



STRUCTURE OF OGALLALA FORMATION  
IN EAST-CENTRAL  
NEW MEXICO

by  
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and  
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Geotechnical  
Information Center

New Mexico State Bureau of Mines and Mineral Resources

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Target Exploration Report E-6

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by

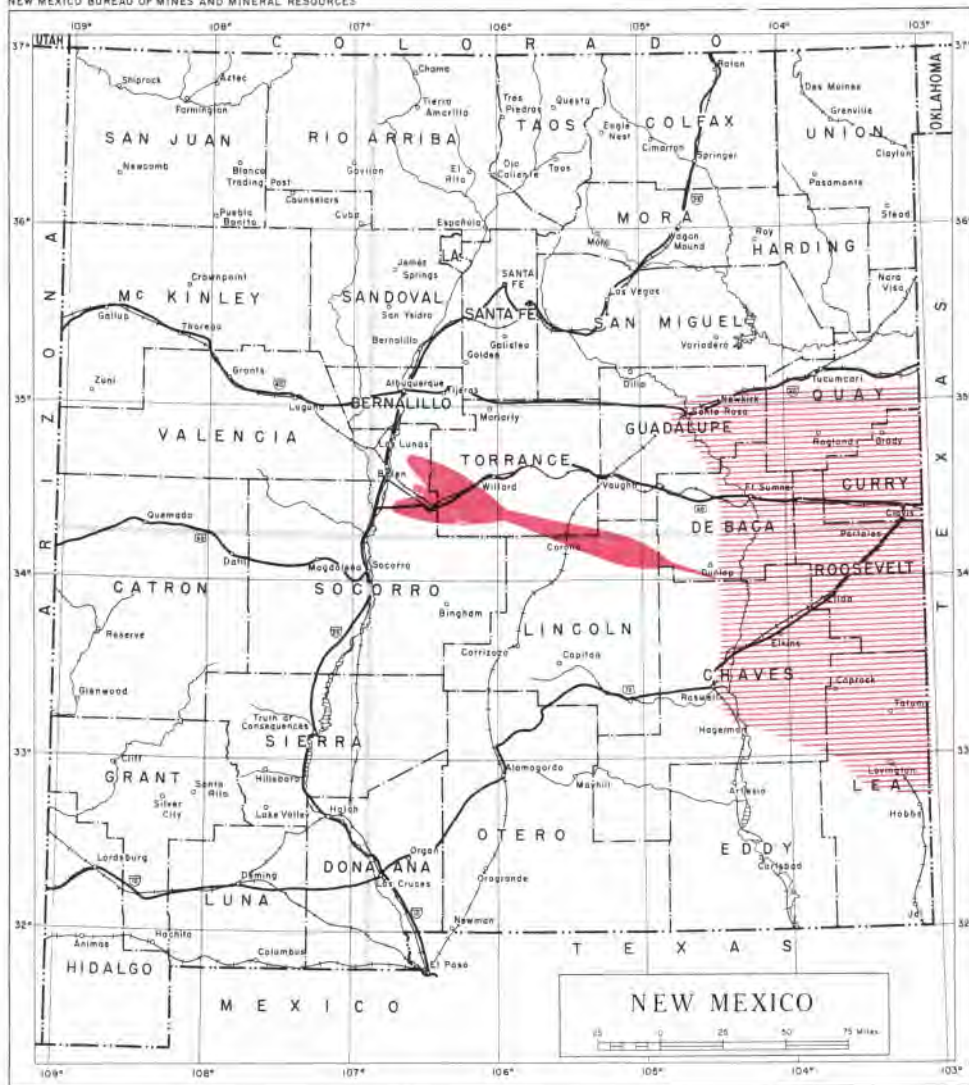
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*The main purpose of this series is the immediate release of significant new exploratory information which otherwise would have to await release at a much later date as part of a comprehensive and formal document. These data are preliminary in scope, therefore, subject to revision and correction.*

Socorro, 1972



## SUMMARY

Preliminary plotting of the elevation of the top of the Ogallala Formation (late Miocene and Pliocene) permits the construction of structure contours on this surface. The contours have been projected across the extensive areas from which the Ogallala has been removed by Pleistocene erosion; also across the many areas of Pleistocene subsidence. The contours have not been corrected for the initial depositional slope of the Ogallala deposits toward the southeast or the minor initial irregularities; nevertheless the contours indicate some structural warping during the Pleistocene.

