

TEXT

Introduction
The Capitan aquifer of Permian (Guadalupe) age is an important source of the ground water used for municipal, industrial, and agricultural purposes at and in the vicinity of Carlsbad, N. Mex. In addition, water pumped from this aquifer in southern Lea County, New Mexico, and Winkler and Ward Counties, Texas, is injected into other subsurface reservoirs by oil companies to increase the recovery of petroleum from partly depleted oil fields (Hiss, 1971; White, 1971). A knowledge of the structural position of the Capitan aquifer in southeastern New Mexico and western Texas will be useful in programs designed either to explore for and develop additional ground-water supplies or to manage this important resource.

The Capitan aquifer
The Capitan aquifer is a lithosome that includes the Capitan and Goat Seep Limestones and most of all the Carlsbad facies of the Artesia Group as recognized by Meissner (1972) and herein used for the near shelf-margin carbonate banks or reefs in the upper part of the San Andres Limestone are included within the Capitan aquifer where they cannot be readily distinguished from the Goat Seep Limestone and Carlsbad facies (Hiss, 1972a; 1975b). The Capitan aquifer closely agrees with the Capitan and Goat Seep Limestones and porous and permeable shelf-margin limestone and dolomite members in the San Andres Limestone (Silver and Todd, 1969, figs. 12 and 13).

Geographic extent
The locations of nearly 400 wells that have been drilled through the Capitan aquifer within the project area, together with the corresponding structural altitude of the Capitan aquifer penetrated in each well, are plotted on this map. Gamma-raysonic, gamma-raysonic, or other combinations of geophysical logs of the Capitan aquifer interval were obtained for nearly all of these wells. Lithologic logs were available for approximately 15 percent of the wells.

The Capitan aquifer parallels the north and east margins of the Delaware basin in an arcuate strip extending from the Guadalupe Mountains southwest of Carlsbad, N. Mex., to the Glass Mountains southwest of Fort Stockton, Tex. Outcrops of the Capitan Limestone have been found in the Glass, Guadalupe, Apache, and Delaware Mountains. Undoubtedly, it is present elsewhere in the subsurface along the west and southwest margins of Delaware basin.

The width of the Capitan aquifer varies from about 10 to more than 14 miles (16 to 23 km) along the edge of the Northwestern shelf in the vicinity of Carlsbad to the central part of southern Lea County, New Mexico. The width of the Capitan aquifer is somewhat more restricted along the western edge of the Central Basin platform, where it seldom exceeds 11 miles (18 km) in width.

Structural position
The structural position of the Capitan aquifer is shown in longitudinal and transverse geologic sections and in a structural map with contours of the top of the Capitan aquifer. The Capitan aquifer is a continuous unit along the north and east margins of the Delaware basin. Large displacements of the Capitan aquifer by faulting appear to be limited to the mountainous areas along the western and southern parts of the Delaware basin, because faults have not been observed in the subsurface along the western edge of the Central Basin platform and the southern edge of the Northwestern shelf. The top and bottom surfaces and the lobate fore and back-reef edges are depositional forms (map and geologic sections A-A' and B-B'). The apparent major lateral displacement of the Capitan aquifer in the vicinity of T. 23 S., R. 25 E., approximately 15 miles (24 km) southwest of Carlsbad, is not a post-Capitan age fault. This shift in position is probably due to growth of the Capitan reef along a pre-Guadalupe age fault-controlled alignment of the Delaware basin (Hills, 1963, p. 1715; 1970).

The fore-reef edge of the Capitan aquifer appears to be relatively steep throughout the area. If exposed, this abrupt slope would undoubtedly resemble the reef escarpment southwest of Carlsbad in the Guadalupe Mountains (Green and others, 1964; Newell and others, 1953). Well control is adequate for definition of the fore-reef slope of the Capitan aquifer in several locations in the subsurface. Approximately 1,200 feet (366 m) of vertical relief along the fore-reef edge of the Capitan aquifer was detected in two oil tests drilled within a few hundred feet of one another in secs. 5 and 9, T. 22 S., R. 33 E., Lea County, New Mexico (Meissner, 1972, plate 11). Similar evidence of the relative steepness of the fore-reef side of the Capitan aquifer is available where deep-well drilling is concentrated in the newly discovered gas fields in the vicinity of Pecos, Wink, and Fort Stockton in Winkler, Mars, and Pecos Counties, Texas, respectively.

