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Introduction

Recent interpretations of seismic and other well log information indicate that Lower Cretaceous strata cover approximately 1,500 mi^2 under the southern High Plains of New Mexico (Fig. 1). Deposited on Late Triassic terrane, and covered largely by alluvial-fan deposits that make up the Ogallala Formation (Neogene; Seni, 1980), the strata form buried mesas with more than 200 ft of subsurface relief at some locations. The buried mesas are erosional outliers of a system that is much more extensively preserved and developed in the Edwards Plateau region of west-central Texas (Fisher and Rodda, 1969).

A typical Lower Cretaceous section under the southern High Plains of New Mexico includes a relatively thin basal sand and sandstone deposit overlain by marls, clays, and associated limestones (Fig. 2). Regional subsurface profiles show that the basal sand and sandstone deposit correlates with the Antlers Formation (Trinity Group) in Texas. The deposit is white to light blue, unconsolidated to moderately well cemented, fine to coarse grained, and quartz-rich; it has scattered lenses of gravel toward the base. Quartz grains in the sand fraction are typically well rounded and frosted in appearance, both characteristics associated with near-shore marine, beach, and dune sand depositional environments.

As an irregular sheet deposit, the thickness of the basal sand and sandstone pinches and swells while thinning regionally to the northwest (Fig. 3). Thickness of the unit ranges from less than a foot to more than 60 feet, and appears to be maximally developed where it fills erosional scour channels and other topographic lows cut into the underlying Dockum Group (Late Triassic; Fig. 4).

Light-blue clay and argillaceous, shallow-marine limestone overlie the basal sand and sandstone in southern parts of the study area (Fig. 5). The limestone is fossiliferous in places and has a spotty distribution pattern. Combined with underlying clay intervals, the limestone rarely exceeds 55 ft in total thickness. The strata correlate sequentially and lithologically with the Walnut and Comanche Peak Formations of the Fredericksburg Group in Texas.

A dark blue-gray shale interval capped with yellow-brown clay overlies all other Lower Cretaceous strata under the southern High Plains of New Mexico. Thickness of the fine-grained sediments ranges from zero to more than 160 ft, with much of the section either partially or completely removed locally by post-depositional erosion (Fig. 6). The upper yellow-brown clay covers the entire subcrop area (Fig. 7), which suggests that it may be an oxidized weathering profile that developed when the Lower Cretaceous strata were uplifted and subaerially exposed during Laramide time. Stratigraphically, middle parts of the fine-grained sequence correlate with the Kiamichi Formation (Fredericksburg Group); upper parts of the section may also include some of the Duck Creek Formation (Washita Group), a unit that has been identified at outcrop localities in neighboring Texas counties (Brand, 1953).

Hydrology

Almost all Lower Cretaceous strata under the southern High Plains of New Mexico lie below the regional water table, and are saturated with fresh (less than 1,000 ppm total dissolved solids) to slightly saline (1,000–3,000 ppm total dissolved solids) ground water. Only in limited updip areas along the northern and western edges of the province are exceptions known to occur.

The Lower Cretaceous strata are hydraulically connected with other water-bearing formations in the region, particularly the bounding and overlying Ogallala Formation, and are considered to be part of the greater High Plains aquifer system. Basal sand and sandstone beds and fractures, joints, bedding planes, and shell facies in the limestone intervals form effective ground-water reservoirs in the section, while clay, shale, and