## INTRODUCTION

In the Great Plains region, Ogallala outcrops are more widespread than any other Cenozoic rock-stratigraphic unit extending 800 miles north-south and over 300 miles east-west. The Ogallala consists of stream-deposited sediments that had their source in the mountains to the west; the deposits initially sloped east-southeast at a rather low gradient. Deposition was initiated in late Miocene time along stream channels across a subdued erosional topography. The channels were filled, and throughout much of the Great Plains region the accumulated alluvial deposits (flood-plain sediments interspersed with channel gravels) were thick enough to bury all but the highest elements of earlier Tertiary topography.

During late Miocene and early to middle Pliocene, the region was well watered, but became progressively drier (Frye and Leonard, 1957a) so that in late Pliocene time this alluvial plain ceased receiving alluvial deposits. With the cessation of alluviation, the uppermost sediments were modified by the development of a widespread, deep, pedocal soil, called the "Ogallala climax" soil. Soil formation occurred on top of the alluvial deposits of the Ogallala and on contiguous surfaces, but, for structural purposes, we are concerned here only with the soil that developed in alluvial deposits and not with that which draped over adjacent topography. During the succeeding episode of desiccation, accompanied by eolian scour, the soil lost the A and B horizons of its solum, and its thick caliche zone was brecciated. The brecciated caliche was recemented during pluvial intervals of the Pleistocene (Swineford, Leonard, and Frye, 1958), only to be followed by further episodes of aridity and brecciation interspersed with moist episodes of recementation, producing a complex, multigeneration rock. The surface of this brecciated soil caliche that mantled the surface of the alluvial is shown on the accompanying structure map. The structure of this surface reflects warping during Pleistocene time in east-central New Mexico.

## MEASURED SECTIONS

Ogallala deposits were recognized over a wide region by Johnson (1901) and by Darton (1905, 1920), and the name was assigned to the unit by Darton in 1905. Early descriptions were local in scope or were meager (Elias, 1931; Sellards and others, 1932), but recent descriptions and correlations cover the formation from Nebraska to southwestern Texas (Lugn, 1939; Condra and Reed, 1959; Frye and Leonard, 1957b, 1959, 1964; Frye, Leonard and Swineford, 1956; Merriam and Frye, 1954; Leonard and Frye, 1962; Frye, 1971).

Southward from the type area in Nebraska, the Ogallala Formation, in general, becomes somewhat thinner, but southward thinning is not uniform because the formation was deposited in ESE-trending valleys, and, therefore, locally thins and thickens north to south. The Ogallala becomes a terrace against the Cretaceous upland in Howard County, Texas (Frye and Leonard, 1968). Field work by the authors in east-central New Mexico during the summers of 1971 and

1972 has shown that the Ogallala is somewhat thinner in eastern New Mexico than it is to the east in Texas. In the northern part of this region of New Mexico the Ogallala ranges from more than 100 feet thick to less than 10 feet thick. Its character is illustrated by the Quay-Curry county line section and by the Ima section given below.

*Quay-Curry county line section*

(Measured along New Mexico highway 93, 9 miles north of Bellview, Curry County, New Mexico, 1971.)

