EOLIAN PROCESSES & LANDFORMS

Wind can be an effective geomorphic agent under conditions of sparse vegetation & abundant unconsolidated sediment – egs. hot & cold deserts, beaches & coastal regions, glacial & periglacial areas

Deserts

< 25 cm mean annual precipitation

high evaporation rates (up to 15-20 X the precipitation)

mechanical weathering predominates

Resisting vs driving forces determine the wind's effectiveness

Resisting: vegetation
particle size (desert pavement)
cementation

Driving: wind → caused by pressure differentials associated with global circulation patterns or local thermal differences
direction (controls dunes)
velocity (determines competence)
degree of turbulence (affects entrainment & dune shape)

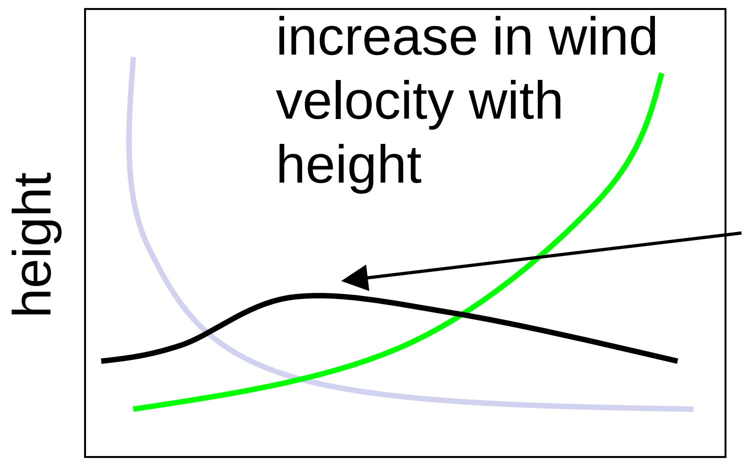
desert pavement, southwestern AZ

EROSION

Particles on the surface start to move when the wind reaches critical drag velocity

Entrainment is a function of

- particle size
- wind velocity
- soil moisture/cohesion
- packing
- surface roughness (vegetation)

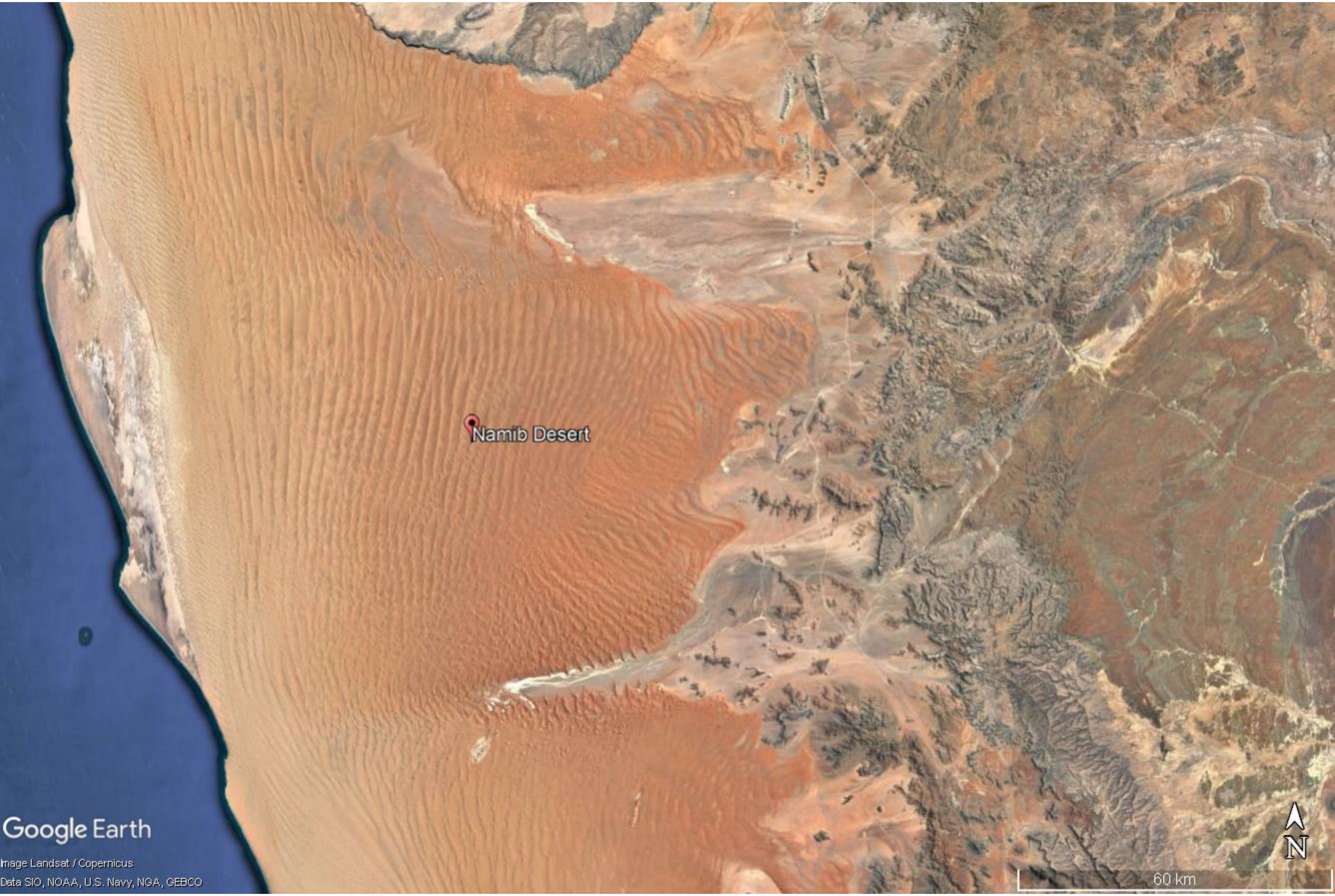


Grains > 0.84 mm seldom move by wind (except in Wyoming)

Sand is composed mostly of quartz because this is the mineral most resistant to chemical weathering, & because quartz forms the proper-sized grains in many granitic rocks – sand is a term for size, & sand can be composed of shells, gypsum, volcanic glass, clay pellets, or basalt fragments

Sand often occurs in relatively large amounts in localized areas because sand prefers to remain on sand – energy is absorbed on landing & the smooth surface prevents the turbulence that kicks sand up

Saltating grains kick up other grains


Namib Desert
Google Earth
Image Landsat / Copernicus
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
N
60 km

