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GEOLOGY AND GROUND-WATER RESOURCES
OF
UVALDE AND MEDINA COUNTIES, TEXAS

BY

ALBERT NELSON SAYRE

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GEOLOGY AND GROUND-WATER RESOURCES OF UVALDE AND MEDINA COUNTIES, TEXAS

By Albert Nelson Sayre

ABSTRACT

This report is based on an investigation by the United States Geological Survey, the Texas State Board of Water Engineers, and the Texas State Board of Health to determine the ground-water resources of Uvalde and Medina Counties, especially in relation to irrigation, both in these counties and in the counties to the south where water is obtained for irrigation from the Carrizo sand and younger formations. This investigation was carried on between September 12, 1928, and May 25, 1930. Observations of the water levels in selected wells were made at intervals up to August 1935.

Uvalde and Medina Counties are divided by an eastward trending escarpment, known as the Balcones escarpment, into two unequal parts of strongly contrasting topography. This escarpment faces southward and when viewed from the south has the appearance of a row of high hills. The Edwards Plateau lies north of the escarpment and is a much dissected plateau characterized near its southern margin by steep-sided hills and deeply cut valleys but toward the north by broader valleys and gently sloping hills. South of the escarpment the country is much lower, is flat or gently rolling, and is underlain by formations of Upper Cretaceous and Tertiary age. This area is known as the West Gulf Coastal Plain. Its surface is broken in places by northward-facing escarpments formed by resistant beds of sandstone or limestone, and in Uvalde County, especially west of Uvalde, the smooth surface is interrupted by hills of igneous rock intruded into the sedimentary rocks in the form of stocks or plugs.

In general the regional dip is to the south or southeast. In the vicinity of Uvalde there is a large anticlinal nose which extends southward from the Edwards Plateau and is terminated on the south by a large fault which has no surface expression. On the west side of this nose the rocks dip toward the southwest; on the east side they dip toward the east or southeast. Besides the large fault or fault zone, known as the Balcones fault, which causes the Balcones escarpment, there are many smaller faults extending in a general east-west direction, and about 10 miles south of the Balcones fault another set of faults crosses the area from east to west. The Balcones fault zone is a rather complicated system of faults, with the downthrow to the south. This fault zone begins to die out in the vicinity of the Uvalde-Medina County line and passes into a large monoclinal fold near the Nueces River. The other fault zone enters Medina County near Castroville and southeast of Hondo consists of a series of en échelon faults. A series of faults, or perhaps a branch of the Balcones fault, passes in a southwesterly direction near Sabinal and continues southwestward to the tip of the Uvalde anticlinal nose and westward to the Nueces River. In the vicinity of Uvalde it has a throw of several hundred feet. Smaller faults occur at several places in the area.

The rocks of Medina and Uvalde Counties range in age from Lower Cretaceous to Pleistocene. The Travis Peak formation, of basal Lower Cretaceous age, is

present beneath the area, and in northwestern Uvalde County it yielded fresh water to the oil test well of the Phantom Oil Co. Throughout most of the area, however, little or no water has been reported from this formation in wells that penetrate to it, and in most places it is so far below the surface that even though it contained potable water in considerable quantity an attempt to obtain water from it by wells would not be economical.

The Glen Rose formation crops out in the Edwards Plateau, where it forms the lower slopes of the hills. The formation consists of about 1,000 to 1,200 feet of alternating beds of marly limestone and marly shale. The difference in the resistance to erosion between the hard and soft beds results in the formation of a bench and terrace topography and gently sloping hills. The Glen Rose formation commonly yields small supplies of more or less highly mineralized water to wells.

Overlying the Glen Rose formation is the Walnut clay, which consists of 1 to 20 feet of yellow clay. Its effect on ground water is negligible.

From 40 to 50 feet of yellow resistant argillaceous limestone, known as the "Comanche Peak limestone", overlies the Walnut clay. The Comanche Peak usually crops out beneath the Edwards limestone on the slopes of the hills of the Edwards Plateau and forms steep slopes. No wells are known which draw their water from this formation.

The Edwards limestone consists of about 500 feet of hard, dense massive limestone occurring in beds from a few inches to many feet in thickness. For a distance of several miles north of the southern margin of the plateau it forms steep-sided hills. Northward the steep dip brings the base of the formation higher until the hills are formed chiefly by the Glen Rose and are only capped by the Edwards. In the vicinity of Uvalde the Edwards occurs as masses of limestone brought to the surface by faulting. The Edwards limestone is more or less cavernous and is therefore one of the principal water-bearing formations in Uvalde and Medina Counties.

The Georgetown limestone comprises about 40 feet of rather massive argillaceous limestone overlying the Edwards limestone. It is usually faulted out of sight and therefore is seldom seen at the surface. It is negligible as a water-bearing formation. The Del Rio clay occurs above the Georgetown limestone and consists of 80 to 120 feet of greenish-gray clay with some hard calcareous layers and some beds of *Exogyra arietina*. The formation commonly forms the gentle slopes of hills and broad valleylike depressions. It does not contain water available to wells.

Overlying the Del Rio clay is the Buda limestone, which is a massive yellow to buff limestone cut by many small calcite veins and having a splintery fracture. It has a thickness of 50 to 120 feet and usually caps low hills south of the Balcones escarpment. The soil is thin and black. This formation contains very little water.

The Eagle Ford shale is about 30 feet thick throughout most of the area, but in the extreme western part its thickness, as indicated by well logs, is 280 feet. It is a calcareous to argillaceous flaggy limestone with interbedded black carbonaceous shale that weathers white. In places it contains a considerable thickness of interbedded altered serpentine. The topography of the Eagle Ford outcrop area is usually flat and featureless. No water supply from this formation is known to the writer.

The Austin chalk is from 150 to about 500 feet thick. It is a white to buff chalk with some marly beds, and in parts of the area it contains considerable thicknesses of interbedded altered serpentine. Rounded hills and a black calcareous soil characterize its outcrop area. It yields water to several domestic and stock wells, and one irrigation well draws a part of its water from this formation.

The Anacacho limestone is a yellow to buff, somewhat arenaceous to argillaceous limestone with interbedded marl or clay beds. Limestone predominates in the western part of the outcrop area and marl in the eastern part. The rock is in places impregnated with asphalt. The hard layers cap hills and some low bluffs, especially in the western part of the area. A few wells near Sabinal and Castroville draw potable water from this formation but in most places the water from the Anacacho is highly mineralized.

The Taylor marl and Navarro formation occur in the eastern part of the area but do not extend into Uvalde County. They consist of clay and marl, and each is about 100 feet thick. They do not furnish water to wells.

The Escondido formation consists of 490 to 700 feet of shale and sandstone, which are locally impregnated with asphalt. The topography in the outcrop area is usually rounded, but the prominent hills near D'Hanis are capped by hard beds of this formation. The soil is usually sandy. A few wells obtain a supply sufficient for stock and domestic use from the Escondido, which is the uppermost of the Cretaceous formations cropping out in this area.

The Midway formation consists of marine limestone, sandstone, and shale and ranges in thickness from 140 feet to a knife-edge. In Uvalde County the formation is in many places completely overlapped by the overlying Indio formation. It yields a clayey soil, and the outcrop area is characterized by rounded forms and low bluffs. No wells are known to produce water from this formation.

The Indio formation overlies the Midway and is from 350 to 600 feet thick. It consists of irregularly bedded sandstone, shale, and calcareous sandstone. It also contains two coal beds and several concretionary beds. Some stock and domestic wells of small yield furnish potable water from the Indio, but the water from this formation is commonly rather highly mineralized.

Overlying the Indio is the Carrizo sand, which is 200 to 300 feet thick. It is a coarse to fine grained massive to cross-bedded sandstone, as a rule poorly cemented, and locally contains a little silt. In most places there is a clay bed about 50 feet thick in the middle of the formation. Its outcrop area is usually flat and featureless, and the soil is sandy and in places deep. In the area of its outcrop in southern Uvalde and Medina Counties it furnishes abundant water of good quality for stock and domestic use, and in the counties to the south it yields abundant water for irrigation.

The Bigford member of the Mount Selman formation, which consists of clay, sand, shale, and calcareous sandstone, with some gypsiferous layers and numerous concretions, has a thickness of as much as 700 feet. The water occurring in this member is usually scanty in quantity and highly mineralized. The undifferentiated part of the Mount Selman consists of red sandstone, shale, and calcareous sandstone with numerous concretions. It crops out in a small area in the extreme southern portion of southeastern Medina County. No wells are known in this formation in this area. In Frio County, however, it furnishes abundant supplies of water.

The Uvalde gravel, of late Pliocene (?) age, is 20 feet in maximum thickness and caps the hills and divides between the valleys south of the Edwards Plateau. It consists of flint gravel, usually coated with red iron oxide, and some black silt. It is not a water-bearing formation.

The Leona formation is as much as 90 feet thick and is composed of limestone gravel and silt. It forms wide terraces along the stream valleys 30 to 75 feet above the beds of the streams and furnishes potable water in the valleys south of the Edwards outcrop. In the Leona Valley the supplies are adequate for irrigation. The later terraces and stream gravel are confined to the lower terraces of the stream valleys and consist of silt, sand, clay, and gravel. These terrace deposits furnish potable water in many places adjacent to the streams.

Water enters the Edwards limestone through cracks and solution channels, both from precipitation on the outcrop area and from the streams that cross the outcrop area. No figures are available to show the amount of water that enters the formation directly from precipitation. However, records at gaging stations above and below the outcrop on the East Nueces, Nueces, and Frio Rivers and seepage measurements on the Nueces, Dry Frio, Frio, and Medina Rivers give some indication of the amount of water lost from the rivers into the Edwards limestone.

The Nueces lost at least 36,000 acre-feet a year into the Edwards in the period from 1927–28 to 1932–33. On the basis of seepage measurements the Dry Frio may have lost over 7,000 acre-feet in 1925. The losses from the Frio River in 1923-27 averaged 40,000 to 50,000 acre-feet annually, and those from the Medina River below the main dam of the Medina Valley Irrigation Co. were nearly 16,000 acre-feet in 1930. No seepage measurements are available to show losses from the Hondo and Sabinal Rivers, but the combined area drained by these streams is about equal to the area drained by the Frio River, and their combined discharge may therefore be of similar magnitude. Most of their flow is normally lost into the Edwards limestone. The total losses from all six streams crossing the Edwards outcrop area and constituting recharge into the Edwards limestone may amount to 150,000 acre-feet annually. Observations on wells indicate that the water in the Edwards moves rather rapidly down the dip from the outcrop, under hydrostatic pressure. This pressure is sufficient to cause a part of the Edwards water to return to the surface near Tom Nunn Hill, on the Nueces River, moving upward along the large fault which occurs there and along the joint cracks in the igneous rocks at that point. A part of the water comes to the surface along the valley of the Leona River south of Uvalde, moving upward along fault planes and entering Leona gravel and giving rise to the Leona River. A small part of the water, probably less than one-tenth, is withdrawn from the formation by municipal wells at Hondo, Sabinal, and Uvalde, and by irrigation wells in the vicinity of Uvalde and some stock and domestic wells throughout that part of the area in which the Edwards is within economical reach of the drill. Still another part of the water entering the Edwards limestone moves laterally and may contribute to the flow of wells and springs in the vicinity of San Antonio, in Bexar County.

It has been suggested that water migrates upward along faults from the Edwards limestone and furnishes an appreciable amount of recharge into the Carrizo sand. If this were the case analyses of the waters from these two formations should show a similarity in chemical composition. A number of analyses of waters from the two formations show no similarity and do not indicate any close relationship. None of the streams crossing the area show losses that can be directly traced into the Carrizo sand. On the contrary, the water level in the Carrizo sand where crossed by streams appears to be very close to the bed of the streams, and there is an actual drainage of water from the Carrizo sand into the Frio River at the Carrizo-Bigford contact. Most of the recharge into the Carrizo sand comes directly from precipitation on the outcrop area.

Throughout much of the area the water level in the Edwards limestone is more than 100 feet below the surface, and consequently the cost of raising the water to the surface in sufficient quantity precludes its use for irrigation. In the vicinity of Uvalde, where the water level in the Edwards limestone is from 30 to 70 feet below the surface, about 2,000 acres have been brought under irrigation. It is probable that considerable additional land in this area could be irrigated. The area is well adapted for the growing of feed crops such as maize, corn, and alfalfa, especially where irrigation is used as a means of offsetting the possibility of a long dry summer.

INTRODUCTION

PURPOSE OF THE INVESTIGATION

Underground water, or ground water, is one of the principal natural resources of Texas. It differs from other underground resources and acquires its relatively great value in that it is continuously replenished from the precipitation and streams. Thus insofar as the ground-water supply is not withdrawn in greater amount than the recharge of the underground reservoirs it will last indefinitely. About 80 percent of the people of Texas are supplied with water from wells or springs, and nine-tenths of the public waterworks of the cities and towns of the State are supplied with water from wells. With the growth of the population there will be constantly increasing demands upon the supply of ground water. In most parts of the State the water supplies for livestock are derived chiefly from wells. Thousands of acres of land that would otherwise be of little value are irrigated with water from wells, and additional land that is now used only for grazing can be brought under irrigation by the use of well water.

Until recently comparatively little has been known as to the quantity of ground water that is available in the different parts of the State for municipal, irrigation, and other uses, and expensive developments have been made without adequate information on the vital question of available supply. Obviously a factor so important in the economic structure of the State should be thoroughly studied in order to obtain its full utilization without disastrous overdevelopment. For a long time the State Board of Water Engineers and the State Department of Health have realized the great need for a thorough State-wide survey of the ground-water resources of Texas. Accordingly, when in 1929 an appropriation was made by the legislature for this purpose, the cooperation of the United States Geological Survey was obtained, and systematic investigation was actively undertaken. The present report gives the results of one of the units of this investigation.

The writer was assigned to the study of the ground-water resources of Uvalde and Medina Counties and began field work in September 1929, under the supervision of Walter N. White, hydraulic engineer in charge of ground-water investigations in Texas. O. E. Meinzer, geologist in charge of the division of ground water of the United States Geological Survey, spent several days in the field and has kept in close touch with the work and given advice and criticisms in the preparation of the report.

In the present investigation an attempt has been made to determine the water-bearing formations, the depth at which they will be encountered throughout the area, the quantity and quality of water that each formation will supply, the source of the water, and its course through the different formations to the points of discharge. No detailed geologic work has been attempted, but the geology was studied with reference to the occurrence, movement, quantity, and quality of the ground water.

At the same time an investigation was begun in Zavala and Dimmit Counties to determine the safe yield of the Carrizo sand, or the proportion between the intake of water into the formation and the discharge. As the outcrop area of the Carrizo sand lies partly in Uvalde and Medina Counties, the writer has mapped this outcrop with some care and has attempted to determine the area of outcrop and the likelihood of intake of water from this portion of the outcrop area and to ascertain whether any appreciable amount of water from the streams that cross the outcrop enters the formation.

METHODS OF INVESTIGATION

The geology of Uvalde and Medina Counties was mapped, use being made of the existing geologic maps of the area. Many logs of wells drilled in search of oil were collected for study and correlation. (See pl. 1.) Information was obtained in regard to about 250 water wells in the area (see pl. 2) with respect to their diameter and depth, the rock formations by which their water is supplied, the quality of the water, the use made of the water, and the depth to water in the wells.

A map of the piezometric or pressure-indicating surface of the water in the Edwards limestone was prepared by measuring the depth to water in a number of wells with a steel tape. A definite point at the top of the well was used as a bench mark from which to measure. The altitudes of the bench marks in Uvalde County were obtained from levels run by E. E. Harris, of the United States Geological Survey, in 1930, and the altitudes of the bench marks in Medina County were obtained from levels run by E. H. Coble under the direction of Penn Livingston, also of the Geological Survey. The altitude of the water surface in each well was obtained by subtracting the depth to water from the altitude of the bench mark. In 1934 additional wells were located in Medina County. As the water level had risen about 20 feet in the period from 1930 to 1934, a correction factor was applied to these water-level measurements in order to make them comparable with the earlier measurements.

After the locations of the wells and the altitude of the water surface in each were plotted on the base map, contour lines or lines showing equal altitudes in 1930 were drawn. From this map the altitude to which water from the Edwards limestone will rise if wells are drilled into the formation in any part of the area can be estimated. (See pl. 2.)

Levels were also carried to several wells producing from other formations, for purposes of comparison. Monthly measurements in selected wells were made from the fall of 1929 to the early part of 1931, and water-stage recorders were set up over two wells to obtain a complete record of water-level fluctuations in these wells. Altogether 8 months was spent in field work in the area. Since 1931 measurements have been made at more or less regular intervals (see records of well measurements, pp. 128–132) and are being continued.

LOCATION AND EXTENT OF AREA

Uvalde and Medina Counties lie west of San Antonio and together comprise an area of 2,944 square miles extending about 80 miles east and west and 37 miles north and south. (See fig. 1.) According to

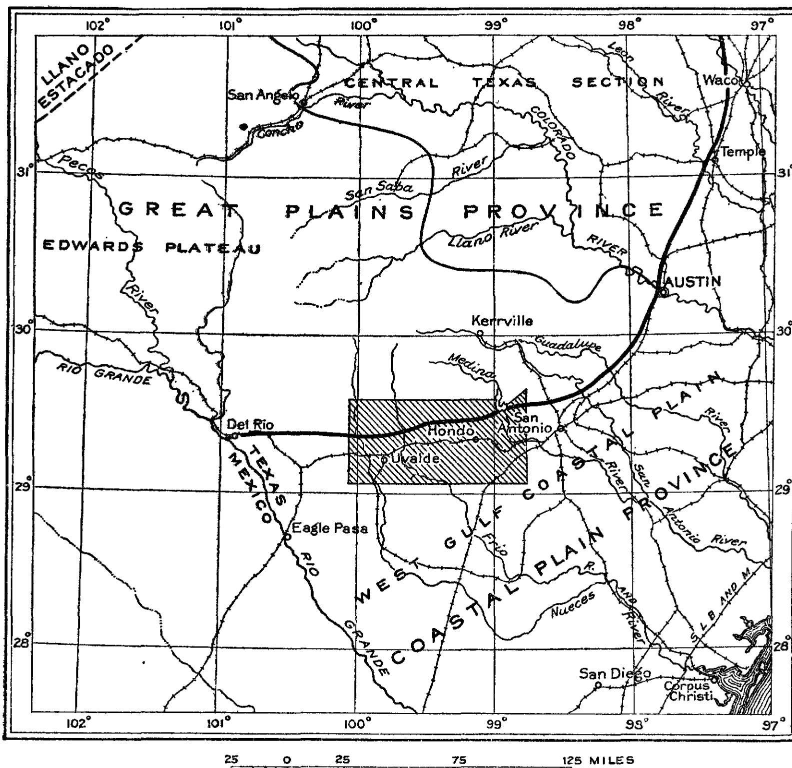


FIGURE 1.—Map of a part of Texas showing geomorphic provinces and location of area covered by this report.

the census of 1930, Medina County had a population of 13,989, compared with 11,679 in 1920. Hondo is the county seat. Devine, the only incorporated town, had a population of 1,093. Other towns are

Castroville, Lacoste, D'Hanis, and Yancey. Uvalde County had a population of 12,945, compared with 10,769 in 1920. Uvalde, the chief town and county seat, had a population of 5,286, and Sabinal was next, with 1,586. The county contains several smaller communities, including Knippa, Sansom (North Uvalde), Cline, and Utopia.

SURFACE FEATURES AND DRAINAGE

The northern third of the area is a part of a high plateau that is much dissected by streams and consequently has a rough topography. It is known as the Edwards Plateau. The southern two-thirds of the area, which is a part of the Coastal Plain, lies about 500 feet lower than the plateau and has relatively little relief. Numerous streams rise in the plateau and flow southward in nearly parallel courses. With the exception of the Medina River, their waters disappear into the Edwards limestone near the southern margin of the plateau. The Medina River and the Leona River, which rises from springs near Uvalde, are the only streams in the area that are perennial and have continuous flow from their sources to their mouths.

COMMUNICATION

Four railroads serve the area. The main line of the Southern Pacific Railroad passes from east to west through about the middle of the two counties; the International-Great Northern Railroad passes through the southeast corner of Medina County; the Uvalde & Northern Railway connects Uvalde with Rock Springs on the north; and the San Antonio, Uvalde & Gulf Railroad connects Uvalde with Crystal City on the south and by an indirect route with San Antonio on the east, thus providing an outlet for the produce of the irrigated farms of the counties to the south. Spur lines run from both the Southern Pacific Railroad and the San Antonio, Uvalde & Gulf Railroad to the rock-asphalt mines about 15 miles west of Uvalde.

An excellent asphalt-surfaced Federal-aid highway extends from San Antonio to the western edge of Uvalde County, paralleling the Southern Pacific Railroad throughout much of this distance. Beyond Uvalde County the highway extends to Del Rio, on the Rio Grande. An asphalt-surfaced highway has recently been completed from Uvalde southward to Crystal City and Carrizo Springs. The San Antonio-Laredo highway passes through the southeast corner of Medina County. Because of the abundance of gravel in the area, gravel-surfaced roads have been constructed wherever there is considerable travel, and this is especially desirable, because the unsurfaced roads are likely to be impassable in wet weather.

AGRICULTURAL AND INDUSTRIAL DEVELOPMENT

The principal occupations in the area are farming and stock raising. In the eastern part of Medina County most of the land is under cultivation, but toward the west the proportion of cultivated land decreases gradually until in the vicinity of Uvalde farming has become of secondary importance and stock raising is the principal occupation. Most of the farming is done without irrigation, but a few farms in the vicinity of Uvalde are irrigated with water pumped from wells, and a dam in northern Medina County stores flood waters of the Medina River in Medina Lake. Water is carried in a canal from the diversion dam below the main dam to the vicinity of Natalia and Devine, in southern Medina County, where it is used for irrigation. In general the uncultivated part of the Coastal Plain is devoted largely to the raising of cattle, and in the Edwards Plateau Angora goats and sheep are raised. A considerable quantity of excellent honey is produced in Uvalde County.

In the western part of Uvalde County a large amount of rock asphalt is mined, and this asphalt is widely shipped for use as road-surfacing material. It is especially adapted for this use because it requires no process of heating and mixing but is applied directly to the road base. The search for oil and gas has been practically continuous for a number of years. A small gas field about 12 miles south of Uvalde, in the north-central part of Zavala County, supplies Uvalde with gas for fuel. Several wells are producing oil and gas in the Ina and Adams fields, along the Hondo River in the south-central part of Medina County. At Knippa large amounts of basalt are quarried and crushed to be used principally as railroad ballast.

HISTORY OF SETTLEMENT

Texas was crossed by Spanish military expeditions probably soon after the conquest of Mexico. A department of light infantry was stationed on the San Antonio River near the site of the present city of San Antonio in 1718,[1] a mission was soon established there, and settlement was carried on by the Spanish and later by the Mexicans and Americans. The mission of San Francisco de los Tejas, founded in 1690 in eastern Texas, was transferred in 1731 to the San Antonio River south of the town and is now known as San Francisco de la Espada. Until after the accession of Texas to the United States, San Antonio was the seat of government of a large area including Uvalde and Medina Counties.