Unit	Lithology	Thickness (feet)
<b>Pliocene Series</b>		
Ogallala Formation		
<i>Kimball zone</i>		
10	Limestone (indurated caliche) grading downward to sand; top 3 feet dense, gray limestone with pisolitic structure in irregular platy beds and with sand grains dispersed throughout; pisolitic structure disappears but limestone is dense and platy 3 to 6 feet below the top and has irregular zones of opal 5 to 6 feet below top; density of cement diminishes downward; lower half of unit contains pockets and irregular lenses of relatively loose red-tan sand.	8.0
9	Sand with some silt, gray to brown, massive, irregularly but not densely cemented.	5.0
8	Sand with some silt, reddish light-brown, massive with irregular blocky structure; irregular nodules of caliche throughout; locally a cemented zone at top.	10.0
7	Sand containing some silt and clay, tan-brown, massive but with strongly developed vertical jointing; contains several thin zones cemented loosely with caliche; an irregular cemented zone at top.	15.0
<i>Ash Hollow zone</i>		
6	Sand, gray-tan, bedded, interbedded with bands of caliche; prominent zone of caliche cement at top.	12.0
5	Gravel, sand, and some silt, poorly sorted but bedded, irregularly cemented; gravels interbedded with fine sand and a zone of cemented fine sand at base; pebbles are approximately 80 percent derived from Triassic and other relatively local rocks.	5.0
4	Silt and sand with some clay and interbedded zones of nodular caliche, red-brown at base, gray and gray-tan; irregularly cemented sand.	8.0
3	Sand, massive, gray and tan, irregularly cemented in some zones; a few bands of nodular caliche.	10.0
2	Sand, bedded, gray-tan, interbedded with thin beds of silty sand, loose; locally a few dispersed pebbles.	14.0

Unit	Lithology	Thickness (feet)
1	Sand with some silt and pebbles, brick-red; pebbles of quartz up to 1 inch in diameter; cobbles of Triassic rocks up to 10 inches in diameter; top 1 foot is a rubble of Triassic cobbles; rests with sharp contact on purple, red, and greenish-gray siltstone, shale, and sandstones of the Triassic.	6.0
Total		93.0

*Ima section*

(Measured in pit and valley sides southeast of Ima, Quay County, New Mexico,  
9 miles N and 4 miles E of common corner of Quadalupe, De Baca,  
and Quay counties, 1971 )

Unit	Lithology	Thickness (feet)
<i>Pliocene Series</i>		
<i>Ogallala Formation</i>		
<i>Kimball zone</i>		
4	Limestone (indurated caliche), dense, irregularly platy; strongly developed pisolitic structures; sand grains dispersed throughout.	4.0
3	Limestone, dense, platy, gray; some travertine banding but lacks pisolitic structures; sand grains dispersed throughout.	4.0
2	Sand, irregularly cemented with caliche, pink-tan where uncemented and pink-gray where cemented; gradational at top and sharp contact at base; areas of loose sand in lower part.	15.0
1	Sand, reddish-tan, massive; contains some dispersed pebbles of Triassic and crystalline rocks; a few irregular zones of pebbles; sharp contact at base on Triassic sandstone.	8.0
Total		31.0

Southward in eastern New Mexico, the Ogallala becomes more uniform in character, and predominantly sand, lacking the prominent channel gravels, as is illustrated by the KBIM Tower section approximately 150 miles south of the two sections given above.

Because the Ogallala is an alluvial deposit, with an initial ESE slope that largely buried the pre-existing topography, the sediments reflect a primary source in the mountains to the west and a secondary source in the terrane they eventually buried.