Erosional Landforms

abrasion: grinding; most effective for soft rocks blasted by hard sand; $\leq$ 2 m of ground

- ventifacts: faceted stones perpendicular to the prevailing wind
- yardang: elongate ridges 10-30 m high parallel to prevailing wind on outcrop
- grooves: parallel furrows in bedrock at various scales

deflation: removal

- pans: deflated basins up to hundreds of km^2
- deflation hollows: smaller
- blow-out: scoop-shaped hollows

blowouts southeast of Ft. Collins


yardangs
Lut Desert
Shahdad
Sirch
© 2017 Google
Image Landsat / Copernicus
Google Earth
30°22'21.80" N 58°29'02.75" E elev 735 ft eye alt 98.55 mi

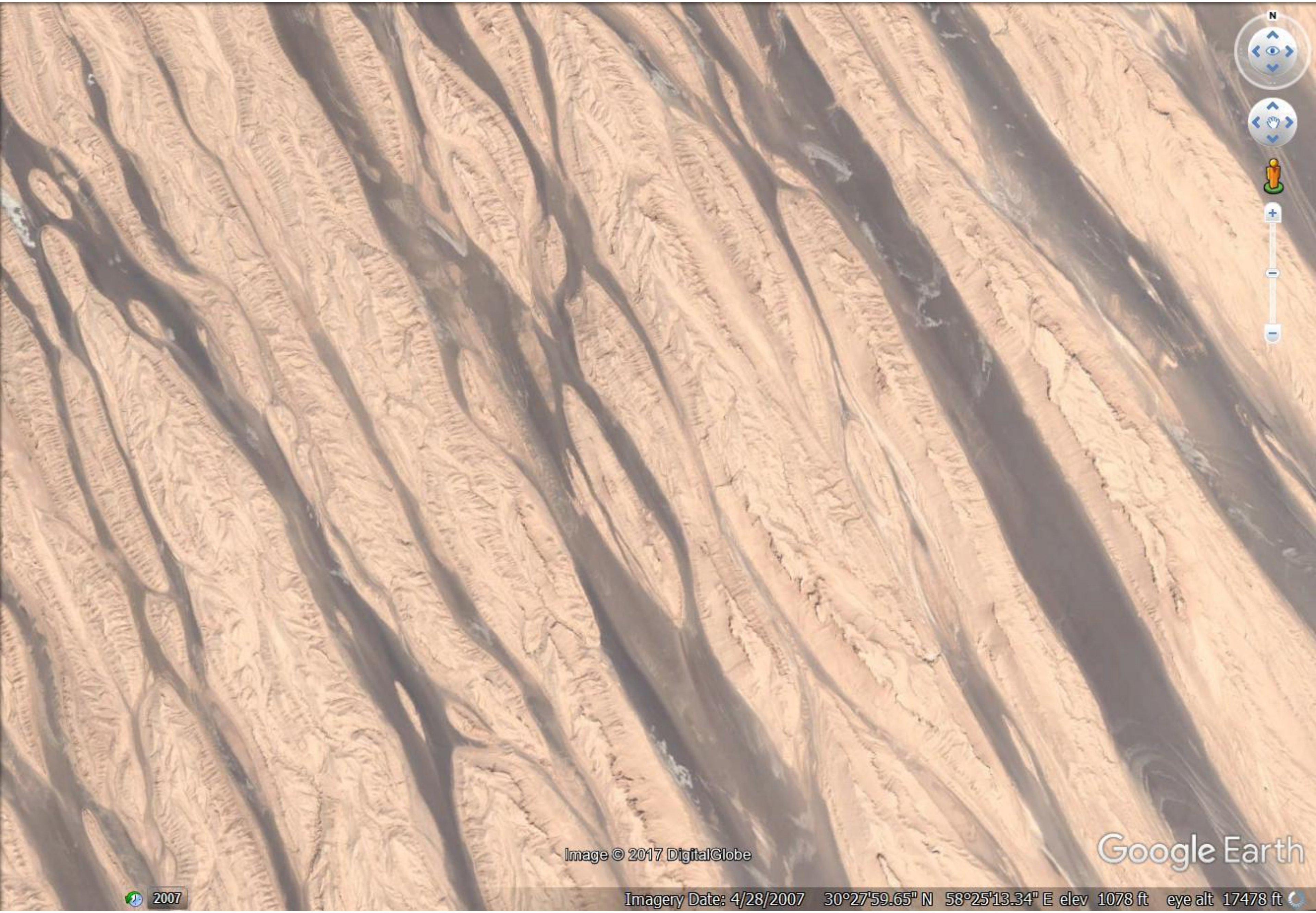

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Image © 2017 DigitalGlobe
Google Earth
2007
Imagery Date: 4/28/2007 30°27'59.65" N 58°25'13.34" E elev 1078 ft eye alt 17478 ft

