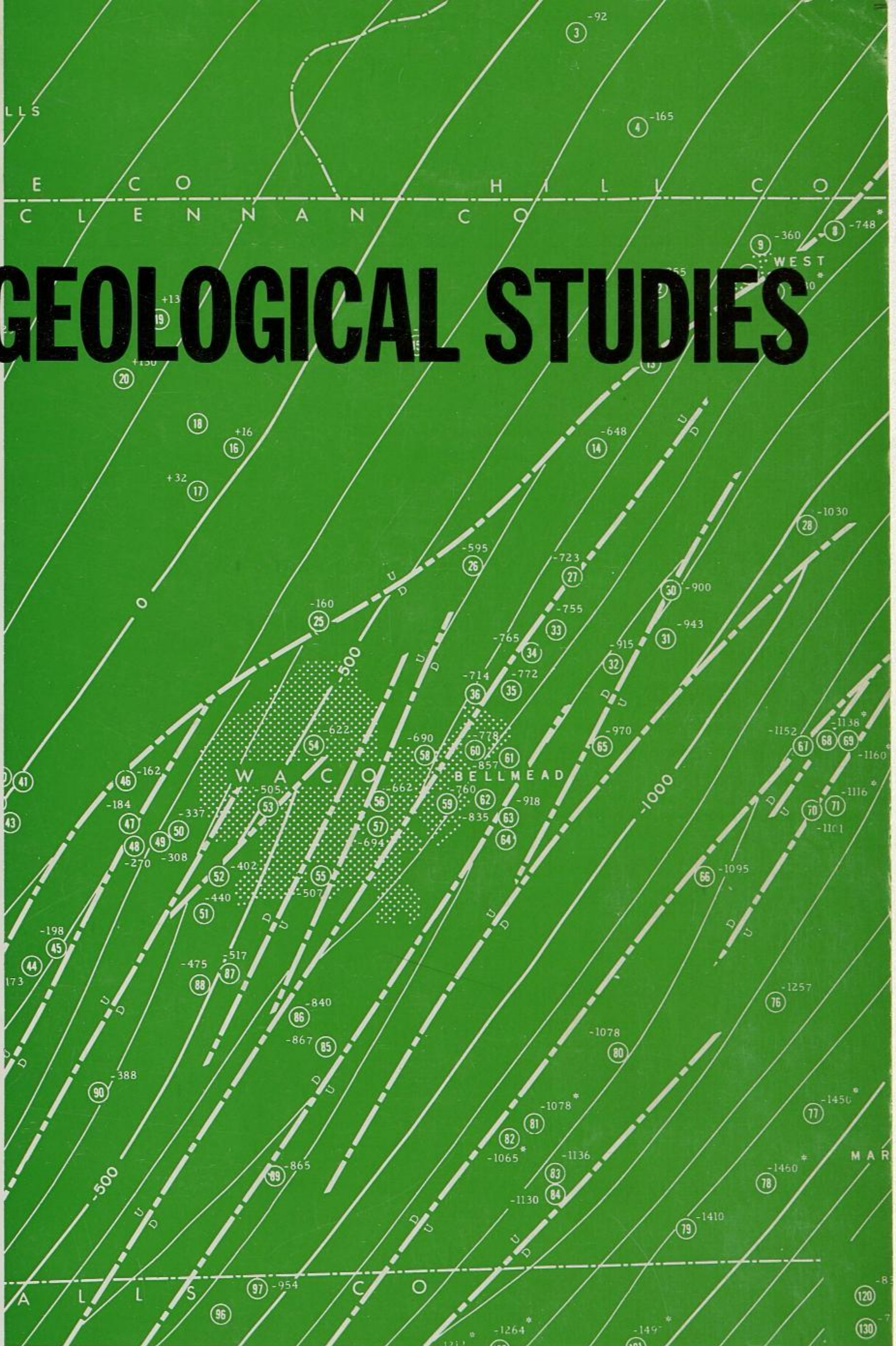
BAYLOR GEOLOGICAL STUDIES



FALL 1961

Bulletin No. 1

The Lower Cretaceous Trinity Aquifers, McLennan County, Texas

HAROLD D. HOLLOWAY

Leon Byrd

"Creative thinking is more important than elaborate equipment--"

Frank Carney, Ph.D.
Professor of Geology
Baylor University
1929-1934

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BAYLOR GEOLOGICAL STUDIES

BULLETIN NO. 1

The Lower Cretaceous Trinity Aquifers, McLennan County, Texas

HAROLD D. HOLLOWAY

Killed 12-21-71
Car wreck in Willmington, Delaware

BAYLOR UNIVERSITY
Department of Geology
Waco, Texas
Fall, 1961

Baylor Geological Studies

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ILLUSTRATIONS

The Lower Cretaceous Trinity Aquifers, McLennan County, Texas

*HAROLD D. HOLLOWAY**

ABSTRACT

The Trinity division in McLennan County is divisible into three units—upper, middle, and lower—on the basis of cyclic sedimentation. Each unit contains a basal clastic phase and an upper carbonate phase; stratigraphic names have been applied to each phase. The upper Trinity division consists of the Glen Rose limestone and underlying Hensel sand member which is one of two principal Trinity artesian aquifers within the county. The middle Trinity division consists of the Pearsall formation containing the Cow Creek limestone member above and the Hammett shale member below. The lower Trinity division consists of the Sligo formation and underlying Hosston formation which is the second principal Trinity artesian aquifer in McLennan County.

The Balcones fault zone trends north-south across McLennan County. The fault zone is shown by structure maps on top of the Glen Rose limestone and Hosston formation, as well as the pre-Cretaceous surface. Faulting appears to have been caused by movement along the Paleozoic Ouachita foldbelt during subsidence and sedimentation in the adjacent East Texas basin.

McLennan County contains two artesian water districts—a western district west of the Balcones fault zone where the Hensel sand member is the major producing aquifer, and an eastern district east of the Balcones fault zone where the Hosston formation is the major producing aquifer.

The drop in the piezometric surface in McLennan County during the past 60 years is the result of increased numbers of wells producing from the aquifers. No changes in quality of water from the Trinity aquifers have been observed.

INTRODUCTION[1]

The purpose of the investigation is to determine the thickness, areal extent, depth, and aquifer properties of the Trinity division in McLennan County, Texas.

Confusing stratigraphic problems as well as a decrease in production of artesian water from the basal Trinity division prompted the study. It is hoped that the new geologic information will help the people of McLennan County and the State of Texas in the search for and conservation of ground water resources.

McLennan County (fig. 1) is situated in Central Texas. The map area extends five miles beyond the limits of the county. Surrounding counties are Bosque and Hill counties on the north, Limestone County on the east, Bell and Falls counties on the south, and Coryell County on the west.

*The writer dedicates this report to the memory of George W. Putnam, Jr. (1930-1961) and Evelyn Emry Putnam (1959-1960).

[1]Modified from a thesis submitted in partial fulfillment of the requirements for the M.S. degree in Geology, Baylor University, 1959.

PRESENT STUDY

In McLennan County, the Trinity division (table 1) is a sub-surface unit. A literature investigation was followed by a study of well records, electric logs, and drillers' logs. Limited use was made of well cuttings and chemical analyses of water from Trinity wells.

The Layne Texas Company #3 James Connally Air Base water well electric log is designated the type log (fig. 2) for the Trinity division. One hundred and one electric logs (Appendix I) were used, including a number logged for this study with a Widco electric logger; all wells are plotted by number on subsurface maps. Samples from three wells (the Chalk Bluff Water Corporation well, the Leroy-Tours-Gerald well, and the Axtell well) were studied for stratigraphic and lithologic control, and samples of the Leroy-Tours-Gerald well and the Connally #3 well were used to interpret the electric logs. Chemical analyses of water from selected wells (Appendix II) were obtained from the Bureau of Sanitary Engineering to determine areal chemical variations in Trinity water.

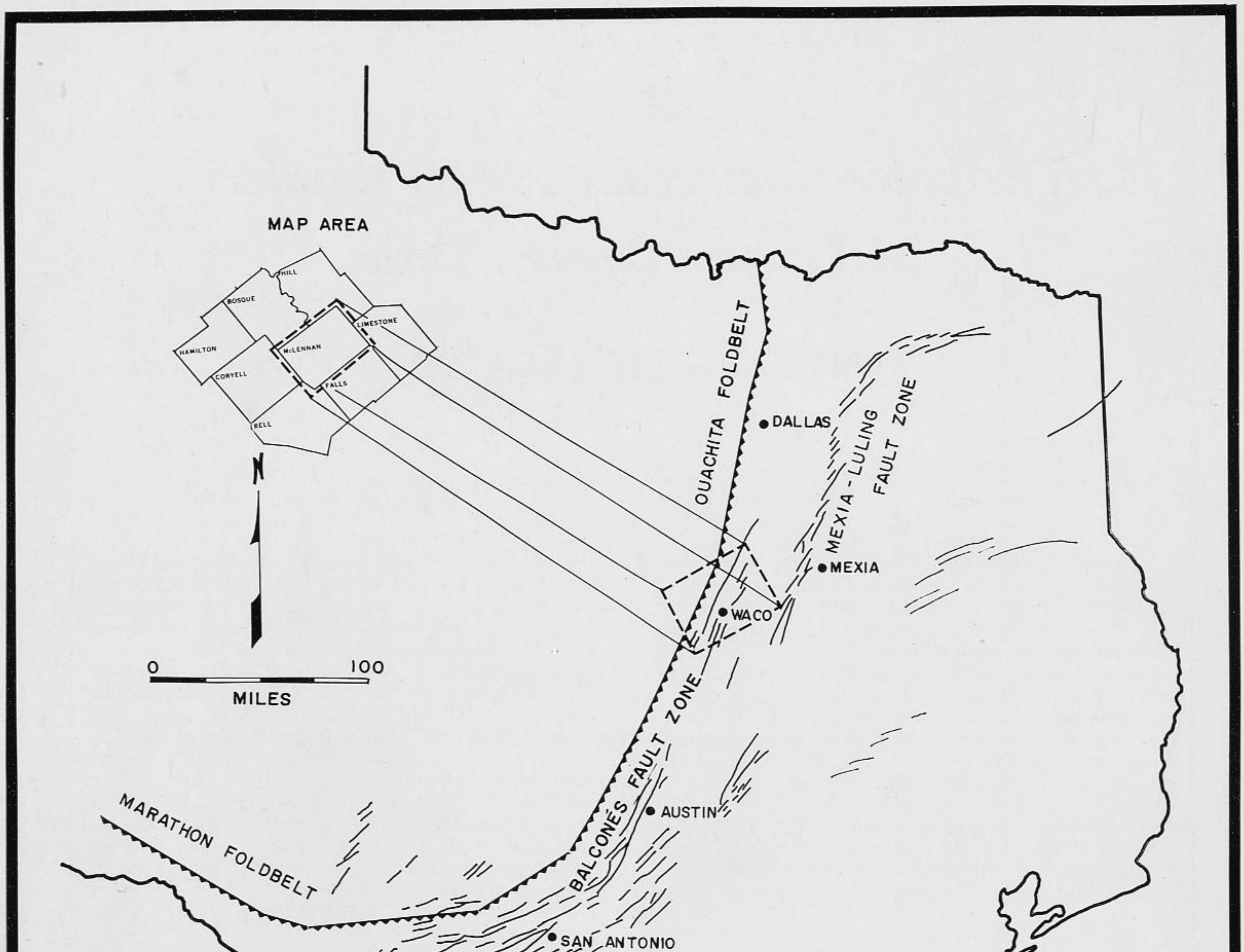

Fig. 1. Regional structure and locality map, Texas Gulf Coast.

Table 1. Geologic formations in McLennan County, Texas

System	Series, group, or division		Formation or member	Maximum Thickness (feet)	Description	Aquifer properties
Quaternary	Recent and Pleistocene		Alluvium and terraces	?	Sand, Silt, and gravel.	Yields potable water in some areas at shallow depth.
Cretaceous	Gulfian Series		Taylor	1170	Calcareous marls, sandy marls, lenses of calcareous sandstone, and chalky limestone.	Yields some potable water from Wolfe City member in eastern part of county at shallow depth.
	Gulfian Series		Austin	295	Marly limestone and limy shale with some bentonite seams.	Not known to yield water in McLennan County.
	Gulfian Series	Eagle Ford Group	South Bosque	140	Shale with limestone flags.	Yields no water in McLennan County.
	Gulfian Series	Eagle Ford Group	Lake Waco	145	Shale with limestone flags and bentonite seams.	Yields small amounts of water for domestic use in western part of McLennan County.
	Gulfian Series	Eagle Ford Group	Pepper	100	Non-calcareous shale with injected sandstone dikes in northern part of McLennan County.	Reported to yield some potable water in northeastern McLennan County.
	Comanchean Series	Washita Division	Buda	35	Hard to chalky fossiliferous limestone.	Yields no water in McLennan County.
	Comanchean Series	Washita Division	Del Rio	85	Fossiliferous clay with occasional limestone beds and sandy streaks.	Yields no water in McLennan County.
	Comanchean Series	Washita Division	Georgetown	210	Nodular limestones and marly shales.	Not known to yield water in McLennan County.
	Comanchean Series	Fredericksburg Division	Edwards	45	Limestone, rudistid reef material, and calcareous siltstone.	Yields some potable water in northwestern McLennan County.
	Comanchean Series	Fredericksburg Division	Comanche Peak	130	Nodular limestones and fossiliferous clay.	Yields no water in McLennan County.
	Comanchean Series	Fredericksburg Division	Walnut	175	Shale with some limestone and sand stringers.	Yields no water in McLennan County.
	Comanchean Series	Fredericksburg Division	Paluxy	20	Sands with some shales interbedded.	Yields potable water in northwestern McLennan County.
	Comanchean Series	Trinity Division, Upper	Glen Rose	800+	Alternating limestones and shales with some anhydrite.	Yields some water in McLennan County.
	Comanchean Series	Trinity Division, Upper	Hensel	75	Fine to coarse sands with green shales.	Principal aquifer in western McLennan County. Yields large supplies for municipal, industrial, and domestic purposes.
	Comanchean Series	Trinity Division, Middle, Pearsall Formation	Cow Creek	75	Limestone and shales.	Yields no water in McLennan County.
	Comanchean Series	Trinity Division, Middle, Pearsall Formation	Hammett	100	Shale with some limestone and sand.	Yields no water in McLennan County.
	Comanchean Series	Trinity Division, Lower	Sligo	95	Limestone and shale.	Yields no water in McLennan County.
	Comanchean Series	Trinity Division, Lower	Hosston	800+	Fine to coarse sand with some conglomerate and varicolored shale.	Principal aquifer in eastern McLennan County. Yields large supplies for municipal and industrial purposes. Water in sands in upper part of formation in southeastern part of county may be highly mineralized.
Jurassic	Cotton Valley Group		Schuler (?)	?	Sands and shales (?).	Yields no water in McLennan County.
Pennsylvanian (?)			?	?	Shales and metamorphics.	Yields no water in McLennan County.

