UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

SALT DEPOSITS OF THE CLOVIS-PORTALES AREA, EAST-CENTRAL NEW MEXICO

By

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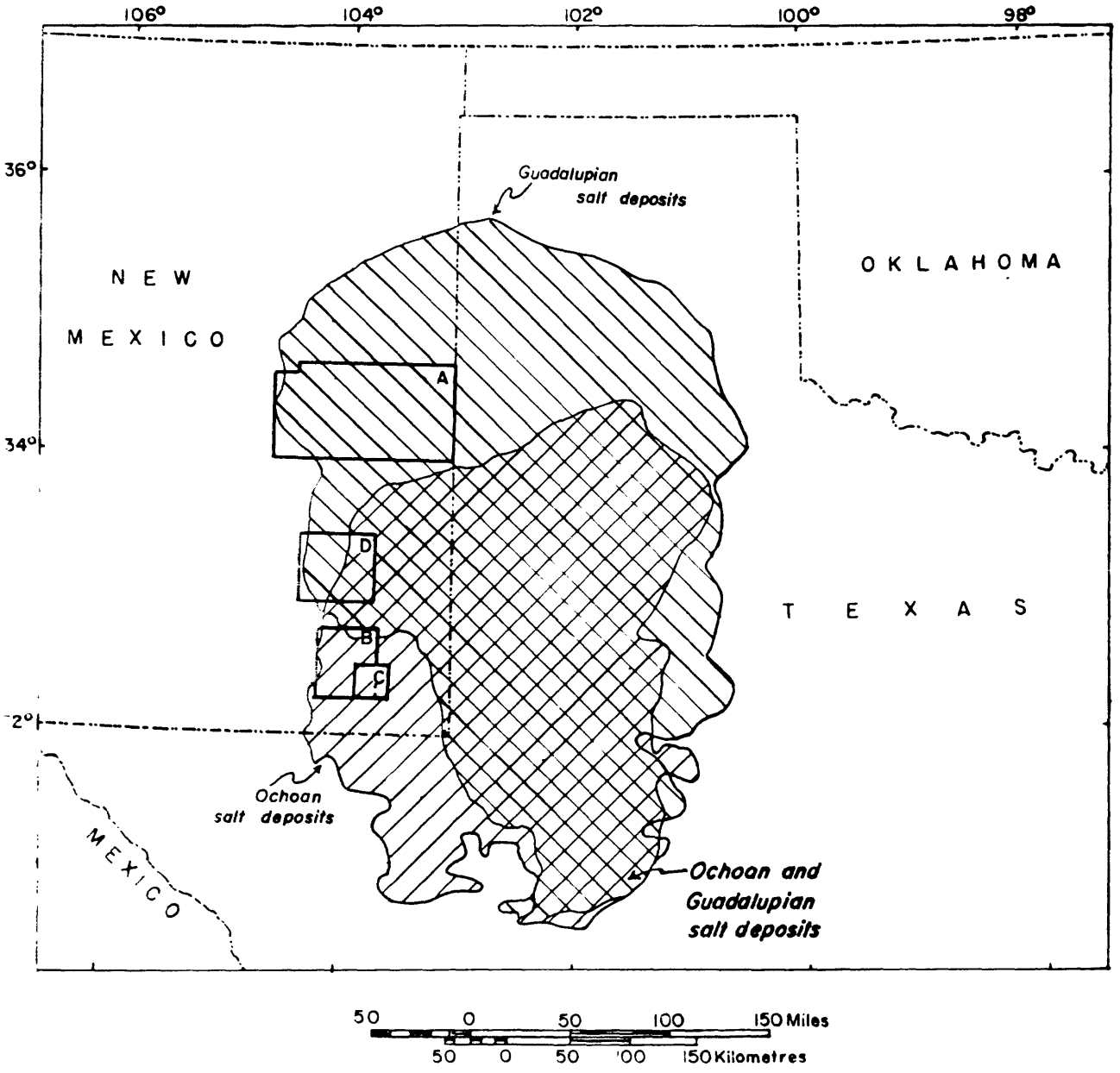

Figure 1.--Map of the Permian basin, southeastern New Mexico and western Texas, showing locations of: A, Salt deposits of the Clovis-Portales area (this report); B, Carlsbad potash area (Brokaw and others, 1972); C, Los Medaños area (Jones, 1973); and D, Mescalero Plains area.

records. All the boreholes from which data were obtained are listed in table 1 and are located on the isopach and structure maps (figs. 3, 5, and 7). The report and maps are of the reconnaissance type and are designed to outline the general characteristics, structure, and distribution of bedded salt deposits in the Clovis-Portales area of the Pecos River valley.

Acknowledgments.--D. M. Van Sickle and P. C. Aguilar assisted in obtaining borehole data and in contributing to a valuable discussion on the subsurface geology of the Clovis-Portales area.

Geography

The Clovis-Portales area covers 4,400 square miles (11,400 square kilometres) of east-central New Mexico about midway between the north and south boundaries of the State. The area straddles the western edge of the Llano Estacado and includes practically the full width of the Pecos River valley. The "Break of the Plains," a steep west-facing escarpment several hundred feet high, splits the area and separates the lowlands of the Pecos River valley and the flat upland surface of the Llano Estacado.

The area is predominantly rural, and its economy depends mainly on agriculture. Almost the entire eastern half of the area is cropland that is intensely utilized for irrigated farming; the rest of the area is mostly grassland devoted to raising cattle and sheep. There is little or no manufacturing, mining, or petroleum production.

Table 1.--List of boreholes with number, name, owner, location, and source of data for each

[Source of data: acs-gr, acoustic-gamma ray log; cal, caliper log; den, density log; es, electrical log; es-gr, electrical-gamma ray log; gr-den, gamma ray-density log; gr-ll, gamma ray-laterolog; gr-n, gamma ray-neutron log; snp, sidewall neutron porosity log; son-gr, sonic-gamma ray log; spl-PBSL, sample log-Permian Basin Sample Laboratory; spl-TPS, sample log-Texas Panhandle Sample Log Service.]

