BHARATHIDASAN UNIVERSITY

Tiruchirappalli- 620024
Tamil Nadu, India

Programme : M.Tech., Geological Technology and Geoinformatics

Course Title : Geomorphology and Geodynamics
Course Code : MTIGT0506

Unit-4: Aeolian Geomorphology

Dr. J. SARAVANAVEL
Professor, Department of Remote Sensing
Bharathidasan University
Tiurchirappalli, Tamil Nadu
Email : drsaraj@gmail.com, saravanavel@bdu.ac.in

AEOLIAN LANDFORMS / GEOMORPHOLOGY

- Land forms formed due to erosion, transportation and deposition by wind

or

- Landforms caused due to the destructional and constructional processes of wind

- Science of studying the aeolian land forms and processes is called Aeolian Geomorphology

Definition

- Land forms formed due to erosion, transportation and deposition by wind

or

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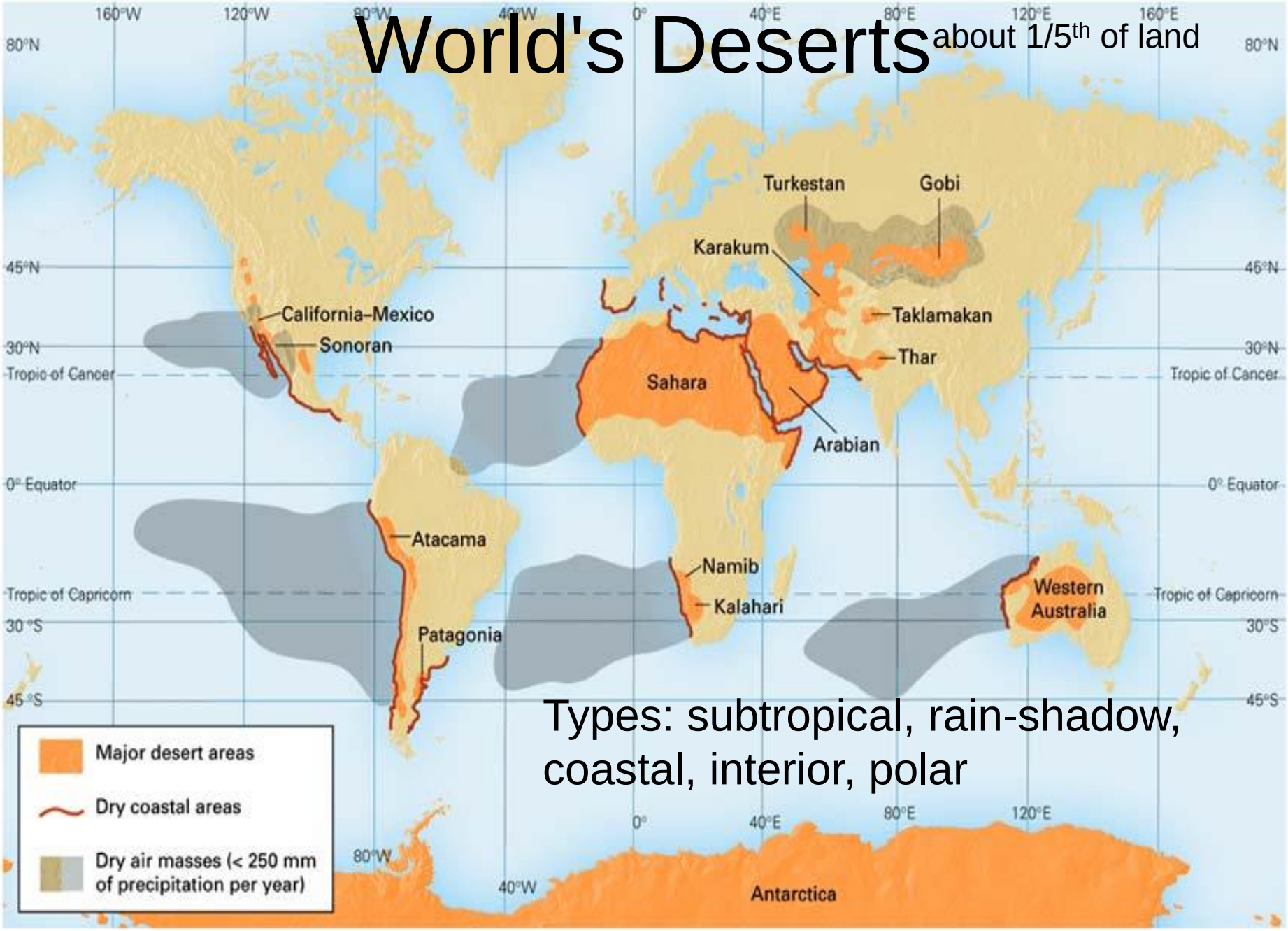
World's Deserts

about 1/5th of land



Types: subtropical, rain-shadow, coastal, interior, polar

Why to study Aeolian landforms

- To understand its resource potential mineral, water hydrocarbons
- To understand the palaeowind direction
- To understand the palaeoenvironment & present environment
- To create developmental plans canals, irrigation
- To understand the hazard potential

SOURCES OF SAND

- Sandy beaches with onshore winds
- Streams with sandy bottoms exposed during dry season
- Dry areas / desert areas where disintegration of sandstone & other rocks provides the sand
- Glacial outwash deposits and sandy glacial lakebed

WIND ACTION

- Wind erosion
- Wind transportation
- Wind deposition

WIND EROSION

- Removal of material by wind

Processes :

Deflation :

- Blowing of fine sand particles leaving the coarser material
- This process scoop out the material and cause depressions
- These depressions cause ‘lakes’
- In Arabian desert – 10 Km long X 3 miles wide and 300’ deep

Collision : Wind with sands collide with rocks and cause wind sculptured features

Abrasion : Wind polished features

LANDFORMS OF WIND EROSION

Wind sculptures / Cavernous features

In Hard rocks

- Undercut hills
- Cave rocks
- Toad rocks (frog rock)
- Mushroom, Table and Pedestal or Pinnacled rocks
- Natural bridges
- Yardang
- Ventifacts
- Desert Varnish

LANDFORMS OF WIND EROSION

Wind sculptures / Cavernous features

In Soft rocks and Unconsolidated material

- Forms bowels and caves
- Deflation Basin
- Desert Lakes
- Desert pavements

Wind Carved Hills

Underside of some hills are removed by the abrasion and impact of wind transported sand particles. The top of the would be bigger in size relative to the bottom. This is due to transportation of sand grains in near surface

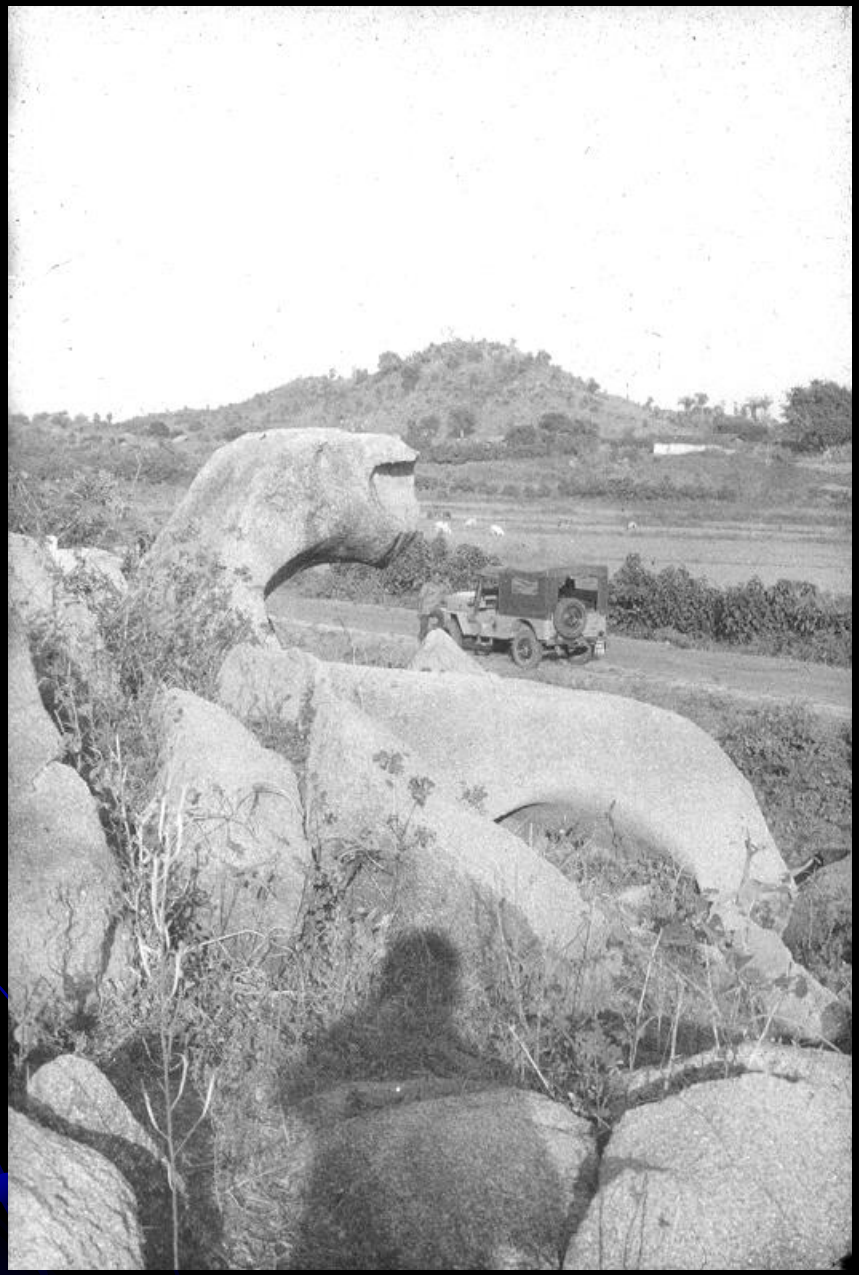
Cave Rocks: The impact and abrasion of sand cut cave like features in the sides of rock

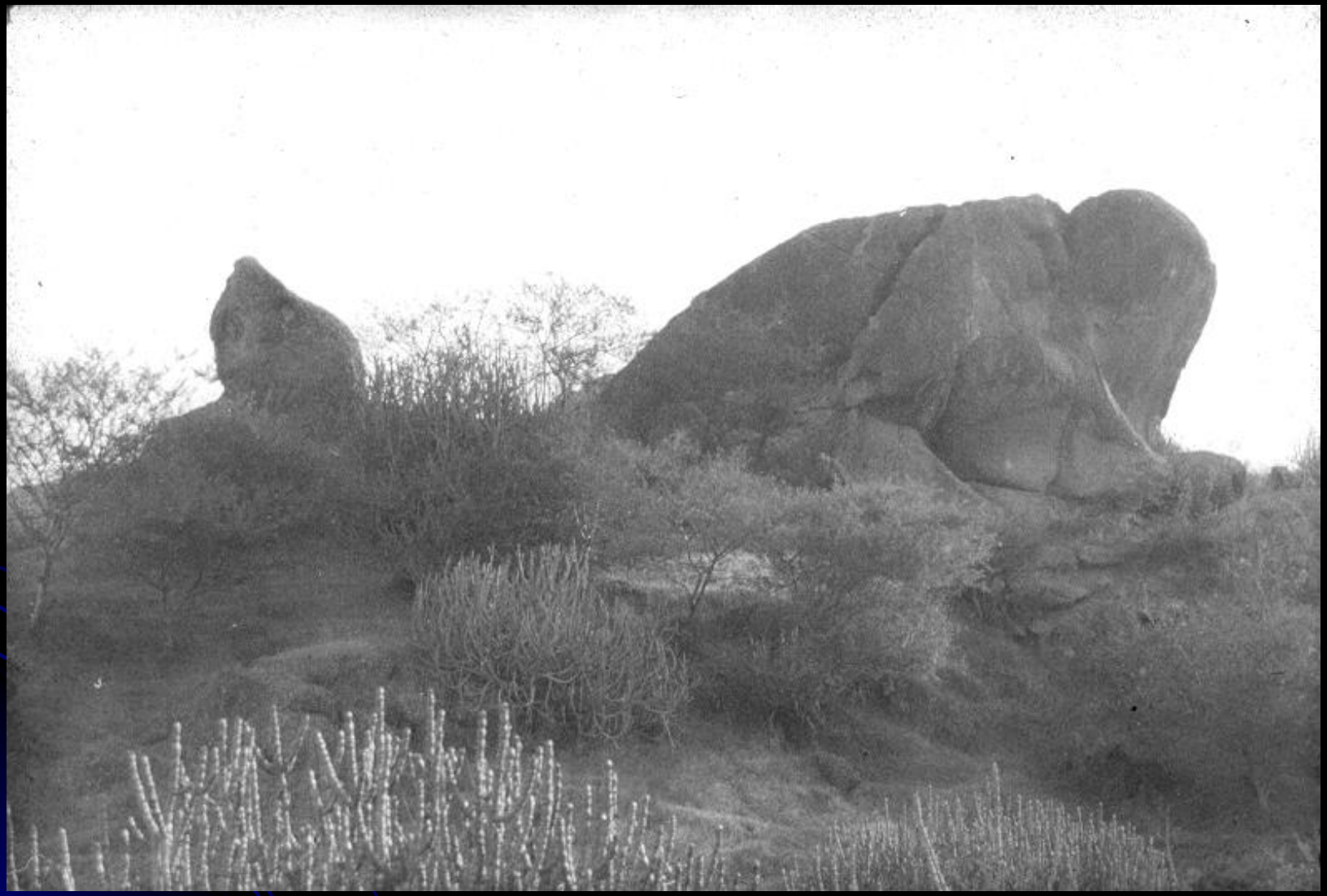
Frog rocks: The impact and abrasion of sand cut features like frog is called frog rocks. This is due to the wind sculpturing. This transportation of sand grains in above the near surface

Jackson, U. S. Geological Survey

CAVE ROCKS NEAR SIERRA LA SAL, DRY VALLEY, UTAH

Wind-swept plain and wind-scoured mesa in a region where the wind is a powerful eroding and transporting agent.



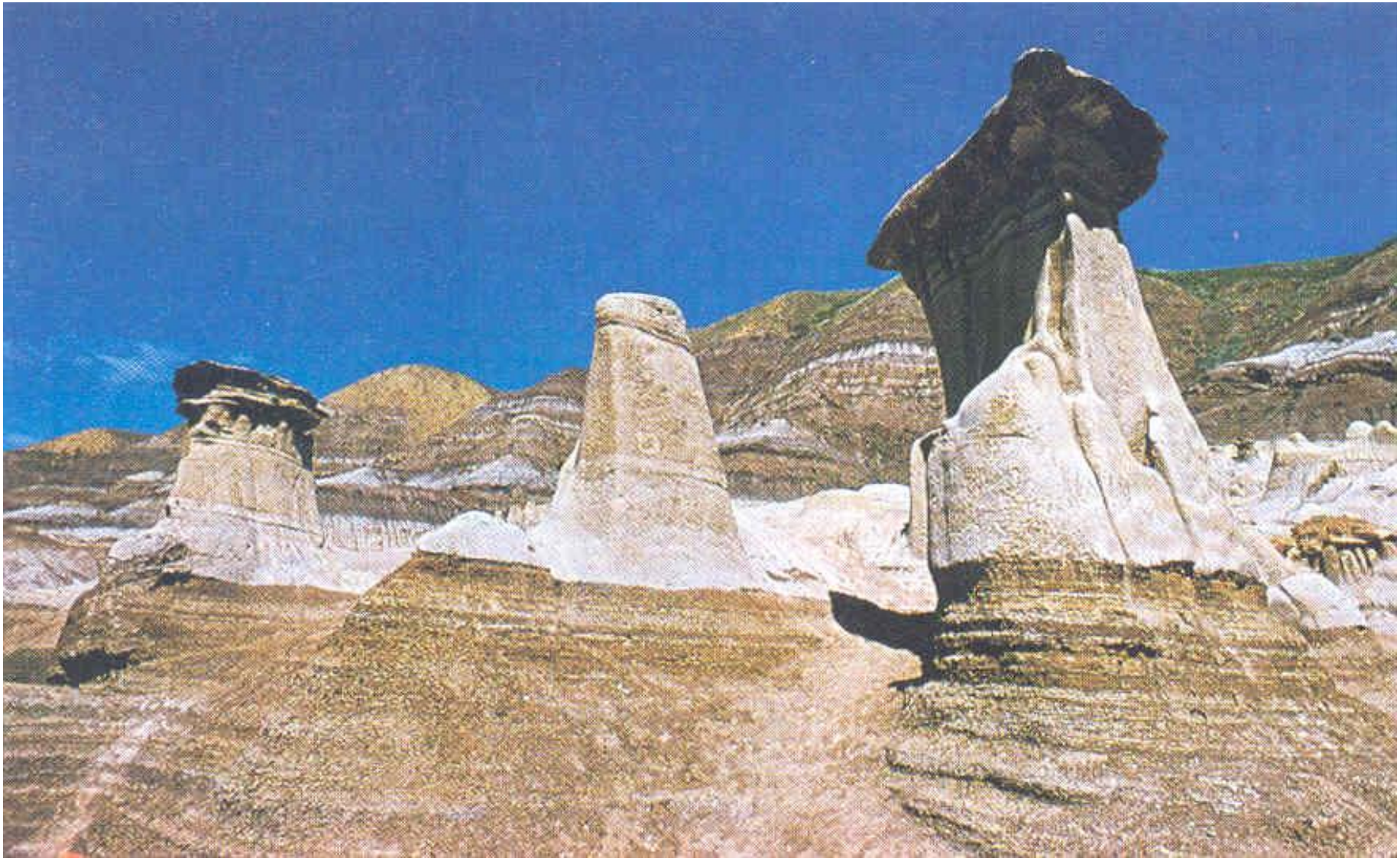


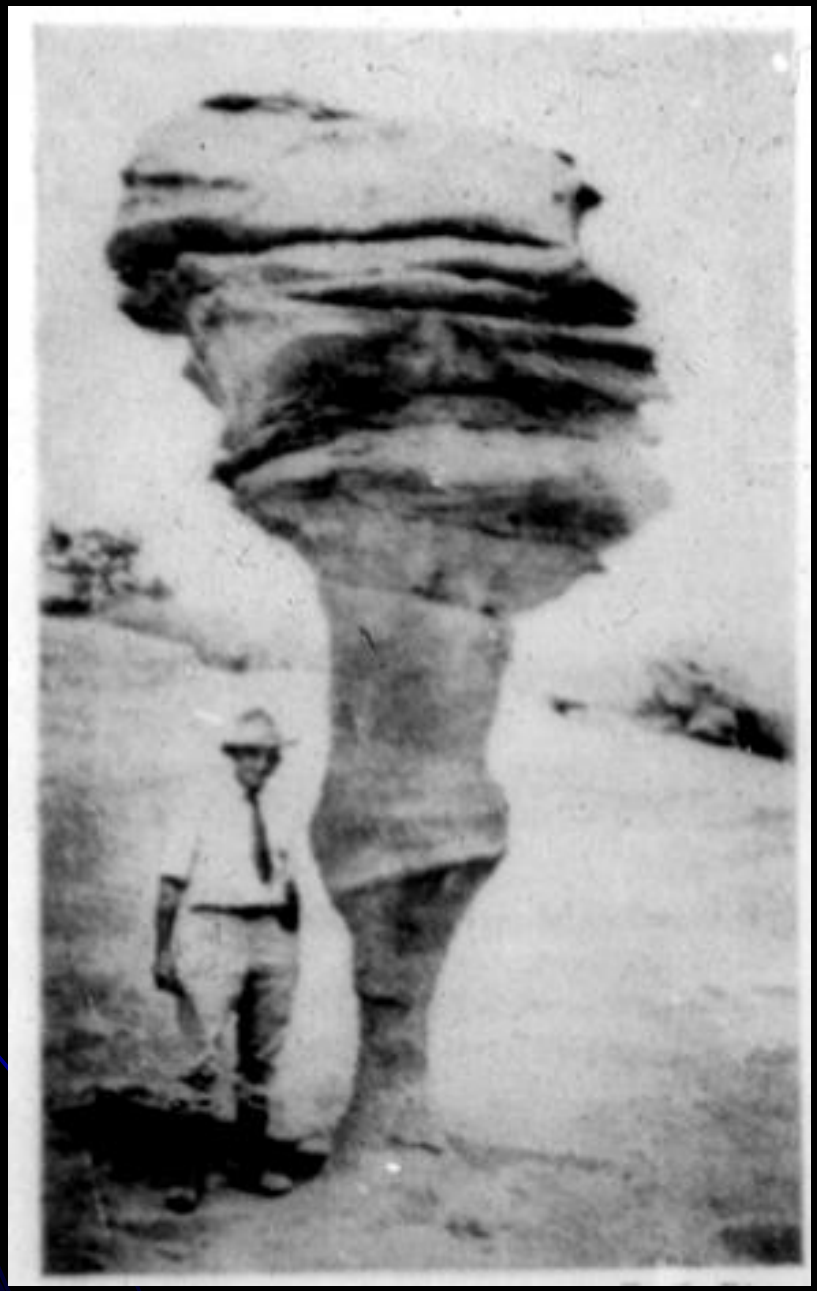
Mushroom and Pedestal or Pinnacled rocks

These are isolated rocks from which the base has been partially cut by undercutting of wind flown sand and create feature like mushroom.