PREVIOUS INVESTIGATIONS

Many reports are available on the Trinity division [group]; some of these are listed in the bibliography. However, only a few of these (fig. 3) refer specifically to McLennan County.

The first subsurface work in the McLennan County area was by R. T. Hill in 1901. In 1921 Lula Pace reported on the area, and in 1923 W. S. Adkins completed a report and geologic map of McLennan County.

Hill (1901) divided the Trinity "division" of McLennan County into the Glen Rose limestone above and the lower "basal sands," and he numbered the water producing horizons in ascending order. Pace (1921) referred to Hill's work but did not add to the knowledge of artesian water supply of McLennan County. Adkins (1923) numbered the water producing horizons in descending order without correlating them with Hill's classification. The confusion arising from Hill's and Adkin's classifications will be discussed later (p. 15).

Hill's work (1901) included Bell, Bosque, Coryell, Falls, and Hill counties; Adkins and Arick (1930) completed a report of Bell County similar to Adkins' McLennan County study. The present investigation is the first detailed study of the Trinity division in the area since 1901. Two unpublished studies by Livingston and Bennett (1942) in the McGregor area, and by George and Barnes (1945) in the Waco area, are open-file reports at the U.S. Geological Survey Ground Water Branch, Austin, Texas.

ACKNOWLEDGMENTS

The writer appreciates the help and support of Professors O. T. Hayward and J. W. Dixon. The following contributed significantly to the project: Dr. Frank E. Lozo, Shell Development Company; Mr. Paul W. Foster, Atlantic Refining Company; Messrs. J. L. Patton and H. D. McCallum, Humble Oil and Refining Company; Dr. P. T. Flawn, Bureau of Economic Geology, The University of Texas; Mr. C. I. Smith, Shell Development Company; Mr. Warren Basye, Layne Texas Company; Mr. R. F. Myers, J. L. Myers & Sons; Mr. Tom Glass, H. B. Glass Drilling Company; Mr. Hervie Meadows, McGregor, Texas; Mr. A. G. Winslow, U.S. Geological Survey Ground Water Branch; Mr. Robert Tobin, Tobin Aerial Survey. Illustrations were drafted by Mr. Johnnie B. Brown, Baylor University.

GEOLOGY

McLennan County (fig. 1) is situated near the interior boundary of the Gulf Coastal Plain of Texas. Rocks exposed in the county (table 1) are of Cretaceous and Quaternary age. Lower Cretaceous (Comanchean series) rocks are exposed in the western part of the county, and Upper Cretaceous (Gulfian series) rocks are exposed in the eastern part. The Fredericksburg Walnut clay and Paluxy sand as well as rocks of the Trinity division are encountered in the subsurface of McLennan County; rocks of the Trinity division crop out west of McLennan County (fig. 4). The Bosque escarpment separates the outcrop of the two Cretaceous series. Exposed Gulfian rocks include the section from the Pepper shale to the Taylor formation. The Quaternary system is represented by Recent alluvium and Pleistocene terrace deposits.

In the western part of the county strata dip about 30 feet per mile southeast, but in eastern McLennan County the dip increases to about 85 feet per mile toward the East Texas basin; individual beds thicken basinward. At the type well (fig. 5), 2437 feet of Cretaceous rocks were penetrated. In the Belcher #1 Smyth well in eastern McLennan County, the Cretaceous section is 3838+ feet thick, and in the western part of the county Cretaceous rocks are 1075 feet thick (Falcon Oil #1 Mattlage). The west to east thickening of the Cretaceous is caused by the occurrence of younger rocks to the east, as well as a pronounced basinward thickening of the rocks in the lower Trinity division in the eastern part of the county.

Several unconformities within the Cretaceous section suggest periodic transgression and regression. Throughout much of the county, Cretaceous sediments rest unconformably on rocks of the "Ouachita facies" of Paleozoic age. However, in the extreme southeastern corner of the county, the Cretaceous section is probably underlain by truncated beds of Jurassic age (Dr. H. H. Beaver, oral communication, 1959).

Stratigraphy and Aquifer Properties

QUATERNARY SYSTEM

RECENT ALLUVIUM

The youngest rocks in McLennan County are alluvial sands and silts of the Brazos River. The alluvial belt is wide where the Brazos River cuts the Taylor marl and narrow where it cuts the more resistant Georgetown limestone and Austin chalk.

PLEISTOCENE TERRACES

Quaternary terraces in McLennan County are related to the Brazos River and its major tributary, the Bosque River system, and to an earlier, apparently unrelated, drainage system. The terraces are in contact with various Cretaceous rock units. Brazos terraces are composed of quartz, quartzite, chert, jasper, and limestone gravels, while Bosque terraces consist predominantly of limestone gravels. A third terrace system, the Uvalde gravels, has a composition similar to the Brazos terraces and may have been the source for much of the Brazos terrace material. The Uvalde gravels commonly occur in a clay soil matrix; the age and origin have not been definitely determined. The Brazos-Bosque terraces have been divided into two groups (Bronaugh, 1950): a lower group including terrace levels from twenty to fifty feet above the river, and a higher group ranging from seventy to two hundred feet above mean low water level. In a more recent study, Stricklin (1961) divided the Brazos terraces into three groups. A small quantity of potable water is produced from the terraces for domestic use.

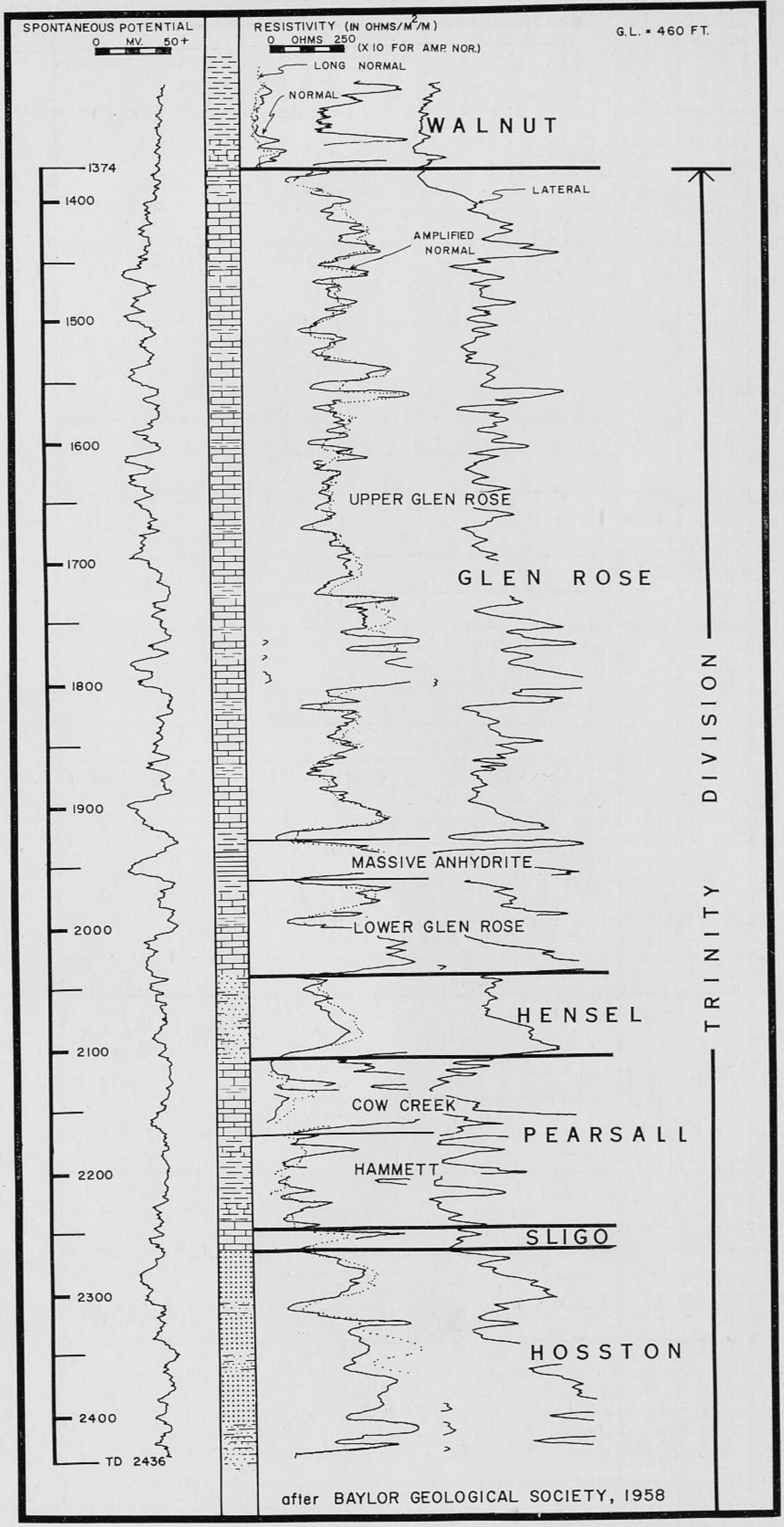

Fig. 2. Type log, Trinity division, McLennan County.
Layne Texas Company No. 3 Connally Air Base water well.

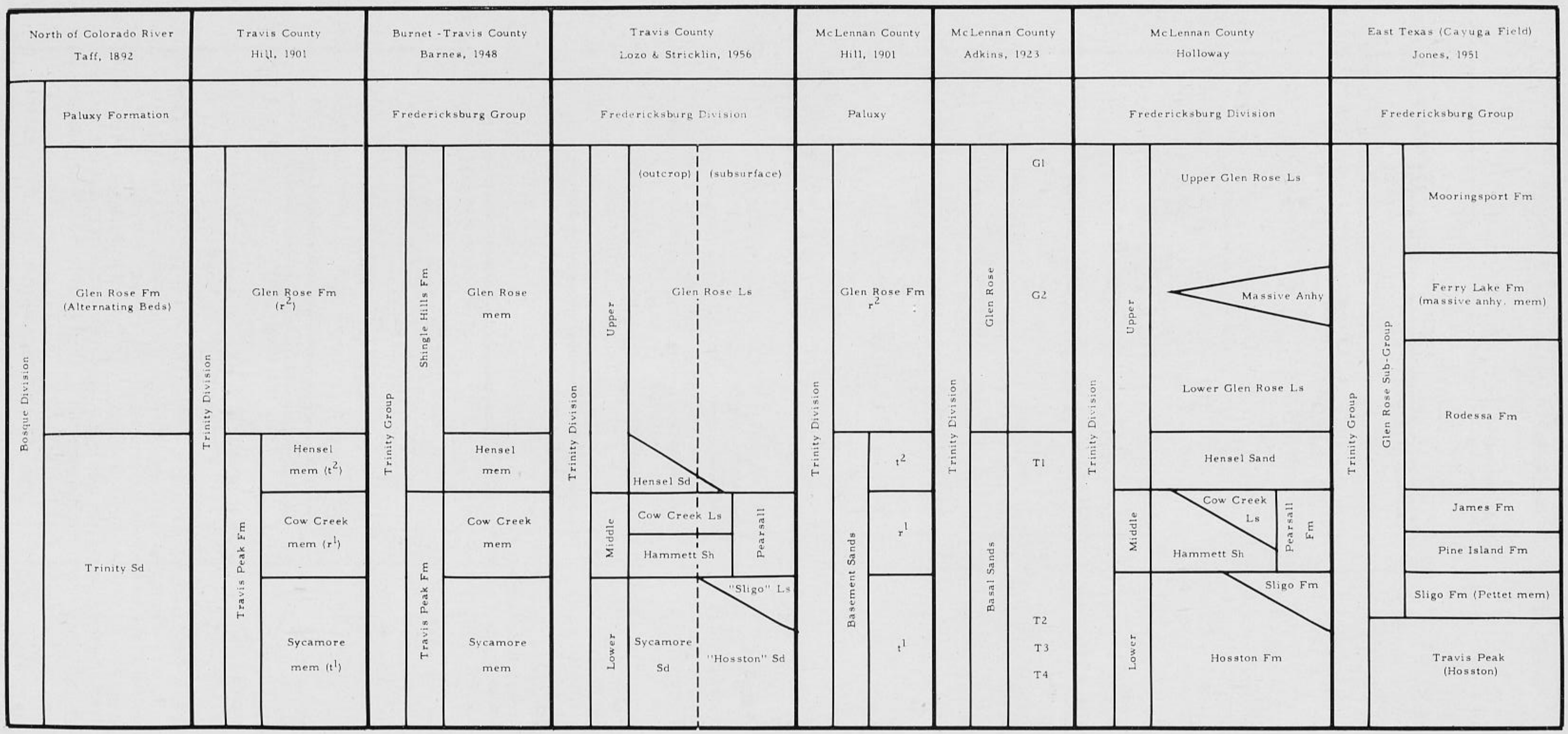

Fig. 3. Correlation chart, Trinity division, Central Texas.

GULFIAN SERIES

The Gulfian series in McLennan County consists of five formations: in descending order, the Taylor marl, the Austin chalk, South Bosque and Lake Waco formations of the Eagle Ford group, and the Pepper shale. The series is exposed in a broad northeast-southwest band across McLennan County. At the type well (fig. 5) Gulfian rocks are 750 feet thick; the thickness increases downdip to 1,745 feet at Mart (Belcher #1 Smyth well). This increase is approximately equal to the thickness of the Taylor marl in eastern McLennan County.

Taylor Marl

The Taylor marl in McLennan County is composed of four members: in descending order they are the Upper Taylor marl, Wolfe City sand, Pecan Gap chalk, and the Lower Taylor marl. The formation consists of blue-gray marls, sandy marl with lenses of calcareous sandstone, and white chalky limestone. At the type well only the lower 185 feet of the Taylor marl is present. Downdip at Mart the formation is 1,170 feet thick (Belcher #1 Smyth well). The Taylor marl rests unconformably on the Austin chalk and is unconformably (?) overlain by the Navarro formation east of McLennan County.

