AEOLIAN FEATURES ON EARTH AND MARS

Due December 8, 2008

Deflation

**Bottomless Lakes, New Mexico, 7.5° quadrangle**

This region of the Great Plains includes a portion of the Pecos River. The Bottomless Lakes themselves are sinkholes formed by solution and removal of gypsum. On the eastern side of the quadrangle, numerous deflation hollows or “buffalo wallows” can be seen in the topography, sometimes filled with water.

1. Besides the deflation hollows, what other clue on this map suggests this region is one of aeolian erosion?
2. Can you say anything about the long-term (Holocene) climate in this region based on the geology?

Yardangs

**Medusa Fossae, Mars, MOC images, ~2°N, 163°W**

These are images taken by the Mars Orbiter Camera (MOC) aboard the Mars Global Surveyor (MGS) spacecraft currently in orbit around Mars. These images typically have very high resolution of meters per pixel; this and the scale are denoted on each image. The Medusa Fossae formation is unique on Mars because it is the only place on Mars that does not return a radar signal, likely requiring that it is a very fine material. Many researchers feel this formation’s primarily composed of volcanic tephra, though the origin remains enigmatic.

Look first at the context image. You see several mesas, knobs and buttes. The close up view of the valley between the mesas is covered by yardangs.

3. What is the dominant wind direction in this region?
4. Based on your answers above and the geomorphology of the region seen in the context image, what can you infer about the resistance of rock layers in this region?
Dunes

**Great Sand Dunes National Monument, Colorado, stereopair and Space Shuttle photograph**

The sand here is trapped largely due to the presence of the Sangre de Cristo Range at the eastern portion of the image; a situation seen better in the Space Shuttle photograph. Wind blows predominantly from the SW (note the north arrow). In image 18A, above the “A” in “Aspen” towards the center of the image is a barchan dune, but its horns are being pulled to the SW. Most of the dunes in this portion of the image are also pointing the windward direction; this probably results from the presence of vegetation that stabilizes the horns and causes them to be left behind as the dune moves on.

5. In the main dune mass, what types of dunes are present?
6. What is the evidence and direction of secondary winds?

**Sarita, Texas, 7.5’ quadrangle**

7. What type of dunes are present here?
8. What is the dominant wind direction when the dunes formed?

To learn more about Sarita, read the last page of the handout.

**Moses Lake, Washington, 7.5’ quadrangle**

Ah, Moses Lake, a true recreational extravaganza! Examine the topography of the dunes in this region.

9. What is the dominant wind direction when these dunes were formed?
10. Why are these dunes submerged?
11. Based on the position of these dunes today, do you think these are active dunes or from a previous era? Explain your answer (hint: think about the Cenozoic history of this region).

**Mars MOC images** M01/00179; M02/02835; FHA 00451; M02/00783

12. For each of the four images describe:

- Type(s) of dunes.
- Direction of wind.
- Are the dunes locally derived?
- What the dune type tells you about the region.
Mars Pathfinder Landing Site, Ares Valles, Mars

Pathfinder Images • Big Crater Pan and Twin Peaks Pan 19.13°N, 33.22°W

These images are taken by the camera on the Pathfinder lander. You can correlate the features seen in the MGS data to features seen on the ground. Look first at the Big Crater Pan; now you can get a sense of the height of the rim of this crater. Zoom in on the features in the foreground and examine the foreground in the Twin Peaks image as well.

13. Describe evidence for aeolian processes at the Pathfinder landing site.

Take a look at the beautiful stereo anaglyph of Barnacle Bill and the Sojourner truth rover.

14. What is the dominant wind direction (s) in this region? Justify your answer.

After you have completed this exercise, take off your glasses and look at a wall with one eye closed and then the other. The human eye adjusts quickly to variations in color.
Exercises

Threshold Condition.

Bagnold’s equation for the critical shear velocity for grain entrainment:

\[ u_{c} = A \sqrt{\frac{\rho_s - \rho_a}{\rho_a}} g D \]  

(1)

where \( A \) is an empirically derived coefficient \(~0.1\) (works for Reynold’s \# > 3.5 where the air is turbulent), \( \rho_s \) and \( \rho_a \) are the density of the sediment and atmosphere, respectively and \( D \) is grain diameter.

Calculate the critical shear velocity in the following two cases:

15. A 0.5 mm basalt sand grain on Earth (\( g = 9.81 \) m/s) with a density of 2900 kg/m\(^3\), air density of 1.2 kg/m\(^3\).
16. The same grain at Mars, \( g = 3.75 \) m/s, atmospheric density = 0.018 kg/m\(^3\).
17. What controls the differences between the two values on the two planets? That is, why does it take stronger wind to entrain particles on Mars?

The time-averaged velocity profile of the wind at height, \( y \) can be modeled by the following equation:

\[ \bar{U}_y = \frac{u_*}{k} \ln \left( \frac{y}{y_0} \right) \]  

(2)

where \( u_* \) is the shear velocity, \( k \) is von Karman’s constant \(~0.4\), \( y_0 \) is the roughness length of the surface (e.g., \(<0.1 \) mm for a smooth surface, 3-10 mm over grass, 1-6 m over forest). This equation calculates the wind velocity at height, \( y \) that corresponds to the fluid threshold condition at the surface.

18. Assuming a roughness height of 0.25 mm, calculate the wind velocity at 1 m and 1 km on Earth and Mars for the same grains as above.
19. High-level (1 km) winds have been measured at Mars at \(~100\) m/s. Are these winds strong enough to carry sediment?