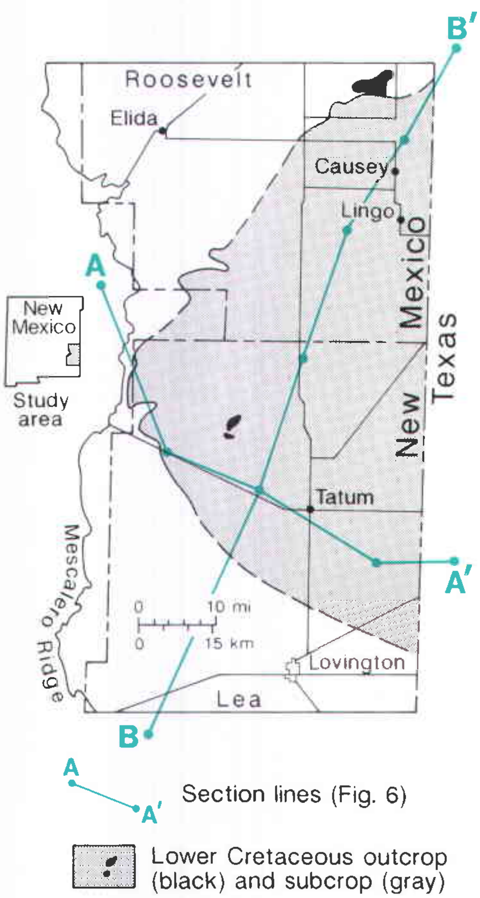

FIGURE 1—Lower Cretaceous outcrop and subcrop areas in the southern High Plains region of New Mexico. Refer to Fig. 7 for cross sections.

Age	System	Group	Formation	Lithology
~100 m.y.	Lower Cretaceous	Washita Group	Duck Creek Formation	Yellow-brown to dark blue-gray shale with thin limestone and siltstone interbeds
		— ? — — ? —	— ? — — ? —	
		Fredericksburg Group	Kiamichi Formation	
			Comanche Peak Formation	Irregularly bedded argillaceous limestone with shell & clay interbeds
			Walnut Formation	Yellow to light-blue clay with some yellow sand
~135 m.y.		Trinity Group	Antlers Formation	White to light-blue sand and sandstone with gravel lenses toward the base

FIGURE 2—Composite stratigraphic section of Lower Cretaceous strata under the southern High Plains of New Mexico.

marl beds define aquicludes. Combined with underlying mudstone sequences in the Dockum Group (Late Triassic), the aquicludes confine the Lower Cretaceous reservoirs in most areas, while also influencing ground-water flow around and over the Lower Cretaceous subcrop. Ponding of ground water also occurs where Ogallala reservoirs are buttressed against fine-grained Lower Cretaceous strata in at least one updip location northwest of Tatum, New Mexico (Figs. 6 and 7).

Tilted to the southeast and confined by fine-grained deposits, Lower Cretaceous reservoirs under the southern High Plains of New Mexico commonly exhibit artesian pressures. Exceptions occur where numerous uncased seismic holes have been drilled into the system, allowing confined ground water to leak upward into the overlying Ogallala Formation while decreasing hydraulic pressures in the underlying Lower Cretaceous reservoirs (Ash, 1963).

Ground-water movement and drainage through the Lower Cretaceous section is generally to the east–southeast in conformance with the head distribution and regional structure. Local cementation, joint patterns, intraformational facies changes, and sinuosity of underlying scour channels, however, prompt local deviations in flow patterns at some locations. The cementation is primarily calcitic in nature, although some quartz also fills pore spaces in basal Lower Cretaceous sandstone beds, restricting and even preventing fluid movement in certain areas.

Surface lineament studies (Reeves, 1970) suggest that joint patterns in Lower Cretaceous limestone reservoirs may be oriented northwest–southeast and northeast–southwest in the study area. Combined with loose shell facies and bedding planes, such fractures would form effective ground-water flow zones in the limestone section.

Ground-water flow rates through Lower Cretaceous reservoirs average less than 1 ft per day (Weeks and Gutentag, 1984), with discharge being to well heads in New Mexico and Texas and to springs and seeps along

