Eolian Landscapes and Deposits

Relevant differences in air versus
water as the transporting fluid

$$\rho_{\text{air}} \approx \frac{\rho_{\text{water}}}{800}$$ density

$$\mu_{\text{air}} \approx \frac{\mu_{\text{water}}}{55}$$ dynamic viscosity

Good match between present-day distribution of active eolian dune fields and worldwide distribution of deserts

Aridity is define as P/ET_p where P = precipitation and ET_p = ability of solar radiation and vegetation to return moisture to the atmosphere by evaporation and evapotranspiration

Correlation between aridity and eolian landforms make eolian deposits attractive candidates for paleoclimate studies.
Complicating issue: Inherited source of wind blown sediment. These sources of sediment can overwhelm potential substrate stabilization by plants.

Relatively unique aspect of eolian system: fluid is very thick/deep (atmosphere) and excursion lengths for small particles can be very long (e.g., breadth of Atlantic Ocean).

Superposition of eolian topography

Order	Wavelength	Height	Suggested Name	Possible Origin	Orientation
1st	300-5500 m	20-450 m	draas	primary aerodynamic instability	longitudinal or transverse
2nd	3-600 m	0.1-100 m	dunes	primary aerodynamic instability	longitudinal or transverse
3rd	15-250 cm	0.2-5 cm	aerodynamic ripples	primary aerodynamic instability	longitudinal or transverse
4th	0.5-2,000 cm	0.05-100 cm	impact ripples	impact mechanism	transverse

The classification of aeolian bedforms.

Figure by MIT OCW.

Erg = genetically related assemblage of draas

Interdraa and interdune areas can be dry or wet and in some cases be sites of flowing water.

In many cases there is not sufficient wind-blown sediment to completely cover landscape.

Barchan dunes develop under these sediment-limited conditions.

Great debate about whether inter-draa horizons represent:

1. Regional water-table surfaces (Implying preservation is connected to climate-change), or
2. Bedform climb.

Climb model requires a lot of sediment coming into the depositional system.

Foreset stratification associated with eolian dunes is the product of grain-flow and air-fall deposits. Air-fall sedimentation produces the tangential strata at bounding surfaces.

Translatent ripple stratification is common in eolian ripple deposits. Stratification is produced by ripples climbing at angles << stoss-side angle.

Collision Stokes Number

Schmeeckle, M.W., Nelson, J.M., Pitlick, J.,3 and Bennett, J.P., Interparticle collision of natural sediment grains in water, Water Resources Research, v. 37 (9), p. 2377–2391, Sept. 2001

When a saltating particle contacts a bed particle, the result may be either a partially elastic rebound or viscous damping by the fluid that must be expelled from the gap between the two particles.

The appropriate physical scaling of this problem is a collision Stokes number:
Measure of the **inertia of the particle** relative to the **viscous pressure force (hydrodynamic force)** exerted on the particle by the fluid.

$$St = \frac{F_i}{F_h} \approx \frac{\rho_s D u}{9\mu}$$

Assuming spheres of equal size.

where ρ_s is the sediment density, *D* is particle diameter, *u* is the velocity of approach between the two particles, and μ is the dynamic viscosity of the transporting fluid.

If *St is small,* < ~ **39** Viscously damped collision: viscous pressure will stop the particle before significant elastic energy can be stored in the deformation of the particles.
In this case, there will be no initial rebound velocity.

St is large, > ~ **105** Partially elastic collision: rebounding particles not significantly affected by interstitial fluid.

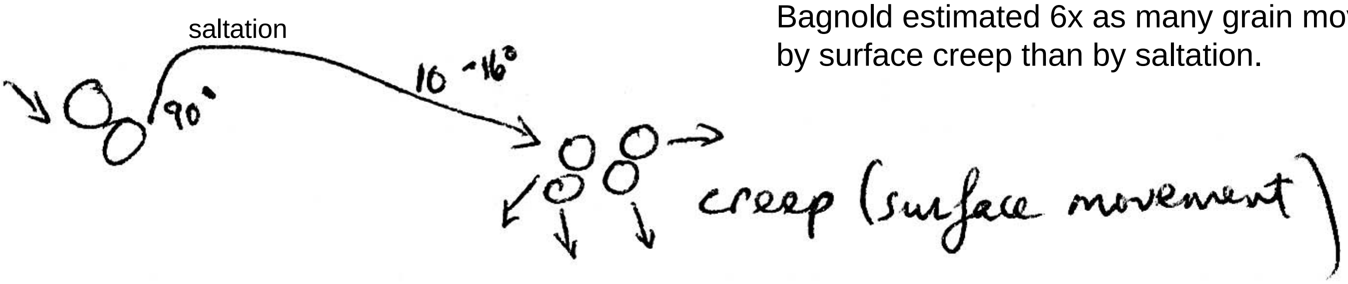
If transporting fluid is water, *St* is small for all sand particles.

