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Monument Headquarters - White Sands

THE WHITE SANDS – A SHORT REVIEW

by

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One of the most striking features of the Tularosa Basin is the large area of pure white gypsum sand dunes. This "gypsum sea" covers an area of about 270 square miles within the basin, and is associated with an area of almost half that extent sufficiently gypsiferous to be termed "alkali flats." The gypsum sands extend for about 27 miles in a northeasterly direction, with an average width of 10 miles, though at some places the dune area is considerably wider. Quartz sand dunes covering more than 20 square miles form the northern part of the dune area. The quartz sand is slightly gypsiferous. Because of the sparkling white color imparted to the sands by the crystals of selenite which compose them, these snow-like dunes are called "The White Sands."

Historically, the Tularosa Basin is probably one of the routes used for commerce by the early Spanish inhabitants of the region, but certainly it was not as well used as the Rio Grande Valley because of the problems of water supply. Undoubtedly the white sands were avoided by the wagonners because of the possibility of bogging down in the softer dunes as well as the easier going on the flats to the east and west. The earlier ranchers are said to have feared the encroachment of the sands over a wider area. Apparently they were among the first to recognize the migratory nature of the dunes. However, their estimates of the rate of movement were undoubtedly exaggerated by their fears. The history of Indian raids, range wars, and outlaw depredations during the late 19th and early 20th centuries has been a source for many interesting adventure tales.

With the advent of a more settled era, the white sands were recognized as a great natural wonder, not only from the standpoint of scenic beauty, but also geologically. Nowhere in the world is there such a large deposit of gypsum sand so beautifully displayed. These facts led Congress to establish in 1933 a National Monument in the area with the purpose of setting aside more than 200 square miles selected for scenic and geologic interest. The Monument includes Lake Lucero, a large playa salt lake which, as will later be discussed, has had much to do with the origin of the sands. A wide stretch of alkali flats, which are of interest in themselves, also lies within the boundaries of the Monument (Fig. 1). However, since the formal opening of White Sands National Monument on April 1, 1934, the development of the area has proceeded only to the extent of construction of a road into one of the more scenic dune areas ("Heart of Sands") and the development of a small picnic area. A small museum has been established at the Monument headquarters.

In 1945 an even more spectacular development in this land of the spectacular, the explosion of the first atom bomb at Trinity site, a few miles to the north, brought White Sands proving ground and the White Sands to national attention. Later rocket and missile experiments, still going on, have kept the area in the nation's eye.

So much for the modern history of this natural phenomenon. Our interest is concerned more deeply with pre-historic events; events so ancient that man was not present to witness them; the geological development of the white sands.

REGIONAL GEOLOGY

The Tularosa Basin is a large graben or fault valley which extends from near Carrizozo, in central New Mexico, south into Texas. Near Alamogordo, it is bordered on the east by the east-dipping block of the Sacramento Mountains and on the west by the west-dipping block of the San Andres Range. The fault scarps are originally Cenozoic and some minor recent scarps of the same trend occur in the valley fill on the east site of the basin.

Formations representing almost the entire geologic section found in that part of New Mexico are exposed in the bordering mountains, but our particular interest is with the gypsum-bearing Permian Yeso and San Andres formations. Tertiary and Quaternary erosion has removed large quantities of gypsum from the Permian formations in the mountains both in solution and as detritus, and has poured it into the basin along with other alluvial material which covers the valley floor to a depth of over 1000 feet at many places.

In addition to valley fill, the Tularosa basin in the vicinity of Alamogordo shows abundant terraces indicative of the presence of a large lake in Pleistocene time. The lake covered a large part of the basin during the time of humid Pleistocene climate, but in the present semi-arid climate shows vestiges only in the few square miles of Lake Lucero. The wide areas of