Prior to the admission of Texas into the United States in 1845 the area occupied by Uvalde and Medina Counties was very sparsely settled, being principally the hunting ground of the Comanche Indians. In 1844, however, the town of Castroville was settled by

[1] Kennedy, William, The Republic of Texas, p. 218, London, 1841.

about 500 French and Alsatians under the lead of Count Henri de Castro, and a little later branches of the Castroville colony moved westward to settle at Quihi, Vandenburg, and D'Hanis. In 1849 a series of forts was established across Texas from the northeast to the southwest to protect routes of travel to California and to protect the settlers from raids of the marauding and thieving Indians. One of these forts, Fort Lincoln, was near the present town of D'Hanis. Another one, Fort Inge, was located near Inge Mountain, 2 miles south of Uvalde. After the establishment of this line of forts and the subjugation of the marauding Indians, settlers began to drift into the two counties in considerable numbers. Farmers of German descent continued to settle in Medina County, and Uvalde County was gradually settled, largely by ranchers.

HISTORY OF IRRIGATION FROM WELLS

The first irrigation well on record in the area was that drilled by John Laird in 1908 southwest of Uvalde. This well apparently penetrated the Leona formation, from which it obtained sufficient water to irrigate about 80 acres. There was little or no other irrigation development from wells until 1924, when W. R. Sweringen drilled a 270-foot well south of Uvalde into the Edwards limestone, to irrigate 25 acres of alfalfa and spinach planted in a young pecan grove. In the same year the Vosatko Bros. dug a well for irrigation into the Leona formation on the west side of the Leona River, across the river from the Sweringen well. In 1925 Will White dug two wells on the west side of the Leona River, about 4 miles south of Uvalde. These wells obtained water from Leona gravel to irrigate 40 acres. After 1925 several other wells were drilled for irrigation. In 1929 and 1930 records were obtained of 19 drilled or dug wells that were equipped with power plants and pumped water for the irrigation of a total of 1,922 acres on 13 farms. The water used in irrigation and municipal supplies comes mainly from two sources, the Leona formation and the Edwards limestone, but it is possible that a small amount is contributed from the Austin chalk.

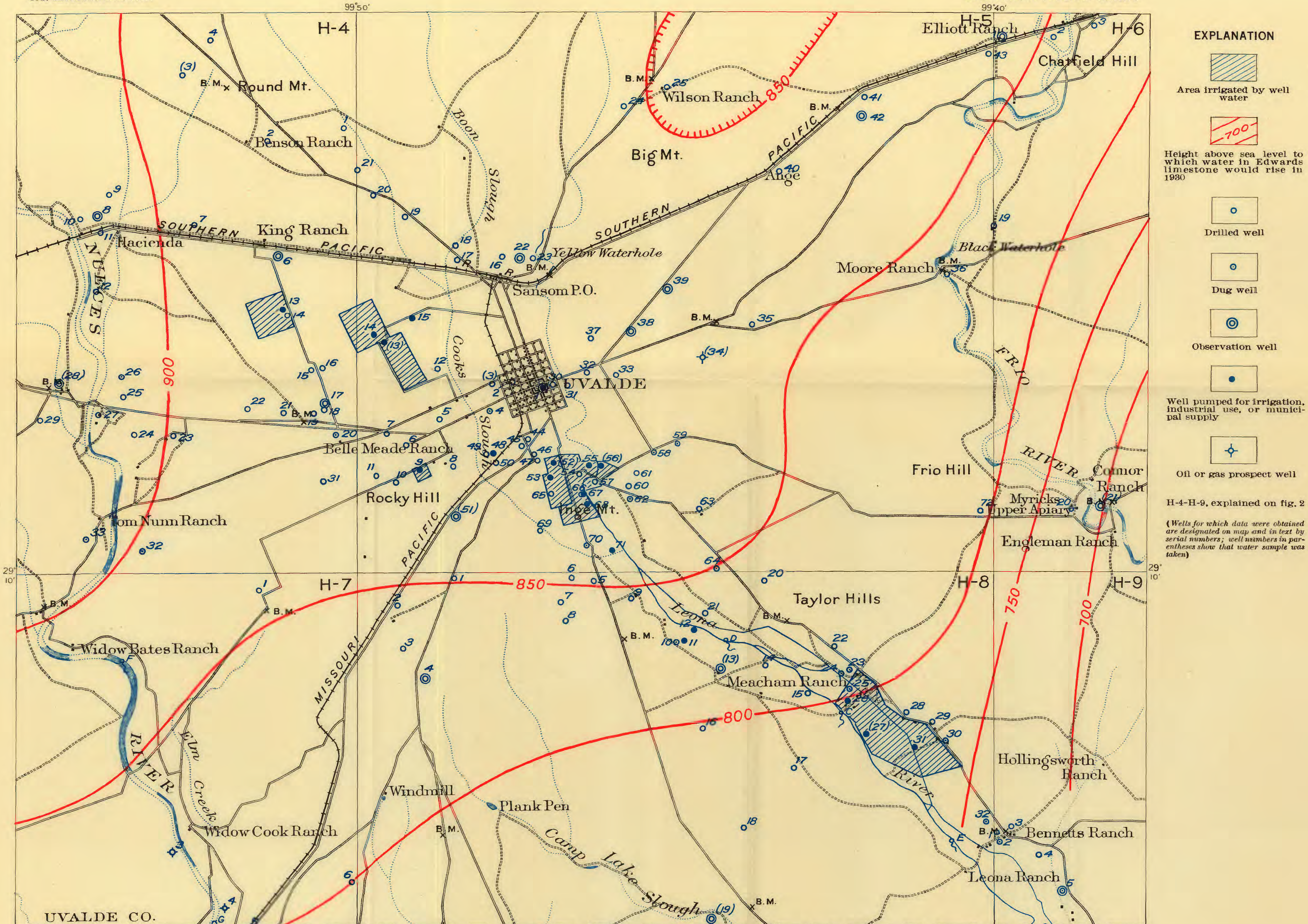
PREVIOUS INVESTIGATIONS

Probably the first work of consequence describing Texas was that of William Kennedy in 1841. A little later Ferdinand Roemer published some excellent papers on the geology of Texas. After the admission of Texas to the Union a series of exploratory surveys of the State was made by the United States Government, and reports were prepared by Marcy, Shumard, Marcou, and others. An excellent account and bibliography of these reports up to 1887 was written by Hill.[2]

[2] Hill, R. T., The present condition of knowledge of the geology of Texas: U. S. Geol. Survey Bull. 45, 1887.

GEOLOGIC AND HYDROLOGIC MAP OF UVALDE AND MEDINA COUNTIES, TEXAS

1936



Lith. A. Hoen & Co.

MAP OF THE VICINITY OF UVALDE, TEXAS

Showing wells for which data were obtained, areas irrigated by well water, and piezometric surface of the water in the Edwards limestone

1 ½ 0 1 2 3 4 5 Miles

In 1849 several expeditions were sent across to Texas with a view to mapping routes for railroads across the State. In the same year Major French [3] made a reconnaissance along the road between San Antonio and El Paso. This road entered Medina County in the vicinity of Castroville, which was at that time a settlement of about 500 people, passed through Quihi and Fort Lincoln, on the Seco about 2 miles north of D'Hanis, and then westward, passing near the site of Uvalde, a short distance north of the old Fort Inge and closely parallel to the present highway. Late in the same year Lieutenant Whiting [4] made a reconnaissance along the line of forts from Fort Washita, in northeastern Texas, to Fort Duncan, near the town of Eagle Pass. In Uvalde and Medina Counties he followed the old Wool Road which passed Castroville, Fort Lincoln, and Fort Inge and then went southwestward to Eagle Pass. This road branched off from the El Paso road near the Frio River. In their reports both of these writers comment several times on the richness of the soil between San Antonio and the Nueces River. The Medina, Sabinal, Leona, and Nueces Rivers were all flowing at that time. In a paper published in 1857 [5] the basalt hills in the vicinity of Fort Inge and the Frio River are noted and commented upon, with the suggestion that these igneous masses are closely allied to those of the Santa Rosa Mountains of Mexico.

The earliest strictly geologic study of this area on record is that of J. Owen, whose brief report [6] was published in 1889. In 1895 and the next few years Hill and Vaughan [7] mapped in considerable detail the geology of the Nueces, Uvalde, and Brackettville quadrangles. Some of their results were published in the Nueces and Uvalde folios; the Brackettville folio has not been published. Part of their results were incorporated in 1898 in a more general paper discussing the geology and ground-water supplies of the region adjacent to Austin and San Antonio.[8]

Udden made a survey of the land of the New York-Texas Land Co. which included the southern and western parts of Uvalde County. His report includes a geologic map of the area surveyed.[9]

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[3] French, H. G., A report relative to the road opened between San Antonio and El Paso del Norte: 31st Cong., 1st sess., S. Ex. Doc. 64, pp. 41–42, 1849.

[4] Whiting, W. H. T., A reconnaissance of the western frontier of Texas: 31st Cong., 1st sess., S. Ex. Doc. 64, pp. 237–250, 1850.

[5] Schott, Arthur, Substance of the sketch of the geology of the lower Rio Bravo del Norte: U. S.-Mexican Boundary Survey, vol. 1, pt. 2, p. 33, 1857.

[6] Owen, J., Report of geologists for southern Texas: Texas Geol. Survey 1st Rept. Progress, p. 72, 1889.

[7] Hill, R. T., and Vaughan, T. W., U. S. Geol. Survey Geol. Atlas, Nueces folio (no. 42), 1898. Vaughan, T. W., idem, Uvalde folio (no. 64), 1900.

[8] Hill, R. T., and Vaughan, T. W., Geology of the Edwards Plateau and Rio Grande Plain: U. S. Geol. Survey 18th Ann. Rept., pt. 2, pp. 193–322, 1898.

[9] Udden, J. A., Report on a geological survey of the land belonging to the New York-Texas Land Co., Ltd., in the upper Rio Grande embayment in Texas: Augustana Library Bull. 6, pp. 51–107, 1907.

In 1902 Taylor [10] discussed the irrigation systems along the Nueces and Leona Rivers.

For several years preceding the publication of his paper on the Cretaceous-Eocene contact in the Coastal Plain, Stephenson [11] had done much detailed work along the contact in Uvalde and Medina Counties, and he has since made many trips to this part of Texas. In 1921 a paper by Liddle [12] was published, giving results of his work in Medina County during the preceding years. A paper by Trowbridge [13] on a geologic reconnaissance that extended into the southwestern portion of Uvalde County was published in 1922. The final report on this area was published in 1932.[14] In 1924 Deussen [15] discussed the general geology of that part of Uvalde and Medina Counties lying within the Coastal Plain. Several of the igneous rock masses in the area are described in a paper by Lonsdale.[16]

Liddle [17] made a survey of southern and southwestern Uvalde County and southeastern Kinney County, in order to determine the usefulness of the magnetometer in locating various igneous masses. For many years F. M. Getzendaner [18] has been studying the geology of Uvalde and the surrounding counties and has recently published the results of his studies in the form of a discussion of the formations of the upper Gulf Coastal embayment. Miss Julia Gardner, in preparing a paper on the Midway formation, has done a large amount of field work in the area under discussion. This paper is not yet ready for publication.

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The writer is very much indebted to Mr. F. M. Getzendaner, geologist for the Humble Oil Co., for many helpful suggestions, copies of numerous well logs in the area, and readiness in counsel and advice in problems relating to the geology of Uvalde and Medina Counties. His unpublished map of the Tertiary formations of the region has been of great assistance in the field work. L. W. Stephenson, T. W. Robinson, S. F. Turner, C. S. Ross, Julia Gardner, and Margaret D. Foster, of the United States Geological Survey, have assisted the

[10] Taylor, T. U., Irrigation systems of Texas: U. S. Geol. Survey Water-Supply Paper 71, pp. 39–42, 65–66, 1902.

[11] Stephenson, L. W., The Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plain: U. S. Geol. Survey Prof. Paper 90, pp. 155–192, 1914.

[12] Liddle, R. A., The geology and mineral resources of Medina County: Texas Univ. Bull. 1860, 1918.

[13] Trowbridge, A. C., A geologic reconnaissance of the Gulf Coastal Plain of Texas near the Rio Grande: U. S. Geol. Survey Prof. Paper 131, pp. 86–107, 1923.

[14] Trowbridge, A. C., Tertiary and quaternary geology of the lower Rio Grande region, Texas: U. S. Geol. Survey Bull. 837, 1932.

[15] Deussen, A., Geology of the Coastal Plain of Texas west of the Brazos River: U. S. Geol. Survey Prof. Paper 126, 1924.

[16] Lonsdale, J. T., The igneous rocks of the Balcones fault region of Texas: Texas Univ. Bull. 2744, 1927.

[17] Liddle, R. A., Magnetometer survey of Little Fry Pan area, Uvalde and Kinney Counties, Tex.: Am. Assoc. Petroleum Geologists Bull., vol. 14, pp. 509–515, 1930.

[18] Getzendaner, F. M., A geologic section of the Rio Grande embayment, Texas, and implied history: Am. Assoc. Petroleum Geologists Bull., vol. 14, pp. 1425–1437, 1930.

writer in the field or in the preparation of the report. Mr. Stephenson spent 10 days in the area with the writer and Mr. Turner, studying the Cretaceous geology, and has since that time given valuable advice and provided free access to field maps and unpublished reports in the files of his office. Miss Gardner spent 2 days with Mr. Stephenson and the writer in studying the Tertiary formations of the area and has given freely of the knowledge acquired in her studies of the Tertiary formations of the Coastal Plain. Mr. Robinson and Mr. Turner were working in Zavala and Dimmit Counties, south of Uvalde County, and have cooperated freely in furnishing information of value to this project. Mr. Turner rendered further assistance by obtaining well data and other information during a week spent in eastern Medina County. Mr. Ross has kindly rendered assistance with the petrologic examination of thin sections of rock. Acknowledgment is due to Miss Foster for the analysis of 51 samples of water and for helpful advice in the preparation of the section of quality of water. The work was very materially advanced by the spirit of hospitality and ready cooperation in which the residents of the area have supplied information concerning wells and ground water and have assisted in giving access to their ranches and farms. Mr. Munroe Finley and Mr. John Roberts have kindly furnished logs and data pertaining to drilling. Mr. E. E. Harris, of the topographic branch of the United States Geological Survey, ran a series of level lines within the area and established the altitudes of the bench marks on more than 100 wells, thus making it possible to determine the piezometric surface in several formations.

MAPS

The base map for the work was a compilation from the Texas base map (scale 1 : 500,000) and the Nueces, Brackettville, and Uvalde quadrangle maps of the United States Geological Survey and the Hondo, Bandera City, Medina Lake, Castroville, and Natalia quadrangles of the United States Army Engineer Corps. The geology has been plotted on this base map (pl. 1). Another map has been prepared showing the location of wells visited, the irrigated areas, and the contours on the piezometric surface of the water in the Edwards limestone (pl. 2). The maps of the Bandera City and Hondo quadrangles were based on a rapid reconnaissance and were quite out of date. Therefore, in those areas the writer has mapped roads by automobile traverse, and no great accuracy is claimed for the mapping, especially north of the Southern Pacific Railroad.

The difficulty of locating exposures on the Hondo and Bandera City maps, the complex faulting, and the fact that in much of the area south of the escarpment the older rocks are covered with later outwash gravel or residual soil have made it necessary to indicate the boundaries between geologic formations and the faults in many places by dashed lines, which express the writer's interpretation of the geology based on exposures seen by Mr. Stephenson, Miss Gardner, and the writer, or on well records.

The wells are numbered according to their location. The 30-minute quadrangles were assigned letters in order from west to east, as shown on figure 2. Each of these areas was then subdivided into

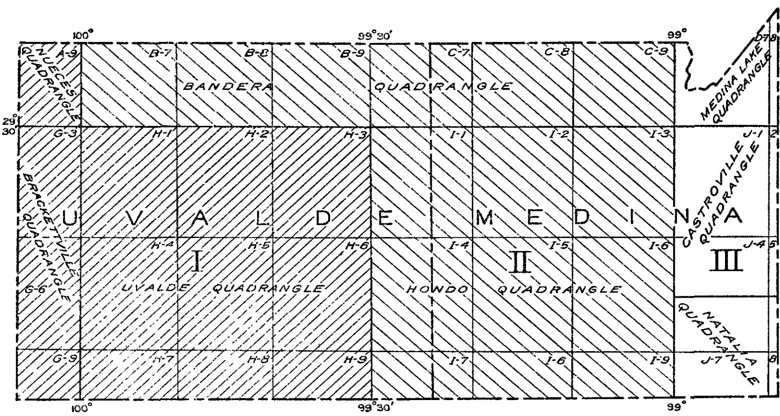

FIGURE 2.—Index map of Uvalde and Medina Counties, Tex., showing source of material for base map, quadrangles covered by topographic maps, and the system of numbering wells used on the map and in the text. I, Topographic maps of the U. S. Geological Survey, with revision of roads by A. N. Sayre; II, reconnaissance military maps of the Corps of Engineers, U. S. Army, extensively revised by A. N. Sayre; III, detailed military maps of the Corps of Engineers, U. S. Army.

10-minute quadrangles and the three rows numbered consecutively from left to right beginning at the upper left-hand corner. Within each 10-minute quadrangle the wells are numbered along the roads, starting with no. 1 at some convenient point. In this way each well is designated by a letter which indicates the 30-minute quadrangle in which the well is located, a number which indicates the 10-minute quadrangle, and an individual well number. For example, all wells in the Uvalde quadrangle are lettered H, and all wells in the 10-minute quadrangle containing Uvalde are numbered H–5, with the individual well number following. Springs are designated in the same manner except that a letter is used instead of a number in the third place.

GEOMORPHOLOGY

Uvalde and Medina Counties are crossed in an east-west direction by the Balcones escarpment, which marks the boundary between two great geomorphic provinces. The northern third of the area covered by these two counties is a part of the Edwards Plateau, which is a section of the Great Plains province; the southern two-thirds of the area is a part of the West Gulf section of the Coastal Plain.[19] The Balcones escarpment itself becomes much lower near the western edge of Uvalde County.

The portion of the Great Plains province that lies in Texas is subdivided into the Llano Estacado, or High Plains, the Edwards Plateau, the Central Texas section, and the Pecos Valley section [20] (fig. 1). Of these the Edwards Plateau is the southernmost. It is roughly diamond-shaped and has an area of about 35,000 square miles, extending about 350 miles from east to west and 225 miles from north to south.

The Edwards Plateau is underlain by the Edwards limestone, which is very resistant to erosion. At the north it is a broad, nearly level plain about 2,500 feet or more above sea level. Near its southern limit the altitude is reduced to 1,600 feet or less. The slope increases rapidly near the escarpment and becomes more than 100 feet to the mile. Numerous streams eroding headward from the Balcones escarpment have cut deep, narrow valleys as much as 500 feet below the upland surface of the plateau, thereby changing the original level surface to a rough and hilly area in which the only lines of communication are the valleys. In Uvalde and Medina Counties the plateau has been cut into buttes and narrow ridges, and the original plateau is represented only by the highest parts of these. Owing to the resistant character of the underlying rock and the torrential character of the rains, the soil of the plateau is thin, and vegetation is correspondingly sparse.

The Balcones escarpment extends from Austin southwestward nearly to San Antonio and thence westward.[21] This escarpment marks the location of a fault plane or fault zone along which movement occurred, dropping the area south of the fault in relation to the area north of it by several hundred feet. The present escarpment has receded very little from the actual fault plane, owing to the resistant character of the Edwards limestone, which underlies the plateau area. It is about 500 feet high in eastern Medina County, but its height decreases toward the west with decrease in the throw of the fault. Near the Nueces River the fault passes into a monoclinal fold which is the chief cause of the increase in slope of the surface near the south margin of the plateau. As in the eastern part of Medina County the height of the escarpment is about 500 feet and the maximum throw of the fault is about 900 feet, several hundred feet of rock must have been eroded from this part of the plateau since the faulting occurred.

[19] Fenneman, N. M., Physiographic boundaries within the United States: Assoc. Am. Geographers Annals, vol. 4, p. 86, 1914.

[20] Idem, pp. 113-117.

[21] Hill, R. T., and Vaughan, T. W., Geology of the Edwards Plateau and Rio Grande Plain adjacent to Austin and San Antonio, Tex., with reference to the occurrence of underground waters: U. S. Geol. Survey 18th Ann. Rept., pt. 2, pp. 204 et seq., 1898.

In contrast to the rough surface of the marginal part of the Edwards Plateau is the West Gulf Coastal Plain. At one time the Edwards Plateau and the Coastal Plain were continuous and nearly identical in character; then the development of faulting caused the relative uplift of the Edwards Plateau and its subsequent dissection.

The Coastal Plain is a great province extending from Cape Cod on the north into Yucatan on the south.[22] It is characterized in southwestern Texas as a nearly flat surface that rises gently from the coast toward the north and west.[23] It is underlain by a series of sedimentary strata that dip gently toward the Gulf of Mexico. The more resistant of these strata form low northward-facing escarpments which in a few places break the smoothness of its surface. Within 10 or 12 miles of the Balcones escarpment in Uvalde County this smoothness is further broken by hills formed by protruding bodies of igneous rock and blocks of older resistant limestone. In Medina County the Escondido formation forms a prominent northward-facing escarpment. The maximum altitude of the Coastal Plain in this area is found in Uvalde County near the Edwards Plateau, on the divides between the streams, where it is nearly 1,100 feet above sea level. In the southwest corner of Uvalde County the highest altitude of the divides is about 900 feet, whereas in southeastern Medina County it is about 700 feet, which gives the plain a slope from west to east of about 200 feet in 80 miles. The soil of the Coastal Plain is usually deep, and it supports an abundant growth of mesquite and other brush which grows to be about 20 feet high. When viewed from a slight elevation this growth gives the country the appearance of being clothed with a rich green carpet.

CLIMATE

In Uvalde and Medina Counties the summers are usually hot and dry. Because of the Gulf breeze that commonly rises in the evening the temperature drops rapidly after sunset and the nights are comfortable. The winters are mild and the temperature is generally well above freezing. Occasionally, however, strong north winds drive the temperature down rapidly to freezing or below, but as a rule it remains cold for only a short time.

The average annual rainfall for the area is about 25 inches, but in general the amount of rainfall increases from the west toward the east. According to the records of the United States Weather Bureau[24]

[22] Thayer, W. N., Physiographic divisions of North America: Jour. Geology, vol. 26, p. 165, 1928.

[23] Hill, R. T., and Vaughan, T. W., op. cit., p. 206. Deussen, Alexander, Geology of the Coastal Plain of Texas west of the Brazos River: U. S. Geol. Survey Prof. Paper 126, p. 2, 1924.

