Brief Guide to Sand Dunes and Dune Fields

White Sands National Park

What is Sand?

• To geologists, sand is a size-term – any type of rock or mineral material that is 0.002 in to 0.08 in (0.06 mm to 2.00 mm) in diameter.
• Tan-colored desert or beach sand is primarily made of quartz grains; quartz is hard and often remains after rocks erode.
• Not all sand is tan-colored. For example, the mineral olivine (peridot) erodes from lava flows to create the green sand beaches of Hawaii, and eroded lava flows produce the black sand beaches. New Mexico's White Sands is produced by sand-size grains of gypsum.

How do Dunes Form?

• Dunes are formed by wind. Geologists call this **aeolian** (windblown) deposition.
• Sand is carried downwind and accumulates when the wind slows and sand grains run into each other.
• As the small mound of sand grows, the windward (facing the wind) slope builds into a low slope (about 8 to 10° from the horizontal) and the lee slope (or slip face), on the opposite side from the wind, steepens to 33° from the horizontal. This is the **angle of repose** (the steepest it can be without collapse) of loose sand. You now have a sand dune.
• Dune Fields are local or regional accumulations of sand dunes. Very large dune fields, greater than 48 square miles (125 sq km) are called "sand seas," or "ergs" after the Arabic name for dune fields.

Small dune field in Petroglyph Nat. Mon.

Where do Dunes Form?

• Dunes form in arid or semi-arid areas with little vegetation that are downwind from a source of dry, loose sand. Sand sources can be dry riverbeds, floodplains, dry lakes (also called **playas**), beaches, or old glacial plains.
• Sand is carried by the wind until it is slowed by a topographic barrier such as mountains or a mesa edge. When the wind slows, the sand is dropped, and begins to accumulate.
• Dunes also form in areas where sandstone is being eroded.
• Sand dunes and dune fields can be evidence for climate change. Inactive or stabilized dunes can indicate a change to wetter conditions. A change to more arid conditions can be indicated by the dismantling of old dunes or by new dunes forming.

How does Sand Move?

• Most sand particles move by a process called **saltation**, where the sand grain bounces or skips within a few inches (centimeters) of the ground. Large sand grains roll along the surface, and very small ones can be carried in suspension within a few yards (meters) above the ground and remain as a haze for hours after a sand storm.
• The way in which sand is moved by different wind speeds can be analyzed by mathematics. An English geologist named R.A. Bagnold defined the equations in the 1940s-1950s and discovered that occasional strong winds are more effective than low velocity steady winds at moving sand. Therefore, dunes may be aligned in a direction that is not the same as the normal wind direction in a given location.

How are Dunes Described?

Dune Field west of Albuquerque

• **Simple dunes** relate to a wind direction. They can be parallel, transverse or longitudinal to the wind direction, and can have a convex or concave shape to the wind direction.
• **Crescent or barchan dunes** are shaped like crescent rolls or croissants. They are formed when the low edges or wings of the slip face move faster than the higher center, giving a crescent-shaped form. They are usually small and occur in an area with a very strong, constant wind in one direction.
• **Compound dunes** are produced by combinations of wind directions. They are sometimes called peaked dunes and can form pyramid or star shapes.
• **Wind ripple marks** on dunes are formed by the wind depositing two different sizes of material. Fine (very small size) sand is capped by coarse (larger size) sand. The coarse sand forms the sharply peaked ridges of the ripples. Ripple marks are often oriented at 90° angles to the wind direction.
• Some sand dunes are called **"singing sands,"** because they squeak or make a tonal sound when avalanches move down the slip face.

Do Dunes Move?

• Yes, dunes (and dune fields) can move or migrate. South of Albuquerque, a highway rest-stop was originally built on raised walkways over a dune field. Within 20 years, the dune field had moved to the west and the raised walkways were no longer over dunes.
• Dunes can be "stabilized," or stopped in their movement, by vegetation. The dunes do not move, but individual sand grains can move through the dunes, so the dunes are constantly renewed with new sand.

Albuquerque's Dune Fields

• There are several patches of dune fields along the western edge of Albuquerque's west mesa.
• Cretaceous and Jurassic age sandstones of the Rio Puerco valley (that were formed originally from dunes) are now being eroded and moved by the wind to create new sand dunes.
• The sand is eroded and moved by prevailing winds from the west. When the wind reaches the edge of the west mesa it slows down, and drops any sand it is carrying.
• There are many old stabilized dunes in this area; and younger, active dunes keep moving and changing.

White Sands National Park

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• A large Ice Age lake once filled the basin north of the White Sands. Rain and snowmelt dissolved limestone from the surrounding mountains carried dissolved gypsum into the lake.
• About 10,000 years ago, the water began to evaporate and gypsum crystals began to precipitate out of the water. Smaller modern Lake Lucero is the last remnant.
• Strong winds eroded and carried gypsum fragments from the lake downwind to accumulate in a dune field.

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NEW MEXICO MUSEUM OF NATURAL HISTORY & SCIENCE

SAND OR SAND DUNES @ the MUSEUM

Where can you find information about sand or sand dunes or specimens on display in the Museum?

- Discussion about New Mexico's sand sea during the Jurassic in the *Age of Supergiants* Hall.
- The footprint sand box, filled with New Mexico gypsum sand, in the *Naturalist Center.*
- Discussion about climate change in *Degrees of Change.*
- NASA-created "Mars sand" in the "Minerals of Mars" exhibit in the *Space Science Wing.*
- In the Ice Age Hall, the camel and mammoth mounted skeletons are standing on rippled sand.
- Fossilized ripple marks in sandstone in the hallway outside the *Naturalist Center.*

New Mexico's Sand Sea

- In the middle of the Jurassic Period (about 165 million years ago) New Mexico was at the southern edge of a vast desert that covered most of what would become the western US.
- The winds piled up a large "sea" of sand dunes in northern New Mexico, which became sandstone.
- Today, these extensive "fossil dunes" have become towering cliffs of sandstone that show crossbedding.
- The sandstone is so massive that it tends to erode by large vertical "slivers" that form cliffs. As this process continues, the slivers become alcoves, then amphitheaters and, ultimately arches.
- Examples of this sandstone are El Morro National Monument, Echo Amphitheater (near Ghost Ranch) and La Ventana Arch (in El Malpais National Conservation area).

Simulated Mars Sand (JSC Mars-1)

- NASA and Johnson Spaceflight Center (JSC) created a simulated Mars regolith (surface material) in the early 2000s for testing future rover vehicles, general research, and education.
- The sand was created to match the actual Mars surface material analyzed and studied by the Viking Landers, the first landers on Mars, and Mars Pathfinder Mission, the first rover mission.
- The match was created by beginning with glassy volcanic ash material, called palagonite, from Hawaii, and treating it to match the color, grain size, spectral characteristics, and chemistry of the actual Mars material.
- The museum was one of the sites fortunate enough to be given some of the original material by JSC and it is on display in a tube in the Minerals of Mars exhibit. As of 2017, JSC Mars-1 is no longer available. The sand that forms the surface in the Mars Rover replica exhibit is actually New Mexican Triassic Chinle Formation – a very good match, at least in color, to Mars surface.

Fossilized Ripple Marks

- This rock was once loose sand. Water or wind moving over the sand produced ridges and troughs that are called ripple marks. The arrow shows the direction of movement over the sand.
- The ripple marks in this rock were preserved over many millions of years as the sand consolidated into sandstone.