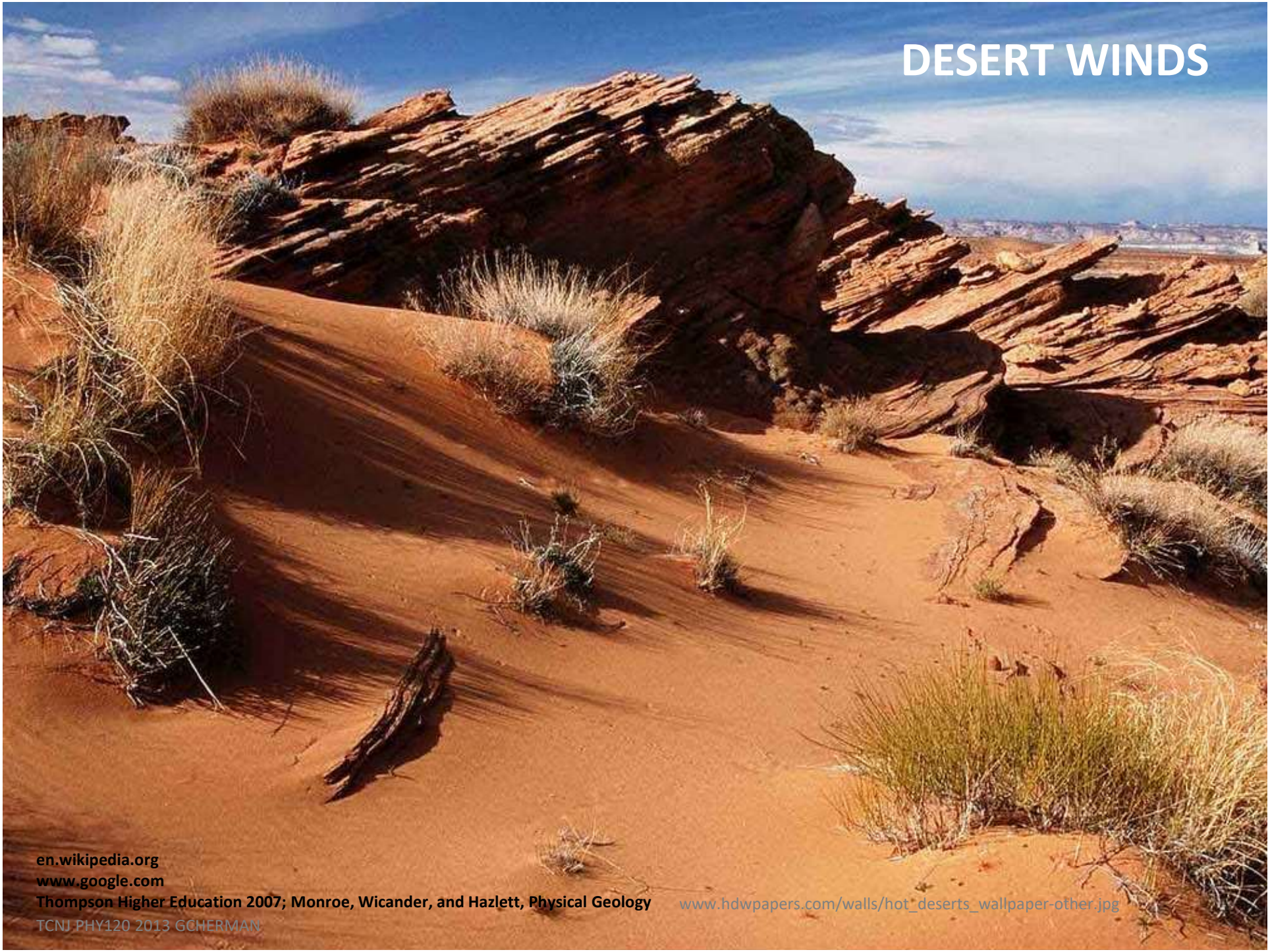
DESERT WINDS



en.wikipedia.org
www.google.com
Thompson Higher Education 2007; Monroe, Wicander, and Hazlett, Physical Geology

www.hdwpapers.com/walls/hot_deserts_wallpaper-other.jpg

PLEISTOCENE AND HOLOCENE TIMES (review)

Subdivisions of the **Quaternary** System			
System	Series	Stage	Age (Ma)
Quaternary	Holocene		0–0.0117
	Pleistocene	Tarantian (Upper)	0.0117–0.126
		Ionian (Middle)	0.126–0.781
		Calabrian (Lower)	0.781–1.806
		Gelasian (Lower)	1.806–2.588
Neogene	Pliocene	Piacenzian	older

- The **HOLOCENE** covers form now to ~11,700 years ago. It has been identified with the current warm period, known as MIS 1 that is considered an interglacial period in the current ice age.
- *The Holocene also encompasses within it the growth and impacts of the human species and impacts of the modern era on the Earth.*
- A new term Anthropocene, is specifically proposed and used informally only for the very latest part of modern history and of significant human impact since the epoch of the Neolithic Revolution (around 12,000 years BP).

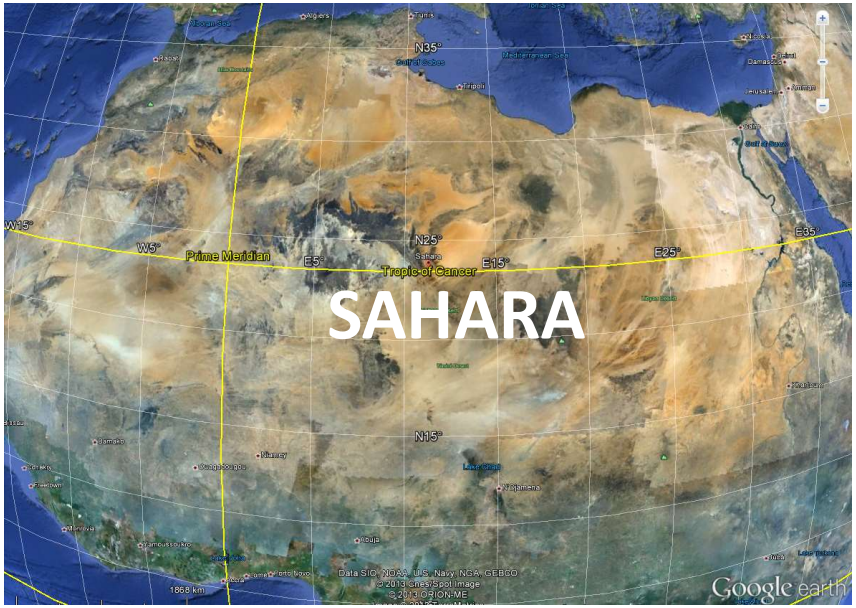
- The **PLEISTOCENE** was ~11,700 years ago to 2.28 Ma.
- It is the first epoch of the Quaternary Period or sixth epoch of the Cenozoic Era.
- *The end of the Pleistocene corresponds with the end of the last glacial period.*
- It also corresponds with the end of the Paleolithic age used in archaeology.

DESERT WINDS

- Deserts and Desertification
- Sediment Transport by Wind
- Wind Erosion
- Wind Deposits
- Air-Pressure Belts and Global Wind Patterns
- The Distribution of Deserts
- Characteristics of Deserts
- Desert Landforms

- *Understanding how desert processes work and studying ancient desert regimes may help provide insight into climate change and related present-day issues.*

DESERTS are regions having poorly developed soil, little or no vegetation, which receive *less than 25 cm of precipitation per year*.



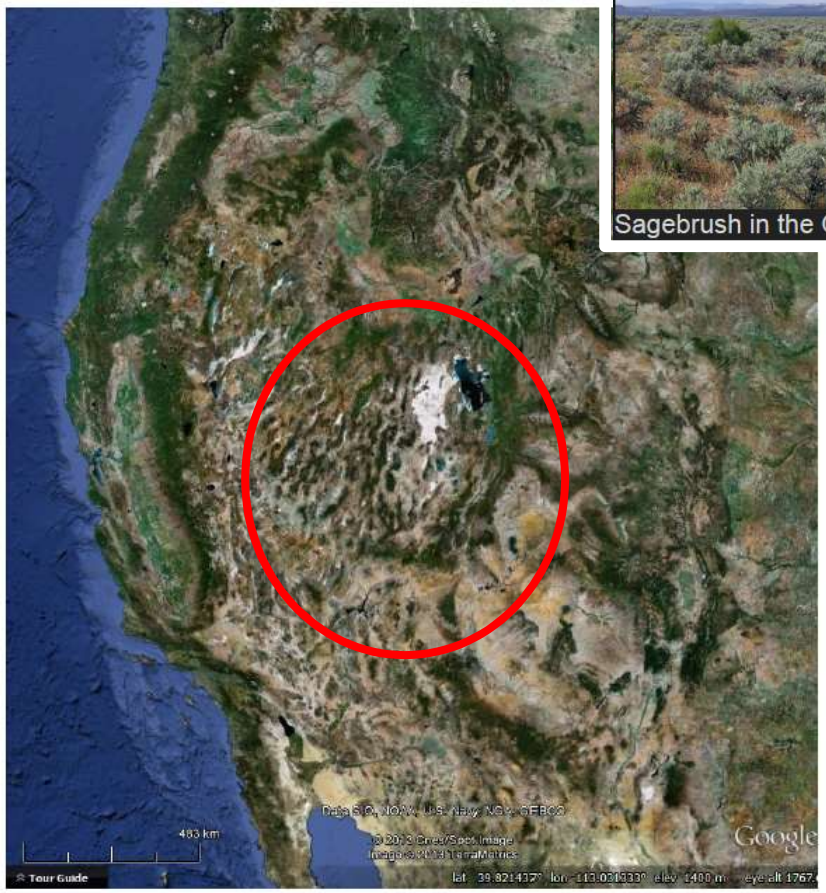
- Deserts are characterized by sparse rainfall and high evaporation.
- Rainfall is unpredictable and often very brief and intense.
- Desert vegetation and animal abundance is therefore minimal

The Tropic of Cancer, also referred to as the Northern tropic, is the circle of latitude on the Earth that marks the most northerly position at which the Sun may appear directly overhead at its zenith. This event occurs once per year, at the time of the June solstice, when the Northern Hemisphere is tilted toward the Sun to its maximum extent. It currently (Year 2013) lies at 23° 26′ 15.143″ north of the Equator

DESERT VEGETATION is typically sparse, widely spaced, and characterized by slow growth rates.

