Great Sand Dunes

National Park Service
U.S. Department of the Interior

Great Sand Dunes
National Park and Preserve

A Landscape in Motion

Introduction to Great Sand Dunes Geology

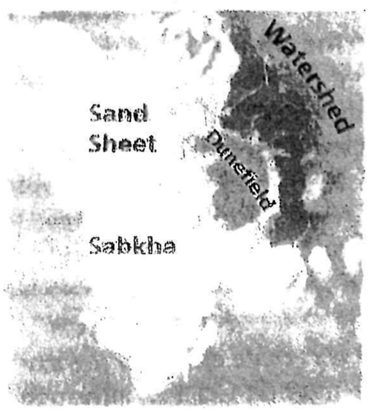
At Great Sand Dunes, geological processes are still in motion. Every day, sand grains are moving - eroding from the mountains, flowing in streams, bouncing, flying through the air, or avalanching down a dune face.

This information sheet is an introduction to what most geologists currently understand to be the series of events that have taken place in the formation of the Great Sand Dunes.

The Setting

The San Luis Valley is a vast, high-altitude desert basin surrounded by two alpine mountain ranges. To the west rise the San Juan Mountains; they cover much of southwest Colorado. On the eastern edge of the valley is the narrow, jagged spine of the Sangre de Cristo Mountains, stretching from central Colorado to northern New Mexico. Both ranges contain extensive forest and tundra, including peaks that rise over 14,000' above sea level.

The Sand System



The Great Sand Dunes sand system consists of four basic parts:

Dunefield - The tallest dunes in North America (750'/229m) are found in a dunefield stretching across 30 square miles. They are pure sand from top to bottom.

Sand Sheet - Here, the presence of grasses and shrubs lessens the wind's ability to move sand. Where vegetation grows on sand, it anchors the sand and hinders dune formation.

Sabhka - The sabkha has developed in response to shallow, salty groundwater; here, sand grains are cemented together with minerals left behind from seasonal wetlands.

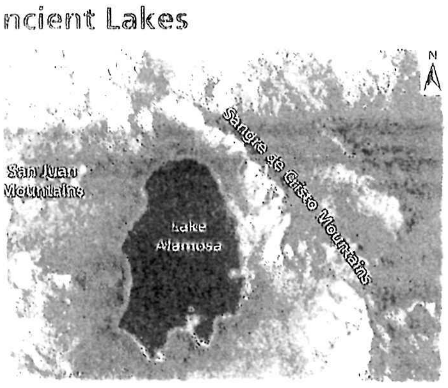
Watershed (Great Sand Dunes National Preserve) - Mountain streams that begin on alpine peaks are crucial in recycling sand sediments, transporting sand back into the dunes, and contributing to their impressive height.

Formation of the San Luis Valley

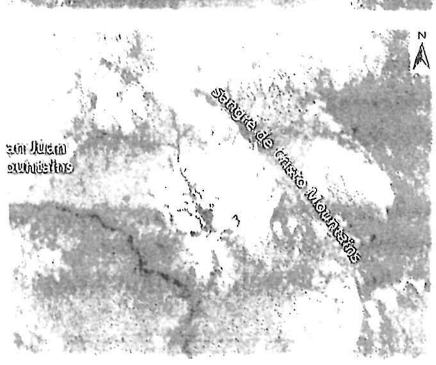
The dramatic scenery viewed here today evolved as the Earth's crust pulled apart, a process called rifting. The San Juan Mountains were among the first to form in the rifting process. One of the largest volcanic explosions in Earth's history was followed by magma flowing over the surface, resulting in the rounded mountain forms visible today in the San Juans. As rifting developed, the crust broke into blocks that began to rotate. Blocks thrusting upward became the Sangre de Cristo Mountains. Downward rotations formed the San Luis Valley, a depositional basin where sand has collected in the great quantities necessary for a dunefield.

Dunefields are quite common in similar rift valleys. White Sands in New Mexico, Eureka and Alogodones Dunes in California, and Sand Mountain in Nevada are a few examples of dunefields that have developed in rift valleys.

ncient Lakes



In 2002, geologists discovered lakebed deposits on hills in the southern part of the valley, confirming theories of a huge lake that once covered much of the San Luis Valley floor. Scientists named this body of water "Lake Alamosa", and estimated it existed from 3.5 to 0.4 million years ago. Lake Alamosa later receded as the climate warmed and dried, and as its water cut through volcanic deposits in the southern end of the valley. With the valley's southern rim breached, Lake Alamosa drained through the Rio Grande River, forming the dramatic Rio Grande Gorge near Taos, New Mexico.



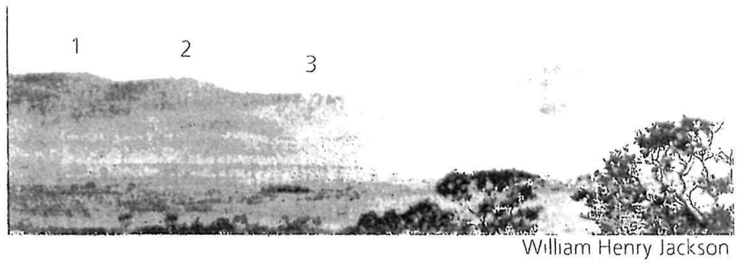
Smaller lakes still covered the valley floor, especially in the northern part of the valley. Further climate change significantly reduced these lakes, leaving behind the *sand sheet*.

