Geology of the Tularosa Basin, New Mexico

William M. Sandeen

1954, pp. 81-88. https://doi.org/10.56577/FFC-5.81

in:

Southeastern New Mexico, Stipp, T. F.; [ed.], New Mexico Geological Society 5 th Annual Fall Field Conference Guidebook, 209 p. https://doi.org/10.56577/FFC-5

This page is intentionally left blank to maintain order of facing pages.

GEOLOGY OF THE TULAROSA BASIN, NEW MEXICO

by

William M. Sandeen[1]

The Tularosa Basin occupies the geographic depression separating the Sacramento-Sierra Blanca Chain From the Organ-San Andres-Oscura Chain on the west. The northern limit is picked at the contact between the Cenozoic and Pre-Cenozoic beds as shown on the State map. Southward, it merges almost imperceptibly into the Hueco Bolson. A logical dividing line is the narrow area west of the Jarilla Mountains.

Structurally, the Tularosa Basin is a graben capped by bolson deposits (valley fill). Tilted fault block mountains, with the upraised fault scarps rising more than 3,000 feet above the desert floor, dip away from the valley on the east and west side. A mantle of Cenozoic deposits of varying thicknesses, consisting largely of gypsum and quartz sand, obscure the underlying Paleozoic and Mesozoic sediments. Much of the valley fill appears to have originated from the erosion of the Yeso formation. In places the gypsum was dissolved and later precipitated in the various playas such as Lake Lucero. A series of scattered Permian limestone knolls trend due north from the Jarilla Mountains in the central portion of the valley and suggest the presence of a buried anticline or fault block ridge. Topographically, the nadir of the basin parallels the San Andres Mountains and terminates in Lake Lucero. In view of the fact that no significant wells have been drilled in the Tularosa Basin proper, it will be necessary to discuss the stratigraphy of the region on the basis of outcrops in the adjacent mountain ranges.

STRATIGRAPHY

Sedimentary rocks ranging in age from Cambrian through Recent are present in the region. Although Triassic rocks are found in the northern portion of the basin near Carrizozo and are exposed near the Jicarilla and Capitan Mountains, no Jurassic units are known. The Pre-Mississippian sedimentary beds thin depositionally and erosionally northward to the Oscura Mountains, where they pinch out completely.

Cretaceous, Triassic and possibly Jurassic sediments are present in the northern portion of the area and Cretaceous sediments may underlie portions of the southern end of the Basin.

PRECAMBRIAN ROCKS

The major outcrops of Pre-Cambrian rocks are found along the east front of the San Andres Mountains and are present on the western and southern flanks of the Oscura Mountains. Several scattered outcrops are located in the Sacramento Mountains southeast of Alamogordo. The Pre-Cambrian rocks generally consist of a coarse pink granite, but vary locally.

Schists, quartzites, and other metamorphic rocks frequently overlie the granite or are present as inliers. Such relationships are seen in the San Andres and Sacramento Mountains. Although the maximum thickness for any one of the metamorphosed units in the Tularosa Basin area is less than 100 feet, Richardson (1909) reported the presence of 1,800 feet of Pre-Cambrian Lanoria quartzite in the Franklin Mountains.