Borehole No.	Owner and name of borehole	Location T. R. Sec.	Source of data
1	Southern Petroleum Expl. Co. 1 R J Harrell	5 N. 31 E. 5	son-gr, cal
2	Snowden Oil & Gas Co. 1 Moberly	5 N. 32 E. 22	es
3	Tenneco Oil Co. 1 Garrett	5 N. 34 E. 31	son-gr, cal
4	Texas Gulf Producing Co. 1 Garrett	5 N. 34 E. 34	acs-gr, gr-n, cal
5	Slick-Moorman Oil Co. 1 Daugherty	5 N. 35 E. 4	gr-n, spl-PBSL, spl-TPS
6	Union Producing Co. 1 Jones	5 N. 37 E. 18	spl-TPS
7	Tenneco Oil Co. 1 Holt Mosley	4 N. 31 E. 12	son-gr, snp, cal
8	Cities Service Oil Co. 1 Widener	4 N. 31 E. 17	gr-n, es, spl-PBSL, spl-TPS
9	Tenneco Oil Co. 1 Linda Dougherty	4 N. 32 E. 28	son-gr, cal, snp
10	Shell Oil Co. 1 Stephenson	3 N. 32 E. 2	gr-n
11	Consolidated Oil & Gas Co. 1 Cash Ramey	3 N. 32 E. 13	gr-ll
12	Southern Petroleum Expl. Co. 1 J H Spearman	3 N. 37 E. 15	son-gr, cal
13	Southern Petroleum Expl. Co. 1 R L Keeters	2 N. 33 E. 2	son-gr, cal
14	Sunray D-X Oil Co. 1 W Crenshaw	1 N. 31 E. 14	son-gr, snp, cal
15	Abercrombie & Hawkins 1 Nappier	5 N. 26 E. 22	es-gr, spl-PBSL; Tait and others (1962, fig. 3)
16	Griggs, et al. 1 State	4 N. 26 E. 11	spl-PBSL
17	General Crude Oil Co. 1 Federal "B"	3 N. 23 E. 25	gr-n
18	General Crude Oil Co. 1 Federal "A"	3 N. 24 E. 6	gr-n
19	Stanfield & Francisco 1 Brown	3 N. 26 E. 7	Mourant and Shomaker (1970, p. 67-68)
20	Pure Oil Co. 1 Federal	3 N. 28 E. 31	es, gr-n, spl-PBSL, spl-TPS
21	Woolworth Hawkins 1 Myrick	2 N. 25 E. 17	es, spl-PBSL
22	Johnson & Stevens 1 Myrick	2 N. 25 E. 18	es
23	Texaco, Inc. 1 Earl Powell	2 N. 26 E. 7	acs-gr, den, cal
24	Katz, et al. 1 Mable Field	1 N. 22 E. 13	es, spl-PBSL, spl-TPS
25	Danciger Oil and Rfg. 1 State	1 S. 26 E. 26	Mourant and Shomaker (1970, p. 77-78)
26	Cities Service Oil Co. 1 Hobson	1 S. 27 E. 12	gr-n
27	J F McAdams 1 White	1 S. 28 E. 4	gr-n; Tait and others (1962, fig. 3)
28	Danciger Oil and Rfg. 1 State "A"	2 S. 26 E. 8	Mourant and Shomaker (1970, p. 78-79)
29	Nearburg & Ingram 1 Murray	3 S. 24 E. 23	gr-n
30	A D Engle 1 State "X"	3 S. 26 E. 8	Mourant and Shomaker (1970, p. 81-82)
31	Daryl Davis 1 State "B"	3 S. 26 E. 35	gr-n
32	Southern Petroleum Expl. Co. 1 Scott R Brown	4 N. 29 E. 30	son-gr, cal, snp
33	Southern Union Gas Co. 1 Lucas	2 N. 30 E. 5	es, spl-TPS
34	Southern Petroleum Expl. Co. 1 State "L"	1 N. 29 E. 5	son-gr, cal, snp
35	C H Osmond 1 Haynes	1 N. 36 E. 24	es, spl-TPS
36	Southern Petroleum Expl. Co. 1 Elizabeth M Hensley	1 S. 31 E. 17	son-gr, cal
37	Hanson Oil Co. 1 Blackwater Draw	1 S. 36 E. 17	gr-n
38	Getty Oil Co. 1 Wendell Best	2 S. 31 E. 14	gr-den, cal
39	Makin Drlg. Co. 2 McCabe	2 S. 31 E. 31	gr-n
40	Texaco, Inc. 1 A Parrish	3 S. 33 E. 27	gr-den, cal
41	Signal Oil Co. 1 Bell Federal	3 S. 33 E. 33	es-gr
42	Sunray D-X Oil Co. 1 J G Clapps	3 S. 35 E. 8	gr-den, cal
43	Transcontinental Oil Co. 1 J O McWhorter	3 S. 22 E. 6	Mourant and Shomaker (1970, p. 79-80)

The area is sparsely populated, and most of its inhabitants are in the towns of Clovis (28,000), Portales (11,200), and Fort Sumner (1,809). Clovis and Fort Sumner are served by U.S. Highways 60 and 84 and by the Atchison, Topeka and Santa Fe Railroad. U.S. Highway 70 and a branch line of the Atchison, Topeka and Santa Fe Railroad give access to Portales and parts of the Pecos River valley to the south of the Clovis-Portales area.

Previous studies

Published reports about the subsurface of eastern New Mexico have presented little information on the salt deposits of the region. Adams (1963) published an account of the stratigraphic distribution of salt in the Permian of eastern New Mexico and western Texas. Somewhat later, McKee, Oriel, and others (1967) summarized available data on the distribution of salt in the Permian of midcontinental United States.

Several reports that describe geology, regional correlation of stratigraphic units, and geomorphology of east-central New Mexico have been published, but only a few that are directly related to the Clovis-Portales area are mentioned here. Tait, Ahlen, Gordon, Scott, Motts, and Spitler (1962) published logs of boreholes in part of the area and presented data on the correlation of Upper Permian stratigraphic units in eastern New Mexico and western Texas. Dixon (1967) summarized the stratigraphy of Permian rocks and interpreted their condition of deposition. Kelley (1972) mapped the part of the area that is west of the 104° meridian in his geologic study of the

Fort Sumner 1:250,000-scale topographic sheet. Foster, Frentress, and Riese (1972) described the subsurface geology in part of the area that is north of T. 1 S. Reeves (1972) reported on the Tertiary-Quaternary stratigraphy and geomorphology in part of the area that is east of the Pecos River.