Sonoran Desert, Arizona showing saguaro and cholla cacti, paloverde trees, and jojoba bushes.

GREAT BASIN OF WESTERN NORTH AMERICA is the second largest, mid-latitude, dry-climate zone and results form the *rain-shadow* produced by the Sierra Nevada Mountains.

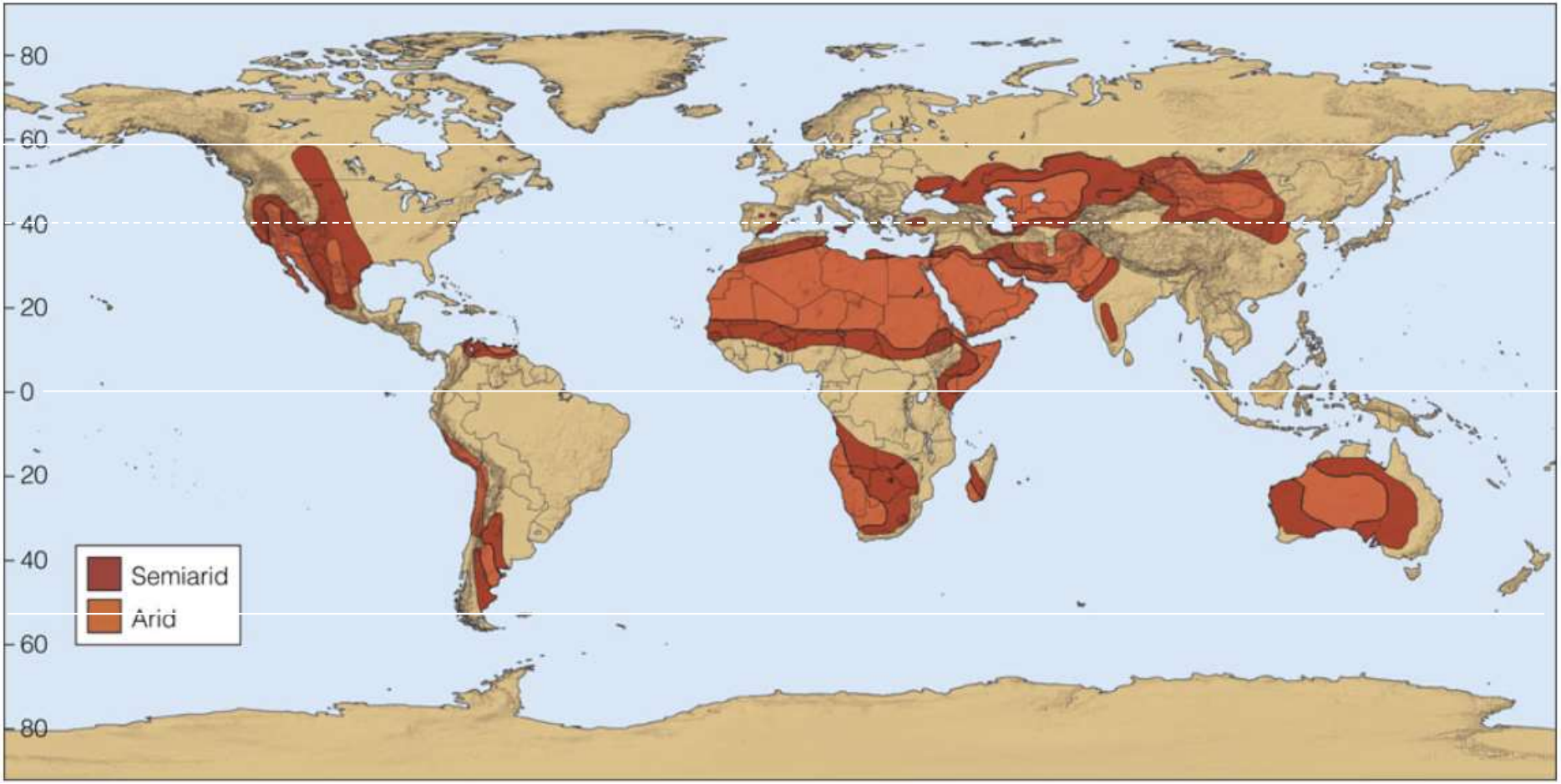


Sources:

PROTEROZOIC PALEOZOIC MESOZOIC CENOZOIC

Arid and semiarid regions form in low and middle latitudes *where potential loss of water by evaporation is greater than that gained by precipitation*.

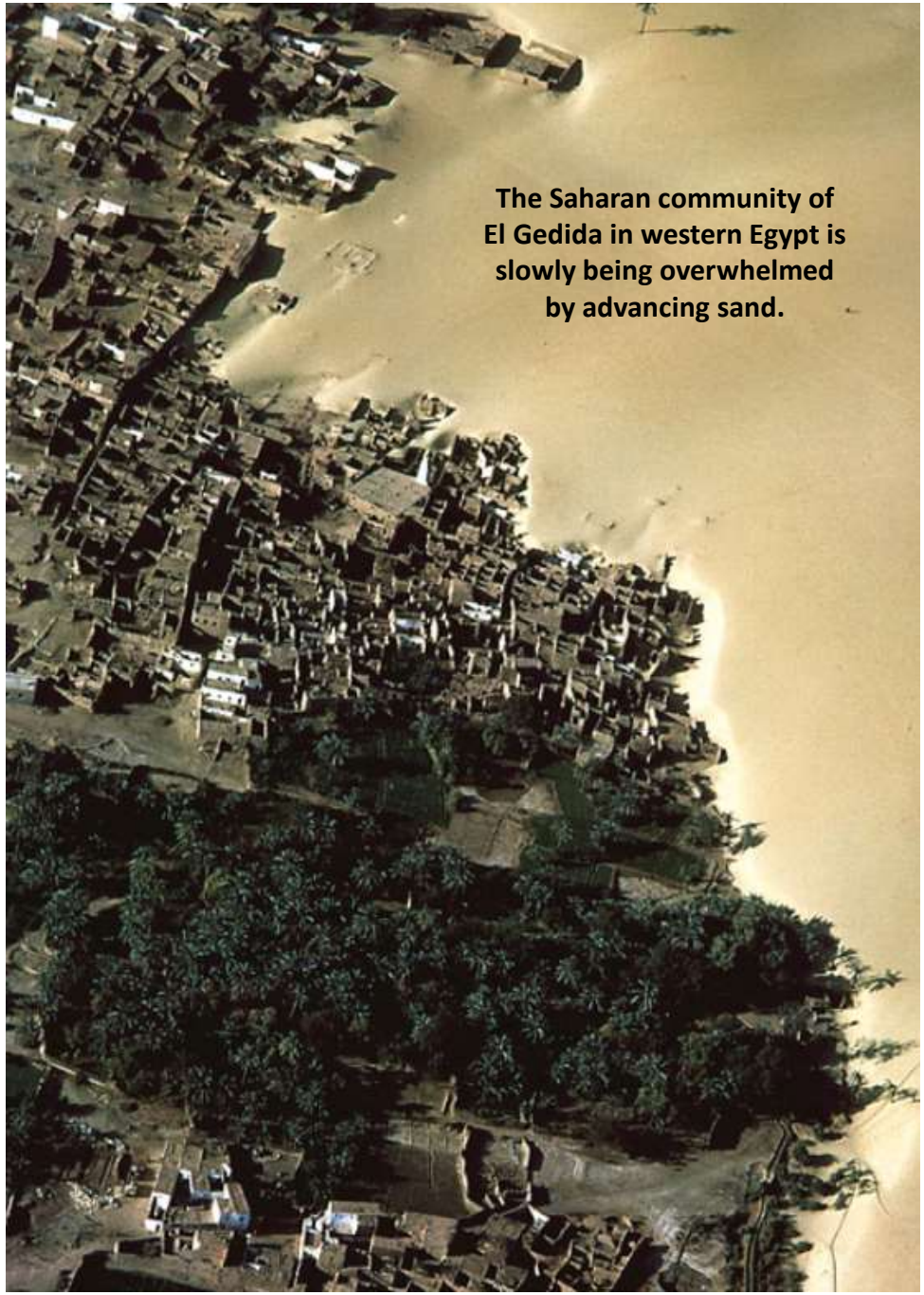
- *These climates include more than 30% of Earth's surface area.*



DESERTIFICATION *is the expansion of deserts into formerly productive lands* and is a major problem in many countries.

- Over the past several decades deserts have expanded at an estimated 70,000 km per year which has exacted a terrible toll in human suffering.
- Most of *these regions lie along desert margins having a delicately balanced ecosystem and in inability to adjust to environmental stresses stemming from both natural and anthropogenic activities*.
- The replacement of natural vegetation with farm crops is a key factors in soil disruption and removal.
- It's a problem that threatens over 250 million people who live in dryland regions covering some 35 million square kilometers in almost 100 countries.

EOS, September 24, 1996.

