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THE GREAT SAND DUNES OF SOUTHERN COLORADO*

by

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Prevailing southwesterly winds that have blown for centuries across the flat expanse of the San Luis Valley of south-central Colorado have deposited a great mass of loose sand near the western flank of the Sangre de Cristo Mountains (fig. 1). This mass of sand is made up of several types of dunes whose structure depends upon the amount of sand available for transport, wind speed, and the amount of vegetation. The most spectacular dunes are high transverse dunes that are almost barren of vegetation; a tract of land has been set aside as Great Sand Dunes National Monument (fig. 2) to preserve these dunes.

Although the transverse dunes are among the highest in the United States, they cover only about a fourth of the 150-square-mile area of dunes in the San Luis Valley. The rest of the dunes are less spectacular types, but they, too, contribute to the interesting story of the origin and formation of the dunes in and near Great Sand Dunes National Monument.

GEOGRAPHIC SETTING

The sand dunes are located in the San Luis Valley northeast of Alamosa, Colorado, and the greatest accumulation of sand is in a small reentrant in the Sangre de Cristo Mountains north of Sierra Blanca where Medano Creek emerges from the mountains (fig. 3). Medano Pass is a low pass (about 10,150 feet) in this high rugged range, which in this part of Colorado has many peaks more than 14,000 feet high. Medano Creek flows from the pass to the dunes through a steep canyon that strikes northeast and forms a natural outlet for the high-velocity, southwesterly winds blowing over the dunes from the valley.

The San Luis Valley lies between the Sangre de Cristo Mountains to the east and the San Juan Mountains to the west. The valley is 105 miles long and 40 miles wide at the latitude of the dunes. The valley terminates northward at Poncha Pass, which separates the Rio Grande drainage from that of the Arkansas. Southward the valley extends a short distance into New Mexico (Baltz, 1965, p. 2068) where it merges with the Taos Plateau (Upson, 1939, p. 722).

The valley is exceedingly flat over most of its extent, except for the San Luis Hills southeast of Alamosa (fig. 1). The altitude of the valley floor ranges from 7,400 feet near the Rio Grande at the Colorado-New Mexico boundary to a remarkably consistent 8,000 feet around the periphery of the valley along the bases of the mountain ranges. However, the flat summits of the San Luis Hills are above 9,100 feet and are more than 1,000 feet higher than the highest part of this vast intermontane valley in which they lie.

The principal stream is the Rio Grande, which drains that part of the San Juan Mountains lying east of the Continental Divide. The Rio Grande flows generally eastward in the mountains until it emerges on the San Luis Valley at Del Norte (fig. 1). It meanders slowly in a southeasterly direction past Alamosa across a broad, flat flood plain to the north end of the San Luis Hills. The gradient increases as it flows south through the San Luis Hills into New Mexico.

North of Alamosa is a large area of interior drainage, in which the streams flowing from the mountains sink into the unconsolidated sediments that floor the valley. The area of interior drainage appears to center in the vicinity of San Luis Lake (fig. 2). San Luis Creek flowing from Poncha Pass and Sand Creek flowing from a cirque in the Sangre de Cristo Mountains terminate in San Luis Lake, which has no outlet. South of Alamosa and east of the Rio Grande, although not in an area of interior drainage, the water of many of the streams sinks beneath the valley floor before reaching the Rio Grande.

The climate of the San Luis Valley is semiarid. The total normal annual precipitation amounts to 6.56 inches at Alamosa and 9.69 inches at Great Sand Dunes National Monument. Showers are most prevalent in April, and thunderstorms are frequent in July and August. Even during the rainiest months, there are few available hours during which the sun does not shine, and evaporation and transpiration are high. Strong dry winds blow throughout the year from the southwest and dry out the soil and vegetation. During winter storms, high-velocity cold winds blow from the northeast for short periods of time. The strongest winds occur in the spring and early summer when dust storms are fairly common. Occasionally, the winds are so strong that clouds of dust are lifted across the Sangre de Cristo Mountains.