Ground-water resources of Permian and younger rocks in and near the Clovis-Portales area have been studied by Theis (1932) in parts of Curry and Roosevelt Counties and by Mourant and Shomaker (1970) in parts of De Baca County. Cronin (1969) summarized available data on the ground-water reservoir in the Ogallala Formation of the Llano Estacado.

Geologic setting

The Clovis-Portales area is part of the Permian basin--a composite sedimentary and structural depression which underlies much of eastern New Mexico and western Texas between the 101° and 104° meridians. In this basin, rock salt and other evaporite deposits accumulated during the Permian Period. The centers of evaporite deposition shifted from place to place as the Permian progressed, thus the thickness, succession, and character of the deposits are variable. In general, the upper or highest deposit containing rock salt is progressively younger from north to south (fig. 2), and the aggregate thickness of salt deposits increases southward. The clay and sand content of the deposits tends to decrease southward, and intercalations of thick units of sandstone and other clastic rocks are fewer in the south than elsewhere.

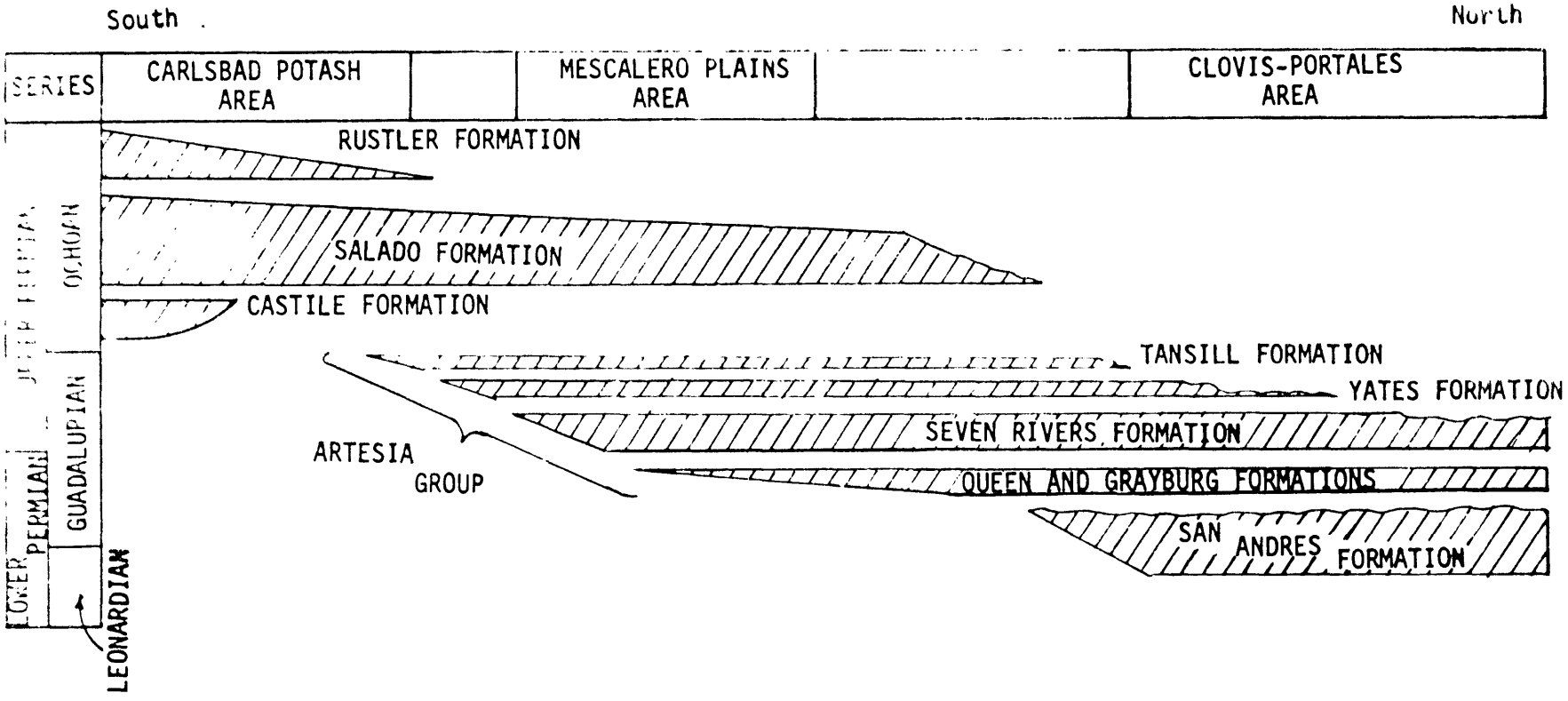

Figure 2.--Correlation of Permian salt deposits in the Clovis-Portales and other areas of the Pecos River valley, eastern New Mexico. Patterns indicate the extent and relative position of the salt deposits in each formation across southeastern New Mexico.

The salt deposits are in the San Andres Formation of the Leonardian and Guadalupian Series (Early and Late Permian age) and the Artesia Group of the Guadalupian Series (table 2). In general, the deposits in the San Andres are the thickest and contain the fewest intercalations of shale, anhydrite, and other rocks, whereas those in the Artesia Group are liberally impregnated with clay and are part of a red-bed sequence in which shale and sandstone are prominent constituents. The deposits in the San Andres and the Artesia are noticeably richer in detrital materials than those in the Ochoan Series of the Carlsbad potash area; but, insofar as has been determined, they are completely free of polyhalite and other hydrous saline minerals reported from the Ochoan salt deposits of the Carlsbad area (Brokaw and others, 1972, app. A).

In addition to the salt-bearing units listed in table 2, rock salt is present in the pre-Glorieta Abo and Yeso Formations of the Leonardian Series. Data on the two formations are meager and the extent, thickness, and general character of their salt deposits are unknown. The deposits are in a red-bed sequence consisting of shale and sandstone and lesser amounts of anhydrite and dolomite.