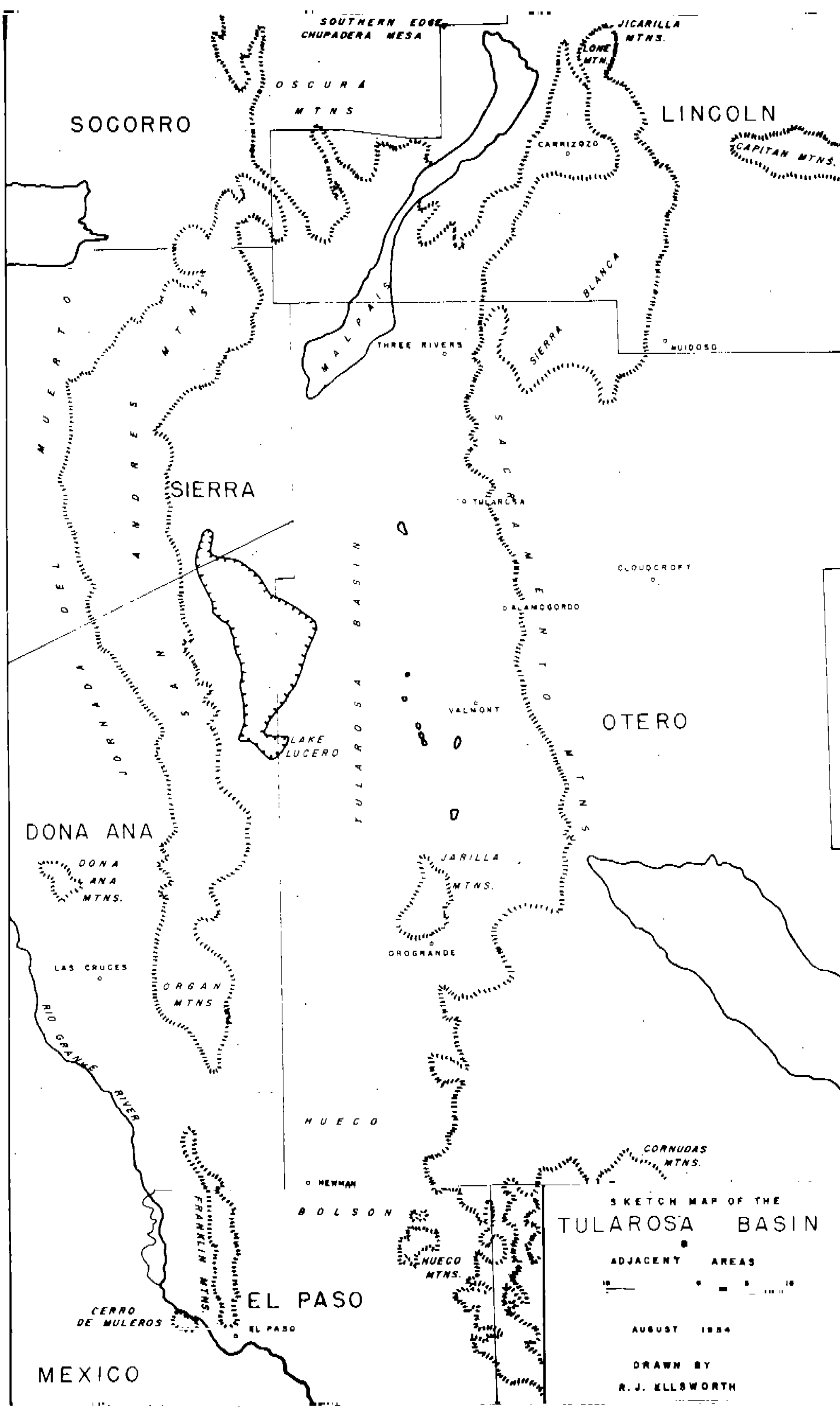
BLISS

The oldest Paleozoic formation, the Bliss sandstone, with its characteristic glauconitic and oolitic hematite beds is a basal sandstone unit which may transgress time boundaries from Upper Cambrian into the Lower Ordovician. Apparently the Bliss is younger in age to the north. The Bliss varies between 6 and 120 feet in thickness in the Sacramentos, and attains a maximum thickness of 16 feet in the Oscuras before pinching out in the central portion of this range.

EL PASO

The El Paso formation of Lower Ordovician age consists of a series of alternating limestones and dolomites which rest conformably on the Bliss throughout most of the region. The El Paso attains a thickness of approximately 400 feet in the Sacramento Mountains. It thickens southward to 1,000 feet in the Hueco Mountains and to 1,590 feet in the Franklin Mountains according to Cloud and Barnes (1946). Kelley and Silver (1952) have divided the El Paso of the Caballo Mountains to the west into the Sierrite and Bat Cave members. The Bat Cave contains stromatolitic reefs with associated bioherms and biostromes, by which it may be distinguished from the underlying Sierrite. These same units may be present in the San Andres and Sacramento Mountains. Although the El

1. Geologist, Standard Oil Company of Texas, El Paso.


SOUTHERN EDGE CHUPADERA MESA
JICARILLA MTNS.
LONE MTN.
OSCURA MTNS
SOCORRO
LINCOLN
CAPITAN MTNS.
CARRIZOZO
MALPAIS
SIERRA BLANCA
THREE RIVERS
RUIDOSO
SAN ANDRES MTNS
JORNADA DEL MUERTO
SIERRA
SACRAMENTO MTNS
TULAROSA
CLOUDCROFT
TULAROSA BASIN
ALAMOGORDO
VALMONT
OTERO
LAKE LUCERO
DONA ANA
DONA ANA MTNS.
JARILLA MTNS.
OROGRANDE
LAS CRUCES
ORGAN MTNS
RIO GRANDE RIVER
HUECO BOLSON
NEWMAN
CORNUDAS MTNS.
FRANKLIN MTNS
HUECO MTNS.
EL PASO
CERRO DE MULEROS
MEXICO
SKETCH MAP OF THE
TULAROSA BASIN
ADJACENT AREAS
AUGUST 1954
DRAWN BY
R. J. ELLSWORTH

