UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN
COOPERATION WITH THE
NEW MEXICO STATE ENGINEER

TEXT

The widespread occurrence, distinctive lithology, and relatively uniform thickness of the Rustler Formation of Late Permian Ochoan age over the Delaware basin, Northwestern shelf, and Central Basin platform make it an ideal marker bed that can be readily distinguished in drill cutting samples and on geophysical logs (Adams, 1944). The Rustler Formation is composed of a sequence of anhydrite and gypsum with interbedded dolomite and clay in the upper section and primarily clastics in the lower section. In places there is considerable salt in the section. The structural map contoured on top of the Rustler Formation was prepared using data obtained from a number of sources. Formation tops were taken directly from the Permian Basin Well Data System data file and geologic sections prepared by the Roswell and West Texas Geological Societies, from geophysical and lithological logs, and from maps prepared by Guyton and Associates (1958), Garza and Wesselman (1962), White (1971), Armstrong and McMillion (1961), Ogilbee, Wesselman, and Irelan (1962), and Runyan (1965).

Regional structure

Regionally, the surface of the Rustler Formation slopes irregularly to the east reflecting the late Mesozoic and Cenozoic uplift and eastward tilting of the western part of the Permian basin. Several of the many anomalous local features superimposed on the larger regional trend coincide with the structural configuration of the older Permian strata. The Hobbs, Eumont, Langlie-Mattix, Hendrick, and many other oil fields on the Central Basin platform are located within structural closures (Stipp and Haigler, 1956; Ackers, DeChicchis, and Smith, 1930; Carpenter and Hill, 1936; Stipp and others, 1956). The low centered in T.25 S., R.34 E., Lea County, New Mexico, is probably due to regional subsidence.

Salt-solution troughs

Maley and Huffington (1953), Olive (1957), Garza and Wesselman (1962), and White (1971) have demonstrated that some of the structural features represented by the configuration of the Rustler Formation accurately depict both the location and amount of solution of the older Ochoan evaporites and the accumulation of alluvium that filled the resulting depressions. Similar features are revealed by a map of the Triassic surface ("pre-Ogallala bedrock") in southeastern New Mexico prepared by Bachman (1974, fig. 12).

Salt-solution troughs are located above the Capitan Reef in the eastern margin of the Delaware basin and at the westernmost extension of the soluble salts of the Ochoan Series in the west and west-central part of the Delaware basin. The two troughs are filled with a variety of sedimentary rocks ranging in age from Triassic to Holocene that, in many instances, form excellent ground-water reservoirs (Garza and Wesselman, 1962; Guyton and Associates, 1958; White, 1971; Reed, 1961). The troughs probably were formed contemporaneously with the uplift of the Delaware basin and the emplacement of the Pecos River.

A series of irregular lens-shaped coalescing troughs extends northward from Balmorhea near the boundary between Reeves and Jeff Davis Counties, Texas, to Pecos, Texas where the trough then extends north along the Pecos River to near Loving in Eddy County, New Mexico. The Ochoan evaporite section was elevated and probably exposed to at least some extent as the Delaware basin was uplifted and tilted to the east. Soluble minerals, particularly halite, were consequently removed by action of surface and ground water. The western limit of the halite beds gradually retreated to a position now coincident with the Balmorhea-Pecos-Loving trough (herein named for purposes of this report and shown on the inset map).

The configuration of the Rustler Formation surface in the Balmorhea-Pecos-Loving trough is much more complex than the map indicates. More detailed description of the salt-dissolution features of this trough are available in Olive (1957) and King (1949).

Another series of linear lens-shaped depressions form a trough 8 to 12 miles (13 to 19 kilometres) wide extending northward from near Belding in southwestern Pecos County, Texas, in an arcuate trend above and parallel to the Capitan aquifer to T.22 S., R.35 E., in the vicinity of the San Simon swale in southern Lea County, New Mexico. Halite and other soluble minerals also have been removed from both the Castile and Salado Formations underlying the Belding-San Simon trough (herein named for purposes of this report and shown on the inset map). Non-soluble beds in the Ochoan Series and Triassic and Cretaceous Systems have subsided as soluble minerals were dissolved and removed.