SALT DEPOSITS AND ASSOCIATED ROCKS

Glorieta Sandstone

The Glorieta Sandstone of the Leonardian Series (Early Permian age) conformably underlies the salt-bearing San Andres Formation. The Glorieta is a permeable sandstore which yields brackish water to wells in the western part of De Baca County and salt water to wells in the

Table 2.--Stratigraphy of Permian and younger formations in the Clovis-Portales area, New Mexico

System	Series		Formation		Lithology	Approximate thickness, feet (metres)
Quaternary					Alluvium, gravel deposits, and drifted sand	
Unconformity						
Tertiary	Pliocene		Ogallala Formation		Sandstone, siltstone, conglomerate, and caliche	15-415 (46-127 m)
Major unconformity						
Cretaceous	Lower		Tucumcari Shale		Shale; minor sandstone	60-165 (18-50 m)
Major unconformity						
Triassic	Upper		Dockum Group	Chinle Formation and Santa Rosa Sandstone	Sandstone and shale; minor conglomerate	840-1,520 (256-464 m)
Major unconformity						
Permian	Upper	Guadalupian	Artesia Group	Tansill and Yates Formations	Sandstone and siltstone; minor dolomite, anhydrite, and rock salt	0-210 (0-64 m)
				Seven Rivers Formation	Rock salt, shale, and anhydrite	155-500 (47-152 m)
	Lower			Queen and Grayburg Formations	Sandstone and shale; minor rock salt, anhydrite, and dolomite	210-370 (64-113 m)
			Unconformity			
		Guadalupian	San Andres Formation		Rock salt, anhydrite, shale, and dolomite	660-1,250 (201-381 m)
		Leonardian	Glorieta Sandstone		Sandstone; minor dolomite and anhydrite	95-160 (29-49 m)

eastern part (Mourant and Shomaker, 1970, p. 14, 77, and 79). The formation ranges in thickness from 96 to 155 feet (30-50 m), and it consists predominantly of sandstone sporadically interbedded with layers of dolomite and anhydrite. Rock salt does not appear to be present, but halite may cement some of the sandstone at places in Curry and Roosevelt Counties.

San Andres Formation

The San Andres Formation of the Leonardian and Guadalupian Series is a major salt-bearing evaporite formation in the Clovis-Portales area. The San Andres probably is known most widely among geologists for the possibilities of obtaining both oil and gas from some of its carbonate-rich zones. Much of the oil and gas produced in southern Roosevelt and eastern Chaves Counties is derived from the San Andres, and this formation has been the strongly favored target of exploratory drilling for petroleum in the Clovis-Portales area during recent years (D. M. Van Sickle, written commun., 1973).

The San Andres Formation crops out in Tps. 2-3 S., R. 22 E., at the southwest corner of the Clovis-Portales area (fig. 3), and it extends northward and eastward beneath different thicknesses of younger rocks. In general, the thickness of the overlying rocks increases with distance from the outcrop, and exceeds 1,500 feet (458 m) over most of the area. The thickness of the overlying rocks is about 1,000 feet (305 m) at the northwest corner of the area and increases southeastward to almost 3,000 feet (915 m) in the vicinity of Portales.