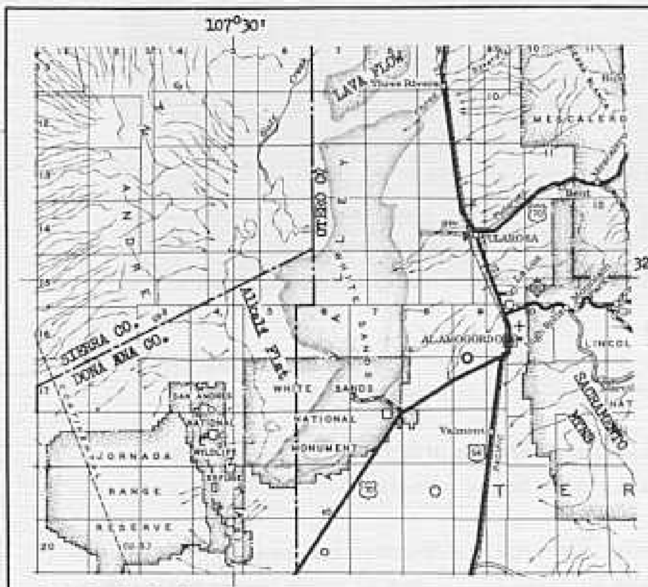

Fig. 1 (The White Sands)

Map of a portion of the Tularosa Basin showing the white sands, alkali flats, and the mountains to the east and west.

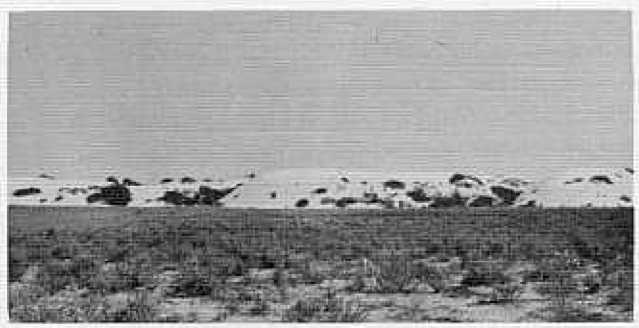

Fig. 2
The eastern margin of the white sands. The edge of the sands is moving slowly eastward at the rate of a few inches per year.

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gypsum-bearing sediments in the Tularosa basin alluvium are one of the results of this evaporative process. Lake Lucero itself contains sufficient sodium sulfate to have made it a prospect for the production of this salt in earlier days.

Origin of the White Sands

A number of explanations have been offered for the origin of the white sands, most of which differ only in the methods called upon for the accumulation of the gypsum in the Tularosa basin alluvium. The explanation of Talmage and Wootton (1937) seems best sup-

Fig. 3
Cross-section of a dune showing cross-lamination typical of wind-blown sand.

ported by the evidence at hand and will be given here first, supplemented by remarks on other ideas.

Briefly, Talmage and Wootton believe that the ancestral Lake Lucero, which was of much larger extent than the present playa, concentrated the salts in its waters upon evaporation to the extent that gypsum was deposited within the silt that formed the sides and bottom of the lake as yellow "giant crystals" up to four feet in largest dimension, though most are about one foot long. The gypsum and other salts in the lake were derived from the surrounding mountains. Destruction of the silt banks to the west of the present lake over a distance of at least 12 miles in a north-south direction has yielded dunes of yellow cleavage fragments as much as a quarter inch across just east of the lake. The yellow color of the gypsum results from inclusions of yellow silt in the crystals and fragments. Still farther to the east are dunes of finer cleavage fragments, still yellow. In dry seasons these dunes and the lake bed develop a thin coating of fresh gray fine gypsum crystals.

East of the cleavage dunes are gray gypsite hills, which appear to be stabilized cleavage dunes that have been compacted and cemented by ground water. Long weathering appears to have reduced the yellow iron oxide in the silt to gray and produced a loosely consolidated mass of fine gray gypsum crystals, such as those which form surface coatings on the more westerly dunes, throughout the entire mass. Destruction of the gypsite hills yields fine-grained gypsum and silt. "The gray silt is liberated as a fine powder which is winnowed out and carried away, even by gentle breezes. The gypsite proper breaks down into fine grains, free from silt and perfectly white, which are carried up into the dazzling white mounds most characteristic of the white sands proper."

"The strips designated as the zones of cleavage dunes, of gypsite hills, and of white sands proper are not sharply separated but overlap to a considerable degree. This indicates merely that there are in the area dunes of several generations, and that the whole process of selective winnowing and recrystallization is still operative."

So, even today, Nature is operating a hydraulic mining and concentrating plant that dwarfs man's puny efforts.