The Taylor marl contains enough water in the Wolfe City sand member in eastern McLennan County for local domestic needs.

Austin Chalk

The Austin chalk in McLennan County forms the crest of the Bosque escarpment. The formation is composed of alternating layers of massive, resistant, blue-gray, marly limestone and blue gray limy shale with a few seams of bentonite and bentonitic shale. The limestone weathers chalky white and the shale weathers gray. The thickness varies from 190 feet in the southern part of the county at Rosenthal (Rosenthal Water Company #1 O'Dowd) to 295 feet near West (Smith & Breyer #1 Russell). The Austin chalk can be easily picked on electric logs and is an excellent subsurface mapping horizon in the eastern part of the county. It rests unconformably upon the South Bosque formation and is unconformably overlain by the Taylor marl. No water is produced from the Austin chalk in McLennan County.

Eagle Ford Group

The Eagle Ford group in McLennan County consists of two formations, the upper South Bosque formation and the lower Lake Waco formation. The Eagle Ford group thickens northeastward. At the type well the Eagle Ford group is 247 feet thick. It unconformably overlies the Pepper shale and is unconformably overlain by the Austin chalk. Water is rarely produced from the Eagle Ford group.

South Bosque formation.—The formation is a blue-black calcareous shale with a few thin buff limestone flags in the lower part. It is 128 feet thick at the type well.

Lake Waco formation.—The formation is a sequence of interbedded brown to black shales and dark gray limestone flags with interbedded bentonite seams. Some carbonaceous material and vertebrate remains occur in

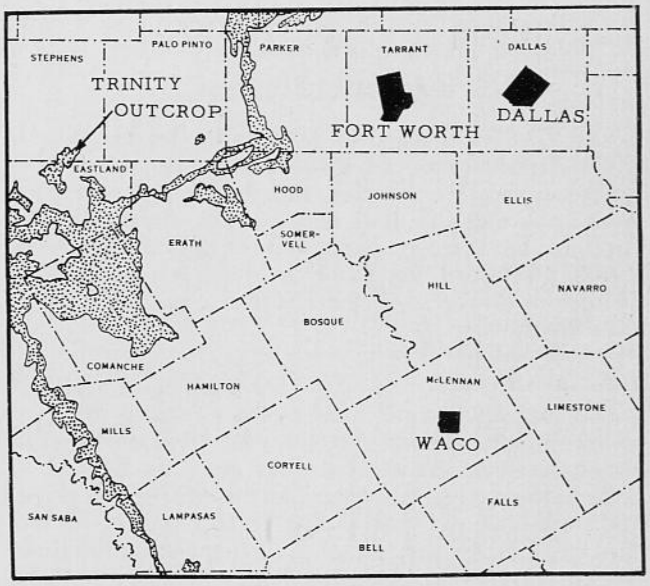

Fig. 4. Outcrop map of Trinity division, West-Central Texas. (*After* Lozo, 1957)

the formation. The Lake Waco formation is 119 feet thick at the type well.

Pepper Shale

The Pepper shale is approximately equivalent to the upper part of the Woodbine group of East Texas. The interfingering of sand and shale facies occurs in northern McLennan and Hill counties. The Pepper shale in McLennan County is a blue-black, non-calcareous shale cut by numerous dikes of sandstone in the northern part of the county. The shale contains abundant selenite and celestite crystals, disseminated pyrite, and jarosite and phosphatic nodules. The thickness ranges from 110 feet at West (Myers #3 City of West) to 70 feet at the type well (fig. 5) to 45 feet just west of Bruceville (Jet Oil Company #1 Wills). The Pepper shale unconformably overlies the Buda limestone or Del Rio clay and is unconformably overlain by the Lake Waco formation.

Brackish water has been reported from sands in the upper part of the Pepper shale in the extreme northern part of the county.

COMANCHEAN SERIES

The Comanchean series of McLennan County consists, in descending order, of the Washita, the Fredericksburg, and the Trinity divisions (Hill, 1901). The Walnut clay and Paluxy sand of the Fredericksburg division and the entire Trinity division occur in the subsurface in McLennan County. At the type well (fig. 5) the Comanchean rocks are 1,672 feet thick, but downdip there is a rapid thickening in the lower part of the Trinity division.

The term "division" is used in this paper in place of the presently used term "group." This use of Hill's (1901) original designation was suggested by Lozo and Stricklin (1956, p. 68).

> "Dual conception of these 'groups' as both lithologic super-formations (American usage) and paleontologic sub-stages (European sense) has introduced needless and increasing confusion. On the basis of cyclic deposition, these established and formally named lithic units may be regarded as tectonic-

sedimentary lithogenetic entities of sub-series rank, hereafter simply called divisions."

WASHITA DIVISION

The Washita division in McLennan County consists of three formations: in descending order, the Buda limestone, the Del Rio clay, and the Georgetown limestone. At the type well the Washita division is 260 feet thick, but there are variations throughout the county due to northward truncation of the Buda, as well as changes in thickness of the Del Rio clay and Georgetown limestone.

Buda Limestone

The Buda limestone in McLennan County is represented by erosional remnants near Bosqueville and elsewhere along the outcrop. As much as 2.5 feet of Buda limestone has been noted at the surface. It thickens southward and downdip to a maximum of 35 feet at Mart (Belcher #1 Smyth). At the outcrop the Buda is a buff-weathering, blue-gray, highly fossiliferous, hard massive limestone which grades to a chalky blue-gray limestone in the subsurface.

A number of wells drilled in the eastern part of McLennan County had oil shows in the Buda limestone, and oil is produced from the Buda limestone in the Satin Field in Falls County. The Buda limestone produces no water in McLennan County.

Del Rio Clay

The Del Rio clay crops out as a thin continuous band at the base of the Bosque escarpment. It is a pale blue-gray fossiliferous jointed clay with limestone beds and sandy streaks. The Del Rio clay is conformable with the underlying Georgetown limestone and is unconformably overlain by the Buda limestone or Pepper shale. It is 78 feet thick at the type well. No water is produced from the Del Rio clay in McLennan County.

Georgetown Limestone

The Georgetown limestone crops out in western McLennan County. It is divided into seven members: in descending order, the Main Street limestone, Pawpaw shale, Weno limestone, Denton limestone, Fort Worth limestone, Duck Creek limestone, and the Kiamichi shale.

The Georgetown is a white nodular limestone interbedded with thin layers of marly shale. The formation thins north to south, the thickness ranging from 178 feet at West (Myers #3 City of West) to 175 feet at the type well, to 140 feet at Bruceville (Paine #1 Eubank). The formation also thickens downdip to a maximum of 225 feet at Mart (Belcher #1 Smyth). The Georgetown limestone contains little water in McLennan County.

FREDERICKSBURG DIVISION

The Fredericksburg division consists of four formations: in descending order, the Edwards limestone, Comanche Peak limestone, Walnut clay, and the Paluxy sand. In McLennan County the Walnut clay and Paluxy sand occur only in the subsurface, though they crop out west of the county. At the type well the Fredericksburg division is 360 feet thick, but slight variations occur throughout the county caused by reefing in the Edwards limestone and westward thinning of the division.

In 1892 Taff (fig. 3) placed the Paluxy sand at the top of the "Bosque division." Hill (1901) classified the Paluxy sand as the upper part of the Trinity division. At present the Paluxy sand is commonly placed in the Fredericksburg division and is believed to represent the influx of terrigenous clastics which initiated the Fredericksburg cycle of sedimentation (Lozo, 1959).

Edwards Limestone

The Edwards limestone crops out in western McLennan County. It is a hard, locally porous limestone. The average thickness is about 40 feet but locally it varies because of biohermal reefs. The Edwards limestone contains a fore-reef limestone facies, a reef facies of rudistid clams, and a lagoonal facies of calcareous siltstones. It rests conformably on the Comanche Peak limestone. North of central McLennan County it is unconformably overlain by the Kiamichi shale member of the Georgetown limestone; to the south it is unconformably overlain by the Duck Creek limestone member of the Georgetown limestone. The Edwards limestone thickens southward.

Some potable water is produced from the Edwards limestone west of the Bosque escarpment. Only a few wells have been drilled for domestic and stock use.

Comanche Peak Limestone

The Comanche Peak limestone which crops out in western McLennan County, consists of alternating layers of highly fossiliferous nodular limestone and clay. At the type well it is 130 feet thick. The Comanche Peak limestone is conformably overlain by the Edwards limestone and it rests conformably upon the underlying Walnut clay. No water is produced from the Comanche Peak limestone.

Walnut Clay

The Walnut clay crops out in Bosque County just west of the McLennan County line. At the type well the Walnut clay is 167 feet thick and is composed of calcareous shale containing some nodular limestone and shell beds. Lenticular sandstone beds are present in the lower portion in western McLennan County.

The productive sand of the South Bosque oil field has been placed in the basal Walnut clay, but the writer believes this sand is the Paluxy sand. No water is produced from the Walnut clay in McLennan County.

Paluxy Sand

The Paluxy sand is a subsurface formation in McLennan County. It is absent in the southeastern part of the county but is about 20 feet thick in the northwestern part. The sand, which overlies the upper massive limestone bed of the Glen Rose limestone of the upper Trinity division, is absent at the type well.

The producing horizon in the South Bosque oil field is probably Paluxy sand, which is from 0.5 to 3 feet thick here, near its southern pinchout.

Several wells in the northern part of the county produce a small quantity of water from the Paluxy sand. The quality is poor, but it is used for domestic and stock purposes. All the wells are artesian; some wells are flowing.

TRINITY DIVISION

Evolution of Terminology

Numerous workers (fig. 3) have contributed to the development of nomenclature for the Trinity division.

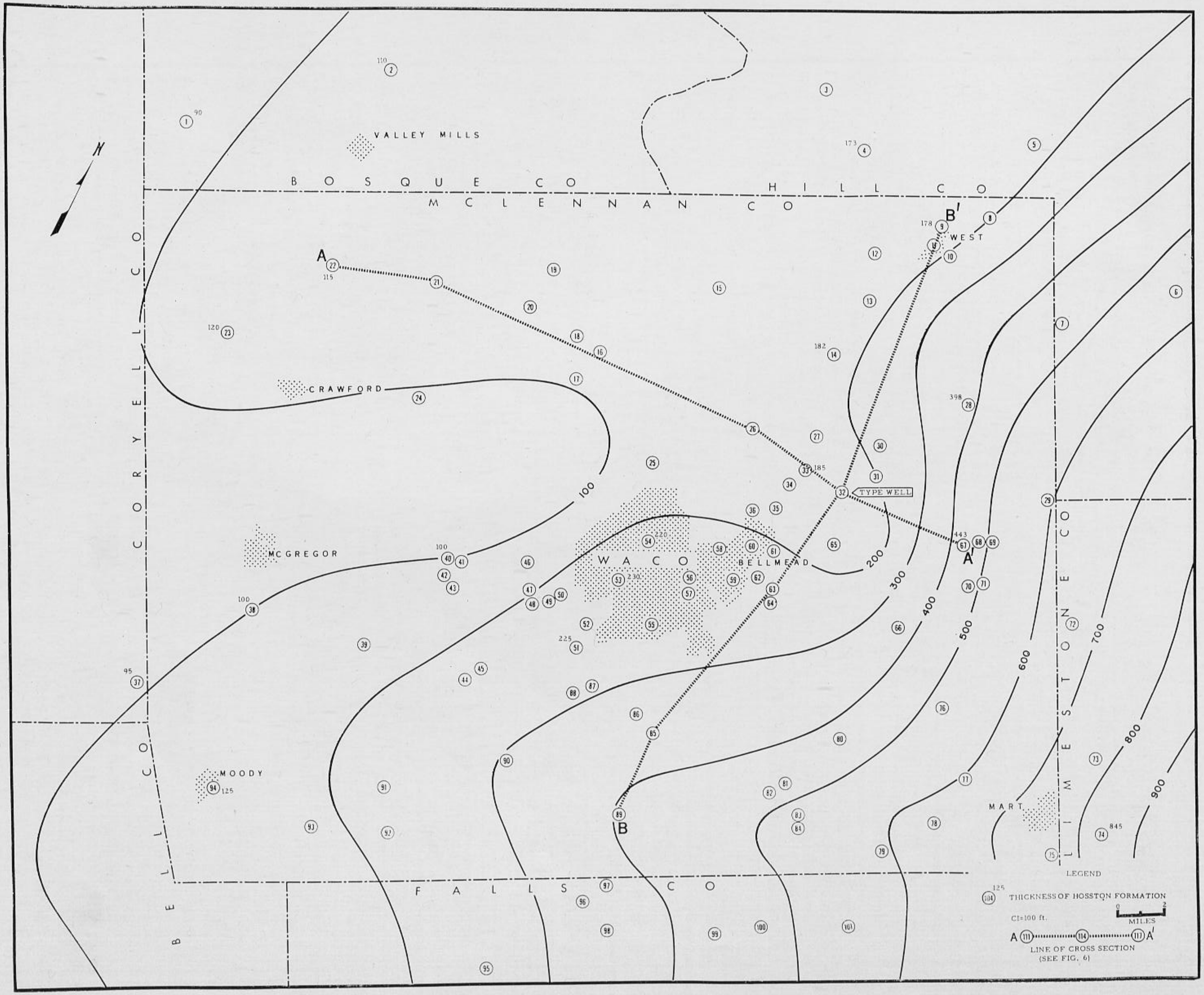

Fig. 5. Isopach map, Hosston formation, McLennan County.