[24] Summary of climatological data for the United States, 1920. See also the annual reports of the Weather Bureau since 1920.

the average annual rainfall was 23.38 inches at Uvalde during a period of 33 years, 27.94 inches at Sabinal during a period of 24 years, and 27.45 inches at Hondo during a period of 34 years. The precipitation is often of a torrential character and is unevenly distributed throughout the year. Although the record shows some heavy rains in both summer and winter the heaviest precipitation usually occurs in the spring or fall. This unevenness of distribution has sometimes proved discouraging to the dry farmer, because of a tendency of the rain to come in the spring, when plowing and seeding are in progress, and to be scanty during the later part of the season, when the crops of corn and cotton are maturing. The growing season is long. Between the last killing frost in the spring and the first killing frost in the fall there is an average of 254 days at Hondo and Uvalde and 259 days at Sabinal.

The climatic data given on the following pages show that Uvalde and Medina Counties are on the whole unfavorable to the growth of many types of winter truck and vegetables, even with irrigation, because of the number of killing frosts that occur at some time during the winter. On the other hand, the area is well adapted for growing feed crops, such as maize, corn, and alfalfa, especially where irrigation is used to offset the handicap of a long dry summer.

Climatic data for Uvalde and Medina Counties, Tex.

[From records of U. S. Weather Bureau]

Average number of days with 0.01 inch or more of precipitation

	Length of record (to 1920) (years)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Devine	7	2	3	4	4	5	4	2	2	3	3	4	6	42
Hondo	21	4	4	4	5	6	3	4	4	4	4	4	4	50
Montell	8	6	3	3	5	6	6	6	6	6	5	5	4	61
Sabinal	17	4	4	4	5	6	4	4	4	6	4	5	4	51
Uvalde	12	3	3	3	5	4	3	4	4	4	3	3	3	42

Temperature (° F.)

	Length of record (to 1920) (years)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Hondo:														
Mean	22	52.8	54.7	63.6	68.3	74.6	82.5	84.9	84.5	79.7	69.7	60.7	52.4	69.0
Highest		89	95	96	100	102	106	108	108	102	98	88	84	108
Lowest		10	14	24	30	46	47	66	55	47	26	20	15	10
Sabinal:														
Mean	17	54.7	56.7	64.9	69.5	75.9	82.3	84.9	84.9	80.6	71.7	61.4	52.3	70.0
Highest		90	97	104	105	105	109	109	110	107	100	99	92	110
Lowest		12	14	21	31	41	46	56	53	44	27	19	18	12
Uvalde:														
Mean	17	53.1	56.6	64.5	70.1	76.6	82.6	84.9	84.1	79.1	71.1	60.3	52.9	69.7
Highest		90	100	100	104	107	114	110	110	105	100	92	91	114
Lowest		10	14	23	27	40	55	61	59	41	23	17	15	10

Climatic data for Uvalde and Medina Counties, Tex.—Continued

Frost data

Hondo, Medina County

[Altitude, 901 feet. Country generally level; rolling east to south; mountainous 10 miles north]

Year	Date of last killing frost in spring	Date of first killing frost in fall	Length of growing season—last killing frost to first killing frost (days)	Latest date with temperature 32° or lower in spring	Earliest date with temperature 32° or lower in fall
1902	Mar. 6	Nov. 27	266		
1903	Feb. 18	Nov. 18	273	Feb. 18	Nov. 18
1904	Mar. 4	Nov. 12	253	Mar. 4	Nov. 12
1905	Feb. 21	Dec. 4	286	Feb. 21	Dec. 4
1906	Mar. 21	Nov. 20	244	Mar. 21	Nov. 20
1907	Feb. 14	Nov. 13	272	Feb. 9	Nov. 13
1908	Apr. 30	Oct. 28	181	Feb. 20	Nov. 14
1909	Mar. 15	Dec. 9	269	Feb. 25	Dec. 9
1910	Feb. 24	Dec. 1	280	Feb. 24	Dec. 14
1911	do	Nov. 13	262	do	Nov. 13
1912	Mar. 25	Nov. 2	222	Feb. 27	Nov. 28
1913	Mar. 27	Oct. 28	215	Mar. 27	Dec. 8
1914	Mar. 23	Dec. 11	263	Mar. 22	Dec. 10
1915	Mar. 22	Nov. 15	238	do	Nov. 15
1916	Feb. 20	Nov. 14	268	Feb. 3	Nov. 14
1917	Mar. 5	Oct. 30	239	Mar. 5	Oct. 30
1918	Feb. 5	Nov. 28	296	Feb. 4	Nov. 24
1919	Feb. 27	Nov. 30	276	Feb. 27	Oct. 13
1920	Apr. 5	Nov. 16	225	Apr. 5	Nov. 16

Sabinal, Uvalde County

[Altitude, 964 feet. Country rolling]

Year	Date of last killing frost in spring	Date of first killing frost in fall	Length of growing season—last killing frost to first killing frost (days)	Latest date with temperature 32° or lower in spring	Earliest date with temperature 32° or lower in fall
1904	Mar. 4	Nov. 12	253	Mar. 4	Nov. 12
1905	Feb. 21	Dec. 4	286	Feb. 21	Dec. 4
1906		Oct. 24			Oct. 24
1907	Feb. 14	Nov. 13	272	Feb. 14	Nov. 13
1908	Feb. 20	Nov. 14	268	Feb. 20	Nov. 14
1909	Feb. 25	Dec. 9	287	Feb. 25	Dec. 9
1910	Feb. 24	Dec. 1	280	Feb. 24	Dec. 1
1911	Feb. 23	Nov. 13	263	do	Nov. 13
1912	Feb. 27	Nov. 28	275	Feb. 27	Nov. 28
1913	Mar. 27	Oct. 27	214	Mar. 27	Dec. 9
1914	Apr. 9	Dec. 11	246	Mar. 22	Dec. 11
1915	Apr. 3	Nov. 15	226	do	Nov. 15
1916	Feb. 19	Nov. 14	269	Feb. 19	Nov. 14
1917	Mar. 5	Oct. 30	239	Mar. 5	Oct. 30
1918	Feb. 4	Nov. 23	292	Feb. 4	Nov. 23
1919	Feb. 27	Nov. 13	259	Feb. 27	Nov. 13
1920	Apr. 5	Nov. 14	223	Apr. 5	Nov. 14

Uvalde, Uvalde County

[Altitude, 937 feet. Generally level country]

Year	Date of last killing frost in spring	Date of first killing frost in fall	Length of growing season—last killing frost to first killing frost (days)	Latest date with temperature 32° or lower in spring	Earliest date with temperature 32° or lower in fall
1908	Apr. 30	Nov. 15	199	Feb. 20	Nov. 15
1909	Feb. 25	Dec. 13	291	Feb. 25	Dec. 8
1910	Feb. 24	Oct. 29	247	Feb. 24	Oct. 29
1911	do	Nov. 29	278		
1913	Mar. 27	Oct. 27	214	Mar. 27	Oct. 27
1914	Apr. 9	Dec. 9	244	Apr. 9	Dec. 9
1915	Mar. 22			Mar. 23	
1916	Feb. 18	Nov. 14	270	Feb. 18	Nov. 9
1917		Oct. 30			Oct. 30
1918	Feb. 5	Nov. 24	292	Feb. 5	Nov. 24
1919	Feb. 27	Dec. 10	286	Feb. 27	Dec. 10
1920	Apr. 5	Nov. 15	224	Apr. 5	Nov. 15

Climatic data for Uvalde and Medina Counties, Tex.—Continued

Monthly precipitation records

Hondo, Mediña County

[Records from August 1877 to March 1882, inclusive, are for Castroville, about 10 miles east of Hondo]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1877	------	------	------	------	------	------	------	0.07	0.02	1.62	1.50	5.05	------
1878	1.27	2.16	0.38	1.80	4.64	2.64	0.82	.96	2.34	.21	1.27	.17	18.66
1879	.12	.29	.63	2.15	1.21	1.43	1.88	5.39	1.17	.55	.18	.23	15.23
1880	3.20	2.63	2.68	2.22	2.76	1.18	7.74	6.69	3.95	1.34	1.76	.29	36.44
1881	.45	.85	.58	3.06	3.69	Tr.	1.98	.38	2.14	4.85	1.39	1.13	20.50
1882	1.78	1.29	2.38	------	------	------	------	------	------	------	------	------	------
1899	------	------	------	1.65	1.98	9.41	1.85	.00	2.06	2.10	1.92	2.20	------
1900	4.67	.00	5.43	7.88	6.84	.34	2.30	2.60	1.77	4.74	1.42	.70	38.69
1901	.32	.63	.12	1.04	3.51	1.83	7.05	.05	2.22	Tr.	.52	.17	17.46
1902	.65	.85	1.45	1.28	4.61	.00	1.12	.00	6.35	2.96	2.97	3.39	25.63
1903	3.23	7.11	2.36	1.50	3.08	3.48	7.41	.17	7.17	.75	Tr.	.65	36.91
1904	.04	.55	.16	4.92	5.28	1.41	1.97	.90	9.02	2.37	1.00	1.25	28.87
1905	1.35	1.75	3.31	6.67	1.98	5.02	2.14	.23	5.82	1.41	2.23	1.58	33.49
1906	.27	1.27	1.00	2.20	9.09	.56	5.86	4.02	6.03	1.54	.70	1.31	33.85
1907	.40	.14	1.81	2.67	8.20	Tr.	3.11	.75	1.06	7.42	6.86	.45	32.87
1908	1.05	1.23	1.57	2.56	9.06	.15	2.04	2.98	2.55	2.62	2.01	1.08	28.90
1909	Tr.	.28	.36	1.94	3.34	2.28	2.71	1.52	.26	1.47	1.90	1.48	17.54
1910	*.67	.28	1.17	3.81	1.78	.31	1.20	.80	.73	4.65	1.29	2.02	18.71
1911	.30	1.87	2.91	3.68	2.63	.00	.67	.55	.54	5.12	2.22	1.96	22.45
1912	.30	2.26	4.17	3.06	3.37	7.11	.35	.25	2.15	3.51	2.57	2.35	31.45
1913	.63	3.15	1.14	.95	4.56	3.52	.08	.58	2.61	6.48	4.99	5.54	34.23
1914	.10	1.53	.61	4.89	6.52	.96	1.20	3.86	1.22	3.81	2.90	1.93	29.53
1915	1.10	1.65	1.26	5.30	1.91	.00	.23	10.09	1.60	2.04	.38	1.08	26.64
1916	2.26	.00	3.16	5.73	5.59	.50	4.18	5.18	.60	2.51	1.20	.21	31.12
1917	1.34	.62	.03	2.50	3.77	.20	1.35	.63	2.90	.21	.90	Tr.	14.45
1918	.15	.83	.64	3.74	3.34	1.08	.55	90	1.75	2.54	2.17	5.82	23.51
1919	2.96	2.15	1.78	2.79	3.74	6.87	7.96	1.39	7.39	4.17	.74	1.45	43.39
1920	3.02	.25	1.50	.34	3.81	3.54	2.67	4.18	1.73	1.46	2.84	.16	25.50
1921	.86	.41	4.30	3.97	4.61	7.40	.23	.70	6.55	.82	.35	1.35	31.55
1922	1.07	.76	3.94	6.46	3.38	3.78	.79	.82	2.65	6.57	1.50	.15	31.87
1923	.30	6.37	3.61	3.09	.41	2.09	2.87	2.33	4.48	3.10	4.14	3.92	36.71
1924	1.39	2.53	2.03	6.22	3.49	4.97	.03	Tr.	2.44	.10	.02	2.65	25.87
1925	.36	Tr.	.40	1.11	1.91	Tr.	1.50	1.65	2.57	1.65	2.57	1.04	14.76
1926	2.26	.08	3.47	10.21	1.79	2.20	1.68	3.54	1.12	.95	1.70	2.01	31.01
1927	.81	2.33	1.26	1.75	1.64	5.12	2.46	.17	1.41	1.44	.05	2.75	21.19
1928	.88	3.29	2.23	1.81	6.57	2.11	2.54	1.24	3.33	.85	.82	1.19	26.86
1929	.59	.44	2.05	2.42	8.55	2.50	2.13	.26	2.13	2.12	1.83	2.62	27.64
1930	.95	.28	2.19	2.52	3.44	5.34	.24	.20	.56	7.18	2.51	.72	26.13
1931	4.99	2.20	2.70	2.87	4.90	1.91	2.53	1.66	.00	.51	1.30	------	------

Sabinal, Uvalde County

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1903	------	------	------	------	------	------	------	------	5.07	0.75	0.00	0.17	------
1904	0.00	0.28	0.00	2.88	7.03	0.96	4.17	0.00	10.40	1.65	.95	.80	29.12
1905	1.32	1.21	8.68	6.75	2.81	5.42	.39	1.35	3.62	1.71	1.90	1.36	31.52
1906	.10	1.24	.76	2.05	6.51	.65	5.92	4.26	7.29	1.59	1.84	.84	33.05
1907	.25	.05	.50	1.77	6.02	.69	1.93	.02	1.21	7.06	4.00	.11	23.61
1908	.90	1.12	1.82	4.15	10.37	.39	1.82	9.27	5.03	.59	1.86	.34	37.66
1909	.10	.36	.72	2.11	4.14	1.30	1.40	4.26	2.17	.36	.99	1.43	19.34
1910	.46	.19	2.50	3.50	3.63	.47	.69	.25	1.70	5.15	1.01	1.11	20.66
1911	.24	1.88	2.66	4.84	1.24	.04	.33	1.03	.04	5.97	2.90	1.83	23.00
1912	.17	1.01	2.36	2.55	2.59	9.22	.79	.00	2.10	4.63	1.79	2.06	29.27
1913	.59	1.39	.39	.54	3.50	5.07	.86	2.14	1.79	9.54	4.29	4.31	34.41
1914	.10	1.35	.70	2.25	6.66	1.61	.55	5.23	1.71	2.14	2.62	1.03	25.95
1915	1.14	1.89	1.06	2.14	.70	.63	.40	2.32	1.47	1.92	.18	.57	14.42
1916	1.43	.00	1.44	7.96	3.51	.77	4.49	3.69	.17	2.26	1.03	.06	26.81
1917	.80	.22	.12	.25	2.29	.36	.53	.42	4.66	.86	1.60	.00	12.11
1918	.16	.63	.71	.77	1.35	1.05	.13	.35	2.51	4.63	2.30	5.14	19.73
1919	2.75	1.62	.60	3.32	4.50	6.12	7.05	5.77	5.55	5.91	.84	1.38	45.41
1920	3.03	.10	1.13	.29	1.53	2.90	2.86	2.45	1.88	2.63	1.59	.13	20.52
1921	.70	.51	3.18	3.02	4.40	5.82	1.01	.06	2.25	.93	.31	1.58	23.77
1922	.72	.69	2.06	6.12	3.61	3.39	.47	.16	1.22	1.86	.78	.10	21.18
1923	.28	5.33	2.36	3.88	.10	2.29	3.50	.68	3.53	4.29	2.71	2.77	31.72
1924	.83	2.29	.98	3.50	3.60	2.04	.43	.01	1.37	.16	.05	2.02	17.28
1925	.14	.00	.56	.60	5.07	.80	.35	2.02	3.05	1.87	.83	.84	16.13
1926	2.01	Tr.	2.89	13.01	2.32	2.46	2.01	.71	1.51	2.75	1.63	2.12	33.42
1927	.89	1.32	2.39	2.61	1.33	7.30	5.25	.75	1.44	1.01	.00	2.09	26.38
1928	.66	1.82	.06	1.16	3.13	3.57	.20	4.75	4.08	.23	.50	.94	21.10
1929	.74	.41	1.96	1.48	6.07	1.72	3.52	.56	3.14	3.65	1.25	2.30	26.80
1930	.72	.04	1.59	1.99	2.28	5.67	.00	Tr.	.82	11.00	2.17	.88	27.16
1931	4.37	1.80	2.44	3.67	2.50	1.90	2.28	.80	Tr.	.67	1.06	------	------

Climatic data for Uvalde and Medina Counties, Tex.—Continued

Monthly precipitation records—Continued

Uvalde, Uvalde County

[Record from November 1849 to February 1861 is for Fort Inge, about 2 miles south of Uvalde]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1849	------	------	------	------	------	------	------	------	------	------	2.05	2.30	------
1850	0.38	0.71	1.42	1.11	1.07	7.00	2.70	3.19	1.50	1.70	3.60	2.10	26.48
1851	.80	3.54	1.45	2.95	1.08	.73	2.84	3.53	.73	1.50	1.43	.29	20.87
1852	.34	1.40	2.62	.15	5.76	8.07	6.82	.12	2.83	3.19	1.52	.00	32.82
1853	2.16	3.58	1.51	2.42	3.28	9.00	4.97	1.59	1.20	6.76	.15	1.02	37.64
1854	.20	2.15	3.00	.75	3.88	2.09	.97	1.67	4.80	.33	3.71	.50	24.05
1855	.10	1.86	.75	.17	------	------	------	------	------	------	------	------	------
1859	.70	.67	.08	.91	1.42	2.80	.26	2.35	5.11	3.15	.06	.55	18.06
1860	1.04	1.79	1.19	3.71	.00	1.85	.04	5.06	.94	2.77	.82	.23	19.44
1861	1.47	.05	------	------	------	------	------	------	------	------	------	------	------
1877	------	------	------	------	.32	.72	1.17	.09	1.92	.77	1.01	6.74	------
1878	.57	1.59	2.62	2.32	2.98	1.53	4.85	2.54	1.28	1.07	1.93	.69	23.97
1879	.08	.90	.94	3.08	3.48	.80	Tr.	5.66	3.29	.89	.01	.09	19.22
1880	2.85	1.82	1.96	2.59	1.76	2.01	4.82	5.71	4.46	.44	1.64	1.23	31.29
1881	.43	.82	.59	2.39	6.44	.00	1.22	1.91	1.44	3.15	2.24	.91	21.54
1882	.84	.71	1.41	.33	4.73	.36	1.37	3.23	4.05	.96	1.88	.17	20.04
1883	.28	.87	4.88	1.99	.17	------	------	------	------	------	------	------	------
1905	------	------	3.48	5.67	------	------		------	------	------	1.72	1.25	------
1906	------	------	------	------	------	------	5.71	------	------	------	------	------	------
1907	------	------	------	------	------	.38	1.62	Tr.	------	------	------	------	------
1908	.98	1.55	1.48	3.16	6.90	1.28	3.57	5.11	1.48	.63	1.58	.57	28.29
1909	.08	.62	1.34	.98	3.40	2.04	3.54	3.13	1.02	.37	.41	1.26	18.19
1910	.55	.49	2.68	3.27	2.04	.50	.42	Tr.	1.30	2.98	.22	.39	14.84
1911	.30	2.48	2.23	3.85	.53	Tr.	1.01	1.05	.03	4.86	3.00	1.13	20.47
1912	.08	------	------	1.69	2.64	------	------	------	------	------	------	------	------
1913	.35	.77	.46	1.26	2.30	12.78	.85	2.08	4.80	6.42	5.95	2.73	40.75
1914	Tr.	1.25	.77	2.43	5.44	3.13	Tr.	2.74	.33	1.90	1.20	.87	20.06
1915	1.52	1.40	1.68	1.53	1.00	Tr.	Tr.	4.78	2.78	.00	.00	Tr.	14.69
1916	2.02	.00	2.62	4.17	1.55	.72	7.66	7.20	5.71	.83	1.20	Tr.	33.68
1917	.86	.16	.08	.20	1.89	5.29	1.00	.60	1.06	.27	.98	.00	12.39
1918	.10	.13	.65	1.56	2.74	1.52	Tr.	1.48	1.80	5.23	1.81	3.15	20.17
1919	3.04	1.36	1.50	2.75	3.91	3.31	4.21	1.63	7.68	6.52	1.42	1.07	38.40
1920	2.25	.25	.28	.06	2.45	2.93	.80	3.30	1.75	1.47	1.24	.16	16.94
1921	.46	.36	4.09	.60	5.22	2.92	1.44	.40	1.46	1.55	.38	.20	19.08
1922	.20	.85	1.35	6.70	1.97	7.45	.75	Tr.	.39	.65	.64	Tr.	20.95
1923	.40	3.88	3.07	4.03	1.03	3.42	.67	.49	3.94	4.00	2.34	2.57	29.84
1924	.60	1.55	1.07	2.30	2.66	.75	.82	.05	1.95	.93	.05	2.95	15.68
1925	.10	.00	.85	1.45	3.45	.45	.90	2.10	2.76	1.67	1.45	1.14	16.32
1926	2.20	.00	2.66	9.83	1.40	3.86	2.15	1.73	.67	2.93	1.55	1.63	30.61
1927	.50	3.01	1.51	1.30	1.38	2.71	3.97	.50	.55	1.85	.00	2.25	19.52
1928	.58	2.17	.63	.84	3.87	4.68	.30	1.90	4.94	.40	.12	.78	21.21
1929	.45	.27	2.07	.74	5.60	2.03	1.90	.10	5.45	2.30	.82	1.60	23.33
1930	.83	.14	1.83	2.15	1.46	8.27	1.00	.71	.88	6.04	2.48	.65	26.44
1931	5.82	1.40	.50	6.74	9.08	2.35	3.85	3.25	Tr.	.10	.64	2.61	36.34
1932	.67	1.85	1.40	1.70	2.19	1.18	21.01	4.55	8.62	.12	.58	1.15	45.02

DRAINAGE

The principal streams of the area, named from east to west, are the Medina, Hondo, Seco, Sabinal, Blanco, Frio, Leona, and Nueces Rivers. All these streams are tributary to the Frio River except the Medina, which empties into the San Antonio River, and the Nueces, which flows into the Gulf of Mexico. The Frio joins the Nueces many miles south of this area.

The streams have many peculiar characteristics. All of those mentioned except the Leona River rise in the Edwards Plateau. During storms and for a few days thereafter the water is muddy, but at other times it contains very little sediment and presents the clear greenish-blue aspect usual in water originating in limestone. Only two streams of the area are continuous, perennial streams; these are the Medina and Leona Rivers. The Leona has its source in springs near Uvalde. The other streams lose their waters on the outcrop of the Edwards limestone near the southern margin of the plateau, and their courses are marked for the next 15 to 20 miles by dry channels. These dry channels are usually bottomed with gravel, but in some places the underlying rock is exposed. The Medina River also loses water in crossing the Edwards limestone, but a part of the water continues onto the Coastal Plain. In a few places along each of the rivers, where the river has excavated a deep hole into impermeable underlying materials, pools are formed during floods, and these pools remain during the drier parts of the year as watering places for stock. Flowing water is usually present in the stream beds of the area about 15 to 20 miles south from the edge of the plateau, and farther downstream they flow perennially. During and immediately after the torrential storms to which the area is subject the streams rise rapidly to flood stages and flow through their whole course, often filling their channels from bank to bank and even overflowing upon the bordering terraces.

GENERAL GEOLOGY

Nearly all classes of rocks are found in Uvalde and Medina Counties. Most of the sedimentary rocks are marine limestones, sandstones, shales, and sedimentary tuffs and ash beds. Silt and sand were carried into the lagoons and embayments along the seashore or were deposited on the floor of the sea and have since been indurated into shale and sandstone. Wind-blown sand and fossil sand dunes are found near the top of the section, and stream deposits are found as high-level, terrace, and flood-plain deposits of silt and gravel. The subjoined geologic table shows the relations and thickness of the various formations and gives a brief description of their lithologic character, topographic expression, and water-bearing properties. Many plugs, dikes, and sills of basalt, locally known as "trap rock", represent a great group of igneous rocks.