Other theories may be summarized as follows:

Meinzer and Hare (1915): The gypsum is derived from gypsum beds in the "Pennsylvanian" rocks outcropping in the mountains. Since it is comparitively soluble it was brought to the low interior of the basin chiefly in solution in the surface and underground waters, and was redeposited when these waters evaporated, either from desiccating lakes or from springs or wet areas fed from underground sources. The deposits thus formed have been altered and further transported by repeated resolution and redeposition and by wind work. (Essentially a shorter explanation similar to that of Talmage and Wootton).

Darton (1928) and Winchester (1933): "The gypsum has been brought to the surface by a seepage of water, probably from the underlying Chupadera beds, and deposited on the surface in crusts, which have crumbled to sand and in the course of many centuries have been piled by wind into great dunes covering many square miles." (Apparently the importance of the lake beds was unrecognized.

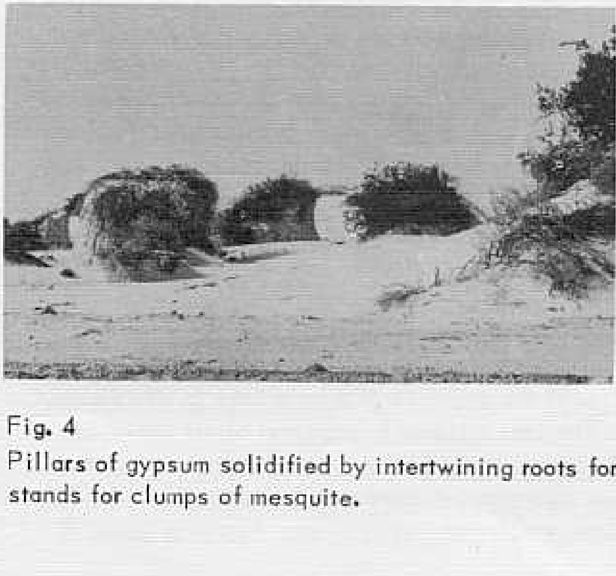

Fig. 4
Pillars of gypsum solidified by intertwining roots form stands for clumps of mesquite.

Richard (1932): Crystals of gypsum were formed by instantaneous crystallization from saturated waters of Lake Lucero when the wind formed waves and spray. The source of the gypsum was erosion into the lake.

Botkin (1933): An enormous deposit of large crystals was formed in sediments over a long period of time, the sands being a comparatively recent and rapidly formed product resulting from wind erosion and weathering of the materials of the dry lake bed. East of the lake outliers of coarse wind-blown crystals capped by vegetation show by their bedding that high dunes of this material recently existed in the region. (A penetrating, though incomplete analysis.)

Russell (1935): Similar to Darton, but agrees that some gypsum may have been brought into the basin by erosion from surrounding gypsiferous sediments.

As may be seen, Talmage and Wootton were the first to synthesize all the data at hand into a completely logical explanation.

The Dunes

The dunes of the white sands are typical of many barchan-type sand dunes in all parts of the world. The slip-off slope is steeper than that of most dunes of quartz sand however, because the gypsum crystals are very angular and give the sands a steep angle of repose. The dunes may be as much as 50 feet high, but most are smaller. They are cross-laminated internally, as seen in areas where the road has been cut across the margins of several dunes (Fig. 3). These shifting sands lie on an essentially flat surface of cemented gypsum related to the water table. This surface is exposed at many places in long "bays" between the dunes. The marginal areas are covered by sparse vegetation (Fig. 2), but the central part of this gypsum sand sea supports no plant life.

No systematic measurements have been made of dune movements. However, it is easy to see if one is present during and after a wind storm that some of the dunes advance intermittently at the rate of 2 to 3 feet in a period of several hours under special conditions. The advance of one dune was measured at 240 feet in one year. But estimates of average movements are given as 6 to 8 inches per year on the perimeter, where the dunes are more stabilized by vegetation, and upwards of 100 feet per year in the interior. The prevailing winds are westerly and the margin of the sands is moving slowly eastward.