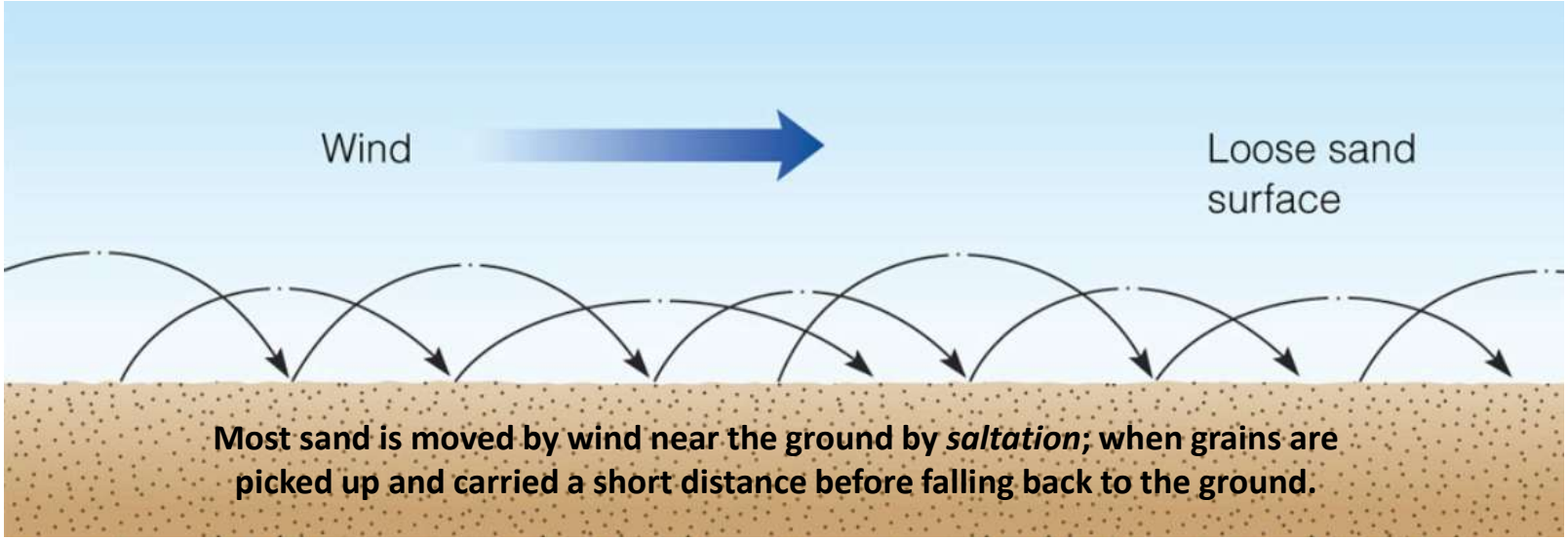


The Saharan community of El Gedida in western Egypt is slowly being overwhelmed by advancing sand.


Rub' Al Khali
Tehran
Nicosia
Cyprus
Syria
Lebanon
Beirut
Damascus
Baghdad
Iraq
Iran
West Bank
Amman
Gaza Strip
Israel
Jordan
Cairo
Gulf of Suez
Kuwait
Kuwait City
Persian Gulf / Arabian Gulf
Persian Gulf
Qeshm Island
Al Manamah
Bahrain
Qatar
Doha
Gulf of Oman
Riyadh
Abu Dhabi
Muscat
United Arab Emirates
Saudi Arabia
Riyadh
Eastern
Oman
Red Sea
Rub' Al Khali Desert
Khartoum
Eritrea
Asmera
Sana'a
Yemen

WIND IS A TURBULENT FLUID and therefore transports sediment in much the same way as running water.

- *Wind transports sediment as suspended load or bed load*.
- Although wind typically flows at higher velocities than water, *it is less dense than water and therefore can carry only clay and silt-sized particles as suspended load*.
- Sand and larger grains are moved along as *bed load*, either by *saltation* or by rolling or sliding along the surface.

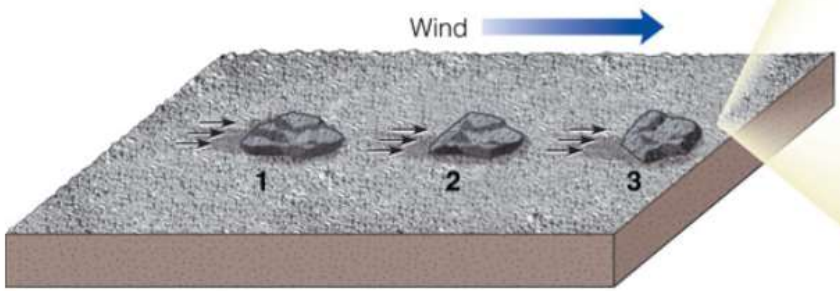


Most sand is moved by wind near the ground by *saltation*; when grains are picked up and carried a short distance before falling back to the ground.

WIND ERODES *through abrasion or deflation*.

- Wind is an erosive agent in deserts, and is a very effective transportation and depositional medium- to fine-grained sediments.
- ***Abrasion*** *is the effect of impacts of saltating grains on the surface of objects*.

- **Ventifacts** are formed by wind-born particles abrading the surface of a rock.



Large ventifacts lying on a desert floor in Death Valley National Monument, California.

- Ventifacts can also form in other environments having wind-born sediment such as beaches and glacial outwash plains

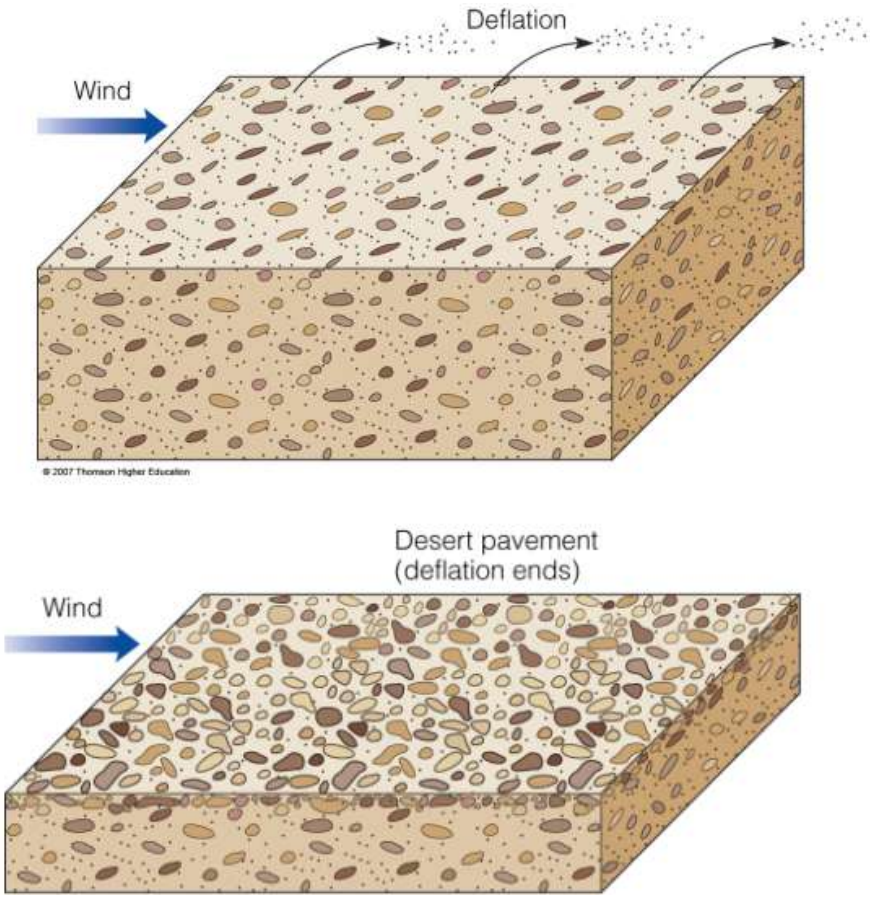
Wind abrasion formed these structures in Egypt by eroding the lower part of the exposed limestone beneath a clastic cap.

Yardangs are larger wind-carved features resembling the bottom of a ship hull. They are larger than ventifacts and typcially found in clusters aligned parallel to the prevailing winds.

DEFLATION is the removal of loose surface material by wind and produces desert pavements and deflation hollows.

Desert Pavement is a hardened mosaic of coarse-grained sediment (coarse-sand, pebbles, and cobbles) left behind by deflation

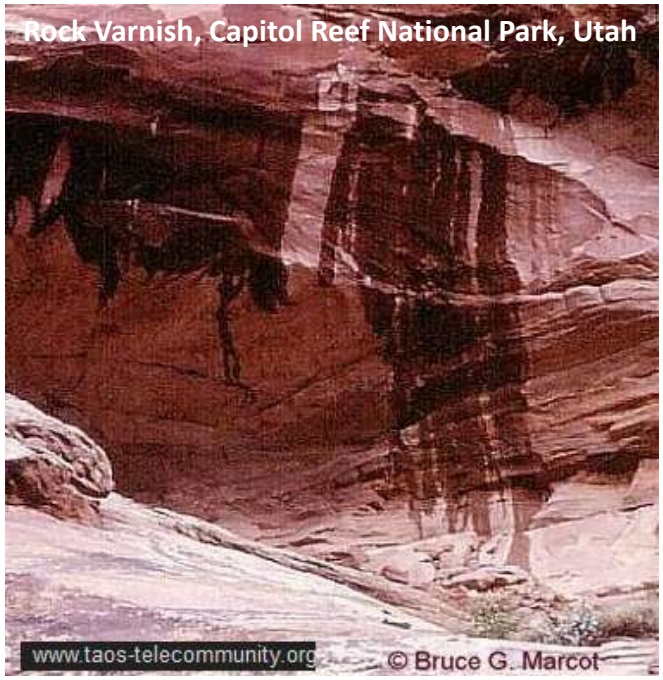
Desert pavement in Mohave desert, California, including many ventifacts



Deflation Hollows are variably-sized shallow depressions in the desert landscape resulting from differential erosion of surface materials by deflation

A deflation hollow located between two sand dunes in Death Valley, California.