Remnants of these lakes are still found today as wetlands. Wetlands here are surface expressions of a high groundwater table, fed by snowmelt and rain from the surrounding mountains. The *sabkha* forms where groundwater evaporates, leaving a white crust of cemented minerals and sand. Some sabkha wetlands are deep, with verdant plant life, shorebirds and amphibians; others are shallow and salty, supporting only saltgrass and limited animal life.

Wind Patterns Forming and Stabilizing Dunes

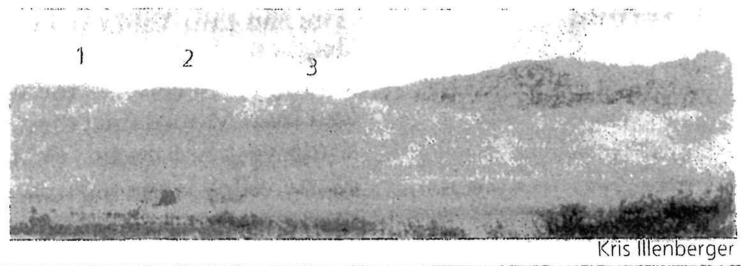
As the lakes receded, sand left behind blew with predominant southwest winds toward a low curve in the Sangre de Cristo Mountains. The wind funnels toward three mountain passes - Mosca, Medano, and Music Passes - and the sand accumulates in this natural pocket. Winds blow from the valley floor toward the mountains, but during storms winds blow back toward the valley. These opposing wind directions cause the dunes to grow vertically.

1873



William Henry Jackson

2011



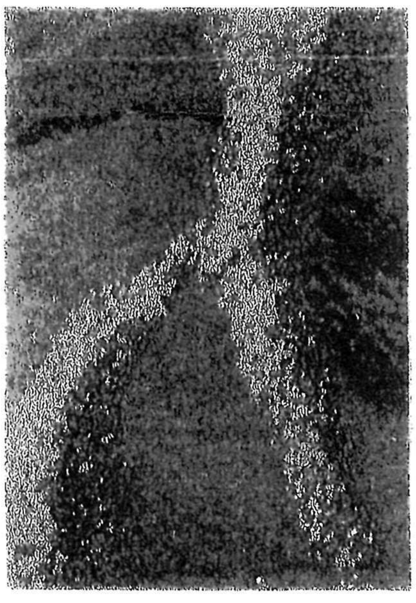
Kris Illenberger

Many visitors expect the landscape to change with each visit. While smaller dune forms show some changes, the massive dunes remain remarkably the same. When an 1873 photo is compared to a 2011 photo taken at the same location, the high dunes show little change in position. The battle of opposing winds cancels any overall migration of the largest dunes.

Sand Recycling from Mountain Creeks

Medano Creek, flowing on the eastern and southern edges of the dunefield, and Sand Creek to the north and west, act as powerful movers of sand. Streamflow transports sand from the mountains to the valley floor during spring/summer runoff; as the streams ebb, the stream-carried sand is exposed to the whims of the wind and is recycled into the dunefield. The high dune ridge above Medano Creek was constructed with creek–carried sand grains. Edges of the dunefield not having this stream-supplied sand have a more gradual rise.

Sand Types



As you observe the main dunefield, you will notice three distinct types of sand. Darker, fine–grained sand makes up the vast majority of the dunes; lighter, coarse–grained sand is found in lower pockets; and, depending on wind speed and direction, black patches of sand are usually seen near ridges.

These three basic sand types reflect the origins of Great Sand Dunes sand. The fine–grained sand is primarily volcanic, traced to the San Juan Mountains across the valley floor. It has traveled over 50 miles to reach the dunes, first on water, then on wind. During their journey, these sand grains have bounced and tumbled until they are finely polished. In contrast, the coarse grains in the dunes were washed down from the adjacent Sangre de Cristo Range. Lighter colored metamorphic and sedimentary rocks make up the majority of the Sangre de Cristos, although there are also some volcanic intrusions and deposits.

Looking closely at a handful of sand, notice the variety of colors - a summary of the many minerals found in each mountain range.

Black magnetite, a heavy mineral with its own magnetic charge, is often left in large patches of black grains on the dunes after winds blow lighter sand away. A compass will spin when placed next to a large patch of magnetite, and a magnet will pick up fuzzy clumps of this strange mineral.

Sand Composition

Over 100 different minerals are found in the sand. Out of approximately 4 billion cubic meters of sand, quartz is the most prevalent mineral, with over 50 percent of the sand grains being quartz. The majority of quartz sand grains in the dunefield are clear or milky white.

A number of researchers have measured sand composition. The values used most often come from a 1961 study undertaken by Arthur E. Burford, a geologist from the University of West Virginia; his results are given below:

Quartz	53.5%
Plagioclase	28.2%
Orthoclase	1%
Pyroxene	1.5%
Amphibole	.6%
Magnetite	.6%
Other Minerals	.2%
Various Volcanic Rocks	14.5%

For More Information

Visit Great Sand Dunes National Park and Preserve's web pages on geology and hydrology for more detailed information, illustrations and animations, and the latest research: **www.nps.gov/grsa/naturescience**