*KBIM Tower section*

(Measured in erosional gulleys in west-facing scarp and in roadcuts, near Cedar Point triangulation station, 1½ miles north of lat. 33°00' and 8 miles east of long. 104°00', Chaves County, New Mexico, 1971)

Unit	Lithology	Thickness (feet)
<i>Pliocene Series</i>		
	<i>Ogallala Formation</i>	
	<i>Kimball zone</i>	
13	Sandstone, gray, densely cemented with CaCO <sub>3</sub> , massive to platy with travertine banding; lacks strongly developed pisolitic structures at this locality.	8.0
12	Sand, gray, densely but irregularly cemented with caliche; some pockets less cemented give cavernous appearance to scarp face; crenulate, platy structure in upper part.	12.0
	<i>Ash Hollow zone</i>	
11	Sand, loosely cemented but with pipes and sheets more densely cemented with caliche; closely spaced vertical joints.	8.0
10	Sand, gray-tan to pinkish-gray, massive, loosely cemented throughout.	12.0
9	Sand, tan, medium to fine, loose, massive.	4.0
8	Sand, gray to gray-tan, irregularly loosely cemented.	7.0
7	Sand, tan, massive, loose.	12.0
6	Sand, tan, massive, loose to weakly cemented with a moderately cemented zone at top.	10.0
5	Sand, gray, irregularly well cemented, lenticular, discontinuous.	1.5
4	Sand, tan, massive, loose, generally noncalcareous but with thin strands of pipe-like caliche.	18.0
3	Sand, gray, irregularly cemented with caliche; platy structure at top.	2.0
2	Sand, tan, medium to fine, massive, loose, generally noncalcareous.	4.0
1	Sand, gray, cemented loosely throughout; stringers and pipes of more densely cemented sand. Contact with Triassic not exposed but, judging from nearby exposures, it is only a short distance below this unit.	5.0
<b>Total</b>		<b>103.5</b>

## CALICHE

Structural mapping must be done on the top of the Ogallala Formation because the base of the formation was an erosional unconformity with several hundreds of feet of relief. Also, the top of the formation is a unique type of caliche. Soil caliche is widespread in the eastern part of New Mexico. If elevations were run on all indurated caliche encountered in the field, the result would be structural chaos. The caliche forming the top of the Ogallala therefore, must be differentiated from the several younger cemented caliches of the region.

In east-central New Mexico, three superficially similar indurated caliche units must be distinguished so that important late Cenozoic stratigraphic units can be recognized. The three caliche units are:

- 1) The pisolitic limestone (dense caliche) at the top of the Ogallala Formation—the thick caliche zone of the Ogallala climax soil that has been repeatedly brecciated and recemented.
- 2) The cemented caliche in the top of the extensive Kansan deposits, as the initial fill of the “Portales Valley” deposits and contemporaneous alluvial deposits in other, less extensive valleys.
- 3) The indurated caliche that caps the extensive soft-rock flanking-pediment surfaces dating back to the Kansan.