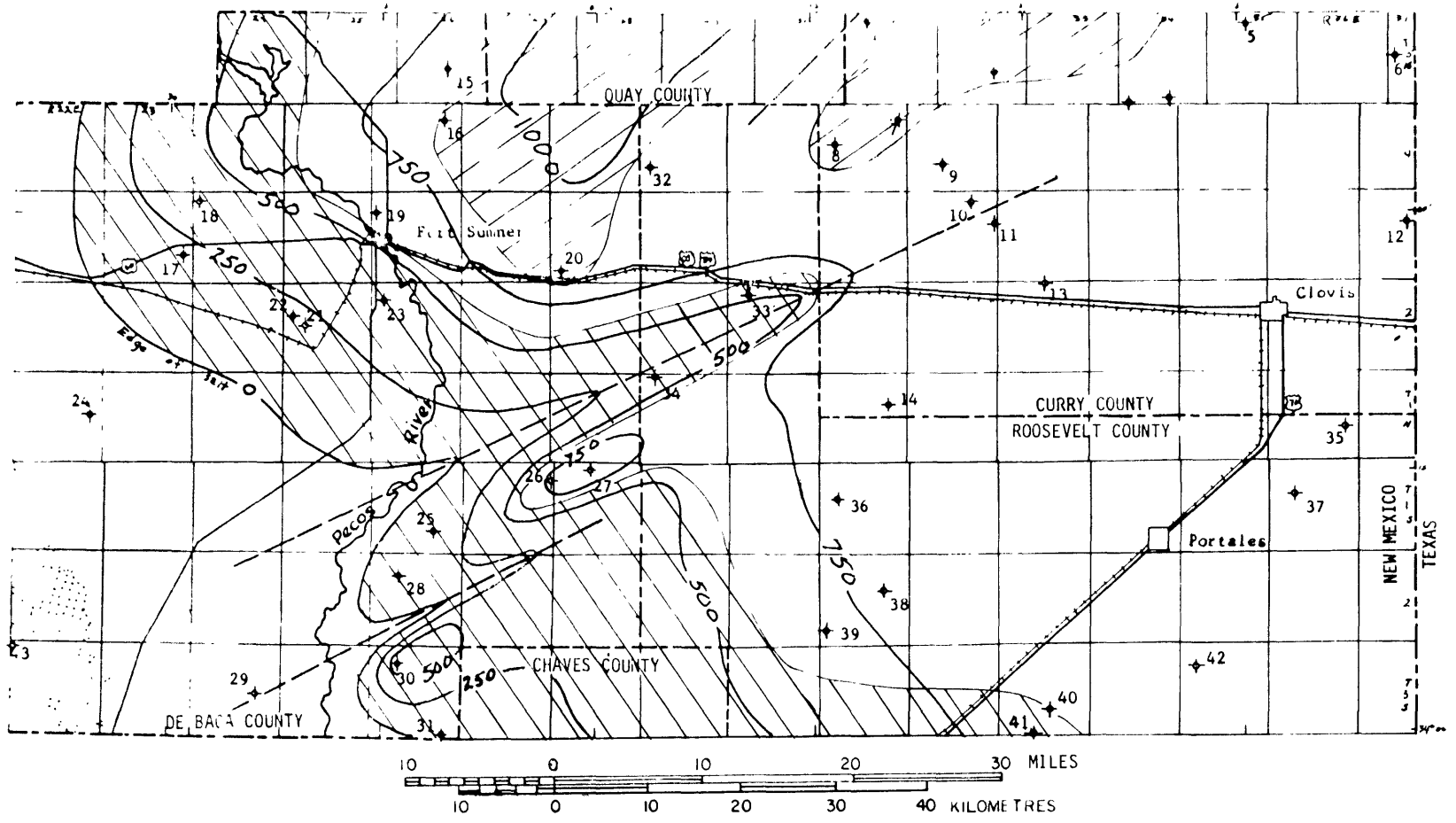

Figure 3.-[illegible] pich map showing thickness, in feet, of salt-bearing interval in upper member of San [illegible] Formation in the Clovis-Portales area of the Pecos River valley, New Mexico. Contour interval: 250 feet (76.3 m).

In the area of outcrop, only the upper part of the San Andres Formation is exposed, but at least 600 feet (183 m) of the formation is known from drilling to be present. The formation thickens northward and eastward from the area of outcrop, and it reaches a maximum thickness of slightly more than 1,250 feet (381 m) southeast of Portales in eastern Roosevelt County.

The San Andres Formation consists of a lower member, 200-300 feet (60-90 m) thick, and an upper member, 400-1,000+ feet (122-305+ m) thick. The lower member is predominantly dolomite and anhydrite interbedded with shale, and the upper member is largely rock salt and anhydrite interbedded with shale and dolomite. The upper member constitutes seven-tenths of the formation in the area of maximum thickness, and it contains seven major seams of rock salt, each 12-155 feet (4-47 m) thick. The stratigraphic distribution of the salt seams and their relation to other rocks in the San Andres are shown on figure 4 (in pocket). These seams have considerable lateral persistence in the Clovis-Portales area, and they extend into other parts of east-central New Mexico.

The seams of rock salt in the upper member of the San Andres Formation have undergone partial or complete solution in some areas. The salt is gone from all the seams over a large part of De Baca County west of the Pecos River, and salt has been leached from one or more seams throughout much of eastern De Baca County and in parts of Roosevelt County where northeast-trending faults cut the San Andres. Where the seams have lost their salt in these parts of the Clovis-Portales

study area, a residual clay, derived from partings and beds of shale within the seams, remains, and the thickness of the upper member of the formation is reduced.

Artesia Group

The Artesia Group of the Guadalupian Series unconformably overlies the San Andres Formation in the Clovis-Portales area. The Artesia is a somewhat thinner, more complex deposit of red beds and evaporites than the San Andres. As defined by Tait, Ahlen, Gordon, Scott, Motts, and Spitler (1962) from outcrops and subsurface sections in the Pecos River valley near the town of Artesia, N. Mex., the Artesia consists of five formations, which are, in ascending order, the Grayburg, Queen, Seven Rivers, Yates, and Tansill Formations. These are distinct well-defined rock units in the vicinity of Artesia, but not all of them can be traced and identified with assurance in the Clovis-Portales part of the valley. Because of considerable similarity in lithologies, the Grayburg and Queen Formations at the base of the group and the Yates and Tansill Formations at the top are not separable, and, for the purpose of this study, they are considered to constitute composite lower and upper units of the Artesia Group (table 2). Accordingly, the group is considered to comprise three discrete units: (1) a basal unit made up of the Grayburg and Queen Formations, (2) a middle unit made up of the Seven Rivers Formation, and (3) an upper unit made up of the Yates and Tansill Formations. This threefold subdivision emphasizes the distribution of shale- and sandstone-rich red beds in

the lower and upper parts of the Artesia Group, and of salt-rich evaporites in the middle part.

The Artesia Group crops out at the northwest corner of the Clovis-Portales area in T. 4 S., Rs. 22-23 E.; along the Pecos River in T. 4 S., Rs. 24-25 E.; and over a wide area of southern De Baca County west of the Pecos River (fig. 5). The group extends from the areas of outcrop eastward beneath different thicknesses of Triassic and younger rocks (table 2) into Curry and Roosevelt Counties. The thickness of the overlying rocks increases with distance from the areas of outcrop, and it is as much as 1,744 feet (532 m) in the northwest part of the area, and 1,800-1,900 feet (550-580 m) in the area southeast of Portales.

The thickness of the Artesia Group varies remarkably. The gross pattern of the variations in thickness of the Artesia is not clear, but many of the variations almost certainly are caused by truncation of the top of the group before the Santa Rosa Sandstone (Upper Triassic) was deposited over it. Artesia beds that range in thickness from 365 to 1,074 feet (105-328 m) are preserved beneath the Santa Rosa. The thickness of the group is least near the areas of outcrop in De Baca County, and it is greatest in small areas located to the northwest of Clovis and to the south and southwest of Portales.

One-half to four-fifths of the Artesia Group is red beds composed of shale and sandstone. Rock salt and anhydrite are interbedded with the red beds at short to long intervals but are most plentiful in the middle part of the group where they form seams as much as 60 feet thick