Wind erodes away the bottom portion of a rock and giving a feature of large mass of rock resting on the piller. This is called pedestal rock

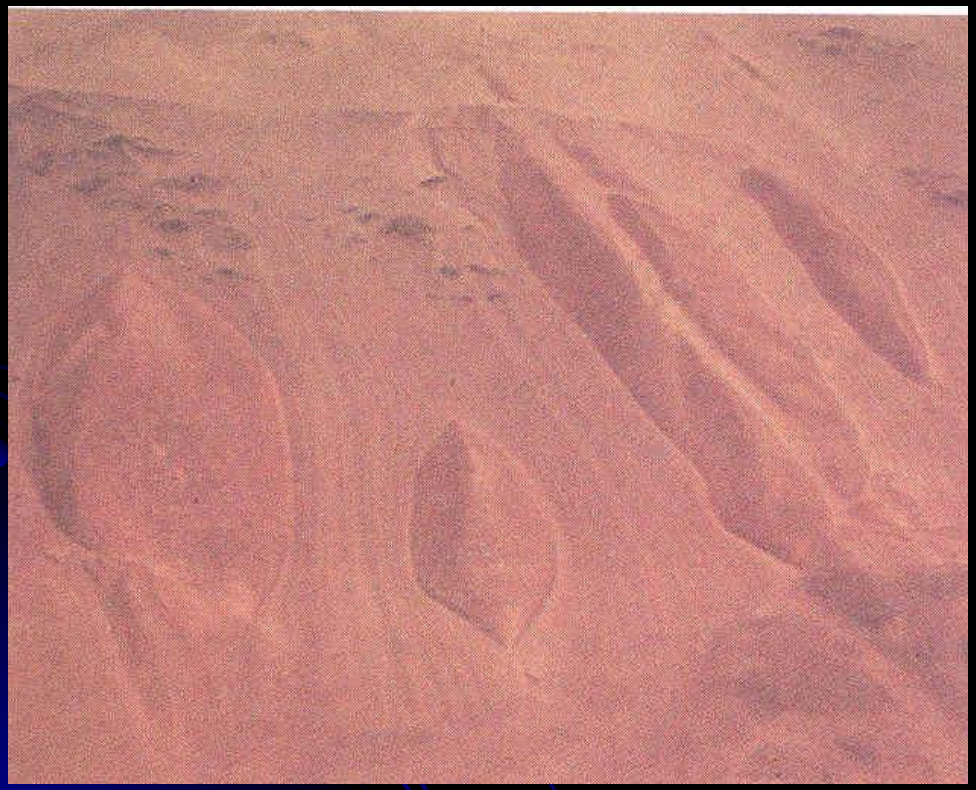
Mushroom rock





Yardangs

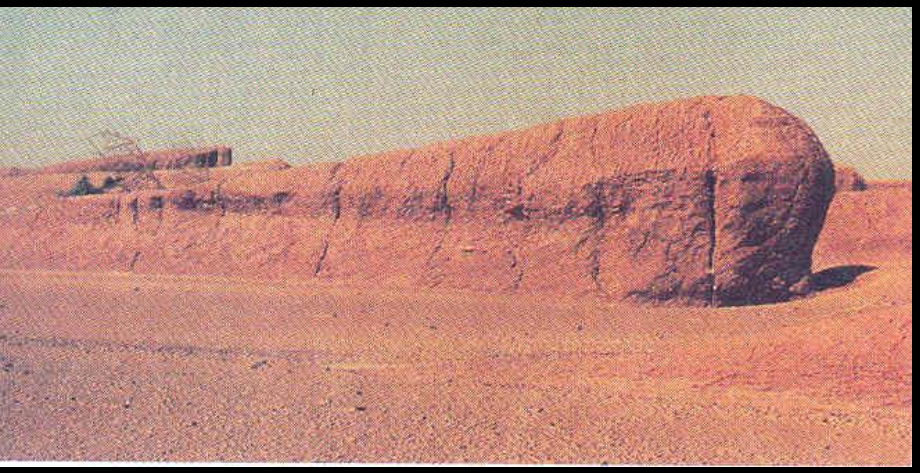
In a region where hard and soft rocks alternate wind erodes away the softer rocks. The hard rocks protruding in between grooves are known as yardangs. These are ridge like features



Coastal desert of Peru

(Roman playa deposits,

Kharga Depression, Egypt)



Yardangs

Yardangs are elongated and streamlined ridges that look like an overturned ship's hull.

They are typically found grouped in clusters aligned parallel to the prevailing winds. They probably form by differential erosion in which depressions, parallel to the direction of wind, are carved out of a rock body, leaving sharp, elongated ridges.

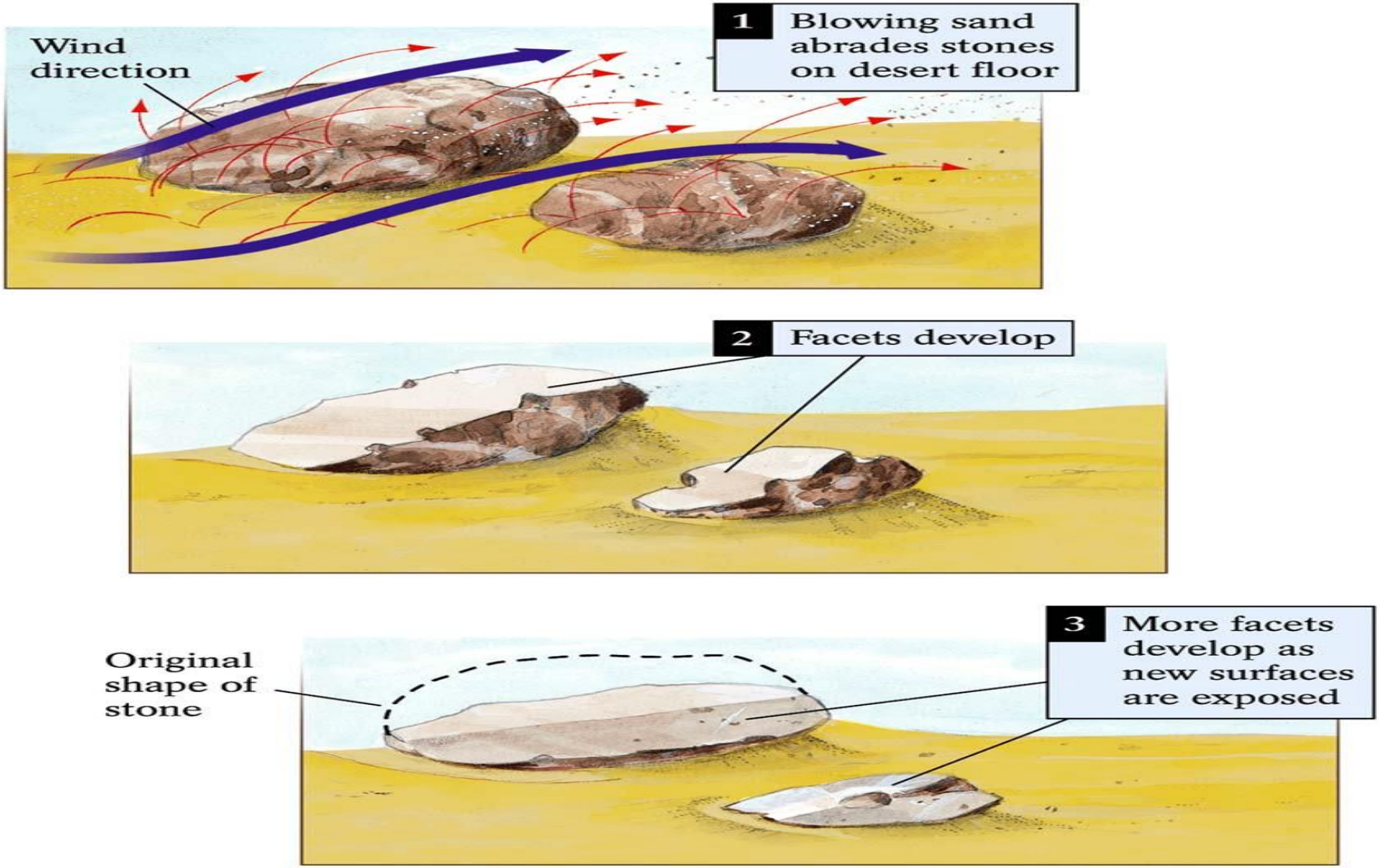
These ridges may then be further modified by wind abrasion into their characteristic shape

VENTIFACTS

Death Valley, California

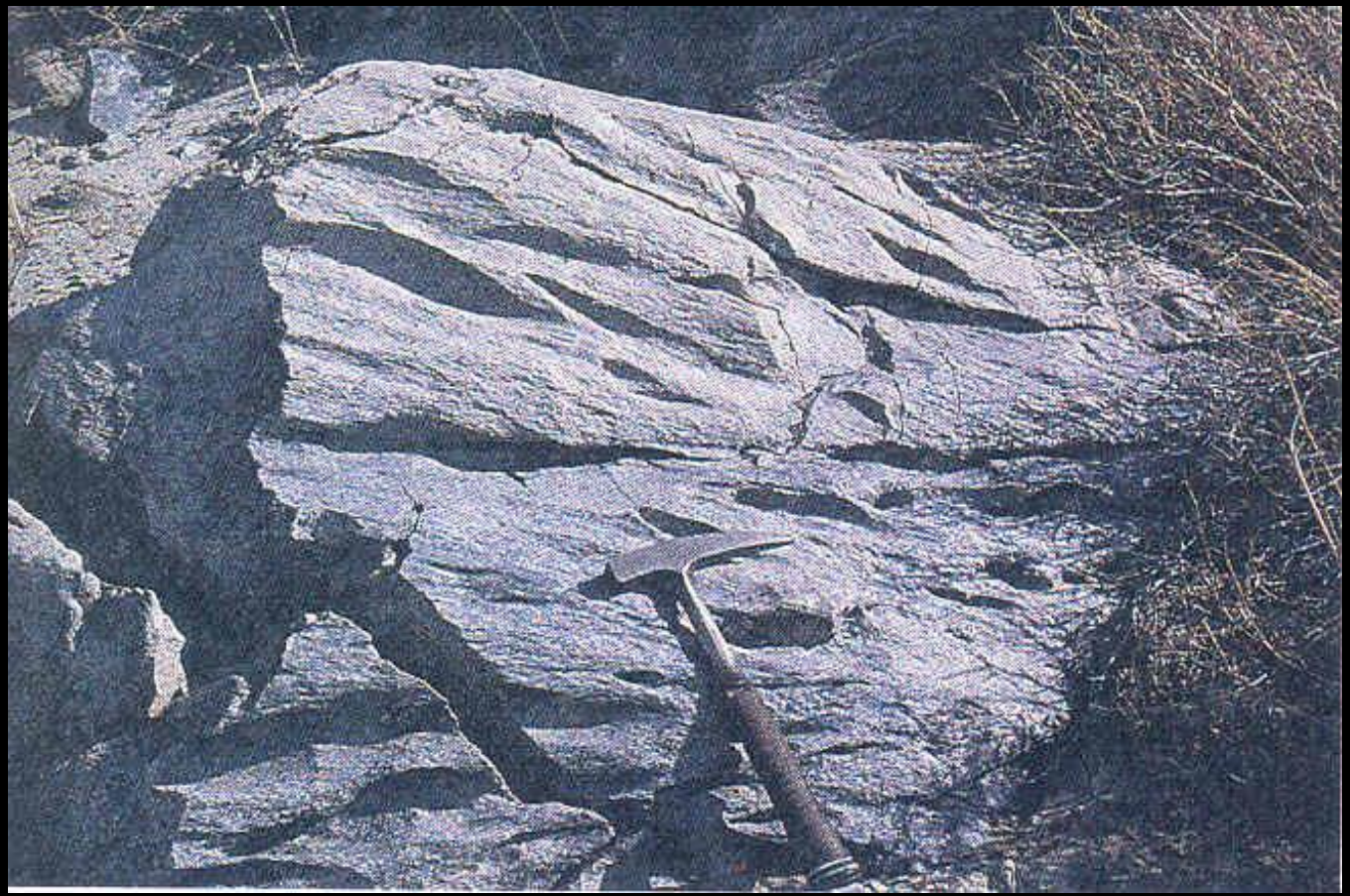
Ventifacts form when wind blowing predominantly from one direction abrades desert floor stones, creating flat surfaces and sharp edges. As the wind changes direction or the stones shift position, exposing other surfaces to wind abrasion, more facets are produced on the newly exposed surfaces

Abrasion Origin of Ventifacts

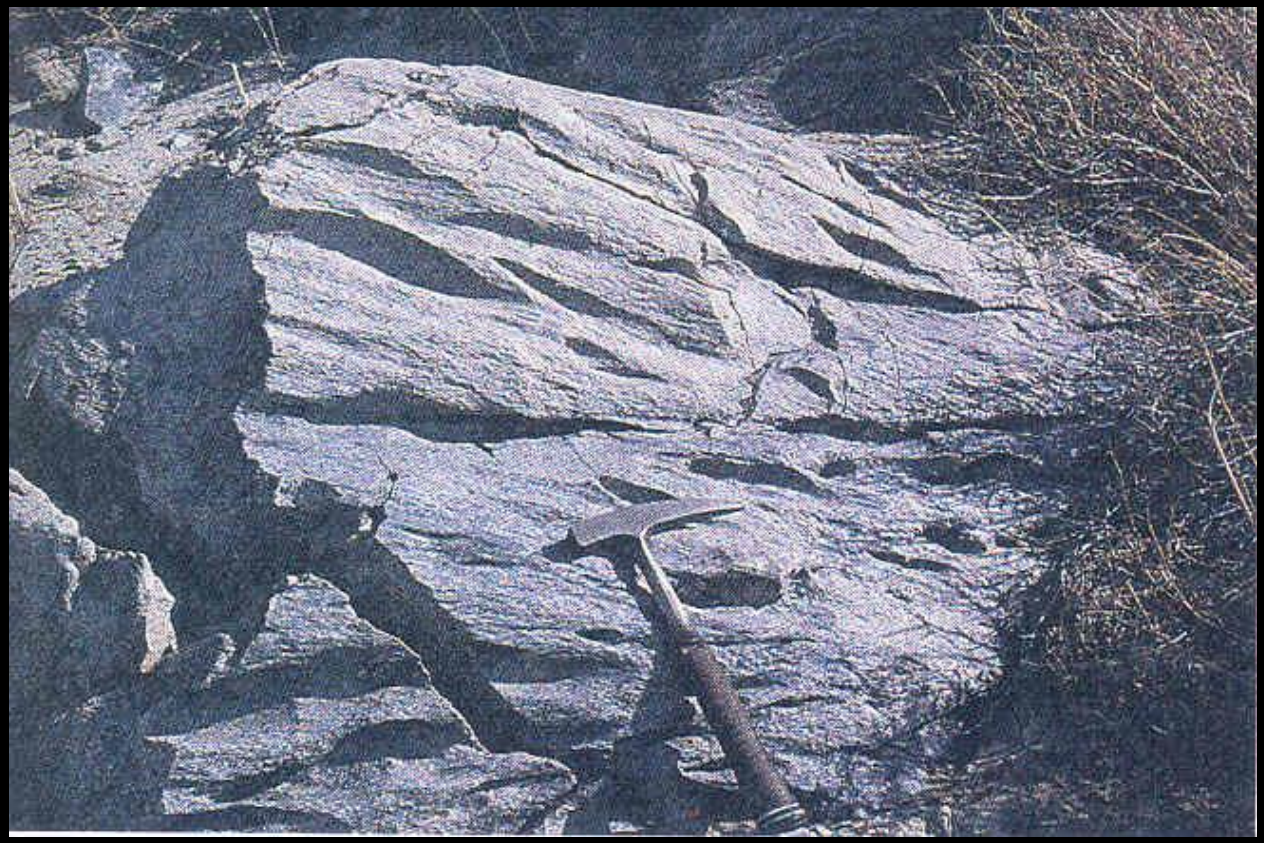


PITTED & POLISHED SURFACES

Where soft, poorly consolidated rock is exposed, wind erosion can be both spectacular and distinctive. Some pebbles called ventifacts (wind made) are shaped and polished by the wind. Some have surface irregularities and groove aligned with the wind direction



PITTED & POLISHED SURFACES



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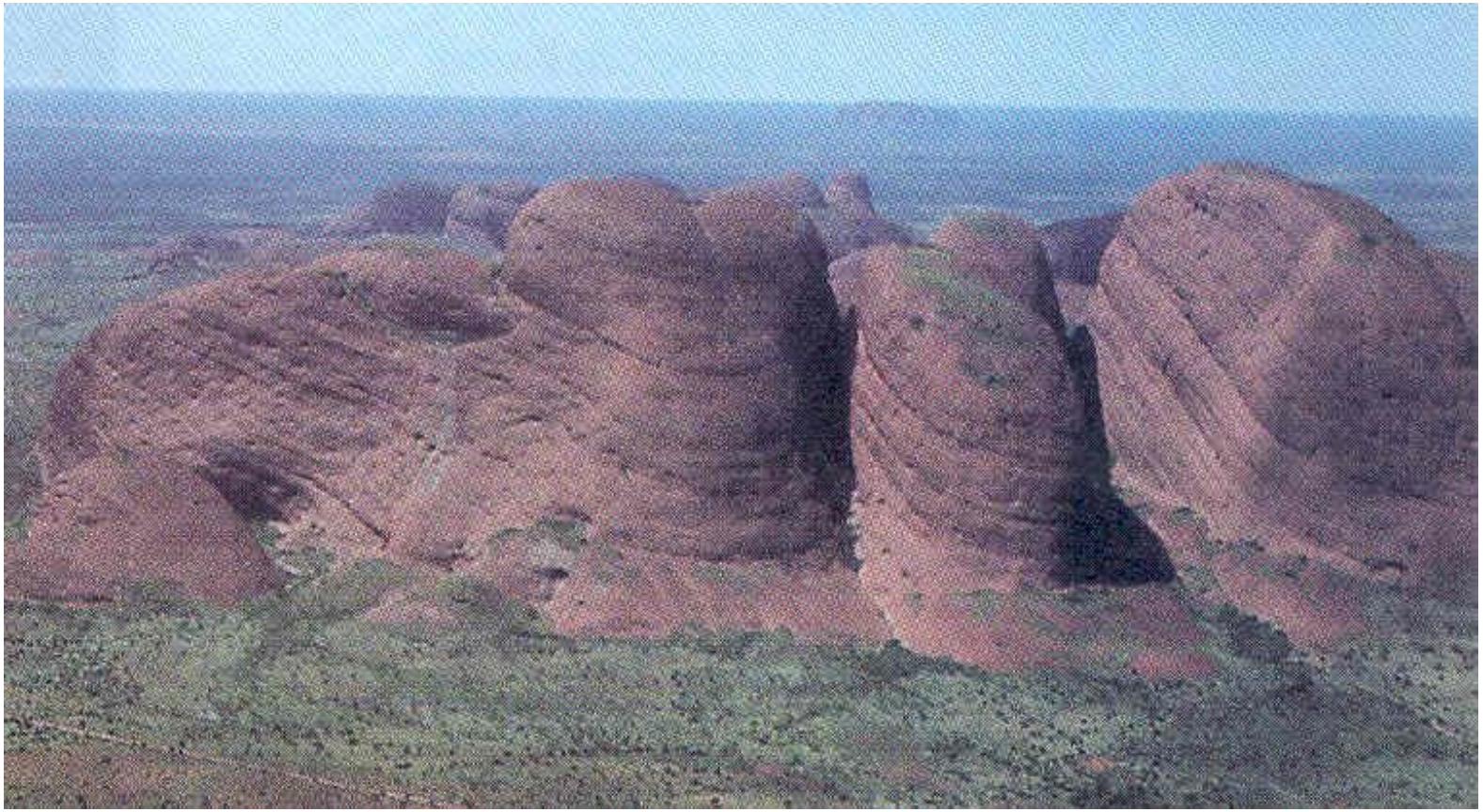
Rock varnish

(Castle Valley, Utah)

An interesting feature seen in many deserts is a thin, red, brown or black shiny coating on the surface of many rocks called rock varnish, is composed of iron and manganese oxides

Chemical Weathering in Deserts

Inselberg
(Olgas, Australia)

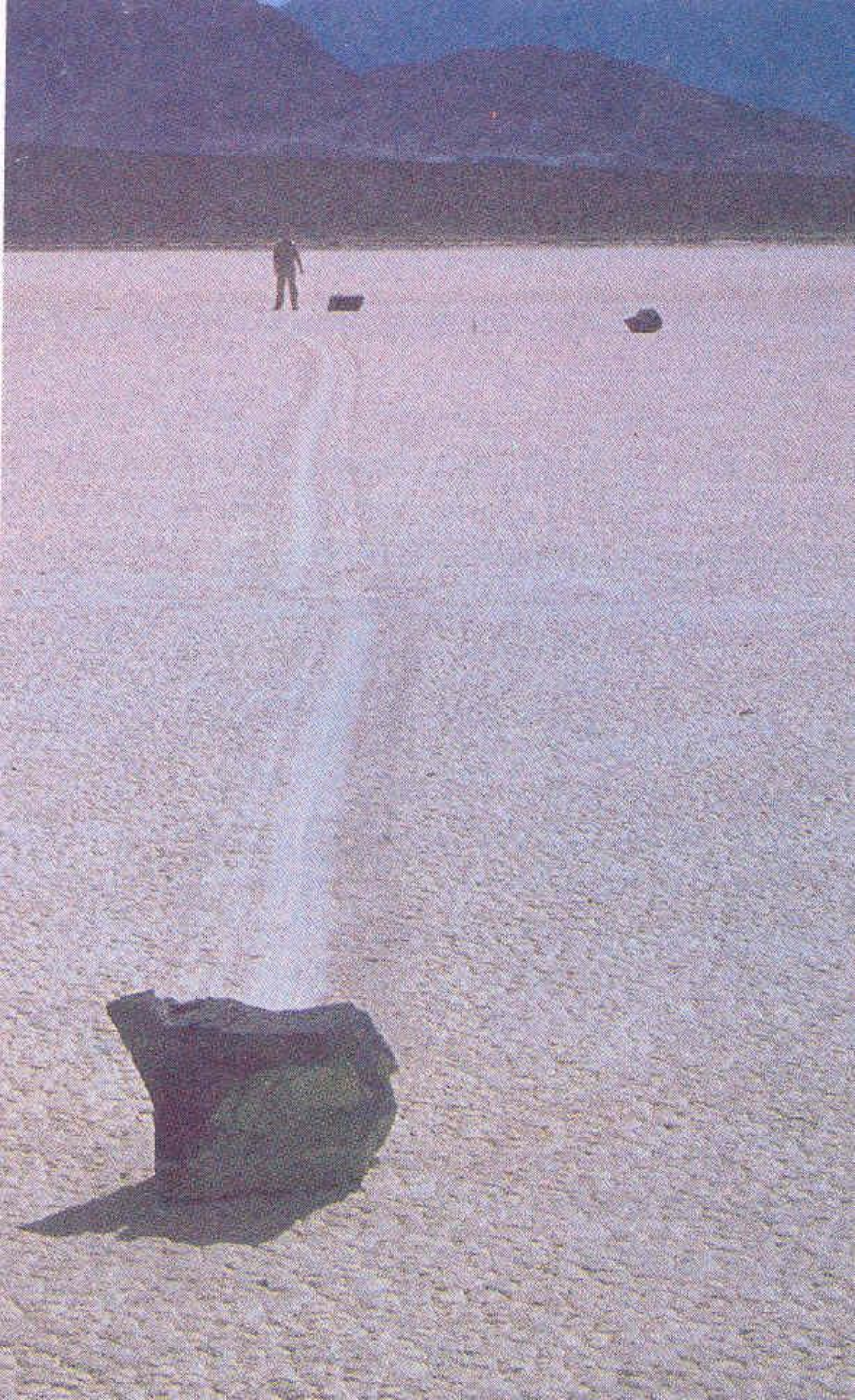


In many arid and semiarid regions there occur steep-sided mountains ridges or isolated hills rising abruptly from adjoining monotonously flat plains called inselbergs (German for “island mountains”) resemble rocky islands standing above the surface of a broad, flat sea.

Bornhardts (inselberg)

(Ayres Rock, Central Australia)

Bornhardts, a special type of inselberg having rounded or domal form are named after a German explorer, Wilhelm Bornhardt, who described such features in East Africa



“Sliding Rocks”

Racetrack Playa in Death Valley, California)

This rock moved over this normally dry lake bed through distances of up to 260 m. The stones probably are moved by strong winds following heavy rains when the playa surface becomes a layer of slippery clay.