Coincident with subsidence of the surface, a network of streams developed as a surface manifestation of the Belding-San Simon trough. As a result more than 1,000 feet (305 metres) of alluvium is now present in some of the depressions. Garza and Wesselman (1962, p. 14) have mapped some of the southward-draining ancient stream channels in Winkler County. Monument Draw in Ward and Winkler Counties, Texas, and a small lake formerly used by oil companies for communal waste-water disposal about 1.5 miles (2.4 kilometres) northwest of Wink, Texas, are the present-day remnants of this drainage system. The thick accumulation of alluvium suggests that the streams did not form the San Simon swale in the Belding-San Simon trough by erosion as indicated by Bachman (1974, p. 72 and fig. 12) but merely supplied the sediment necessary to fill the subsiding trough. The Belding-San Simon trough was formed by dissolution of salt caused by ground water moving through aquifers adjacent to salt-bearing formations several thousand feet below the surface--not by the action of surface water or near surface solution by ground water.

A complementary stream system undoubtedly originated in the vicinity of the ancestral Glass Mountains and flowed to the north, although no similar surface expression of such a system is evident today. Cretaceous sediments were partially stripped from the surface above the Belding-San Simon trough prior to burial by alluvium in Pecos County (Armstrong and McMillion, 1961). Cenozoic alluvium rests directly on the Upper Triassic Dockum Group farther to the north in Ward and Winkler Counties, Texas, and Lea County, New Mexico.

The Capitan aquifer and overlying competent sandstones and carbonates within the Artesia Group were apparently strongly jointed and perhaps even fractured by movements in the western Permian basin during the Laramide orogeny (Adams, 1944, p. 1623; Adams and Frenzel, 1950, p. 301). Ground water from the Capitan aquifer was able to move through the fractures and joints in the overlying Artesia Group and attack the soluble beds in the Castile and Salado Formations. The original relatively high hydraulic conductivity of the Capitan aquifer was also enhanced by the fracturing and jointing.

The relatively good quality of ground water in the Capitan aquifer compared to the highly mineralized water found in adjacent rocks of the same age in the Delaware basin, Northwestern shelf, and Central Basin platform is thought by Hiss (1975a, p. 208-213; 1975b) to reflect preferential movement of water through the more transmissive Capitan aquifer.

Ground water flowing northward through the Capitan aquifer as a consequence of the uplift of the Glass Mountains dissolved and removed soluble beds in the adjacent Castile and overlying Salado Formations during late Cenozoic time. The rate of movement and solution undoubtedly varied greatly and depended in part upon the amount of precipitation, the relief of the Glass Mountains, and the hydraulic gradient imposed upon the water in the Capitan aquifer. Historical records of subsidence in the San Simon swale suggest that solution and collapse processes are still operative (Nicholson and Clebsch, 1961, p. 13-17). The route of ground-water movement is recorded by the quality of water in the Capitan aquifer and other Guadalupian age sedimentary rocks and is substantiated by maps of the potentiometric surface (Hiss, 1975a, p. 258-269; 1975b).

The Pecos River, the dominant factor in controlling the movement of the ground water in the northwestern part of the project area, very obviously is younger than the Pliocene Ogallala Formation. The present drainage system and landscape were probably established in very late Pliocene or early Pleistocene time (Plummer, 1932; Motts, 1968; Hayes, 1964; Thornbury, 1965).

The depressions in the surface of the Rustler Formation above the Capitan aquifer east of Carlsbad are undoubtedly also due to the solution and removal of the underlying halite. The Pecos River at Carlsbad has been in good hydraulic communication with the Capitan aquifer and has functioned as an upgradient drain for a long period of time. Therefore, these solution-collapse features were probably caused by eastward-moving ground water prior to the excavation of the Pecos River valley in Eddy County. The solution-collapse features above the Capitan aquifer east of Carlsbad are fewer in number and smaller in size than those formed along the western margin of the Central Basin platform; probably as a result of both the less extensive system of joints or fractures and the smaller amount of ground water that has moved through the Capitan aquifer.