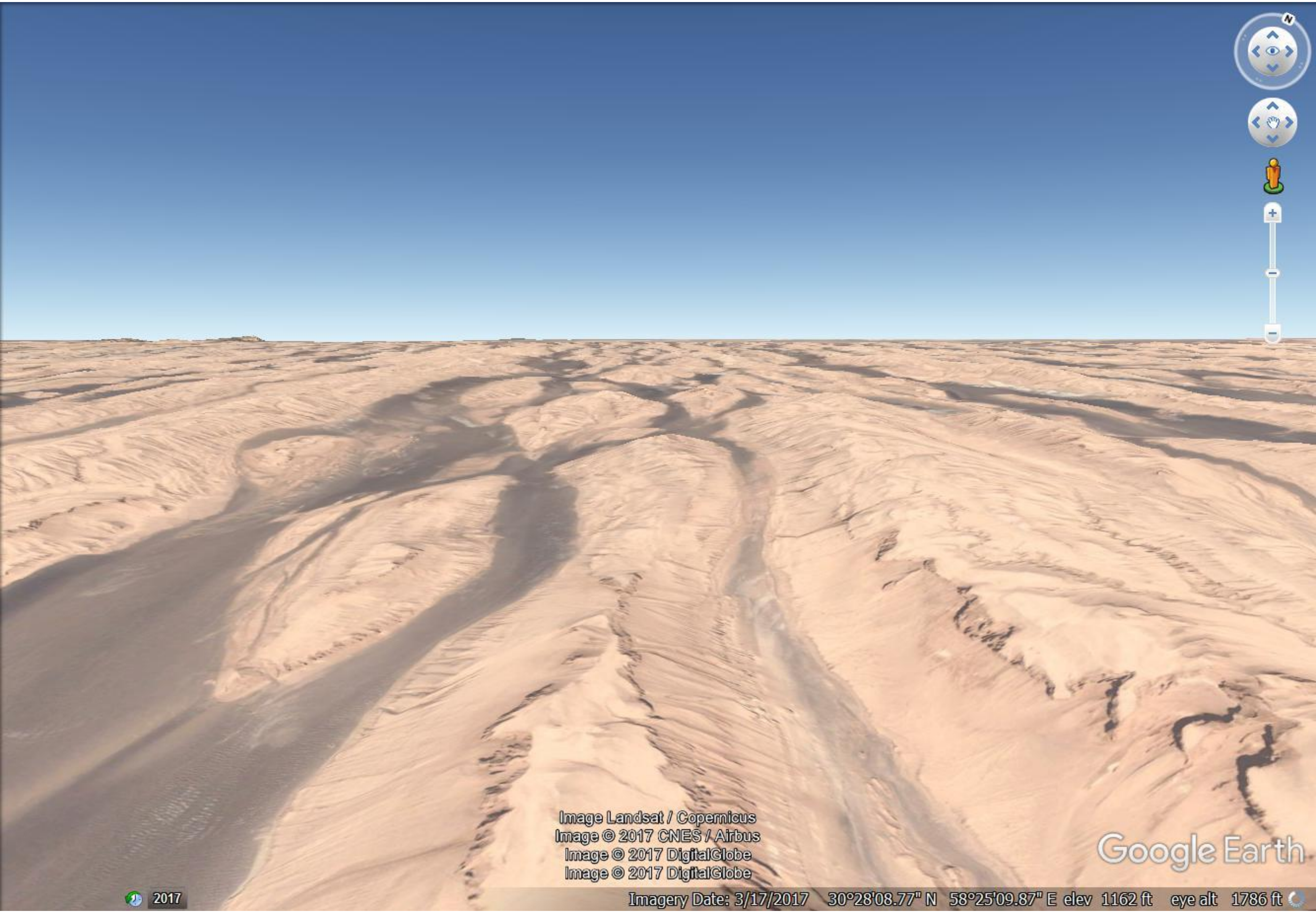


Image Landsat / Copernicus
Image © 2017 CNES / Airbus
Image © 2017 DigitalGlobe
Image © 2017 DigitalGlobe
Google Earth
2017
Imagery Date: 3/17/2017 30°28'08.77" N 58°25'09.87" E elev 1162 ft eye alt 1786 ft

ventifact, India

ventifact, Death Valley, CA

Transportation

depends on size   silts & clays = suspended
fine & medium sands = saltation
coarse sands = surface creep (rolling, sliding)

Most eolian features are made of sand because silt/clay is harder to entrain & to deposit in one place

After entrainment, saltating sand exerts extra drag, & silt/clay change the viscosity of the air

Deposits

tiny ripples (cm high)

→ dunes (up to 100 m high)

→ draa (20-450 m high)

↓ increasing size

ripples: 0.01-100 cm amplitude, up to 20 m apart, dimensions are a function of

- wind velocity
- particle size
- type of ripple

ripples superimposed on barchan dune, southern CA

Namibia

dunes: usually 3-100 m high

occur in groups with regular spacing

form wherever local conditions favor sand deposition (eg., topographic irregularity)

balance between volumes of erosion & deposition maintained through adjustment of backslope & slip face angles, which are also controlled by particle size & velocity gradients

Dunes advance in tractor-tread fashion: Haynes story (1980 discovery of 1930 Bagnold camp – average rate of 7.5 m/yr movement for barchan dune 233 m long, 321 m wide, & 21 m tall)

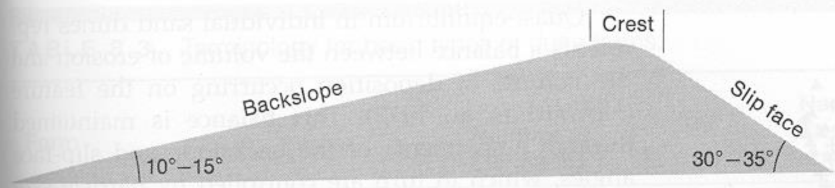


FIGURE 8.12
Cross-profile of normal dune showing common geomorphic components.

Structure: foreset beds, on leeward side, at or near angle of repose

backset beds, on windward side, at shallow angles

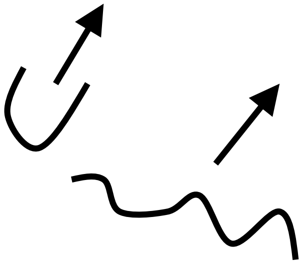
Avalanche sand: loose, on foreset side

Accretion sand: smooth & firm, on backset side

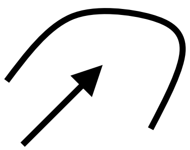
avalanche sand, Oregon coast

Dunes are classified by plan-view shape, or dune pattern:

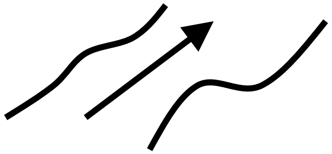
1) Transverse – perpendicular to prevailing wind
    barchan – limited sand, constant wind
    transverse – abundant sand, constant wind



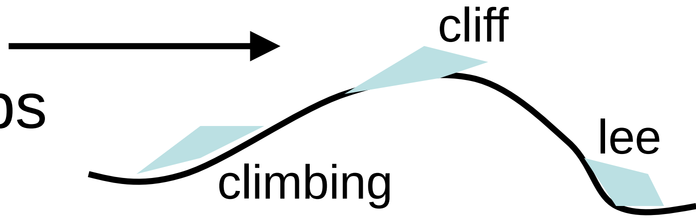
2) Parabolic – perpendicular to wind, arms fixed by vegetation
    blowout – scoop-shaped hollow providing sand



3) Longitudinal – parallel to wind, spacing controlled by
    large-scale wind vortices
    seif