Geologic formations in Uvalde and Medina Counties, Tex.

System	Series and group	Formation	Thickness (feet)	Character of rocks	Topographic expression and soils	Water supply
Quaternary.	Recent.		0–25±	Silt, sand, clay, and gravel.	Confined to lower terraces of stream valleys.	Furnishes potable water in valleys of Edwards Plateau.
Quaternary.	Pleistocene.	Leona formation.	0–93	Gravel and silt.	Wide flat terraces in stream valleys 30 to 75 feet above bed of streams. Buff silt; in many places "shell land"; gravel foundation.	Furnishes potable water in valleys of streams south of the Edwards limestone outcrop. Supplies often adequate for irrigation.
Tertiary (?).	Pliocene (?).	Uvalde gravel.	0–20	Mostly iron-stained flint gravel with some black silt.	Caps hills and divides. Coarse flint gravel with some black silt in places.	Not a water-bearing formation.
Tertiary.	Eocene. Claiborne group.	Mount Selman formation. Undifferentiated Mount Selman.	0–100+	Red sandstone, shale, and calcareous sandstone with numerous concretions.	Rounded forms. Soil usually red and sandy.	No wells are known in this formation within this area. In Frio County it furnishes abundant supplies of water.
Tertiary.	Eocene. Claiborne group.	Mount Selman formation. Bigford member.	0–700 (?)	Clay, sandy shale, and calcareous sandstone with some gypsiferous layers and numerous concretions.	Rounded forms. Soils usually clayey or sandy clay.	Water usually in small quantities and highly mineralized.
Tertiary.	Eocene. Claiborne group.	Carrizo sand.	200–300	Coarse- to fine-grained sandstone, poorly cemented and usually clean but in some places containing a little silt; very little mica and no lime. Usually has a clay bed about 50 feet thick in the middle.	Usually flat and featureless plains. Sandy soil developing into deep sand in places.	Furnishes abundant water of good quality for stock and domestic use. It is used for irrigation in Zavala County.
Tertiary.	Eocene. Wilcox group.	Indio formation.	355–600	Sandstone, shale, and calcareous sandstone, irregularly bedded; contains two coal seams and concretionary beds.	Rounded forms or low bluffs along the streams. Clayey to sandy clay.	Some weak stock and domestic wells of potable water. However, the water is usually highly mineralized.

		Midway formation.	0–140	Marine limestone, sandstone, and shale, rather irregular and in places completely overlapped by the Indio.	Rounded forms or low bluffs. Clayey soil.	No wells are known to produce water from this formation.
Cretaceous.	Gulf series.	Escondido formation.	490–700	Shales and sandstones sometimes impregnated with asphalt.	Usually rounded forms; hard beds cap prominent hills near D'Hanis. Usually sandy soil.	A few weak stock and domestic wells obtain their supply from this formation.
		Navarro formation.	0–100	Clay, sand, and marl, with some indurated layers.	Pinches out in eastern Medina County. Does not extend into Uvalde County.	No wells are known which draw water from these formations.
		Taylor marl.	0–100	Calcareous clay and marl.	Pinches out in eastern Medina County.	
		Anacacho limestone.	300–700±	Yellow to buff limestone, somewhat arenaceous to argillaceous, with interbedded marl or clay beds. Limestone predominates in the western part of the area, and marl in the eastern part. Impregnated with asphalt in places.	Hard layers cap hills and form low bluffs, especially in the western portion. Calcareous, argillaceous brown soil.	A few wells near Sabinal obtain good water in abundance from this formation, but in most places the water is highly mineralized.
		Austin chalk.	125–495	White to buff chalk with some marly beds and in parts of the area considerable thicknesses of interbedded altered serpentine.	Rounded forms. Black calcareous soil.	Some domestic and stock wells and one irrigation well draw part of their water from this formation.
		Eagle Ford shale.	30–280	Calcareous to argillaceous flaggy limestone with interbedded black carbonaceous shale which weathers white. Considerable thickness of interbedded altered serpentine in southwestern Uvalde County.	Flat, featureless topography. Brown to black calcareous and argillaceous soil.	No water supply.
	Comanche series. Washita group.	Buda limestone.	50–120	Massive yellow to buff limestone cut by many small veinlets of calcite and having a splintery fracture.	Caps low hills. Soil thin, silt-like.	

Geologic formations in Uvalde and Medina Counties, Tex.—Continued

System	Series and group		Formation	Thickness (feet)	Character of rocks	Topographic expression and soils	Water supply
Cretaceous	Comanche series.	Washita group.	Del Rio clay.	80–119	Yellowish-green clay with some hard calcareous layers; abundant *Exogyra arietina*.	On slopes of hills. Brown clayey soil.	No water supply.
			Georgetown limestone.	40–50	Argillaceous limestone. Cannot be distinguished from the Edwards except on fossil evidence.	Similar to Edwards.	Probably no water.
		Fredericksburg group.	Edwards limestone.	400–620	Hard, resistant massive limestone with a few porous chalky layers; very cavernous; contains numerous flint nodules but very few fossils.	Forms high bluffs and rugged hills. Soil usually thin, black.	Usually furnishes large amounts of excellent water.
			Comanche Peak limestone.	40–50	Yellow resistant argillaceous limestone.	Occurs on slopes of canyons.	No wells are known to obtain water from this formation.
			Walnut clay.	1–20	Yellow clay.		Effect on ground water negligible.
		Trinity group.	Glen Rose limestone.	1,040–1,175	Alternating beds of marly limestone and marly shale.	Benches and terraces in the canyons.	A few wells enter this formation. The water is usually highly mineralized and of small quantity.
			Travis Peak formation.	263–420	Mostly sandstone and conglomerate, becoming finer and more shaly toward the top.	Does not crop out in this area.	Deep oil tests in the Edwards Plateau show that this formation contains abundant water under good head. Its quality is not known.
Paleozoic sandstone, limestone, and shale.							

SEDIMENTARY ROCKS

The oldest of the exposed sediments are Lower Cretaceous, and the youngest are of recent age. Paleozoic rocks of undetermined age are exposed beneath the Cretaceous in the Central Texas section by the erosion of the Colorado River,[25] and are also encountered in wells.

In the Edwards Plateau, however, the well drill has reached the Paleozoic rock beneath the Cretaceous in several places, notably at Kerrville and at the Morris ranch, in Gillespie County. From the data derived from these drillings we are led to believe that the horizontal Cretaceous beds of the Edwards Plateau lie upon an uneven floor of older rock.

Paleozoic rocks also underlie Uvalde and Medina Counties and form the foundation on which the Cretaceous and younger sedimentary rocks rest. They are encountered in several wells drilled in the Edwards Plateau portion of the area. Near Montell, in the northwest corner of Uvalde County, a well drilled by the Phantom Oil Co. penetrates the Cretaceous and enters slates thought to be of Paleozoic age.[26] (See p. 133.) In the Patterson Brothers' well on the I. K. Henry survey, in north-central Uvalde County (see p. 133), the drill encountered slates apparently of Paleozoic age at 1,723 feet. In the Coastal Plain region a few wells appear to have penetrated the Lower Cretaceous and entered the underlying Paleozoic shales, limestones, and sandstones, according to the compiled log of the Bell well 1, near Ange siding, Uvalde County (see p. 137) and the log of the Pure Oil Co.'s well, J. B. & W. A. Smythe no. 1, in western Uvalde County (see p. 135). In the Rothe well, about 4 miles north of the Southern Pacific Railroad and 3 miles east of the Uvalde-Medina County line, the drill passed into shale at about 3,085 feet. This is probably also Paleozoic shale.

It is thought that during the earlier part of the Mesozoic era the part of Texas with which this report is concerned was above sea level and therefore subject to erosion. Consequently, the Triassic and Jurassic periods are represented not by deposits of sedimentary rock, but rather by the uneven surface which the erosion of that time imposed upon the surface formed by the Paleozoic rocks.

After this long period of land conditions the sinking of the land surface permitted the advance of the sea and the formation of the Lower and Upper Cretaceous deposits, with continuous deposition except for a period at the end of Lower Cretaceous time and another period between the Anacacho and Escondido epochs, when deposition was interrupted.

Cretaceous rocks underlie the surface in more than half of the area under consideration, as indicated on plate 1, and indeed, a large pro-

[25] Hill, R. T., and Vaughan, T. W., Geology of the Edwards Plateau adjacent to Austin and San Antonio: U. S. Geol. Survey 18th Ann. Rept., pt. 2, p. 217, 1898.
[26] Haynor Monty, of the Phantom Oil Co., oral communication.

portion of the State of Texas. They are composed for the most part of limestone and shale, with sandstone and sandy shale near the base of the section. The sandstone was laid down as the sea advanced over the eroded Paleozoic surface. During the time that followed shale and limestone were deposited in somewhat deeper seas. Volcanic activity in Upper Cretaceous time supplied material which was laid down as sedimentary tuffs and ash beds.

At the end of the Cretaceous period the sea withdrew, and for a long time the area was exposed to erosion. But early in Eocene time the sea readvanced, and the Midway deposits were laid down on the sea floor. After the Midway the sea oscillated gently back and forth, and deposits were laid down in lagoons and embayments or along the seashore and in the sea. At one time a large sand-dune area existed. During the later part of the Tertiary the sea withdrew from the area, leaving it above sea level, where it has since remained.

Late in Pliocene time and early in Pleistocene time faulting and uplift caused gravel and silt to be spread over the existing land surface. Valleys were then cut into this surface, and a second uplift increased the gradient of the streams, so that more gravel and silt was carried out from the high land and deposited in the stream valleys. At present the streams are eroding into the floors of these old valleys.

Cretaceous rocks, especially the Lower Cretaceous, are exceedingly important in connection with water resources, for it is from these rocks that much of the inner portion of the Gulf Coastal Plain and the adjacent Edwards Plateau obtain water. Some of the water comes from drilled wells, as at San Antonio, Austin, Dallas, and Kerrville. Some comes to the surface along great faults which cut water-bearing formations and provide a conduit to the surface, as at the San Pedro and San Antonio Springs, in San Antonio; the San Felipe Springs, at Del Rio; and the Comal Springs, at New Braunfels. The Carrizo sand, of Tertiary age, which crops out in southern Uvalde and Medina Counties, is the principal water-bearing formation in Zavala and Dimmit Counties and supplies the water used in irrigation in that area.

The Cretaceous rocks also provide rock asphalt in large quantities, much petroleum, and building material.

IGNEOUS ROCKS

Several masses of igneous rocks occur in the area of Cretaceous outcrop in Uvalde and Medina Counties. These are all of the fine-grained variety and belong to two general groups—basalt, composed of ferromagnesian minerals, and phonolite, which is very rich in silica and alkalies.[27] Most of these masses of igneous rocks occur in Uvalde County, but there are a few in Medina County. Their structural

[27] Vaughan, T. W., U. S. Geol. Survey Geol. Atlas, Uvalde folio (no. 64), pp. 2-3, 1900.

position is not definitely known. Most of them, such as the basalt at the Black water hole and at Knippa and the phonolite at Inge Mountain, south of Uvalde, have been called plugs, or stocks, and Lonsdale [28] and Vaughan [29] refer to the mass of igneous rock of which Allen Hill, west of the Nueces River, is a part as a huge batholith. Almost everywhere the contact between the igneous rock and the adjacent sedimentary rock is covered either by gravel or by soil so that the nature of the contact cannot usually be definitely ascertained. However, several drilled wells have passed through basalt that appeared to have the form of a sill. At the Knippa quarry of the Texas Trap Rock Co. (see pl. 3, *A*) the basalt forms a rounded hill which suggests a neck or stock. Mr. Getzendaner has informed the writer that a tunnel was once driven under the lower contact of the basalt in search of precious metal. Lying next to the basalt on the north side is several feet of serpentine that contains angular fragments of chalk, black on the outside but white inside and containing minute marine fossils. About 200 feet north of the mass Austin chalk appears to be dipping slightly toward the mass. At the Black water hole, near the old Uvalde-Sabinal road crossing of the Frio River, the igneous mass is surrounded by serpentine underlain by the Eagle Ford shale, which dips away from the mass. Material removed from the Jones & Son well (H–6–8) was identified by C. S. Ross as altered peridiotite tuff. There are numerous igneous masses near this well, which lies in the outcrop area of the Austin chalk.

In the Pure Oil Co.'s well, J. B. & W. A. Smythe no. 1 (G–9–1) (see p. 135), several hundred feet of serpentine was encountered. This well is near the igneous masses lying west of the Nueces River.

It appears, therefore, that some of the igneous masses came into existence in the early part of the Upper Cretaceous epoch and that some of them existed as islands in the seas of Eagle Ford and Austin time. There was apparently also more or less volcanic activity which caused the deposition of volcanic tuff in the sea at that time.[30]

The youngest formation intruded by igneous rocks in this area is the Escondido, and consequently there must have been igneous intrusion since the Escondido was laid down. Bailey [31] has described a formation in Duval County composed of volcanic ash and ejectamenta 190 to 970 feet thick. This formation is now considered the southern extension of the Catahoula tuff, of probable lower Miocene age, according to the classification of the United States Geological Survey. Although numerous beds of volcanic ash are encountered in

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[28] Lonsdale, J. T., Igneous rocks of the Balcones fault region: Texas Univ. Bull. 2744, p. 25, 1927.

[29] Vaughan, T. W., op. cit., p. 5.

[30] Getzendaner, F. M., Geologic section of the Rio Grande embayment: Am. Assoc. Petroleum Geologists Bull., vol. 14, p. 1428, 1930.

[31] Bailey, T. L., The Gueydan, a new middle Tertiary formation from the southeastern Coastal Plain of Texas: Texas Univ. Bull. 2645, p. 147, 1927.

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the Oakville of Duval County, also of Miocene age, much of the finer material in these formations may have originated in Uvalde County, but the coarse Soledad volcanic conglomerate member contains boulders as much as 18 inches in diameter, and it seems very unlikely that this coarser material could have originated in Uvalde County as has been suggested by some authors.

From the considerations above set forth it seems probable that there was a great amount of igneous activity in Uvalde County in Upper Cretaceous time. This activity reached its maximum in Eagle Ford and Austin time. Some volcanism may have occurred in the Oligocene and Miocene epochs, or even later, but if so all traces of it, except possibly the igneous masses themselves, have been removed, for no bombs or ash that can be shown to be of post-Cretaceous age have been found in the area.

STRUCTURAL GEOLOGY

The principal structural features in Uvalde and Medina Counties are those produced by faulting, the most recent phases of which have resulted in the formation of a long, strong escarpment which is the most striking topographic feature of the area and separates the Edwards Plateau from the Gulf Coastal Plain. When viewed in a general way the structure of the Coastal Plain is very simple, the rock strata dipping gently toward the Gulf and succeeding one another vertically in regular order. The Edwards Plateau is similarly of simple structure; the rocks dip very gently indeed on the interior of the plateau but show a marked increase in dip near its edge. However, when the area is examined carefully it becomes evident that the structure is in reality complex.

Two structure sections (see pl. 4) give a general idea of the structure from north to south. One of these is drawn from the Edwards Plateau southward to the Pulliam ranch, in northern Zavala County, along a line parallel to the Nueces River. The other passes from the Edwards Plateau south by east through Dunlay, in Medina County, nearly to the Medina-Frio County line. (For location of sections see pl. 1.)

BALCONES FAULT

The Balcones escarpment enters Medina County from the east a few miles north of the Culebra road and extends west by south to a point near the diversion dam in the Medina River, thence westward across Medina County to a point about 10 miles north of Sabinal, thence west-southwestward to a point 12 miles north of Uvalde, thence southwestward to a point near which the West Fork of the Nueces enters the main stream. This escarpment locates the site of a fault having in places a throw of about 200 feet, because the Buda, Del Rio, and Eagle Ford formations are all faulted out of sight, Austin chalk being thus brought against Edwards limestone, and in other places, where the Escondido was brought into contact with the Edwards, the movement amounted to as much as 900 feet. Toward the west this fault becomes less pronounced, and becomes more of a fault zone, until on the west side of Uvalde County it passes into a monoclinal fold, so that in some places the Balcones escarpment was formed by the main Balcones fault or the northernmost fault of the Balcones fault zone, whereas in other places it was formed by the greatly increased dip of the underlying strata at the southern edge of the Edwards Plateau. North of the escarpment dips of 5° to 10° bring the Glen Rose formation to the surface within a few miles, and in some localities, as along the Hondo River about 17 miles north by west of Hondo, the dip is nearly 45° for a few miles east and west, so that one looking northward from the plain sees a row of hills and steep-sided, abrupt canyons and a few miles farther north a group of higher hills which have less abrupt sides. The steep-sided hills are composed of Edwards limestone (pls. 5, *A*, and 7, *B*). The higher, more gently sloping hills are composed of the Glen Rose limestone and are known as the "Glen Rose Hills." Most of these hills are capped by the Edwards limestone. South of the escarpment the complexity of the structure increases. It has not been possible to study the geology of the two counties completely, nor is it possible to describe in detail all the structural features noted in the field work performed. The large area to be covered in a limited time, the complexity of the structure, and the fact that the highly faulted area is covered by heavy surface deposits of Leona gravel, which effectively obscure the underlying geologic conditions, have been great handicaps to detailed mapping of the area.

North of Hondo the Balcones fault is broken up into several smaller faults, one of which is well exposed in Hondo Creek (see pl. 3, *B*), and in the vicinity of Uvalde a large number of block faults have in places brought blocks of the Edwards limestone to the surface to form isolated hills. Examples of hills of this sort are Big Mountain, Frio Hill, the unnamed hill between Black Mountain and Blue Mountain, north and east of Uvalde, and Rocky Hill, southwest of Uvalde. These faults and the Balcones faults are well shown topographically, and for that reason they have been considered late Pliocene or early Pleistocene. However, evidence is accumulating which indicates that they may be early Pliocene or possibly Miocene.

OTHER FAULTS

There is another set of faults which are not marked by escarpments or other topographic features. South of Tom Nunn Hill in the bed of the Nueces River one of these faults brings Austin chalk into contact with the Escondido formation. On the La Prior-Uvalde highway near Cook Slough the Buda limestone is exposed, but not more than 100 yards to the southwest, in the railroad cut of the San Antonio, Uvalde & Gulf Railroad, the Escondido is exposed. Again, below the Connor ranch on the Frio River the Austin chalk is exposed, whereas 0.6 mile downstream the Escondido is exposed. On the Sabinal River 8 miles south of Sabinal the Anacacho limestone is observed dipping 6° ESE., but 1½ miles upstream from this point a dip of 3½° NW. is observed. On Hondo Creek the Indio formation is brought into contact with the Escondido by a fault that extends northeastward to a point just south of Castroville. Another fault observed on Medio Creek in Bexar County about 1 mile south of the San Antonio and Del Rio highway, where the Midway formation is faulted down against the Navarro formation, passes in a southwesterly direction through a point about 1 mile south of La Coste. Some of these faults extend for considerable distances; others, such as the faults immediately below Tom Nunn Hill, apparently die out into folds in a short distance. Extending from the Hondo-Butts Gin road to a point about 3 miles south of the San Antonio highway and midway between Dunlay and Castroville there is a series of step faults arranged en échelon.[32] Individually most of these faults trend east-northeast, but all of them seem to be of rather small throw. Some well logs have served to show faults that would not otherwise have been known. An example of this is found 2½ miles west-northwest of Uvalde. On John Monagin's dairy farm the Edwards is reached in an irrigation well (p. 136) at a depth of 263 feet, whereas in the well on the Bowman farm, about 150 yards to the northwest (p. 106), it is struck at less than 107 feet. This difference of 156 feet in the depth to the Edwards is not indicated in any way by the surface relief.

FOLDS

In addition to the faulting, folding has played an important part in shaping the geologic structure. Between the San Antonio highway and the Culebra road (see pl. 1) there is an anticlinal fold which extends into Medina County from the northeast and brings the Austin chalk to the surface entirely surrounded by Anacacho limestone. United States Highway 90 from the Medina River at Castroville crosses from the Anacacho onto the Escondido formation and continues on this formation to a point just west of the boundary between Medina and Uvalde Counties. Here the formation begins to swing rapidly southward, and the highway passes onto the Anacacho again. The Anacacho-Austin contact trends northeast and is crossed about 2 miles east of Knippa. Between this point and Uvalde the highway rapidly climbs the dip onto the Eagle Ford shale west of the Frio River and over a small fault onto the Buda limestone

[32] Cannon, R. L., manuscript map. Gardner, Julia, manuscript map.

at Ange siding and crosses another small fault, which apparently cuts out part of the Del Rio clay, to reach the Edwards formation. Farther west the dip of the strata is reversed, and the road crosses successively higher Cretaceous formations. It is thus seen that in the vicinity of Uvalde there is a large anticlinal nose which brings the Edwards limestone to the surface at a point farther south than it would normally occur.

The large monoclinal fold that appears in western Uvalde County is an extension of the Balcones fault zone and has been mentioned on page 29. Somewhat south of this fold, in the outcrop area of the Anacacho limestone, is a large dome known to local geologists as the "Little Fry Pan dome." This is one of a group of domes, and the area in which they occur is referred to as the Little Fry Pan area. This area has been drilled in search of oil, and Liddle [33] has described the structural relations of the Little Fry Pan area in a recent paper.

Numerous other structural features have been located on the Coastal Plain south of the Edwards Plateau, such as the dome which brings the Escondido formation to the surface, surrounded by Midway beds, near the old Lewis ranch house on the Frio River. A high dip on the Escondido formation near the old "Widow Cook ranch" forms a natural dam across the Nueces. (See pl. 5, *C*.) Many of these features have been drilled in prospecting for oil. It is of course not possible to detail all the structural features found within the area worked, and in many places the underlying formations are not known, owing to a heavy covering of later gravel. Nevertheless, the writer has attempted to interpret the geologic structure of the area from such information as was available and has therefore omitted from the map the gravel and silt mantles, with the full realization that this omission has doubtless led him into errors.

RELATION OF STRUCTURE TO IGNEOUS INTRUSION

The relation between the structure and the intrusion of igneous rocks is not clear. All the faulting in the area appears to have occurred simultaneously and is certainly all post-Midway. Several faults in the southern part of the area cut the Carrizo sand and the Bigford member of the Mount Selman formation and are therefore later than the Bigford. The Uvalde gravel is nowhere involved in the faulting, which is therefore pre-Uvalde and must have occurred between middle Eocene and late Pliocene or early Pleistocene time. It is thus obvious that much of the older igneous activity is not directly connected with the faulting.

In parts of the area, as around Uvalde, there are numerous faults and igneous masses, so that here there is at least a geographic association, and it seems very probable that the faulting may have occurred

[33] Liddle, R. A., Magnetometer survey of Little Fry Pan area, Uvalde and Kinney Counties: Am. Assoc. Petroleum Geologists Bull., vol. 14, no. 4, pp. 509 et seq., 1930.

as a result of igneous activity. Throughout much of Medina County there are only a few small igneous masses, but the magnitude of the faulting is fully as great as that in Uvalde County.