The back-reef edge of the Capitan aquifer is much more irregular than the fore-reef edge and is gradational in nature. In some areas, especially along the western edge of the northern part of the Central Basin platform, it is difficult to distinguish the Capitan aquifer from the upper part of the San Andres Limestone. In this area the Capitan aquifer has been extended to include the stratigraphic reef facies of the San Andres Limestone because of the proximity, and similar lithology and hydraulic behavior of the two units. (Geologic sections A-A' and B-B').

The contours showing the structural position of the top of the Capitan aquifer may falsely suggest a series of closed structural highs alternating with plunging synclines. However, when the configurations of the contours of the structural position and the thickness of the Capitan aquifer (Hiss, 1975b) are compared, there is a striking coincidence of features. Apparently, most of the features appearing as structural lows are depositional and (or) erosion in surge channels and submarine canyons of Guadalupe age rather than to warping of the Capitan aquifer (Hiss, 1974; 1975).

Most of the features resembling structural highs are not due to structural uplift but are probably carbonate rock mounds. The Hendrick Monument, and other fields along the western margin of the Central Basin platform produce the closed highs depicted on structural maps with contours of the top of the Yates Formation (Ackers, DeChicchi, and Smith, 1930; Stipp and Haisler, 1956; and Meissner, 1972, fig. 2; Hiss, 1975b, figs. 15 and 19). The carbonate rock mounds described by Stipp and Haisler (1956), and Meissner (1972) that form the traps for the small fields east of Carlsbad are probably primarily due to structural deformation. Apparently, very few closed structures in the Capitan have been found along the northern margin of the Delaware basin.

The Capitan aquifer plunges to the northeast away from the Guadalupe Mountains and passes beneath the surface about 10 miles (16 kilometers) east of Carlsbad. The crest of the Capitan aquifer is at an altitude of approximately 3,000 feet (915 metres) at Carlsbad. At this point the Capitan aquifer turns eastward and continues to plunge in the subsurface, until altitudes of 500 to 750 feet (150 to 230 metres) below sea level are reached along the Central Basin platform west of Eunice, N. Mex. The crest of the Capitan aquifer generally remains at altitudes between 500 and 750 feet (150 and 230 metres) below sea level along the western margin of the Central Basin platform from the vicinity of Carlsbad, N. Mex., southward to near Belting, southwest of Fort Stockton, Texas. The Capitan aquifer rises steeply southward from Belting to outcrops in the Glass Mountains, where altitudes exceed 4,000 feet (1,220 metres) above sea level.

Depths to the top of the Capitan aquifer from the land surface in New Mexico vary from not more than a few hundred feet in the Pecos River valley at Carlsbad to more than 4,300 feet (1,310 metres) in the western part of southern Lea County. Depths to the Capitan aquifer in Ward, Winkler, and northern Pecos Counties, Texas, range from less than 2,500 to more than 3,300 feet (760 and 1,005 metres, respectively).

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References
Ackers, A. L., DeChicchi, R., and Smith, R. H., 1930, Hendrick Field, Winkler County, Texas. Am. Assoc. Petroleum Geologists Bull., v. 14, no. 7, p. 252-284.

Garza, Sergio, and Wesselman, J. B., 1962, Geology and ground-water resources of Winkler County, Texas. U.S. Geol. Survey Water-Supply Paper 1582, 162 p.

Green, W. R., chm., Avall, E. R., Fickman, Philip, and Neff, E. R., eds., 1964, Geology of the Capitan reef complex of the Guadalupe Mountains, Culberson County, Texas and Eddy County, New Mexico: Roswell Geol. Soc. Guidebook, Field trip, May 6-9, 1964, 124 p.