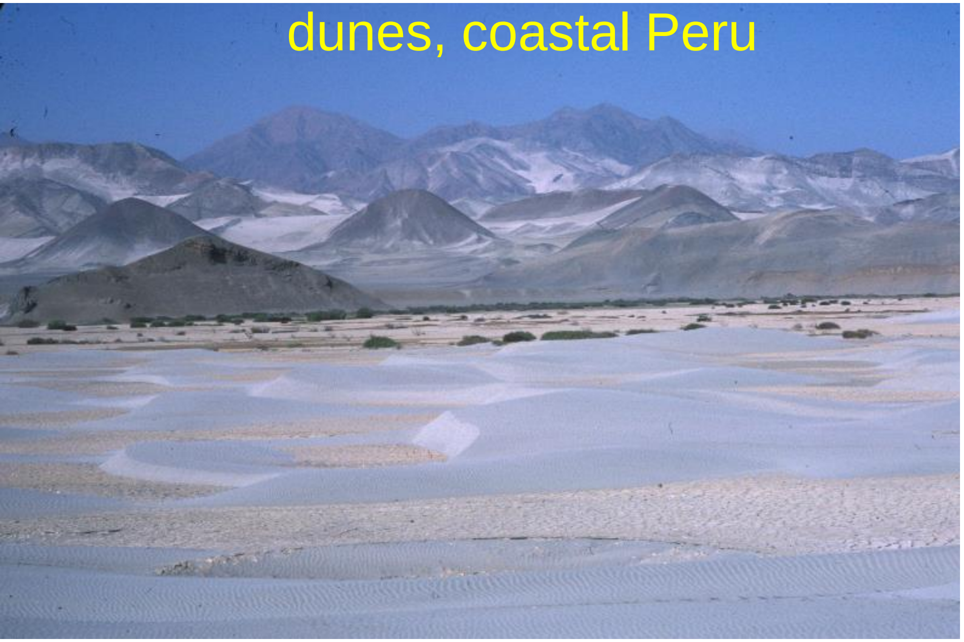


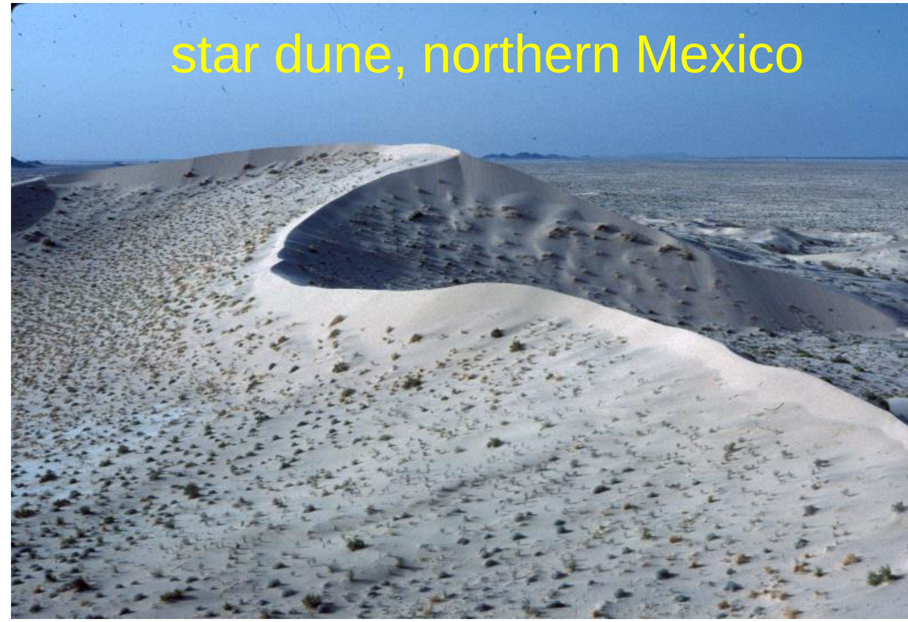
4) Others –
    coppice – fixed by vegetation clumps
    star – alternating wind directions
    cliff, climbing, lee – named with respect to position with other features



barchan dunes, southern CA

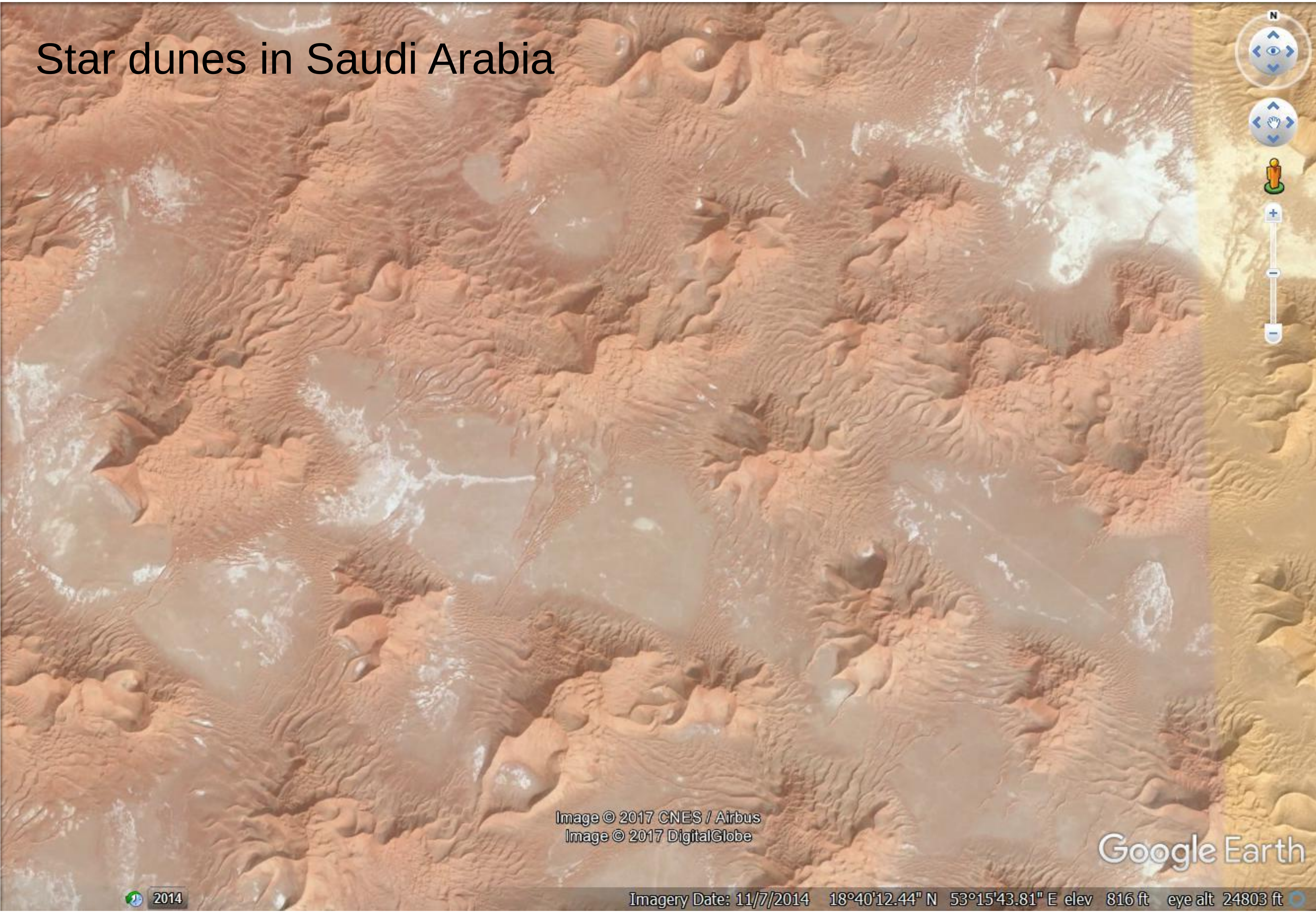
transverse dunes,
Great Sand Dunes
National Park, CO