Acknowledgments

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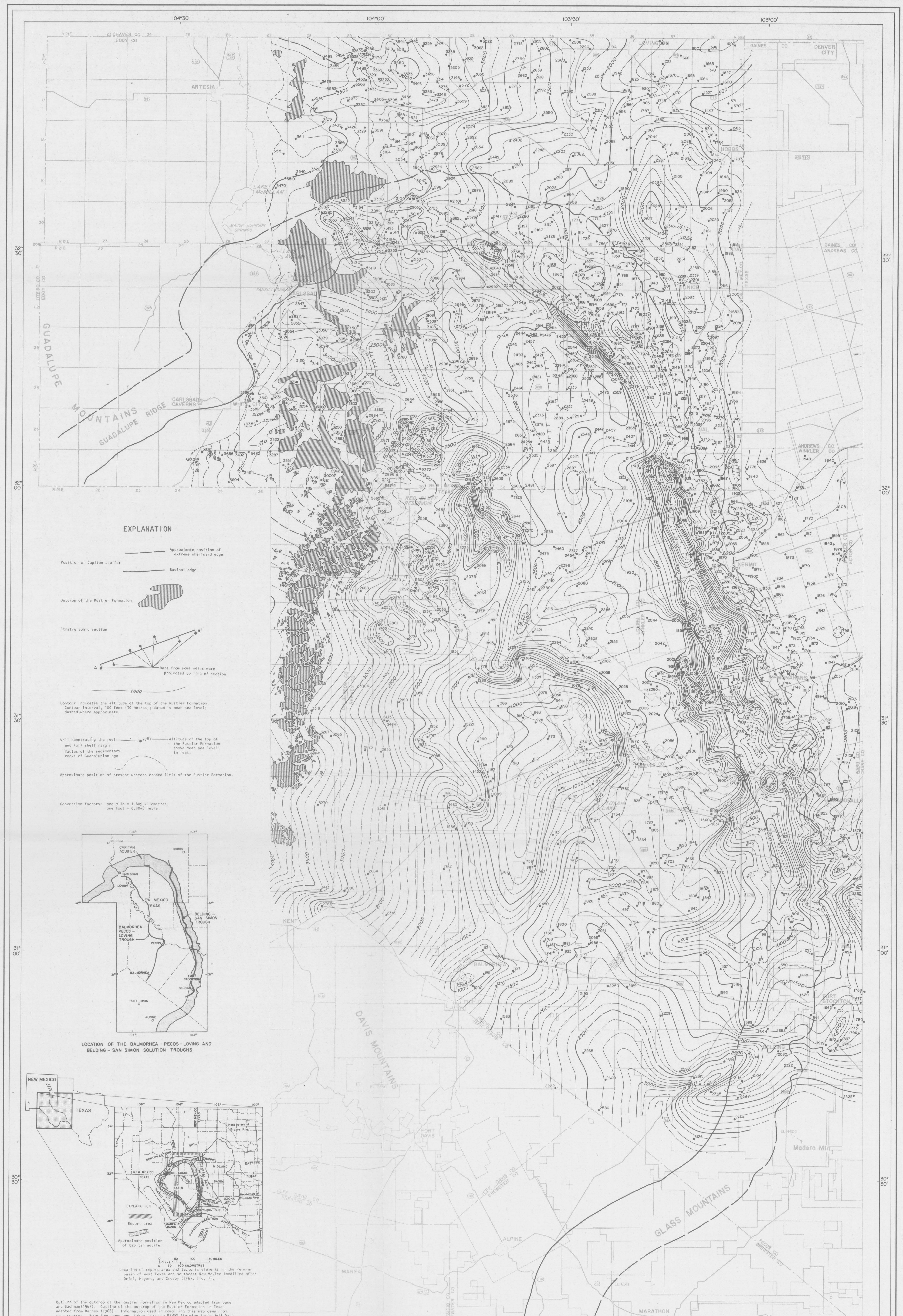


New Mexico base from U.S. Geological Survey, Branch of Oil and Gas Operations, Roswell 9 South 1 inch = 2 miles (1963). Texas base from Midland Map Co. BM-2 (1969), BM-3 (1966), BM-4 (1961), BM-11 (1956), BM-12 (1956), BM-13 (1961), BM-17 (1955), and BM-18 (1955) 1 inch = 5,000 feet, used with permission of Midland Map Co.