GENERAL GEOLOGY

The geologic structure and rock types of the San Luis Valley, the Sangre de Cristo Mountains, and the San Juan Mountains have largely controlled the formation and composition of the sand dunes. The San Luis Valley is a large north-trending structural depression that lies between the two mountain ranges. This depression is filled with 5,000-7,000 feet of alluvial fan gravel, volcanic debris, and interbedded basaltic flows which are here all included in the Pliocene and Pleistocene undifferentiated Santa Fe and Alamosa formations. Quaternary stream deposits, pedi-

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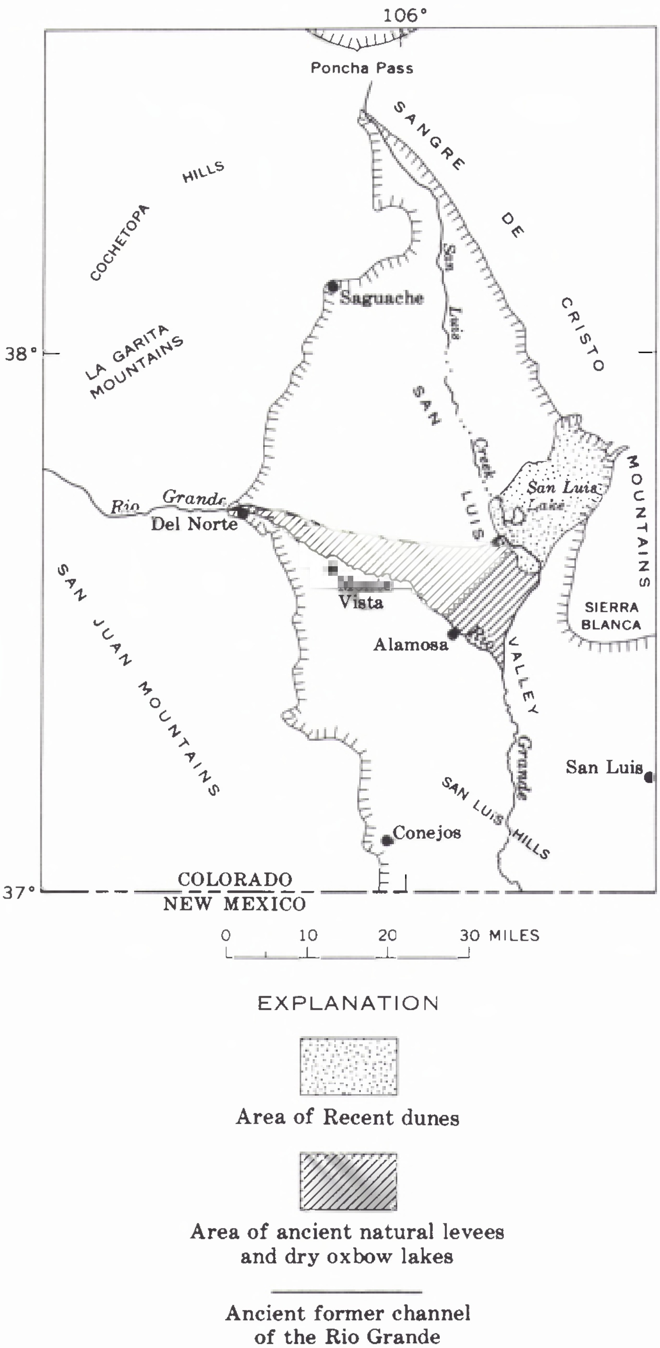

FIGURE 1

Location map of sand dunes in southern Colorado.

ment gravels, and alluvial fan materials mantle most of the valley floor, and a smaller part of the floor is overlain by dune deposits which are younger than most of the alluvium.

The Sangre de Cristo Mountains are composed of a wide variety of igneous and metamorphic rocks of Precambrian age, sedimentary rocks of Paleozoic and Mesozoic age, and igneous intrusive and volcanic rocks of Tertiary age. The bedrock on the western slope of the mountains is mostly Precambrian gneiss, granite, and granodiorite; almost all the debris being eroded from the Sangre de Cristo Mountains into San Luis Valley is derived from these Precambrian rocks. Alluvial fan material, an extension of that filling the San Luis Valley, covers many of the rocks and structural features on the west-facing slopes south of Sierra Blanca (fig. 1).

The San Juan Mountains that border the San Luis Valley on the west are composed mainly of volcanic rocks of Middle Tertiary age (A. Steven, oral commun., 1966). The principal rocks are flows, tuffs, and breccias that range in type from quartz latite to rhyolite (Larsen and Cross, 1956, p. 157).