dunes, coastal Peru


star dune, northern Mexico


coppice dunes, coastal Peru

Star dunes in Saudi Arabia




N
Image © 2017 DigitalGlobe
Google Earth
2014
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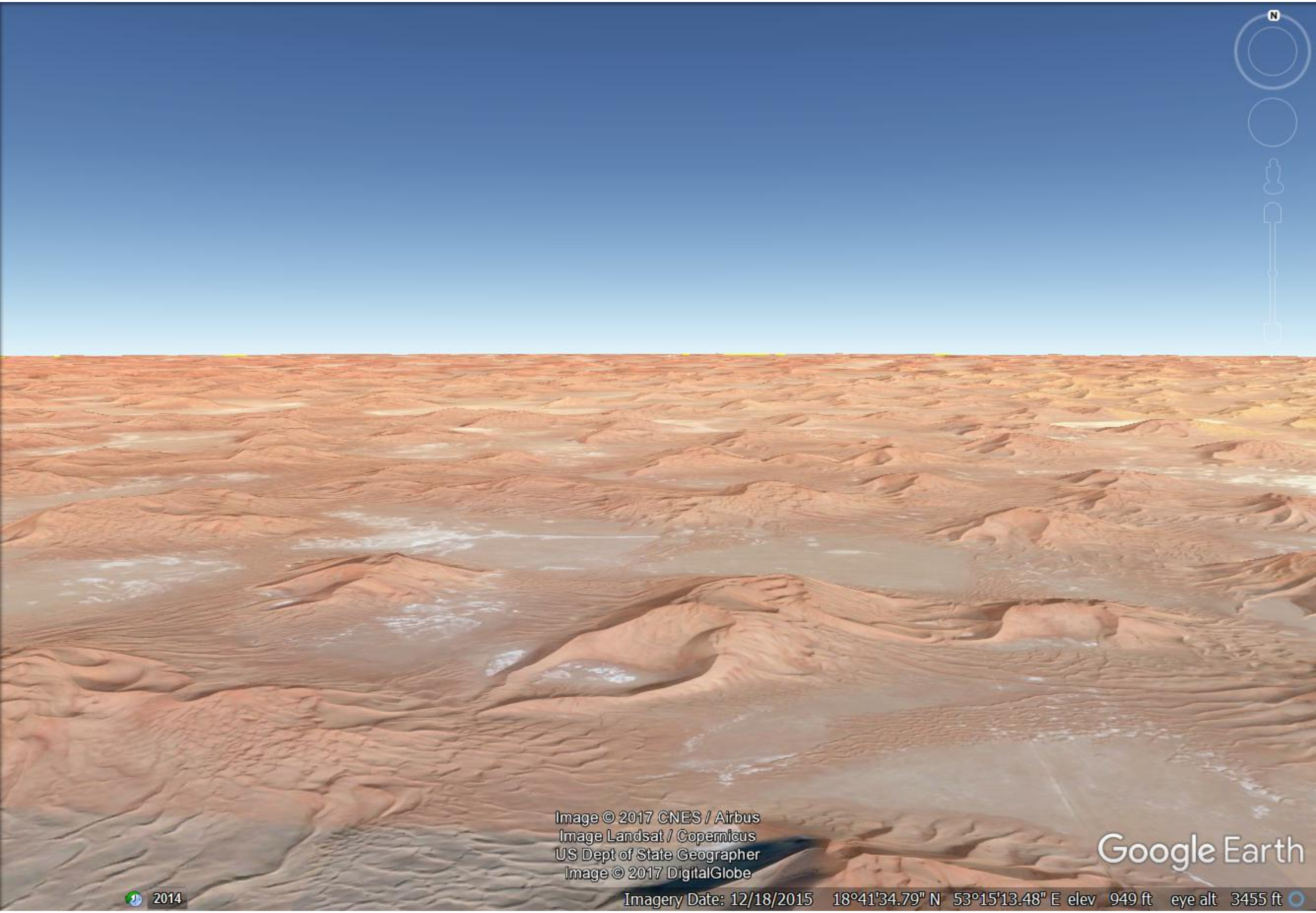
Image © 2017 CNES / Airbus
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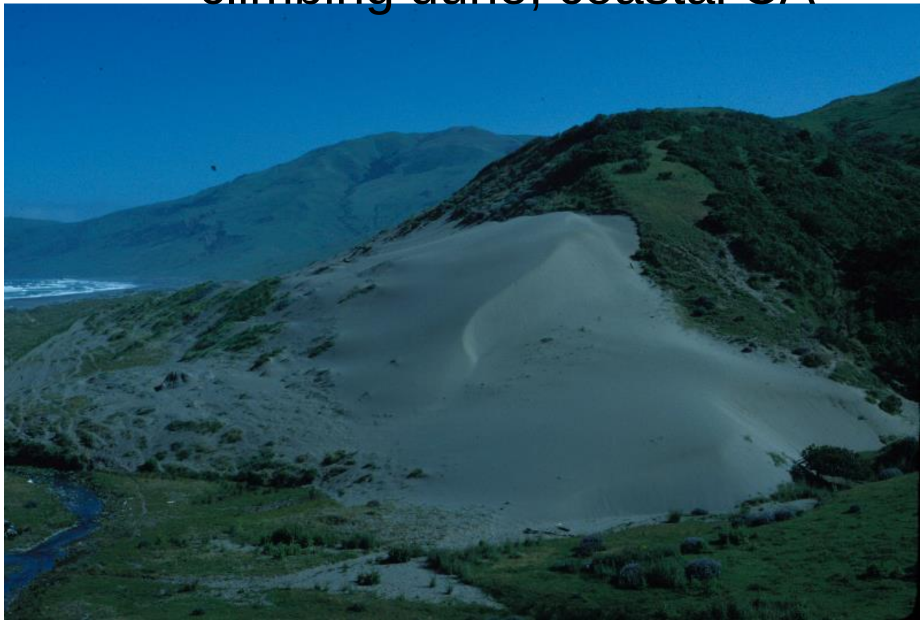
US Dept of State Geographer
Image © 2017 DigitalGlobe
Google Earth
2014
Imagery Date: 12/18/2015 18°41'34.79" N 53°15'13.48" E elev 949 ft eye alt 3455 ft