ROCK VARNISH is a thin coating of iron and manganese oxides on the surface of many desert rocks



- Due to the scarce rainfall, *the dominant form of weathering in desert climates is mechanical*, including freeze-thaw and frost wedging, *and soils are poorly developed or absent*.
- *Erosion in deserts results primarily from running water*, an erosive agent that was especially important in modifying desert landforms during the periods of pluvial climates in the Pleistocene Epoch.
- Most of the dominant desert features today were formed during the Pleistocene

WIND DEPOSITS *mostly include dunes and loess*

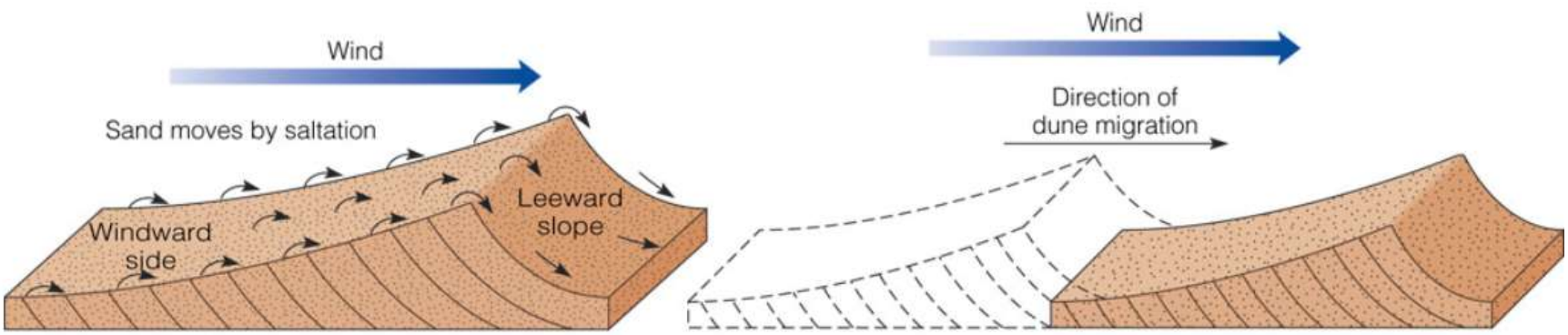
- ***Dunes*** *are the most characteristic feature of sand-covered regions.*

- *They form when wind flows around or over an obstruction, resulting in the deposition of sand grains in mounds or ridges of wind-deposited sand.*

- As they grow, they become self-generating in the way they form ever-large wind barriers that further reduce the winds' velocity, resulting in more deposition and growth.

DUNES *typically have asymmetric profiles with a gentle windward slope and a steeper downwind (leeward) slope that is inclined in the direction of the prevailing wind at the angle of repose for sand (30º-34º)*

- When the angle of repose is exceeded, the slope collapses, and sand falls to rest at its base.



- As sand moves from the windward to leeward slopes, *dunes slowly migrates in the direction of the prevailing wind.*

DUNES TYPES are recognized on the basis of morphology that is *dependant on sand volume, prevailing wind direction, wind velocity, and vegetation cover*.

- **Barchan** – crescent shaped, less than 30 m high, and the most mobile moving at rates that can exceed 10 m per year

- **Longitudinal –** form long ridges parallel to the prevailing wind when the sand supply is limited. Crests below about 100 m.

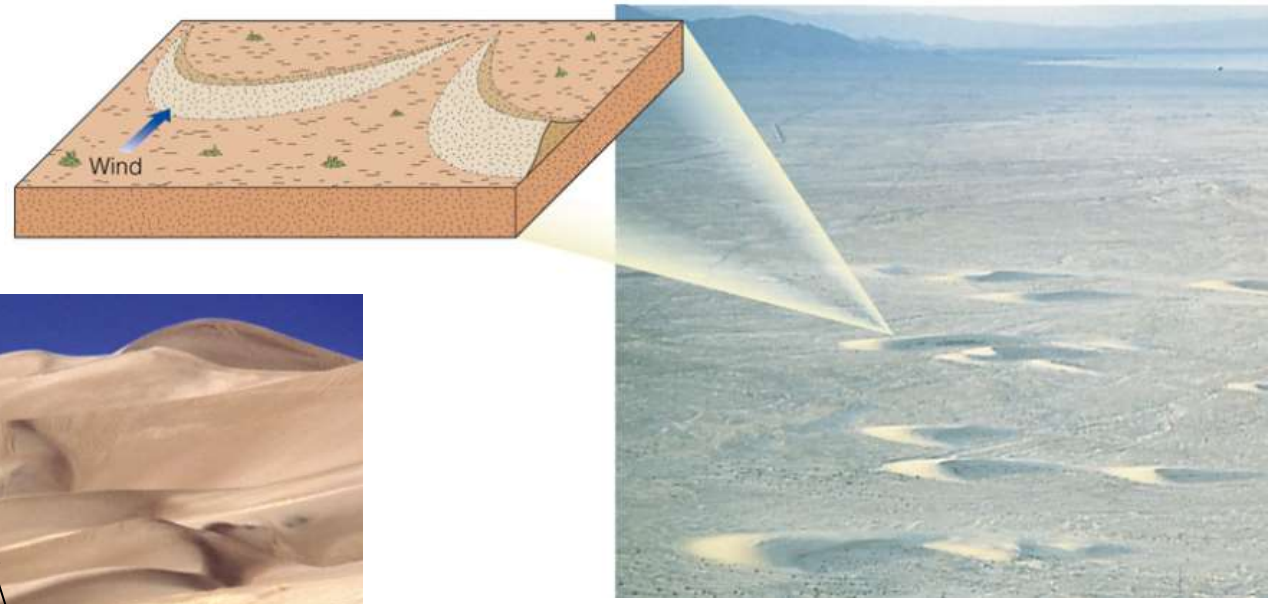
- **Transverse -** form long ridges perpendicular to the prevailing wind in areas with abundant sand and little vegetation with crests > 200m; sometimes called *sand seas*

- **Parabolic –** are most common in coastal areas with abundant sand, strong onshore winds, and a partial vegetative cover abundant; deflation hollow or blowout is common.

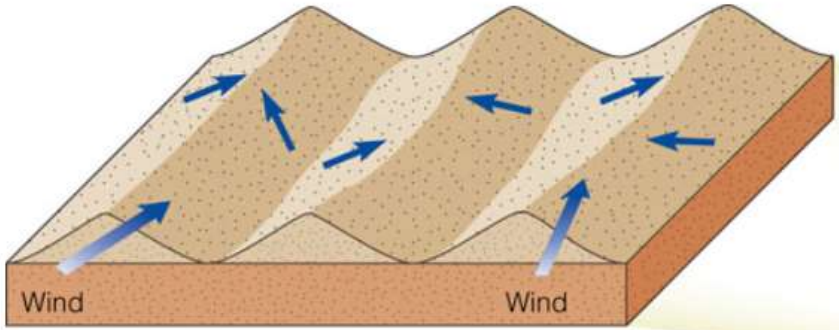
- **Star dunes –** are most common in the Northern African deserts. Among the tallest in the world, they can rise more than 100 m above the surrounding desert plain.

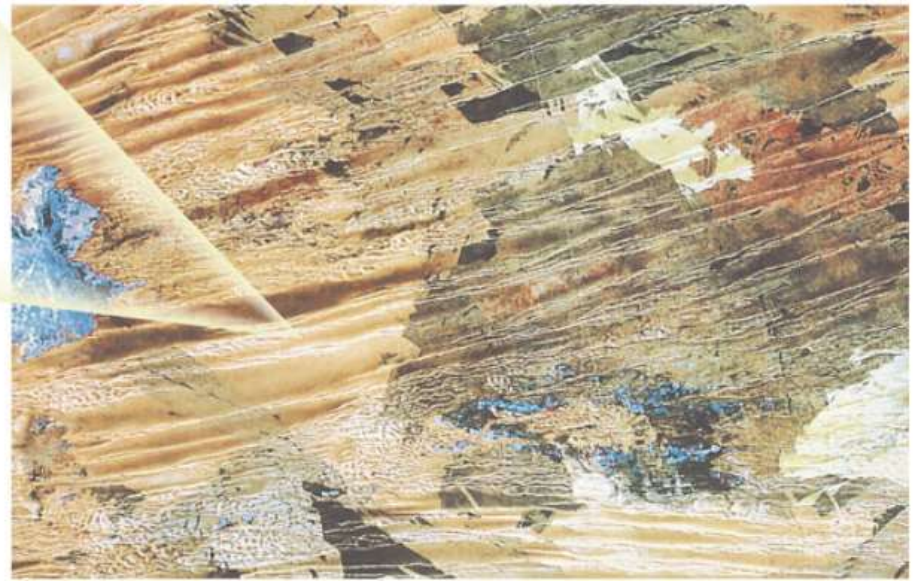
Barchan Dunes are crescent shaped, less than 30 m high, and the most mobile moving at rates that can exceed 10 m per year

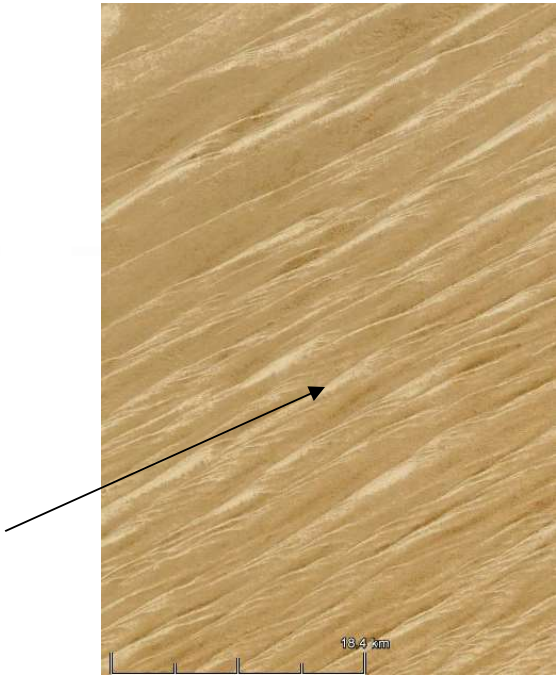
- Form in areas with consistent wind directions, limited sand, and a flat dry surface with little vegetation