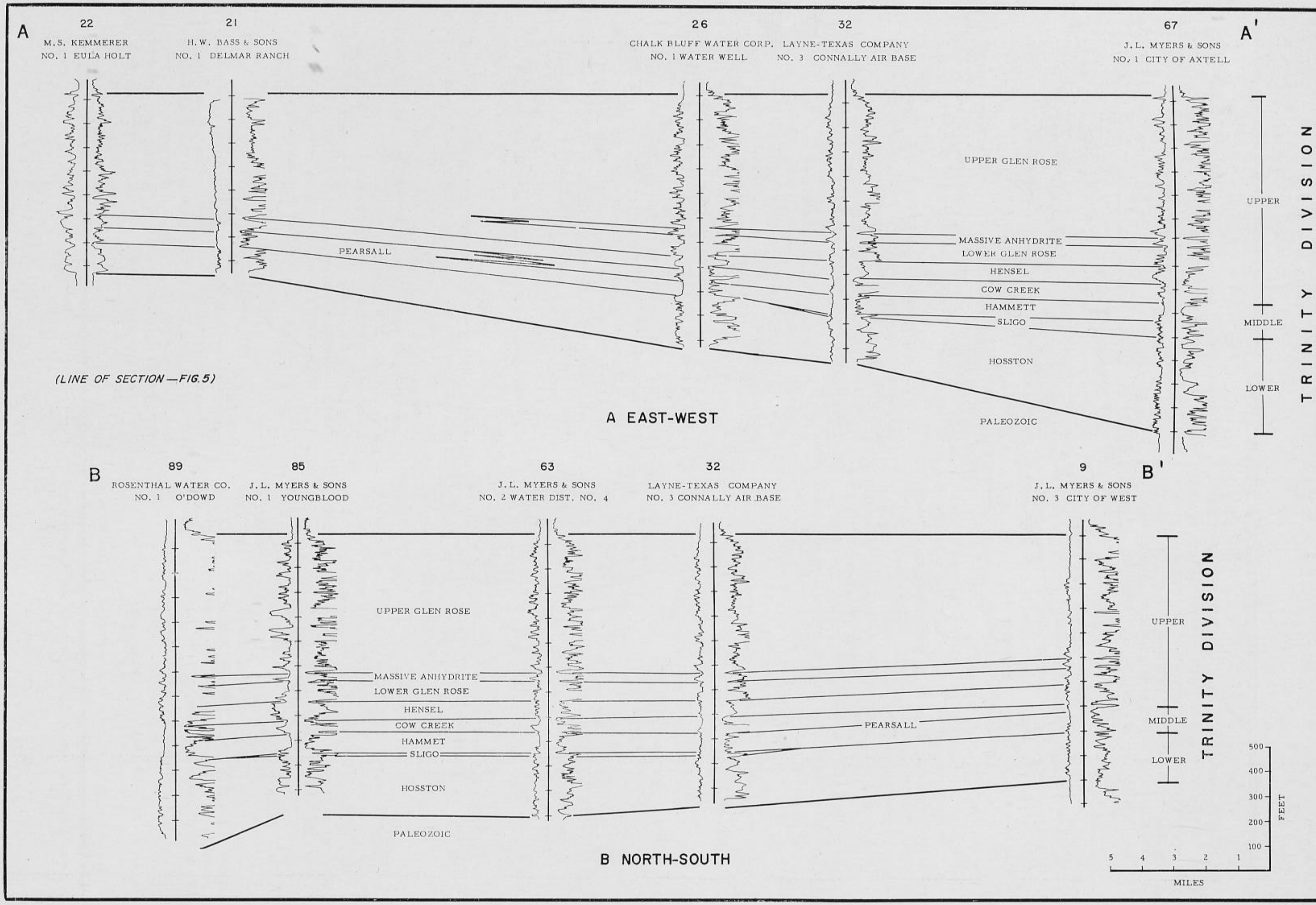

Fig. 6. Cross sections, Trinity division, McLennan County.

Taff (1892), in his work north of the Colorado River, designated a sequence of formations the "Bosque division." These included, in descending order, the Paluxy formation, Glen Rose (Alternating Beds) formation, and Trinity sands. Following his work in Travis County, Hill (1901) redesignated the same sequence of rocks the "Trinity division" and renamed the "Trinity sands" (Taff, 1892) the "Travis Peak formation." Hill further divided the Travis Peak formation into three members: in descending order, the Hensel sand, Cow Creek limestone, and the Sycamore sand. Subsequent work (Lozo, 1949) has suggested that the Paluxy sand belongs to the basal Fredericksburg division.

The Travis Peak-Glen Rose terminology of Hill (1901) was accepted until Barnes (1948) noted that the Cow Creek limestone member near the Travis-Burnet county line, was in contact with Paleozoic rocks and that the Sycamore sand member did not grade laterally into the Hensel sand member as previously believed. With this new evidence, in addition to confirmation of Taff's original contention that the Hensel sand member was transitional with the Glen Rose limestone, Barnes (1948) proposed that the Travis Peak formation be amended to include only the Cow Creek limestone and Sycamore sand members, and that the Glen Rose limestone and Hensel sand member be designated the "Shingle Hills formation."

Later, Lozo and Stricklin (1956) studied the type Travis Peak formation and proposed to use Hill's (1901) original term "division" and to divide the Trinity rocks into the lower, middle, and upper units. Recognizable disconformities between the Hensel sand and Cow Creek limestone members and between the Cow Creek limestone and Sycamore sand members justified this subdivision. The lower part of the Trinity division consists of the Sycamore sand member and its subsurface equivalents, the Sligo and Hosston formations; the middle part consists of the Cow Creek limestone and Hammett shale members (originally included in Hill's definition of the Cow Creek limestone). The Cow Creek limestone and Hammett shale members are the outcrop equivalents of the subsurface Pearsall formation of South Texas. The upper part of the Trinity division consists of the Glen Rose limestone and the Hensel sand member. Lozo and Stricklin (1956) proposed to suppress the term "Travis Peak formation."

Previous Investigations in McLennan County

Hill (1901), the earliest of several workers in McLennan County (fig. 3), used the terms "Glen Rose formation" and the "Basement sands" when he referred to the subsurface Trinity division. He defined "Basement sands" as the time equivalent of any of the three formations—Paluxy, Glen Rose, or Travis Peak—where these "Basement sands" were in contact with Paleozoic rocks. Hill also divided the subsurface Travis Peak formation into units designated t^1, r^1, and t^2 in ascending order and designated the Glen Rose limestone as r^2 with a t^3 water horizon within the Glen Rose formation. He correlated t^1 with the Sycamore sand, r^1 with the Cow Creek limestone, and t^2 with the Hensel sand of Travis County and Bluffdale sands (local name) of Erath County. Hill noted the presence of the t^1, r^1, t^2, and t^3 in McLennan County but t^3 is a relatively unimportant aquifer.

In 1921 Pace used the terms Glen Rose limestone and Trinity sand in her McLennan County report but did not attempt a detailed study.

In 1923 Adkins divided the Trinity division into Glen Rose limestone and Basal Trinity sands, and numbered the Basal sands T1-T4 in descending order. Adkins' classification differs from Hill's system, but it appears that unit T1 equals Hill's t^2 and unit T2-T4 equals Hill's t^1. Adkins designated unit G2 in the Glen Rose limestone, which probably correlates with Hill's t^3, and G1 at the top of the Glen Rose formation. Except for changes in the numbering system, Adkins contributed little information about the lower Trinity sands.

In 1942 a brief ground water report on the McGregor area was prepared for the War Production Board by Livingston and Bennett. They used the terms "Glen Rose limestone" and "Travis Peak formation," but did not attempt further subdivision.

George and Bennett (1945) divided the Trinity "group" into the Glen Rose and Travis Peak formations during a study of Waco wells. They recognized sands at the base of the Glen Rose formation which, however, they excluded from the Travis Peak formation.

Proposed Stratigraphic Terminology

In developing stratigraphic terminology for the Trinity division of McLennan County, electric logs were used primarily. Lithologic interpretations were discussed with geologists and drillers; drillers' logs were checked. Few well cuttings of the Trinity division are available, and depth control for these is poor.

McLennan County is in a transitional zone between the stable shelf to the west and the East Texas basin. It is difficult to correlate certain units across the county because sands, shales, and limestones interfinger in this transition zone. However, certain units are distinctive on the electric logs and satisfactory correlations can be made.

The top of the Trinity division at the type well (fig. 2) is at a depth of 1,374 feet. No Cretaceous rocks older than those of the basal Trinity division occur in McLennan County. Except for the extreme southeast corner of the county near Mart, where Jurassic rocks probably underlie the Cretaceous section, the Cretaceous section rests on rocks of Paleozoic age. The contact between the Trinity division and Paleozoic rocks can be recognized on electric logs by either of two characteristics: (1) the sudden decrease in the self potential (*SP*) curve in Paleozoic rocks, or (2) the total loss of all *SP* variation in the Paleozoic section. The change in *SP* at the contact can be noted in the Kemmerer #1 Holt well (fig. 6-A).

Sample description of several wells was used to describe the lithology of the Trinity rock units. These cuttings analyses made by major oil companies were used to correlate lithology with electric log character.

Upper Trinity Division

The interval between 1,374 feet and 2,105 feet at the type well (fig. 2) is designated the upper Trinity division. It is composed of the Glen Rose limestone above and the Hensel sand member below. At the type well (fig. 2) the top of the Glen Rose limestone is at a depth of 1,374 feet, and the top of the Hensel sand member is at 2,045 feet. The upper division thickens eastward; thickening is especially exhibited by the Glen Rose limestone (fig. 6-A, B).

Glen Rose Limestone

In McLennan County the Glen Rose limestone can be divided into an upper and lower Glen Rose limestone with an anyhydrite section, the "massive anhydrite," separating the two units. At the type well (fig. 2) the massive anhydrite occurs at a depth of 1,931 to 1,960 feet.

The upper Glen Rose limestone is tan porous shelly limestone, slightly glauconitic at the top and partly oolitic with gray thinly laminated interbedded shales. Miliolid Foraminifera are present.

The massive anhydrite is white crystalline anhydrite interbedded with tan chalky highly porous limestone and gray thinly laminated shale. The anhydrite thins rapidly westward and is rarely encountered in wells of western McLennan County; the anhydrite affects drilling fluids in the eastern part of the county.

The lower Glen Rose limestone is tan porous chalky limestone with gray thinly laminated interbedded shale. The foraminifer *Orbitolina texana* is common in this unit.

Hill (1901) and Adkins (1923) recognized water horizons in the Glen Rose limestone. Several wells within the county produce from the Glen Rose limestone, but the water is highly mineralized. The Meadows #1 Smith well near Erath, which penetrated the upper part of the formation, contained potable water.

Hensel Sand Member

The Hensel sand member (t^2 of Hill and T1 of Adkins), within McLennan County, is the first sand encountered in drilling below the basal limestone beds of the Glen Rose limestone. It is white, fine to coarse-grained, sub-rounded to sub-angular unconsolidated sand. Green shales are interbedded in the Hensel sand member in the western part of the county.

Electric logs indicate that the sand thins in the northwest part of the county. The Hensel sand member contains abundant high quality water; many wells near Waco produce from the sand.

MIDDLE TRINITY DIVISION

The middle Trinity division is defined as that section between 2,105 feet and 2,251 feet at the type well (fig. 2). The middle division consists of the Pearsall formation, composed of the Cow Creek limestone member above, and the Hammett shale member below. The top of the Cow Creek limestone member is at a depth of 2,105 feet, and the top of the Hammett shale member is at 2,165 feet at the type well (fig. 2).

Pearsall Formation

The Cow Creek limestone member is cream to tan, oolitic to finely sucrosic, slightly porous limestone, and the Hammett shale member is gray shale with some cream, slightly oolitic crystalline limestone beds which become sandy westward. The Cow Creek limestone member cannot be traced in the subsurface of western McLennan County; based on electric log interpretation the Hammett shale member is more sandy westward.

The Pearsall formation is not an important artesian aquifer in the county, but it is an excellent subsurface marker between the overlying Hensel sand member of the upper division and the underlying Hosston formation of the lower division.

LOWER TRINITY DIVISION

At the type well (fig. 2) the lower Trinity division is designated the interval from a depth of 2,251 feet to the base of the Cretaceous section. This division in McLennan County consists of the Sligo and Hosston formations (fig. 3). At the type well (fig. 2) the top of the Sligo formation is at a depth of 2,251 feet, and the top of the Hosston formation is at 2,255 feet.

Sligo Formation

The Sligo formation at the type well (fig. 5) is near the updip limit. In the central part of the county the Sligo formation interfingers with sands and shales of the Hosston formation and is no longer a distinctive, traceable unit. The exact updip limit of the Sligo formation is arbitrary. The formation is well delineated on the electric log of the Mae Belcher Smyth well near Mart. At this well the top of the Sligo formation is picked at a depth of 3,495 feet and the base at 3,585 feet. At the Belcher well the Sligo formation is mostly limestone containing some shale near the middle and base of the formation. The top of the Sligo formation in this well was determined by correlating with the Farrell Drilling Company #1 Gillam well which Imlay (1944) included on his correlation chart. No water is produced from the Sligo formation.

Hosston Formation

The Hosston formation (t^1 of Hill and T2 through T4 of Adkins (p. 15) is the basal Cretaceous formation in McLennan County. The thickness of the Hosston formation (fig. 5) increases from 120 feet in the western part of McLennan County (Falcon Oil #1 Mattlage) to 845 feet at the Farrell #1 Gillam just east of the county line in Limestone County.

The Hosston formation is commonly fine to coarse, red to white, silty porous sand, locally cemented with calcite and interbedded with variegated shale. In two wells, the J. L. Myers & Sons #1 City of Mart and the City of Moody #2, gravels are encountered in the basal part of the formation. These gravels are too coarse to pass through a shale shaker (I. N. Grant, J. L. Myers & Sons, oral communication). Pebble to granule sized quartz and chert fragments have been reported from other wells. Electric logs indicate an increase in shale in the formation in the eastern part of the county; individual beds cannot be correlated because the shales grade westward into sandy shales and sand.

The depth of the Hosston formation increases eastward from 955 feet in the Falcon Oil #1 Mattlage well west of Crawford to 3,585 feet in the Belcher #1 Smyth well at Mart. West of the Balcones fault zone the Hosston formation dips eastward about 40 feet per mile, but east of the fault the dip is about 80 feet per mile.

The Hosston formation is the more productive of the two Trinity aquifers in McLennan County. In the eastern part of the county all public and industrial artesian wells produce from this formation. Water from the Hosston formation is normally good quality. In drilling an artesian well to the Hosston formation, it is best to drill into the lower part of the formation where sands are coarser and more permeable.