climbing dune, Colorado River, AZ

climbing dune, coastal CA



climbing dunes,
North Park, CO


Lees Ferry Boat Ramp
river flow direction
Google Earth
1 km
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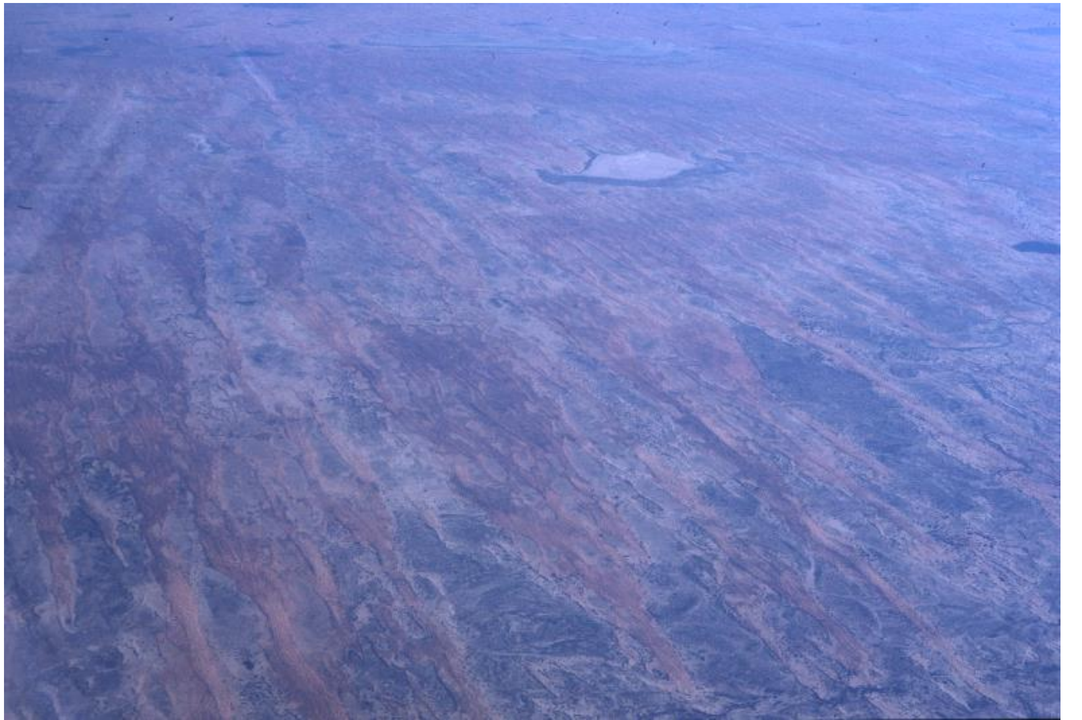
stabilized coastal dunes,
Lake Michigan