Haves, P. T., 1957, Geology of the Carlsbad Caverns East quadrangle, New Mexico, with a chapter on geologic development of the Carlsbad Caverns by B. T. Gale: U.S. Geol. Survey Quad. Map Q0-98.

—1964, Geology of the Guadalupe Mountains, New Mexico: U.S. Geol. Survey Prof. Paper 146, 69 p.

Haves, P. T., and Koogler, R. L., 1958, Geology of the Carlsbad Caverns West quadrangle, New Mexico-Texas: U.S. Geol. Survey Geol. Quad. Map Q0-112 (1959).

Hills, J. M., 1963, Late Paleozoic tectonics and mountain ranges, western Texas to southern Colorado: Am. Assoc. Petroleum Geologists Bull., v. 47, no. 3, p. 1709-1725, 6 figs.

—1970, Late Paleozoic structural directions in southern Permian basin, west Texas and southern New Mexico: Am. Assoc. Petroleum Geologists Bull., v. 54, no. 10, p. 1809-1827, 16 figs.

Hiss, W. L., 1971, Water-level changes in the Permian Capitan aquifer, Eddy and southern Lea Counties, New Mexico: New Mexico Prof. Engineer, November 1971, p. 16-22.

—1974, Reduction of ground-water flow through the Capitan and Goat Seep Limestones by incised contemporaneous submarine canyons (abs.): Geol. Soc. America, In Abstracts with programs, October 1974, v. 6, no. 7, p. 797.

—1975a, Stratigraphy and ground-water hydrology of the Capitan aquifer, southeastern New Mexico and western Texas: Unpub. Ph. D. dissert. Univ. Colorado, 396 p.

—1975b, Thickness of the Permian Capitan aquifer, southeast New Mexico and west Texas: New Mexico Bur. Mines and Mineral Resources, Resource Map 5, 1 sheet, [in press].

—1975c, Possible stratigraphic entrapment of oil in complex sedimentary facies associated with Permian (Guadalupe) age submarine canyons in southeastern New Mexico (abs.): Am. Assoc. Petroleum Geologists Bull., v. 59, no. 5, p. 911-912.

King, P. B., 1930, The geology of the Glass Mountains, Texas: Part 1, Descriptive geology: Texas Univ. Bull., 30:8, 167 p. (1931).

Meissner, F. F., 1972, Cyclical sedimentation in mid-Permian strata, in Elam, J. G., and Chuber, Stewart, eds., Cyclical sedimentation in the Permian basin, second ed.: West Texas Geol. Soc. pub. 72-18, p. 203-232.

Motts, W. S., 1962, Geology of the West Carlsbad quadrangle, New Mexico: U.S. Geol. Survey Geol. Quad. Map Q0-167.

—1972, Geology and paleoenvironments of the northern segment, Capitan shelf, New Mexico and west Texas: Geol. Soc. America Bull., v. 83, no. 3, p. 701-722.

Newell, R. D., and others, 1953, The Permian reef complex of the Guadalupe Mountains region, Texas and New Mexico—a study in paleogeology. San Francisco, W. H. Freeman & Co., 236 p.