ERRATA – GUIDEBOOK
FIFTH NEW MEXICO FIELD CONFERENCE

p. 18 Caption, line 6
Change "steamboat" to "Steamboat"

p. 18 Mileage 3.0, para. 3, line 6
Change "descernible" to "discernible"

p. 19 para. 3, line 3
Change "alwo" to "also"

p. 20 para. 3, line 2
Delete "the"

p. 21 para. 1, line 4
Change "prophyry" to "porphyry"

para. 1, line 5
Change "sulcoretopora anomalotruncate" to "Sulcoretopora anomalotruncata"

para. 4, line 8
Change "as much as" to "as much at"

para. 5, line 5
Change "prophyry" to "porphyry"

p. 23 Mileage 1.2, line 2
Change period after "here" to comma

p. 24 para. 1, line 4
Change "fusslinids" to "fusulinids"

p. 24 Caption, line 4
Change "Pig Canyon fault" to "Fresnal fault".

p. 25 Mileage 7.0, line 6
Delete "view in northern Sacramento Mountains toward east along New Mexico 83", and substitute "cross-section shown on page 27".

p. 27 Caption, line 2
Change "Plumbley" to "Plumley"

p. 28 Mileage 12.5, line 1
Delete comma after Abo

Line 2
Change "in" to "In"

p. 29 Mileage 13.4, para. 2, line 1
Change "exposure" to "exposures"

Line 5
Change "alteration" to "alternation"

p. 30 Mileage 16.6, line 8
Change left to right

p. 30 Mileage 18.0, line 7
Add "which" after above

line 17, Change "that" to "the"

p. 93 Add * after Bug Scuffle ls mbr* in Pennsylvanian.

p. 94 Column 2, para. 2, line 9
Change "controversey" to "controversy"

p. 95 Caption, line 2
Change "stratographic" to "stratigraphic"

p. 97 Column 2, line 11
Change "or" to "of"

p. 98 Column 1, para. 5, line 6
Change "lithology. Thickness," to "lithology, thickness," . . .

Column 2, line 1
Change "Rancheris" to "Rancheria"

Column 2, para. 2, line 6
Change "easternmost to "southeasternmost"

p. 99 Column 1, line 10
add (pages 102, 105) after photographs

Column 1, line 11
Add (page 18) after "one".

Column 2, para. 2, line 17
Change "Meremecian" to "Meramecian"

p. 100 Column 1, para. 2, line 2
Change "southeast" to "southwest".

Column 2, line 4, add "pre-Abo erosion" after "locally".

Column 2, para. 4, line 4, add "the" after "locally".

p. 101 Column 1, para. 4, line 4, Change 1,100 to 1,400.

Column 2, para. 1, line 7, change "Mountains" to "Mountain".

p. 103 Column 1, para. 2, line 2, add absence "of outcrops" of the . . .

Column 1, para. 2, line 3, change "Basin" to "basin"

Col. 1, para. 4, line 10, change "sturctural" to "structural"

Col. 1, para. 5, line 4, add after "drawing" (p. 22)

Col. 1, para. 6, line 2, change to read: "into two major groups"

Col. 2, para. 1, line 9, change "Mountain" to "mountains"

p. 104 Col. 1, par. 5, line 6, change "mesozoic" to "Mesozoic"

Col. 2, par. 2, line 10, "disturbances" should be "disturbance"

Col. 2, par. 3, "structure" should be "structures"

p. 107 Col. 2, line 19, delete "Age and"

p. 185 2nd para. from bottom, line 1, "Central" should be "central".

p. 186 Mileage 1.9. "Canyon" should be "canyon"

p. 187 line 6, "preceeded" should be "preceded"

line 9, "presumbaly" should be "presumably"

Mileage 5.2, line 8, change "sly Gap" to "Sly Gap"

Mileage 7.0, line 1, change "Tongue" to "tongue"

p. 188 Mileage 11.5, line 1. "In the Canyon" should be "In the canyon".

p. 189 Mileage 17.1 should read 17.3

Mileage 17.3, line 3, delete "of this knob"

Paso is equivalent to the Ellenburger of West Texas, no sediments comparable to the overlying Simpson shale of West Texas are known in this region. Simpson time here, however, could be represented by the deposition of a carbonate sequence included with the El Paso or may be represented by the Cable Canyon sand.

MONTOYA

The Montoya, according to Flower (1953), represents Richmond time (Ordovician). It is separated from the underlying El Paso by an unconformity and by the Cable Canyon sandstone wedge. This sandstone, named by Kelley and Silver (1952) from outcrops in the Caballo Mountains, varies from 5 to 36 feet in thickness and is widely distributed throughout southwestern New Mexico. Although Pray (1953) did not mention the Cable Canyon by name, he shows a sandstone unit, which attains a thickness of 12 feet, occupying a comparable stratigraphic position in the Sacramento Mountains. The Cable Canyon is probably present in the San Andres Mountains.