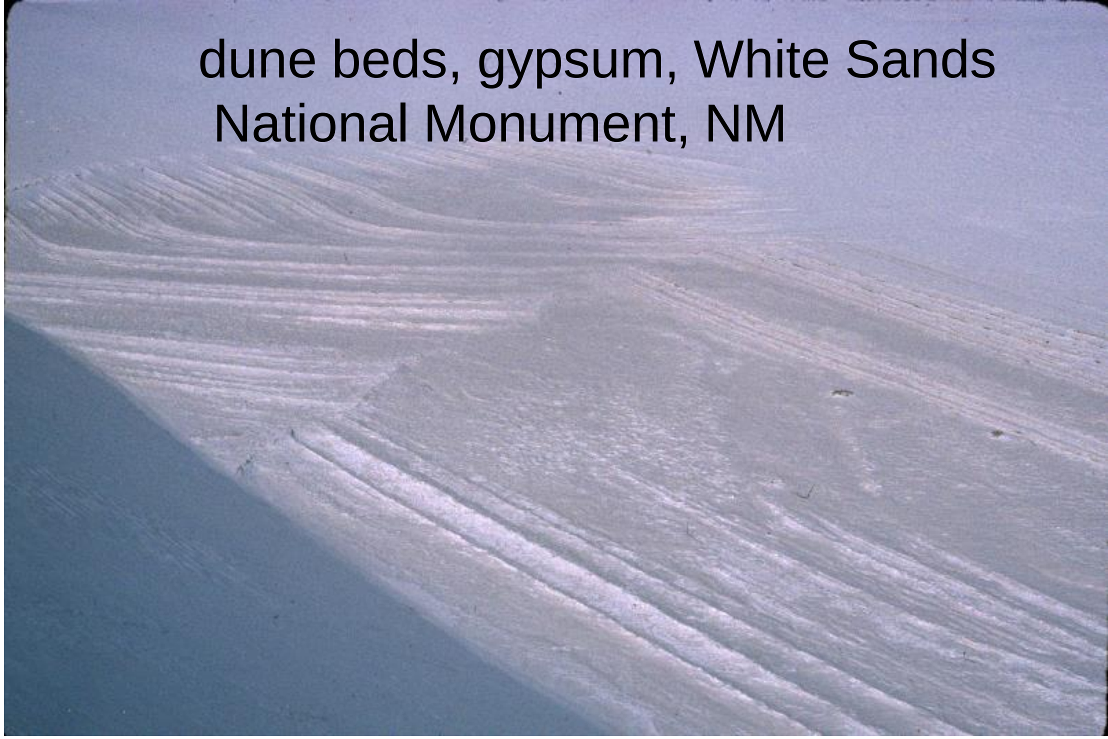
stabilized dunes,
central Australia

biogenic crust on dune sand, western Israel

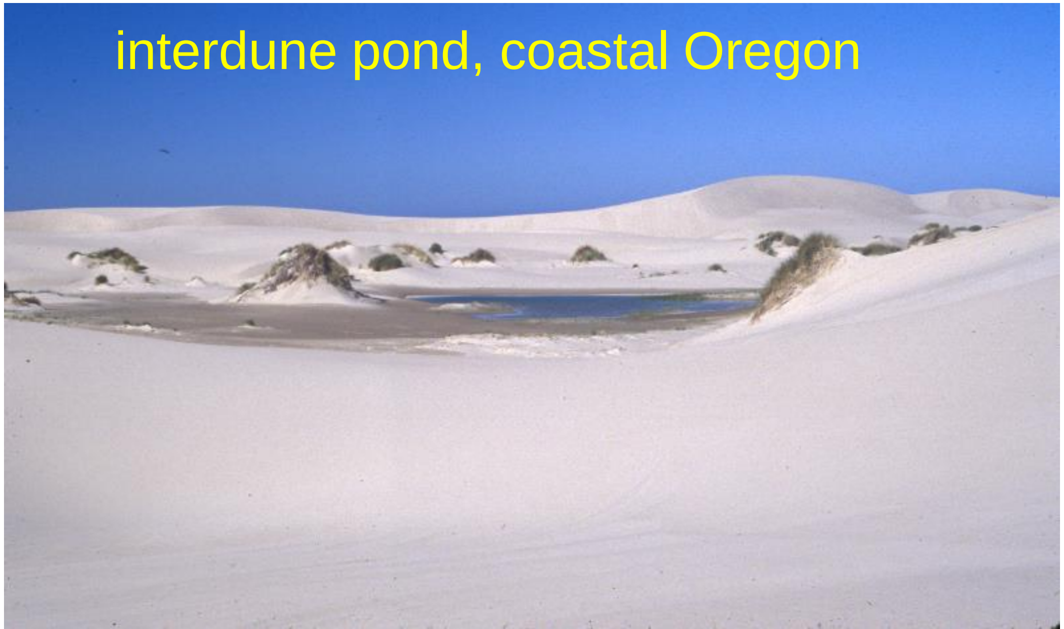

avalanche sand & ripples on dune crest, coastal Oregon


moving surface layer on dune, coastal Oregon

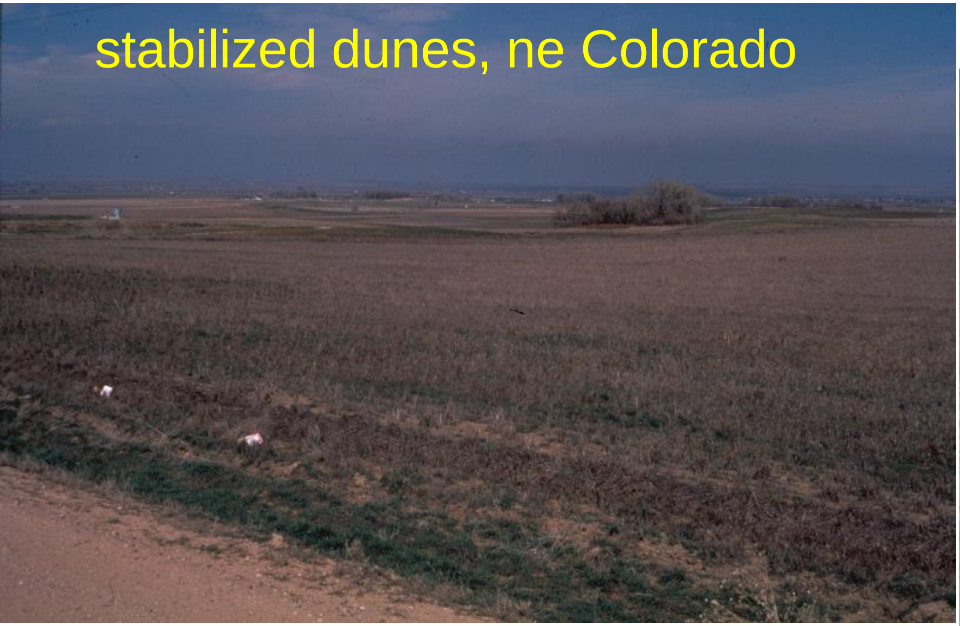
alternating dune sand & playa silt, western Israel