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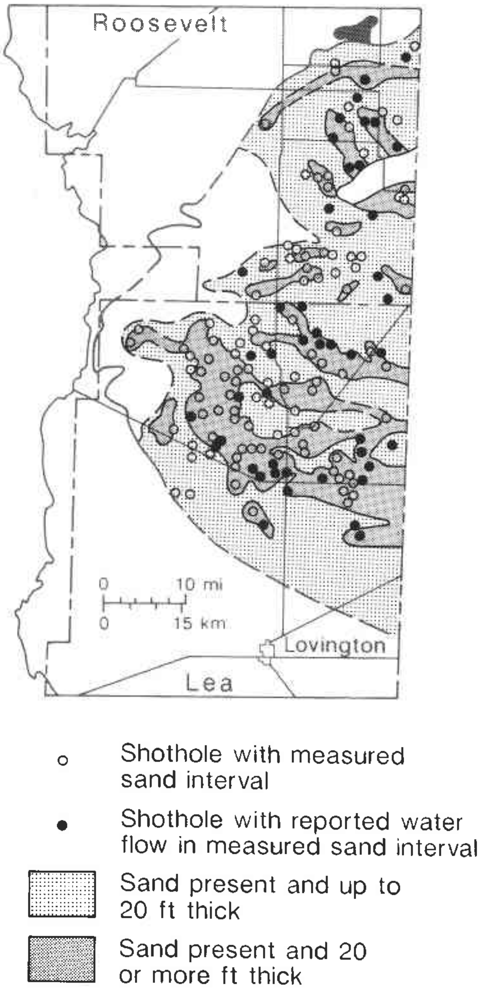

FIGURE 3—Distribution and thickness of the basal Lower Cretaceous sand and sandstone unit (Antlers Formation) under the southern High Plains of New Mexico.

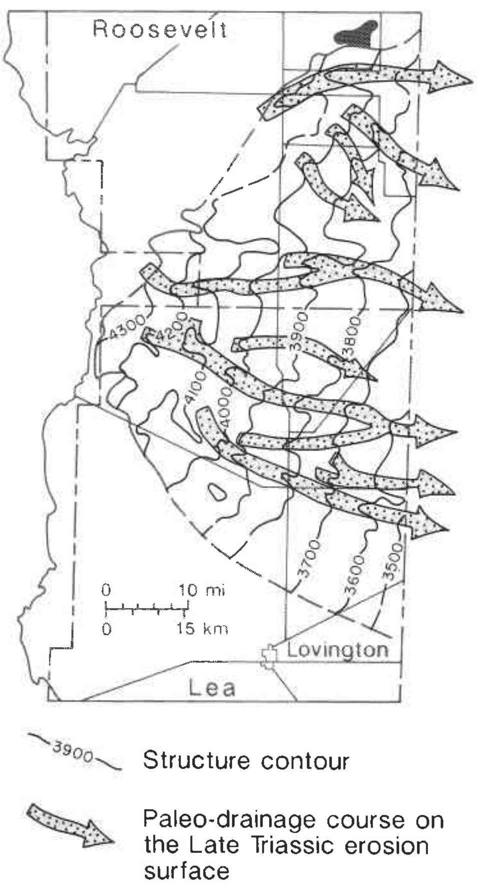

FIGURE 4—Structure contour map showing the altitude of the top of Late Triassic strata under the southern High Plains of New Mexico.