LANDFORMS OF WIND EROSION

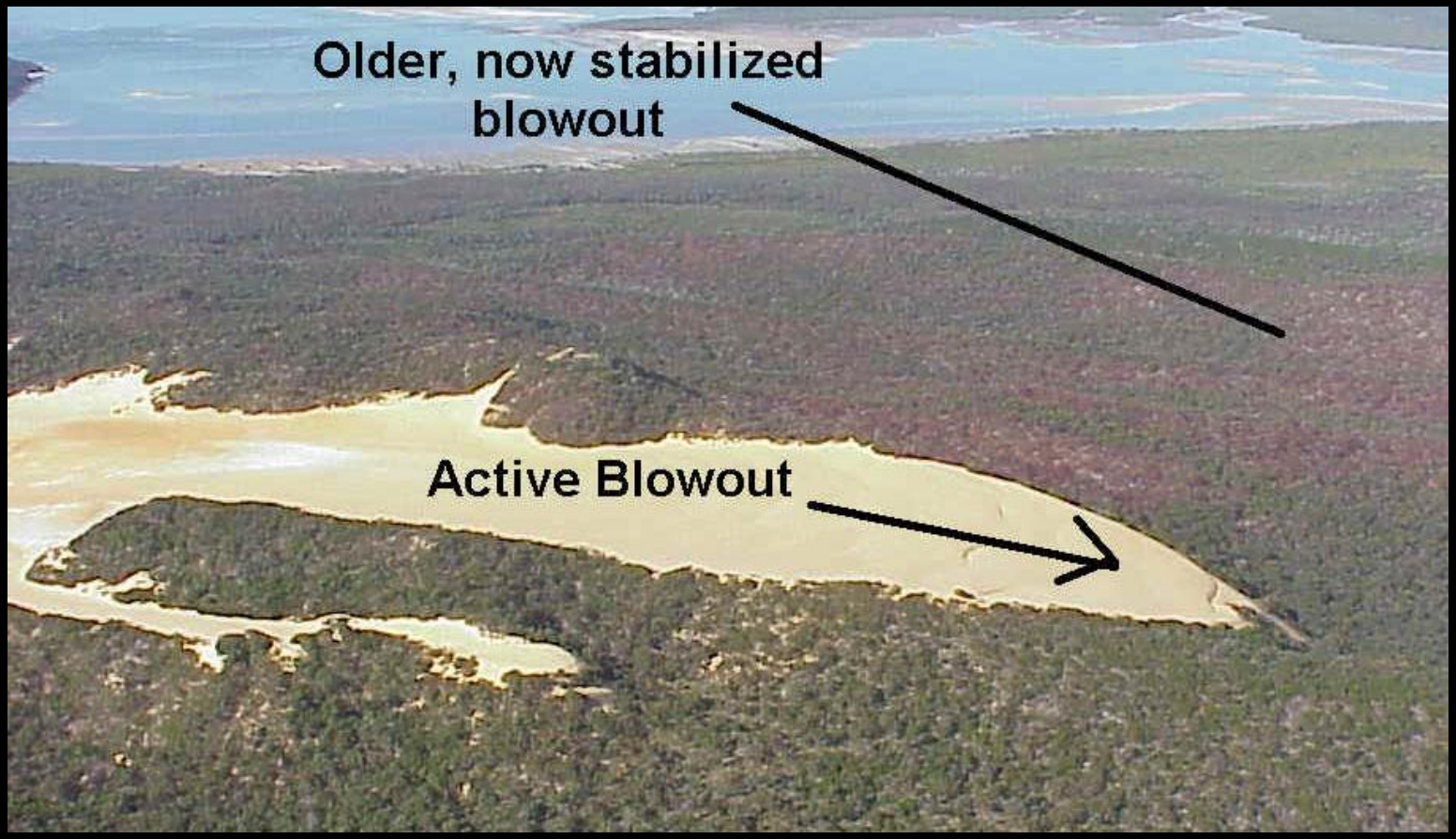
Wind sculptures / Cavernous features

In Soft rocks and Unconsolidated material

- Deflation Hollows or Blow outs
- Deflation Basin
- Desert Lakes
- Desert pavements

Deflation Hollows or Blow outs: Depression formed from barren unconsolidated materials by deflation.

They ranging from several centimeter to some km. **Depth may be 1 cm up to 10m. Similar pot holes by stream**



Deflation hollow

(Death Valley, California)

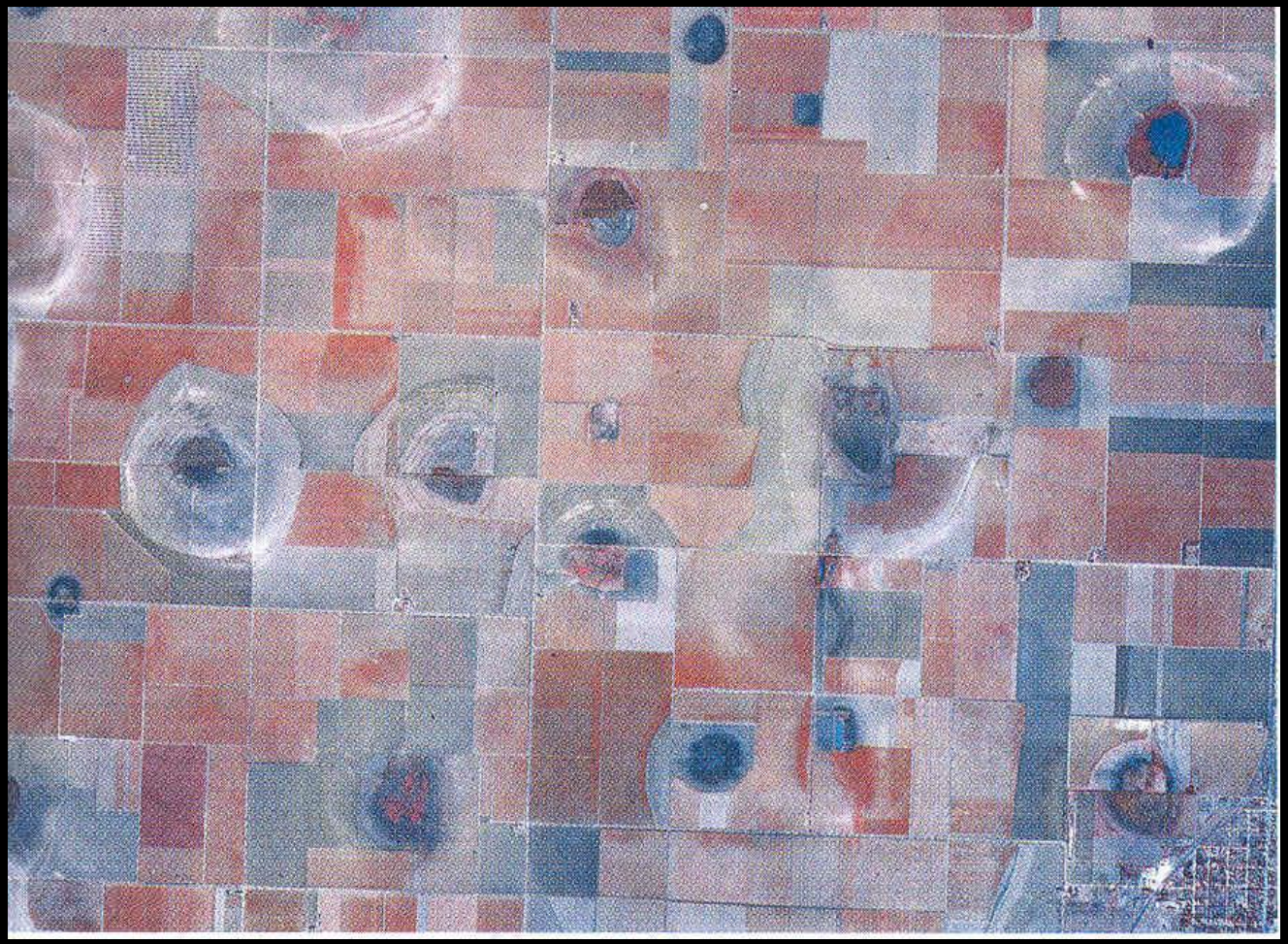
These shallow depressions of variable dimensions result from differential erosion of surface materials. Ranging size from several kilometers in diameter and tens of meters deep to small depressions only a few meters wide and less than a meter deep

(caused by deflation in sand hills, State park, Texas)

Erosional Landform - Deflation Hollow

Anecdote – How fast does this occur?

DEFLATION BASINS, GREAT PLAINS



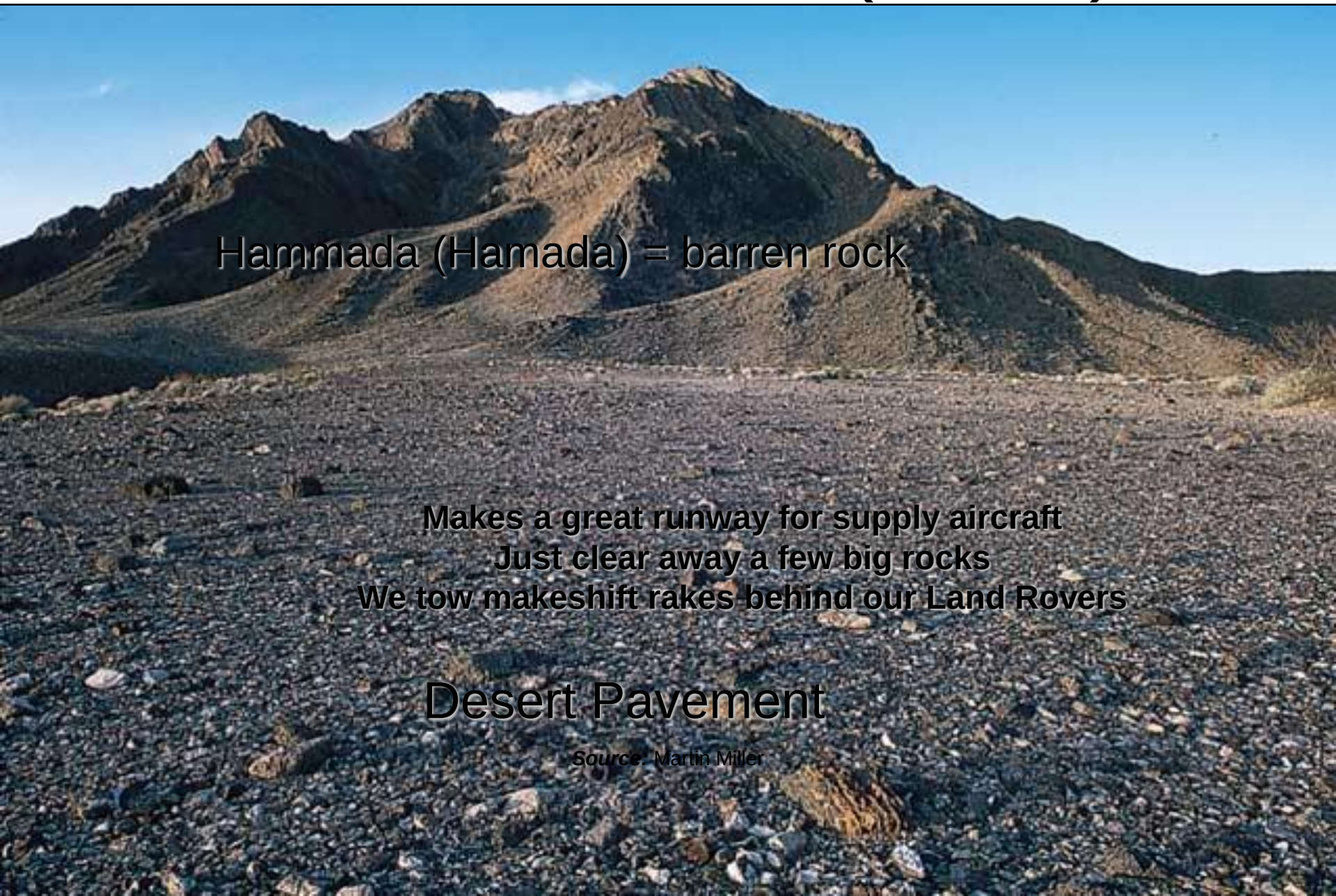
are produced where solution activity in the layers of horizontal bedrock dissolves the cement that binds the sand grains together. The loose sand is removed by the wind and a basin is formed. Water trapped in the basin dissolves more cement and the basin is enlarged

DESERT PAVEMENT (lag deposits)

(KUWAIT, NORTH EAST SAUDI ARABIA AND SOUTHERN IRAQ)

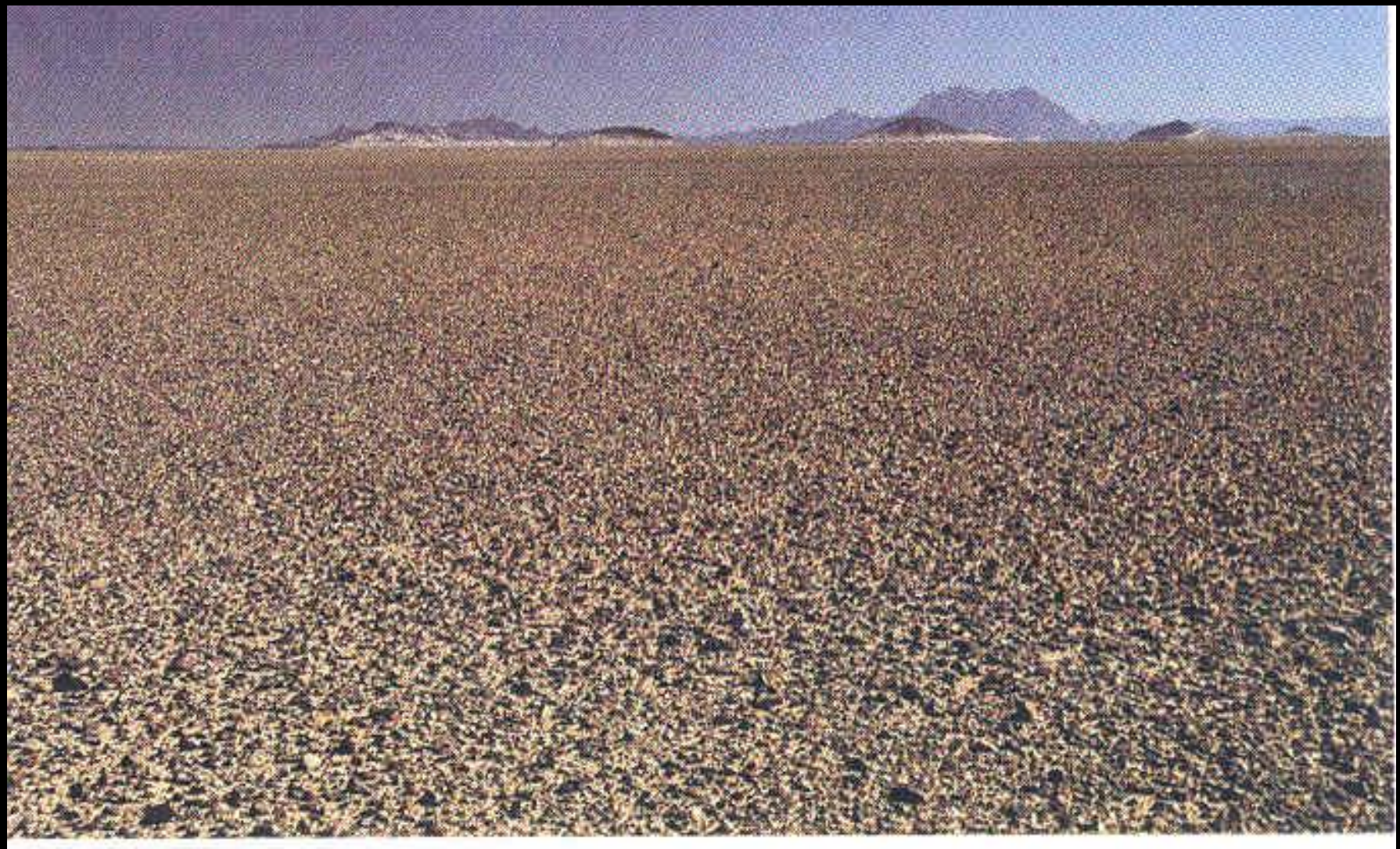
Sorting action of wind during deflation produces desert pavements. Wind can move only sand and dust-size particles, so deflation leaves concentrations of coarser material called lag deposits or desert pavement. These striking desert features of erosion stand out in contrast to deposits in dune fields and playa lakes

Desert Pavements (cont'd) –



Desert Pavement, Sahara

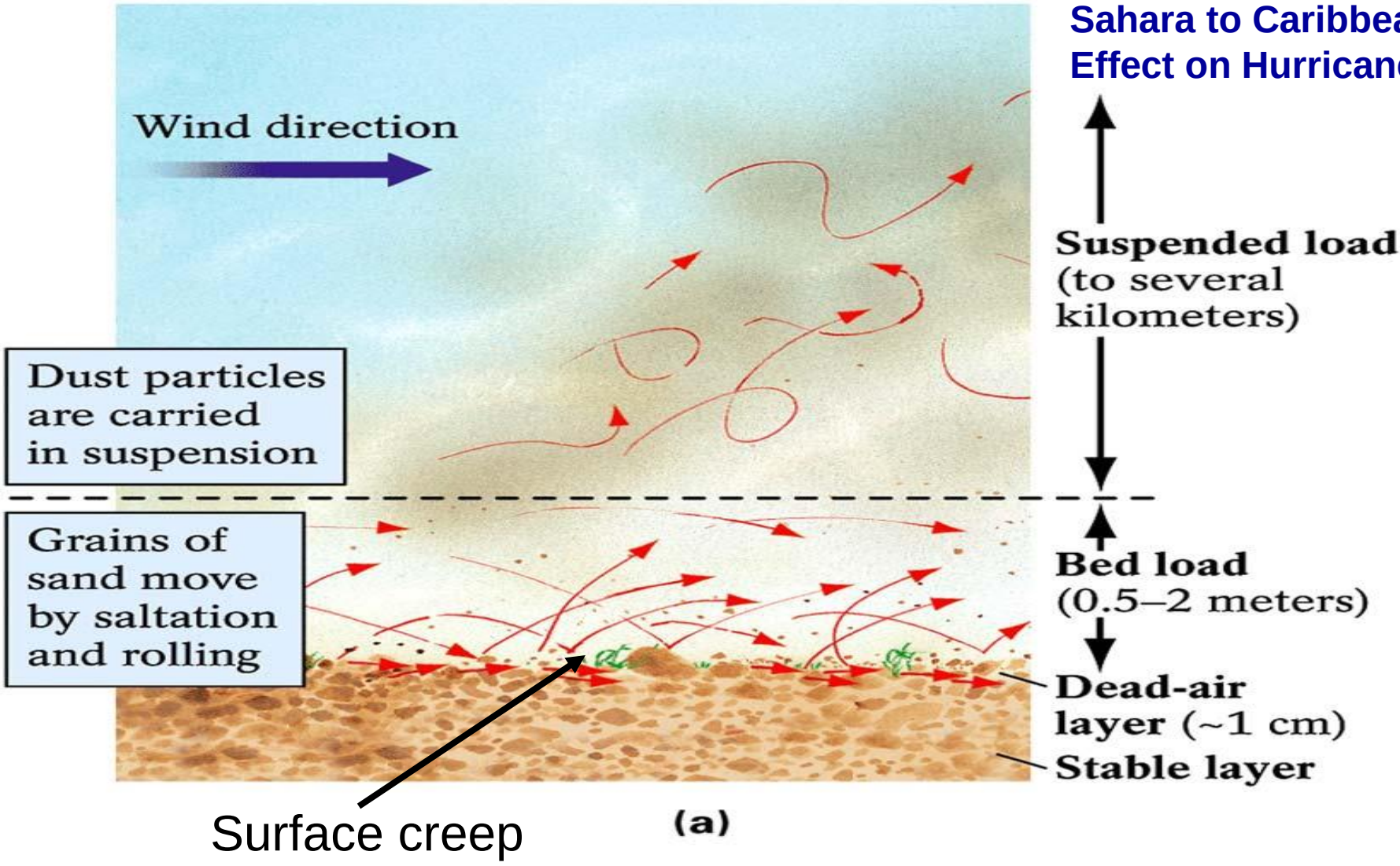
(formed from the progressive deflation of fine particles, concentrating coarse materials at the surface)



Desert Oases

Oases occur in arid climates where artesian water rises to the surface, such as along a fault or anticline or wind erosion up to water table

Wind Transportation



Landforms of Wind Transportation

- Wind carries coarser to fine sands from bottom to top laterally
- This is called “Dust Strom”

Dust Storm

(Death Valley, California)

When a sediment layer is disturbed, silt and clay sized particles are easily picked up and carried in suspension by the wind, creating clouds of dust or even dust storms. Once these fine particles are lifted into the atmosphere, they may be carried thousands of kilometers from their source

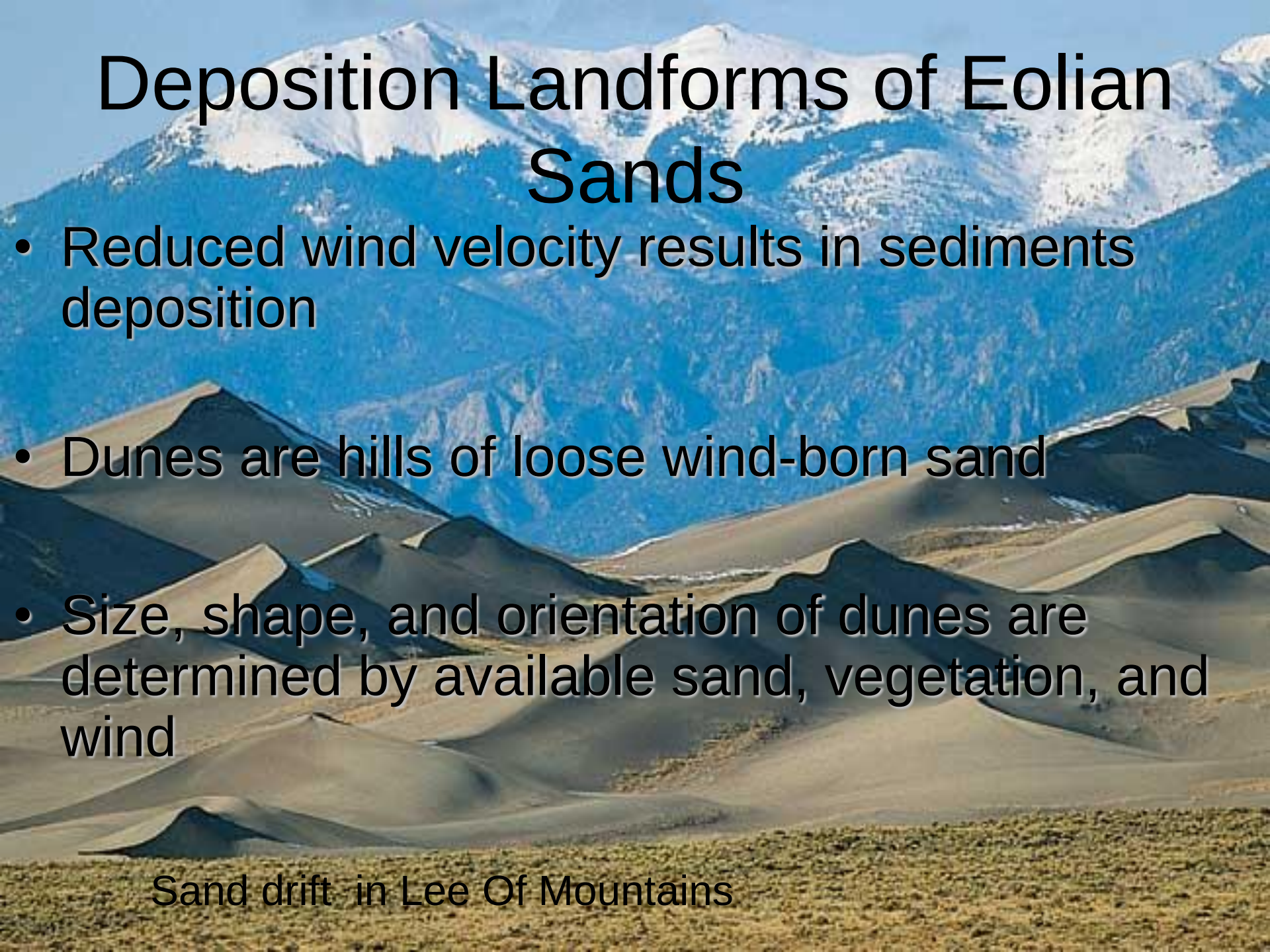
Dust storm or “haboob”, The blue Nile area – Sudan, Africa

(results when cool air descends and moves laterally over the surface as a density current. As the dense, cool air moves across the surface it sweeps up dust and sand by its turbulent flow, creating a dust storm or haboob)

Flying sand erodes by abrasion

Deposition Landforms of Eolian Sands

- Reduced wind velocity results in sediments deposition
- Dunes are hills of loose wind-born sand
- Size, shape, and orientation of dunes are determined by available sand, vegetation, and wind



Sand drift in Lee Of Mountains

LANDFORMS OF WIND DEPOSITION

RIPPLES

LOESS

DUNES : a. Longitudinal dunes

b. Transverse dunes

d. Barchan dunes

e. Parabolic dunes

f. Sand dunes

Depositional landforms

- Ripples:- small sand waves with a wavelength of about 1 m

  they are ephemeral and mobile, i.e. move, disappear and reform during wind storms

  common the windward slopes of sand dunes

Loess

it is a fine, silty, windblown type of unconsolidated deposit.