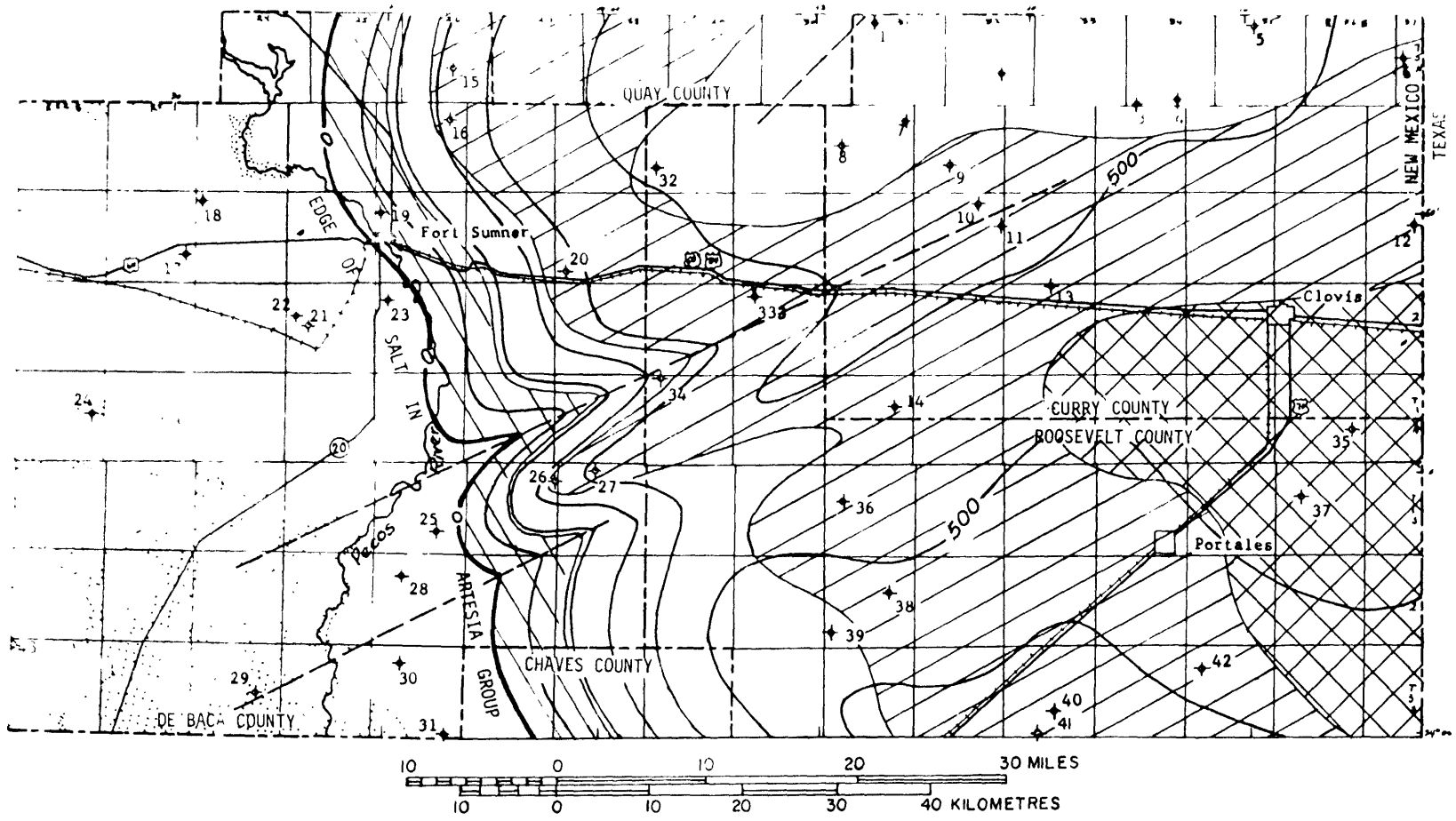

Figure 5.--Isopach map showing thickness, in feet, of salt-bearing interval in Artesia Group in the Clovis-Portales area of the Pecos River valley, New Mexico. Contour interval: 100 feet (30.5 m).

(fig. 6, in pocket). Many of the seams of rock salt and anhydrite have considerable lateral continuity and can be traced tens of miles. However, there are other seams, particularly some in the lower and upper parts of the group, that are lentils and small irregular bodies having very little lateral extent.

The salt-bearing interval in the Artesia Group includes all of the Seven Rivers Formation, a considerable part of the basal unit (Grayburg and Queen Formations), and a small part of the upper unit (Yates and Tansill Formations). The thickness and salt content of the interval are greatest in the vicinity of Clovis and Portales, but the thickness of the overlying rocks, 1,650-2,000 feet (503-610 m), near the two towns is the maximum for the area of this report. The interval has undergone partial to complete solution in most of De Baca County and in adjoining parts of Roosevelt County. Where the salt is gone, residual clay and sand, derived from partings and seams of shale and sandstone within the beds of rock salt, remain; the thickness of the Artesia Group is thus reduced. The sandstone beds are water bearing.

Post-Permian rocks

Post-Permian rocks in the Clovis-Portales area consist of consolidated sedimentary rocks of Triassic, Cretaceous, and Tertiary ages (table 2). In many places these rocks are mantled by unconsolidated alluvium, gravel deposits, and drifted sand of Quaternary age.

Triassic rocks crop out over a section of several hundred square miles extending from the northwest corner of the area into southern

De Baca County east of the Pecos River. The Triassic rocks are a 1,500-foot-thick (763-m) sequence of terrigenous red beds classed as the Dockum Group of the Upper Triassic Series, and they include a variety of sandstones and conglomerates which are water bearing in the area of outcrop and in a great part of the region to the east.

The Cretaceous is represented at the surface only by widely separated outliers of shale and sandstone which are considered to be part of the Tucumcari Shale. Cretaceous rocks have been penetrated by several boreholes and appear to be fairly extensive in the subsurface of parts of Curry and Roosevelt Counties.

Tertiary rocks form the Llano Estacado, as well as some of the adjacent smaller flat-topped tablelands to the west. The Tertiary rocks are assigned to the Ogallala Formation, a varied sequence of sandstones, siltstones, and conglomerates capped by a well-consolidated caliche. They are the principal ground-water reservoir rocks in the irrigated parts of the Clovis-Portales area.

STRUCTURE

The structure of the salt deposits and associated rocks in the Clovis-Portales area is fairly simple (figs. 7 and 8). The rocks have tilted, and they are involved in moderate folds and, locally, are cut by steep faults. The age of the deformation is unknown, but it is clearly pre-Ogallala and is considered to be Late Cretaceous or early Tertiary.