Kelley and Silver (1952) have divided the Montoya of the Caballos Mountains into the Upham, Aleman, and Cutter, while Pray (1953) has subdivided this same sequence into two units in the Sacramento Mountains. The lower one, a massive cherty dolomite attaining a maximum thickness of 225 feet, retains the name Montoya, while the upper one, a light gray sublithographic limestone, attains a thickness of 200 feet, and has been named Valmont. According to Darton (1928), the Montoya in the San Andres Mountains thins from 200 feet in the southern end to about 30 feet in the northern portion, and pinches out in the Oscura Mountains.

FUSSELMAN

Silurian time is represented in the Tularosa Basin by the Fusselman dolomite, which pinches out north of Sulphur Canyon in the San Andres Mountains and is absent in the northeastern portion of the Sacramentos. In both ranges it attains a thickness of not more than 100 feet, but thickens rapidly southward toward its type section in the Franklin Mountains, where it is 1,000 feet thick. The exposures in the Franklin Mountains are on the east flank of the Southwestern New Mexico Silurian Basin, which is centered in the vicinity of the Florida Mountains, where Kelley and Bogart (1952) have reported a thickness of 1377 feet of Fusselman.

DEVONIAN

The Devonian unconformably overlies the Silurian Fusselman dolomite. A local post-Silurian uplift is well represented in Ash and San Andres Canyons of the San Andres Mountains, where according to Laudon and Bowsher (1949) the Devonian Onate formation was deposited directly on an eroded El Paso surface. Northward, however, in Lostman and Andrecito Canyons the siltstones and shales of the Onate rest directly on the Fusselman. This indicates, assuming these correlations to be correct, that several hundred feet of the Montoya and Fusselman, which are present to the north, have been removed by erosion in the vicinity of Ash and San Andres Canyons. The aggregate thickness of all Devonian units in the San Andres Mountains is approximately 80 feet compared to about 100 feet in the Sacramentos.

The Middle Devonian Canutillo formation, outcropping in the Franklin Mountains (Nelson, 1940) is the oldest Devonian representative in southwestern New Mexico. Here these shales, siltstones, cherts, and limestones total approximately 175 feet in thickness.

Stevenson (1945) recognized and named another Middle Devonian unit, the Onate, which is restricted to the San Andres and Sacramento Mountains. These siltstones and shales average about 40 feet in thickness and are correlated with the Canutillo by Stevenson (1945).

The Upper Devonian units in ascending order are the Sly Gap and Contadero formations, both of which consist of shales, limestones, and siltstones with wide lateral facies variations and the Percha shale which has been divided into a basal Ready Pay member and an upper Box member.

The Percha has been correlated with the "Mississippian" Woodford shale of the Permian Basin. Lloyd (1949) mentions Ellison's studies (1946) based on condonts and fossil wood and feels that there is strong evidence to support the view that the Woodford is Upper Devonian. Flower (1953) states that a late Devonian age for the Percha is indicated by clymenid ammonites Stainbrook, (1947) who recognized megafossils of both Devonian and Mississippian aspect, concluded that it is Mississippian. Stratigraphically there is no reason why the Percha Woodford facies may not cross the system boundry and include both Mississippian and Devonian rocks.

MISSISSIPPIAN

The Mississippian is separated from the underlying Percha by an unconformity and is characterized by numerous facies changes. The basal Mississippian representative in the region is the Caballero formation (Kinderhook), a gray calcareous shale and nodular limestone, which attains a thickness of approximately 60 feet in both the San Andres and Sacramento Mountains.

Laudon and Bowsher (1949) have divided the Lake Valley (Osage) formation into the following members (ascending order): Andrecito, Alamogordo, Nunn, Tierra Blanca, Arcente, and Dona Ana. The Lake Valley consists of a series of limestones and shales with some siltstones. The overlying Las Cruces and Rancheria (Meramec), silty gray thin-bedded limestones, are both present in the San Andres and Sacramento Mountains and are separated from the Lake Valley formation by a marked unconformity. The Helms formation (Chester), largely a siltstone and shale sequence, is also represented in the Sacramento Mountains. Probably the aggregate thickness of the Mississippian at any one locality in the Sacramentos is not more than 400 feet.

The Mississippian in the San Andres Mountains averages approximately 200 feet, but locally it has a thickness of as much as 285 feet. The Mississippian pinches out rapidly in the northern end of the San Andres Mountains. It is approximately 20 feet thick in Mockingbird Gap and is absent in the Oscura Mountains.