Saltation.

Once saltation commences, less wind velocity is required to entrain particles. A rule of thumb is that the impact velocity is \(~80\%\) of the critical shear velocity. The mean saltation height (in absence of drag) is given by:

\[ h = C \frac{u_*^2}{g} \]  

(3)
where $C \sim 0.82$.

20. Considering the same grains, calculate the mean saltation height for grains on Earth and Mars.

21. Based on your answer, what would you predict about the size of Mars ripples as compared to the Earth?

Dust.

The Dust Bowl of the 1930’s was precipitated by land clearing and ploughing. Dust storms are also caused by drought, particularly in areas dominated by loess. The maximum likely transport distance, $L$, of a particle is inversely proportional to its Stoke’s settling velocity, $w$:

$$L = \frac{U^2 \varepsilon}{w^2}$$  \hspace{1cm} (4)

$$w = \frac{1}{18} \frac{\Delta \rho g D^2}{\mu}$$  \hspace{1cm} (5)

where $U$ (bar) is the average wind speed, $\varepsilon$ is the kinematic eddy viscosity, a measure of the upward component of turbulence, $\Delta \rho$ is the difference between the density of sediment and air, $D$ is the grain diameter, and $\mu$ is the viscosity of air = $1.8 \times 10^{-5}$ Nm$^2$s$^{-1}$.

22. Using equation (4), calculate the maximum transport distance for silt grains ($\rho = 2650$ kg/m$^3$) of diameters 10, 30 and 60 $\mu$m. Perform the calculation for a wind speed of 15 m/s for two endmember values of eddy viscosity: 1 and 10 m$^2$s$^{-1}$.

23. Loess deposits comprise coarse silt grains in the region of 30-60 $\mu$m. Using the higher value for eddy viscosity, how far do you expect these particles to travel?
Across America
Tiny Sarita, Texas, a blast from past, with few amenities, it doesn't want change spaceport will bring

By Mary Lee Grant / Scripps Howard News Service

SARITA, Texas -- In Sarita you can only buy three things: postage stamps, a soft drink from a vending machine or a horse. Some of the 250 residents want to keep it that way: a town with no stores, no bars, no gas stations. And no spaceport.

Most of the people who live here are cowboys whose families have worked for generations on the surrounding King, Kenedy and Armstrong ranches, among the largest ranches in Texas. Some fear that this rural area, which has managed to avoid many of the developments of the 20th century, isn't ready to jump headlong into the 21st century.

Two companies are interested in launching commercial satellites from a port that will be built early in the next century -- Space Access, a Palmdale, Calif., company, and Lockheed Martin.

Similar to an airport, a spaceport is used to launch space vehicles carrying satellites to and from orbit. The project could create thousands of jobs and turn south Texas into a hub of space transportation.

In Kenedy County, a man is still judged by how well he rides and ropes. The main entertainment is gathering for back-yard barbecues, where the conversation is likely to be in Spanish. The amount of property on the tax rolls averages 44,000 acres per person.

Some residents and officials say that a spaceport in the area would be detrimental to this close-knit community. Others say that it will damage the unspoiled beauty of the South Texas brushland.

Still others hope that the spaceport will come, bringing more business and excitement to traditional South Texas communities.

King Ranch heir Stephen J. "Tio" Kleberg said he is strongly opposed to building the spaceport close to Sarita and doesn't want it near his 825,000-acre ranch. "They are going to disrupt some of the best habitat in the state," Kleberg said. "I just hate to see something like that in this pristine habitat."

"If this were the only place it could go, I would be for it. But it isn't. I would rather see it in Corpus Christi, where they already have established facilities."

Jack Turcotte, who has served as county treasurer for 46 years, said area ranchers are against the spaceport. "These places have hundreds of windmills on them," Turcotte said. "There is a concern there won't be enough water left if the spaceport is built."

Turcotte hopes that a spaceport won't change the ranching style of the area. "I would hate for it to make us lose our traditional way of life," he said. "I think it would be good for south Texas, but I don't think it would do any good for Kenedy County."

Still, some residents hope the proposed spaceport would change Kenedy County -- not a lot, but just a little.

Anita Gonzalez, 30, said that while her husband is away being a cowboy, she has nothing to do in Sarita. "We don't even have a convenience store," she said. "To go to a big grocery store, we have to drive 25 miles to Kingsville. I have been looking for a job, but I can't find anything around here. If (the) spaceport came in, I might be able to get a job."

Olga Serna, 60, said she hopes it will bring more diverse jobs to the area. "My sons both work at the Bass family's La Paloma Ranch, and my husband was a cowboy," Serna said. "Spaceport might give us chances to do other things than be cowboys."

Sheriff Rafael Cuellar said he hopes the spaceport will allow more local children to get professional jobs at home rather than move away.

But County Commissioner Leonard May said he doesn't think the spaceport will help local people. "I think they are going to look for more educated, specialized workers than we have," May said. "I am going to have to see that it will benefit the people of Kenedy County. So far, I have seen nothing to show that it would."

Many residents are ambivalent about what the spaceport might bring.

Ranch hand Joe Salazar frequently visits his father, 81-year-old working cowboy Jose Salazar, who lives a few houses away. "I like the peaceful and slow life here," Salazar said. "I think a spaceport would change that. It could bring good things. I'm just not sure what they are."