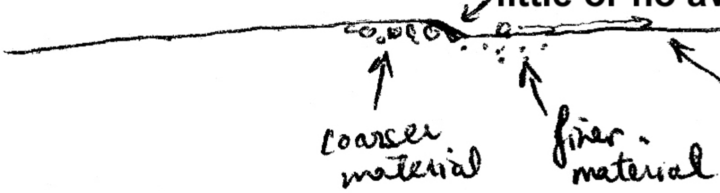
If transporting fluid is air, *St* is large for all sand particles.

Impact or ballistic ripples

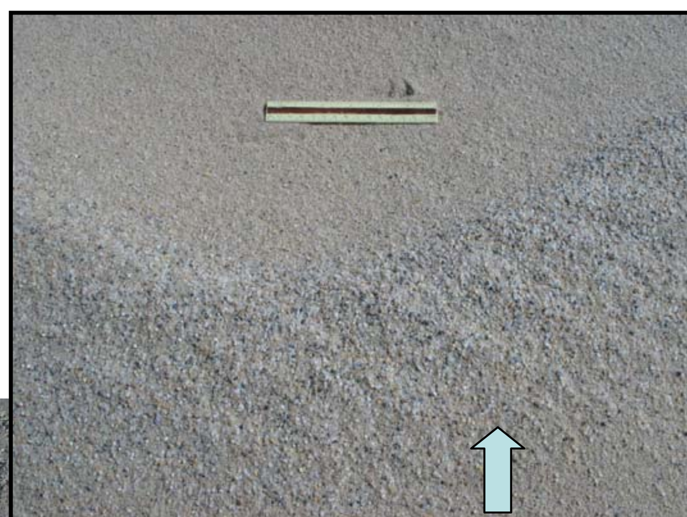
Kinetic energy of the impacting grain > energy necessary to raise a similar grain out of its pocket in the bed against the force of gravity.

Bagnold estimated 6x as many grain moved by surface creep than by saltation.

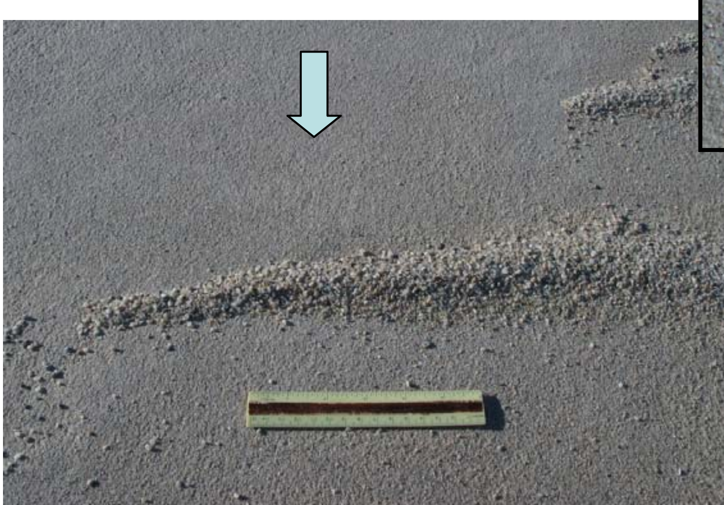




Hypothesis: Tight distribution of particle-ejection velocities translates into tight distribution of characteristic grain-excursion lengths, setting ripple wavelength.