Loess forms near vertical walls.

Loess Deposit

Yukon river, Yukon Territory, Canada

Windblown silt and clay deposits composed of angular quartz, feldspar, micas and calcite are known as loess. The distribution of loess shows that is is derived from three main sources: deserts, Pleistocene glacial outwash deposits and the flood plains of rivers in semiarid regions. It must be stabilized by moisture and vegetation in order to accumulate. Because of its unconsolidated nature, loess is easily eroded and as a result, eroded loess areas are characterised by steep cliffs and rapid lateral and head ward stream erosion

Loess Deposit

Shaanxi Province, China

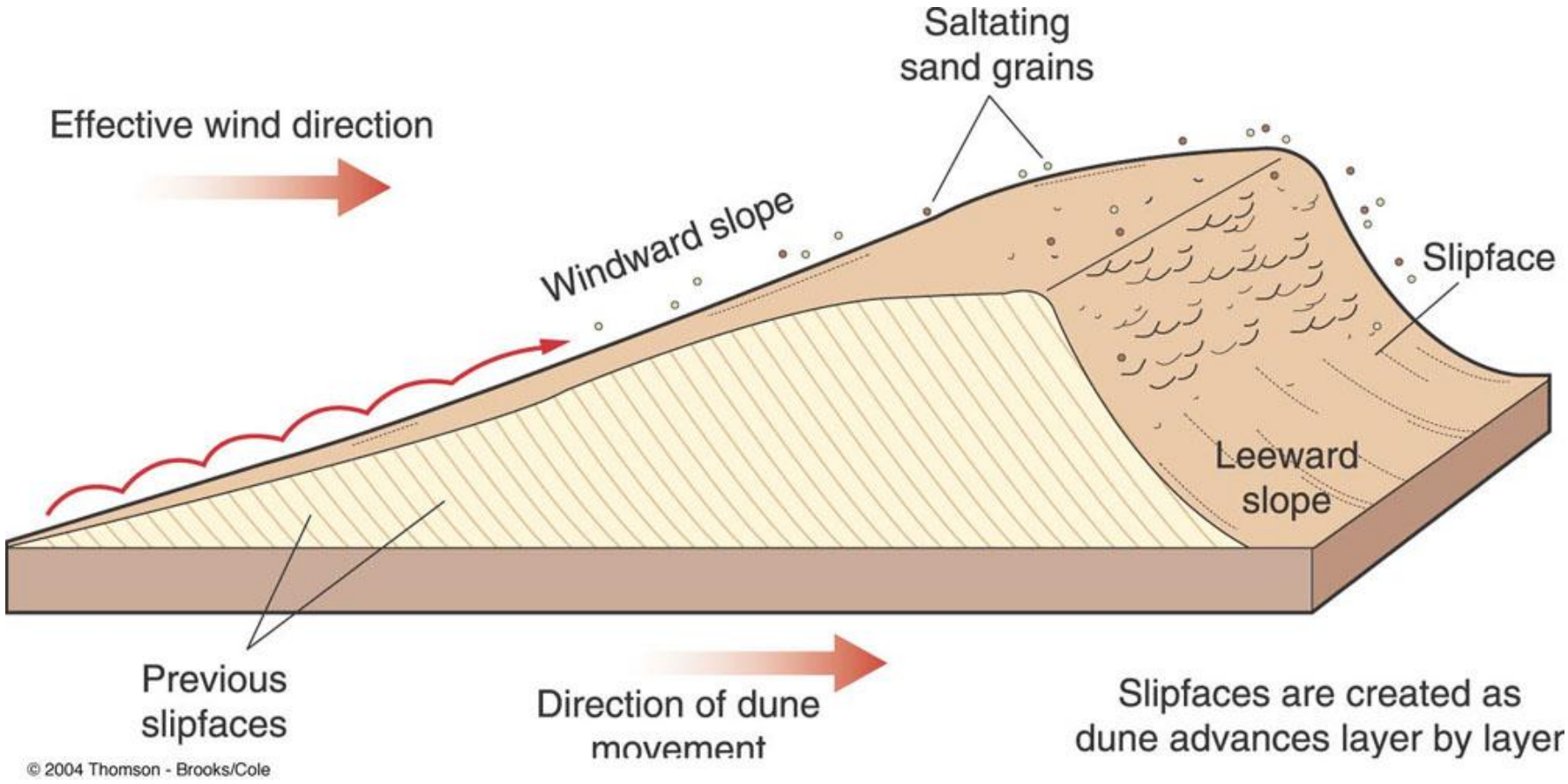
It reach a thickness of more than 150 m. Reddish-brown bands crossing the section are paleosols. Erosion of the deposits, which were laid down over a period of about 2.5 million years, generates a vast load of silt that is responsibe for the striking color of the yellow river.

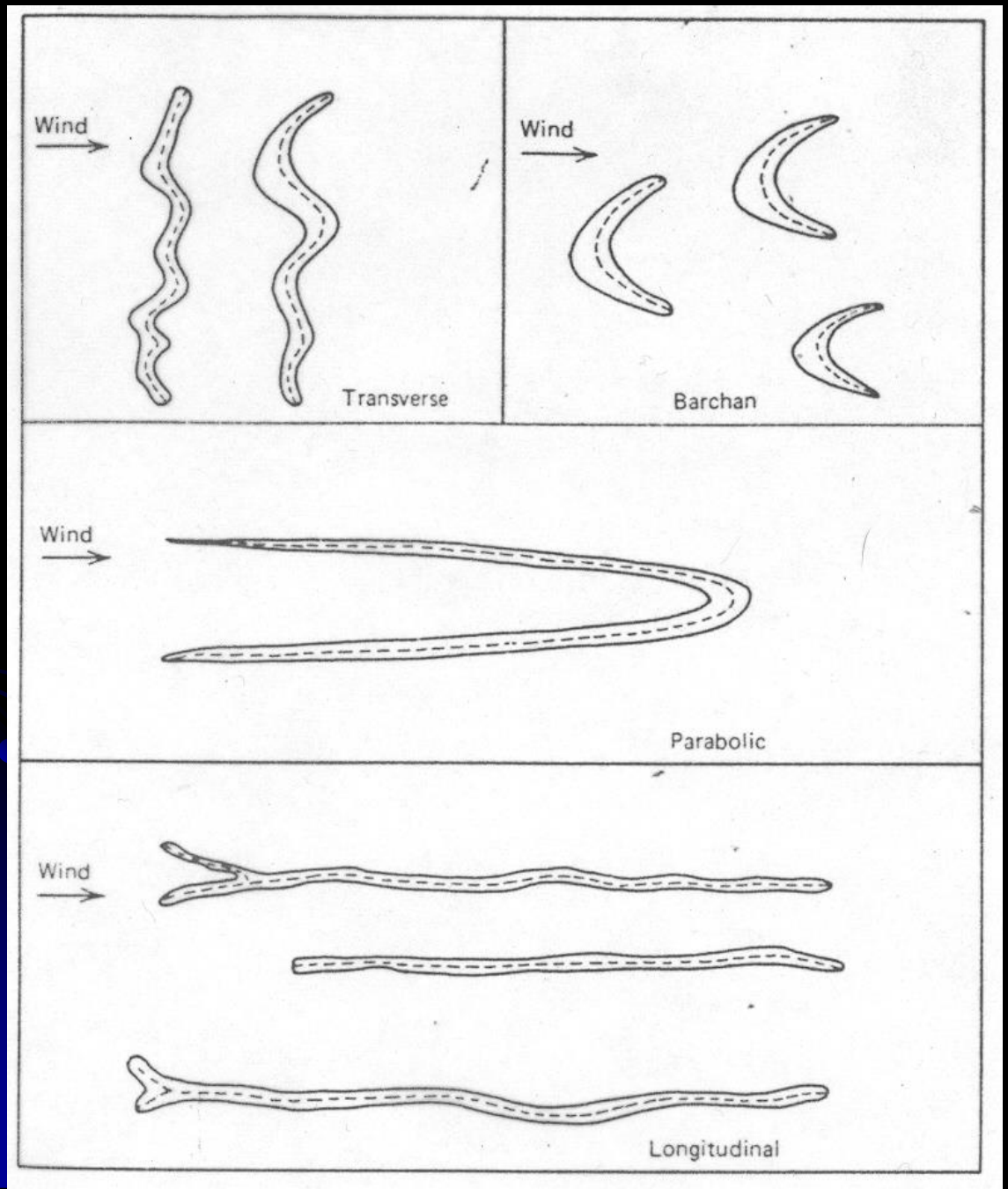
Dunes

- classic aeolian landform
- stable or advancing landform of windblown sand
- originates as a mound of free sand from a sandy surficial deposit (e.g. beach, weathering sandstone) or from a blowout.

Dune

SAND DUNES





DUNES :

a. Longitudinal dunes

b. Transverse dunes

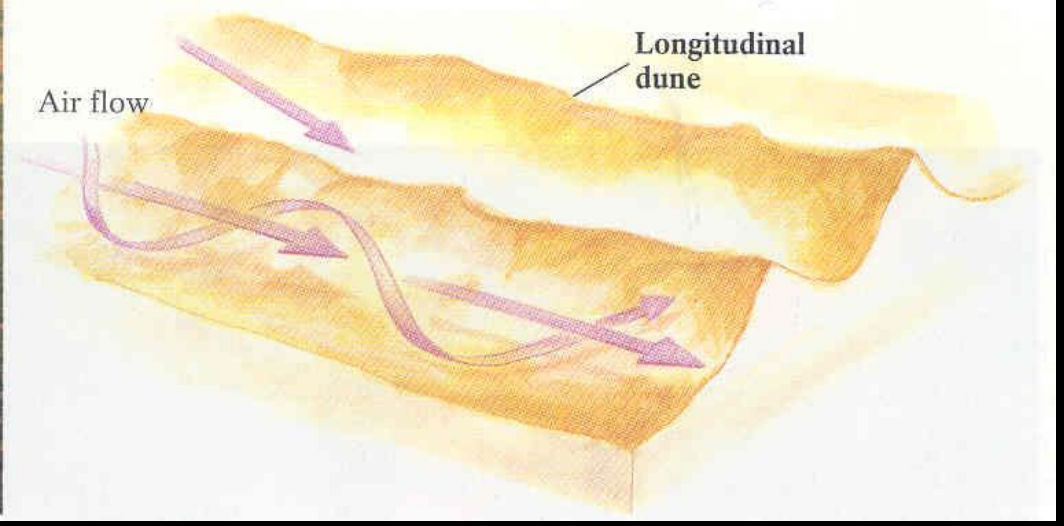
d. Barchan dunes

e. Parabolic dunes

f. Sand dunes

LONGITUDINAL DUNES

- Long, nearly straight ridges, parallel to the wind direction
- Where strong prevailing wind in a constant direction
- Symmetrical cross section, width several times the height
- Height < 15cm and several Kms long (200 – 300 km)

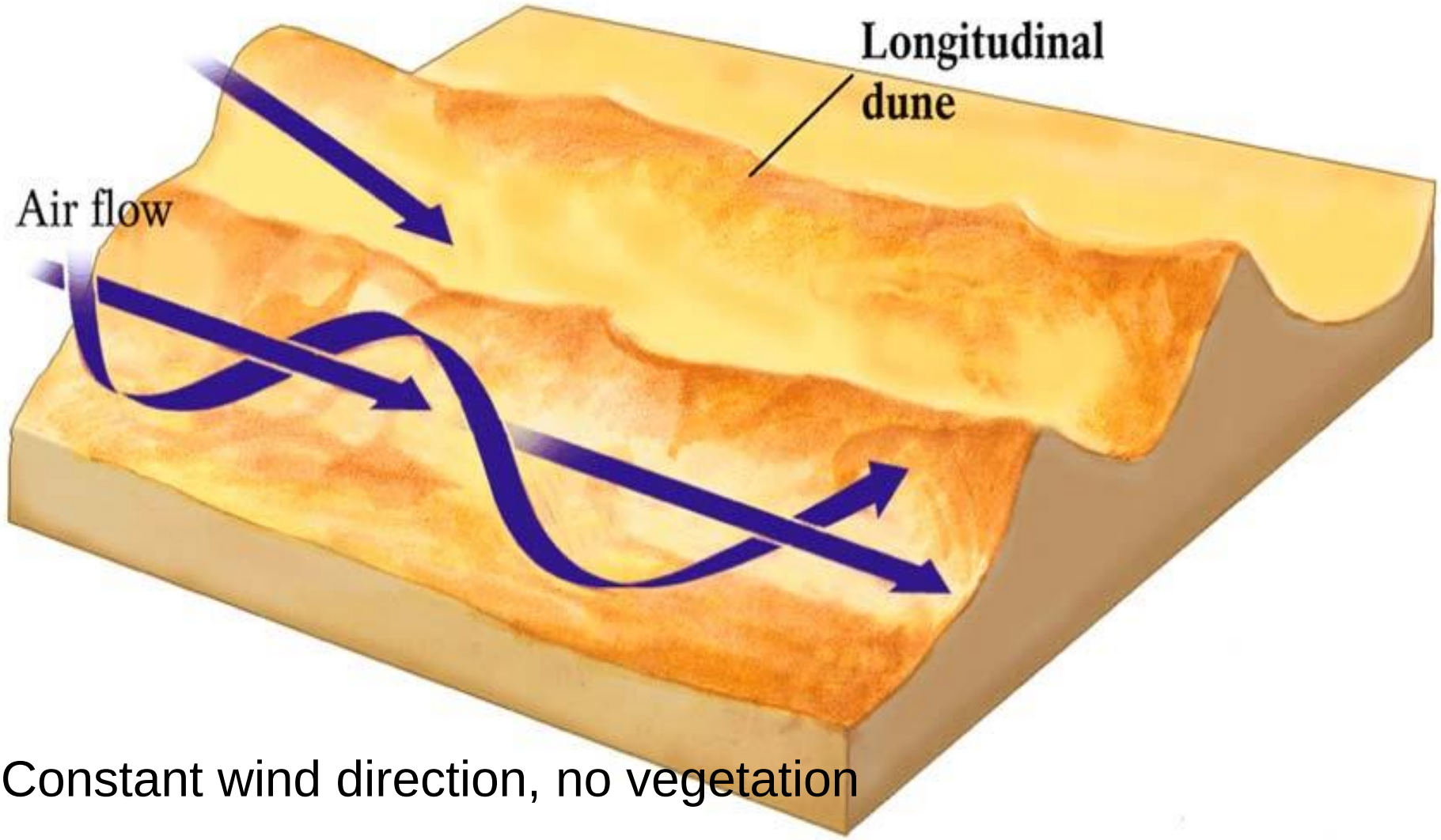


Longitudinal Dunes

(Simpson Desert, Central Australia)

Longitudinal dunes are parallel ridges and oriented parallel to the prevailing wind direction. They form when sand supply is moderate and wind direction various within a narrow range

Longitudinal Dunes

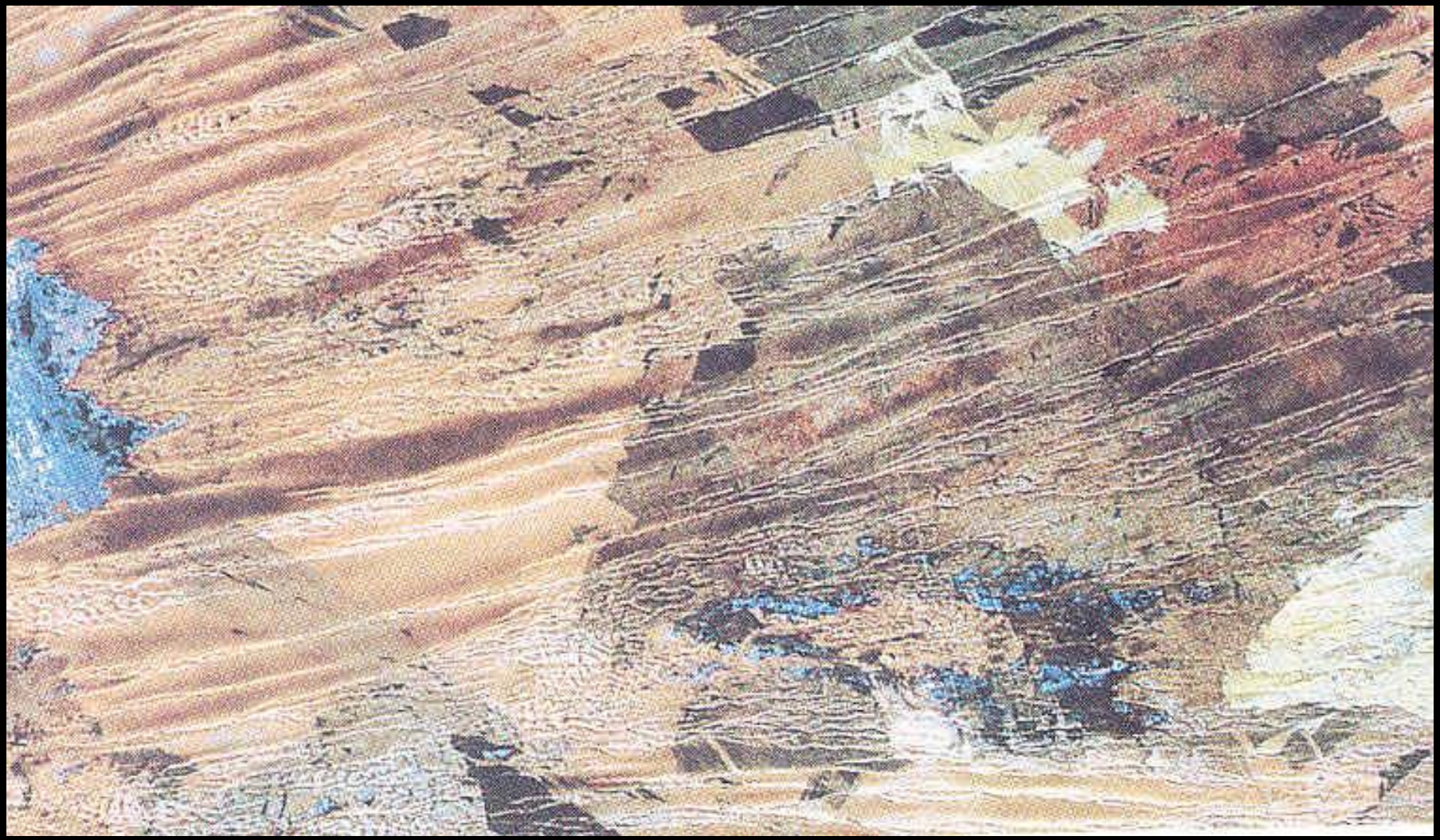


Constant wind direction, no vegetation

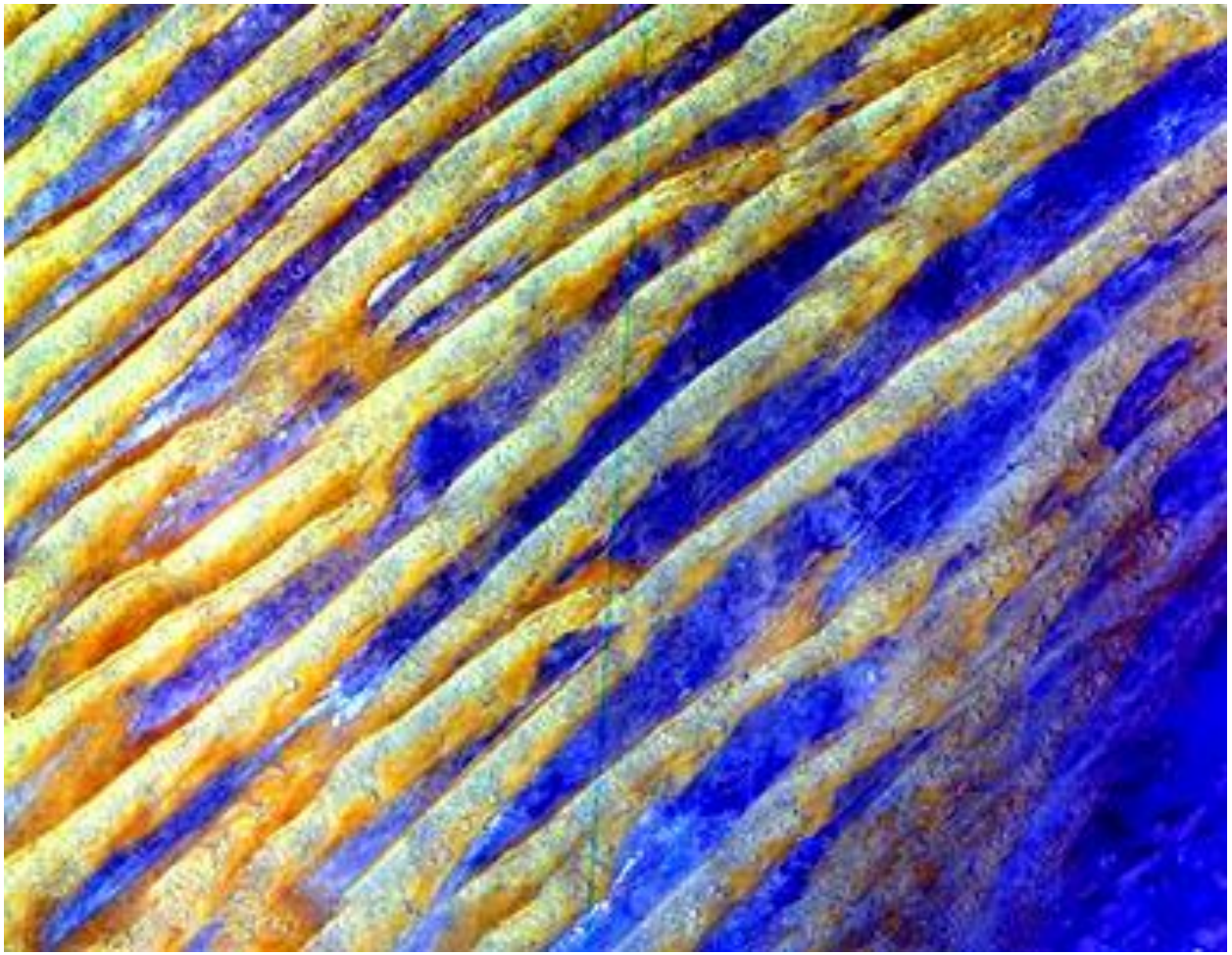
Longitudinal Dunes

(Gibbson Desert, West central Australia)