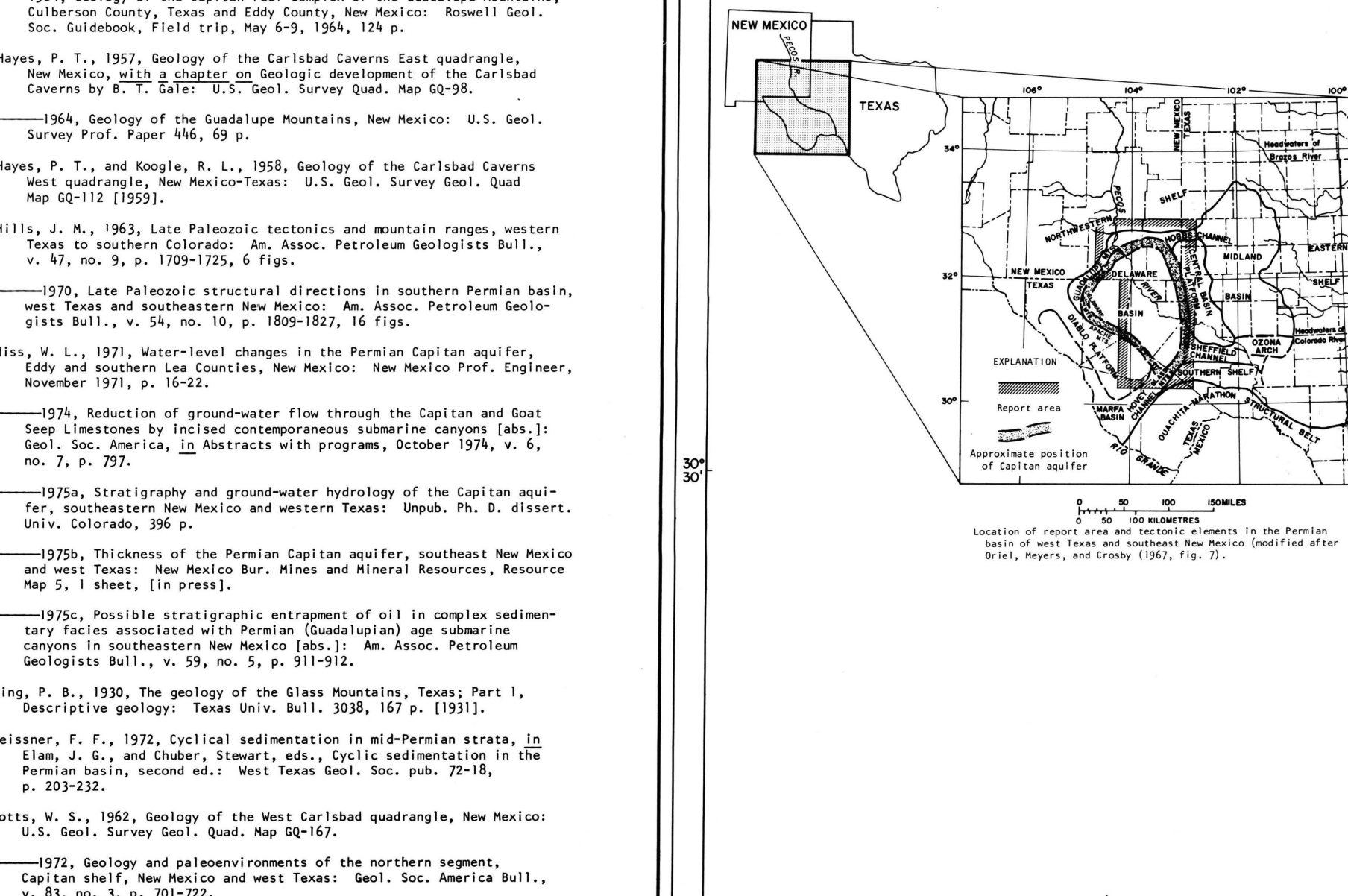
Oriel, S. S., Myers, D. A., and Crosby, E. J., 1967, West Texas Permian basin region, in McKee, E. D., and Oriel, S. S., eds., Paleontological Investigations of the Permian System in the United States: U.S. Geol. Survey Prof. Paper 515, p. 17-60.

Pratz, W. E., 1954, Evidence of igneous activity in the northwestern part of the Delaware Basin, in New Mexico Geol. Soc. Guidebook, 5th Field Conf., Oct. 1954, p. 143-147, 2 figs.

Silver, B. A., and Todd, R. G., 1969, Permian cyclic strata, northern Midland and Delaware basins, west Texas and southeastern New Mexico: Am. Assoc. Petroleum Geologists Bull., v. 53, no. 11, p. 2233-2251.