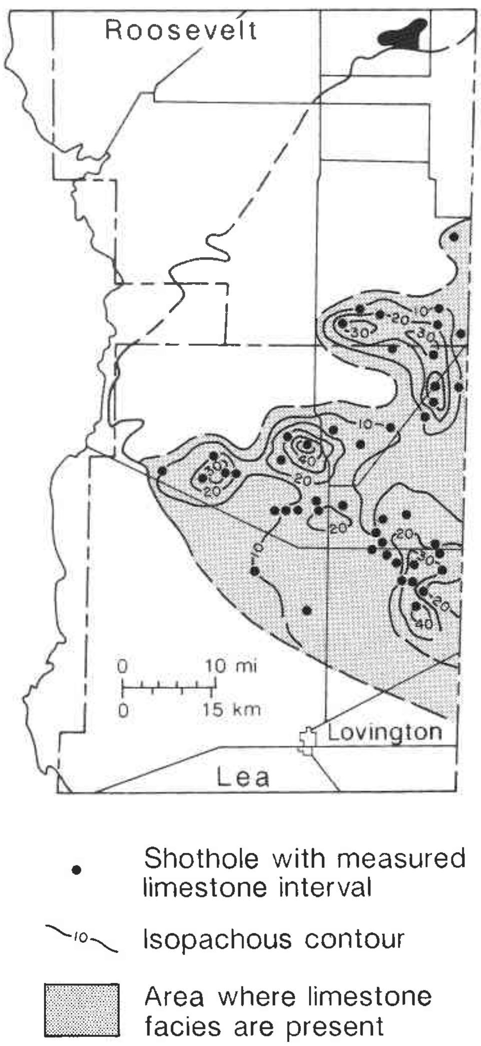

FIGURE 5—Distribution and thickness of Lower Cretaceous limestone strata (Comanche Peak Formation) under the southern High Plains of New Mexico.

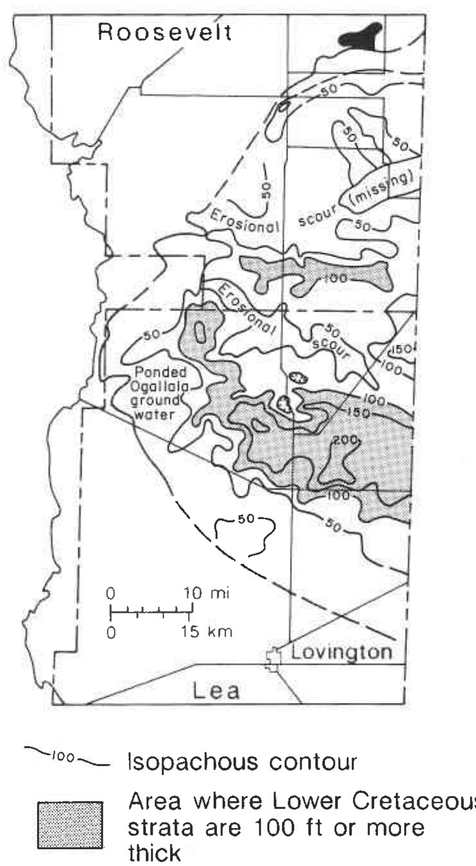

FIGURE 6—Isopach map of Lower Cretaceous strata under the southern High Plains of New Mexico.