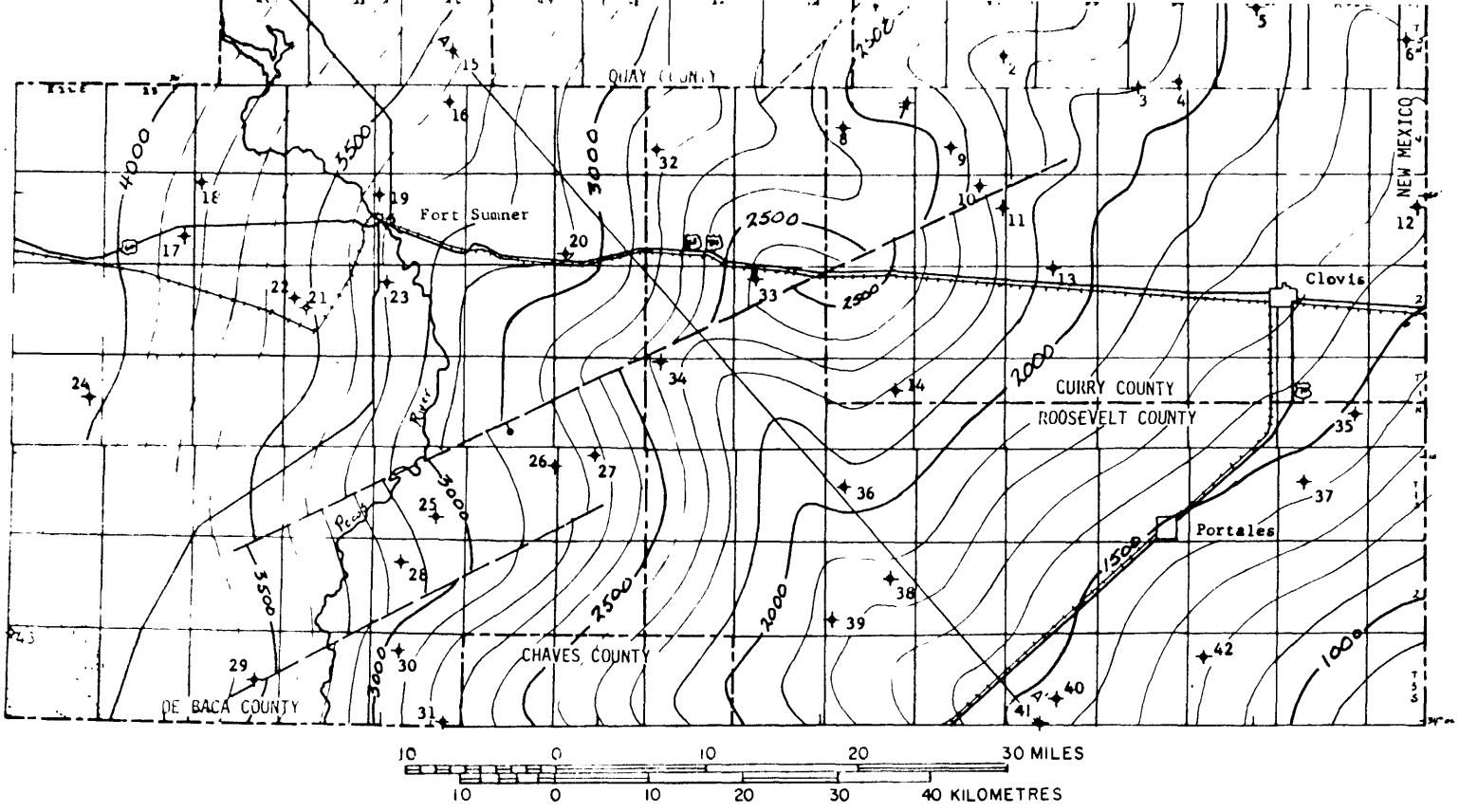

Figure .--Structure contour map of the Upper Permian salt deposits in the Clovis-Portales area of the Pecos River valley, New Mexico. Structure contours, in feet, drawn on top of the San Andres formation.