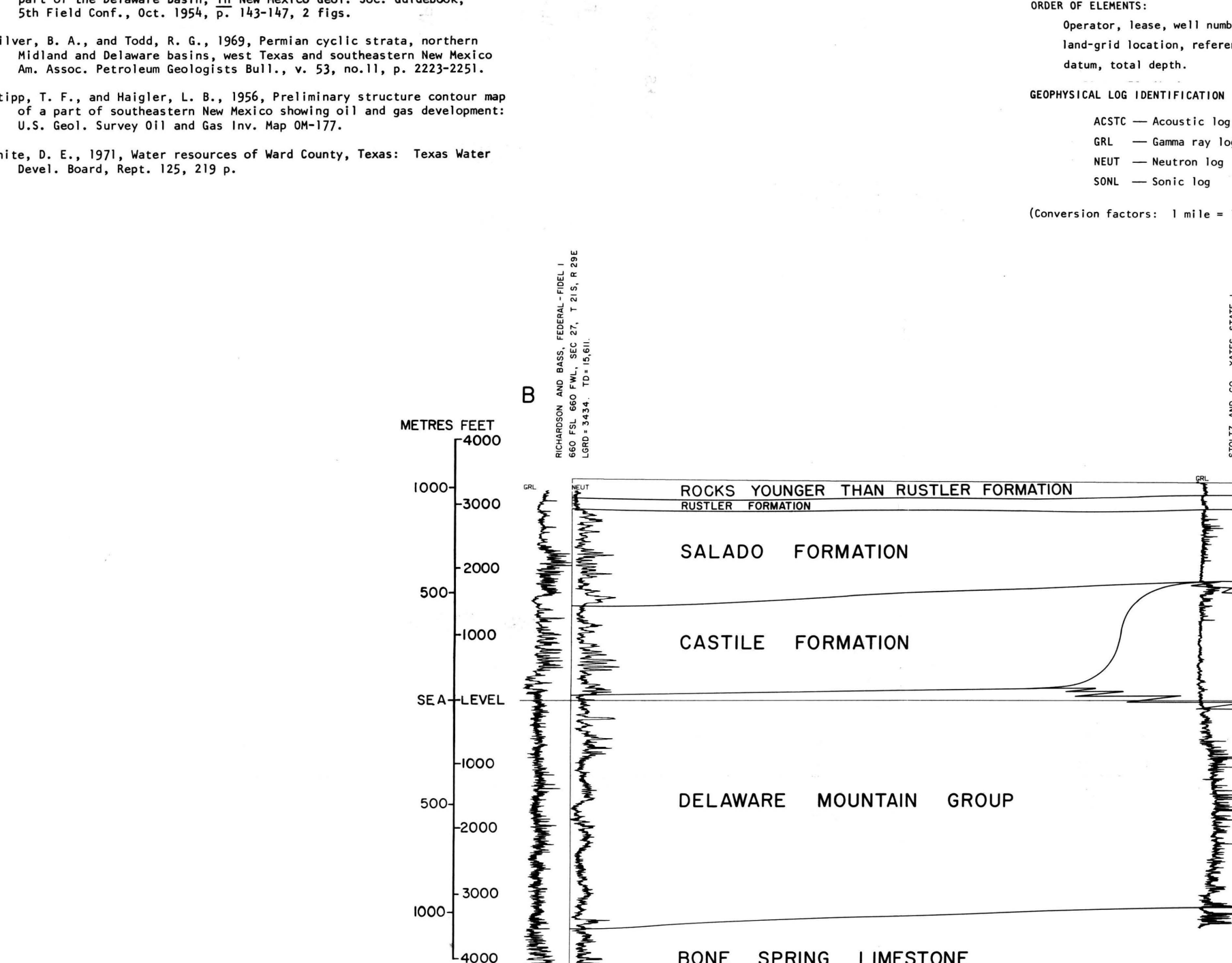
Stipp, T. F., and Haisler, L. B., 1956, Preliminary structure contour map of a part of southeastern New Mexico showing oil and gas development: U.S. Geol. Survey Oil and Gas Inv. Map O0-177.

White, D. E., 1971, Water resources of Ward County, Texas: Texas Water Devel. Board, Rept. 125, 219 p.