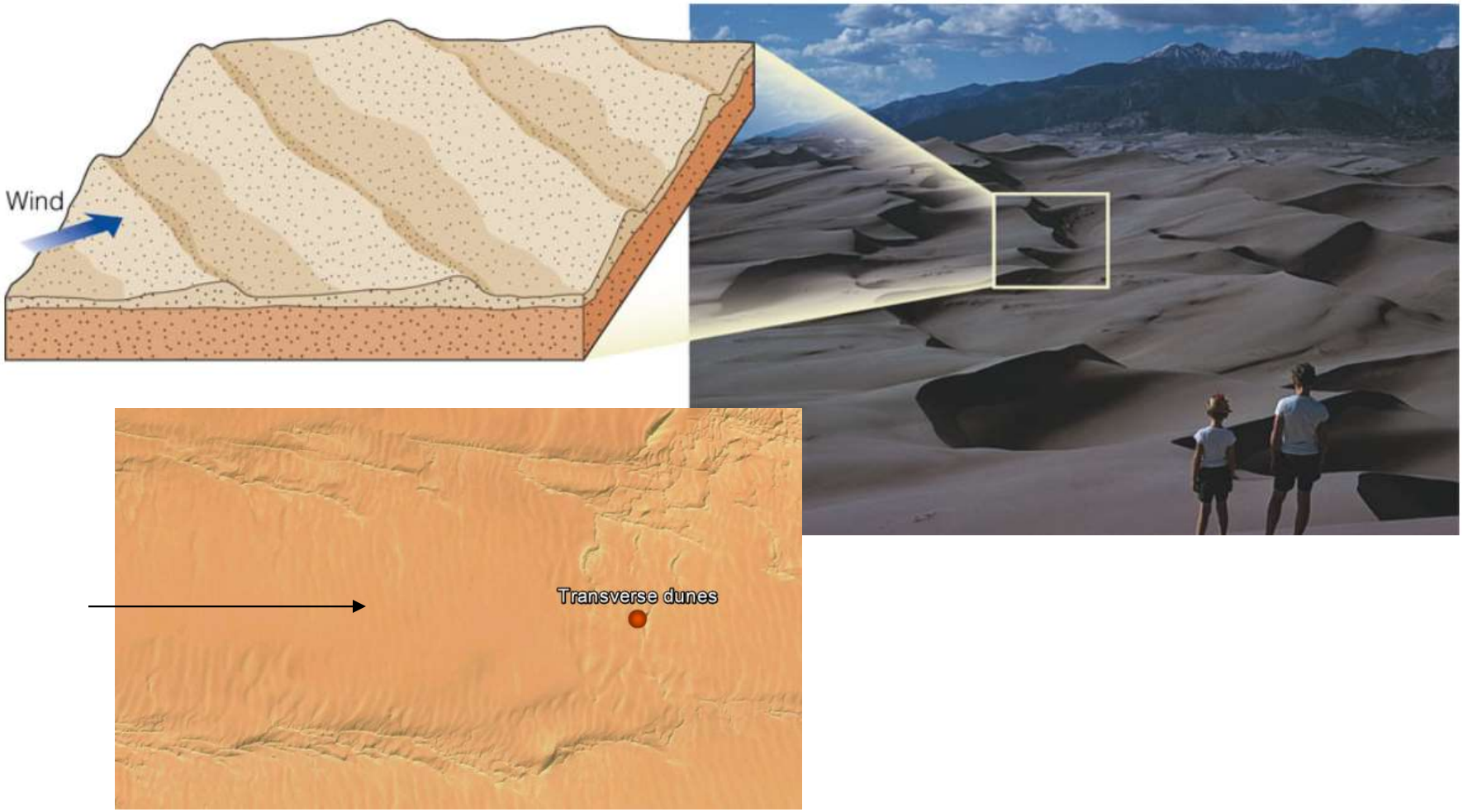
Longitudinal Dunes form long ridges parallel to the prevailing wind when the sand supply is limited. Crests below about 100 m.



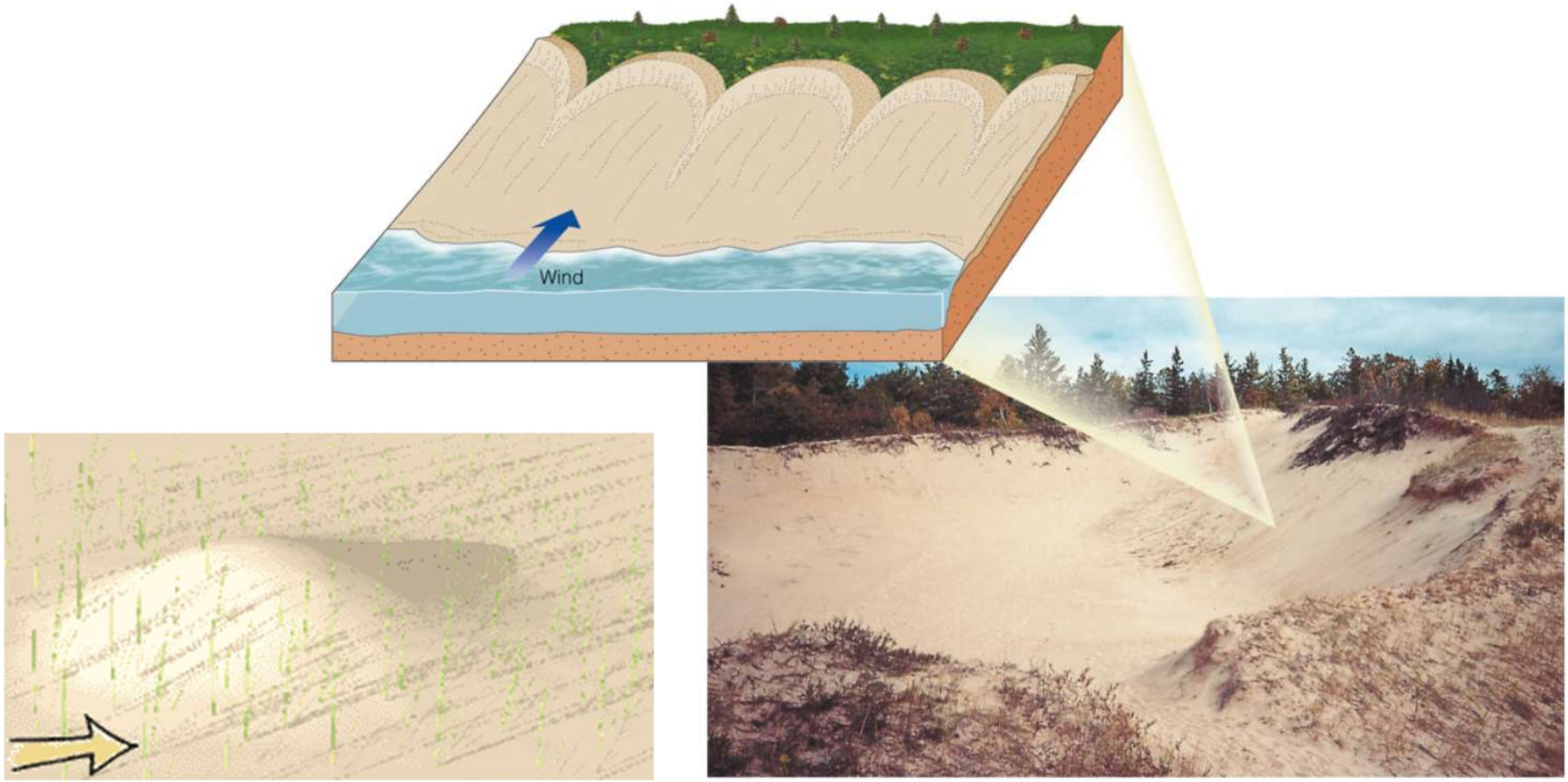




Transverse Dunes form long ridges perpendicular to the prevailing wind in areas with abundant sand and little vegetation with crests > 200m; sometimes called *sand seas*



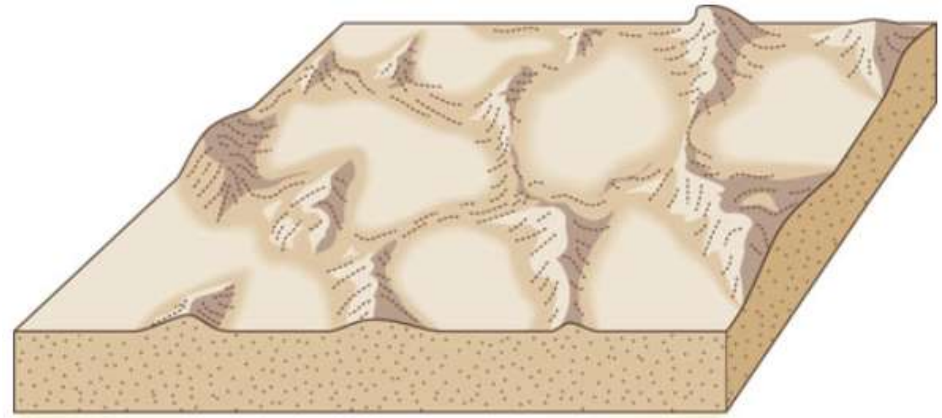
Parabolic – are most common in coastal areas with abundant sand, strong onshore winds, and a partial vegetative cover abundant; deflation hollow or blowout is common.

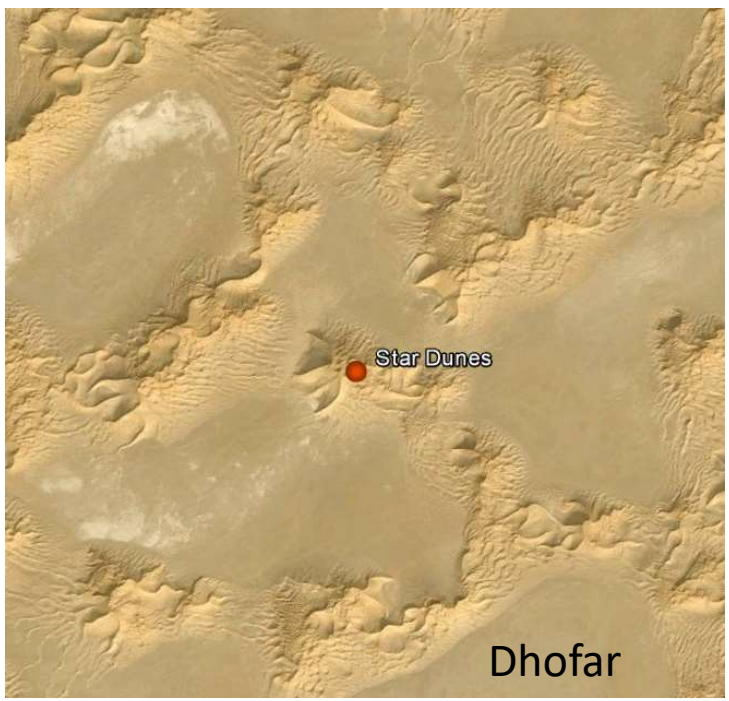


Animation showing the formation of a parabolic dune. NPS/David Zelenka

Star dunes – are most common in the Northern African deserts.