DESCRIPTION OF THE DUNES

The sand dunes in and adjacent to Great Sand Dunes National Monument were mapped according to the classification of Hack (1941, p. 240-245) as transverse, parabolic, and longitudinal dunes (fig. 2). Parabolic dunes are divided into parabolic dunes of deflation and parabolic dunes of accumulation (Hack, 1941, p. 242-243). The parabolic dunes of accumulation are further subdivided into fixed and active. Special dune features such as barchans, climbing dunes, and large blowouts are also present (fig. 2). Locally, there is mixing of several types of dunes, and precise delineation is not always possible.

The parabolic dunes of deflation cover a large area southwest, or windward, of all the other dune types (fig. 2), and leeward of an area of ancient oxbow lakes and natural levees (fig. 1) abandoned by the Rio Grande during its lateral migration to the southwest. The parabolic dunes of deflation consist largely of low mounds of loose sand that are covered by grass and shrubs in most places. Blowouts form on the windward side of the dunes and are the sources of sand being supplied to the actively forming dunes downwind. The blowouts range in size from a few feet to several thousand feet across. Large lakes and barren playas are characteristic of this area of dunes. In fact, the lakes and playas may have originated as blowouts and reached their present size by wind deflation.

Both the longitudinal dunes and the fixed parabolic dunes of accumulation form downwind from the parabolic dunes of deflation. The longitudinal dunes lie in a long, low, and slightly arcuate area south and east of the parabolic and transverse dunes (fig. 2). The longitudinal dunes are lower than the parabolic dunes of deflation, and are only slightly higher than the duneless valley floor to the south. These dunes are long, low mounds containing a little loose sand at the surface and are covered with grass and a few scattered small shrubs. Although formed here under maximum wind velocities, the longitudinal dunes are stable south and east of Medano Creek. Grains of sand mainly from the parabolic dunes of deflation are piled up by strong winds to form two groups of barchans in the upper and lower reaches of the longitudinal dunes (fig. 2). The upper barchans are now slowly covering a grove of ponderosa pine. Sand and silt are also winnowed from coalescing alluvial fans nearby to add material to these dunes.