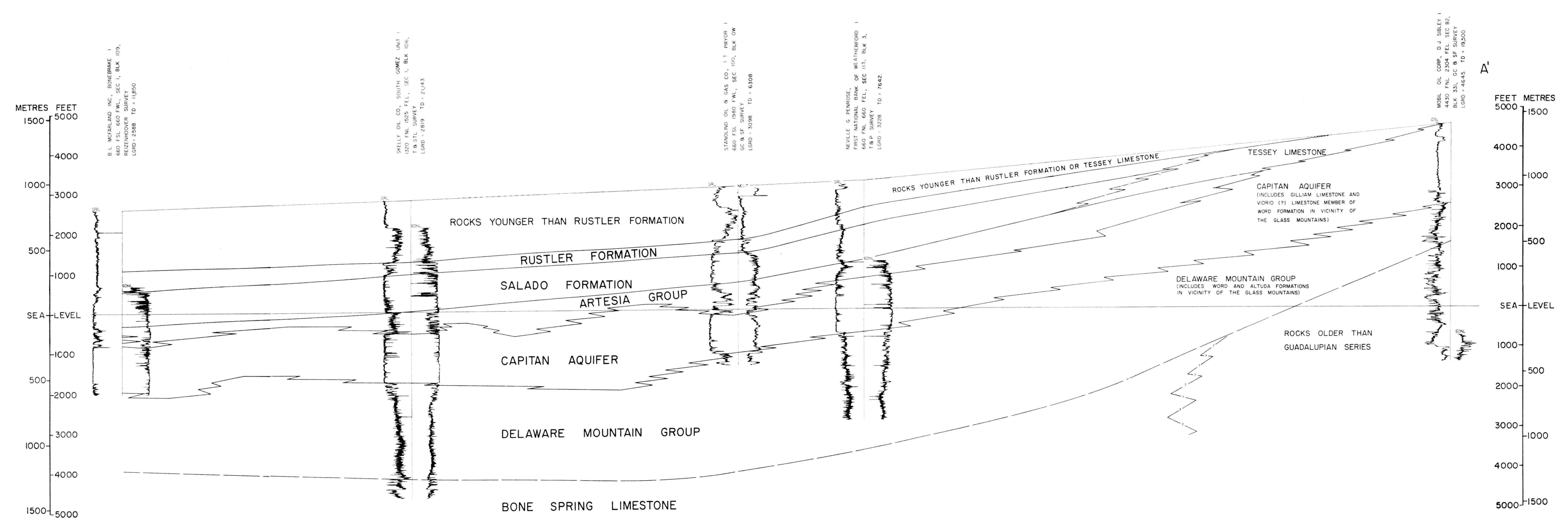
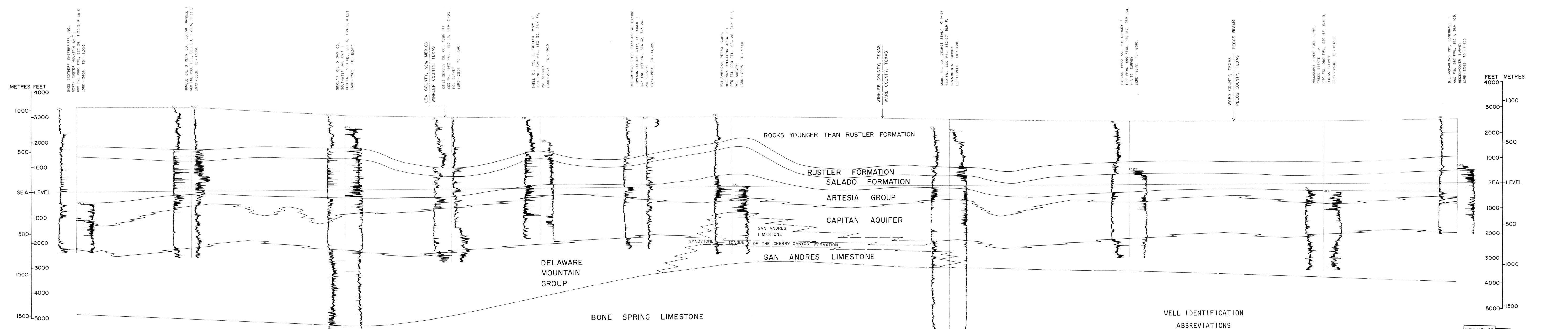
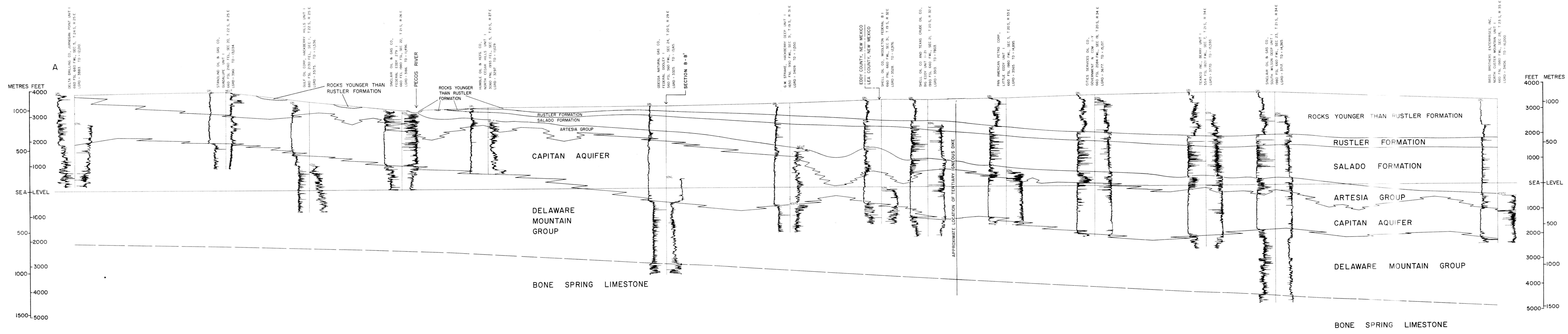
EXPLANATION FOR STRATIGRAPHIC SECTION
ORDER OF ELEMENTS:
Operator, lease, well number, land-grid location, reference datum, total depth.
GEOPHYSICAL LOG IDENTIFICATION
ACST - Acoustic log
GRL - Gamma ray log
NEUT - Neutron log
SONL - Sonic log
ABBREVIATIONS:
FNL - Distance, in feet, from north line
FSL - Distance, in feet, from south line
FEL - Distance, in feet, from east line
FWL - Distance, in feet, from west line
FNEL - Distance, in feet, from northeast line
FNEW - Distance, in feet, from northwest line
FSEL - Distance, in feet, from southeast line
FSWL - Distance, in feet, from southwest line
SEC - Section
T - Township
S - South
R - Range
E - East
BLK - Block
T - Township
S - South
LGR - Log reference datum, in feet, above sea level
TD - Total depth of well, in feet, below log reference datum