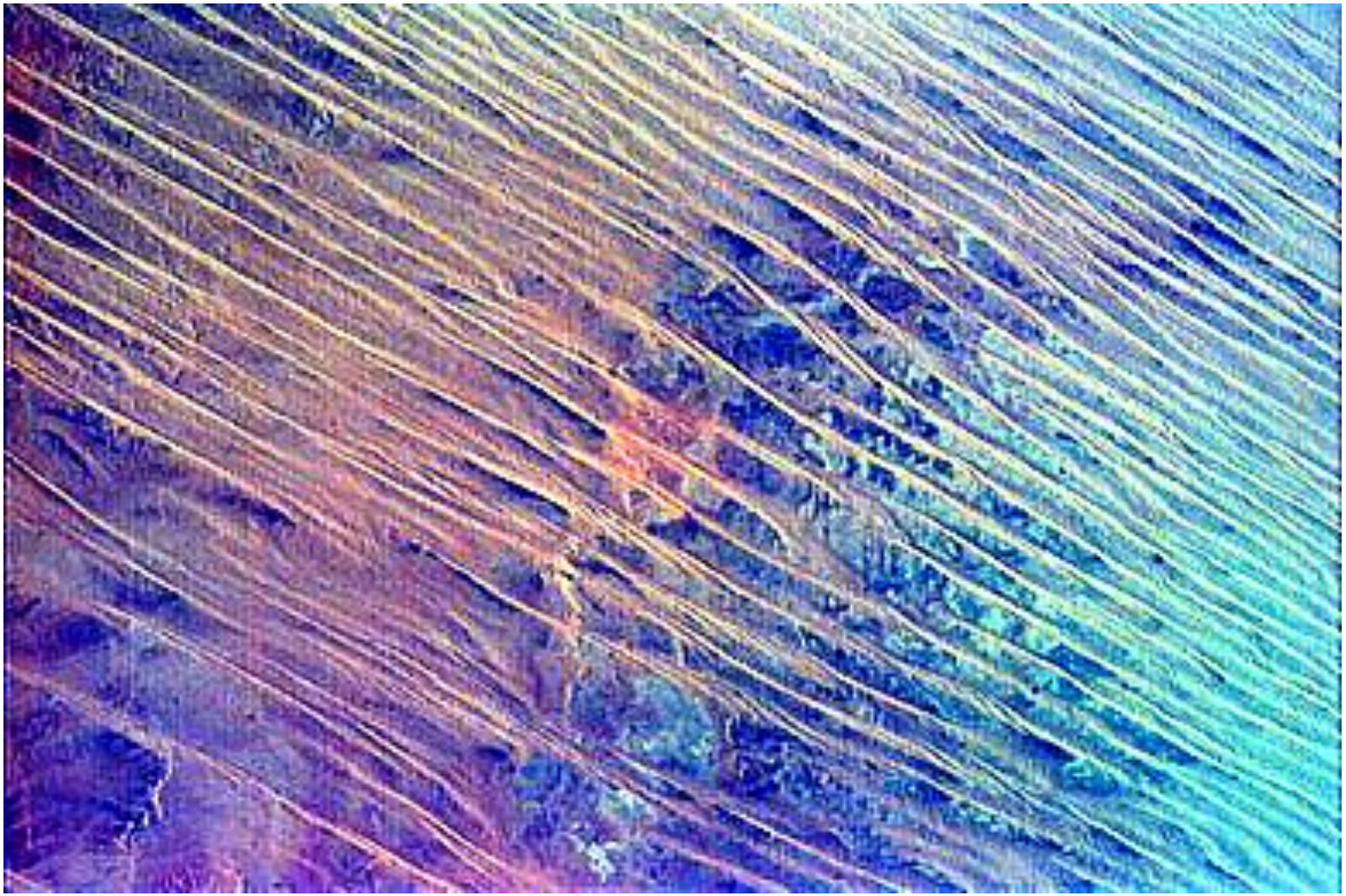
The bright blue areas between the dunes are shallow pools of rainwater, while the darkest patches are areas where the Aborigines have set fires to encourage the growth of spring grasses



The ASTER sensor onboard Terra has generated false-color images of some of these Empty Quarter dunes)longitudinal type) in southern Saudi Arabia. In the version below, dunes are bright yellow and brown whereas the blue relates to the spectral response of interdune clays and silts.

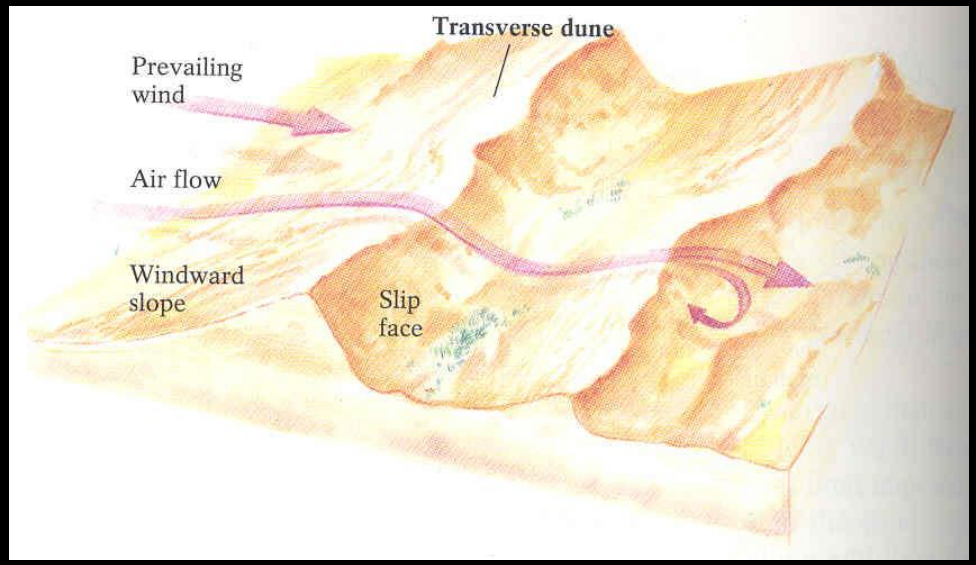


longitudinal dunes in the Egyptian desert

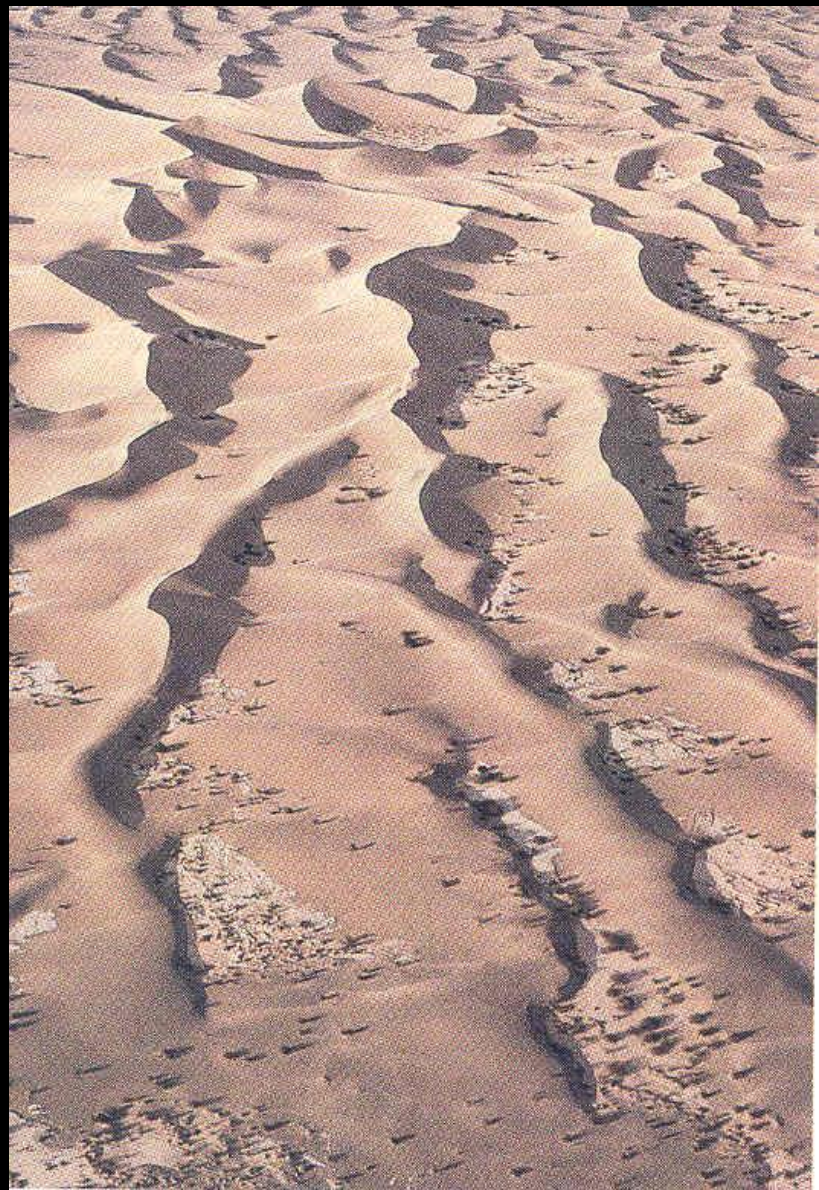


Transverse dunes

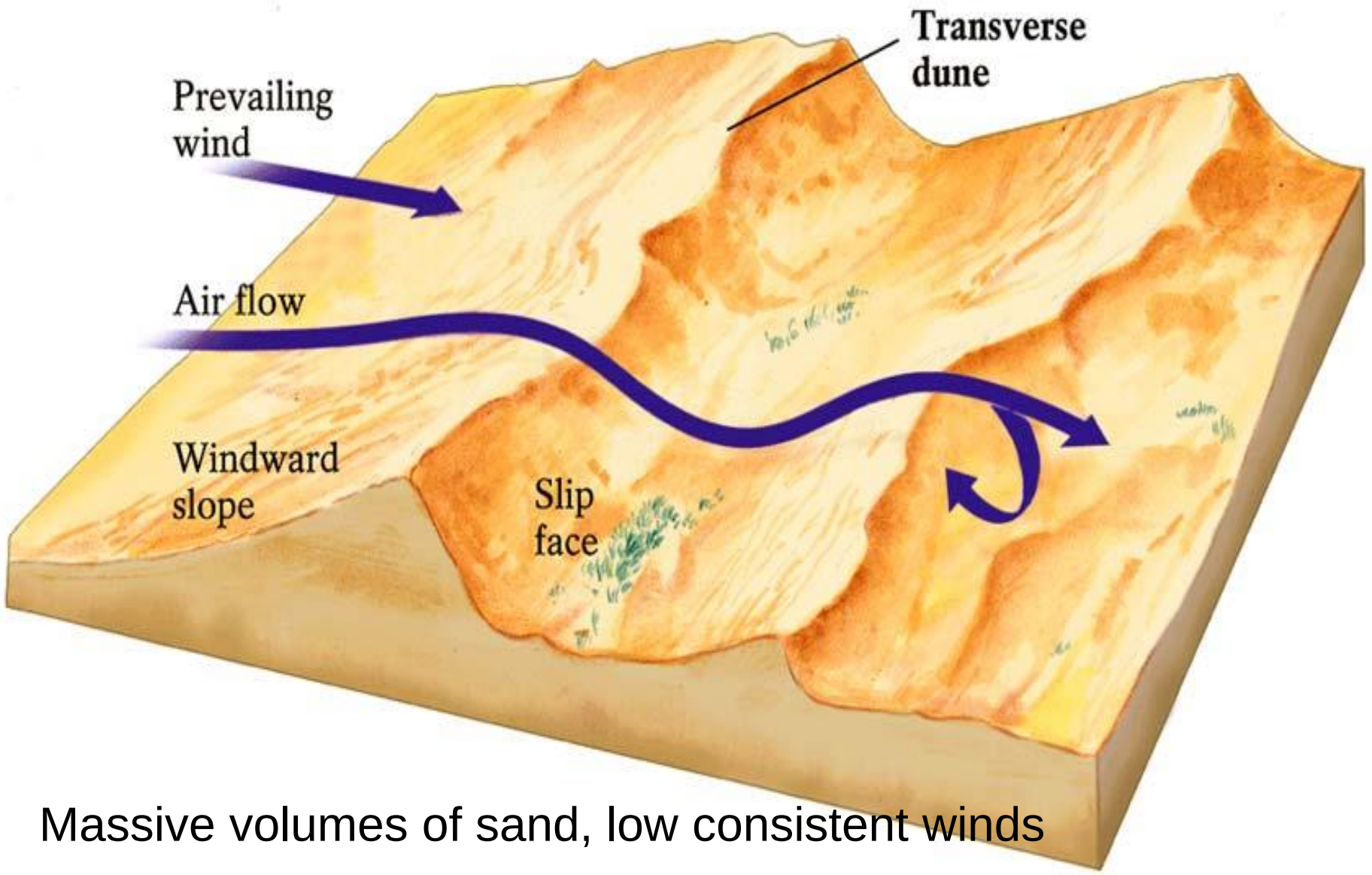
(Mesquite Flat, Death Valley, California



Transverse dunes are a series of parallel ridges that typically occur in arid and semi-arid regions where sand is plentiful, wind direction constant and vegetation scarce. These dunes form perpendicular to the prevailing wind direction and have a gentle windward slope and steep leeward slip face. They also develop along the shores of oceans and large lakes where abundant sand is shaped by strong onshore winds



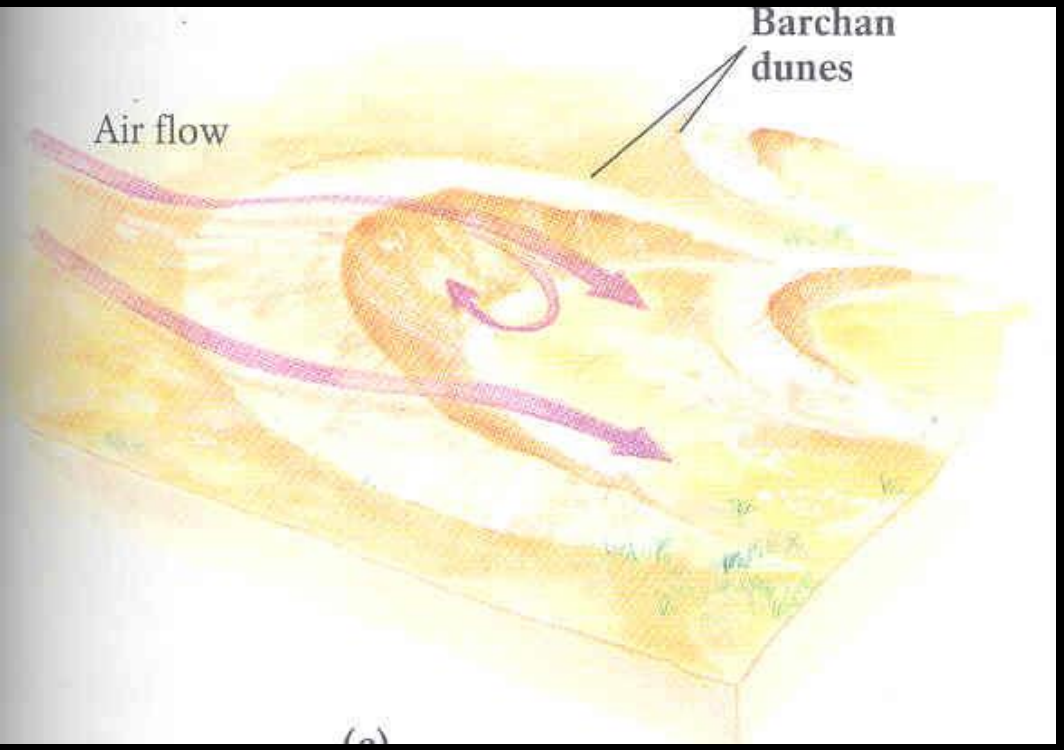
Transverse Dunes



Massive volumes of sand, low consistent winds

Barchan Dunes

(Baja Desert, Baja California)

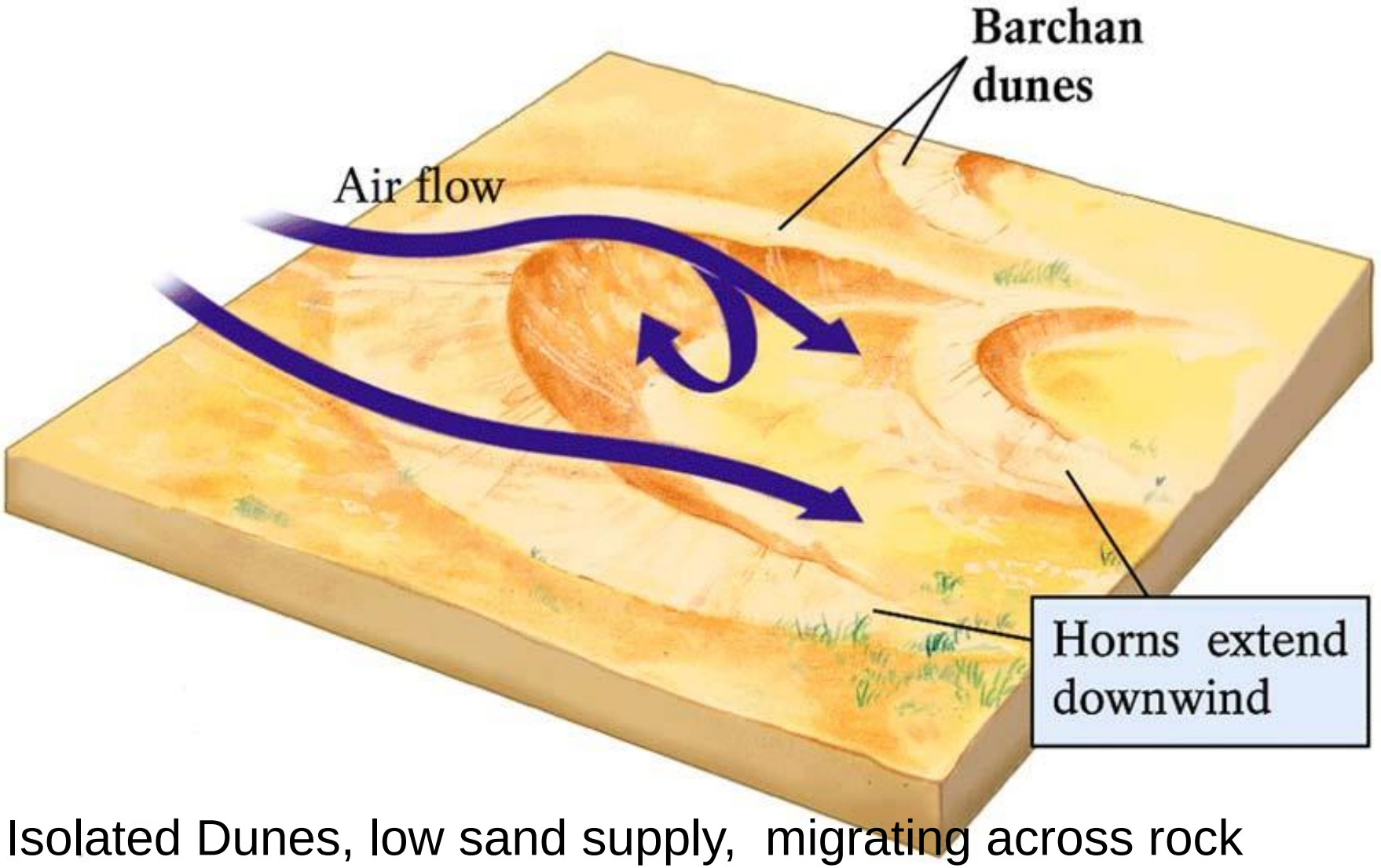


Barchan dunes (pronounced bar'- kane) are crescent shaped ridges that form perpendicular to the prevailing wind as sand begins to accumulate around small patches of desert vegetation.

Barchans develop in arid regions on flat, hard ground where there is little available sand and wind direction is fixed.