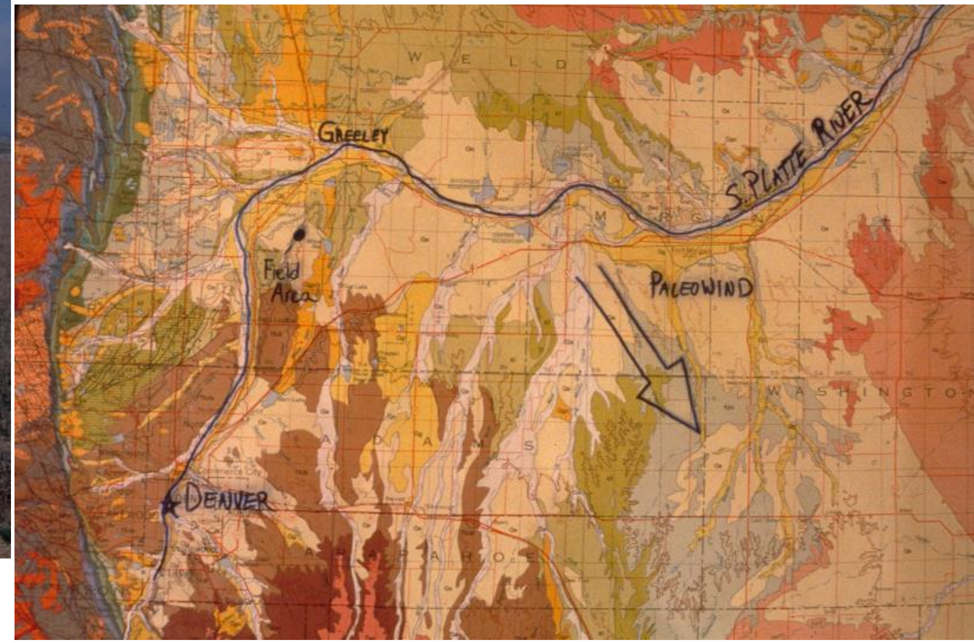


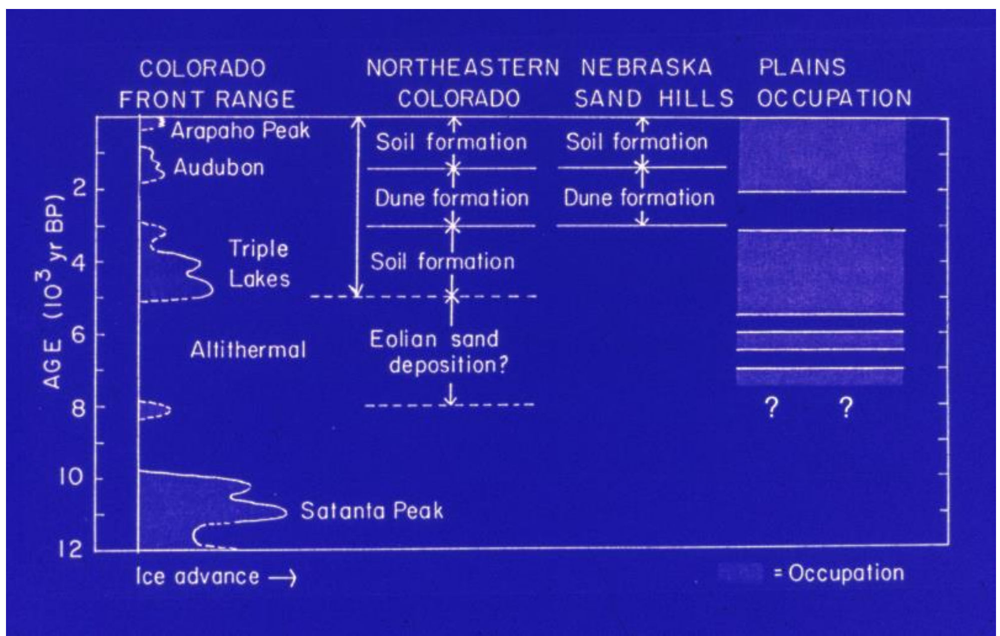
dune beds, gypsum, White Sands National Monument, NM



interdune pond, coastal Oregon


stabilized dunes, ne Colorado


GREELEY
S. PLATTE RIVER
Field Area
PALEOWIND
DENVER
W E L D


COLORADO FRONT RANGE
NORTHEASTERN COLORADO
NEBRASKA SAND HILLS
PLAINS OCCUPATION
AGE (10³ yr BP)
2
4
6
8
10
12
Arapaho Peak
Audubon
Triple Lakes
Altithermal
Satanta Peak
Soil formation
Dune formation
Soil formation
Eolian sand deposition?
Soil formation
Dune formation
? ?
Ice advance ⟶
= Occupation

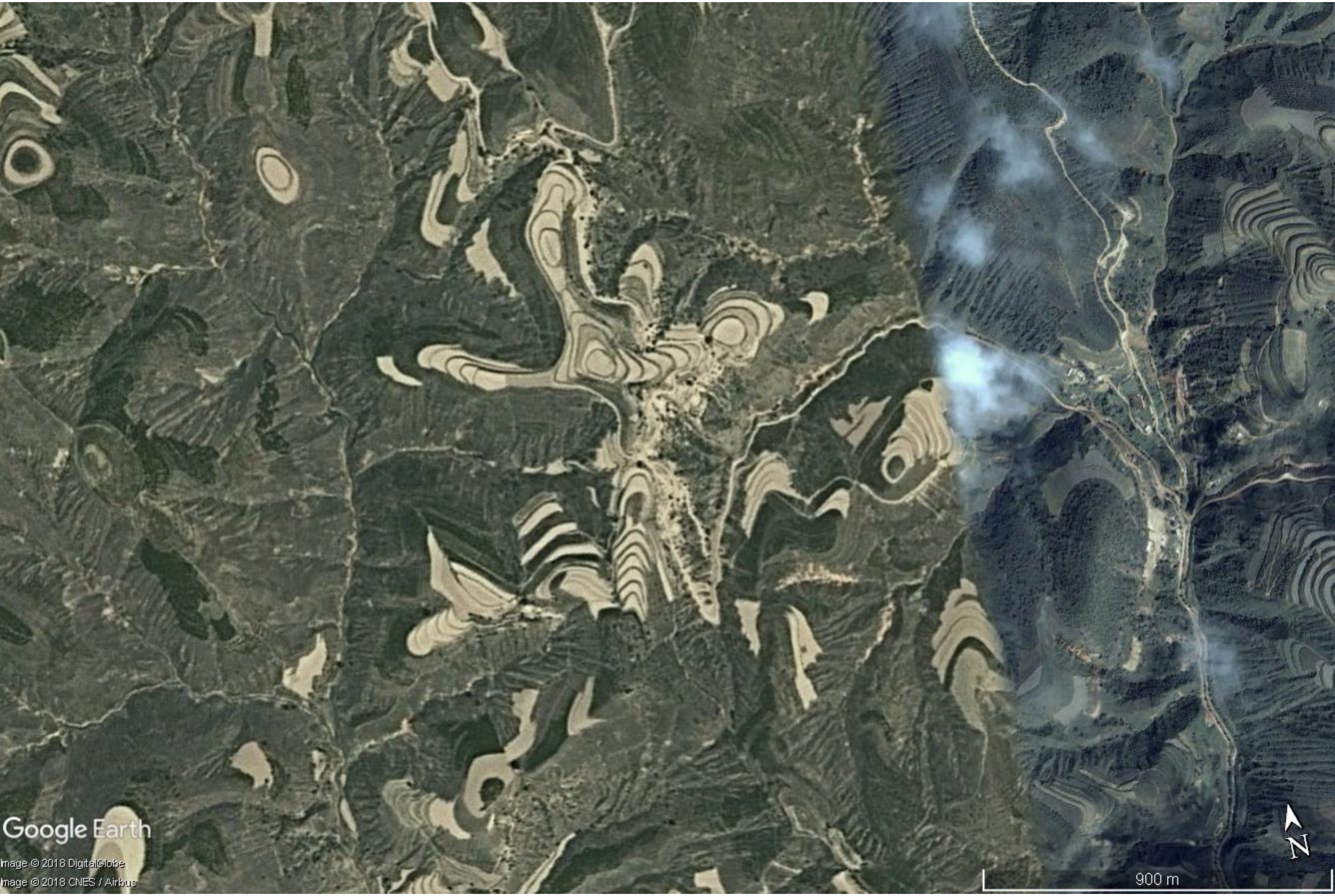
Fine-grained deposits

Clay dunes develop near coastal lagoons or evaporating salt flats where clay aggregates into pellets, moves into dunes, then stabilizes due to rain & salt solution; slopes $\leq$ 15° and steepest on windward side, $\leq$ 15 m high

Loess: homogeneous, unstratified silt up to 100 m thick
- highly porous
- keeps vertical slopes
- originates in deserts or glacial outwash (eg. China, Illinois)
- decreases in thickness with increasing distance from source

Loess is widespread, distinctive (soil development, fossils, minerals, etc), & associated with glacial intervals (used for regional correlation)

Loess Plateau, China


Google Earth
Image © 2018 DigitalGlobe
Image © 2018 CNES / Airbus
900 m
N


Google Earth
Image © 2018 CNES / Airbus
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600 m