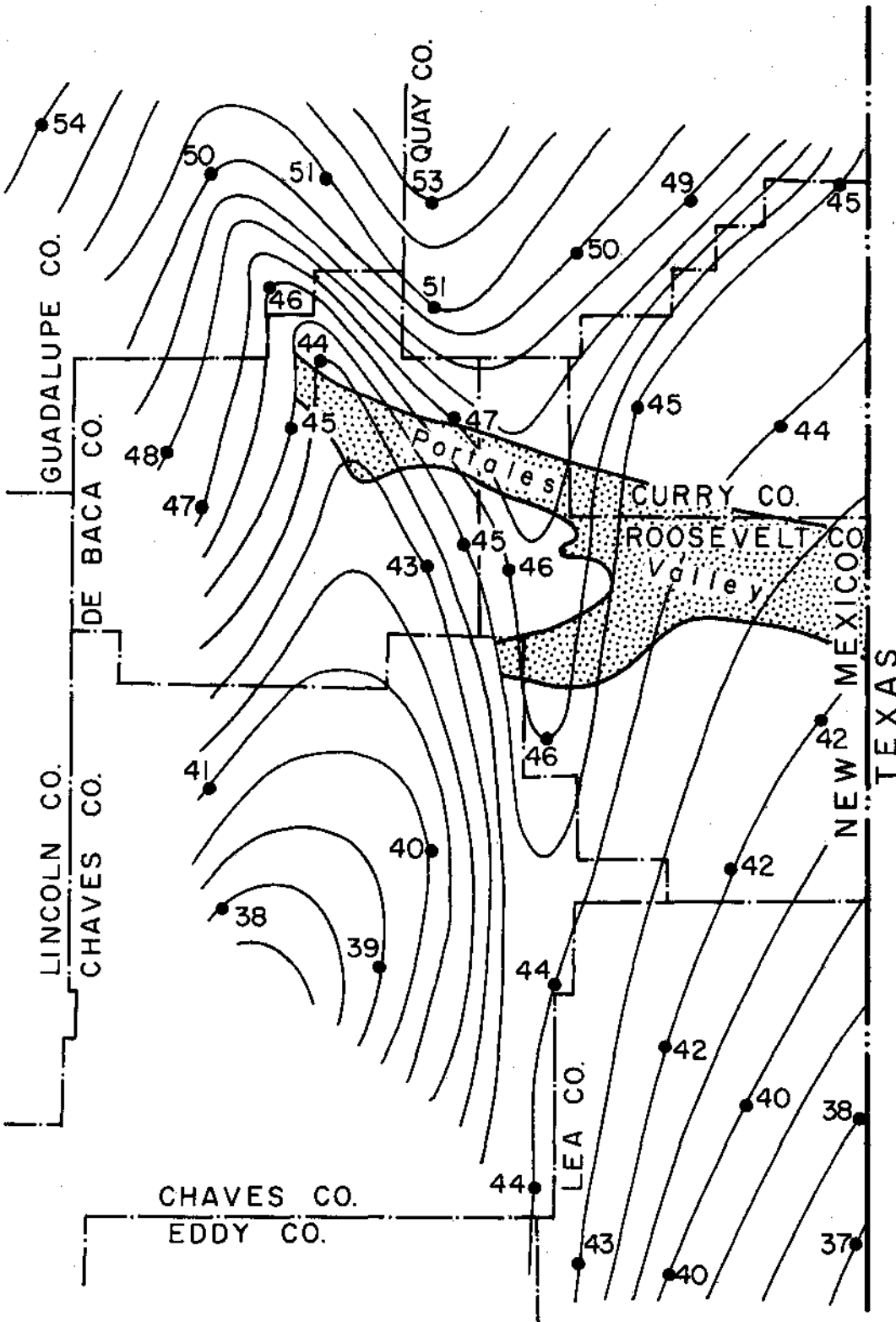
The younger Pleistocene caliches are less indurated and less mature, and generally can be easily differentiated from the above three. Measuring elevations of the caliche at the top of the Ogallala, where a satisfactory section is exposed is always more desirable. Where the exposure is small, being able to differentiate one caliche from another is helpful.

In differentiating the several caliche zones, their historical origins are important. The Ogallala climax caliche was a very thick soil caliche formed during the interval of semiaridity of the late Pliocene on the surface of the Ogallala alluvial plain. Ultimately, the climate became so arid that the A and B horizons of the solum were removed by wind action, or sheet wash, or both, leaving the caliche zone widely exposed at the surface. This same thing has now happened to the Kansan caliche in places in eastern New Mexico.

After the Tertiary, the Nebraskan and Kansan Ages were both intervals of high rainfall, separated by the low rainfall interval of the Aftonian. After Kansan time, the only episode of high precipitation was the Woodfordian Substage of the Wisconsinan, which was in turn followed by an interval of desiccation. This climatic succession dried and brecciated the caliche during at least four prolonged intervals of time. Following three of these intervals (although not the present one as yet), episodes of high precipitation partially dissolved and reprecipitated the calcium carbonate to recement the brecciated caliche. It is this dry-wet sequence that gave rise to the distinctive pisolitic limestone at the top of the Ogallala. The pisolites are fragments of dense caliche, surrounded and cemented by concentric layers of travertine.