The main area of parabolic dunes of accumulation is lee-

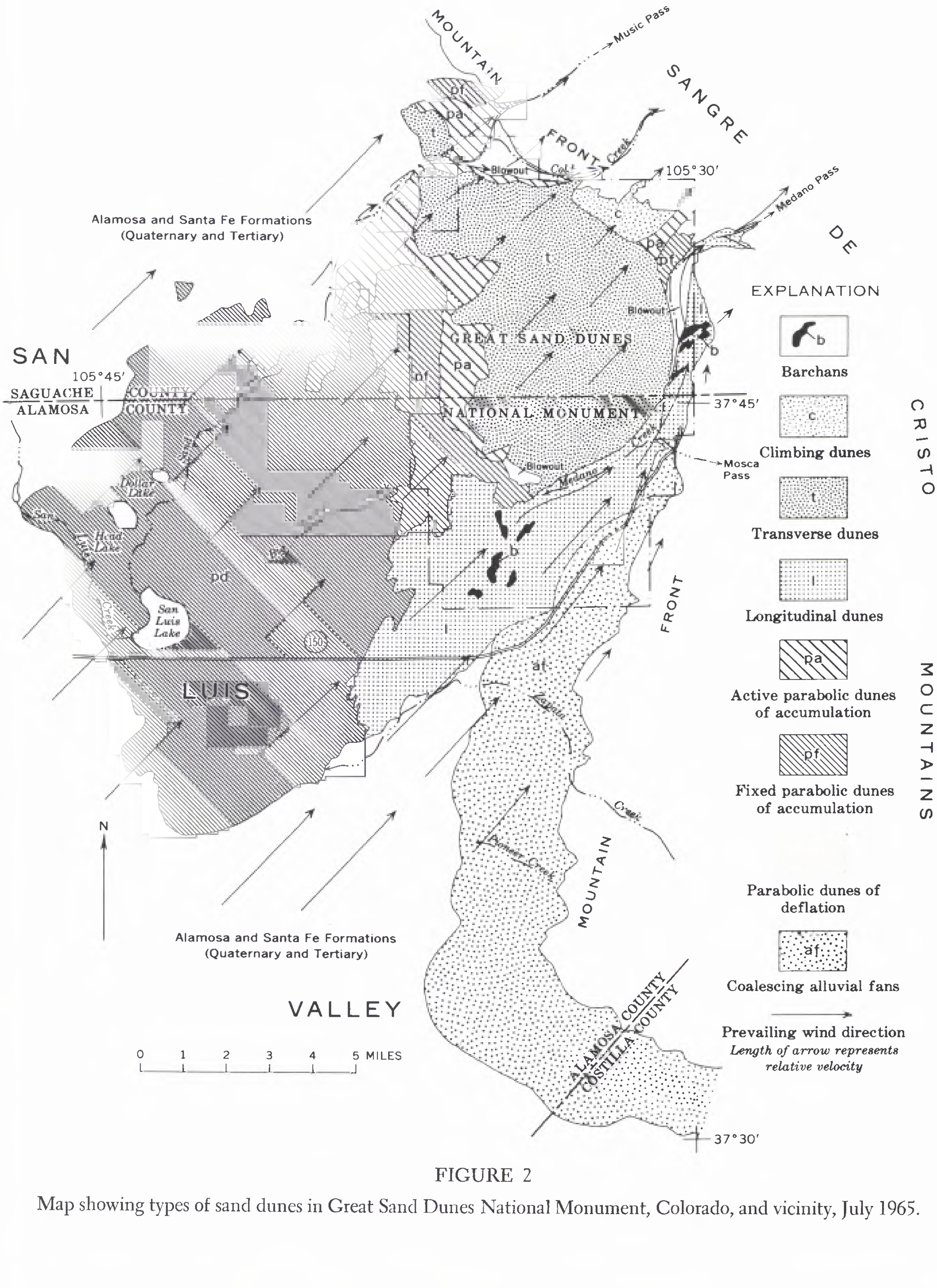

FIGURE 2

Map showing types of sand dunes in Great Sand Dunes National Monument, Colorado, and vicinity, July 1965.

FIGURE 3

Southeast margin of transverse dunes. Medano Creek in foreground is clogged by eolian sand. View is north toward Sangre de Cristo Mountains.
W. H. Hill, National Park Service

ward of the parabolic dunes of deflation and north of the longitudinal dunes. The fixed parabolic dunes of accumulation are upwind from the active dunes of accumulation. The area of fixed dunes stands generally only a few feet higher than the parabolic dunes of deflation and longitudinal dunes, whereas the active dunes rise for 100-200 feet on a rather steep slope from the fixed dunes to the transverse dunes. Smaller isolated patches of parabolic dunes of accumulation occur near the mouth of the canyons of Medano Creek and Sand Creek (fig. 2). The fixed parabolic dunes are sparsely covered with grass and low shrubs, and the active dunes are even more sparsely covered. The fixed dunes seem to be almost inactive at the present time; only small amounts of sand are collecting on the leeward side of some plants. Most of the sand derived from blowouts in the area of parabolic dunes of deflation seems to be blown across this area to the active parabolic dunes of accumulation.

The transverse dunes from which the Great Sand Dunes National Monument draws its fame (figs. 3, 4) stand 500-600 feet above the parabolic dunes of accumulation to the west and nearly 700 feet above the logitudinal dunes along Medano Creek. The transverse dunes are downwind from the main bulk of the active parabolic dunes of accumulation, which appear to be the immediate source of sand for the transverse dunes. North of Sand Creek (fig. 2) a small patch of transverse dunes is upwind from parabolic dunes. This apparent anomaly may be due to wind eddies. Occasionally strong winds of short duration, especially during the winter (R. L. Burroughs, oral commun., 1966), blow from the northeast and east (Merk, 1960, p. 128) and every winter reverse the crests of the transverse dunes (fig. 4).

The transverse dunes are relatively stable and do not appear to be migrating northeasterly (Merk, 1960, p. 129). Sand blown up from the active parabolic dunes of accumulation appears to be adding mainly to the bulk of the transverse dunes; a small amount of sand blows beyond to form dunes of other types. These great transverse dunes are almost barren of vegetation; the small amount that is present grows in the interdune hollows where the sand is damp.

FIGURE 4

Transverse dunes showing reversal of crests by strong northeasterly winds of short duration. The eastward-facing slopes are steeper than westward-facing slopes and indicate that predominant winds are from the west. Lag gravels cover floor of blowout in foreground. View is north toward Sangre de Cristo Mountains. W. H. Hill, National Park Service

Blowouts occur at three places adjacent to the transverse dunes (fig. 2) and are the result of eddying. The blowouts north and east of the transverse dunes appear to be created by strong eddies resulting from sharp changes in wind direction as the prevailing winds funnel into the steep mountain canyons. No reason has been determined for the origin of the eddies that have formed the blowout at the south end of the transverse dunes. Sand is being actively removed from the blowout and moved to the east.