SEDIMENTARY HISTORY

Within McLennan County the basal Cretaceous Trinity division exhibits a transition from carbonate to clastic phases of deposition, and includes within the carbonate section the updip limit of an anhydrite phase of deposition. The slow initial transgression of the Cretaceous sea westward across Central Texas onto truncated

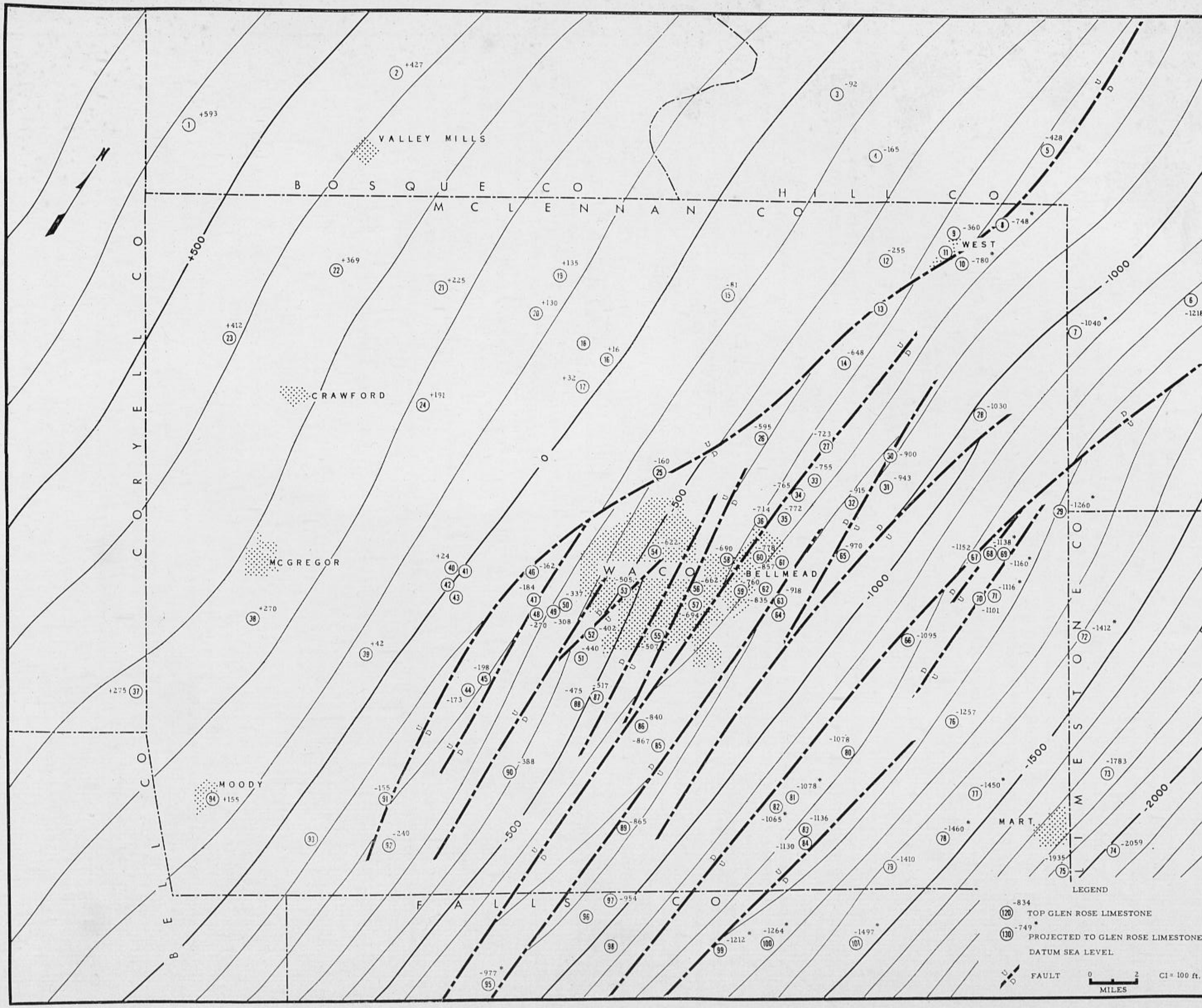

Fig. 7. Structure map, top of Glen Rose limestone, McLennan County.

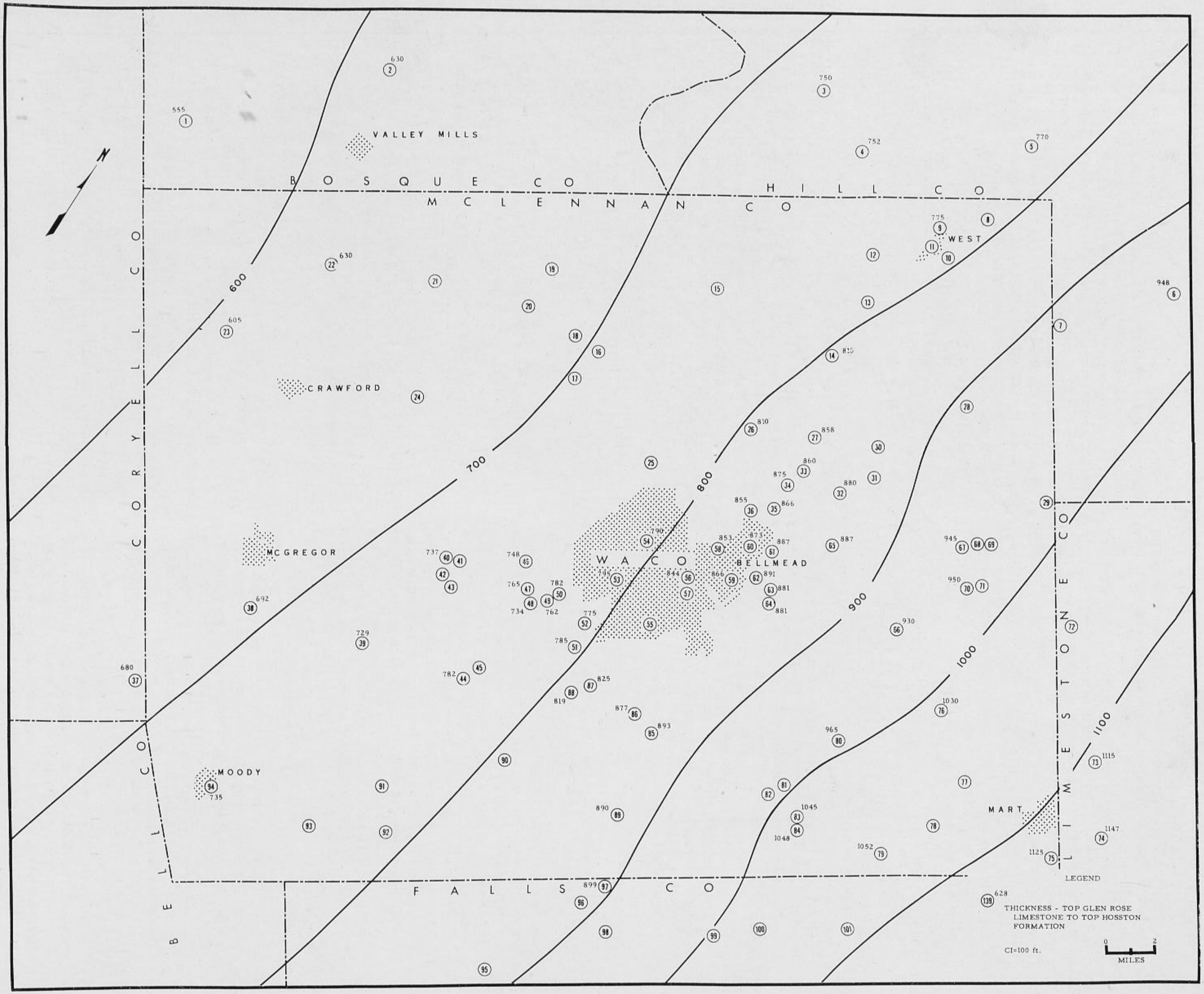

Fig. 8. Isopach map, top of Glen Rose limestone to top of Hosston formation, McLennan County.

Jurassic rocks and the deformed Paleozoic Ouachita foldbelt was accompanied by gradual subsidence in the East Texas basin. Relief in Central Texas at the time of the initial transgression was similar to that today; this is indicated by the isopach map of the Hosston formation (fig. 5) which reflects underlying topography.

The Trinity division in McLennan County represents cyclic deposition. The cyclic nature has been used by Lozo and Stricklin (1956, p. 68) as a basis for dividing the Trinity rocks into three subdivisions—lower, middle, and upper. As they point out, "In a gross sense, each cyclic unit may be considered a couplet consisting of a basal terrigenous detritus phase, quartzose or argillaceous, succeeded by a carbonate phase." They consider the pattern of repetition reflects tectonic activity more pronounced in the source area than in the depositional area, and their interpretation involves (*idem*) "episodic rejuvenation in the source area, resulting in an increased supply of clastics and a consequent detrital depositional phase, succeeded by relatively quiescent sedimentation of carbonate deposits, the later phase in part contemporaneous with the clastic phase."

Three sedimentary couplets are identifiable within the Trinity division in McLennan County, and on this basis it has been divided into lower, middle, and upper units. The only apparent tectonic activity in the depositional area was that of slow subsidence indicated by thickening of sediments basinward.

Carbonate deposition in both the lower and middle Trinity division terminates westward within McLennan County. In the lower Trinity division (fig. 6-A) the carbonate phase is replaced westward by clastics near the central part of the county, and in the middle Trinity division the replacement of carbonates by clastics occurs in the western part of the county. These facies changes probably occur because central McLennan County lay along the hinge line of the subsiding East Texas basin; carbonate deposition existed eastward in deeper water away from a clastic source.

Subsidence was not pronounced in the area during deposition of the Hensel sand member of the upper Trinity division; the sand thickens but slightly eastward. The sea probably transgressed farther north and west during deposition of the overlying Glen Rose limestone. This is indicated by the great thickness of the Glen Rose limestone and the absence of coarse clastics in McLennan County. The sea was restricted during precipitation of the "massive anhydrite," the middle member of the Glen Rose limestone; the area including McLennan County lay on the updip limit of anhydrite deposition. Following anhydrite deposition, unrestricted circulation was again established and the upper Glen Rose limestone deposited.

After deposition of the Glen Rose limestone, the sea apparently retreated before transgressing to begin deposition of the Fredericksburg division. This is suggested because central McLennan County is the downdip limit of basal transgressive Paluxy sand of the Fredericksburg division. Further, an erosional unconformity has been noted at the top of the Glen Rose limestone in Hamilton County (J. B. Jameson, oral communication).

JURASSIC SYSTEM

The exact westward limit and thickness of Jurassic rocks in McLennan County is not known. The U. S. Geological Survey (Imlay, *in* McKee, *et al.*, 1956) charts the western edge of truncated Jurassic rocks in the extreme southeast corner of the county. At the Farrell #1 Gillam well in western Limestone County, Swain (1949) picked the top of the Cotton Valley group at a depth of 4,570 feet. The Schuler formation (upper Cotton Valley) is 260 feet thick in the Farrell well, and consists of red beds and conglomerate resting unconformably on Paleozoic rocks.

No wells in eastern McLennan County are known to penetrate Jurassic rocks, but it is probable that the Cotton Valley group extends westward for a short distance into this area. An electric log of the Farrell #1 Gillam indicates that Jurassic rocks may contain brackish or salt water.

PALEOZOIC SYSTEMS

As previously mentioned (p. 8) Cretaceous rocks in most of McLennan County rest unconformably on the deformed and metamorphosed rocks of the Paleozoic Ouachita foldbelt. Several wells have penetrated these Paleozoic rocks; samples include rock types such as shales and sandstones, weakly metamorphosed dark fine-grained clastic rocks, phyllites, slates, and metaquartzites (Flawn, 1958). No fresh water has been reported in Paleozoic rocks.

Structure

REGIONAL STRUCTURE

McLennan County (fig. 1) lies at the interior boundary of the Gulf Coastal Plain of Texas. Cretaceous rocks of McLennan County were deposited primarily on the truncated Paleozoic Ouachita foldbelt. During Cretaceous deposition basin subsidence occurred to the south and east, resulting in an eastward increase in dip and thickness of the Cretaceous rocks.

The Paleozoic Ouachita foldbelt, which lies buried beneath the county, is characterized by complex mountain structures and associated thrust faults of great magnitude (Flawn, 1958). This belt was formed by folding and westward thrusting of thick Paleozoic deposits of the Ouachita geosyncline. The foldbelt follows a line (fig. 1) southward from the present Ouachita Mountains of Oklahoma through Central Texas and around the southeastern flank of the Llano uplift, then westward to the Marathon region of Texas. Most of the deformation of the geosyncline was completed by the end of the Pennsylvanian period; Permian rocks are but slightly deformed (King, 1951). At the initial transgression of the Cretaceous sea, the old Ouachita mountain range was in an advanced stage of erosion.

The major structural feature of the upper Gulf Coastal Plain is a wedge shaped homocline of Cretaceous and Tertiary rocks which thicken toward the coast. The strata lie in imbricate fashion, tilted slightly southeastward, with younger beds cropping out coastward. However, this broad uniform pattern is broken by other prominent structural features (fig. 1) such as the Balcones fault zone, and the Luling and Mexia-Talco fault zones.

The Balcones fault zone is the innermost zone of faulting in the Gulf Coastal Plain. It marks the approximate present updip limit of Gulfian rocks and separates the structurally flat area of the Edwards Plateau from the more steeply dipping beds of the Gulf Coastal Plain. The Balcones fault zone is a line of predominantly down-to-the-coast, somewhat *en echelon* faults extending from near Uvalde eastward to the vicinity of San Antonio and northward through Austin to terminate near Dallas. This zone of faulting follows the trend of the old Ouachita Mountains which apparently marked the western hinge of the subsiding East Texas basin.

East of the Balcones fault zone are the Luling and the Mexia-Talco fault zones. The westernmost Luling system is characterized by predominantly up-to-the-coast *en echelon* faults. The eastern Mexia-Talco system is characterized by both up-to-the-coast and down-to-the-coast, slightly *en echelon* faults. The two zones more or less parallel the Balcones zone, as well as the outcrop of the basal Tertiary rocks of the Gulf Coastal Plain.

Major movement along these three fault zones, according to Weeks (1945), occurred during early Miocene time with possible recent movement along the most easterly of the faults in Lee County. Wiggins (1954), after a study of the Mexia-Talco zone in the Ham Gossett oil field, Kaufman County, considered that a portion of the faulting occurred during deposition of the Trinity division; he suggested that faulting is still active.

Structure of McLennan County

The northern extension of the Balcones fault zone strikes slightly east of north, essentially parallel to the strike of the Cretaceous strata in McLennan County.

The zone of faulting, which separates the outcrop of Comanchean and Gulfian rocks is topographically expressed by the Bosque escarpment (Hayward, 1957).

A major northeast-trending, down-to-the-coast fault extending northward from a few miles south of Waco to West has long been recognized (Pace, 1921; Adkins and Lozo, 1951; Hayward, 1957). Similar faults have been traced from five miles south of Lorena to midway between Lorena and Waco (Pace, 1921) and from Bullhide Creek in south-central McLennan County to the south Waco city limits (Holloway, 1958). In addition to these faults, other small displacements constitute a zone several miles wide east and west of the major faults. Some of the smaller faults are down-thrown to the west but are obviously related to the Balcones system.