•Among the tallest in the world, they can rise more than 100 m above the surrounding desert plain.





LOESS is wind-deposited silt and clay-sized sediment including grains of quartz, feldspar, mica, and calcite

- Originates from deserts, glacial outwash deposits, and river floodplain deposits in semiarid regions.
- Loess weathers to become rich, productive soil and covers about 10% of Earth's land surface., and about 30% of the United States
- Thickest deposits found in China locally > 30 m

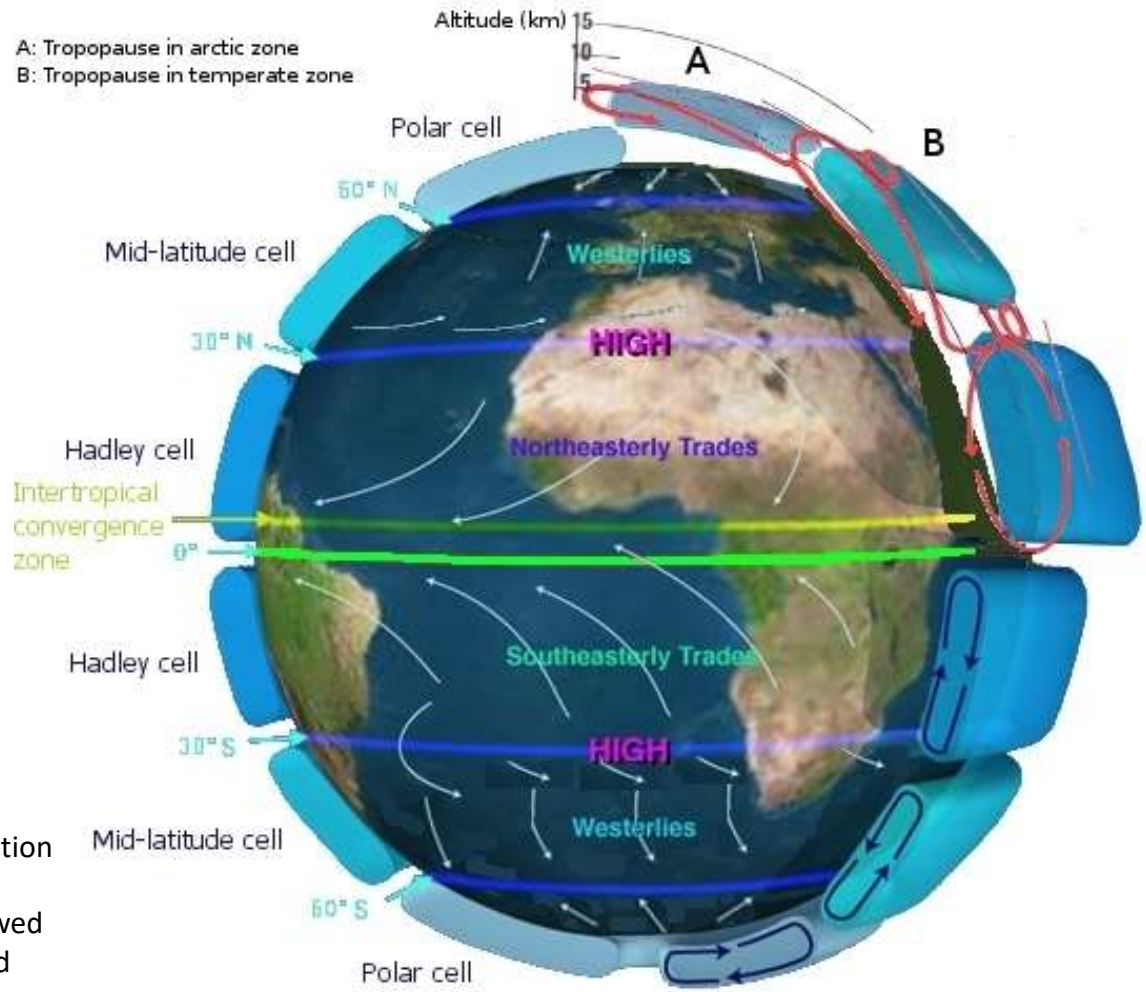
Terraced wheat fields in the Loess soil at Tanga Village, China

AIR PRESSURE AND TEMPERATURE

- ***Air pressure*** *is the density of air exerted on its surroundings (that is, its weight).*
- When *air is heated, it expands and rises, reducing its mass for a given volume and causing a decrease in air pressure*.
- Conversely when *air is cooled, it contracts and air pressure increases*.
- Therefore, those area on Earth surface that receive the most solar radiation, such as the ***equatorial regions, have low pressure, whereas the colder regions have the high air pressure.***
- To understand the work of wind and the distribution of deserts, we need to consider the global pattern of air-pressure belts and winds, which are responsible for Earth's atmospheric circulation patterns.

AIR-PRESSURE BELTS AND WIND PATTERNS

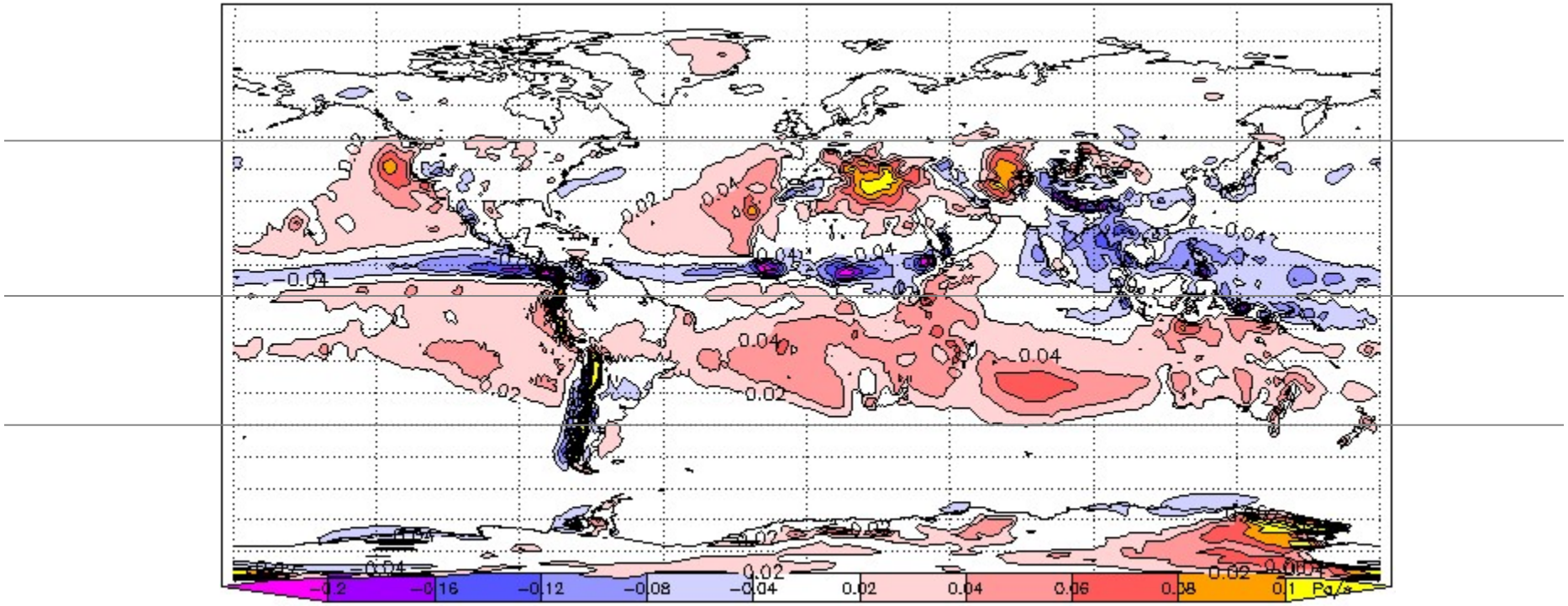
- The east-west winds of the major air pressure belts result from heating and rising of warm air masses (low pressure belts), and descent and warming of cool air masses (high pressure belts).
- These pressure belts influence the global climate, including the distribution of deserts.
- *Prevailing wind directions in these belts are deflected from east-west courses to either the right or left by the Coriolis effect*[1].



[1]The Coriolis effect is a deflection of the flow direction and flow-lag of non-rigid material due to friction between a solid and a nonsolid material when viewed in a rotating reference frame (e.g., atmosphere and oceans experience the Coriolis effect when moving over Earth's surface).