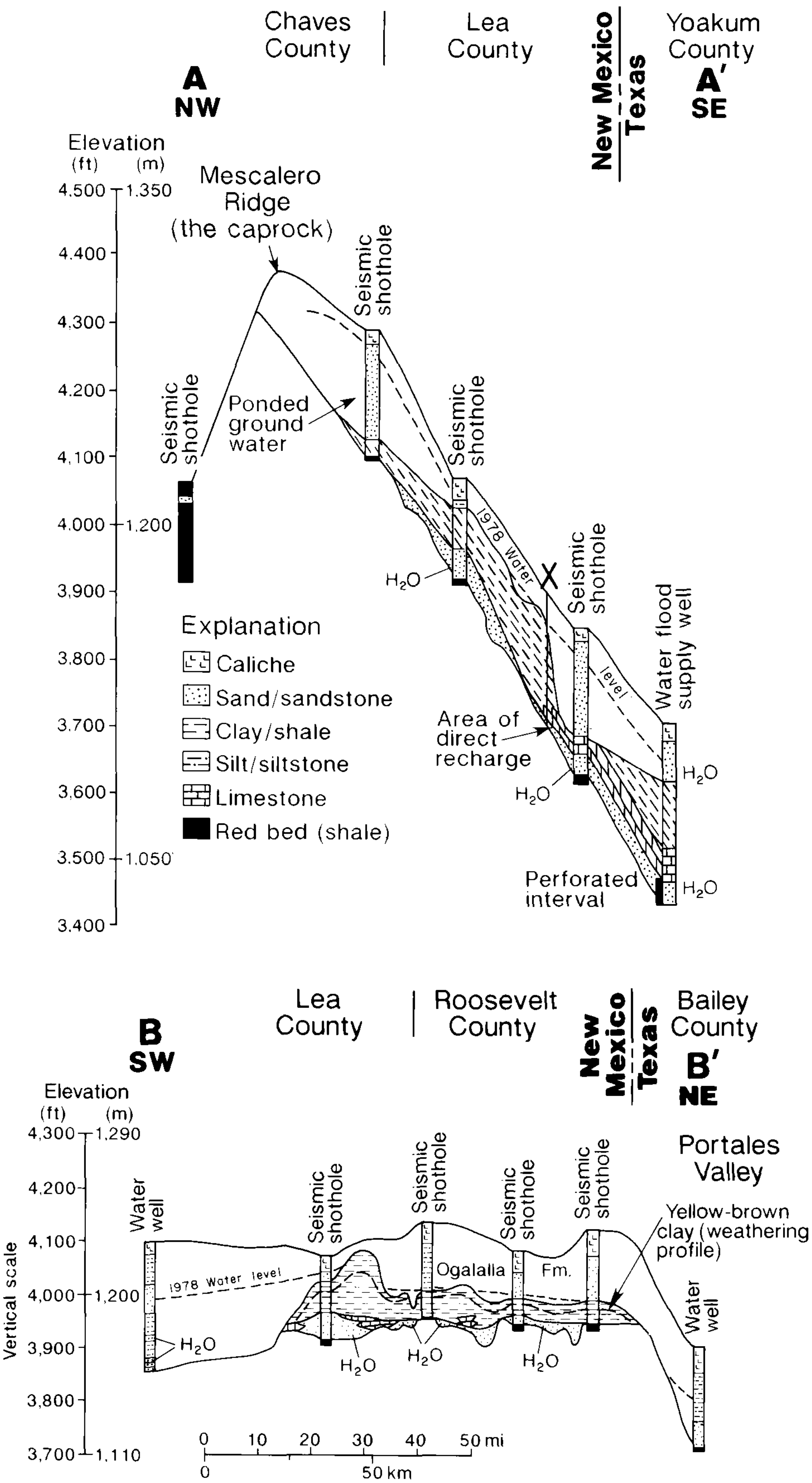

FIGURE 7—Geologic cross sections A—A' and B—B' showing profiles of Lower Cretaceous strata and regional water levels under the southern High Plains of New Mexico. (See Fig. 1 for section lines.) According to Ash (1963), a well was completed in 1940 (near the "X" on the top diagram) that penetrated rocks of Cretaceous age from 25 to 185 ft. Artesian water in the basal sand flowed 25 gal/min with a static head 14 ft above land surface until 1946 when the flow ceased. Note: Details shown on the cross sections come from additional seismic hole data that was originally plotted at a larger scale. The "H_2O" notation shows where ground-water flow was reported in seismic and water well holes.

the southern High Plains escarpment in Texas. The reservoirs have relatively low coefficient of storage, transmissivity, and conductance characteristics when compared to many ground-water flow zones in the bounding and overlying Ogallala Formation. Pumping-test data show that two wells drawing from the basal Lower Cretaceous sandstone resevoir in neighboring Cochran and Yoakum Counties, Texas, had specific capacities of 1.63 and 1.1 gallons of water per ft of drawdown when pumped at rates of 150 and 65 gallons per minute, respectively, for several hours (Rayner, 1963; Mount, et al., 1967). Notably, the Lower Cretaceous reservoirs also had low recoverable artesian storage characteristics around the investigation sites in Texas. Elsewhere, flow conditions are clearly better developed because some wells in the Causey–Lingo area of Roosevelt County, New Mexico, have produced more than 1,000 gallons of water per minute from channel fill in Lower Cretaceous reservoirs for sustained periods of time (Cooper, 1960).

Limited water-quality data show that both calcium–sulfate ($Ca-SO_4$) and sodium–bicarbonate ($Na-HCO_3$) hydrochemical facies exist in Lower Cretaceous reservoirs under the southern High Plains of New Mexico. The ground water is slightly basic, with pH values ranging from 7.5 to 8.0, and it is moderately to extremely hard, with dissolved concentrations of calcium carbonate ranging between 100 and 700 mg/l (Cooper, 1960).