EXPLANATION FOR STRATIGRAPHIC SECTION

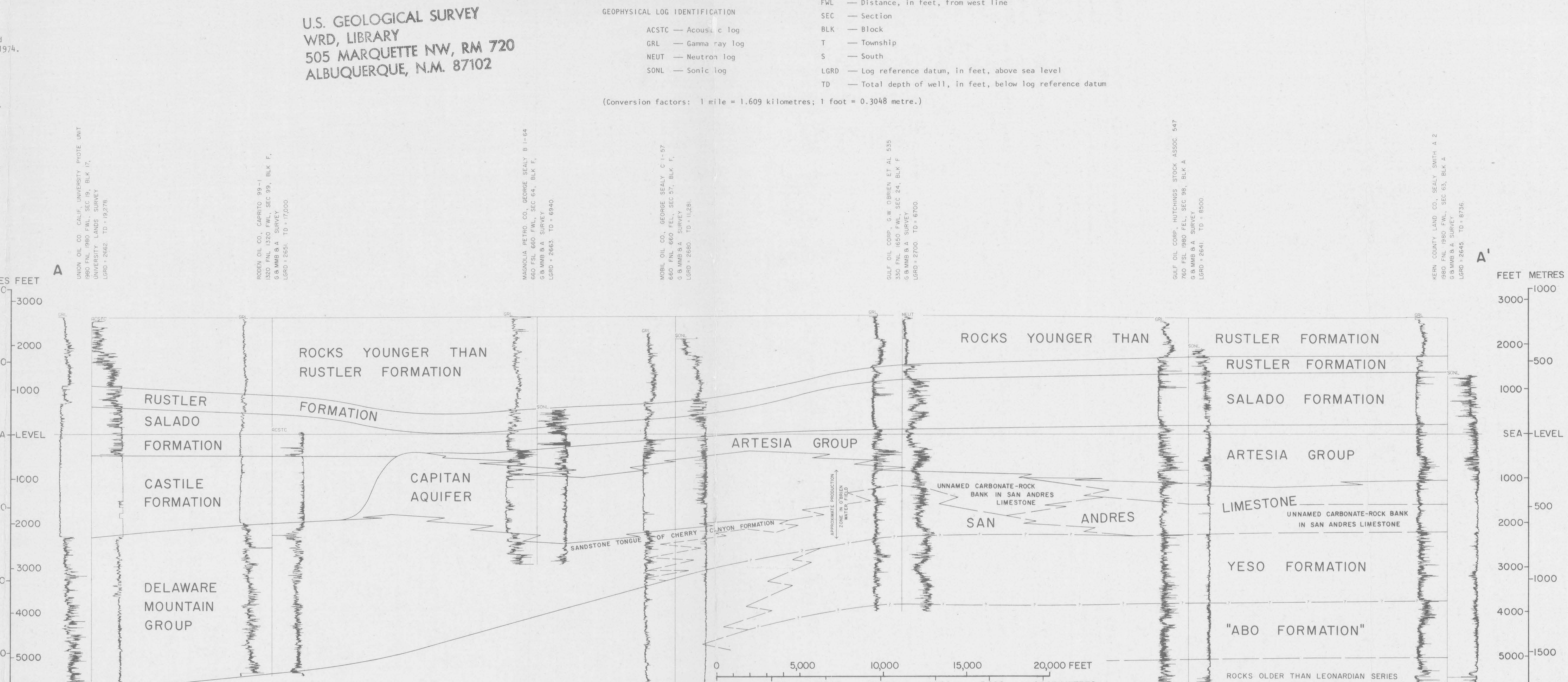
WELL IDENTIFICATION

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

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
- SEC — Section
- BLK — Block
- T — Township
- S — South
- LGRD — Log reference datum, in feet, above sea level
- TD — Total depth of well, in feet, below log reference datum

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



TRANSVERSE STRATIGRAPHIC SECTION A-A' SHOWING THE POSITION OF THE CAPITAN AQUIFER ALONG THE EAST MARGIN OF THE DELAWARE BASIN

STRUCTURE OF THE PERMIAN OCHOAN RUSTLER FORMATION, SOUTHEAST NEW MEXICO AND WEST TEXAS

by W. L. HISS

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