AIR-PRESSURE BELTS AND WIND PATTERNS

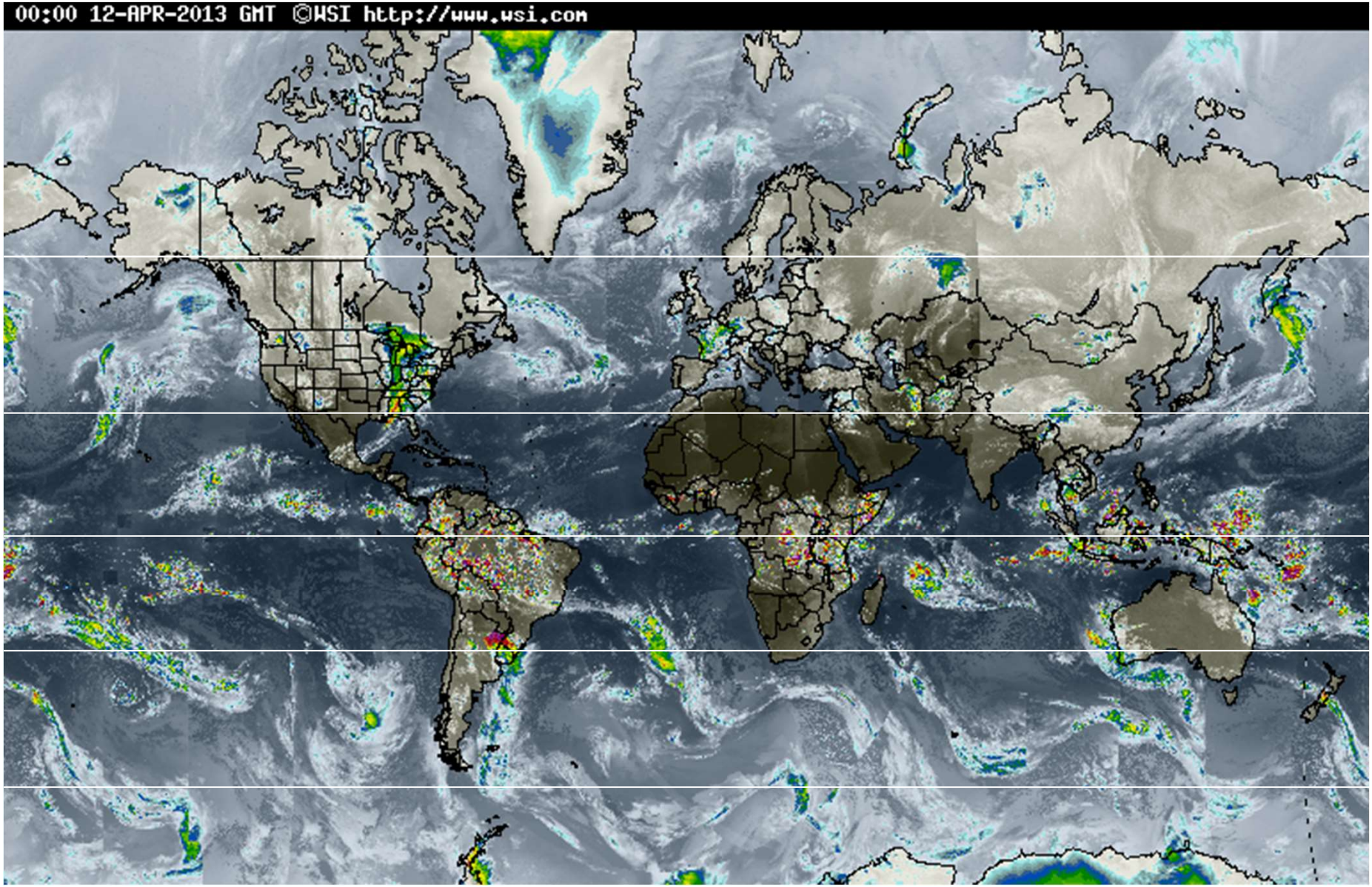
• The dry climate of arid and semi-arid regions result from the descent of dry air masses within the high pressure belts.



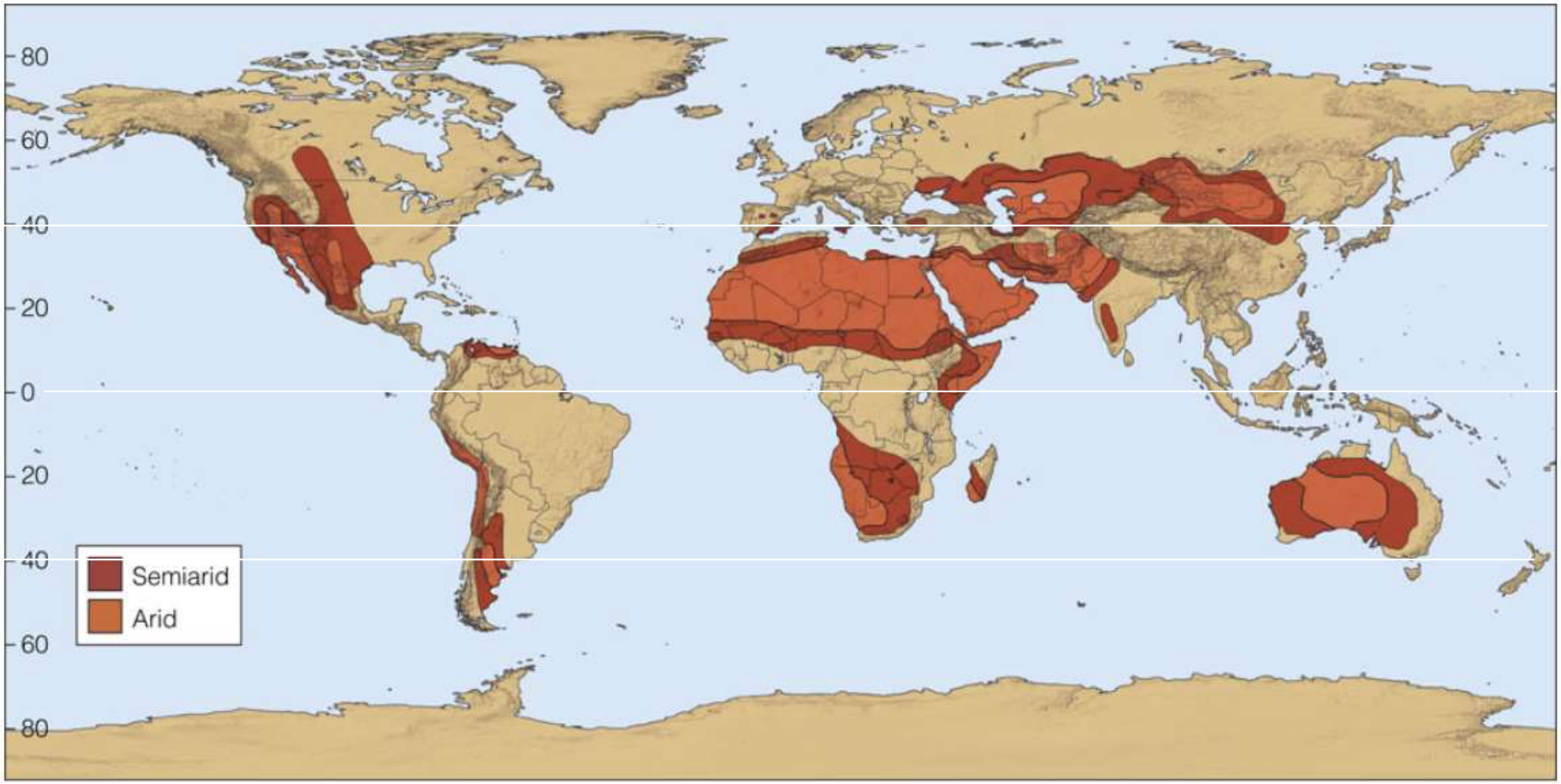
Vertical velocity at a specific atmospheric elevation (500 hPa), July average. Ascent (negative values) is concentrated close to the solar equator; descent (positive values) is more diffuse but also occurs mainly in the Hadley cell.

http://en.wikipedia.org/wiki/Atmospheric_circulation

EARTH'S ATMOSPHERIC CIRCULATION



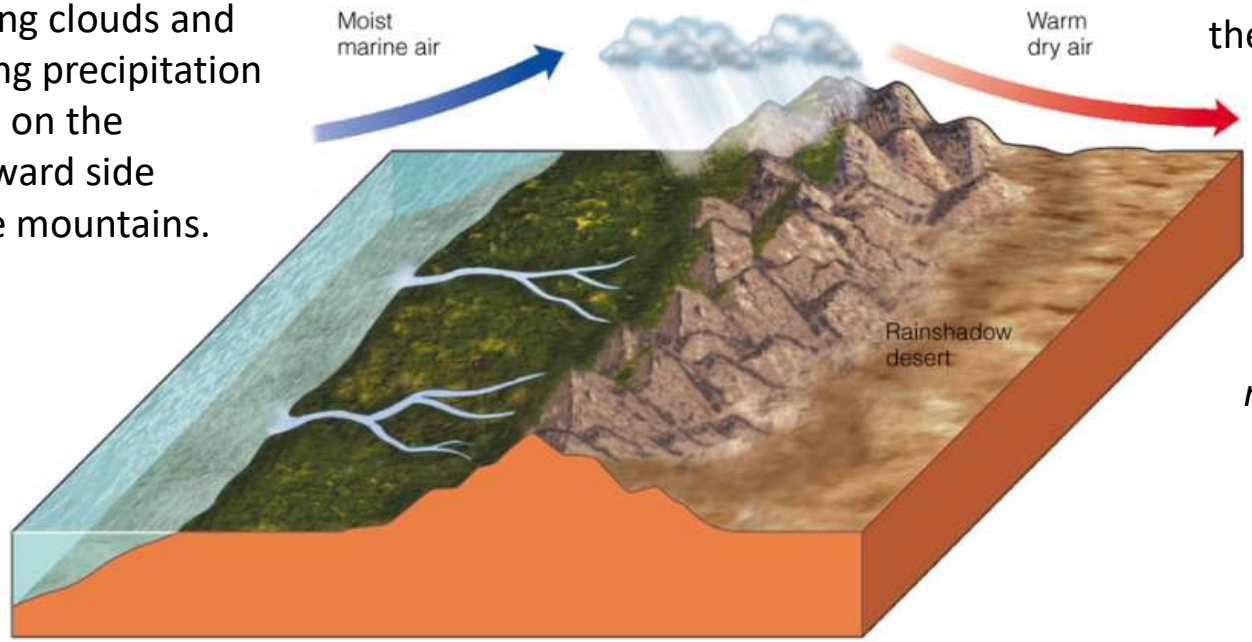
EARTH DESERTS mostly lie within dry regions located between 50° N to 50° S of the equator.



RAIN-SHADOW EFFECT

• The remaining deserts in mid- and polar latitudes result from the *rainshadow effect*, when moist marine air moves inland and meets a mountain range where it is forced upward.

• As it rises, it cools, forming clouds and causing precipitation to fall on the windward side of the mountains.



•The air descending on the leeward mountain side is much warmer and drier, producing the semi-arid conditions, and locally, *rainshadow deserts*.

POLAR DESERTS in mid- and polar latitudes result from descent of dry air within the high pressure caps of polar regions, respectively.

Geography:

Polar desert

This article has been reviewed by the following Topic Editor: Mark McGinley

Published: November 30, 2011, 12:00 am

Updated: December 5, 2011, 2:37 pm

Lead Author: C Michael Hogan

Expansive Svalbard Arctic landscape, northern Norway. Source: Hannes Grobe

A **polar desert** is a biome with precipitation below 250 millimeters per annum and a mean temperature during the warmest month of less than 10 degrees Celsius. Typically occurring at higher latitudes than tundra biomes, polar deserts occupy approximately 5,000,000 square kilometers of land surface, chiefly comprised of exposed bedrock, talus or rocky plains. In the northern hemisphere this biome is often termed the High Arctic. The soils regime of the polar desert is generally characterized by occurrence of permafrost. Remarkably, the reddish soils of much of the Antarctic montane region suggest that the McMurdo Dry Valleys are a relict of an earlier, much warmer climate.