TRANSVERSE STRATIGRAPHIC SECTION B-B' SHOWING THE POSITION OF THE CAPITAN AQUIFER IN EASTERN EDDY COUNTY, NEW MEXICO



STRUCTURE OF THE PERMIAN GUADALUPIAN CAPITAN AQUIFER, SOUTHEAST NEW MEXICO AND WEST TEXAS

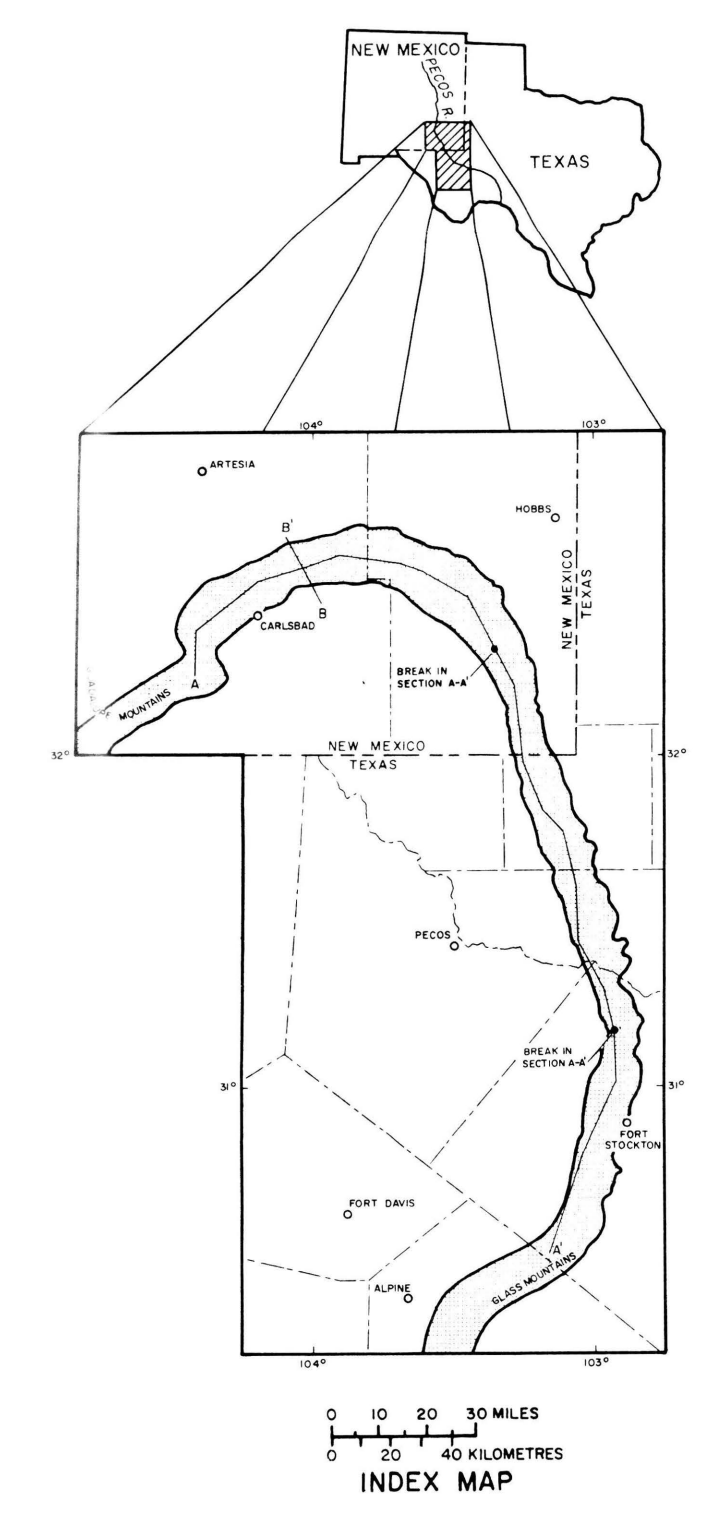
by W. L. HISS



- WELL IDENTIFICATION ABBREVIATIONS**
- FNL - Distance, in feet, from north line
 - FSL - Distance, in feet, from south line
 - FEL - Distance, in feet, from east line
 - FWL - Distance, in feet, from west line
 - FNEL - Distance, in feet, from northeast line
 - FNWL - Distance, in feet, from northwest line
 - FSEL - Distance, in feet, from southeast line
 - FSWL - Distance, in feet, from southwest line
 - SEC - Section
 - T - Township
 - S - South
 - R - Range
 - E - East
 - BLK - Block
 - T - Township
 - S - South
- } New Mexico only
 } Texas only
- LGRD - Log reference datum, in feet, above sea level
 - TD - Total depth of well, in feet, below log reference datum

- ORDER OF ELEMENTS**
- Operator, lease, well number,
land-grid location, reference
datum, total depth.
- GEOPHYSICAL LOG IDENTIFICATION**
- ACSTC - Acoustic log
 - GRL - Gamma ray log
 - NEUT - Neutron log
 - SONL - Sonic log

(Conversion factors: 1 mile = 1.609 kilometres; 1 foot = 0.3048 metre.)



STRATIGRAPHIC SECTION A-A' SHOWING THE POSITION OF THE CAPITAN AQUIFER ALONG THE NORTH AND EAST MARGINS OF THE DELAWARE BASIN