Where Medano Creek emerges from the mountains, strong winds blowing northerly here must turn nearly at right angles to blow easterly up the canyon through Medano Pass. The entire area of the longitudinal dunes is in effect a wind tunnel, and strong eddies are formed where the wind must turn easterly up the canyon. Here these eddies have created a blowout opposite the mouth of the canyon, and have piled up high parabolic dunes north of the canyon mouth, and have carried some sand up the canyon to form barren longitudinal dunes with much loose sand. The longitudinal dunes are unstable in the canyon and could be easily converted to other dune types by seasonal variations in wind velocity and sand supply.

Climbing dunes (Hack, 1941, p. 241) are northeast, or leeward, of the transverse dunes between Medano and Cold creeks (fig. 2). These dunes are piled up against the steep western flank of the Sangre de Cristo Mountains opposite the highest part of the transverse dunes from which the climbing dunes are derived. They rise from about 8,800 feet to 9,500 feet in about a mile. The climbing dunes have no regular dunelike surface features but seem to consist of irregular mounds and swales on a steeply rising slope. They are practically devoid of vegetation, and appear to be accumulating rather rapidly at the present time as the result of the prevailing winds not being able to carry their load of sand over the mountains at this point. However, the turbulence of the eddies that form the large blowouts on either side of the climbing dunes (fig. 2) may have an important influence in containing the dunes laterally.

HISTORY OF THE DUNES AND SOURCES OF THE SAND

Eolian sand, which makes up the dunes, is derived from alluvium deposited by the Rio Grande in the San Luis Valley. During Late Pleistocene time the Rio Grande flowed directly eastward from the San Juan Mountains across the San Luis Valley to the vicinity of San Luis Lake where the river made a 90° bend and flowed directly south through the San Luis Hills (fig. 1). Since that time the Rio Grande has gradually moved southwestward away from this sharp bend until it now occupies a gently curved channel between the east flank of the San Juans and the north end of the San Luis Hills (fig. 1). The area between the oldest and youngest channels now consists of shallow crescent-shaped swales that are abandoned oxbow lakes and low serpentine-shaped mounds of loose sand and silt that are ancient natural levees of the Rio Grande.

The original source area of most of the grains of sand that make up the dunes is the volcanic terrane in that part of the San Juan Mountains drained by the upper reaches of the Rio Grande and the western tributaries of San Luis Creek. Much smaller amounts of sand were derived from streams flowing into the San Luis Valley from the crystalline and sedimentary rocks of the Sangre de Cristo Mountains north of Sierra Blanca. Alluvial material from these two mountainous terranes was deposited by the Rio Grande and San Luis Creek in the area of ancient natural levees and dry oxbow lakes (fig. 1). This area of loose sand and silt was the ready, immediate source of abundant material for the prevailing southwesterlies to build parabolic dunes to the northeast.

The remnants of these earliest dunes are the parabolic dunes of deflation (fig. 2). The structure of the dunes of deflation appears to have been parabolic when deposited and gives no indication of a history of longitudinal or transverse structures. An increase in vegetation due to an increase in rainfall or relatively low wind velocity has tended to stabilize or fix these early parabolic dunes.

Strong southwesterly winds continued to blow sand out of the Rio Grande flood plain and across the early parabolic dunes. Newly formed parabolic dunes migrated downwind until they reached nearly to the mountain front. There, wind turbulence and eddying were so violent that the sand began to pile up, but a wind-swept valley was kept open along the face of the mountains to the south. As the wind continued to bring in more sand, this sand was piled higher in a transverse pattern, and the interface between the transverse and parabolic dunes gradually moved westward as the large pile of sand stopped the migration of parabolic dunes. A steady and continuous supply of sand accumulated on top of this large pile of transverse dunes and formed climbing dunes against the high barrier formed by the Sangre de Cristo Mountains.

Today, sand is still being derived from the area of natural levees and oxbow lakes and the area of the parabolic dunes of deflation. It is blown across the fixed parabolic dunes to the active parabolic dunes of accumulation to collect in small amounts; however, most of the sand accumulates in the area of transverse dunes. Excess sand from the transverse dunes forms the climbing dunes. Small amounts of sand blow across the long expanse of longitudinal dunes to collect only temporarily on the barchans, but eventually sand is blown up Medano Pass or piled upon the south side of the climbing dunes as parabolic dunes.

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