Assuming an average thickness of 15 ft, 20% porosity, and an areal extent of 1,300 mi^2, it is estimated that the basal Lower Cretaceous sand and sandstone reservoir under the southern High Plains of New Mexico holds approximately 2.5 million acre-ft of ground water under full-reservoir conditions. With an average thickness of 10 ft, 1.5% porosity, and 750 mi^2 areal extent, the Lower Cretaceous limestone reservoir holds approximately 72,000 acre-ft of ground water when full.

The primary source of natural ground-water recharge to Lower Cretaceous reservoirs under the southern High Plains of New Mexico is inflow from bounding and overlying reservoirs in the Tertiary Ogallala Formation. The Ogallala Formation, in turn, receives most of its water supply via infiltration of surface precipitation and runoff that periodically fills playa lakes and other ephemeral drainages over the study area, a source of limited and often overdrawn supply in recent times.

Cross-formation recharge between Tertiary and Lower Cretaceous reservoirs occurs most readily where updip saturated sand and gravel beds in the Ogallala Formation abut against, or overlie porous and permeable intervals in the Lower Cretaceous section. Saturated sand and gravel beds in the Ogallala Formation, in turn, occur most frequently where distributary channel systems are best developed in the formation.

In the southern High Plains region, Ogallala distributary channel deposits are best developed where they fill valleys that cut across Lower Cretaceous and older subcrop terrane (Fig. 8). The valleys formed mostly before Ogallala deposition primarily by westward headward erosion across the southern High Plains (Seni, 1980).

Significantly, Lower Cretaceous reservoirs also discharge some ground water into bounding reservoir systems. In the Causey–Lingo area of Roosevelt County, New Mexico, basal Lower Cretaceous sand and gravel reservoirs are truncated in downdip areas by coarse-grained "valley fill" Ogallala deposits, permitting cross flow into the Ogallala system. Vertical leakage into the underlying Dockum Group (Late Triassic) also occurs at isolated locations, particularly where coarser-grained fluvial-deltaic facies exist in upper parts of the red bed sequence (Granata, 1981).

Wells completed in Lower Cretaceous reservoirs under the southern High Plains of New Mexico provide ground water for various surface uses. Widely spaced over much of the study area, wells drawing from the reservoirs are thus far noticeably concentrated only in the Causey–Lingo area of Roosevelt County, where they supply water for both crop irrigation and domestic use. Undeveloped parts of the reservoir systems showing potential for supplying additional surface water to the southern High Plains exist in northern Lea County, particularly where relatively thick basal Lower Cretaceous sands and sandstones occupy erosional scour channels that are cut into the underlying Dockum Group (Late Triassic).

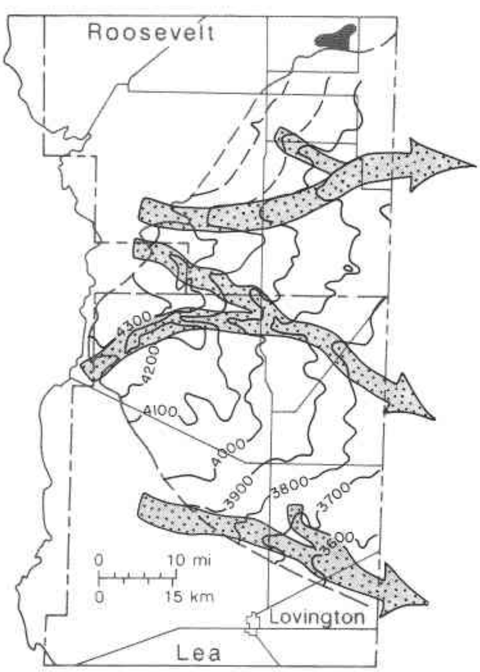

FIGURE 8—Structure contour map showing the altitude of the top of Lower Cretaceous strata under the southern High Plains of New Mexico.

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