Their horns, the points of the crescents are thinner than their centers the horns migrate downward rapidly, thus extending the barchan with its characteristic sharply pointed horns in the downwind direction

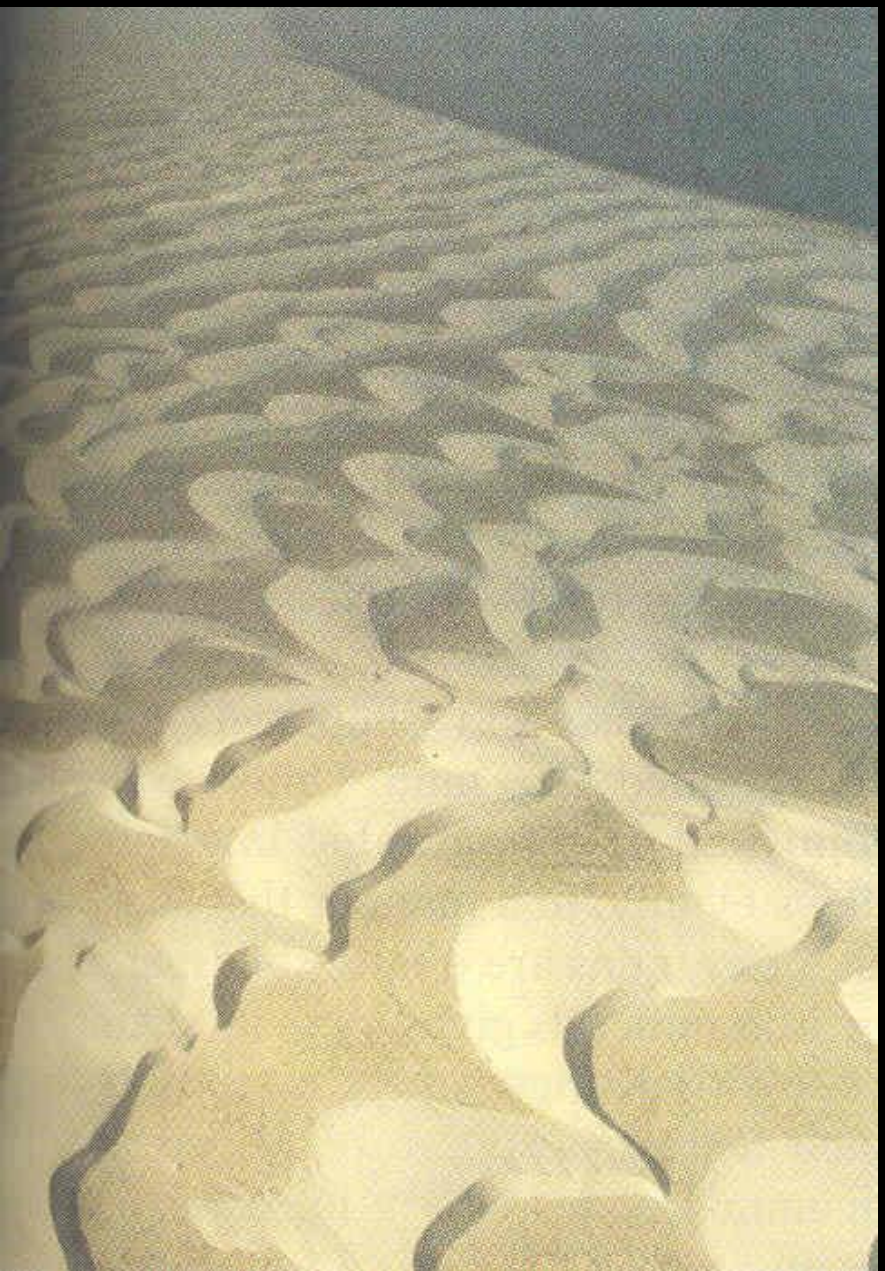
Barchan Dunes

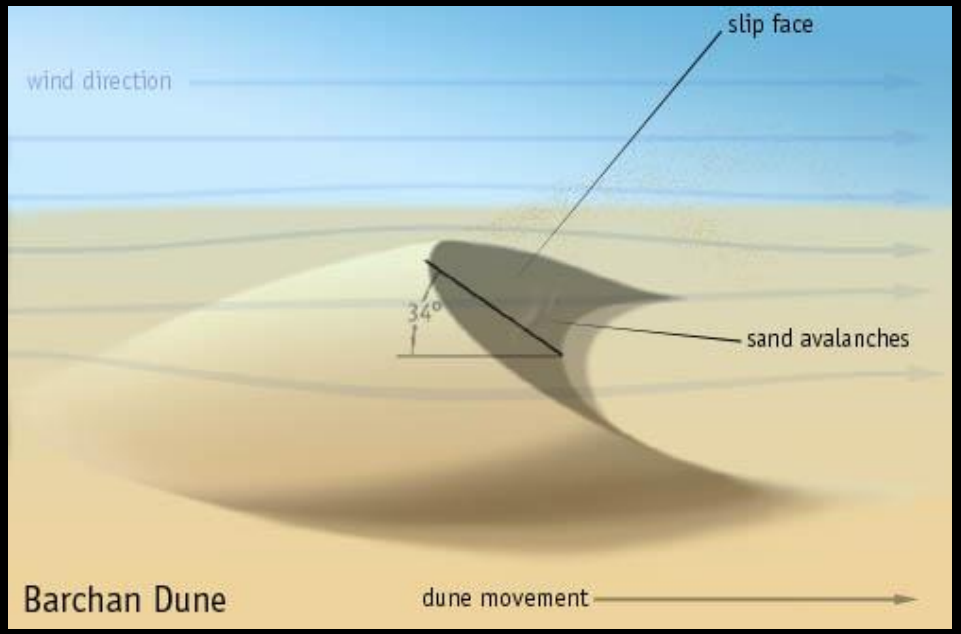


Isolated Dunes, low sand supply, migrating across rock

Barchan Dunes

(Baja Desert, Baja California)





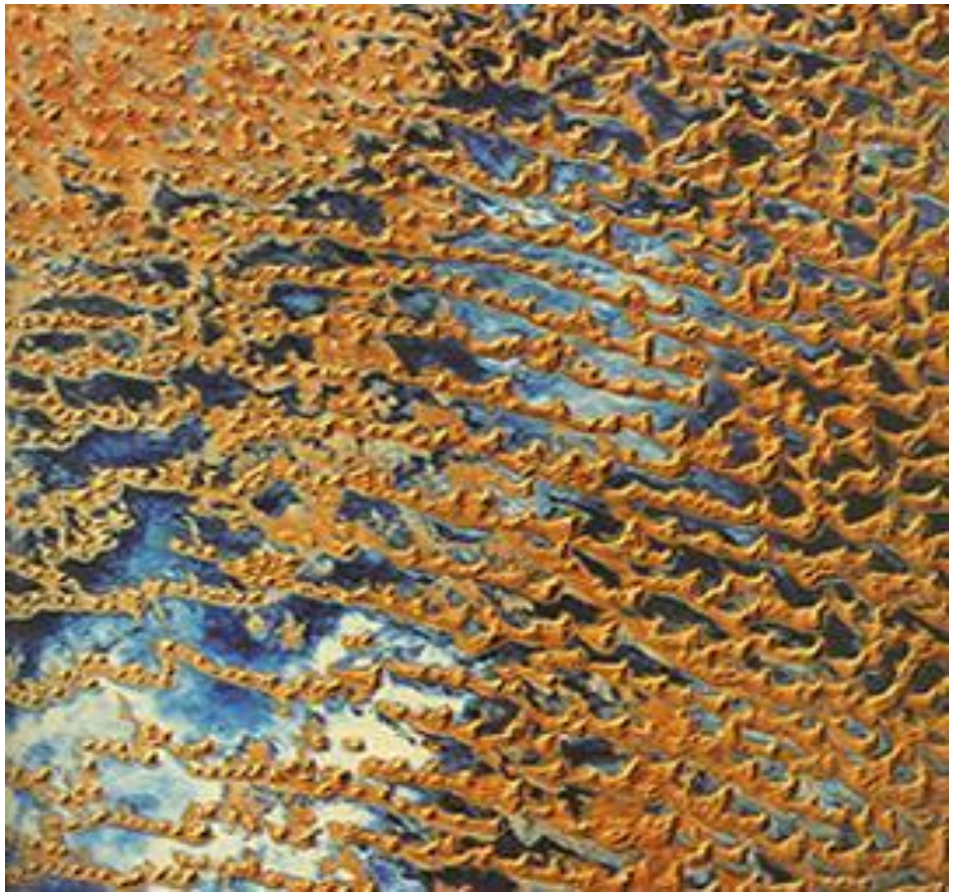
Barchanoid dunes

(White Sands National Monument, New Mexico)

Barchan Dunes

- Isolated – low sand supply; migrating across rock

Seif Dunes



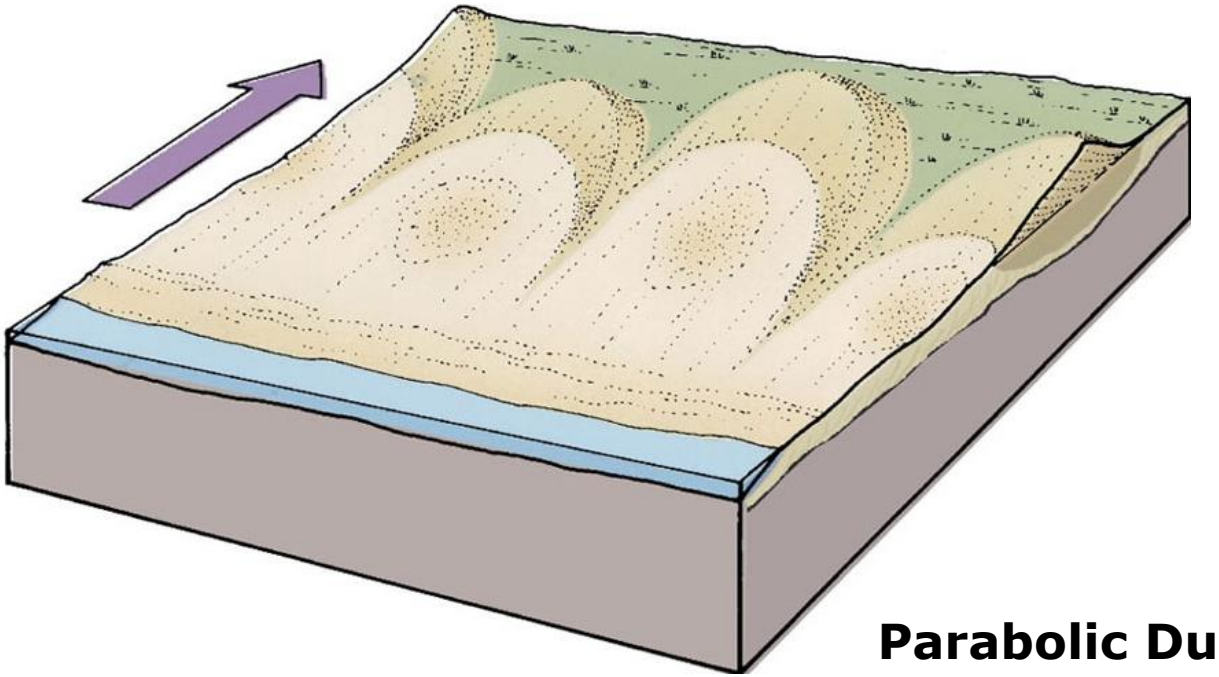
Seif dunes

- Formed due to occasional shift in wind direction
- These dunes are similar to BARCHANS where one wing is not developed.

Parabolic

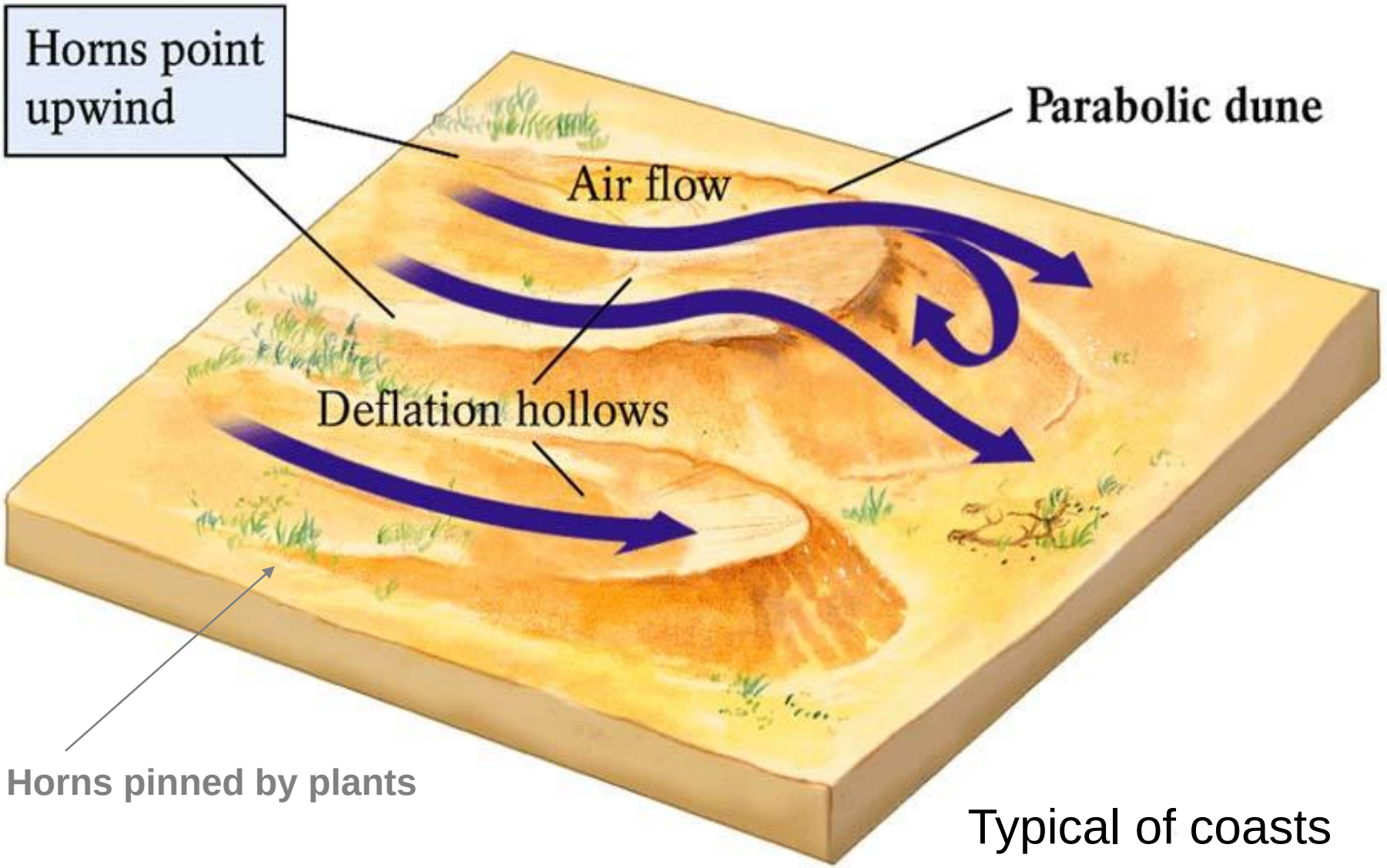
Parabolic dunes are horseshoe-shaped, differing from barchans in that their horns point upwind. They commonly form along sandy ocean and lake shores, the only appreciable dune areas outside of deserts. Parabolic dunes develop from transverse dunes that are exposed to accelerated wind deflation, especially after removal of some vegetation.

U-shaped mounds of sand with convex noses trailed by elongated arms are parabolic dunes. Sometimes these dunes are called U-shaped, blowout, or hairpin dunes, and they are well known in coastal deserts.



Parabolic Dune

Parabolic Dunes

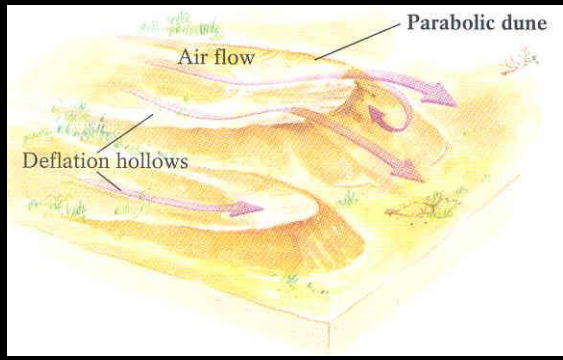


Typical of coasts

Parabolic Dunes

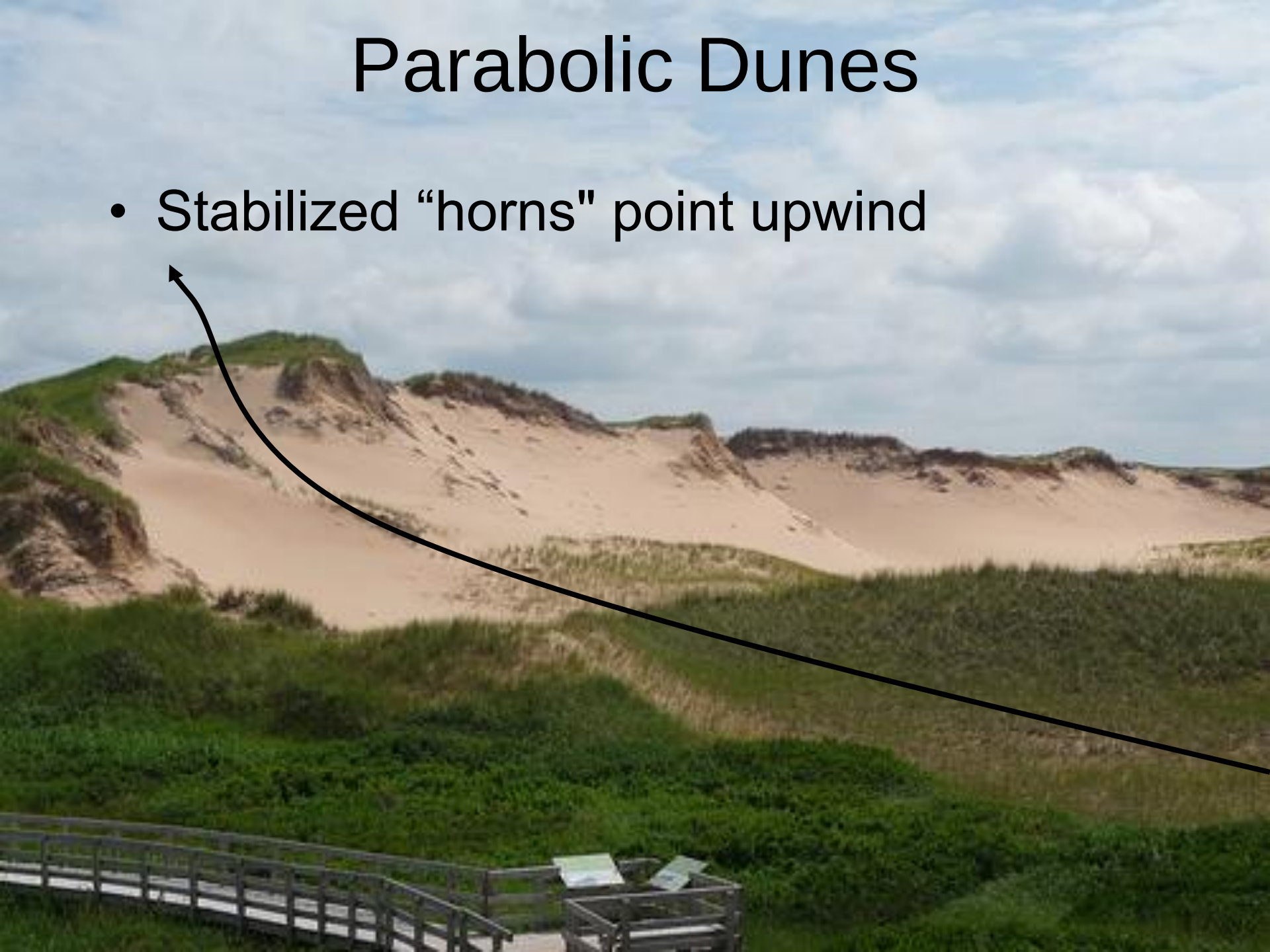
(Lake Michigan shoreline west of St.Ignace, Michigan)

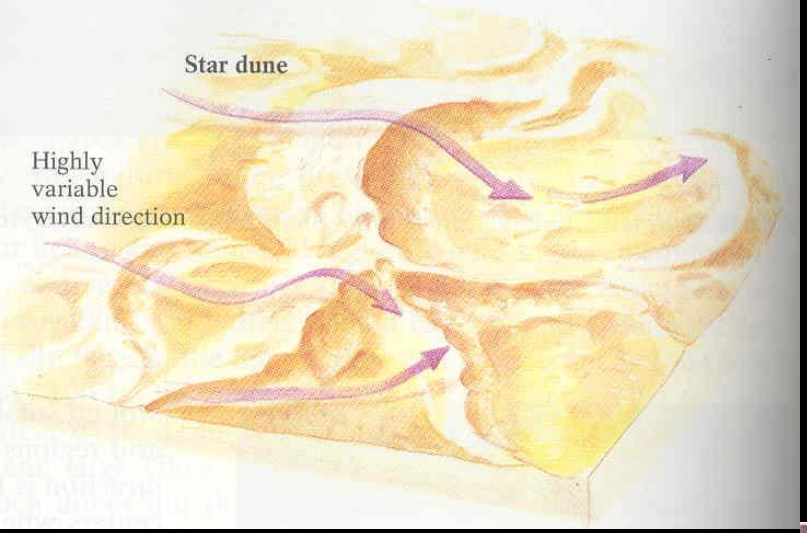
Parabolic dunes are horseshoe-shaped, differing from barchans in that their horns point upwind. They commonly form along sandy ocean and lake shores, the only appreciable dune areas outside of deserts. Parabolic dunes develop from transverse dunes that are exposed to accelerated wind deflation, especially after removal of some vegetation.



Parabolic Dunes

- Stabilized “horns" point upwind

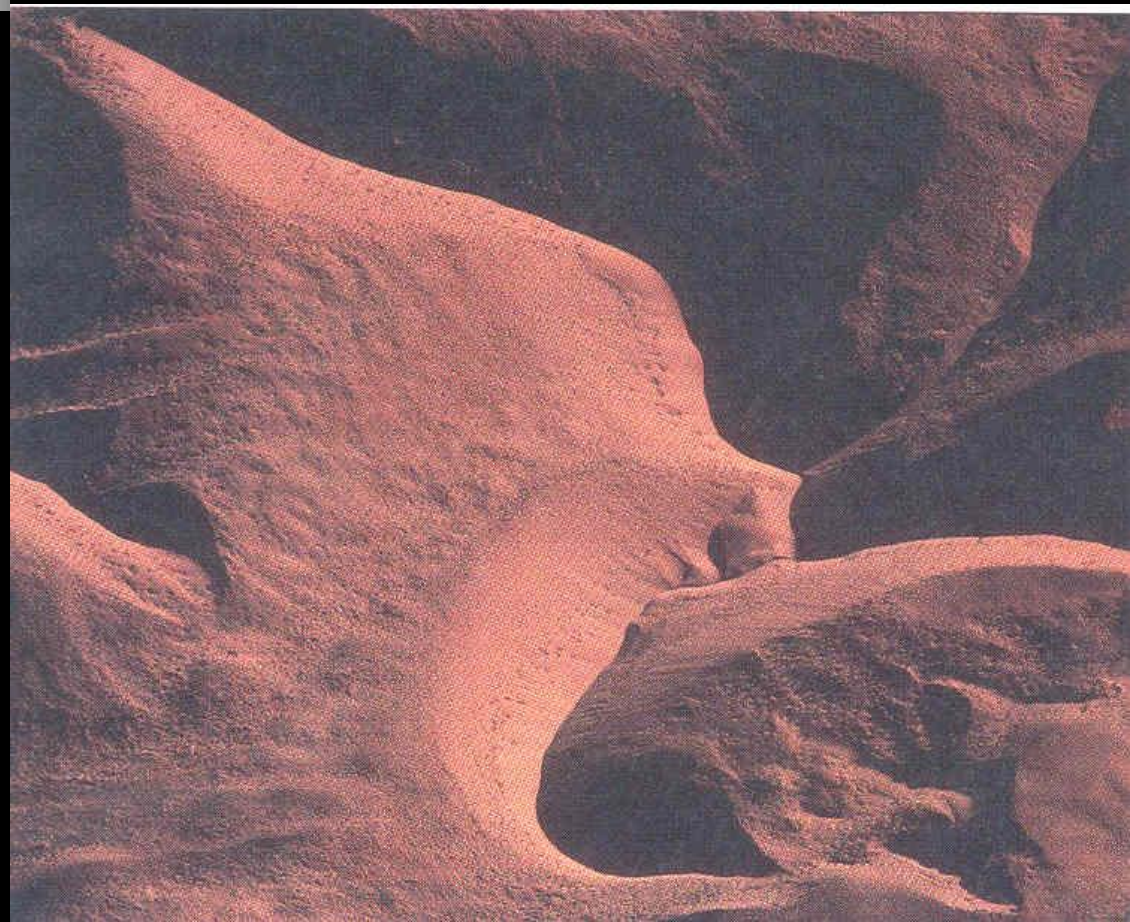




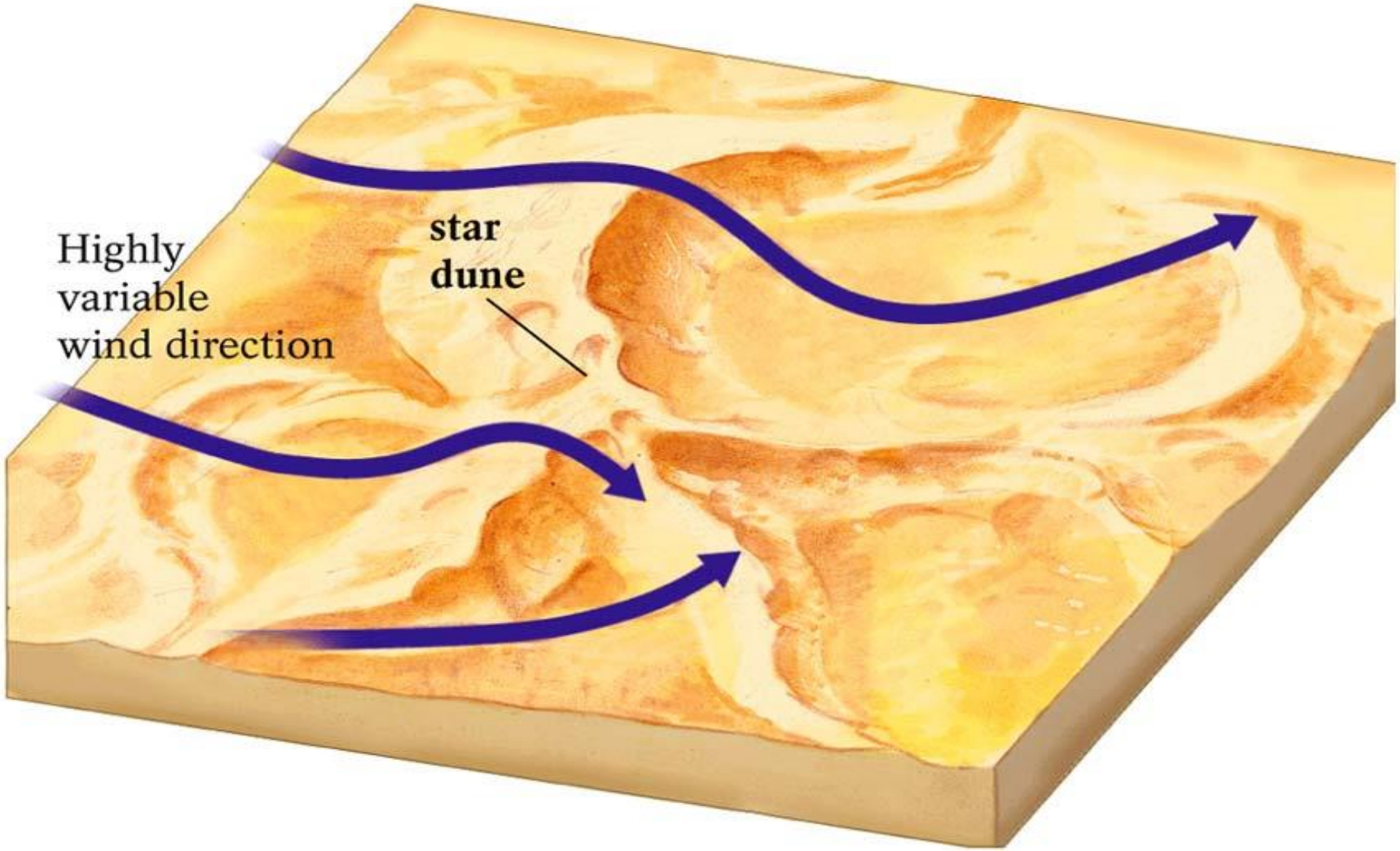
Star Dunes

(Namib Desert)