PENNSYLVANIAN

One of the most pronounced Paleozoic unconformities in southern New Mexico occurs between the close of the Mississippian and the beginning of the Pennsylvanian. The Pennsylvanian seas which first inundated the area at the beginning of Pennsylvanian time were controlled in southwestern New Mexico by two extensive land masses. One of these, lying to the northeast of the Tularosa Basin and trending southward to the Guadalupes, was the Pedernal Uplift. This positive area with its southernmost extension provided an effective barrier between southwestern New Mexico and the Delaware Basin. The other dome controlling the pattern of sedimentation for the period was the Zuni Uplift if Valencia County. The Tularosa Basin was one of the three negative areas in New Mexico at that time. As the higher Pennsylvanian seas transgressed across highly irregular surfaces near shore, clastics were deposited around the flanks of these uplifts, followed by shelf carbonates, reef limestones, and in the deepest waters basinal shales. Subsequent crustal movements and truncations have made these relationships difficult to decipher.

The Pennsylvanian of the Tularosa Basin is characterized by lateral faciés changes varying from gray shales to near shore clastics. Probably the most satisfactory solution for the subdivision of the Pennsylvanian was the work of Thompson (1942), who divided the Pennsylvanian into series on the basis of fusilinids. Unfortunately, later workers have tended to reject his subdivisions because they were not mappable units, but the writer proposes that they be retained for at least regional considerations and that facies differentiation be used to supplement the series definitions.

This classification shown below retains the major series definitions used by Thompson (1942)

CLASSIFICATION OF THE PENNSYLVANIAN SYSTEM IN SOUTHWESTERN NEW MEXICO

Names commonly used in Southwestern New Mexico	Names commonly used in West Texas
Virgil series	Cisco series
Missouri series	Canyon series
Des Moines series	Strawn series
Atoka series	Bend series
Morrow series	Morrow series (present in southeastern New Mexico)

Approximately 3,000 feet of Pennsylvanian is present in the Sacramento Mountains and about 3,200 feet in the San Andres Mountains. Northward in the southern Oscura Mountains this section thins to approximately 2,400 feet and to less than 900 feet at the north end of this range.

The Pennsylvanian section is quite variable lithologically and may be generally described as consisting of near shore clastics, inner shelf carbonates, marine limestones, and shales. Virgil reefs have been described from the Sacramento Mountains by Pray (1953).

PERMIAN

The Permo-Pennsylvanian boundary is poorly defined throughout most of the region. The base of the Abo red shales and sandstones is generally regarded as the base of the Permian throughout much of southwestern New Mexico, but the Bursum carbonate wedge is present beneath the Abo in the vicinity of the Tularosa Basin. Bursum age limestones have been recognized as far south as the Robledo Mountains by Kottlowski (1953).

Basal Permian lithologies transgress time boundaries. The contact between the Pennsylvanian and Permian is gradational in local areas of deposition, but is unconformable in the regions of uplift. Read and Wood (1947) have shown that the Abo interfingers with the Pennsylvanian in the Manzano Mountains to the northwest of the Tularosa Basin. Northward the Bursum also interfingers with the Pennsylvanian, while in the Sacramento Mountains it interfingers with the Abo. Southward in the Hueco Mountains of Texas the clastics of the Abo and Yeso are represented by the Hueco limestone. This region was also an area of uplift, as evidenced by the Powwow conglomerate (Wolfcamp), which rests directly on an eroded Virgil surface in the Huecos.

The Type section of the Bursum formation is located about five miles west of the granite outcrops along the west side of the Oscura Mountains. Here it consists of arkose, reddish purple shales, and limestone. The red shales and sandstones of the overlying Abo are quite variable in thickness and range from about 400 to 1,000 feet in the vicinity of the Tularosa Basin. The maximum thickness of the Abo, about 1,400 feet, was encountered in the Standard of Texas # 1 Heard Well, which was drilled about 8 miles northwest of Carrizozo. The overlying Yeso, consisting of gypsum, red and yellow siltstones, and limestone, also attains a maximum thickness of about 4,000 feet in this well. The average thickness of the Yeso is approximately 1,000 feet elsewhere in the vicinity of the Tularosa Basin, but may be thicker within basins of local deposition. The Standard of Texas # 1 Heard, which was drilled in such an area, also encountered a relatively thick sequence of salt within the Yeso. This suggests that portions of the Yeso section which have not been exposed to weathering may encounter a somewhat thicker sequence than can be measured in surface outcrops. The removal of salt may explain the contortions of the Yeso beds in the surrounding mountain outcrops. Another Permian representative in the region is the Glorieta sandstone, which intertongues with the Yeso and attains a thickness of several hundred feet in the vicinity of Chupadera Mesa. This is overlain by the limestones and dolomites of the San Andres, which attain a maximum thickness of about 700 feet in the Sacramentos. The upper portion of the San Andres has been removed by erosion throughout most of this region.