In some localities it is evident that the intrusion of the igneous masses has had the effect of causing slight folding in the adjacent sedimentary formation. Such folding is seen at the Black waterhole, near the crossing of the old Uvalde-Sabinal road at the Frio River, where the Eagle Ford shale is raised on the north side of the basalt mass and is immediately overlain by tuffaceous material. In other places the effect of the igneous intrusions in uplifting the surrounding sedimentary rock seems to be very slight indeed. Such is the case at the Texas trap-rock quarry at Knippa, where the Austin chalk appears to dip slightly toward the igneous mass, and is also overlain near the basalt by tuffaceous material, which is in turn overlain by the basalt. In practically every other locality where basalt or other igneous material exists the contact between the igneous material and the sedimentary rocks is obscured by the overlying silt or gravel of later age.

GENERAL PRINCIPLES OF THE OCCURRENCE OF GROUND WATER

The occurrence of ground water in Uvalde and Medina Counties is entirely dependent on the local geologic conditions. Some formations seem everywhere to yield an abundant supply of good water, others are not known to yield water of any sort, and still others are water-bearing in some areas but not in others. Because of the existing structural conditions, water-bearing formations that crop out at one place (see pl. 4) may be buried several thousand feet beneath the surface at another place, and consequently it may be almost impossible to obtain a ground-water supply at a reasonable cost in certain parts of the area. The chemical character of the water also differs widely. There seems to be a distinct tendency for certain formations to carry a definite type of water, but it does not necessarily follow that a formation everywhere carries water of the same type.

Ground water occurs in Uvalde and Medina Counties under both artesian conditions[34] and water-table conditions.[35] Artesian conditions are found in this area where a water-bearing formation is overlain by impervious formations and dips in the same direction as the slope of the surface but at a somewhat greater angle. The formation thus becomes increasingly far below the surface in the direction of the dip.

[34] For a full discussion of artesian conditions see Chamberlin, T. C., The requisite and qualifying conditions of artesian wells: U. S. Geol. Survey 5th Ann. Rept., pp. 125-173, 1885; Fuller, M. L., Summary of the controlling factors of artesian flows: U. S. Geol. Survey Bull. 319, 1908; and Simpson, H. E., Geology and ground-water resources of North Dakota: U. S. Geol. Survey Water-Supply Paper 598, p. 45, 1929.

[35] For a full discussion of water-table conditions see Meinzer, O. E., Occurrence of ground water in the United States: U. S. Geol. Survey Water-Supply Paper 489, pp. 1-192, 1923.

The water contained in the formation may be likened to the water in a standpipe, being under hydrostatic pressure. If a well is drilled into the formation the water will rise in the well to a level determined by the hydrostatic pressure of the water. Because of the friction opposing movement of water in the conduit the height to which water will rise in a well will be less than the height of the water table in the outcrop area. If the water in the well rises appreciably above the top of the formation in which it was encountered the well may be considered to be an artesian well. If the hydrostatic pressure is sufficient to bring the water to the surface and cause it to flow, the well is a flowing artesian well. An open fissure may connect the water-bearing formation with the surface, and there may be sufficient hydrostatic pressure to cause the water to rise to the surface and form a spring. Many such springs are known along the line of the Balcones fault.

The essential difference between artesian conditions and water-table conditions lies in the fact that where water-table conditions exist there is no overlying impervious layer, and therefore the water is not confined under pressure. Water, on entering the formation, tends to move laterally and to fill the empty pore spaces to a level determined by geologic conditions. Above this level the pore spaces may be filled partly with water and partly with air. The surface that separates the saturated portion of the formation from the overlying unsaturated portion is called the water table. This surface is not absolutely level but slopes from the areas of principal intake to the areas of principal discharge. Artesian conditions are encountered in the Travis Peak formation, the Glen Rose and Edwards limestones, the Austin chalk, the Anacacho limestone, the Carrizo sand, and to some extent in the Indio formation. Water-table conditions are encountered in Leona gravel, except where this formation is entirely drained, and also in the outcrop areas of the other water-bearing formations where there are no overlying impervious layers to confine the water under pressure.

CHEMICAL CHARACTER OF WATER

Forty-five samples of the water from different sources throughout the area were collected during the course of the field work for complete or partial chemical analyses by the Geological Survey in Washington. The results are given in the table on pages 35–37. Three samples were collected from the Leona River and four from the Nueces River; the remainder were taken from wells. Samples were taken from each of the principal water-bearing formations.

The complete analyses involved the determination in parts per million of the mineral constituents commonly present in determinable quantities. Partial analyses consisted of the determination of total amounts of dissolved iron, calcium, bicarbonate, sulphate by turbidity, chloride, and nitrate; sodium and potassium were calculated. Total hardness in both complete and partial analyses was calculated from the calcium and magnesium.

Miss Margaret D. Foster made the analyses and assisted very materially in their chemical interpretation.

The usefulness of water for stock, domestic, irrigation, and industrial purposes is directly affected by the kind and quantity of the mineral constituents that it contains. A greater range of mineral constituents may be tolerated in water to be used by stock and human beings than in water for irrigation and industrial uses, but some of the waters of the area are so highly mineralized as to be unfit for any use. Others, however, are of very good quality, being very low in dissolved solids. The mineral constituents usually give no indication of the sanitary quality of the water, which is determined entirely by the presence or absence of disease-producing organisms in the water.

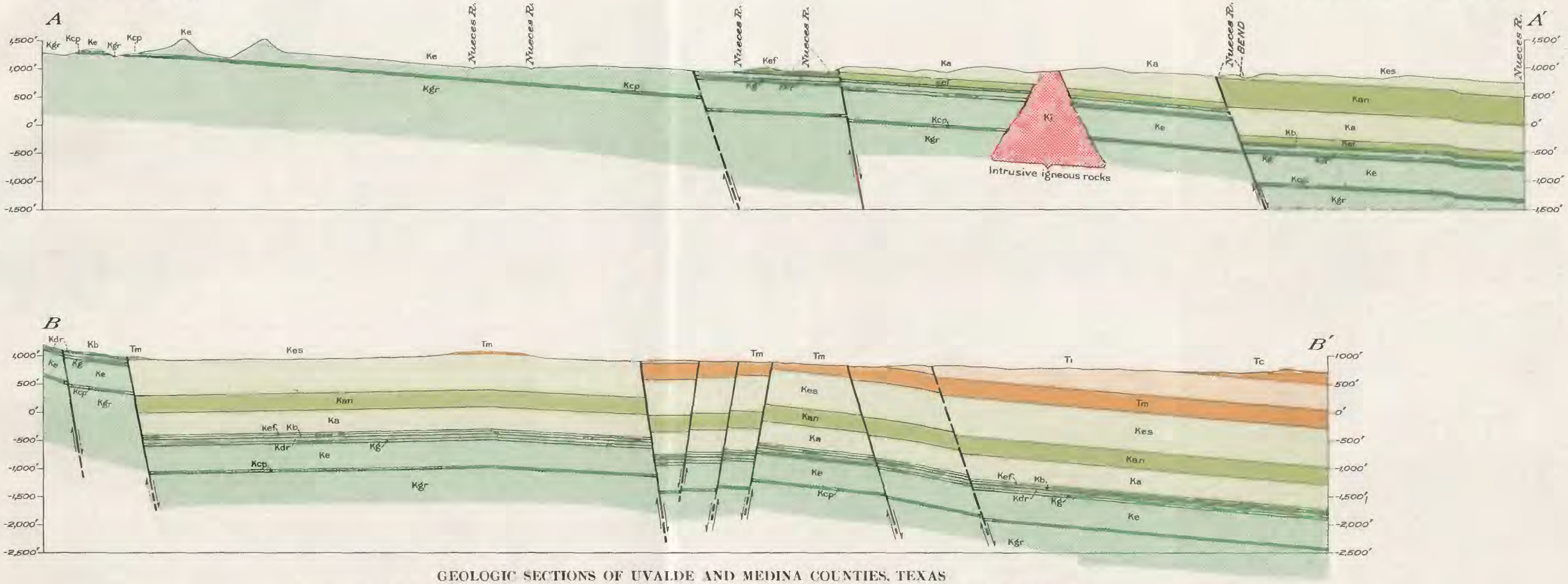
The chemical character of ground water is usually fairly constant but may change over a period of years. Changes in sanitary conditions are much more rapid, often taking place in a very short time, so that sanitary conditions might be entirely different in two successive months. Samples for the analyses here listed were chosen in an attempt to obtain representative samples from the principal water-bearing formations. The samples from the Edwards and Leona formations probably represent an average selection. This is very probably not true of the samples from the other formations, because many wells have been drilled which struck water so highly mineralized as to be unfit for use even by stock, and these wells were accordingly abandoned. Consequently, only the better waters from the Indio and Anacacho formations are represented, the poorer water being represented in the abandoned wells, from which no samples could be taken.

The analyses are grouped according to the geologic formations to make possible a comparison of different waters from the same formation. A commonly accepted upper limit of concentration of dissolved mineral matter in water acceptable for drinking is 1,000 parts per

A. NORTH END OF TEXAS TRAP ROCK CO.'S QUARRY AT KNIPPA, TEX.

B. FAULT IN BUDA LIMESTONE ON HONDO CREEK 6¾ MILES NORTHWEST OF HONDO, MEDINA COUNTY, TEX.

Photograph by L. W. Stephenson.



GEOLOGIC SECTIONS OF UVALDE AND MEDINA COUNTIES, TEXAS

Tc, Carrizo sand; Ti, Indio formation; Tm, Midway formation; Kes, Escondido formation; Kan, Anacacho limestone; Ka, Austin chalk; Kef, Eagle Ford shale; Kb, Buda limestone; Kdr, Del Rio clay; Kg, Georgetown limestone; Ke, Edwards limestone; Kcp, chiefly Comanche Peak limestone; Kgr, Glen Rose limestone.

1 ½ 0 1 2 3 4 5 Miles

million.[36] Waters carrying chiefly magnesium or sodium sulphate or sodium chloride may be suitable for drinking even if the mineral content is over 1,500 parts per million. It is recognized [37] that water containing more than 2,500 parts per million of dissolved solids cannot well be used regularly for domestic consumption. Stock may often be able to drink water too highly mineralized for human consumption, but water containing more than 10,000 parts per million of dissolved solids is not satisfactory for stock and may even have a harmful effect. The usefulness of water for irrigation depends upon the drainage and the nature of the soil as well as upon the character of the water. The alkalies are apt to be most harmful to irrigated crops.

Analyses of surface waters in Uvalde County, Tex.

[Analyzed by Margaret D. Foster. Parts per million]

	Nueces River				Leona River		
	H-1-H	H-7-F	H-7-F1[a]	H-7-G	H-8-D	H-8-C	H-8-E
Silica (SiO_2)	16	19	--------	15	--------	13	--------
Iron (Fe)	.03	.05	--------	.04	--------	.04	--------
Calcium (Ca)	50	46	76	57	110	80	94
Magnesium (Mg)	15	13	14	13	14	13	13
Sodium (Na)	5.0	6.3	[b]3.8	7.0	[b]17	9.8	[b]9.7
Potassium (K)	1.4	1.7		1.6		2.1	
Bicarbonate (HCO_3)	208	176	267	208	343	237	307
Sulphate (SO_4)	10	21	[c]15	22	[c]58	54	[c]32
Chloride (Cl)	10	11	10	12	18	17	16
Nitrate (NO_3)	1.8	.50	8.6	.50	2.4	.07	2.1
Total dissolved solids	203	201	[b]259	221	[b]388	312	[b]318
Total hardness as $CaCO_3$ (calculated)	186	168	247	196	332	253	288

[a] Collected by W. N. White and W. A. Lynch.
[b] Calculated.
[c] By turbidity.

H-1-H. Nueces River 14 miles northwest of Uvalde. Sample taken 2 miles above the point of disappearance of the last water in the river north of the Southern Pacific Railroad bridge, May 31, 1930.
H-7-F. Nueces River 7 miles southwest by west of Uvalde. Near this point water appears in the river bed, which carries running water from here to Pulliam's Crossing, in northern Zavala County, May 20, 1930.
H-7-F1. Nueces River at same point as H-7-F, Nov. 26, 1930.
H-7-G. Nueces River, Zavala County, 10 miles southwest of Uvalde. Sample taken at Pulliam's bridge. River continues to flow for several miles downstream from this point, May 22, 1930.
H-8-D. Leona River 5 miles south of Uvalde. Sample taken immediately below the first spring, May 18, 1930.
H-8-C. Leona River 7.1 miles south of Uvalde. Sample taken from a long pool below a travertine dam, Apr. 8, 1930.
H-8-E. Leona River 10 miles south of Uvalde. Springs in the Leona River about 1 mile below Kincaid Reservoir, which is now above water, and no water flows over the dam, May 19, 1930.

[36] U. S. Public Health Service, Drinking-water standards: Public Health Reports Reprint 1029, p. 24, 1928.
[37] Hall, G. M., and Howard, C. S., Ground water in Yellowstone and Treasure Counties, Mont.: U. S. Geol. Survey Water-Supply Paper 599, p. 16, 1929.

Analyses of ground waters in Uvalde and Medina Counties, Tex.

[Analyzed by Margaret D. Foster. Parts per million. Numbers in first column refer to well records listed in table on pp. 102–127]

Edwards limestone

No.	Owner	Date of collection, 1930	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$ (calculated)
H-2-8	F. C. Brigman	Apr. 10	213	15	0.05	58	15	5.6	1.0	236	8.5	10	3.8	206
H-3-1	G. C. Sanderlin	do	208	14	.93	50	15	5.9	1.1	211	8.5	10	4.3	186
H-4-3	—— Harper	May 18	[a] 247		.40	66	14	[a] 10		254	[b] 15	13	3.6	222
H-5-13	John Monagin	May 20	[a] 253			76	9.2	[a] 8.9		256	[b] 18	10	5.2	228
H-5-26	Geo. Kennedy	Apr. 10	249	21	.25	75	8.9	6.3	1.1	262	8.4	10	3.0	224
H-5-34 [c]	—— Houston	Nov. 28	[a] 2,313		12	256	94	[a] 402		340	933	460	.92	1,025
H-5-51	O. T. Cardwell	Apr. 20	828	28	2.2	182	29	49	3.4	435	230	56	8.3	574
H-5-52 (1)	Ingraham & Jenkins	Apr. 10	489	13	.04	134	15	13	2.2	287	52	95	3.6	396
H-5-52 (2) [c]	do	Nov. 28	[a] 319			94	11	[a] 12		279	31	29	4.7	280
H-6-16	Illinois Pipe Line Co	Apr. 10	508	19	.57	65	31	59	5.6	269	146	36	.13	290
H-7-2 [c]	Smythe Bros	Nov. 26	[a] 4,149			652	197	[a] 399		344	2,239	490	2.0	2,438
I-1-3	E. B. Kincaid	May 21	[a] 282			64	17	[a] 22		274	[b] 26	17	1.2	230
I-2-1	W. A. Weynand	May 20	[a] 248		3.7	74	13	[a] 3.5		258	[b] 20	9.0	1.0	238
I-2-7	Alfred Schlentz	May 17	[a] 231		3.8	66	13	[a] 4.4		234	[b] 18	9.0	5.6	218
I-3-2	Hondo Waterworks	Apr. 30	227	15	.03	63	16	6.7	1.1	251	15	11	2.9	223
I-3-5	L. H. Heyen	do	266	16	14	73	11	6.9	1.3	266	12	9.0	4.2	228
I-4-4	City of Sabinal	Apr. 10	942	18	.06	127	61	72	11	268	445	34	4.0	568
I-4-30	Virgil Johnson	Apr. 30	259	13	.07	59	19	14	1.4	244	18	26	.71	225
J-1-9	L. W. Burell	May 16	[a] 302		5.7	74	16	[a] 7.8		164	[b] 108	14	1.0	251
J-5-1	Southern Pacific lines	do	[a] 223			60	17	[a] 2.6		233	[b] 13	13	3.0	220

Leona formation and terrace gravel

No.	Owner	Date of collection, 1930	Total dissolved solids	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulphate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Total hardness as $CaCO_3$ (calculated)
H-4-28	Robert Ingraham	Apr. 10	305	16	0.02	89	11	7.6	1.6	299	17	12	10	268
H-5-3	L. Borgas	May 19	[a] 280			78	9.3	[a] 16		268	[b] 28	10	6.7	233
H-5-56	T. G. Hines	Apr. 8	314	14	.02	90	10	7.2	1.3	288	27	12	.05	266
H-6-10	Herbert Stevens	May 20	[a] 409			90	25	[a] 26		230	[b] 14	113	28	328
H-6-21	—— Connor	Apr. 7	376	22	.02	99	26	6.8	1.3	406	22	6.0	5.3	354
H-8-13	W. R. Lee	Dec. 3	[a] 410			114	14	[a] 26		409	[b] 34	20	.20	342
H-8-27	Uvalde Pecan Plantation	Apr. 8	340	15	.02	98	12	8.6	1.4	310	31	15	2.8	294
I-5-1		May 15	515		.57	128	9.9	[a] 30		264	[b] 23	48	146	361

Anacacho limestone														
I-4-1	L. F. Heard	Apr. 30	531	24	1.8	49	24	126	4.5	544	3.0	38	.10	221
I-4-28		May 21	[a] 1,567		1.8	84	77	[a] 431		749	[b] 13	592	.75	526
J-1-11	L. W. Burell	May 16	[a] 385		21	84	20	[a] 38		355	[b] 35	33	0	292
Indio formation														
H-8-19	A. W. West	May 18	[a] 560			[b] 15		[a] 215		535	[b] 5	65	2.0	69
H-9-8	Kincaid estate	Apr. 7	680	18	2.0	113	31	81	8.6	387	110	115	.22	410
I-8-10	Frank Martin	May 18	[a] 2,562		4.6	197	61	[a] 636		390	740	730	6.0	743
Carrizo sand														
I-9-4	—— Crane	May 20	[a] 439			111	12	[a] 42		403	[b] 40	28	7.5	327
J-7-10	Lou. Crawford	May 16	[a] 342		0.37	66	14	[a] 42		126	[b] 30	127	.83	222
J-7-13		May 20	[a] 131		10	[b] 16		[a] 27		39	[b] 20	42	2.3	56
J-7-23	Josephine Haegelin	Apr. 25	529	31	2.7	71	22	50	12	42	40	126	162	268

[a] Calculated. [b] By turbidity. [c] Collected by W. N. White and W. A. Lynch.

ROCK FORMATIONS AND THEIR WATER-BEARING PROPERTIES

LOWER CRETACEOUS OR COMANCHE SERIES

The Lower Cretaceous or Comanche series is divided into three groups—the Trinity group at the base, the Fredericksburg group in the middle, and the Washita group at the top.

TRINITY GROUP

TRAVIS PEAK FORMATION

The Travis Peak or lowest formation of the Trinity group does not crop out in this area, the nearest exposures being on the slopes of the valley of the Colorado River between the mouths of Sycamore and Cypress Creeks, in Burnet and Travis Counties, according to Hill and Vaughan.[38] The formation consists of

> conglomerate, composed of coarse rounded pebbles of Silurian and Carboniferous limestones, granite, Llano schists, quartz derived from the adjacent Paleozoic rocks, beds of finely cross-bedded pack sand, white siliceous shell breccia resembling the Florida coquina, and some clay. At the base is usually conglomerate. Succeeding this is coarse, angular cross-bedded sand, which becomes more finely triturated until it reaches the condition known in Texas as "pack sand."

The thickness of the section at the mouth of Hickory Creek, in Burnet County, is given as 263 feet. In the area here considered the thickness is not given in the log of the Phantom well (A–9–1; see p. 133). The Patterson Bros.' well (B–8–1; see p. 133) shows 433 feet of sand, boulders, and shell rock, and the Rothe well (I–1–5) shows 413 feet of sand, gumbo, sandy lime, and gray shale. In general it appears that the Travis Peak formation becomes more shaly toward the top.

The Travis Peak is the deepest known water-bearing formation in the area. It supplied good water to the cities of Austin, Kerrville, and San Marcos, according to Hill and Vaughan.[39] Although no wells are known to obtain water from this formation in Uvalde and Medina Counties, wherever the drill has penetrated the formation in drilling for oil there appears to have been a supply of water available under a fairly high head.

Four wells penetrated the Travis Peak formation in Uvalde and Medina Counties. The Rothe well 1 of the California-Medina Association apparently struck the Travis Peak at 2,470 feet. The water above the Trinity group was cut off by casing, and although no mention of striking water in the Travis Peak is made, the driller's log states that at 2,500 to 2,504 feet water was bailed down 600 feet and at 2,514 feet water was bailed down to 1,620 feet, which suggests that a small supply of water was encountered in the Travis Peak. It is believed that the supply was small because of the fact that the

[38] Hill, R. T., and Vaughan, T. W., op. cit., p. 219.
[39] Idem, pp. 279–287.

driller was able to bail the water down to such an extent. No mention of the quality of the water or of the height to which it rose in the well is made.

The Phantom Oil Co.'s well Cloudt no. 1, in Uvalde County 4 miles northwest of Montell, apparently struck the Travis Peak formation at about 1,198 feet. Water is recorded at 7 different levels throughout the formation, at 5 of which it was under sufficient head to rise nearly to the surface but not to overflow. Fresh water is reported at about 1,500 feet.

The well of the Transcontinental Oil Co., drilled on the I. K. Henry survey, 22 miles north of Uvalde, struck the Travis Peak formation at about 1,290 feet, and water was reported in three sands throughout the formation, but no information is available as to the character of the water.

The Bell Oil & Gas Corporation's well Walcott no. 1 (see log, p. 137), at Ange siding, 5 miles east-northeast of Uvalde, entered the Travis Peak formation between 1,580 and 1,780 feet, according to Mr. Getzendaner, who has compiled the log from memory. No report of the water at this depth is given in the log.

As these wells were drilled primarily as oil tests, there is no record of the exact level to which the water rose or of the quantity encountered and no record of the quality of this water, except the driller's statement that the water in the Phantom well was fresh. It is entirely possible that the water of the Travis Peak, south of the fault, is usually too highly mineralized for most purposes. But even where the water is fresh the great depth to which it is necessary to drill in order to obtain water from the Travis Peak renders the cost of such a well prohibitive for any ordinary purpose. It is possible that north of the fault this water may be obtained by drilling from 1,200 to 1,500 feet, more or less, but flowing wells could probably not be obtained on account of the high altitude of the area. The lack of wells drilled for water to the Travis Peak formation within the area is doubtless due to the fact that water supplies can be obtained from formations that lie nearer the surface.