Flora and Fauna

The flora and fauna of the white sands make an interesting study in themselves. Over 60 species of plants grow in the white sands, but of these all but a few are restricted to the interdunal bays. However, yuccas and several types of bushes and trees possess the ability to grow longer roots when the dunes advance over them. Yuccas have been found with roots extending over 40 feet through the dune sands. Of these plants, the Yuccas are the only ones that can survive disinterment. The others usually preserve their root systems by binding the sand together into pillars of hardened gypsum which are left behind by the advancing dunes (Fig. 4). The adaptation of these plants to conditions so severe that the water they use is a saturated solution of calcium sulfate is remarkable.

Interestingly, natural selection has left only pale forms of most animals to inhabit the white dunes. Especially noteworthy are the colorations of the pocket mice which inhabit the area. They are white in the dunes, reddish in the surrounding reddish-colored hills and flats, and almost black in the lava area to the north.

Economic Value

As may well be imagined, the amount of gypsum in the Tularosa basin sediments and the white sands combined is staggering. Talmage and Wootton (1937) have calculated that the white sands alone contain about 4.5 billion tons, based on an average thickness of 15 feet, an areal extent of 270 square miles, and 25 cubic feet of gypsum per ton. The gypsum sand is about 96 percent pure. The total gypsum in the basin is estimated as about 40 billion tons. In the white sands proper, outside the National Monument alone, there is enough gypsum to supply the needs of the United States at the present rate of consumption for about 325 years. Unfortunately, this gypsum is not now of economic value because of the distance to markets where it could not compete because of the high freight rates. And indeed, if it were, it could not be exploited because it is on a Federal reserve.

Such is the story of the White Sands, one of the world's strangest and most spectacular deserts. "Here is a unique bit of America. The loveliness of its white and green, the cleanliness of its vast expanse, and its appeal to the lover of the unexplored mark it as an area which attracts those discerning travelers who would see Nature's masterpieces."

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OUTLINE OF THE STRATIGRAPHY AND STRUCTURE OF THE SACRAMENTO MOUNTAIN ESCARPMENT

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INTRODUCTION

The Sacramento Mountains form one of the major mountain masses in southern New Mexico. About midway between the east and west borders of the state, these mountains extend northward for 40 miles from a point about 40 miles north of the Texas border. The mountains are sharply asymmetrical and rise abruptly in two major steps to a mile above the Tularosa Basin on the west. From the crest, the range slopes almost imperceptibly eastward to the Pecos River, 80 miles away and about 6000 feet lower. Although the crest of the range lies about 9000 feet for more than 20 miles, no part is as high as 9700 feet. The Sacramento Mountains are a large east-dipping cuesta, uplifted on the west side along a normal or gravity fault zone. In this sense, they are structurally similar to, and en echelon with the Guadalupe Mountains to the southeast, and the Oscura Mountains to the northwest. The stratigraphic section is almost entirely composed of Paleozoic rocks, ranging in age from Cambrian (?) to middle Permian. Rock units of this area have many similarities with the Paleozoic sections of the Basin Ranges farther to the west, visited by the previous Field Conference, and with the down-dip subsurface sections of southeastern New Mexico. The outcrops along the Sacramento Mountain escarpment are the closest major surface exposures in the state to the subsurface pre-Permian stratigraphic section of southeastern New Mexico, a part of the section which has been of increasing significance in petroleum exploration in recent years.

This brief paper is designed to supplement the road log and the discussion at the stops in presenting the salient geological features of the western escarpment of the Sacramento Mountains, with particular reference to those features that will be seen during the Fifth Field Conference. An index map of the western part of the Sacramento Mountains is included. A generalized geologic map of the northwestern part of the escarpment area that will be viewed or visited during the Field Conference accompanies this paper. Essentially this same map was used during the 1949 G.S.A. field trip sponsored by the West Texas Geological Society (King, et al 1949). A composite stratigraphic section of the pre-Cambrian and Paleozoic rocks will be found in the guidebook and the structural features along two east-west cross sections from the base to the crest of the range are given elsewhere in this guidebook. Several aerial views of the western escarpment are shown.

The writer has worked intermittently in the escarpment area of the Sacramento Mountains since 1947, and has mapped most of the western escarpment and part of the crest of the range at a scale of two inches equals one mile. Geologic maps and a report will be published by the New Mexico Bureau of Mines and Mineral Re-

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