TRIASSIC AND JURASSIC

Triassic rocks are present in surface outcrops near the northeastern edge of the Tularosa Basin. They outcrop near Carrizozo, are present in a wide band near the Capitan, Sierra Blanca, and Jicarilla Mountains, and are present in several scattered outcrops near the Oscuras. Northeastward in the vicinity of the Capitan quadrangle, for instance, approximately 350 feet of the Bernal, a red siltstone and medium-grained sandstone, is present. This is overlain by about 280 feet of Santa Rosa, a fine to coarse-grained buff sandstone containing thin lenses of conglomerate. The upper portion of the Triassic in this locality consists of the bright colored (red, green, and purple) mudstones and siltstones of the Chinle. Westward from Carrizozo the Triassic sequence consists of reddish purple silty shales and siltstones termed Dockum. The Sun # 1 Victorio Land and Cattle Company, T 10 S, R 1 W, abandoned wildcat, drilled in the Jornada del Muerto, encountered 150 feet of this sequence.

No Jurassic rocks are known in this region.

CRETACEOUS

Erosion or burial has obscured the relationships of the Cretaceous throughout most of the Tularosa Basin. Evidence is available that Cretaceous seas once covered the entire region.

No Lower Cretaceous units are known to exist here, although outcrops are present along the west side of the Franklin Mountains, in the Hueco Mountains and in the Cornudas Mountains to the south.

Upper Cretaceous sediments are present in the northern portion of the region, where they are represented by the Dakota, consisting of a brown to white sandstone, varies in thickness from 80 to 130 feet throughout the region. It is overlain by the Mancos, which consists predominantly of about 450 feet of gray to black, sometimes green shales, containing thin limestone beds and sand lentils. Approximately 550 feet of the Mesaverde shales and sandstones can be measured in outcrops near the Capitan Mountains, but this is an incomplete section. Approximately 2,000 feet of Mesaverde has been measured near Elephant Butte Reservoir.

Cretaceous sediments parallel the west front of the San Andres and Oscura Mountains, but are usually obscured by bolson deposits. Although they have not been encountered in any wells drilled in the southern end of the Tularosa Basin, they are present in the Hueco Bolson to the south and may underlie most of the basin.

CENOZOIC DEPOSITS

The term bolson deposits is used here to describe the heterogeneous, poorly consolidated sediments which cover the underlying Mesozoic and Paleozoic sediments of the region. This name is derived from the term bolson, a flat-floored desert valley which drains to a central playa. This terminology is preferred because it is difficult to describe these deposits lithologically and age determinations are almost impossible to make.

The bolson deposits consist generally of fanglomerates, conglomerates, soft sandstones, caliche, shale, and gypsum. They include Tertiary beds such as those present in the vicinity of Three Rivers and La Luz Canyon, which probably represent the oldest known Cenozoic sediments present in the region.

These beds within the Tularosa Basin consist of red clay and silt intercalated with sands and conglomerates. Gypsum and salt beds have been deposited locally within the bolsons.

The maximum known thickness of bolson deposits which were encountered in the Tularosa Basin were found in a railroad well drilled approximately one and one-half miles west of Alamogordo, where approximately 1000 feet of section is present. No lithified sedimentary rocks were reported from this well. South of the Tularosa Basin proper in the northwestern portion of the Hueco Bolson three wells encountered more than 3,000 feet of bolson deposits. Sayre and Livingston (1945) report that the Cinco Minas test, drilled in the Hueco Bolson, was bottomed at 4,010 feet without encountering bedrock. The thickness of the Bolson deposits in the Hueco Bolson may range upward to 10,000 feet.

STRUCTURE

Southwestern New Mexico and the Tularosa Basin have undergone a great number of separate deformations commencing in Pre-Cambrian time and continuing intermittently to the present day. A brief understanding of these relationships is helpful in enabling one to obtain an idea of the present structural configuration of the Tularosa Basin and adjacent areas.

Evidence of an early submergence during Pre-Cambrian time is found in the metasedimentary units underlying the Bliss in the Sacramento and San Andres Mountains. The deepest known portion of this Pre-Cambrian Basin was in the vicinity of Van Horn, where 19,000 feet of metamorphosed units have been recognized by Flawn (1953). All of southern and central New Mexico appears to have been a positive land area for some time before the deposition of the Upper Cambrian Bliss Sandstone.