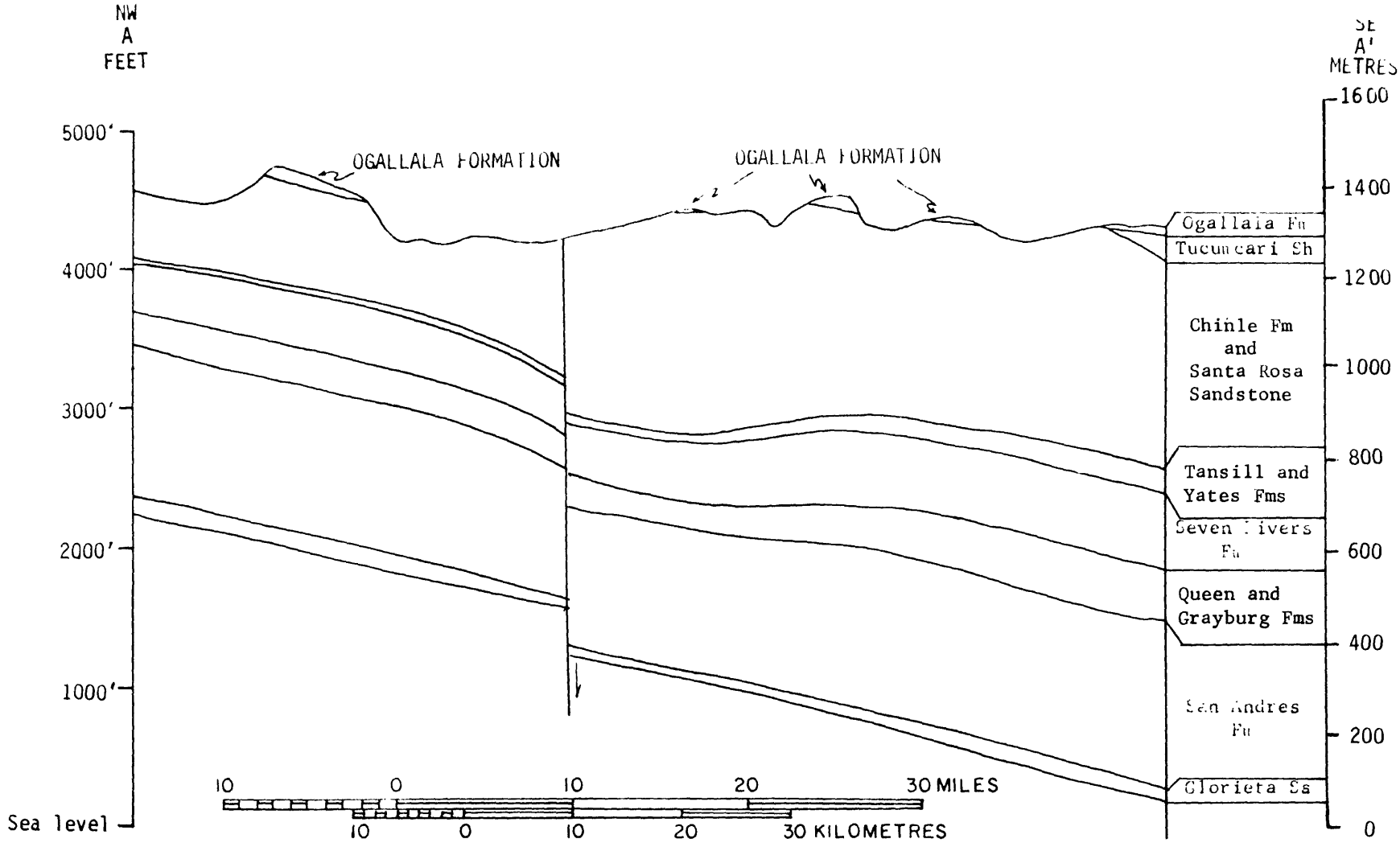

Figure 8.--Geologic cross section along line A-A' (fig. 7). Line A-A' is from borehole No. 15 (Abercrombie and Hawkins, 1 Nappier) to borehole No. 41 (Signal Oil Co., 1 Bell Federal). Vertical exaggeration is about X40.

Several earthquakes have been located in and near the Clovis-Portales area during the past few decades (Northrop and Sanford, 1972, p. 149), but fractures or other surficial evidence of rock deformation have not been observed in outcrops.

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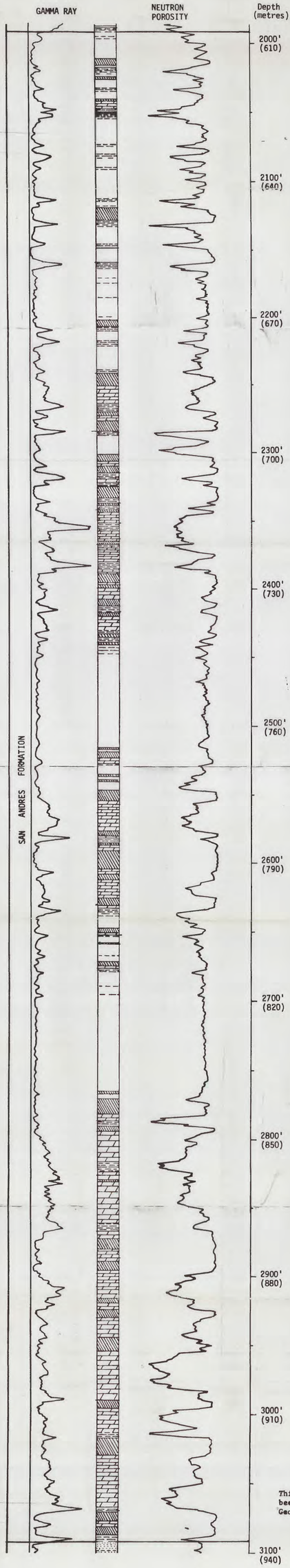

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Figure 4.--Stratigraphic distribution of salt seams and detailed logs of the San Andres Formation, Clovis-Portales area, east-central New Mexico.

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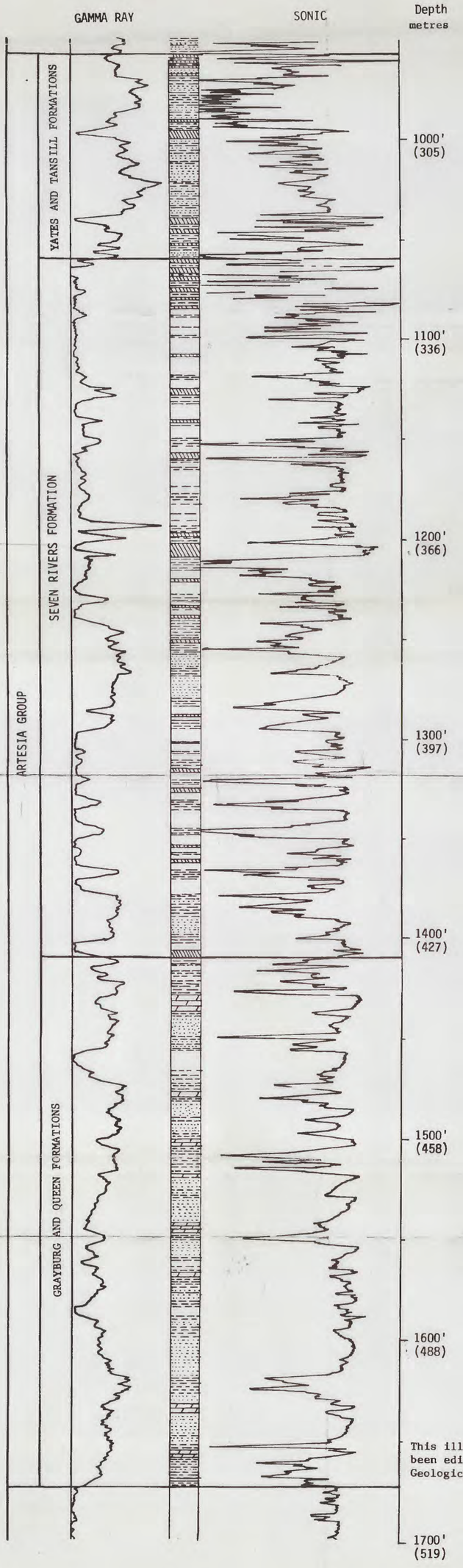

SOUTHERN PETROLEUM
EXPLORATION, INC.
1 S. R. Brown
(Borehole 32)

EXPLANATION

Rock salt

Anhydrite

Dolomite

Shale

Sandstone

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Figure 6.--Stratigraphic distribution of salt seams and detailed logs of the Artesia Group, Clovis-Portales area, east-central New Mexico.