In McLennan County faults associated with the Balcones zone can easily be traced on aerial photographs and in the field. However, in the eastern part of McLennan County, up-to-the-coast faults, which have commonly been located by subsurface methods, are rarely visible in the field; color alignments may be visible on aerial photographs to support a fault trend.

The cause and date of Balcones faulting in McLennan County are uncertain, but structural patterns suggest a relationship with the underlying Paleozoic Ouachita foldbelt. The Balcones faulting in McLennan County is younger than Cretaceous and older than Pleistocene. Since there are no post-Cretaceous, pre-Pleistocene rocks in the area, a more accurate date cannot be proposed. Weeks (1945) dates the Balcones fault zone as Miocene, based on evidence in Tertiary rocks east of the Balcones system.

The origin of the Balcones fault zone has been attributed to a number of factors: compaction, salt intrusion, and landslides toward the Gulf. It was a modification of this last view that was proposed by Hayward (1957). Hayward suggested that the Ouachita foldbelt, acting entirely in a passive manner, furnished the "anvil" over which Gulf Coast Mesozoic and Cenozoic deposits were folded and eventually broken by normal gravitational forces created by the inclination of a deep "glide-plane" (Louann salt) toward the free face of the continental slope in the Gulf of Mexico. Hayward (oral communication) believes that the faulting probably dies out within the Cretaceous strata and thus does not necessarily penetrate the Paleozoic basement.

The Balcones fault zone in McLennan County is a zone of essentially north-south trending faults, predominantly down-to-the-coast, slightly *en echelon* with displacement up to 400 feet. This zone follows the trend of the Ouachita foldbelt, a hinge between the stable craton to the west and the subsiding East Texas basin. The pattern of faulting is revealed by the structure on top of the Glen Rose limestone (fig. 7).

The pattern of faulting (fig. 7) resembles that indicated by surface mapping and aerial photographic interpretation. Some small faults are not revealed because of a large contour interval. The similar fault pattern observed in all rocks of Cretaceous age indicates that faulting was probably post-Cretaceous.

The thickness of the section from the top of the Glen Rose limestone to the top of the Hosston formation (fig. 8) increases uniformly from west to east. This indicates that faulting did not occur during the deposition of this section.

The pre-Cretaceous surface configuration (fig. 9) suggests two major faults. One fault enters McLennan County at West and disappears in the southern part of the county. Displacement along this fault, which is approximately 400 feet at West, decreases southward. The fault coincides with a fault mapped at the top of the Glen Rose limestone and the Hosston formation (figs. 7, 10). The second major fault enters McLennan County from the south and disappears near Waco. The displacement along this fault is approximately 100 feet; the fault trend also coincides with faulting noted on structure maps (fig. 7, 10) of Cretaceous horizons.

Control points on the pre-Cretaceous surface map (fig. 9) are limited; the two major north-south trending, down-to-the-coast and *en echelon* faults are based on map interpretation. Other faults noted in the Cretaceous section were not included on the pre-Cretaceous map. The topography of the pre-Cretaceous surface at the time of Cretaceous transgression is revealed by the thickness of the Hosston formation (fig. 5). Despite limited control points, it appears that Waco is situated on a pre-Cretaceous topographic platform. Pre-Cretaceous topography east of Waco is a gentle coastward slope.

The Ouachita foldbelt is the hinge line separating the stable area to the west from the East Texas basin. Movement along the foldbelt and major normal down-to-the-coast faulting occurred in the pre-Cretaceous floor as subsidence and deposition occurred in the basin. With renewed movement in the pre-Cretaceous floor, the overlying Cretaceous beds were faulted. Minor faulting along the Balcones zone consisted of normal compensating faults associated with major movements. The up-to-the-coast faulting in the eastern part of the county, which lines up with the Luling fault zone to the south, is related to the Balcones system. Present con-

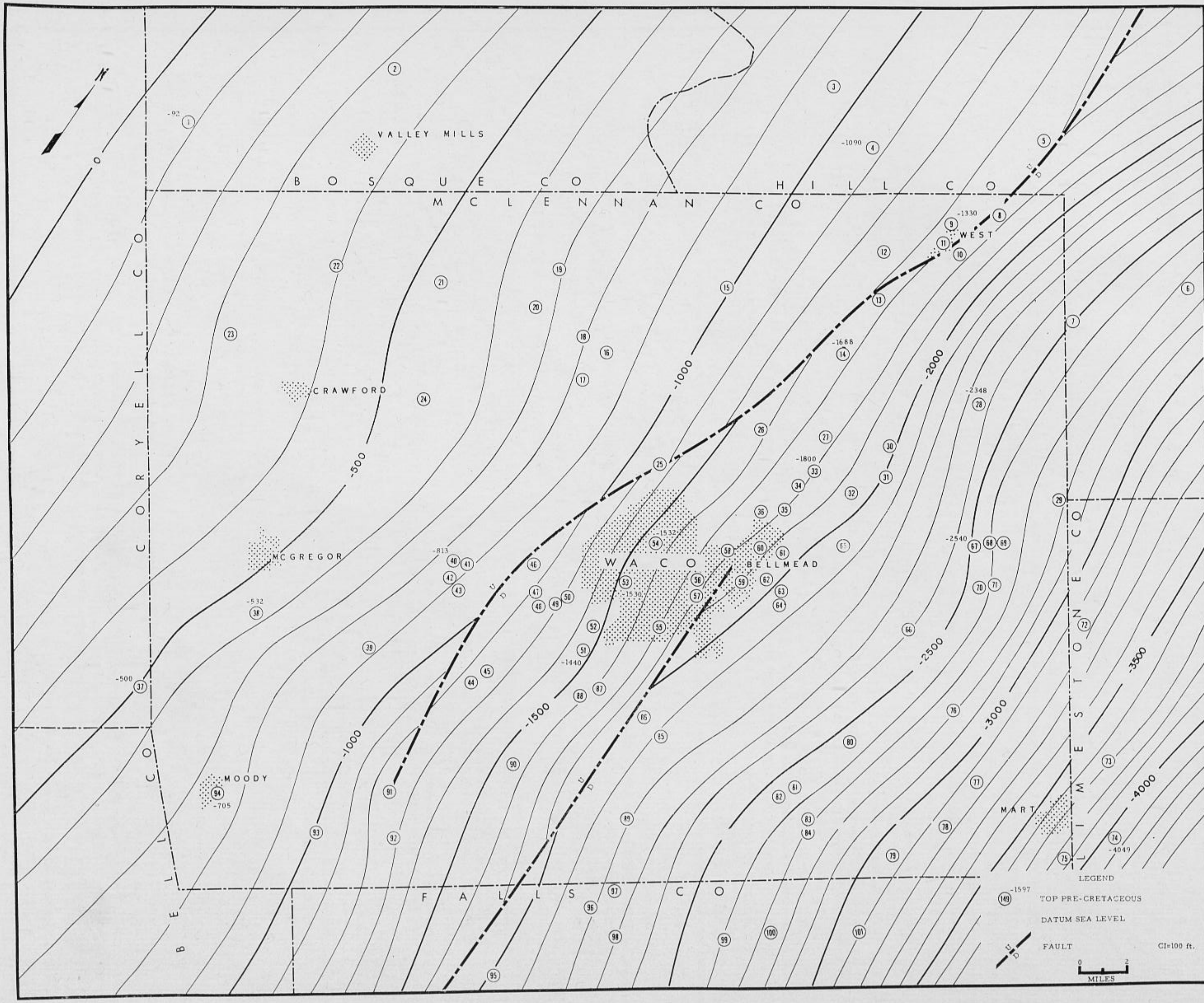

Fig. 9. Pre-Cretaceous surface, McLennan County.

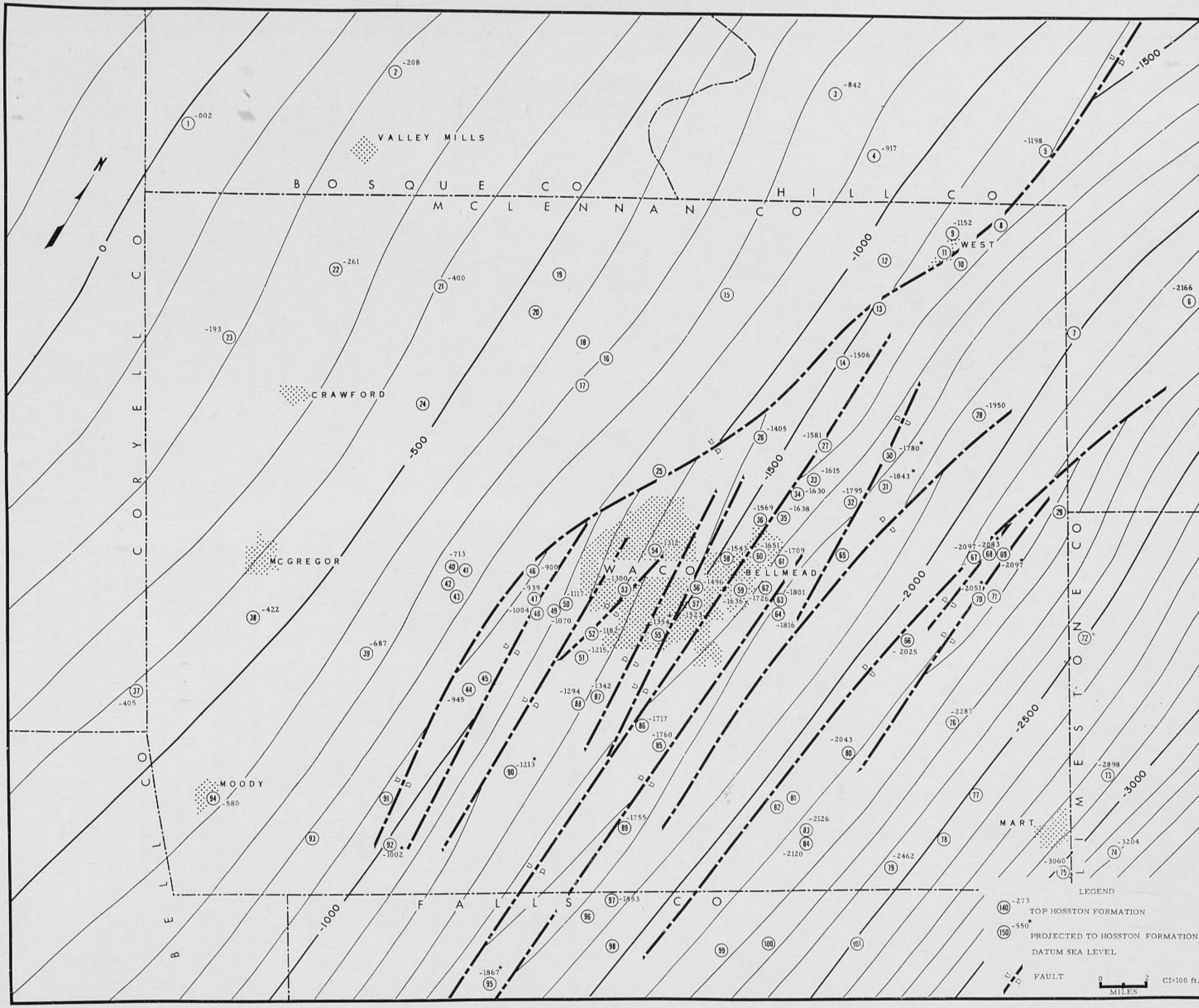

Fig. 10. Structure map, top of Hosston formation, McLennan County, Texas.

trol suggests this faulting may penetrate the pre-Cretaceous surface.

Faulting shown on the pre-Cretaceous surface (fig. 9) was mapped because of a sudden increase in dip along a zone from the town of West to southern McLennan County. If coastward slippage of sediments along the Louann salt (p. 20) was the mechanism for faulting, a sudden increase in slope in the pre-Cretaceous surface could explain the disappearance of the faults at the base of the Cretaceous section.

The Hosston formation is 178 feet thick in the J. L. Myers #3 City of West well. Displacement along the fault at West is approximately 400 feet. With dip increase in the pre-Cretaceous floor in the vicinity of West, it is possible that faulting would die out at the base of the Cretaceous section. However, since the Hosston formation is only 178 feet thick at West and the fault displacement is approximately 400 feet, it is not likely that high angle faulting would flatten and suddenly disappear within the Hosston formation.

ARTESIAN WATER

OCCURRENCE

The volume of artesian[1] water produced in McLennan County ranks high in the State of Texas. Adkins (1923) reported eleven flowing wells near Waco in 1891; Hill (1901) reported twenty-seven flowing wells and eight non-flowing wells within the county; today hundreds of artesian wells occur in McLennan County, although flowing wells are less numerous.

The chief aquifers are two sands of the Trinity division—the Hensel sand member and the Hosston formation (table 1). Hill (1901) designated the Hensel sand member t^2 and the Hosston formation t^1. Adkins (1923) designated the Hensel sand T1 and the Hosston formation T2-T3.

McLennan County is divided into an eastern and western artesian district by the Balcones fault zone (Hill, 1901; Pace, 1921). Because the sands are not as deep in the western district, more wells have been drilled than in the eastern part of the county.

WESTERN DISTRICT

The large volume of artesian water produced in the western district is from the Hensel sand member. Wells penetrating this sand are numerous, and more are being drilled for public, industrial, domestic, and stock use.

The elevation of the piezometric surface[2] is a function of the number of wells and volume of production in a given area. Depth to the piezometric surface varies with elevation at the well site. Near McGregor an apparent depression in the piezometric surface occurs because of the large quantity of water produced in the area. However, the piezometric surface in the Crawford and China Springs areas is higher and less variable.

McGregor, Crawford, China Springs, and the Rocketdyne Corporation near McGregor obtain water from the Hensel sand member. Moody obtains water from the Hosston formation. Wells at McGregor are about 1,030 feet deep and wells at the Rocketdyne Corporation several miles south of McGregor are about 1,065 feet deep. McGregor has two wells in operation and the Rocketdyne Corporation has five producing wells. The present static water level at McGregor is 325 feet below the surface (piezometric surface=+388 feet). Livingston and Bennett (1942) reported the static water level at McGregor in 1942 at 150 feet below the surface (piezometric surface=+563 feet). This decrease of 175 feet in water level in 17 years is attributed to the increased volume of water produced at McGregor and the high volume wells drilled at the Rocketdyne Corporation site in 1942.