Arrows mark transport direction

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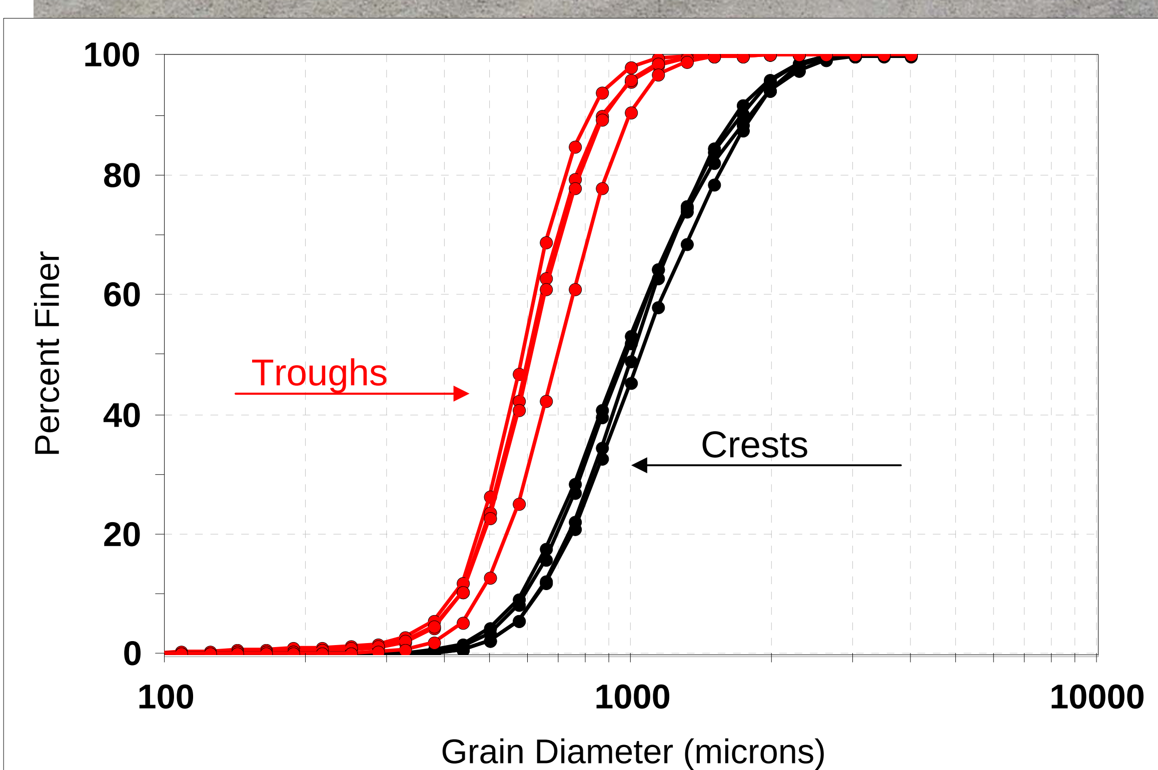
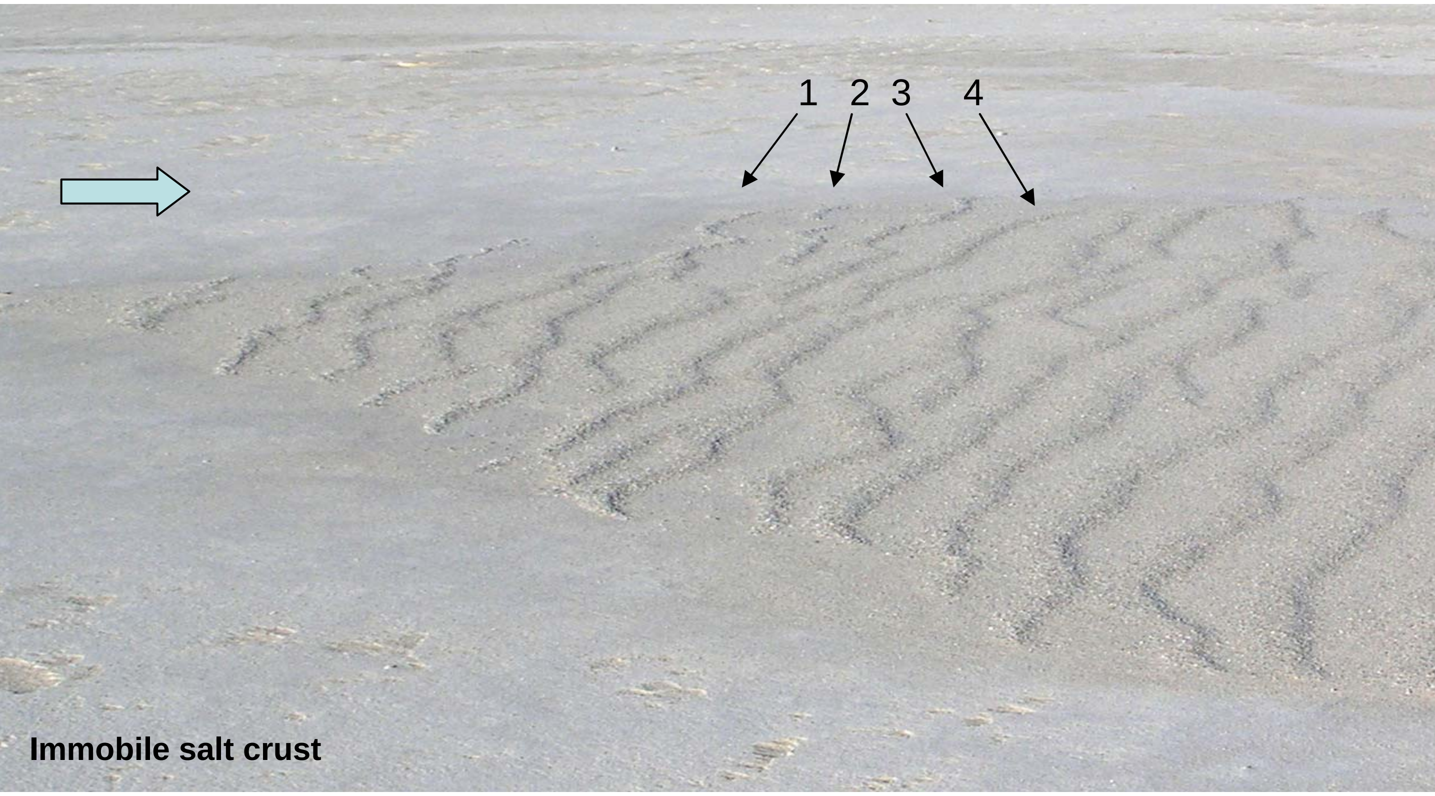

Troughs
Crests
Percent Finer
Grain Diameter (microns)
0
20
40
60
80
100
100
1000
10000



Coarsening of active surface layer associated with deflation.