GLEN ROSE LIMESTONE

The Travis Peak formation passes upward into the Glen Rose without perceptible break, and the predominantly sandy beds of the Travis Peak give way to the predominantly calcareous beds of the Glen Rose. This is the oldest formation that is exposed in Uvalde and Medina Counties. It is named for the town of Glen Rose, in Somervell County, where it is well exposed. In the western part of the area about 300 to 350 feet of the Glen Rose is exposed along the Nueces River where its valley cuts into the Edwards Plateau. Smaller thicknesses are exposed along neighboring and tributary streams. In northern Medina County a dip of nearly 40° brings the Glen Rose to the surface 4 or 5 miles from the northern edge of the county, and in this area it occupies all but the tops of the highest hills.

The Glen Rose formation consists of alternating beds of white to buff chalky to argillaceous limestone, usually varying from 1 to 3 feet in thickness, separated by white to yellow soft, rather argillaceous marls. These marl beds may range from 6 inches to 10 or 12 feet in thickness. However, individual layers seem to be very persistent and may be traced for considerable distances.

The difference in the resistance offered to erosion by the marly layers and the limestone layers of the Glen Rose is well illustrated in the terrace type of topography developed in its outcrop area. (See pl. 5, *B*.) Where streams swing against a wall of the Glen Rose formation, a nearly vertical cliff is likely to result. However, where erosion has been less rapid and the slopes are more gentle, the more resistant layers protect the underlying softer marls from erosion, and a series of benches and terraces is found on the hillsides. The Glen Rose formation is exceedingly fossiliferous and contains large numbers of echinoids, casts of large mollusks, and, near the middle of the formation, many large disk-shaped Foraminifera of the genus *Orbitolina*.

The nearest locality at which the total thickness of the Glen Rose formation is exposed is Kerrville. At this place, according to Hill and Vaughan,[40] the total thickness is 500 feet. Sellards [41] gives a thickness of about 800 feet in Bexar County, basing his estimate on the combined surface measurements and well logs. In the Patterson well (B–8–1), in northern Uvalde County, it has a thickness of 1,040 feet, whereas in the Rothe well (I–1–5), in Medina County, it is apparently 1,175 feet thick, which would seem to indicate that the formation becomes thinner toward the northwest. This seems to bear out the statement of Hill and Vaughan [42] that the formation retains a remarkably uniform thickness along the strike but apparently becomes much thinner toward the landward margin of its outcrop. Getzendaner [43] has also noted this character in his study of well logs in neighboring areas.

In the area that lies north of the Balcones escarpment the Glen Rose formation supplies most of the water pumped from wells other than that obtained from the river and terrace gravel. The yield usually does not exceed 10 gallons a minute. Reports of users indicate that some of the Glen Rose water is fairly good, but practically all of it is hard, and in some places it is so highly mineralized as to be unfit for drinking.

[40] Hill, R. T., and Vaughan, T. W., op. cit., p. 225.

[41] Sellards, E. H., Geology and mineral resources of Bexar County, Tex.: Texas Univ. Bull. 1932, p. 24, June 5, 1919.

[42] Hill, R. T., and Vaughan, T. W., op. cit., p. 225.

[43] Getzendaner, F. M., oral communication.

FREDERICKSBURG GROUP

WALNUT CLAY

The Walnut clay is not sufficiently thick or important in its effect on ground-water occurrence to be mapped separately. In the bed of the Nueces River it consists of 1 or 2 feet of yellow clay lying between the Glen Rose limestone and the Comanche Peak limestone. It becomes somewhat thicker toward the east and in northern Medina County. Liddle[44] assigns to it a thickness of 20 feet along the Medina River. Hill and Vaughan[45] state that along the Colorado River, at the northern limit of the Edwards Plateau, the formation is only 10 to 12 feet thick.

COMANCHE PEAK LIMESTONE

Overlying the Walnut clay is the Comanche Peak limestone. Hill and Vaughan[46] state, "Although it is insignificant as regards thickness and lithologically might be considered the base of the Edwards limestone, it is one of the most persistent paleontologic horizons of the Texas Cretaceous section." Its outcrop is limited to the tops of the hills where the Edwards is absent or very thin in the northeastern part of the area and to narrow belts along the valley walls in that part of the area where the Edwards forms the tops of the hills. It is a marine, rather massive light-yellow to buff argillaceous limestone, and is lithologically very much like the overlying Edwards limestone. On weathering, however, it presents a nodular appearance, which is perhaps its most persistent lithologic character. Although in several places, notably in the canyon of the Frio River, near the contact, the Comanche Peak limestone has been observed to be rather honeycombed and porous, this character is not thought to continue below the surface. The thickness is from 40 to 50 feet and remains nearly constant. The formation is not known to be water-bearing. In wells it appears as a limestone at the base of a thick section of limestone and has therefore not been satisfactorily differentiated in well logs. It is possible that some water, believed to come from the lower part of the Edwards, may actually come from the Comanche Peak, but it seems likely that the Comanche Peak is not water-bearing.

EDWARDS LIMESTONE

GENERAL FEATURES

The Edwards limestone is the most important of the formations which crop out in Uvalde and Medina Counties, not only because it yields abundant water over a wide area but also because it exerts more influence upon the topography than any of the other formations.

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[44] Liddle, R. A., Geology and mineral resources of Medina County, Tex.: Texas Univ. Bull. 1860, p. 29, October 25, 1918.

[45] Hill, R. T., and Vaughan, T. W., op. cit., p. 226.

[46] Idem., p. 226.

Because of its resistant character the Edwards limestone has maintained the high-angle escarpment originated by the Balcones fault. For the same reason it accentuates the rugged character of the canyons and serves to cap the higher hills of the Edwards Plateau. (See pl. 5, *A*.) It is also largely the cause of the thin soil found in that province. In the innermost parts of the Coastal Plain region it caps numerous hills where it has been brought upward by folding and by block faulting. Because of its importance as a water-bearing formation, it is here described in considerable detail.

The Edwards limestone overlies the Comanche Peak limestone and is overlain by the Georgetown limestone. It strongly resembles both of these formations lithologically and is distinguished from them with difficulty. However, the faunas are entirely distinct, and separation is easy where fossils are present. The Comanche Peak may also be distinguished by its mode of weathering.

The Edwards limestone crops out in the Edwards Plateau, where in Uvalde County it forms the hills and has been removed by erosion only in the valleys of the larger streams, whereas in Medina County, particularly in the north-central part, the Glen Rose is brought to the surface by the high dip of the formations and the Edwards is seen only along the south margin of the plateau and on the tops of the highest hills north of the margin. Near Uvalde the Edwards appears at the surface at several places because of block faulting, and it also occupies the southern part of the crest of the northwestward-trending anticline that passes just east of Uvalde.

The Edwards limestone is a marine formation consisting of massive beds of rather pure light-buff to light-gray coarse- to fine-grained, usually nonfossiliferous limestone. These massive beds are interbedded with a few layers of thin-bedded flaggy or marly limestone. Both the color and the character of the limestone are remarkably constant. The weathered limestone is hard and gray, rings under the blows of the hammer, and has a very distinctive miniature mountain and valley type of surface with small, long, level ridges flanked on each side by spurs. The softer parts of the formation show no bedding planes on the fresh surface, but these parts weather quickly, and the bedding planes then become very evident. Layers containing nodular chert are present in certain parts of the formation and are not known to occur in other formations in this area. The chert ranges in color from black to buff or light gray, and some nodules are several feet in diameter. The outside of weathered nodules is a spongy-looking chert which grades into solid chert in the center.

Caverns are exceedingly numerous in the Edwards limestone, especially in the plateau area. Many of the ranchers know of one or more caves in their ranches, and Hill and Vaughan [47] note many of

[47] Hill, R. T., and Vaughan, T. W., op. cit., p. 210.

A. FRIO RIVER VALLEY NORTH OF SHUT-IN, NEAR CONCAN, UVALDE COUNTY, TEX.

B. TWO HILLS IN NORTHERN BEXAR COUNTY, TEX., SHOWING TERRACES ON THE GLEN ROSE LIMESTONE.

C. LEDGES OF ESCONDIDO SANDSTONE ON THE NUECES RIVER.

Dipping steeply downstream and striking at right angles to the channel, 1.7 miles below the Uvalde-Eagle Pass road crossing.

these caves. (See pls. 6 and 7, *B*.) Numerous caves have been encountered in drilling operations throughout the county. The writer, in company with Messrs. Stephenson and Turner, located a cave in the bed of the Dry Frio River just below the Uvalde-Leakey road crossing. This cave was about 18 inches long and 8 inches wide at the entrance and extended downward a distance of 40 to 50 feet, beyond which it could not be followed with the eye. It was apparently very extensive, as indicated by the fact that a current of cold air issued from the opening. Water wells that blow and suck are also rather common in the area and indicate an underground connection of considerable extent. The water that is so abundant in the Edwards limestone is largely contained in these or similar caverns and in fissures.

Fossils are not common in the Edwards, but several distinctive forms have been found. Among these are several aberrant mollusks, such as *Requiena* and *Monopleura*.

The Edwards is distinguished from the Georgetown by its fossils where these are present and from the Comanche Peak by its fossils and the distinctive way in which each weathers. It is distinguished from the other limestones of the area by the character and purity of the massive beds, by its usual lack of fossils, and by its tendency to form high bluffs. It is, moreover, the only formation containing nodular chert.

In the plateau area Hill and Vaughan [48] have estimated a thickness of 638 feet by comparing adjacent measured sections. In the Coastal Plain area well logs indicate a thickness of 400 to 500 feet.

On the Edwards Plateau the formation lies nearly flat. However, near the edge of the plateau, in Uvalde County, the dip increases rapidly and is more than 100 feet a mile. North of Hondo the dip is much greater, but south of the Balcones escarpment the dip is much less and probably averages about 50 feet a mile near Uvalde. At the Balcones fault zone the upper part of the Edwards limestone on the south side of the fault zone is dropped so that it rests against the lower part of the Edwards on the north side, and in one place, north of Quihi, the formation is completely offset.

OCCURRENCE OF WATER

In Uvalde and Medina Counties the Edwards limestone is the chief water-bearing formation. On the Edwards Plateau it supplies water for numerous springs. South of the plateau, for a distance of several miles, it is the only water-bearing formation and supplies water to all the stock and domestic wells. Practically all the larger wells in the

[48] Idem, p. 234.

two counties draw their supply from this formation, although the Anacacho limestone supplies good water to a few wells, and in the vicinity of Devine the Carrizo sand usually yields an abundance of good water to wells.

The water in the Edwards limestone occurs in cracks, fissures, and channels in the rock produced by earth movements or by solution, or both. Large quantities of water can usually be obtained from the limestone in areas where these openings are large or numerous and interconnected. Wells in such areas are the Monagin well (H–5–13), the Bowman well (H–5–14), and the Uvalde city well (I–5–1), all of which yield several hundred gallons of water a minute without lowering the water level more than very slightly. Wells in areas where these openings in the limestone are scattered may not encounter openings of sufficient size to yield much water. Some wells of this class yield a maximum of only 10 gallons of water a minute, and the water level is drawn down as much as 150 feet.

Many springs and seeps issue at the contact between the Edwards limestone and the Comanche Peak limestone. Where the contact rises above the stream bed the Edwards is likely to yield water as springs or seeps. Such a spring occurs on Hackberry Creek on the old Peters ranch, near the north edge of the Uvalde quadrangle. This spring has an estimated flow of 10 gallons a minute. All the streams in the area rise from such springs. Where the contact dips below the stream bed the formation takes in water from the stream. From the relations of this contact to the occurrence of water it seems likely that the Comanche Peak serves as an impermeable barrier to the downward movement of the Edwards limestone water. Therefore, this water moves laterally through the formation, and some of it emerges in the stream valleys while much of it moves down the dip under the Coastal Plain.

South of the Balcones fault zone the Edwards becomes increasingly deep in all parts of the area except near Uvalde, where it is brought to the surface on the crest of the anticline and by block faults.

Practically everywhere in the area south of the Georgetown-Edwards contact the water in wells drilled into the Edwards limestone rises above the level at which it is struck by the drill. In some wells the water rises only 2 or 3 feet, but in others it rises several hundred feet. This is because the water is under hydrostatic head, or, in other words, under artesian pressure.

The height of the water table in the outcrop area of the formation determines in large measure the height to which water will rise in wells down the dip from the outcrop area. If friction were negligible and there were no movement due to withdrawal, the water would rise to the same altitude in a deep well where the limestone is buried several hundred feet below the surface as in the outcrop area. As there is movement in the system, however, friction is not negligible, and the altitude of the water surfaces in wells down the dip is always somewhat less than in wells in the outcrop area.

As the land surface near the Edwards Plateau is much higher than that 15 miles south of the plateau, where the Edwards limestone is under a thick cover of younger formation, there is a good chance for the water to rise near the surface of the ground or overflow in the area to the south. In the Monagin well, northwest of Uvalde, the water rises within 60 or 70 feet of the surface. In the Ingraham-Jenkins well, south of Uvalde, the water rises within about 60 feet of the surface. In the Smythe Brothers' water well, where the Edwards limestone is about 1,800 feet below the surface, the water level is within 17 feet of the surface, and according to Hans Smythe, when the windmill that pumps water from the well is shut off for about a week the water rises to the surface and flows over the top of the casing. In the Sabinal city well the Edwards limestone is encountered at a depth of about 900 to 1,000 feet, and the water from this formation rises within about 200 to 215 feet of the surface. In the Hondo city well the Edwards limestone is encountered at about 1,300 feet, and the water rises within 180 to 200 feet of the surface. The head under which the Edwards limestone water exists is shown for a large number of wells in the table on pages 102–127, which give the depth to water in most of the wells visited during the field work.

A study of several wells that reach or penetrate the Edwards limestone seems to show that water occurs at three zones in the formation—one near the top, one considerably below the top, and one near the bottom. The records of these wells are given in the tables on pages 102–127, 133–143. In some wells all three zones contain water; in other wells two or one of them, or perhaps none, contain water.

Well B–8–1 is situated on the outcrop of the Edwards about 250 feet above its base. The well encountered water at depths of 85 and 95 feet, or 165 and 155 feet respectively above the base of the formation. The Gulf Production Co.'s well Smythe no. 1 (G–6–1; see p. 134) enters the Edwards limestone at a depth of 1,386 feet. Sulphur water is struck at the top of the limestone. A second water zone is encountered about 40 feet below the top of the Edwards, and a third at a depth of about 1,812 feet, or 182 feet above the base of the formation.

The Pure Oil Co.'s well, J. B. & W. A. Smythe no. 1 (G–9–1; see p. 135), entered the Edwards limestone at a depth of 1,920 feet. Five bailers of water an hour were drawn from the well at this depth; at 2,107 feet, or 187 feet below the top of the Edwards, the well was full of water. A "water sand" was reported at 2,122 feet, and at 2,470 feet the well was reported as being half full of water. At 2,480 to 2,500 feet the drill entered a cavity in the limestone. This may have been a solution cavity or a crevice due to fracturing of the limestone.

The Pure Oil Co.'s well, J. B. & W. A. Smythe no. 2 (G–9–2; see p. 136), entered the Edwards limestone at a depth of 1,815 feet, and water was encountered at 1,820 feet. Again at 2,203 feet, or 383 feet below the top of the formation, sulphur water was encountered, and at 2,295 feet a "water sand" was recorded. At 2,420 feet another water-bearing zone was encountered from which the water rose 1,500 feet, or to a level 1,420 feet below the surface. This zone is probably near the base of the formation.

In J. A. Monagin's irrigation well (H–5–13; see p. 136) a small amount of water was encountered in what was supposed to be the Georgetown limestone. The Edwards limestone was entered at 285 feet, and water was recorded at this depth. No other water was reported above a depth of 390 to 400 feet, or about 105 feet below the top of the Edwards. The record of this well is apparently not complete, as the total depth recorded by the driller is 400 feet, while Mr. Monagin's records show a depth of 475 feet.

Well H–5–14 encountered water at a depth of 107 feet. This water probably occurs in the Buda limestone but enters that formation along faults connecting it with the Edwards limestone. In the log of the C. S. Bowman well (H–5–15; see p. 137), half a mile northeast of the Monagin well, the driller reported the base of the Del Rio clay at 407 feet and the Edwards limestone at 407 to 540 feet, which would seem to indicate that the Georgetown limestone is absent in this well. In this well water was encountered at 446 feet, or 39 feet below the base of the Del Rio, and also at 515 feet, or 108 feet below the base of the Del Rio. No other water was reported in the well, and drilling was discontinued at 655 feet, which is probably considerably above the base of the Edwards limestone. A yield of 280 gallons a minute was reported, which compares unfavorably with the yield of wells H–5–14 and H–5–13, both of which are now used for irrigation.

The Ingraham-Jenkins well, south of Uvalde (H–5–52; see p. 137), struck the top of the Edwards limestone at 345 feet. Water was encountered at this horizon and again at 495 feet or 150 feet below the top of the Edwards and no other water was reported to the bottom of the well. The recorded yield of the well is 450 gallons a minute with a drawdown of 42 feet. A small part of this water comes from the Austin chalk.

The Union Oil Co.'s well Anderson no. 1 (H–7–3; see p. 138) encountered the Edwards limestone at a depth of 1,500 feet. No water was reported in the well.

The Humble Oil & Refining Co.'s well Kincaid no. 1 (H–9–9; see p. 139) is said to have entered the Georgetown and Edwards limestones at a depth of 1,680 feet. Sulphur water is reported at 1,680 feet and has sufficient head to rise nearly to the surface. At 1,706 feet water is reported to have flowed while the well was being bailed. Water seems to be present in the Georgetown limestone in this well.

The record of the Texas Trap Rock Co.'s well at Knippa (H-6-2; see p. 138) indicates that the drill entered the Edwards limestone at a depth of 612 feet. Water was encountered at 625 to 630 feet, 13 feet below the top of the Edwards, and at 810 feet, 198 feet below the top of the formation. The well was drilled to 946 feet, 347 feet below the top of the formation, and the driller thought some water was struck at the bottom of the hole.

In the Sabinal city well (I-4-4; see p. 139), according to a record compiled partly from the driller's log and partly by Dr. J. A. Udden, water occurred at 915 to 940 feet, which would correspond with the Georgetown limestone if that formation is present. The top of the Edwards limestone was apparently reached at 940 feet. Therefore, if this record is correct, no water occurs in the Edwards, the base of which is at 1,647 feet, and the Sabinal well is one of the very few wells that draws water from the Georgetown limestone, but F. M. Getzendaner, who was present when the well was being drilled, states that the Sabinal water is drawn from the Edwards limestone. It seems likely, therefore, that there is some mistake in the record and that the Sabinal city well in reality draws its water from the Edwards limestone and not from the Georgetown limestone. A second well was drilled close by to a depth of 1,400 feet and draws water from the same horizon.

The Mid-Kansas Co. recently drilled a well (I-5-2; see p. 140) on the Jesse Newton farm. This well was discontinued a little below the top of the Edwards limestone, at a depth of 1,990 feet. In the upper 50 feet of the Edwards, at 1,940 to 1,990 feet, sufficient water to fill the hole was encountered.

The record of the Medina Oil Co.'s well A. L. Haegelin no. 1 (I-5-4; see p. 141) indicates that the Georgetown limestone was encountered at 1,800 feet. It contained sulphur water. At 1,861 feet fresh water was encountered near the top of the Edwards limestone. Drilling was discontinued in the Edwards at 1,950 feet.

In the Ina Oil Co.'s well Blackburn no. 1 (I-6-2; see p. 141), Medina County, the Edwards limestone was encountered at 1,893 feet. Fresh water was reported at 1,895 to 2,006 feet.

In the eastern part of Medina County, northeast of Dunlay, sulphur water was reported from the top of the Edwards limestone at 1,300 to 1,315 feet in the Wheless Peters well Burger no. 1 (J-1-3; see p. 142). In the Golden West Oil Co.'s well Courand no. 1 (J-1-4; see p. 142) water was reported in the Georgetown limestone at 1,052 to 1,067 feet, and again at 1,099 to 1,122 feet, which is about the top of the Edwards limestone. Water occurred also in the Edwards at 1,147 feet, 48 feet below the top of the formation. Drilling was discontinued at this depth. The Mid-Kansas Oil & Gas Co.'s well on the Jake Haby farm, 4 miles south by east of Dunlay (J–4–1; see p. 143), encountered the Edwards limestone at a depth of 1,507 feet. Sulphur water was reported at the top of the Edwards, and the well was abandoned at 1,616 feet.

Stovers & May drilled a well (J–4–3; see p. 143) on the Emil Bendel farm, about 3 miles west of Noonan. The Edwards limestone was struck at 1,556 feet below the surface, according to the log. No water was recorded.

The J. R. McCaldin well Thompson no. 1 (J–7–8; see p. 144), northwest of Devine, entered the Edwards limestone at a depth of 2,908 feet and penetrated the uppermost 104 feet of the formation. No water was reported from the limestone. However, according to B. C. Armstrong, of Hondo, salt water now flows from the well. Mr. Armstrong thinks that this salt water comes from the Edwards limestone. The writer had no opportunity to verify this opinion.

From the foregoing records it is evident that in most wells that reach the Edwards limestone a water-bearing zone is struck at the top of the formation. In nearly every well in which water was reported from the Edwards at least a part if not all of it came from this zone. In Uvalde County a second water-bearing zone occurs between the top and the middle of the Edwards. Most wells, especially the oil tests, are abandoned in the upper 100 to 150 feet of the Edwards limestone, and therefore the water-bearing zones in the Edwards below this level are imperfectly known. However, in some wells a third water-bearing zone is present near the base of the formation. In general, large quantities of water are available from the Edwards limestone.

QUALITY OF WATER

Most of the water from the Edwards limestone, although moderately hard, is satisfactory for most uses. Twenty samples from wells widely scattered throughout the area were analyzed by Miss Margaret D. Foster in the laboratory of the United States Geological Survey. (See p. 36.) Of these samples 13 (H–2–8, H–3–1, H–4–3, H–5–13, H–5–26, H–5–52 (2), I–1–3, I–2–1, I–2–7, I–3–2, I–3–5, I–4–30, J–5–1) are very uniform in chemical character. The total dissolved solids range from 208 to 319 parts per million and consist mainly of calcium bicarbonate with minor amounts of other salts. These may be considered typical Edwards waters. Of the remaining 7 samples, 4 (H–5–51, H–5–52 (1), H–6–16, J–1–9) are calcium bicarbonate waters but with greater amounts of other constituents present, and 3 (H–5–34, H–7–2, I–4–4) are calcium sulphate waters.

The sample from well H–6–16 is a calcium bicarbonate water, with 508 parts per million of total dissolved solids. This is nearly 200 parts per million more than is contained in the normal waters, and is accounted for by an increase in sodium, magnesium, and sulphate. As there is no record of the length of casing and the method of finishing this well, it is possible that a part of this water was derived from formations other than the Edwards, which may account for the larger amounts of sodium, magnesium, and sulphate.

The water from the O. T. Cardwell well (H–5–51) contained 828 parts per million of total dissolved solids. The concentration of calcium and bicarbonate is higher than in the normal Edwards water, and there is a notable increase of sulphate. This well is located on the Buda limestone outcrop and appears to draw its water from the Buda or the Del Rio clay rather than from the Edwards limestone. However, there is not a single well in these counties than can be definitely assigned to the Buda limestone, and near this well there is a fault or fault zone of major dimensions. It therefore seems probable that this water comes from the Edwards limestone and moves upward along fissures opened by faulting to the opening tapped by the well. During its passage upward it may have dissolved considerable mineral matter from the Del Rio clay and possibly from the Buda limestone.