Star dunes, the most complex of the dune types form when winds blow from three or more principal directions or when wind direction is constantly shifting. They tend grow vertically to high central point and may have three or four arms radiating from the center. Continued variability of wind direction causes star dunes to remain relatively fixed in position

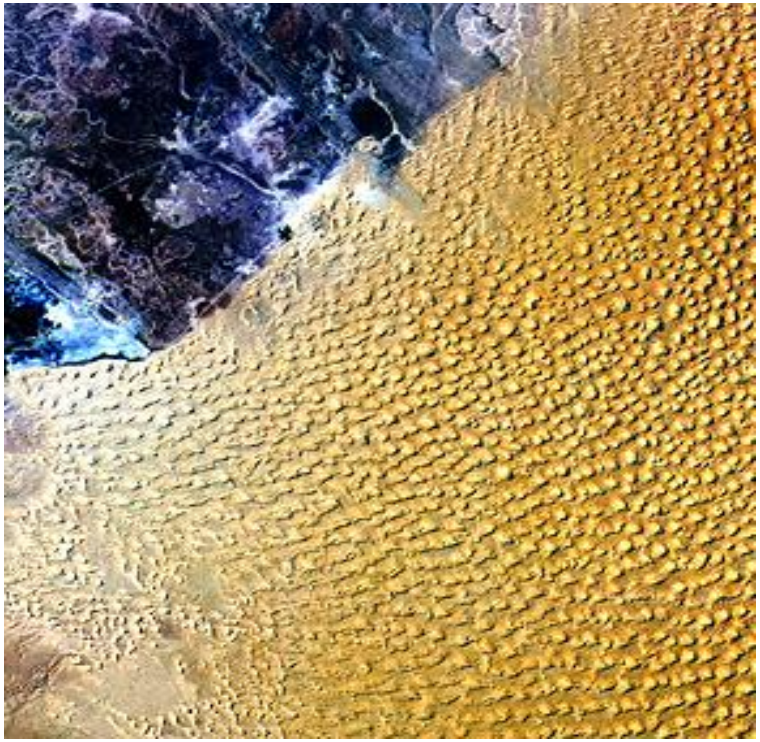


Star Dunes



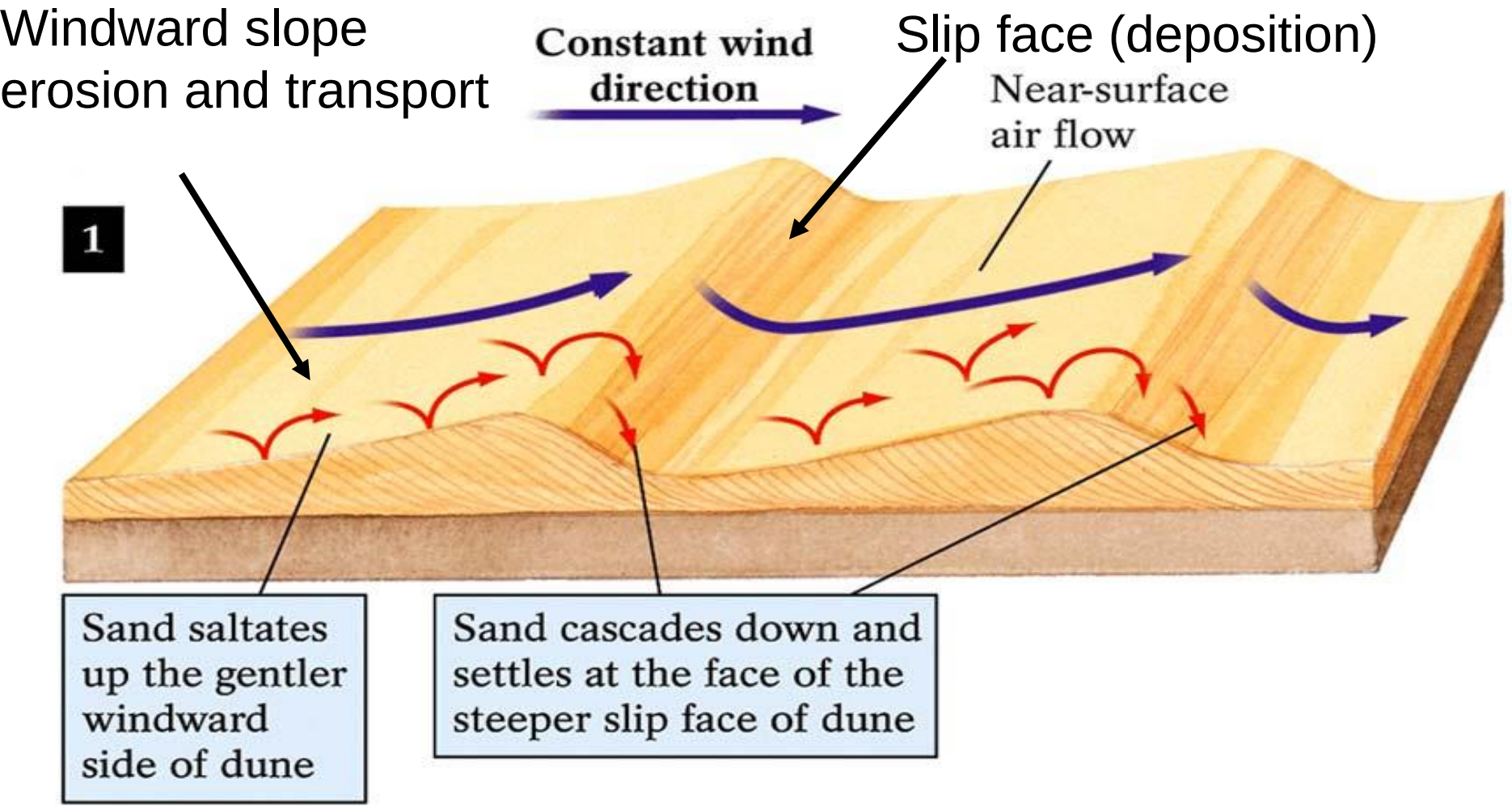
Star Dunes

Variable Wind Direction



Star Dune

Dune Migration



Just like ripples in a stream

Dome

- Oval or circular mounds that generally lack a slipface, dome dunes are rare and occur at the far upwind margins of sand seas.

Wadis - (Dry Stream Channels)

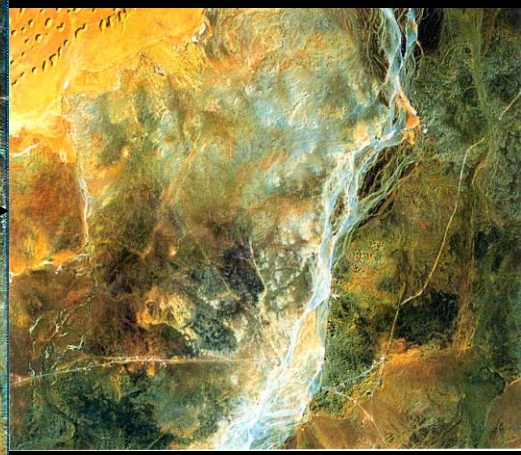
Sinai Peninsula, West of Gulf of Aqba

Dry river system in the Arabian desert

(begins in the Hijaz Mountains of western Saudi Arabia and end in kuwait)

This Landsat TM image (7,4,2 RGB) led geologists to a dry river bed long covered by two dune fields. Sand dunes in the flat desert form linear patterns, and as sand descends into depressions made by an ancient river channel, the wind pattern is disturbed, breaking the long dune into little segments, making individual dome dunes and creating the ‘corncob’ pattern. In this image blue is rock desert surface and gold is sand.

Two wadis, light blue extend south from the sand dunes. The desert floor, mostly rocky gravel plain and exposed limestone bedrock, dominates the southern and eastern portions of the image. A triangle of roads encircles the village of Shisar, which is the probable site of the ancient city of Ubar



Lost city of Ubar

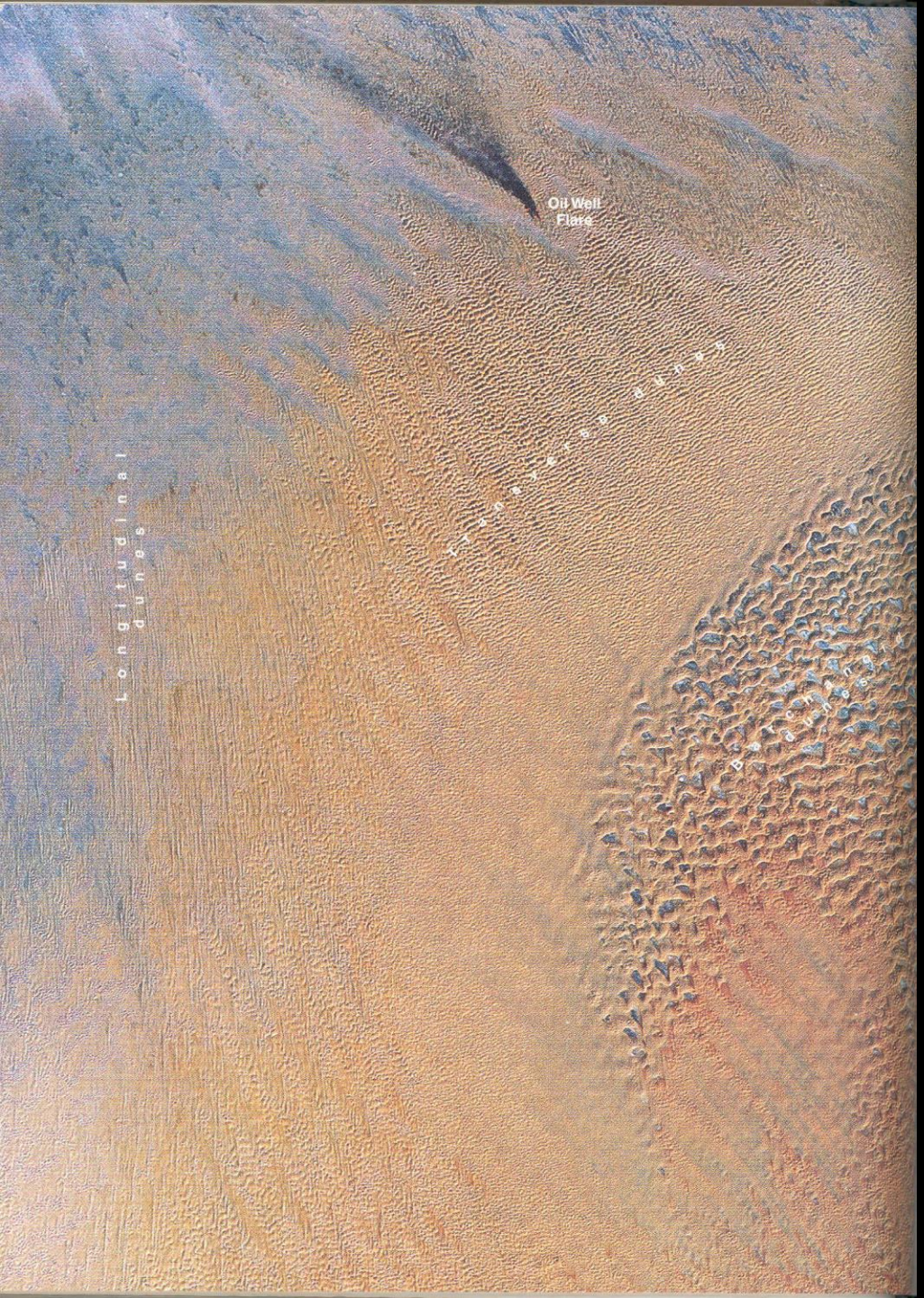
Playa Lake

Moiave desert, California

In arid regions, after an infrequent and particularly intense rainstorm, excess water that is not absorbed by the ground may accumulate in low area and form playa lakes. These lakes are temporary, lasting from a few hours to several months, most of them are shallow and have rapidly shifting boundaries as water flows in or leaves by evaporation in the ground. The water is often very saline

Sand Advance

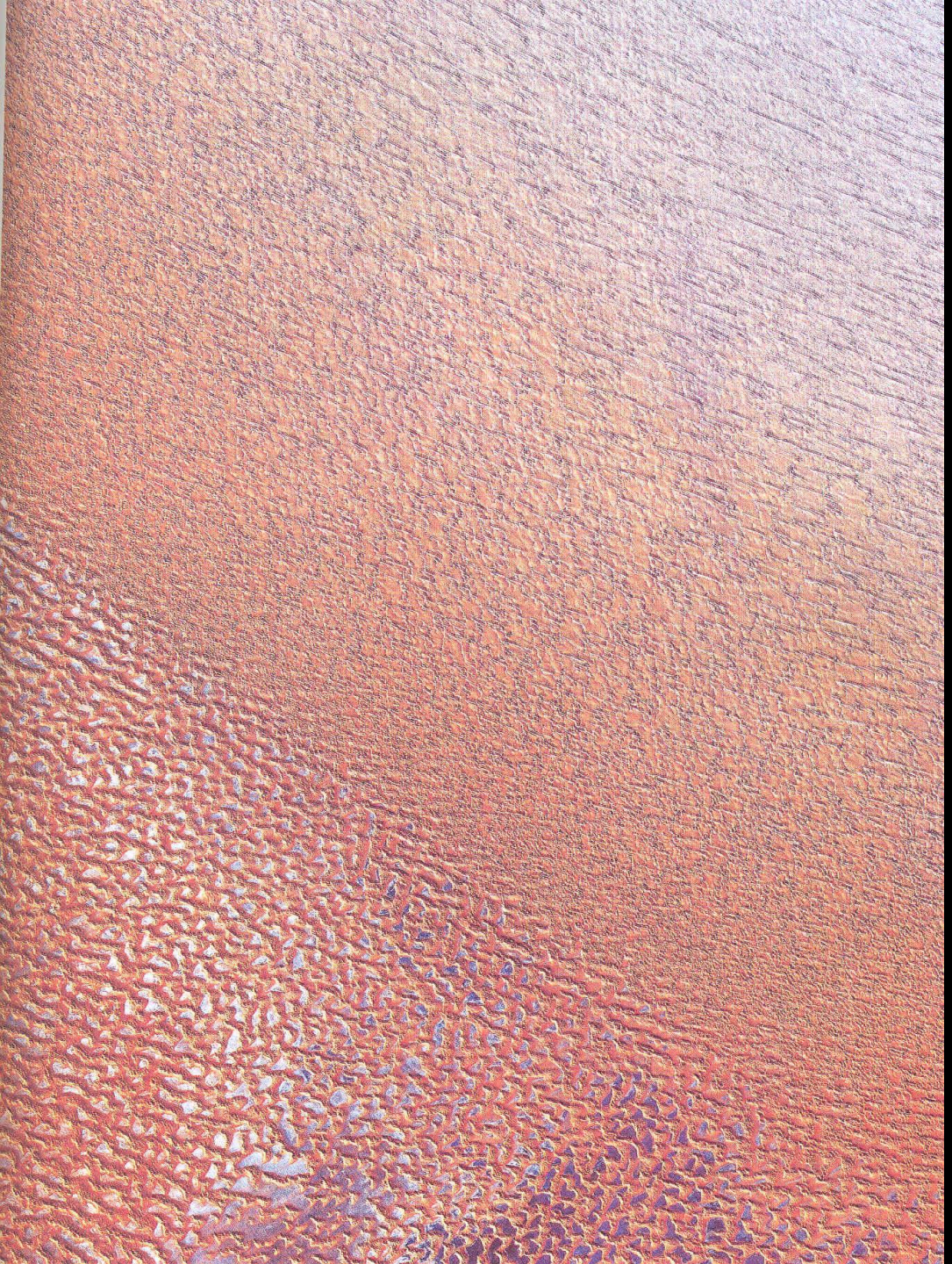
Barchans, advance across irrigated fields in the Danakil Depressions, Egypt



THE EMPTY QUARTER

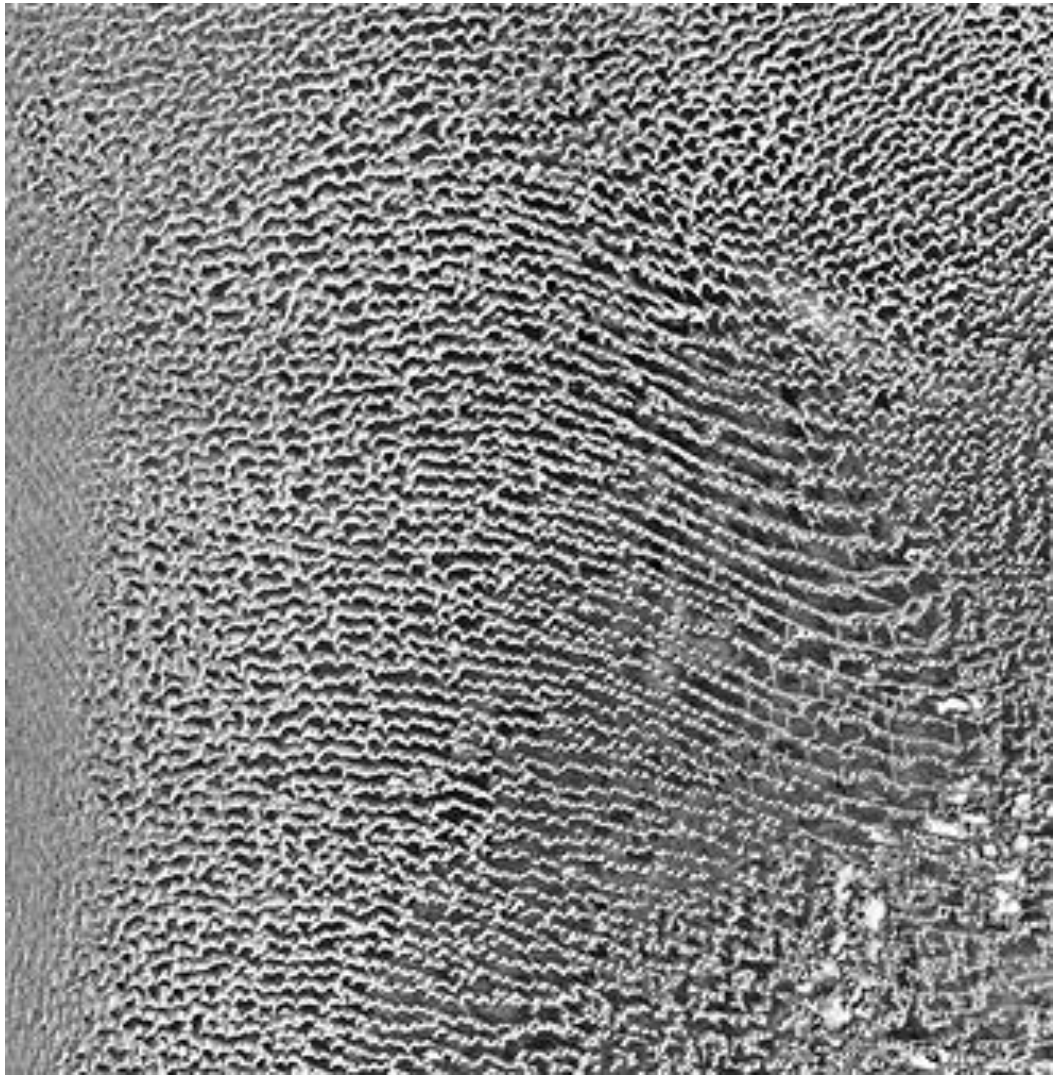
(Rub' al Khali) of Saudi Arabia

- which is a sea of sand covering an area of almost 650,000 sq.km. This image lies on the northern flank of the empty quarter and shows part of the United Arab Emirates



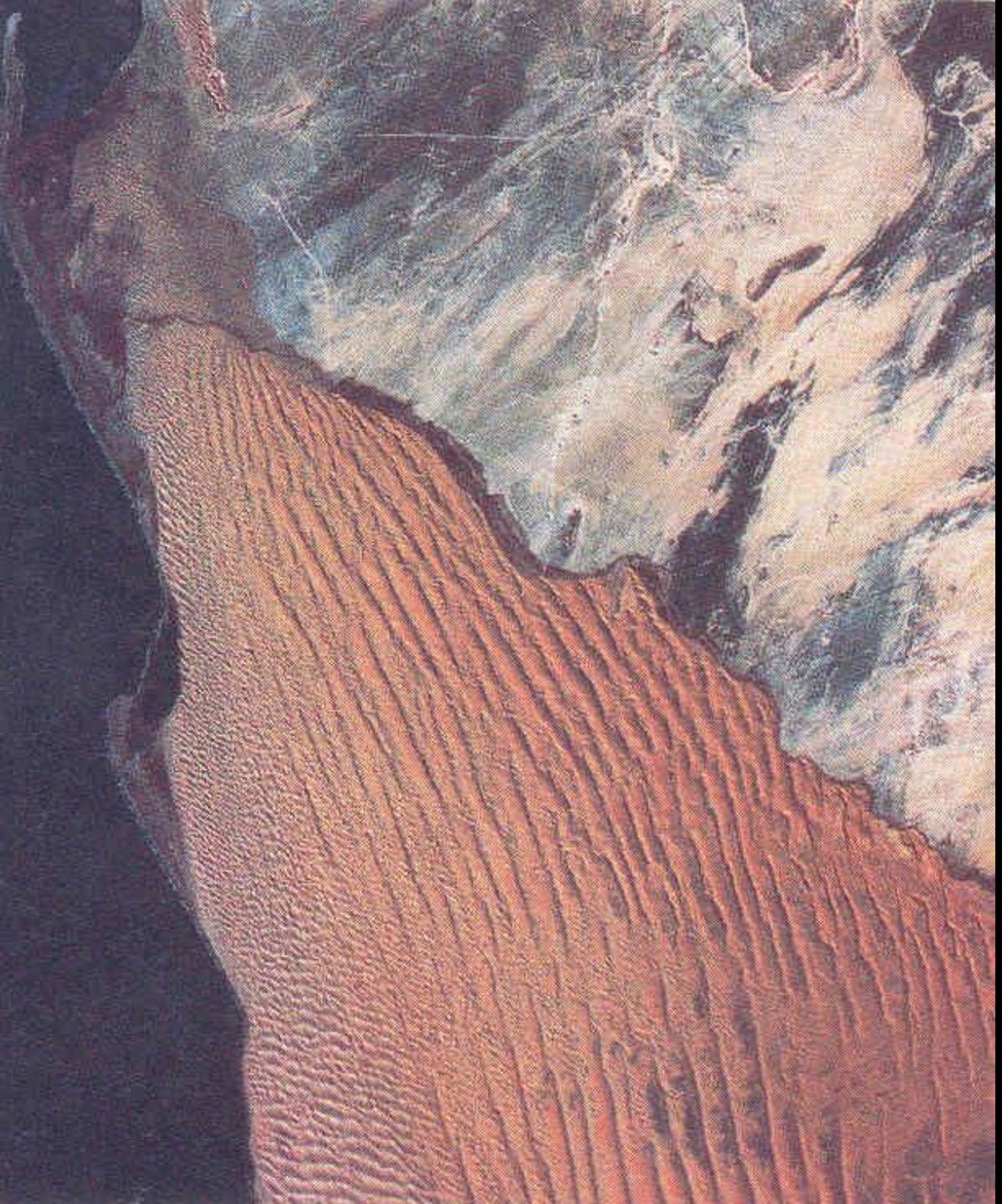
Sand seas, North Africa

The main sand seas in Algeria, Tunisia and western Libya are located in structural and topographic basins, separated by plateaus and low mountain ranges. A variety of dune types are formed as a result of variations in wind velocity and direction, supply of sand, the nature of the surface over which the sand moves



In the southern Arabian Peninsula. Loose sand, up to several hundred meters thick, covers most of the solid rock landscape in this region.