The caliche capping the Kansan alluvial deposits is dense, platy, and ranges up to more than 4 feet thick and is locally quite hard and brittle and banded with travertine, and can be distinguished from the Ogallala by its lack of recemented brecciation.

The caliche capping the extensive early Pleistocene pediment veneers is equally as hard as the caliche capping the Kansan alluvial deposits, and locally approaches the density of the Ogallala pisolitic limestone. Occurring on the surface of a pediment may make the origin of this caliche obvious, but if this relationship is not clear from the gently sloping broad surfaces themselves, the composition of the caliche is distinctive. The caliche on the pediment veneers occurs largely as cementation of the poorly sorted rubble of the pediment. Commonly the caliche consists of gravel (in the southwestern part of this area, largely of carbonate rocks), sand, and some silt, cemented by calcium carbonate. In the upper part, the cobbles of carbonate rocks, including the detrital cobbles of Ogallala cemented caliche, are commonly solution-cusped in the top (a characteristic erroneously attributed by Bretz and Horberg (1949) to the Ogallala), with botryoidal caliche on the lower part. In some places the pediment caliches have travertine banding or platy structure in the upper part, but they do not show brecciation and recementation.



Structure contours on stratigraphic top of Ogallala

Elevations and locations from the 100-foot contour, 1:250,000 scale maps. Contours have been projected across areas where the Ogallala was eroded during the Pleistocene, and across collapse and subsidence areas; they have not been corrected for the initial depositional slope of the Ogallala deposits.

## STRUCTURE

By using points on the top of the Ogallala Formation, determined by stratigraphy and the character of the pisolitic limestone at the top of the formation, we plotted the contours shown on the accompanying structure map. The elevation of all points and locations of the points were determined from the 100-foot contours from maps in the United States topographic series on scale of 1:250,000. Therefore, the structure contours are preliminary. Also, the contours are projections of the structure of the top of the Ogallala Formation across erosional valleys and the many and extensive solution-subsidence areas.

Structural interpretation of the Ogallala Formation rarely has been attempted. Smith (1940, p. 136) suggested arching in western Kansas and extreme eastern Colorado; Merriam and Frye (1954) presented structure contours on top of the Ogallala for much of western Kansas, but generally the Ogallala has been assumed to represent only the post-Tertiary regional tilting of a generally uniform coalescent alluvial plain (Frye and Leonard, 1964; Frye, 1971). In western Texas the Ogallala has been assumed to have a regional slope of about 8 to 9 feet per mile toward the southeast. Although such a slope was several times the initial depositional gradient of the alluvial deposits, the uplift of the Rocky Mountains at the end of Tertiary time had accentuated the initial gradient.

The structure contours indicate that post-Tertiary warping has modified the attitude of the top of the Ogallala. Furthermore, the fact that the floor of the Portales Valley, on Kansan alluvial deposits, flattens west of Melrose, Curry County, and that the floor actually slopes westward east of Ft. Sumner, De Baca County, suggest that at least some of the warping took place after Kansan time.

In addition to the inherent inaccuracies, the structure contours do not indicate structural deformation only, because the surface on which they are drawn was not initially a horizontal surface. The top of the Ogallala coalescent alluvial plain had the initial irregularities of local topography that are characteristic of extensive alluvial deposits, as well as an unknown, though small, initial slope to the east-southeast; and post-Ogallala, pre-Pleistocene regional tilting in the same direction significantly increased this slope. Apparently, however, significant structural deformation of this region occurred during Pleistocene time.

An alternate explanation for the extensive trough that approximately parallels the present course of the Pecos River is that removal of salt by solution from the underlying Permian rocks lowered the entire topography along this belt. Arguing against such an interpretation, however, are the many sharply localized solution-collapse and solution-subsidence areas within this belt (how could they occur later in an area where extensive regional salt solution had previously taken place?) This alternative may be settled with certainty only by detailed subsurface data.

The foregoing is a preliminary statement of results of field work in this part of New Mexico. The data will be presented more fully in a subsequent report.

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