Two samples were taken from well H–5–52, one after a 5-minute period of pumping and the other after half an hour of pumping. The first sample is similar to some of the samples of water from the Carrizo sand. It contained larger amounts of calcium, sulphate, and chloride than normal Edwards water, and had 489 parts per million of total dissolved solids. The other constituents are comparable to those of normal waters. The sample taken after pumping half an hour contained very much less chloride and sulphate than the first sample and 319 parts per million of total dissolved solids. The second sample is therefore a normal Edwards limestone water. Mr. Fenley, who drilled the well, states that the casing opposite the Austin chalk was perforated to allow Austin water to enter the well. Consequently, the first sample of water from this well was a mixture of water from the Austin chalk and the Edwards limestone. As the yield of the Edwards is much greater than that of the Austin, pumping would quickly draw into the well a larger proportion of the Edwards limestone water, which is less highly mineralized, than of the Austin water, which is more highly mineralized, and thereby decrease the amount of dissolved solids in the water.

The sample from well J–1–9 contained 302 parts per million of dissolved solids. This includes more sulphate and less bicarbonate than the normal Edwards limestone water, but calcium bicarbonate is still the predominant substance. This water also contains 5.75 parts per million of iron.

Three wells draw sulphate waters from the Edwards limestone. The water from the Sabinal city well (I–4–4) had 942 parts per million of dissolved solids. The bicarbonate was about normal, but the water contained more calcium, magnesium, sodium, and sulphate. A sample from the Houston well (H–5–34) contained 2,313 parts per million of dissolved solids and showed a predominance of sodium, sulphate, and chloride.

The sample from the Smythe Bros.' water well (H–7–2) contained 4,149 parts per million of total dissolved solids. The water is very high in chloride and sulphate, about normal in concentration of bicarbonate, and very high in magnesium, sodium, and calcium.

It is noteworthy that the wells which show a high concentration of sulphate and chloride, in contrast with the normally predominant calcium carbonate of the Edwards waters, are near the southern limit of the area in which water is drawn from the Edwards limestone. The Smythe Bros.' well is farther south than any other well drawing water from the Edwards in the western part of the area. Well H–5–51 is farthest south in the section immediately south of Uvalde, and the Houston well (H–5–34), well H–6–12, and the Sabinal city well (I–4–4) are also near the southern limit of the area of wells producing water from the Edwards limestone. On the other hand, well I–4–30 is probably also at the southern edge of the productive area of the Edwards limestone yet yields very good water.

WASHITA GROUP

GEORGETOWN LIMESTONE

The Georgetown limestone was named for the town of Georgetown, in Williams County, Tex., where it is well exposed and has a thickness of about 75 feet.[49] In Uvalde and Medina Counties it consists of rather massive beds of impure argillaceous marine limestone, usually white to buff and containing a few bands of more or less marly shale. It lies above the Edwards limestone but has been faulted out of sight in many places south of the Balcones fault zone, whereas north of the fault zone it was elevated with the Edwards Plateau and has since been eroded from the plateau in Uvalde and Medina Counties. Consequently, it is rather poorly exposed. Its thickness is variable but, in general, is less than 50 feet, and in some wells the formation is thought to be missing. Toward the west the thickness increases, and in the vicinity of Del Rio the formation is exposed in prominent bluffs.

In most places the Georgetown is rather fossiliferous. Its fauna is very characteristic and includes *Kingena wacoensis*, which with its associated forms serves to distinguish the Georgetown from formations that are similar lithologically.

The Georgetown is easily separated from the overlying formations by its lithology as well as by its fossils. Its top is usually recognized

[49] Hill, R. T., and Vaughan, T. W., Geology of the Edwards Plateau and Rio Grande Plain: U. S. Geol. Survey 18th Ann. Rept., pt. 2, p. 235, 1898.

particularly in wells, because it is the first massive limestone underlying the easily recognized Del Rio clay. The formation is very similar in lithology and topographic expression to the Edwards limestone, so that it has not been possible to distinguish them in the field except on the basis of fossil evidence. Consequently, the Edwards and the Georgetown are mapped together (see p. 1), and in well records, where the Georgetown has not been identified by paleontologic evidence, the upper 50 feet of the massive limestone below the Del Rio clay has been tentatively assigned to the Georgetown.

The Georgetown, unlike the Edwards, is not commonly cavernous and is not likely to contain large amounts of water. In the Sabinal city well (I–4–4), according to the well log, water was encountered in the Georgetown limestone but not in the Edwards limestone, but Mr. Getzendaner, who was present when the well was drilled, states that the principal supply of water in this well comes from the Edwards and not from the Georgetown. Water was encountered in the Georgetown limestone in the Golden West Oil Co.'s well J. Courand no. 1, but in this well water was also encountered in the Edwards.

A small amount of water was struck in the Georgetown limestone in the Monagin well (H–5–13). Sulphur water was struck in the Georgetown in the Humble Oil & Refining Co.'s well Kincaid no. 1 (H–9–9), and sulphur water was also struck in the formation in the Medina Oil Co.'s well A. L. Haegelin no. 1 (I–5–4).

Many of the older stock and domestic wells, of which there are usually no well logs, may also draw a part or all of their water from the Georgetown. However, from such information as is available, it seems likely that the Georgetown does not commonly yield large quantities of water.

No samples were obtained from wells drawing water principally from the Georgetown, and its quality is not definitely known. Well records commonly report it as "sulphur water."

DEL RIO CLAY

Overlying the Georgetown limestone is the Del Rio clay, which derives its name from the town of Del Rio.[50] In Uvalde and Medina Counties it is a peculiar bluish-green clay that weathers brown. The clay yields rather readily under pressure and caves in drill holes, making it necessary to case all drill holes that penetrate the formation. For this reason local drillers call it the "sea mud." Near the base of the formation there are great numbers of a small oyster shell, *Exogyra arietina*, locally called the "ram's horn oyster." In places these shells are cemented together into layers 1 to 6 inches thick. In other places the shells have been weathered out of the

[50] Hill, R. T., and Vaughan, T. W., op. cit., p. 236.

formation and lie on the ground in great numbers. The shell is thick, especially at the beak, and is therefore very seldom completely destroyed by drilling operations, and the zone in which it occurs therefore forms a horizon marker that is readily distinguished in wells. A few feet above the *Exogyra arietina* zone the formation becomes much less fossiliferous and contains almost no fossils, but near the top of the formation it is more arenaceous and more calcareous and may contain thin slabs of limestone and numerous specimens of an oyster somewhat larger than *E. arietina*, known as *Gryphaea mucronata*. Small crystals of pyrite occur on many of the fossils in the formation. On weathering they give the whole formation a peculiar yellow or brown color, and in many places the sulphate formed by the weathering of the pyrite has united with calcium to form selenite, and the iron coats the outside surface of the fossils with brown iron oxide.

The Del Rio has an average thickness of about 90 feet and a maximum of 120 feet, but in some wells its thickness appears to be very much reduced.

The Del Rio clay crops out in an irregular belt south of the Balcones fault zone. (See pl. 1.) Because of its lithologic character it usually forms valleys and low areas. On weathering the clay forms a black to brown soil. The Del Rio is conformable both above and below and dips toward the Gulf of Mexico at about the same rate as the Edwards limestone.

No water is known to occur in the Del Rio clay.

BUDA LIMESTONE

The uppermost formation of the Washita group, and therefore of the Lower Cretaceous or Comanche series, is the Buda limestone. This formation is a dense, massive, resistant light-gray to buff limestone. The surface has a characteristic smooth, almost putty-like appearance, and the fresh surface contains numerous small red to black spots, caused, according to Hill and Vaughan, by the glauconitic coating of some of the Foraminifera of which the rock is largely composed. Numerous small veinlets of crystalline calcite cut across the rock. The Buda weathers to a light-gray color and breaks down into a large number of small sharply angular fragments with more or less conchoidal fracture. Even the soil formed from the Buda contains fragments of this kind. The rock also shatters into angular fragments under the blows of a hammer.

Because of its resistance to erosion the Buda usually crops out in low hills and bluffs (see pl. 7, *A*), and is therefore well exposed in Uvalde and Medina Counties. In general it occupies a belt about a mile south of the Balcones escarpment, although in eastern Medina County it is faulted out of sight.

The Buda has a uniform thickness in its outcrop area of about 50 to 65 feet, but some well logs (G–9–1, H–5–15) seem to indicate a thickness of 100 feet or more.

The Buda limestone lies conformably on the Del Rio and is overlain unconformably by the Eagle Ford shale.

No wells are known unquestionably to draw water from the Buda limestone.

UPPER CRETACEOUS OR GULF SERIES

The Lower Cretaceous sediments indicate that during the epoch there was an advance and retreat of the sea, accompanied by minor fluctuations which caused increase or decrease in the depth of the sea. At the end of the period the sea completely withdrew from this region, as indicated by the absence in Uvalde and Medina Counties of the oldest formation of the Upper Cretaceous or its time equivalent. However, there was apparently very little erosion during the time in which the area was above sea level.

The Upper Cretaceous deposits indicate a general readvance of the sea, with minor fluctuations in depth, a complete withdrawal and readvance at the end of Anacacho time, and a second withdrawal of greater duration at the end of the epoch. The great thickness of serpentine in the Upper Cretaceous rocks indicates considerable igneous activity during the epoch.

The Upper Cretaceous formations are composed principally of soft limestone or chalk, shale, marl, and near the top a few sandy strata. With the exception of the Anacacho limestone and the Austin chalk, they yield very little water, and therefore they serve principally in this area as a barrier between the water in the Lower Cretaceous and that in the Tertiary water-bearing formations.

EAGLE FORD SHALE

The Eagle Ford shale was named for its outcrop near Eagle Ford, in Dallas County, Tex.[51] In Uvalde and Medina Counties it consists of laminated blue to black shale with interbedded flaggy limestone that on weathering becomes light buff to white, and there is a considerable thickness of interbedded sedimentary serpentine in the Eagle Ford shale in southwestern Uvalde County.[52] This material is also found in the Eagle Ford near the old crossing of the Uvalde-Sabinal road over the Frio River. Near the top of the formation there is a notable increase in lime, and the formation becomes more marly and is in many places distinguished with difficulty from the portion of the Austin chalk immediately overlying it. It contains numerous fossils,

[51] Hill, R. T., The topography and geology of the Cross Timbers and surrounding regions in northern Texas: Am. Jour. Sci., 3d ser., vol. 33, p. 298, 1887.

[52] Getzendaner, F. M., Geologic section of the Rio Grande embayment: Am. Assoc. Petroleum Geologists Bull., vol. 14, p. 1428, 1930.

such as ammonites, the imprints of large mollusks, and fossilized fish remains. These are rather easily recovered from the shale, owing to its platy or laminated structure. In Medina County the Eagle Ford has a thickness of 30 feet; in Uvalde County it has a thickness of 75 feet at its outcrop. Some wells indicate a thickness of as much as 280 feet (G–9–2). In Maverick County Getzendaner [52] assigns to the Eagle Ford and the Austin a thickness of 1,600 feet. Usually the outcrop of the Eagle Ford shale in Uvalde and Medina Counties is not wide, partly because of its comparatively small thickness and partly because in many places it is faulted out of sight. However, in central Uvalde County a considerable area is underlain by Eagle Ford shale where it is brought to the surface by the Uvalde anticline. The formation is well exposed on the west bank of the Nueces River north of the Southern Pacific Railroad bridge.

Well H–3–12 may draw its water from the Eagle Ford shale. The well ends in serpentine, and its bottom is a short distance above the Buda limestone, according to information from the driller based on nearby wells that have penetrated the Buda. On the other hand, it may be in Austin chalk. This well does not yield much water. No other wells that end in the formation are known.

AUSTIN CHALK

Overlying the Eagle Ford shale is the Austin chalk, so named for its outcrop at Austin, Tex. The application of this term has a rather long history, which is discussed by Deussen.[53]

The Austin chalk is in most places a massive impure chalky limestone, often reported as being blue in well logs but weathering to light gray or white. The fresh chalk is soft and easily cut with a knife, but on weathering it becomes harder or more firmly cemented, and the weathered surface is usually covered with fairly large, flat, rough-surfaced fragments. Under the magnifying glass it is seen to contain numerous small crystals of calcite and many minute fossils.

In the southwestern part of Uvalde County considerable thicknesses of sedimentary serpentine are interbedded with the chalk, and in the vicinity of Knippa several hundred feet of this material has been found in wells drilled for water both in this formation and in the Eagle Ford shale.

In some places the surface in the outcrop area of the Austin chalk is rather even, but in parts of the area, as near the Nueces River in Uvalde County and in northwestern Medina County, it is rather rough and broken.

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[52] Getzendaner, F. M., Geologic section of the Rio Grande embayment: Am. Assoc. Petroleum Geologists Bull., vol. 14, p. 1428, 1930.

[53] Deussen, Alexander, The geology of the Coastal Plain of Texas west of the Brazos River: U. S. Geol. Survey Prof. Paper 126, p. 24, 1924.

Vaughan[54] assigned to the Austin in the Uvalde quadrangle a thickness of 350 to 400 feet, probably nearer 400, and Liddle[55] assigned to it a thickness of 350 feet in Medina County. In the Union Oil Co.'s well Anderson no. 1 (H–7–3) this formation is assigned a thickness of 495 feet.

The Austin chalk is exposed in a nearly continuous belt of variable width across Uvalde and Medina Counties, as shown on plate 1.

In most places the Austin chalk is very fossiliferous, and there are several places at which the formation is composed principally of shells. One fossil zone, the *Gryphaea aucella* zone, apparently extends for a considerable distance.

The Austin grades downward into the Eagle Ford shale without perceptible break. It also grades upward into the Anacacho formation, and in places the position of the boundary between these formations is very difficult to determine. Especially is this true in drilled wells.

West of Uvalde, in the vicinity of the Nueces River, several wells obtain a fair supply of water from the Austin chalk. Such wells are the Monguam well (H–4–25), the A. Milam well (H–4–32), and the Robert Ingraham well (H–4–29). Some wells in the vicinity of Knippa encounter a fair supply of water in the Austin chalk. No wells drawing from the Austin chalk are known that yield more than 10 or 15 gallons a minute. The Ingraham & Jenkins irrigation well (H–5–52) obtains some of its water from the Austin chalk,[56] but it is believed that the amount is not large.

Most of the water from the Austin is known to carry comparatively large quantities of dissolved mineral matter, but no samples were taken for chemical analysis.

ANACACHO LIMESTONE

The Anacacho limestone overlies the Austin chalk and underlies the Escondido formation. It was named for its excellent exposure in the Anacacho Mountains, in Kinney County, Tex.[57] In its type locality the Anacacho consists of thick layers of hard yellow subcrystalline limestone with a few softer, marly beds. Some of the thick layers are composed entirely of comminuted fossil shells. The limestone beds may be somewhat cavernous, as in the vicinity of Sabinal and along Geronimo Creek.

Near Sabinal the formation contains some asphalt and petroleum, and in the western part of Uvalde County in the vicinity of Carbonville the lower portion of the Anacacho is so thoroughly impregnated

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54 Vaughan, T. W., U. S. Geol. Survey Geol. Atlas, Uvalde folio (no. 64), p. 2, 1900.

55 Liddle, R. A., Geology and mineral resources of Medina County: Texas Univ. Bull. 1860, p. 461, 1921.

56 Fenley, Munroe, oral communication.

57 Hill, R. T., and Vaughan, T. W., op. cit., pp. 240–241.

with asphalt that it is quarried and used as road metal and surfacing material on many of the roads in the surrounding part of Texas.

The proportion of marl in the Anacacho increases from west to east. The hard limestones in the formation are resistant to erosion and therefore commonly cap high, steep-sided hills, especially in western Uvalde County, but in eastern Uvalde County and in Medina County, because of the predominance of marly beds, the outcrop area of the formation is not likely to be very hilly, though there are in this area some hills held up by resistant limestone beds of the Anacacho. In the Anacacho Mountains the formation is about 300 feet thick. Toward the east it becomes thicker, and its greatest thickness is probably 490 feet in eastern Uvalde County. Farther east the formation becomes thinner and finally pinches out in Bexar County.

The Anacacho crops out in a rather wide band that extends almost continuously across the two counties (see pl. 1), but between the Nueces and Frio Rivers it is largely faulted out of sight.

The Anacacho contains a large number of fossils, principally ammonites, mollusks, and echinoids. It lies conformably on the Austin chalk and in the western part of the area is overlain by the Escondido formation, but in eastern Medina County it is overlain by the Taylor marl.

As a water-bearing formation the Anacacho is erratic both in the quantity and in the quality of water it yields. In the vicinity of Sabinal it yields a considerable amount of satisfactory water and is the formation that supplies most of the domestic wells in the neighborhood. (See well tables, pp. 1021–27.) North of Castroville it also yields water to a number of wells. West of the Nueces River, on the other hand, no water has been encountered in the Anacacho.

The chemical character of water from the Anacacho varies considerably. Near Sabinal it is rather low in total dissolved solids. The sample taken from well I–4–1 was a sodium bicarbonate water, containing 531 parts per million of dissolved mineral matter. (See table, p. 37.) A sample from well I–4–28, southeast of Sabinal, contained 1,567 parts per million, predominantly sodium bicarbonate and chloride, whereas a sample from well J–1–11, northeast of Castroville, contained only 385 parts per million of dissolved solids and was a predominantly calcium carbonate water.

According to B. C. Armstrong there is only one well near Hondo that draws water from the Anacacho. This is the oil test on the Bendele ranch. The water is reported as "sweet."

On the whole, the Anacacho is not likely to yield much water in most places, and the water it does yield is likely to be moderately to highly mineralized.

TAYLOR MARL

In central Texas the Taylor marl is composed of more or less calcareous clay and marl of marine origin with chalky or sandy phases.[58] It has a thickness of 500 feet or more and rests unconformably on the Austin chalk. In Medina County the formation is not more than 100 feet thick, and toward the west its place is taken by the Anacacho formation.

NAVARRO FORMATION

The Navarro formation, according to Stephenson, is composed in central Texas of 400 to 600 feet or more of marine clay, marl, and sand, more or less glauconitic, and the formation is believed to rest unconformably upon the Taylor marl. This formation pinches out near the east side of Medina County, where it is about 100 feet thick. Throughout the rest of the area its middle and upper portions are represented by the Escondido formation and its lower part is missing.

ESCONDIDO FORMATION

Overlying the Anacacho is the Escondido formation, the highest Cretaceous formation in Uvalde and Medina Counties. This was formerly called "Eagle Pass formation", from its outcrop near Eagle Pass, and † "Pulliam[59] formation", from its outcrop at the Pulliam Bridge on the Nueces River, where it is very well exposed from the bridge northward to the Widow Bates ranch. It consists of hard flaggy calcareous to argillaceous fine-grained dirty-buff sandstone. This grades upward to slightly coarser sandstone that is less well cemented and in places contains asphalt. It is interbedded here and there with shaly, marly layers, and there are a few resistant beds, such as the *Ostrea cortex* layer, which crops out at Pulliam Bridge. This layer consists of a very dense, hard agglomerate composed of well-preserved oyster shells strongly cemented together. A short distance downstream from this outcrop occurs a thick-bedded loose sand, cemented by asphalt. This is the locality called Waxy Falls in the early reports. The stratigraphic relation between the *Ostrea cortex* zone and the asphalt beds is obscured by stream gravel, and they are separated by a normal fault of unknown throw. Vaughan [60] supposed that the *Ostrea cortex* zone represented the top of the formation in this area and that the part of the formation which lies above this zone as exposed at Eagle Pass was missing in the Uvalde area. However, about 1½ miles north of Pulliam Bridge, 0.6 mile southeast of the old Widow Cook ranch, and 0.8

[58] Stephenson, L. W., Correlation of the Upper Cretaceous Gulf series of the Gulf Coastal Plain: Am. Jour. Sci., 5th ser., vol. 16, p. 490, 1928.

[59] A dagger (†) preceding a geologic name indicates that the name has been abandoned or rejected for use in classification in publications of the U. S. Geological Survey. Quotation marks, formerly used to indicate abandoned or rejected names, are now used only in the ordinary sense.

[60] Vaughan, T. W., U. S. Geol. Survey Geol. Atlas, Uvalde folio (no. 64), p. 2, 1900.

mile east of the Nueces River, fossils collected by L. W. Stephenson, S. F. Turner, and the writer from the Escondido a short distance below the Cretaceous-Eocene contact were determined by Stephenson as being identical with those found in the upper part of the Escondido along the Rio Grande. Therefore, the whole formation is present in this area.

It is extremely difficult to determine the thickness of the Escondido along the Nueces, because of complications produced by faulting, variable dips (see pl. 5, *C*), and the intrusion of igneous masses. Vaughan estimated the thickness along the Nueces as 100 to 200 feet. This figure is undoubtedly too low. East of this area, on the Frio River, the thickness as shown in the log of the Humble Oil & Refining Co.'s well Kincaid no. 1 (see p. 139) is about 490 feet, and in Medina County Liddle[61] assigns to it a thickness of about 700 feet. The formation is well exposed in the vicinity of D'Hanis, where it forms a high northward-facing escarpment. The shaly portions are here used in the manufacture of bricks. In western Uvalde County along the Nueces River many of the asphalt beds of the formation appear at the surface.

This formation, like the underlying formations, dips toward the Gulf and is exposed in a belt across the two counties from east to west. (See pl. 1.)

The Escondido rests directly on the Anacacho in Uvalde County and the western part of Medina County. In the eastern part of Medina County it grades into the middle and upper parts of the Navarro, and the lower part of the Navarro is missing. The Midway overlaps the Cretaceous. The top of the formation is not noticeably eroded at any one place, but there are broad irregularities which indicate a long period of erosion.

Very few wells are known which undoubtedly obtain water from the Escondido formation. A well on the Ross Kennedy estate, southeast of Sabinal (I–4–26), draws water from the Escondido. The water from this well contains enough dissolved mineral to give it a bad taste. On the Schuddemagen ranch, south of Sabinal, is another well in the Escondido. This well is between 150 and 175 feet deep and according to reports struck a large yield of fairly good water. Large areas in which the Escondido forms the underlying rock are reported as being without water. On the Smythe ranch, west of the Nueces River, several wells have been drilled within a few miles of one another without obtaining any water in the Escondido.