Most of the center consists of Complex Crescentic Dunes on the left and Complex Linear Dunes on the right. In the lower right corner are Star Dunes, and along the left is a separate sea consisting of small Linear and Complex dunes.



Sand Sea

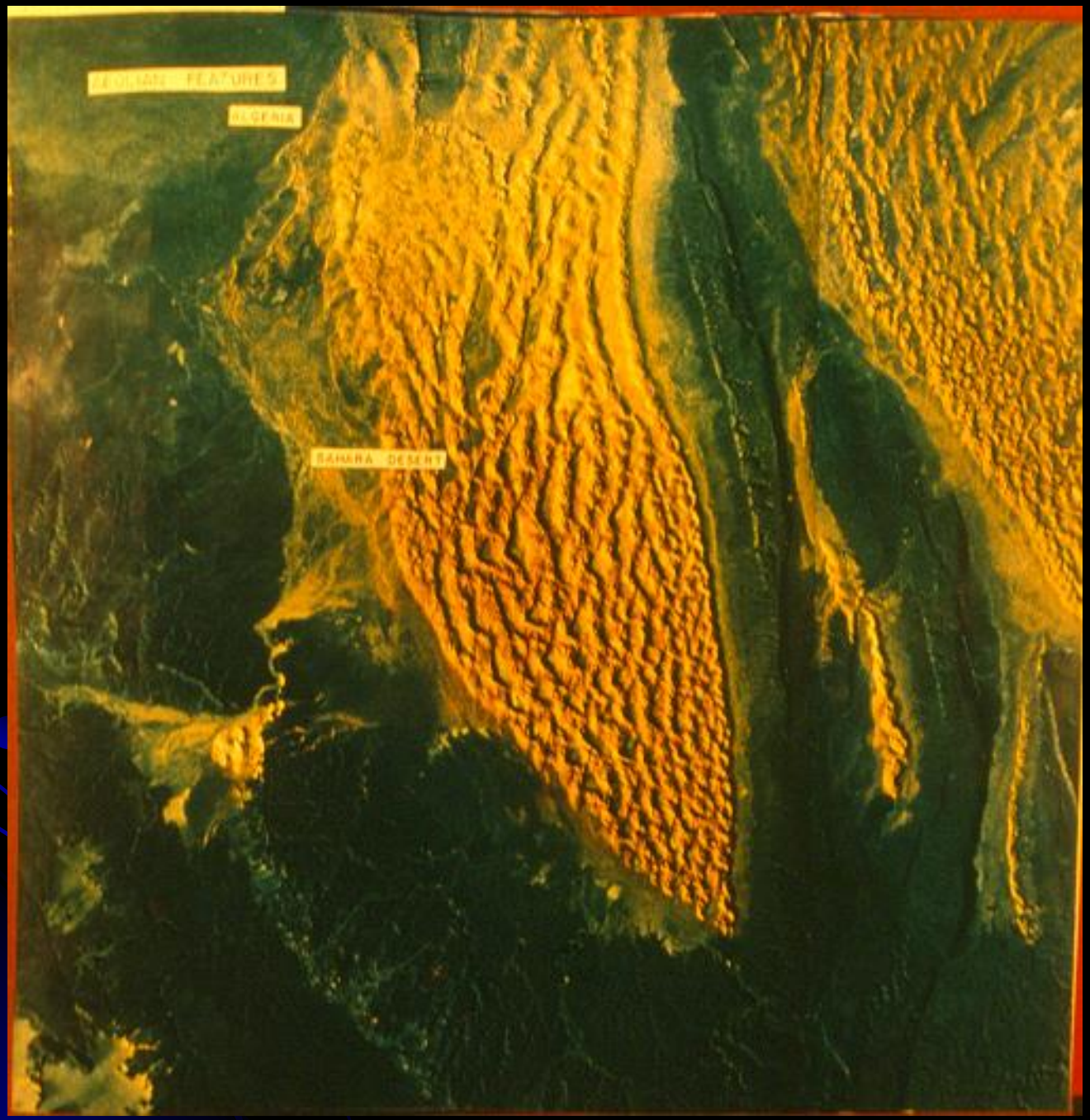
in the Central Namiba, Western Africa

Large, complex linear dunes pass shoreward into barchanoid ridges that have been reworked along the coast to form pronounced spits

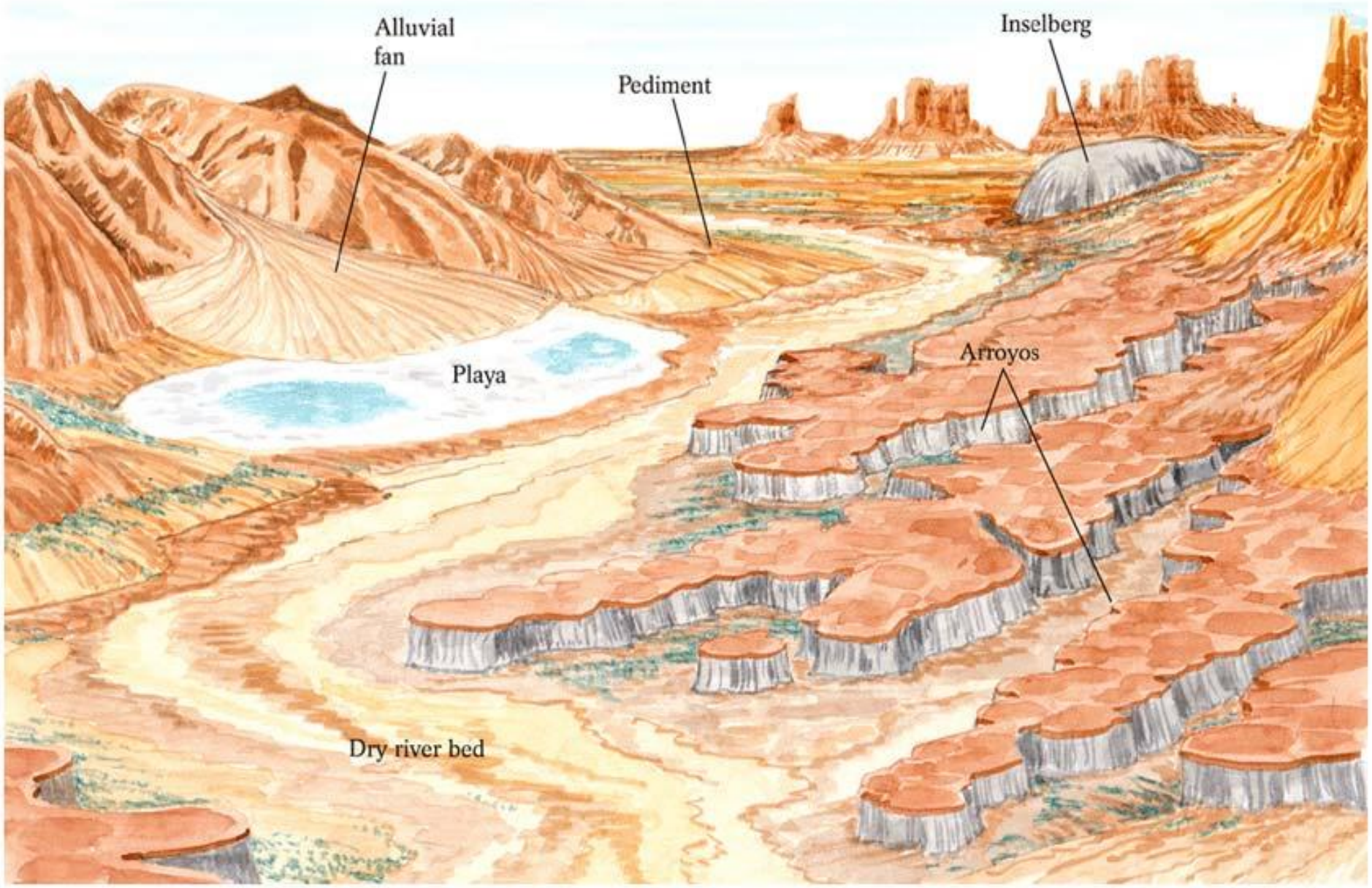
Huge Sand Dune

(Alashan Plain of Western China)

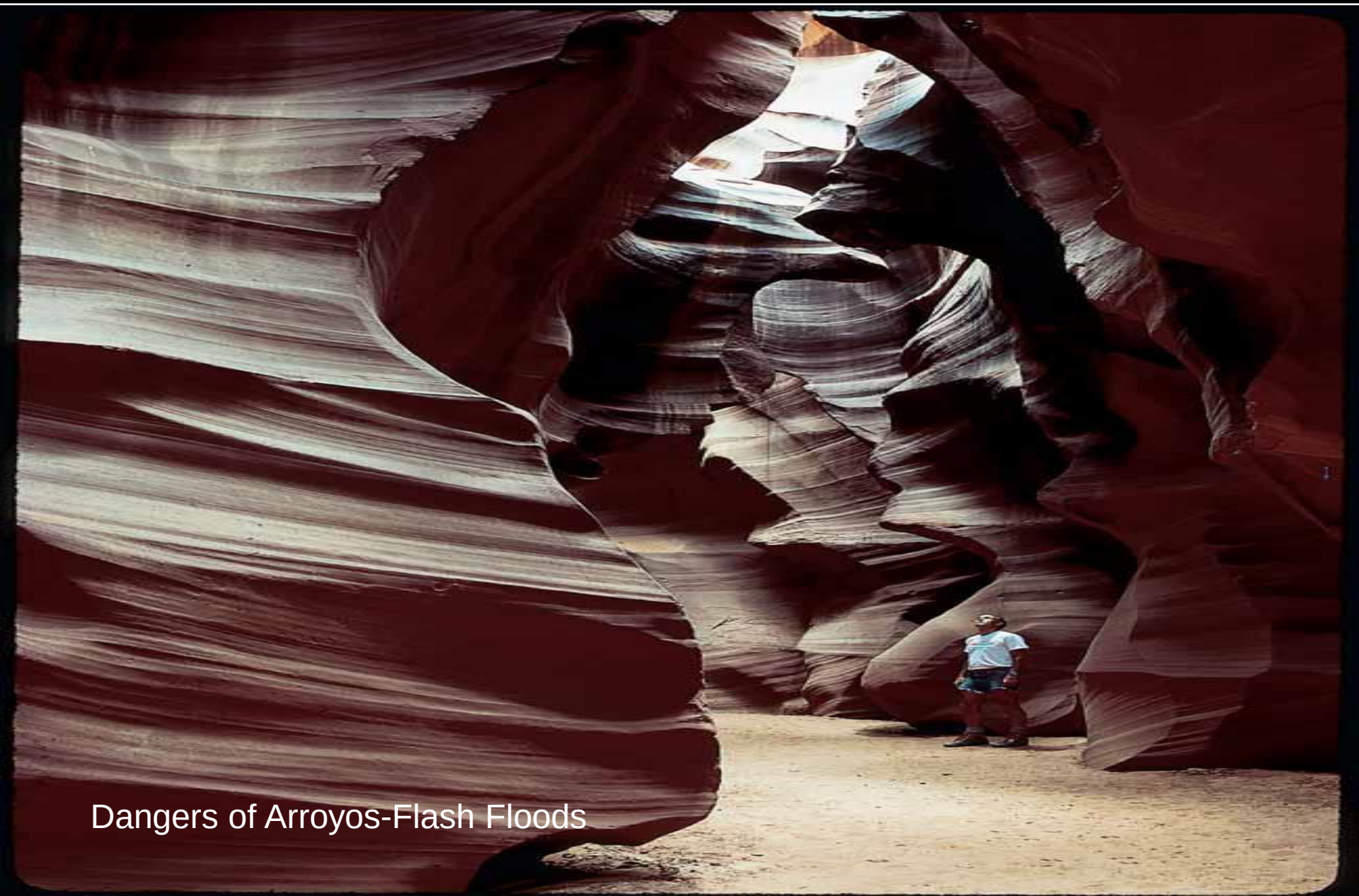
It reaches a height of several hundred meters (< 500 m)


SAHARA DESERT

Desert Landforms Produced By Water



Water-Carved Canyon



Dangers of Arroyos-Flash Floods

Playas (cont'd) – A Playa in Death Valley, California

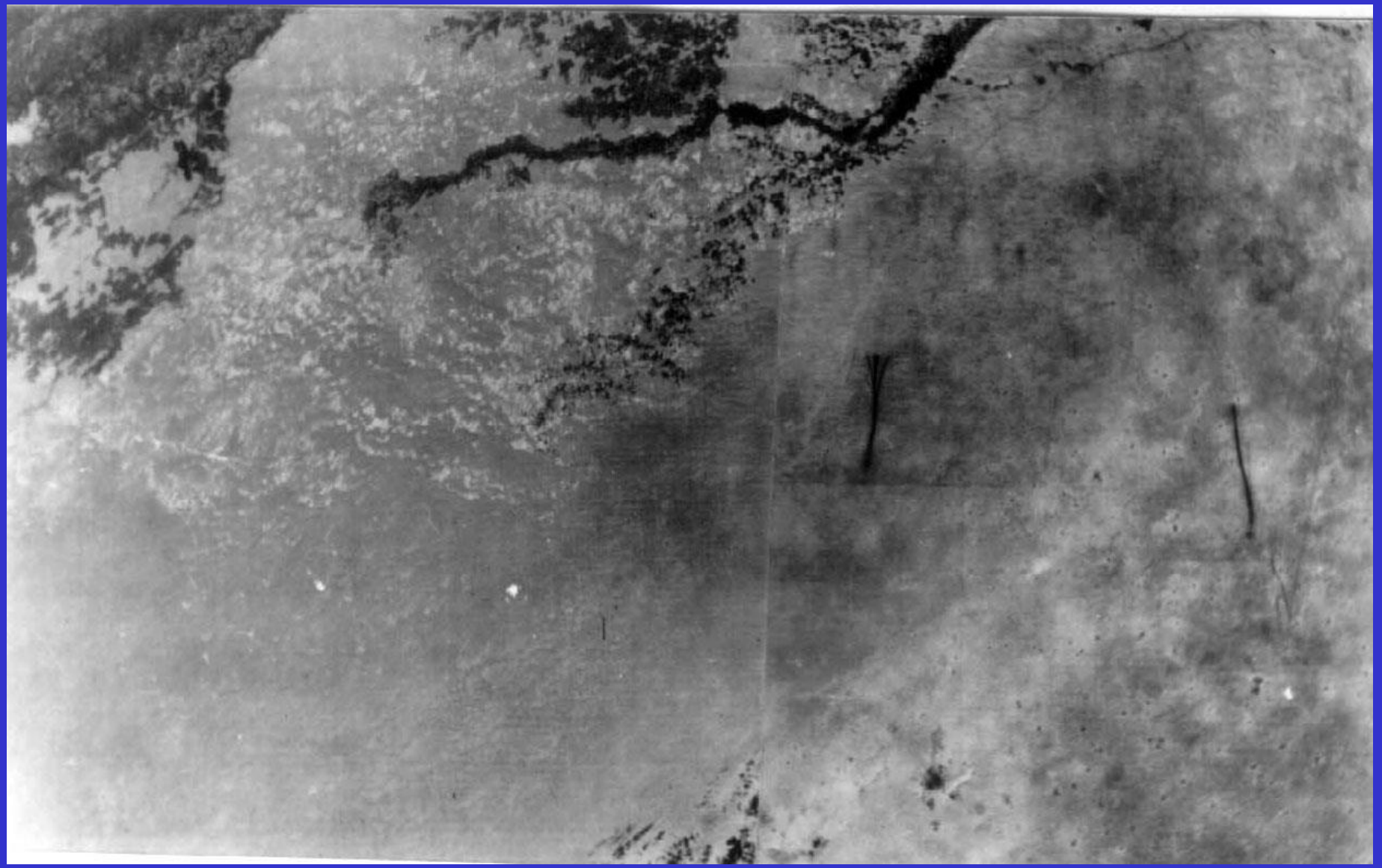
Spadefoot Toad Anecdote

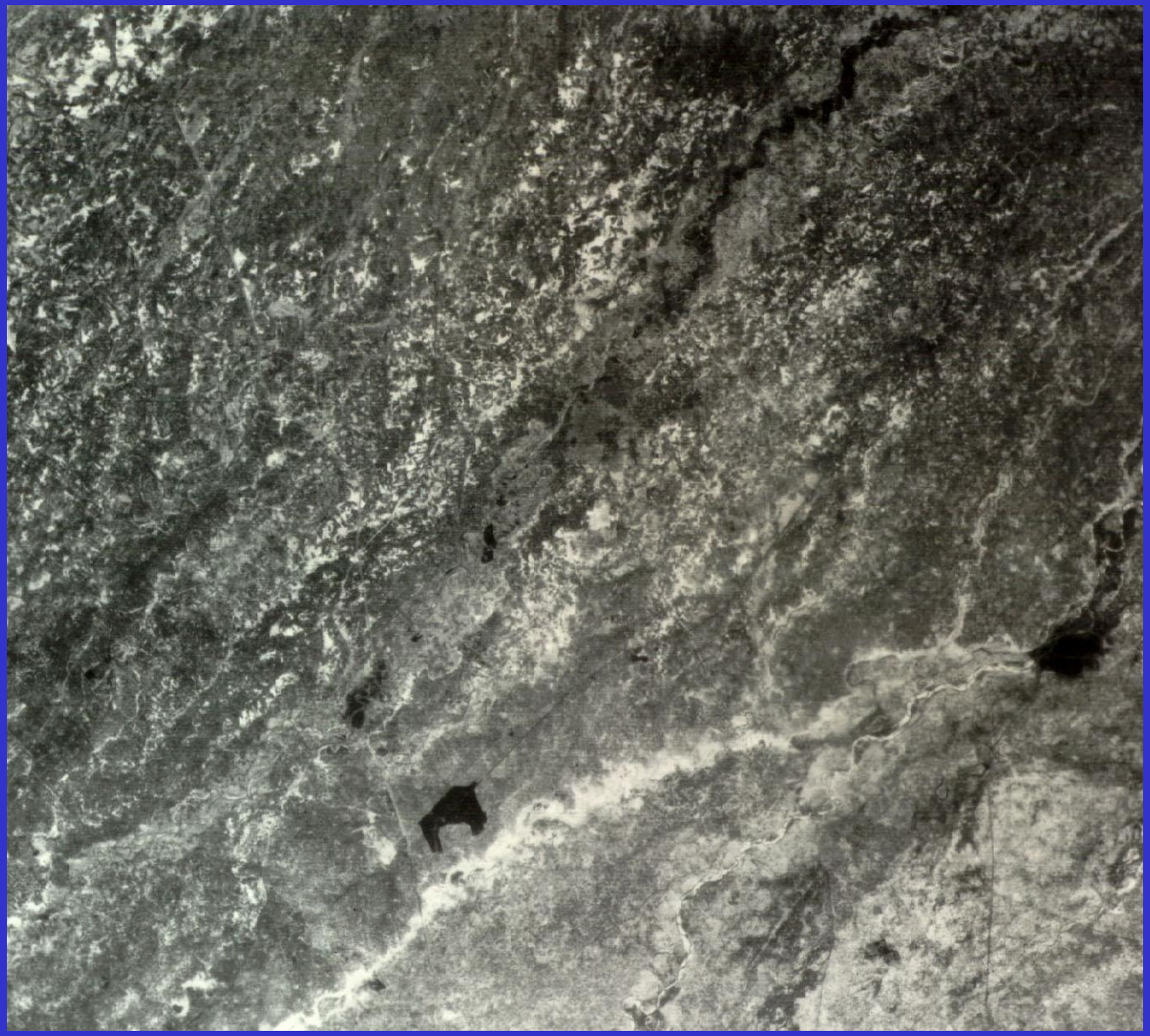
Evaporites 20 mule team Borax

Alluvial fan

(Death Valley, California)

Coalescence of Alluvial fans





River

Migration &

Salinity

LAPLACIAN EDGE DECTECTED IMAGE USING IRS-P4 OCM DATA

(P 9 - R 13 , 5 December 2000)

IN RAJASTHAN