The Cambro-Ordovician seas advanced on this late Cambrian landmass from the south and southwest. Limits of the transgression occur somewhere in the vicinity of the northern Tularosa Basin. Pre-Devonian movement was largely epeirogenic and is represented by broad gentle downwarping to the south.

Widespread unconformities are found at the close of Silurian time and at the close of Devonian time. Laudon and Bowsher (1949) report a number of possible unconformities to be present within the Mississippian, which appears to have transgressed more widely than any of the earlier seaways. A widespread orogenic movement occurring at the close of the Mississippian, denuded most of the Mississippian sediments from Central New Mexico, leaving occasional outliers present in the vicinity of the Magdalena and Sandia Mountains.

The Pedernal uplift north and east of the Tularosa Basin controlled the pattern of sedimentation in the region during Pennsylvanian time. By the beginning of the Permian this hinge line had moved east of the Paleozoic axis to form a generalized positive trend connecting the Pedernal and Guadalupe regions.

Stead and Waldschmidt (1953) have discovered Pre-Cambrian granite in the Pump Station Hills south of the Cornudas Mountains, which is possibly a Pre-Cambrian batholith. They show a positive arch which trends northwestward through the Sacramentos into the Pedernal uplift and suggest that this may represent the divide between the Permian Basin and the Southwestern New Mexico Basin.

Although sedimentation was probably continuous from the Pennsylvanian into the Permian throughout a large portion of southwestern New Mexico, an unconformity is present southeast of the Tularosa Basin. In the Hueco Mountains this is marked by the Powwow Conglomerate which rests on a well-eroded Virgil surface. A more pronounced break is recorded by the Abo resting on the Missouri and Des Moines in the Sacramentos and on the Pre-Cambrian of the Diablo Plateau.

The Permian Cretaceous unconformity is widespread and is marked by a well-developed conglomerate in regions where the contact between the Lower Cretaceous and Permian can be seen. This was followed by the rapid invasion of Upper Cretaceous seas. If the Tularosa Basin was covered by Lower Cretaceous seas, most of these sediments were removed by erosion and are not known to be present. Volcanics interbedded with Cretaceous sediments elsewhere in southwestern New Mexico attest to the fact that movement was occurring during Lower Cretaceous time.

The most pronounced movement which occurred in the Tularosa Basin began with the Laramide revolution at the close of the Cretaceous. This was followed by the Cascadian revolution which set up the pattern of Basin and Range structure for the region. These two revolutions have had a pronounced effect on the present structural pattern. Kelley and Silver (1952) outlined the events which occurred in the Caballo Mountains as follows:

1. Laramide overturning and thrusting.
2. Miocene (?) high angle faulting and tilting and moderate folding.
3. Cascadian faulting, tilting, and regional uplift.
4. Quaternary faulting.

A similar sequence of events is suggested for the Tularosa Basin. Lasky and Hogland (1949) recognized six distinct periods of movement in the Santa Rita area, and Dunham (1935) recognized seven periods of movement in the vicinity of the Organ Mountains. The history of nearly every major mountain range adjacent to the Tularosa Basin during Cenozoic time appears to have been one of intermittent uplift.

BIBLIOGRAPHY

Bose, E., 1910, "Monografia Geologica y Paleontologica del Cerro del Muleros", Bol. Inst. Geol. Mex., No. 25.

Cloud, P. E., and Barnes, V. E., 1946, "The Ellenburger Group of Central Texas", Texas Univ. Bull. 4621.

Darton, N. H., 1928, "Red Beds and Associated Formations of New Mexico", U. S. Geolo. Survey, Bull. 794.

Dunham, K. C., 1935, 'Geology of the Organ Mountains", New Mexico Bur. Mines, Bull. 11.

Ellison, S. P., Jr., 1946, "Conodonts as Paleozoic Guide Fossils", Bull. Amer. Asso. Petro. Geol., vol. 30, no. 1, p. 99.

Ellison, S. P., Jr., 1949, "Subsurface Woodford Black Shale of West Texas and Southeast New Mexico", abstract, Geol. Soc. Am. Bull., Vol. 60, p. 1885.

Flawn, P. T., 1953, "Precambrian Rocks of the Van Horn Area", West Tex. Geol. Soc. Fall Field Trip Guidebook, p. 56.

Flower, Rosseau H., 1953, "Age of Bliss Sandstone", Bull. Amer. Assoc. Petrol. Geol., Vol. 37, no. 8, p. 2054.

__________, 1953 "Franklin Mountains Section", New Mex. Geol. Soc. Field Trip Guidebook, p. 15.

__________, 1953, "Paleozoic Sedimentary Rocks of Southwestern New Mexico", New Mex. Geol. Soc. Field Trip Guidebook, p. 106.