In the paleoclimate view of Earth, Polar deserts were much more common during previous Ice ages in areal extent than at present, not only because of the expansive cold regime, but also because of the prevailing aridity common to Ice age environments.

DRY-CLIMATE SUMMARY

$F = (9/5 \times C) + 32$

- *Dry climates cover 30% of Earth's land surface and are subdivided into semiarid and arid regions.*

- *Semiarid regions receive more precipitation that arid regions, yet they are moderately dry.*

- *Arid regions, generally described as deserts, receive less than 25 cm (~10") of rain per year, have high evaporation rates, poor soils, and sparse to no vegetation.*

- *The majority of the world's deserts are in the dry climate belts of low and middle latitudes.*

- *The remaining ones at middle and high latitudes are found mostly in the continental interiors in the Northern Hemisphere.*

- Summer desert temperatures range from about 32° - 38° C, but 10° – 18° in winter.

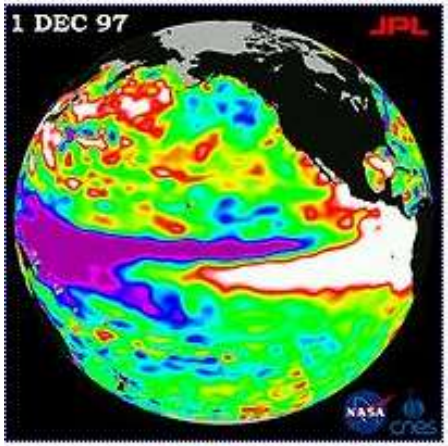
- The highest desert temperature recorded in Libya was 58° C (136° F)

El Niño / La Niña Southern Oscillation is a band of anomalously warm ocean water temperatures that occasionally develops off the western coast of South America and can cause climatic changes across the Pacific Ocean.

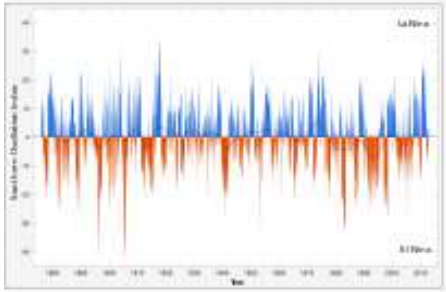
- The 'Southern Oscillation' refers to variations in the temperature of the surface of the tropical eastern Pacific Ocean (warming and cooling known as El Niño and La Niña, respectively) and in air surface pressure in the tropical western Pacific.

- The two variations are coupled: the warm oceanic phase, El Niño, accompanies high air surface pressure in the western Pacific, while the cold phase, La Niña, accompanies low air surface pressure in the western Pacific.

- Mechanisms that cause the oscillation remain under study.



The 1997 El Niño observed by TOPEX/Poseidon. The white areas off the tropical coasts of South and North America indicate the pool of warm water[1]



Southern Oscillation Index timeseries 1876-2011.

El Niño and Climate and Crop Prediction

• *Advances in theory, observations, and modeling enable climatologists to predict the onset of El Niño up to 1-1/2 years in advance with reasonable skill.*

• Tropical countries severely affected by El Niño benefit most from these forecasts, and countries like Brazil and Peru already use them to prepare for climate-related emergencies, adjusting water use or crop plans.

• So far, *similar predictions are not yet possible for many mid-latitude countries, including most of the united States.*

EOS, February 22, 1994.

• Researchers have also found an "astonishing" link between the periodic shifts of El Niño and the maize crop yield in southern Zimbabwe in southern Africa.

• Forecasts will be made for future years, hopefully warning of pending dangerous fluctuations.

• In addition, it is possible that the model may be used to predict crop yields in other parts of the world, since El Niño affects the climate of more than half the planet.

EOS, July 26, 1994.

DESERT LANDFORMS include dry lake beds (playas), playa lakes, alluvial fans (fan-shaped deposits of coarse, poorly sorted sediment) and bajadas (coalesced alluvial fans)

Bonneville Salt Flats is a densely-packed salt pan in northwestern Utah. The area is a remnant of the Pleistocene Lake Bonneville and is the largest of many salt flats located west of the Great Salt Lake

A playa lake formed after a rainstorm in the Mojave Desert, California.

- **Playa lakes** are *ephemeral*, meaning short-lived, or lasting a few hours to several months.

- The bed of playa lake is ***salt pan.***

SALT PANS a flat expanse of ground covered with salt and other minerals, usually found in deserts

Race track playa, Death Valley, California

A playa lake formed after a rainstorm in the Mojave Desert, California.

DESERT LANDFORMS

- **Alluvial fans** are fan-shaped deposits of coarse, poorly sorted sediment

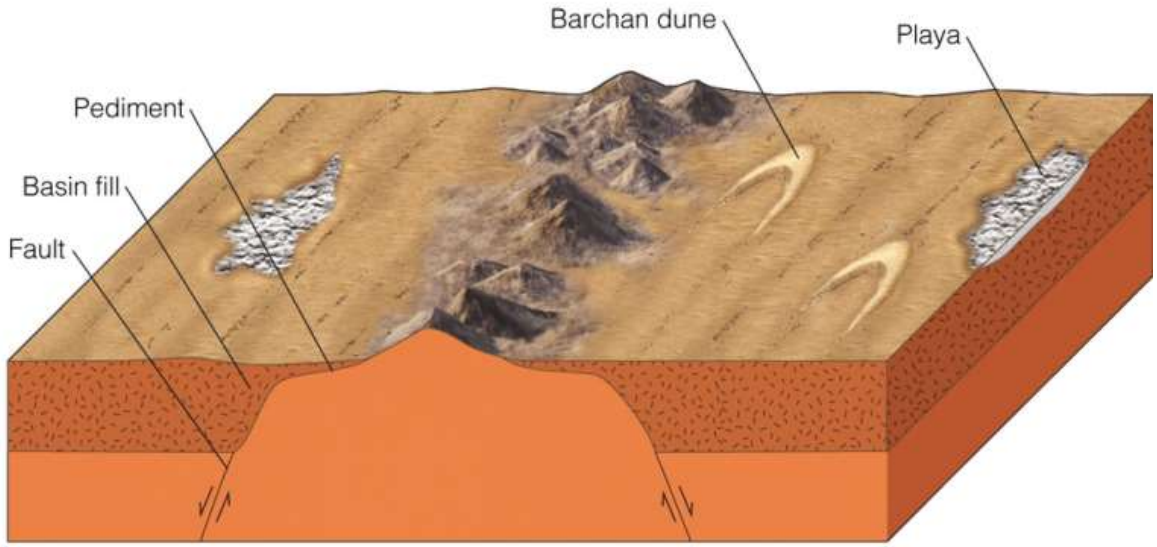
- **Bajadas** are coalesced alluvial fans

A playa lake formed after a rainstorm in the Mojave Desert, California.

PEDIMENTS *are erosional bedrock surfaces of low relief that slope gently away from mountain bases*

- Most are covered by a thin layer of debris, alluvial fans, or bajadas.

- Pediment origins are controversial, but most probably result from a combination of lateral erosion by streams, sheet flooding and mechanical weathering.



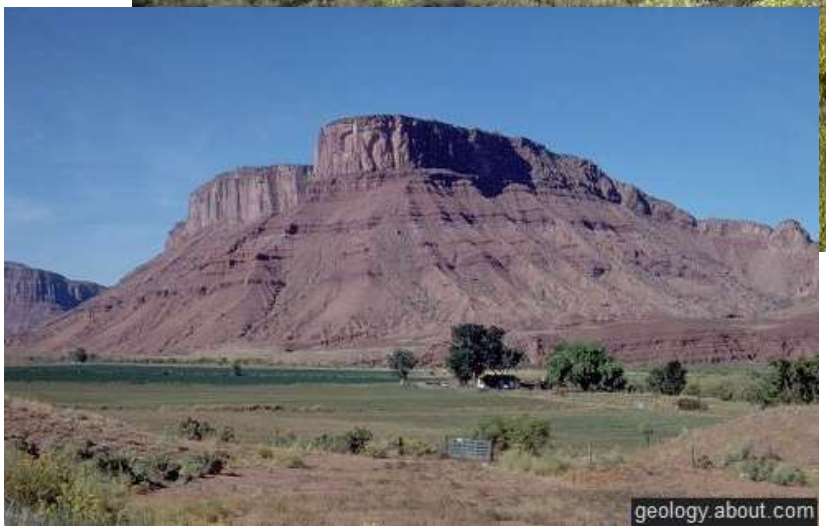
A pediment north of Mesquite, Nevada

INSELBERGS are isolated and steep-sided erosional remnants that rise above desert plains.

Murphy's Haystacks, Australia

Mountain Island' in 'Valley of the Gods, Utah, USA

MESAS are broad, flat-topped erosional remants



Northern Utah mesas

BUTTES are isolated, pillar-like structures

Utah

Monument Valley Navajo Tribal Park, Utah

DESERT MISCONCEPTIONS AND FACTS

Misconception: Deserts are always hot.

Fact: Desert temperatures can be extremely hot, in the day, during the summer.

At night temperatures drop, and in the winter may get down below 0°C.
Temperatures during a 24-hour period can fluctuate as much as 40° C (~ 100° F)

Misconception: Deserts are always giant seas of sand.

Fact: Sand only covers approximately 25% of the world's deserts.

Misconception: Deserts are lifeless.

Fact: Although life is less abundant than in more humid areas, it is usually present.

- Even in Death Valley, for example, more than 600 species of plants have been identified.

DESERT MISCONCEPTIONS AND FACTS

Misconception: Any desert can be farmed, and made to "bloom" if only given enough water.

Fact: Besides lacking water, the region may also lack appropriate soil.

• The soils typical of deserts, frequently containing caliche deposits, are not good for farming.