Near Crawford, Erath, and China Springs, wells produce from the Hensel sand member and have a water level of about 100 feet below the surface (piezometric surface=about +520 feet); the exact depth varies with surface elevation. Three wells drilled south of Oak Grove church in north central McLennan County flow over standpipes about 30 feet above the surface.

A well drilled in Moody in 1957 produces from the lower Hosston formation; the well was drilled 76 feet into Paleozoic rocks, to insure penetration of a complete basal sand section. A very coarse gravel was encountered in the lower part of the formation. The producing interval occurs at a depth of 1,343 to 1,482 feet. The static water level eight days after pumping began was 280 feet below the surface (piezometric surface = +496 feet).

EASTERN DISTRICT

The largest volume of artesian water is produced in the eastern district. Wells in this district produce from sands of the Hosston formation and supply water to many public and industrial systems. In the eastern district sands are encountered from a depth of about 1,590 feet in the Stoner #1 Midway well west of Waco to a depth of 3,585 feet in the Belcher #1 Smyth well near Mart. Water from these sands supplies James Connally Air Base, Bellmead, Elm Mott, West, Leroy-Tours-Gerald, Axtell, as well as the General Tire and Rubber Company, laundries, office buildings and industries within the city of Waco.

The static water level in the vicinity of Waco is erratic because of the large number of wells and high volume of production. In February, 1958, three wells at Connally Air Base produced 13½ million gallons of water, the minimum produced that year. In August, the three air base wells produced 30½ million gallons, the maximum produced in 1958. Presently the General Tire and Rubber Company uses 625,000 gallons per day from two wells.

In May, 1959, the static water level in the H. C. Buchanan Laundry well at 11th and Webster Streets, Waco, was 108 feet below the surface (piezometric

[1]In this report an *artesian well* is defined as one in which water rises above the aquifer by hydrostatic pressure; when hydrostatic pressure is sufficient to raise water level above the ground, the well is *flowing*.

[2]*Piezometric surface* is the surface to which water in an aquifer would theoretically rise by hydrostatic pressure if penetrated by wells; in any well the piezometric surface coincides with static water level.

surface=+308 feet); at 300 gallons per minute (gpm), the pumping level reported was 130 feet below the surface. In May, 1957, the same well had a static water level at 77 feet below the surface (piezometric surface=+339 feet) with a 330 gpm pumping level of 119 feet. The piezometric surface in Waco dropped 31 feet in two years and approximately 100 feet in the past nine years.

In the eastern district, flowing wells are in isolated areas away from other deep wells; among the flowing wells are the Leroy-Tours-Gerald well, the city of Mart well, the Texas Power and Light Company wells at Lake Creek, and others (Appendix I). Surface elevation at each flowing well is below 500 feet, and screens are set in coarse sands in the basal Hosston formation.

Flowing wells are limited to areas below 500 feet elevation. Even in these areas additional wells may lower the water level until flowing ceases. The effect of nearby production on a flowing well is illustrated by the Rosenthal Water Company well in south central McLennan County, which flowed when drilled but ceased to flow when the Golinda Co-op well was drilled 2½ miles south of Rosenthal.

Wells in the eastern part of McLennan County should penetrate the lower part of the Hosston formation and, where practical, the upper few feet of the Paleozoic section. Sands in the lower part of the Hosston formation are coarser and more permeable. Electric logs can be used to pick the most productive sands. Wells that penetrate the upper part of the Hosston formation will be less productive than those penetrating the lower permeable coarse sand; also the quality of water in the upper Hosston sands is less desirable.

RECHARGE

Artesian water produced from sands of the Trinity division in McLennan County originated as precipitation in the outcrop area (fig. 4). A very small part of the precipitation in the outcrop area infiltrates the sands and percolates downdip in the artesian aquifers.

The outcrop area (fig. 4) of the sands of the Trinity division is about 80 miles west and northwest of McLennan County. Water recharge of these sands depends on precipitation in excess of soil requirements. Runoff approximates one-tenth the annual precipitation, and direct infiltration normally occurs only during periods of heavy persistent rainfall.

The Leon and Bosque rivers, which cross the outcrop area, help recharge the aquifers. Measurements have not been made to determine the volume of recharge by these rivers.

Water moves from outcrop area to discharge area in McLennan County by gravity. Because of a low coefficient of transmissibility and increasing withdrawals, the water level of the sands will continue to decline in the vicinity of Waco.

The Balcones fault zone does not appreciably impede the movement of Trinity water in McLennan County. The quality and quantity of the water is about the same in the eastern and western districts, although in the eastern district water in the lower part of the Hosston formation is better quality than water in the upper part of the formation. This salinity anomaly in the upper part of the Hosston formation may have resulted from mixing Glen Rose and Hosston water in the Balcones system.

QUALITY

Chemical analyses of water were not made during this investigation. However, analyses of water from Trinity aquifers made by the Texas State Department of Health are listed in Appendix II.

State and municipal authorities have adopted standards of the U. S. Public Health Service set in 1946 for drinking water on common carriers in interstate commerce. The recommended maximum concentration (Bureau of Sanitary Engineering) of the more important dissolved minerals is listed below.

Iron (Fe) and manganese (Mn) together should not exceed 0.3 part per million.

Magnesium (Mg) should not exceed 125 parts per million.

Sulfate (SO_4) should not exceed 250 parts per million.

Chloride (Cl) should not exceed 250 parts per million.

Fluoride (F) must not exceed 1.5 parts per million.

Dissolved solids should not exceed 500 parts per million for water of a good chemical quality. However, if such water is not available, a dissolved solids content of 1,000 parts per million may be permitted.

The chemical content of the water throughout McLennan County (Appendix II) is uniform except for highly saline water at Riesel. An electric log of the Belcher #1 Smyth well (oil test) at Mart also indicates mineralized water in the upper part of the Hosston formation.

Water from the Glen Rose limestone is poor quality and highly mineralized. A few wells in McLennan County produce from the Glen Rose limestone, but the water is not commonly used for domestic purposes.

The temperature of water in the Trinity aquifers increases with depth of the sands. Water from the Buchanan Laundry well is 103°F, and water from the Mt. Carmel well is 124°F. During pumping tests on the City of Bellmead well, a temperature of 115°F was recorded. This well, which is located between the Buchanan and Mt. Carmel wells, illustrates an increased temperature with depth of the sands; the temperature gradient is about 20° per 1,000 feet of depth.

FUTURE DEVELOPMENT

The quantity of Trinity water available in McLennan County is unknown. A few wells within the county are allowed to flow continuously, decreasing pressure in the aquifer and wasting water which takes centuries to replace. This waste must be corrected by either the well owner or by state authorities.

In future drilling for Trinity water, proper well spacing should be practiced to eliminate the probability of overdraft with consequent lowering of piezometric surface and contamination by brackish waters from the overlying Glen Rose limestone.

CONCLUSIONS

(1) The Trinity division in McLennan County is divisible into three units—upper, middle, and lower—on the basis of cyclic deposition. Each unit contains a basal clastic phase and an upper carbonate phase. The two phases of each unit can be traced by electric logs and have been given stratigraphic names. The upper Trinity division is divided into an upper Glen Rose limestone and a lower Hensel sand member which is one of two principal artesian aquifers in the county. The middle Trinity division is designated the Pearsall formation with an upper Cow Creek limestone and a lower Hammett shale. The lower Trinity division is divided into an upper Sligo formation and a lower Hosston formation which is the second principal artesian aquifer.

McLennan County is in a transitional zone between the clastic and carbonate deposits in the middle and lower parts of the Trinity division. The Cow Creek limestone in the middle Trinity division interfingers with sands and shales of the Hammett shale of western McLennan County. In central McLennan County the Sligo formation interfingers with the sands and shales of the Hosston formation.

(2) The Balcones fault zone crosses McLennan County in a north-south direction. Faults of this zone are principally normal, down-to-the-coast, slightly *en echelon*. Two major down-to-the-coast faults associated with the Balcones zone have been postulated in pre-Cretaceous rocks within the county. The Balcones system probably owes its origin to faulting along the Paleozoic Ouachita foldbelt because of subsidence and sedimentation in the East Texas basin.

(3) McLennan County can be subdivided into two artesian water districts; a western district west of the Balcones fault zone where the Hensel sand member is the principal aquifer, and an eastern district east of the Balcones fault zone where the Hosston formation is the principal aquifer. The fault zone does not greatly impede the movement of water within the formations.

(4) The piezometric surface in McLennan County has dropped during the past 60 years because of an increased number of public and industrial wells producing from the aquifers. Conservation practices should be initiated, such as well spacing and capping of flowing wells to avert permanent damage of the aquifer from overproduction.

(5) The quality of Trinity water is high throughout the county except locally where the upper Hosston formation contains brackish water, such as in the Riesel Independent School District well.

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APPENDIX I

RECORDS OF ELECTRICALLY LOGGED WELLS IN McLENNAN COUNTY, TEXAS

Water level: All water levels were reported by operators.
Use of water: D, domestic; I, industrial; P, public; S, stock.

Well Number	Driller	Owner	Date completed	Depth of well (ft.)	Aquifer	Altitude of land surface (ft.)	Water Level: Below land-surface datum (ft.)	Water Level: Date of measurement	Use of Water	Remarks
1.	O. C. Proffit	J. W. Henry No. 1	1953	3505	-	933	-	-	-	Oil Test
2.	American Liberty Oil Company	Reichert No. 1	1948	7706	-	827	-	-	-	Oil Test
3.	J. L. Myers & Sons	Aquilla No. 1	1959	1482	Hosston	523	60	Nov. 1960	P	Pumping level 73 gpm at 100 ft.
4.	A. P. Merritt	H. Noris No. 1	1947	3127	-	535	-	-	-	Oil test
5.	J. L. Myers & Sons	Abbott Water Well No. 1	1953	2112	Hosston	712	-	-	-	No information available
6.	J. L. Myers & Sons	Penelope Water Well No. 1	1959	3138	Hosston	570+	-	-	P	No information available
7.	Camtex Oil Corp.	Cartright No. 1	1952	1218	-	540	-	-	-	Oil test
8.	Smith & Breyer	C. A. Russell No. 1	1955	904	-	617	-	-	-	Oil test
9.	J. L. Myers & Sons	City of West No. 3	1953	2089	Hosston	645	218	Nov. 1960	P	Pump set at 560 ft. May 1959. Water level reported dropping 6 ft. per year. Perforated pipe set at 1863-2045 ft.; pumping 460 gpm Nov. 1960.
10.	Smith & Breyer	Alfred Brem No. 1	1955	776	-	605	-	-	-	Oil test
11.	J. L. Myers & Sons	City of West No. 2	1945	2010	Hosston	648	218	Nov. 1960	P	Pumping 175 gpm Nov. 1960
12.	C. P. Quinlan	Prause No. 1	1950	970	-	577	-	-	-	Oil test
13.	Baylor Univ. Geol. Dept.	J. L. McCain No. 1	1959	628	-	590	-	-	-	Oil test
14.	H. B. Glass Drilling Co.	Ross Water Supply Corp. No. 1	1959	2271	Hosston	568	211	Sept. 1960	P	Pumping level 500 gpm at 350 ft.
15.	Frank Place	R. Quillian No. 1	1958	1144	Hensel	435	flowing	Oct. 1958	DS	Artesian well
16.	Hervie Meadows	M. M. Boyd No. 1	1958	1134	Hensel	560	135	Sept. 1958	DS	Water level estimated by driller.
17.	Hervie Meadows	W. D. Smith No. 1	1958	803	Glen Rose	523	30	Sept. 1958	DS	Contractor states water potable.
18.	Hervie Meadows	W. L. Johnson	1958	1078	Hensel	538	70	Sept. 1958	DS	Water level estimated by driller.
19.	Hervie Meadows	S. F. Foster No. 1	1958	1076	Hensel	615	100	Sept. 1958	DS	Water level estimated by driller.
20.	Hervie Meadows	Dameron No. 1	1958	1020	Hensel	590	100	Sept. 1958	DS	Water level estimated by driller.

Well Number	Driller	Owner	Date completed	Depth of well (ft.)	Aquifer	Altitude of land surface (ft.)	Water Level		Use of Water	Remarks
							Below land-surface datum (ft.)	Date of measurement		
21.	H. W. Bass & Sons	Delmar Ranch Water Well No. 1	1956	1186	Hosston	680	-	-	DS	No information available.
22.	M. S. Kemmerer	Eula Holt No. 1	1951	3297	-	749	-	-	-	Oil Test
23.	Falcon Oil Co.	Henry Mattlage, Jr. No. 1	1954	7585	-	762	-	-	-	Oil test
24.	Hervie Meadows	McKethan No. 1	1958	1003	Hensel	600	150	Sept. 1958	DS	Water level estimated by driller.
25.	Fulton Place	F. M. Orelup No. 1	1958	1203	Hensel	455	-	-	D	Artesian well. No information available.
26.	Chalf Bluff Water Supply Corporation	Chalk Bluff No. 1 Water Well	1958	2113	Hosston	505	197	1960	P	Pumping level 218 ft. below surface at 75 gpm. Pump set at 150 ft.
27.	J. L. Myers & Sons	Elm Mott School No. 1	1946	2269	Hosston	537	175	May 1959	P	Estimated daily production 35,593 gpd, May 1959.
28.	Layne Texas Co.	Leroy Tours-Gerald Water Well No. 1	1958	2860	Hosston	495	flowing	Jan. 1961	P	Flowing 5ft. above land surface. Pumping level 38 ft. after 24 hrs. at 226 gpm.
29.	S. H. Riggs	Grandstaff No. 1	1951	1631	-	554	-	-	-	Oil test
30.	C. R. Porter	Kophal No. 1	1957	1405	-	490	-	-	-	Oil test
31.	C. R. Porter	Ed Mazanec No. 1	1957	1591	-	467	-	-	-	Oil test
32.	Layne Texas Company	Connally Air Base No. 3	1952	2436	Hosston	460	187	Dec. 1957	P	Pumping level 525 ft. at 580 gpm.
33.	J. L. Myers & Sons	Youngblood & Flowers	1951	2363	Hosston	495	50	1951	DS	Pump set below 400 ft., May 1959. Owner states pump needs to be set lower.
34.	Lakeview Water Co.	J. E. Passmore No. 1	1955	2336	Hosston	485	220	Jan. 1961	P	Pumping level reported 210 ft. below land surface at 250 gpm, June 1959.
35.	J. L. Myers & Sons	Lakeview School No. 1	1949	2323	Hosston	480	-	-	P	No water levels available. Perforated pipe set at 2100-2323 ft.
36.	J. L. Myers & Sons	Lacy Lakeview No. 3	1960	2329	Hosston	478	250	Nov. 1960	P	Pumping level 455 ft. at 500 gpm.
37.	General Crude Oil Co.	Ernest Day No. 1	1957	9264	-	720	-	-	-	Oil test
38.	Delta Drilling Company	Horstmann No. 1	1939	2258	-	698	-	-	-	Oil test
39.	J. L. Myers & Sons	Tilton No. 2	1950	1435	Hosston	617	-	-	DS	No information available.
40.	R. C. Smith & Falcon Oil Co.	H. C. McKethan No. 1	1953	1603	-	502	-	-	-	Oil test
41.	Fair-Glenn Co.	Clay No. 1	1953	485	-	512	-	-	-	Oil test; producing
42.	Roy Snider	Guy Shelton No. 1-A	1952	478	-	480	-	-	-	Water injection well
43.	Roy Snider	Guy Shelton No. 7-W	1952	496	-	475	-	-	-	Oil test