Heindl, L. A., 1952, "Gila Conglomerate", Arizona Geol. Soc. Field Trip Guidebook, p. 113.

Kelley, V. C., and Bogart, L. E., 1952, "Gym Limestone in New Mexico", Bull. Amer. Asso. Petrol. Geol., vol. 36, p. 1644.

Kelley, V. C., and Silver, C., 1952, "Geology of the Caballo Mountains", Univ. New Mex. Pub. in Geol., No. 4.

King, P. B., King, R. E., and Knight, J. B., 1945, "Geology of the Hueco Mountains, El Paso and Hudspeth Counties, Texas", Oil and Gas Inv. 36.

Kottlowski, Frank E., 1953, "Tertiary- Quaternary Sediments of the Rio Grande Valley in Southern New Mexico", New Mex. Geol. Soc. Field Trip Guidebook, p. 144.

Lasky, S. G., and Hoagland, A. D., 1948, "Central Mining District, New Mexico", 18th International Geol. Cong., London, p. 86.

Laudon, L.L., and Bowsher, A.L., 1949, "Mississippian Formations of Southwestern New Mexico", Geol. Soc. Am. Bull., Vol. 60, p. 1.

Lloyd, E.R., 1949, "Pre-San Andres Stratigraphy and Oil Producing Zones in Southeastern New Mexico", New Mex. Bur. Mines Bull. 29.

Meinzer, O. E., and Hare, R. F., 1915, "Geology and Water Resources of Tularosa Basin, New Mexico", USGS Water Supply Paper. 343.

Nelson, L.A., 1940, "Paleozoic Stratigraphy of the Franklin Mountains of West Texas", Bull. Amer. Assoc. Petrol. Geol., Vol. 24, No. 1, p. 37.

Pray, L.C., 1953, "Geology of the Sacramento Mountains", master's thesis, California Inst. of Tech., unpublished.

__________1953, "Upper Ordovician and Silurian Stratigraphy of the Sacramento Mountains", Bull. Amer. Assoc. Petrol. Geol., Vol. 37, No. 8, p. 1894.

Read, C.B., and Wood, G.H., Jr., 1947, "Distribution and Correlation of Pennsylvanian Rocks in Late Paleozoic Sedimentary Basins of Northern New Mexico", Journ. of Geol., vol. 55, p. 220.

Read, C.B., Wilpolt, R.H., Andrews, D.A., Summerson, C.H., and Wood, G.H., Jr., 1944, "Geologic Map and Stratigraphic Sections of Permian and Pennsylvanian Rocks of Parts of San Miguel, Santa Fe, Sandoval, Bernalillo, Torrance, and Valencia Counties, North-Central New Mexico", US Geol. Sur., Oil and Gas Inves. 21.

Richardson, G.B., 1909, "El Paso Folio", US Geol. Sur., Atlas, No. 166.

Sayre, A.N., and Livingston, P., 1945, "Ground Water Resources of the El Paso Area, Texas", USGS Water Supply Paper, 919.

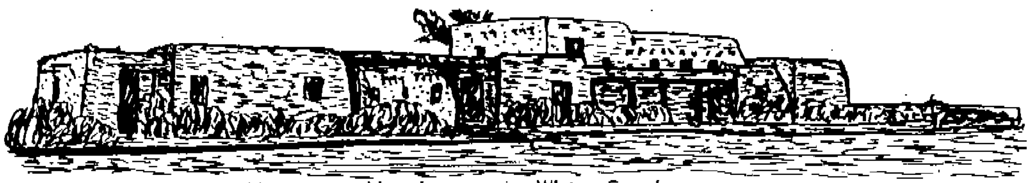
Stainbrook, M.A., 1947, "Brachiopoda of the Percha Shale of New Mexico and Arizona", Jour. Paleontology, vol. 21, no. 4, p. 197.

Stevenson, F.V., 1945, "Devonian of New Mexico", Jour. Geol., Vol. 53, p. 217.

Stead, F.L. and Waldschmidt, W.A., 1953, "Regional Significance of the Pump Station Hills", West Texas Geol. Soc. Field Trip Guidebook, Trans-Pecos Area, p. 71.

Thompson, M.L., 1942, "Pennsylvanian System in New Mexico", New Mex. Bur. Mines Bull. 17.

Wilpolt, R.H. and Wanek, A.A., 1952, "Geology of of the Region from Socorro and San Antonio east to Chupadera Mesa, Socorro County, New Mexico", U.S. Geol. Surv., Oil and Gas Inves. 121.



Monument Headquarters - White Sands

THE WHITE SANDS — A SHORT REVIEW

by
Henry L. Jicha, Jr.
New Mexico Bureau of Mines & Mineral Resources

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