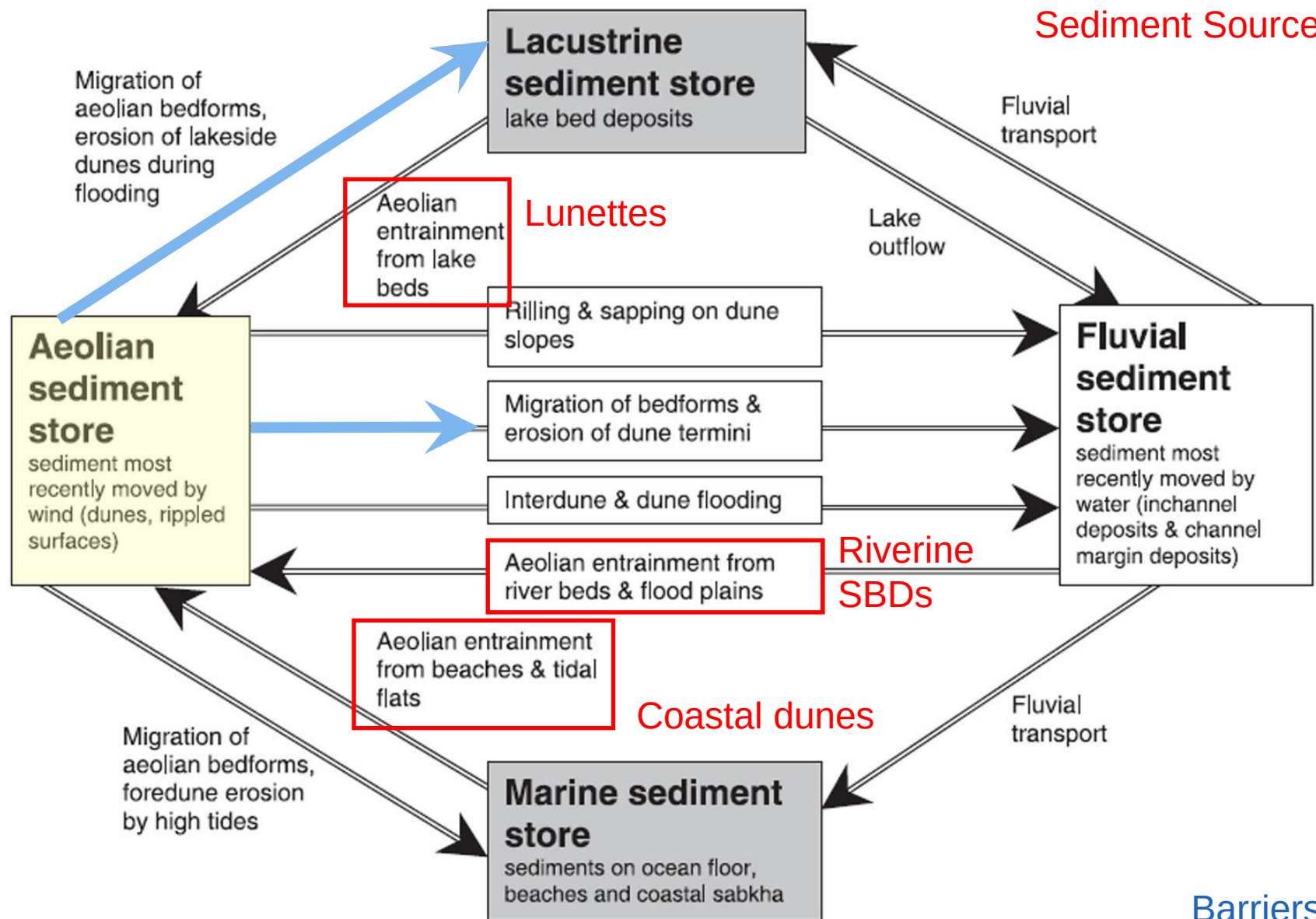
sand ramps – interaction
between aeolian processes
and fluvial reworking

Sand sea in Mongolia





From source to “sink”...



Variety of aeolian sources and pathways

SBDs inform on conditions of dune initiation in source areas (e.g. lake, river)

Dune formation strongly depends on wind strength and sediment supply conditions

Dune activity (migration and evolution) depends strongly on vegetation (non-linear system)

Therefore climatic interpretation of dunes not straightforward ($\neq$ existence only in drylands)