Well Number	Driller	Owner	Date completed	Depth of well (ft.)	Aquifer	Altitude of land surface (ft.)	Water Level		Use of Water	Remarks
							Below land-surface datum (ft.)	Date of measurement		
44.	Beacon Oil Co.	Myrtle Trice No. 1	1956	1807	-	675	-	-	-	Oil test
45.	Stroud Bros. Oil Co.	M. A. Taylor No. 1	1955	870	-	655	-	-	-	Oil test
46.	Jackson et al	J. D. Lovelace No. 1	1955	656	-	508	-	-	-	Oil test
47.	C. M. Stoner	Midway Water Well No. 1	1956	1779	Hosston	651	280	May 1959	P	Pumping level 355 ft. at 380 gpm.
48.	J. L. Myers & Sons	Midway Ind. School No. 1	1950	1714	Hosston	670	140+	1950	P	School supt. states water level drops 10-12 ft. per year.
49.	J. L. Myers & Sons	J. W. Broughton No. 1	1951	1860	Hosston	630	120	1952	P	Pumping level 150 ft. at 100 gpm, 1952. Perforated pipe set at 1750-1860 ft.
50.	R. F. Caraway	Powell No. 1	1953	1923	Hosston	633	235	1957	P	Static level, Oct. 1953, 195 ft. Pumping level 335 ft. at 210 gpm, 1957.
51.	J. L. Myers & Sons	Dr. Barnes No. 1	1951	2082	Hosston	585	180	Dec. 1956	DS	On pump house wall: May 1952, 90 ft. to water; Dec. 1954, 135 ft. to water; Dec. 1956, 180 ft. to water. Perforated pipe set at 1920-2082 ft.
52.	Layne Texas Company	Bryan-Maxwell-Bryan No. 1	1947	2005	Hosston	593	90	1947	-	Shut-in; never used.
53.	Layne Texas Company	Texas Water Co.	1942	2150	Hosston	550	-	-	P	Artesian well. No information available.
54.	Texas Water Company	Texas Water Co. Well No. 3	1945	2151	Hosston	523	-	-	P	Artesian well. No information available.
55.	Joe Thompson	Paul Shelby No. 1	1948	1560	Hosston	545	-	-	P	Artesian well. No information available.
56.	Pure Milk Co.	Water Well No. 1 (Jefferson Street)	1950	2095	Hosston	408	12	1952	I	Flowed when drilled.
57.	H. C. Buchanan	H. C. Buchanan No. 1	1956	1920	Hosston	416	108	May 1959	I	Water level 77 ft. below land surface Oct. 1957. Pumping level 130 ft. at 300 gpm temperature 103° F, May 1959.
58.	Pure Milk Company	Water Well No. 1 (Garrison Street)	1957	2194	Hosston	415	100	1959	I	Artesian well.
59.	General Tire & Rubber Co.	General Tire & Rubber Co. Water Well No. 1	1944	2310	Hosston	415	162	1960	I	Flowed 30 ft. above land surface in 1954
60.	Layne Texas Company	McLennan Co. Water Control Dist. No. 1	1948	2304	Hosston	435	-	-	P	No information available.

Well Number	Driller	Owner	Date completed	Depth of well (ft.)	Aquifer	Altitude of land surface (ft.)	Water Level: Below land-surface datum (ft.)	Water Level: Date of measurement	Use of Water	Remarks
61.	City of Bellmead	City of Bellmead No. 1 Water Well	1957	2405	Hosston	440	160	Dec. 1960	P	Pumping level 281 ft. at 675 gpm; 1957 Temperature 115° F. Perforated pipe set at 2198-2405 ft. Pumping level 354 ft. at 615 gpm, 1960.
62.	General Tire & Rubber Co.	Water Well No. 2	1945	2320	Hosston	405	178	1957	I	Flowed 40 ft. above land surface, 1945.
63.	J. L. Myers & Sons	McLennan County Water Dist. No. 4, Well No. 2	1958	2493	Hosston	445	95	June 1956	P	Static level 20 ft. when drilled; present level steady 120 ft. at 300 gpm. Pumping 175 gpm, Nov. 1960.
64.	J. L. Myers & Sons	Pardo No. 1	1949	2500	Hosston	460	-	-	-	Artesian well; not in use. Perforated pipe set at 2337-2500 ft.
65.	J. L. Myers & Sons	Tiery No. 1	1951	2531	Hosston	440	-	-	DS	Flowed when drilled. Stopped flowing when Connally No. 3 well drilled.
66.	J. L. Myers & Sons	Axtell Water Well	1959	3129	Hosston	528	60	Dec. 1960	P	Pumping level 57 ft. below surface at 300 gpm, static level 10 ft., Mar. 1959.
67.	Mt. Carmel Center	Mt. Carmel Center Water Well No. 1	1958	2775	Hosston	505	60	1959	P	Pumping level 160-170 ft. at 75 gpm.
68.	H. K. Hamilton	Morris No. 1	1955	1702	-	554	-	-	-	Oil test.
69.	James H. Snowden et al	Eubanks No. 1	1955	1068	-	522	-	-	-	Oil test.
70.	William H. Winn	James L. Morrow No. 1	1955	2534	-	449	-	-	-	Oil test.
71.	Hamilton & Smith	C. C. Barron No. 1	1954	1259	-	474	-	-	-	Oil test.
72.	H. H. Hodde et al	Ernest Weiss No. 1	1955	1530	-	609	-	-	-	Oil test.
73.	Balcones Oil Company	Jackson No. 1	1949	3525	-	552	-	-	-	Oil test.
74.	Farrell Drilling Company	J. R. Gillam No. 1	-	4867	-	521	-	-	-	Oil test.
75.	Mae Belcher	E. B. Smyth No. 1	1942	3838	-	525	-	-	-	Oil test.
76.	J. L. Myers & Sons	City of Mart No. 1	1951	3181	Hosston	493	flowing	May 1959	P	Reported flowing 250 gpm (?). Perforated pipe set at 3030-3181 ft.
77.	R. F. Caraway	Slaughter No. 1	1954	2240	-	580	-	-	-	Oil test.
78.	George F. Hurt	Helm No. 1	1951	1712	-	560	-	-	-	Oil test.
79.	Riesel Ind. Sch. Corp.	Riesel Ind. Sch. Land No. 1	1949	3109	Hosston	510	flowing	1949	-	Not flowing, pump set at 200 ft., May 1959.

Well number	Driller	Owner	Date completed	Depth of well (ft.)	Aquifer	Altitude of land surface (ft.)	Water Level		Use of Water	Remarks
							Below land-surface datum (ft.)	Date of measurement		
80.	J. L. Myers & Sons	H & H Water Supply Corp. No. 1	1960	2870	Hosston	479	4	Jan. 1961	P	Pumping level 200 ft. at 100 gpm.
81.	F&H Oil Production Co.	Wardlaw No. 1	1950	1206	-	429	-	-	-	Oil test.
82.	Max McCotter	Wardlaw No. 1	1952	1322	-	360	-	-	-	Oil test.
83.	Layne Texas Company	Texas Power & Light No. 2	1952	2851	Hosston	429	flowing	Sept. 1958	I	Flows about 90 ft. above land surface.
84.	Layne Texas Company	Texas Power & Light No. 1	1951	2822	Hosston	410	flowing	Sept. 1958	I	Flows about 90 ft. above land surface.
85.	J. L. Myers & Sons	Youngblood No. 1	1950	2400	Hosston	495	flowing	May 1959	P	Pump set at 30 ft.; temperature 107° F.
86.	E. H. O'Dowd	O'Dowd No. 1	1952	2391	Hosston	535	50	June 1959	P	Flowed when drilled. Pumping level 180 ft. at 300 gpm.
87.	J. L. Myers & Sons	Waco Memorial Park No. 1	1950	1965	Hosston	558	120	May 1959	I	Water level 45 ft. below land surface when drilled. Pumping level 130 ft. at 230 gpm, May 1959.
88.	Chapel Hill Water Co.	Chapel Hill No. 1	1957	2091	Hosston	595	135	1957	P	Pumping level 175 ft. at 100-125 gpm, 1957.
89.	Rosenthal Water Co.	O'Dowd No. 1	1956	2550	Hosston	483	surface	June 1959	P	Flowed when drilled. Pumping level less than 100 ft. below land surface at 160 gpm.
90.	Gray Oil Co.	C. B. & H. C. Warren No. 1	1950	1702	-	554	-	-	-	Oil test.
91.	Jet Oil Co.	Wills No. 1	1953	1129	-	685	-	-	-	Oil test.
92.	Henry C. Paine	H. C. Eubanks No. 1	1951	1160	-	545	-	-	-	Oil test.
93.	Plummer	McKie No. 1	1945	2073	-	705	-	-	-	Oil test.
94.	City of Moody	Moody Water Well No. 2	1957	1558	Hosston	775	280	Aug. 1957	P	Pumping level 457 ft. at 400 gpm after 4 hrs. when drilled.
95.	P. W. Curry	Newman No. 1	1951	958	-	478	-	-	-	Oil test.
96.	H. K. Hamilton & L. S. Torrance	Guderian Estate No. 1	1951	1711	-	472	-	-	-	Oil test.
97.	Golinda Co-op	Water Well No. 1	1957	2640	Hosston	486	flowing	May 1959	P	Reported flowing 70 gpm, May 1959
98.	Abshier & Jones	Avery No. 1	1951	1012	-	441	-	-	-	Oil test.
99.	Midstates Oil Corp.	B. E. Mitchell No. 1	1951	1237	-	360	-	-	-	Oil test.
100.	J. E. Banks	Kerr No. 1	1950	1162	-	386	-	-	-	Oil test.
101.	A. R. Scheaf & W. T. Baresch	Pavelka No. 1	1952	1814	-	473	-	-	-	Oil test.

APPENDIX II

CHEMICAL ANALYSES FROM SELECTED WELLS IN McLENNAN COUNTY

Town	Date	Total Solids	pH	Alkalinity $CaCO_3$	Silica Residue SiO_2	Total Hardness $CaCO_3$	Calcium Ca^{++}	Magnesium Mg^{++}	Sodium Na^{+} (calc.)	Iron Fe^{++}	Manganese Mn^{++}	Sulfate $SO_4^{=}$	Chloride Cl^{-}	Fluoride F^{-}	Nitrate NO_3^{-}	Remarks
Bellmead	9/25	660	8.3	365	23	46	11	5	231	.18	*	106	53	1.0	**	Layne Texas Co. Water Dist. No. 1
Connally No. 3	2/53	660	8.3	375	22	42	7	6	229	.14	*	86	53	.8	.4	Layne Texas Co. Connally Air Base No. 3
	10/57	612	8.3	367	20	10	2.9	0.8	98	.0	*	78	53	.8	.2	
Crawford	8/53	558	8.3	365	30	87	10	15	198	.30	*	107	36	.80	**	Well designation unknown. Depth 965 ft. Hensel sand production
Mart	11/52	700	8.2	420	20	44	6	7	260	.08	*	114	50	1.6	**	J. L. Myers & Sons City of Mart No. 1
McGregor (a)	12/53	720	8.4	380	21	39	4	7	260	.08	*	134	60	1.3	**	(a) City of McGregor No. 2. Depth 1080 ft.
(b)	12/53	726	8.5	365	11	38	10	3	261	.1	*	144	64	1.1	**	(b) City of McGregor No. 3 Depth 1250 ft.
Moody	9/51	862	7.8	405	14	39	9	4	327	.16	*	120	156	2	1.8	Well designation unknown. Total depth 1596 ft.
Riesel	4/49	2668	7.2	180	42	337	102	20	725	1.10	*	159	78	1.10	**	Riesel Ind. Sch. Dist. Producing from upper part of Hosston formation.
Waco	4/52	638	8.6	360	18	48	14	3	244	.04	*	138	53	1.0	2.2	Well designation unknown.
West	5/52	830	8.8	365	17	82	13	12	206	.08	*	91	53	.7	**	J. L. Myers & Sons City of West No. 2

Data given in parts per million (ppm)
* Denotes less than .05 ppm
**Denotes less than .4 ppm
(This data obtained from State Department of Public Health)

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BAYLOR GEOLOGICAL PUBLICATIONS

Baylor Geological Society

1. Type electric log of McLennan County. 1"-100'; 1"-50'- $2.00. Available from Daniel's Blue Print Company, Waco.
2. Reptile charts—Available from Baylor Geological Society. Comparison of flying and swimming reptiles. $0.10 each. Comparison of the dinosaurs. $0.10 each.
3. Guide to the mid-Cretaceous geology of Central Texas, May, 1958, $4.50 per copy. Available from the Baylor Bookstore, Waco.
4. Location map of logged wells in McLennan County, 1959. 1"-1 mile, $7.50 per copy. Available from Daniel's Blue Print Company, Waco.
5. Layman's guide to the geology of Central Texas, 1959. Out of print.
6. Collector's guide to the geology of Central Texas, 1959. Out of print.
7. One hundred million years in McLennan County, 1960. Out of print.
8. Cretaceous stratigraphy of the Grand and Black Prairies, 1960, $5.00 per copy. Available from Baylor Geological Society.
9. Popular geology of Central Texas, west central McLennan County, 1960. Out of print.
10. Popular geology of Central Texas, Bosque County, 1961, $1.00 per copy. Available from Baylor Geological Society.

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