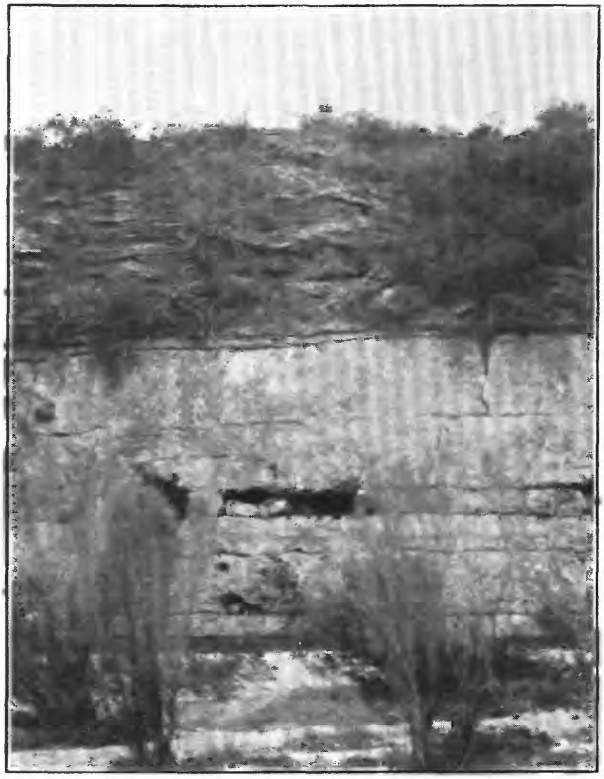
TERTIARY SYSTEM

EOCENE SERIES

At the end of the Cretaceous period there was throughout Texas a general uplift of the land and consequent withdrawal of the sea.

[61] Liddle, R. A., Geology and mineral resources of Medina County: Texas Univ. Bull. 1860, p. 58, 1921.

HILLCOAT CAVE, EDWARDS COUNTY, TEX.



A. MASSIVE BUDA LIMESTONE OVERLAIN BY SHALE AND PLATY LIMESTONE OF EAGLE FORD AGE.

In a northward-facing bluff 0.9 mile below the junction of the West Nueces and Nueces Rivers, Uvalde County, Tex. Photograph by L. W. Stephenson.

B. EDWARDS LIMESTONE IN A BLUFF ON THE WEST BANK OF THE NUECES RIVER ABOUT 18 MILES NORTHWEST OF UVALDE, TEX.

About 1 mile northwest of Chalk Bluff.

However, it does not seem likely that the area was elevated to a great height or that a great thickness of sediments was removed in the interval between the latest Cretaceous and the earliest Eocene sediments. There are almost no local irregularities in the upper surface of the Escondido formation, but erosion is indicated by the absence of certain of the upper beds in parts of the area. This break in sedimentation has been noted by several writers,[62] who recognize that the Cretaceous surface was reduced to a peneplain.

Stephenson [63] states that the great geographic extent of the unconformity that separates these deposits is in itself an evidence of both lapse of time and great diastrophic movements, and that, according to Vaughan, the changes that took place in the marine animal life of the Atlantic and Gulf Coastal Plain during the time represented by the unconformity were more striking than the changes that have taken place between Midway (early Eocene) time and the present day.

MIDWAY FORMATION

After the long period of erosion at the end of the Cretaceous period the sea advanced over the land, depositing sandstone, limestone, and clay, which constitute the Midway formation, the oldest division of the Eocene series in the Gulf region.

The Midway formation received its name from Midway Landing, on the Alabama River, Ala.[64] It consists of sandstone, sandy limestone, and sandy shale and usually has a greenish cast, owing to the presence of glauconite. At the base there is a conglomerate phase consisting of a few inches of sand, or small pebbles, shark teeth, phosphate pebbles, casts of shells, and small rounded pieces of the underlying Escondido. In Medina County and eastern Uvalde County it contains layers of resistant limestone, which cap the hills of the outcrop area. In Medina County the outcrop area is rather narrow and in places discontinuous, because the formation is faulted out of sight. (See pl. 1.) In Uvalde County the formation crops out on the Sabinal River below the Schuddemagen ranch house, on Irishmans Hill nearby (see pl. 8, *B*), on Blanco Creek, on the Frio River near the Myrick lower apiary, and on the east side of the Nueces River southeast of Widow Cook's ranch house. In the intervening

[62] Harris, G. D., The Midway stage: Bull. Am. Paleontology, vol. 1, p. 119, 1896. Dall, W. H., A table of North American Tertiary horizons: U. S. Geol. Survey 18th Ann. Rept., pt. 2, pp. 332–335, 1898. Vaughan, T. W., Reconnaissance in the Rio Grande coal fields of Texas: U. S. Geol. Survey Bull. 164, pp. 35–36, 1900; U. S. Geol. Survey Geol. Atlas, Uvalde folio (no. 64) pp. 2–3, 1900. Hill, R. T., and Vaughan, T. W., U. S. Geol. Survey Geol. Atlas, Austin folio (no. 76), p. 6, 1902. Stanton, T. W., Succession and distribution of later Mesozoic invertebrate faunas in North America: Jour. Geology, vol. 17, p. 422, 1909. Dumble, E. T., Tertiary deposits of northeastern Mexico: Science, new ser., vol. 33, pp. 232–234, 1911.

[63] Stephenson, L. W., The Cretaceous-Eocene contact in the Atlantic and Gulf Coastal Plains: U. S. Geol. Survey Prof. Paper 90, p. 159, 1915.

[64] Deussen, Alexander, Geology of the Coastal Plain of Texas west of the Brazos River: U. S. Geol. Survey Prof. Paper 126, p. 40, 1924.

areas it is either overlapped by the Indio formation or covered by later gravel.

In most of Uvalde County the exposed thickness of the Midway is not more than 30 feet; along the Sabinal River the formation is about 60 feet thick, and in Medina County, according to Liddle,[65] the lower part is 30 to 40 feet thick and the upper part is 75 to 100 feet thick. The formation thickens in the direction of dip and according to Getzendaner [66] has a thickness of 250 to 375 feet in wells drilled near Carrizo Springs. The fauna of the Midway is very different from that of the Escondido, according to Harris.[67] No species is known which is found in both formations. Perhaps the most striking difference is the absence of the ammonites in the Midway and their comparative abundance in the Cretaceous strata.

The Midway overlaps the Escondido unconformably and is in turn overlapped by the Indio.

No wells are known that produce water from the Midway formation in Uvalde and Medina Counties.

WILCOX GROUP

INDIO FORMATION

Overlying the Midway is the Indio formation, which was named for its occurrence on the old Indio ranch, in Maverick and Dimmit Counties, Tex.[68]

The Indio formation is extremely variable. It is composed mainly of thin-bedded argillaceous sandstones and arenaceous shales. In some places it contains thick beds of clay and in others fairly massive sandstones. The formation also includes beds of lignite and low-grade coal.

The sandstones are commonly light gray to buff and contain more or less iron oxide, thin beds of very low grade coal in places, and bog iron ore. In other places the sandstone is calcareous and may be so firmly cemented as to form resistant ledges at the surface. The shales are in many places black or chocolate-colored, carbonaceous, thinly laminated, and gypsiferous. In general both the sandstones and the shales are more or less lenticular. The formation is largely nonmarine, although a bed containing *Ostrea tasex* is found on the Sabinal River near the Schuddemagen ranch. Foraminifera and beds of *Ostrea tasex* are reported by Trowbridge [68] in Dimmit County. This indicates marine shallow-water conditions for at least a short time. It seems likely that the formation was deposited near a shore

[65] Liddle, R. A., Geology and mineral resources of Medina County: Texas Univ. Bull. 1860, pp. 75, 80, 1921.

[66] Getzendaner, F. M., Geologic section of the Rio Grande embayment: Am. Assoc. Petroleum Geologists Bull., vol. 14, p. 1434, 1930.

[67] Harris, G. D., The Midway stage: Bull. Am. Paleontology, vol. 1, p. 119, 1896.

[68] Trowbridge, A. C., A geologic reconnaissance of Texas near the Rio Grande: U. S. Geol. Survey Prof. Paper 131, p. 90, 1923.

line similar to the present shore line of the Gulf of Mexico, along which the landward side was low and probably had numerous small lagoons, whereas the seaward side was shallow. The shore line may have oscillated slowly back and forth during the deposition of the Indio, and the greater part of the formation was laid down on the landward side of the old shore, but occasionally a temporary advance of the sea or the development of an embayment permitted the deposition of marine beds.

The outcrop area of the Indio is commonly even or slightly rolling. In some places, however, strongly cemented sandstone beds or lenses crop out at the surface or form the tops of low hills, and locally, as along the Nueces River south of the Pulliam ranch, the formation makes high bluffs.

The thickness of the Indio is variable. It has not been possible to obtain the true thickness of the formation anywhere in Uvalde and Medina Counties from surface measurements. In Zavala County, a few miles south of its outcrop, it has been assigned a thickness of 355 feet in a well drilled by B. F. Kite.[69] Farther south and east of the outcrop well records show a thickness of 880 feet. In Medina County Liddle [70] assigns the formation a thickness of 600 feet.

The outcrop of the formation swings across the southern portion of the area, entering it about 8 miles west of the Nueces River and crossing it in a direction about east by north. The width of the outcrop is variable, but averages about 4 miles.

In most of the western part of Uvalde County this formation overlaps the Midway and rests directly upon the Escondido formation. It is overlain unconformably by the Carrizo sand. It is rather well exposed in several places in these or adjacent counties. One excellent exposure is along the Nueces River below the Pulliam ranch house in Zavala County, and another along the Frio River below the Kincaid ranch house.

The formation dips toward the Gulf of Mexico at a rate of about 50 feet to the mile, passing under the Carrizo sand. The Indio formation does not contain many fossils. However, a few oysters and some Foraminifera have been found in parts of the formation, also a few plant fossils that were identified by Berry [71] as being of late Wilcox age. The Indio overlaps the Midway unconformably and rests directly on the Escondido. Its upper surface was exposed to erosion before the overlying Carrizo sand was laid down.

The Indio is distinguished from the Midway because it usually lacks fossils and is more sandy. It is distinguished from the overlying Carrizo sand by the fact that it is usually not so coarse and clean

[69] Getzendaner, F. M., well-log correlation.
[70] Liddle, R. A., Geology and mineral resources of Medina County: Texas Univ. Bull. 1860, p. 82, 1921.
[71] Berry, E. W., Additions to the flora of the Wilcox group: U. S. Geol. Survey Prof. Paper 131, p. 3, 1922.

as the Carrizo, is commonly thin-bedded, and is very rarely cross-bedded.

Ground water is found in the Indio in wells ranging from 50 to 200 feet in depth at several places in its outcrop area. (See well table, pp. 102–127.) Many wells obtain a supply that is quite adequate for windmill pumping, but others yield very small amounts of water and have a considerable draw-down. None of the wells yield sufficient water for irrigation. Because of the varied lithology of the formation the success of a well in the Indio cannot be predicted, but in most of the outcrop area at least a little water may be obtained from wells drilled into this formation.

The Indio waters are variable in both quantity and quality, as might be expected of waters coming from a formation so varied in lithology. In general, they are high in total dissolved solids. Three samples of water from this formation range from 560 to 2,562 parts per million of dissolved solids. (See p. 37.) Two of these samples contain moderate quantities of dissolved mineral matter. One shows a predominance of sodium and potassium bicarbonate, but the other contains principally calcium bicarbonate. The third contains both sulphate and chloride in excess of bicarbonate and a large amount of sodium. On the whole the Indio water is moderately to highly mineralized.

CLAIBORNE GROUP

CARRIZO SAND

The Carrizo sand was first described by Owen [72] in 1889. It is by far the coarsest of the sandstones in Uvalde and Medina Counties. It consists of coarse rounded grains of windblown sand which in places attain the size of fine gravel. It is commonly very poorly cemented, but in places it is silicified and indurated into a quartzite. The formation is characteristically red but may be light gray to brown. It contains little or no mica, no gypsum, and usually very little calcite. In places it contains considerable iron oxide. Near the middle of the formation is a clay and shale bed, usually less than 50 feet thick, which is apparently a result of a flooding of the sands in middle Carrizo time. The part of the formation below this shale bed is very coarse grained and in most places, though not everywhere, strongly cross-bedded. (See pls. 8, *A*, and 9, *A*.) The part above the shale is usually somewhat finer and contains a little more silt. Concretions are rare in the Carrizo, the only concretions known to the writer occurring on the east side of the Nueces River in Zavala County. These are spherical concretions composed of sand and cemented by iron oxide on the outside but containing coarse unconsolidated sand on the inside.

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[72] Owen, J., Texas Geol. Survey 1st Rept. Progress, p. 70, 1889.

Perhaps the best example of the indurated quartzitic portions of the Carrizo is on the west side of the Nueces River in Zavala County, about three-quarters of a mile north of the old Uvalde-La Pryor road and extending in a westerly direction to the present Uvalde-La Pryor highway. Another longitudinal exposure is seen on Sand Mountain, in northwestern Zavala County, and similar exposures occur near the Kincaid ranch house, on the Uvalde-Friotown road in Uvalde County, and at several other places. The attitude and shape of these indurated portions of the Carrizo sand are not known. They are supposed by some geologists to be more or less vertical and to represent induration along fault planes; others suppose them to be horizontal and interbedded with the Carrizo. If they are horizontal they must range from a few feet to about 60 feet in thickness, to judge from surface exposures. It seems probable that any considerable thickness of quartzite within the Carrizo would be recognized by even the most careless driller, and the fact that these masses of quartzite have not been recognized in wells is a strong argument against any great lateral extent beneath the surface.

The outcrop area of the Carrizo sand is a nearly even surface except where hard or indurated layers crop out or where the formation is covered by later gravel. Under these conditions the relief may be moderately high. Where the sandstone is loosely cemented and not covered by later formations it weathers rapidly and washes badly during storms, and numerous deep arroyos are likely to be formed. The vegetation on the Carrizo outcrop area is distinctive. The country is open as a rule, and the vegetation seldom entirely conceals the sand, which may be loose and is very often deep and difficult to drive a car through in dry weather. Mesquite and prickly pear are usually dominant in the outcrop area, and sand burrs are common. In the early spring and summer the Carrizo outcrop area may be readily distinguished from the outcrop of other formations by the variety and abundance of its flowers.

In Uvalde and Medina Counties the Carrizo has a thickness of about 200 to 300 feet. In Dimmit, Zavala, and Maverick Counties, according to Trowbridge,[73] it is 118 to 400 feet thick, and in Medina County, according to Liddle,[74] 200 to 250 feet. The outcrop area of the Carrizo sand enters Uvalde County about halfway between the Leona River and Camp Lake Slough, and the Indio-Carrizo contact passes from this point east by north to Lytle, on the Medina-Bexar County line. The outcrop is from 3 to 6 miles-wide, the average width being about 4 miles.

[73] Trowbridge, A. C., A geologic reconnaissance of Texas near the Rio Grande: U. S. Geol. Survey Prof. Paper 131, p. 91, 1922.

[74] Liddle, R. A., op. cit. (Bull. 1860) p. 93.

Fossils are exceedingly rare in the formation, but leaves considered by Berry to be of Wilcox age have been found in the middle portion,[75] and a few casts of marine mollusks have been found near the top.[76]

The Carrizo sand lies unconformably on the Indio formation. The contact is well shown on the Nueces River at Bee Bluff, south of the Pulliam ranch, in Zavala County; on the Frio River on the Hiler ranch, in northern Frio County; and on the Kincaid ranch, in southeastern Uvalde County (pl. 8, *A*). The writer has not seen the Carrizo-Bigford contact, but Trowbridge [76] reports that it is conformable.

The Carrizo sand yields most of the water used for irrigation in Dimmit and Zavala Counties. It is present at the surface in the southeastern part of Uvalde County and the southern part of Medina County and in these areas yields abundant water for domestic and stock use. In the vicinity of Devine there are a large number of wells that enter the Carrizo sand at the surface and continue to a depth of 50 to 150 feet in the sandstone, but none of this water is used for irrigating more than a small garden plot, most of the water used for irrigation in this vicinity coming from the Medina River by canal. West of Devine the area underlain by the Carrizo is rather sparsely populated, but practically all the stock wells go into the Carrizo sand for their water supplies.

The samples of the waters from the Carrizo sand collected in southern Medina County show a considerable variation in chemical character. (See table, p. 37.) The total dissolved solids range from 131 to 529 parts per million. Water from well I–9–4 is a calcium bicarbonate water, although a fair proportion of sodium sulphate and chloride is present. The water from wells J–7–13 and J–7–10 has slightly more chloride than bicarbonate. In well J–7–13 sodium predominates over calcium, but in well J–7–10 the calcium is predominant. In well J–8–23 there is about three times as much chloride as bicarbonate, and the nitrate reaches a total of 162 parts per million, which is more than in any other water sampled in Uvalde and Medina Counties. The cause of these discrepancies in chemical composition in the Carrizo sand is not apparent. All the wells are on the outcrop of the Carrizo, and all except one (J–7–13), are used principally for stock or domestic purposes. Well J–7–13 was drilled for use in nearby oil-prospecting tests and consequently supplies considerably more water than any of the other wells.

MOUNT SELMAN FORMATION

BIGFORD MEMBER

The Bigford member crops out in a small area south of the Carrizo area in south-central Medina County. It pinches out to the east

[75] Berry, E. W., op. cit. (Prof. Paper 131), p. 3.
[76] Trowbridge, A. C., op. cit., p. 91.

near Yancey, where the undifferentiated Mount Selman rests directly upon the Carrizo sand.

The Bigford is a series of clay beds with a few thick sandstones and some very thin limestones. It is in part marine and in part non-marine. It is difficult to separate this member from the overlying beds of the Mount Selman formation. Leaves of Wilcox age have been recovered from the Bigford.[77]

Only a very small part of the area is underlain by the Bigford, and the writer has no information regarding wells yielding water from this member.

UNDIFFERENTIATED BEDS

The upper undifferentiated part of the Mount Selman formation crops out in a rather small area in the southeast corner of Medina County overlying the Carrizo. These strata consist of a series of beds of clay and sand, the clay more common near the base. They are very similar in lithology to the underlying Bigford member. Some of these Mount Selman sands are sufficiently thick to yield good supplies of water, and satisfactory water can usually be obtained from dug wells in them.

TERTIARY (?) SYSTEM

PLIOCENE (?) SERIES

UVALDE GRAVEL

The Uvalde gravel was originally defined by Hill [78] as the gravel formation which occurs on the divides between the streams in the Coastal Plain area of Uvalde and Medina Counties. In 1890 Penrose [79] described a terrace gravel cemented by caliche at the town of Reynosa, Tamaulipas, Mexico, and applied to it the term "Reynosa." In 1894 Dumble [80] extended the term to include the series of sandstone, gravel, and clay, commonly more or less covered with caliche, which crop out on the plateau between the Nueces River and the Rio Grande and rest on the Lagarto clay. In 1922 Trowbridge [81] extended the term "Reynosa" to include Hill's Uvalde gravel.

The terrace deposits at Reynosa are now considered to be younger than the high-terrace deposits in Uvalde County, and the name has been abandoned by the United States Geological Survey. The term "Uvalde" is here used as originally applied by Hill.

In Uvalde and Medina Counties the Uvalde formation consists of coarse gravel deposits capping the divides between the streams.

[77] Berry, E. W., Revision of the lower Eocene Wilcox flora of the Southeastern States: U. S. Geol. Survey Prof. Paper 156, p. 10, 1930.

[78] Hill, R. T., Notes on the geology of the Southwest: Am. Geologist, vol. 7, pp. 366-370, 1891.

[79] Penrose, R. A. F., Jr., Report on the geology for eastern Texas: Texas Geol. Survey 1st Ann. Rept., pp. 57, 58, 63, 1890.

[80] Dumble, E. T., The Cenozoic deposits of Texas: Jour. Geology, vol. 2, p. 560, 1894.

[81] Trowbridge, A. C., op. cit., p. 98.

The gravel consists predominantly of flint with some limestone pebbles, which in many places contain fossils that have been derived from the Edwards limestone of the Edwards Plateau. On the divide between the Frio and Leona Rivers in the vicinity of the Lewis windmill, on the Kincaid ranch, the gravel is covered by deposits of fine gray or black silt, in which the pebbles are embedded and which apparently forms the upper portion of the formation. In places a part of the pebbles are cemented together by secondary calcium carbonate which is locally known as caliche. The Uvalde gravel is characteristically red because of a coating of iron oxide on the pebbles and boulders. Where silt is present this red color may be masked to some extent by the black color of the silt. The formation supports a dense growth of catclaw and guajillo. It is not shown on the geologic map because it contains no water and has no effect on the occurrence of ground water in the area, so far as is known. Moreover, to map it would obscure the structural relations of the older formations.

Vaughan [82] estimated the original thickness of the Uvalde as more than 100 feet. It now ranges, so far as it has been observed, from a mere film over the surface to a layer about 20 feet thick and possibly is thicker in places. Because the formation caps the hills and spreads down the sides, as a result of erosion and weathering, the maximum thickness is not easily observed. Deussen [83] reported a thickness of 20 feet on the hill at the cemetery a quarter of a mile west of Castroville. Liddle [84] reported 8 feet of Uvalde on the ridge southeast of the Seco Pressed Brick & Tile Co.'s plant at D'Hanis. On the San Antonio-Laredo highway, where it cuts the hill southwest of Moore, a gravel deposit of the Uvalde formation about 8 feet thick was observed. This deposit has a matrix of soft caliche in which pebbles and boulders are embedded. A pit on top of this hill supplies caliche for road-surfacing material.

Along the southern boundary of the area in Uvalde County the formation lies 150 to 250 feet above the level of the Leona and Frio Rivers and 100 to 200 feet above the Leona formation terrace. Northward the difference in height decreases, and in the canyons of the Nueces, Frio, and Sabinal the two formations merge into one. The only fossils found in the Uvalde in Uvalde and Medina Counties are forms which came from the Edwards limestone.

During most of the Tertiary period the area north of the Cretaceous-Eocene contact was exposed to weathering and erosion, so that by the end of this time the area was reduced to base-level, and a deep soil was developed. In the Edwards limestone area the limestone at the surface was pretty thoroughly dissolved, but the chert in the limestone

[82] Vaughan, T. W., U. S. Geol. Survey Geol. Atlas, Uvalde folio (no. 64), p. 3, 1900.
[83] Deussen, Alexander, op. cit., p. 107.
[84] Liddle, R. A., op. cit., p. 96.

A. CARRIZO-INDIO CONTACT ON THE KINCAID RANCH ALONG THE FRIO RIVER SOUTH OF SABINAL, UVALDE COUNTY, TEX.

B. BASAL MIDWAY LIMESTONE SOUTH OF SABINAL.

On the northward-facing slope of Elm Creek near its junction with the Sabinal River. Photograph by L. W. Stephenson.

A. CROSS-BEDDING IN THE CARRIZO SAND 1 MILE NORTHWEST OF DEVINE, MEDINA COUNTY, TEX.

B. LEONA FORMATION IN THE BANK OF THE FRIO RIVER ON THE CONNOR RANCH 9 MILES EAST OF UVALDE, TEX.

was left as residual nodules in the soil. Late in Pliocene time or perhaps early in Pleistocene time the first movement of the Balcones faulting occurred, and the Edwards Plateau was uplifted. As a result the streams, their carrying power increased by the increase of gradient, moved large quantities of material from the Edwards Plateau. The finer material was carried far downstream. The coarser, predominantly chert gravel was spread out as alluvial fans south of the Balcones fault for a distance of many miles and was later covered by silt. Erosion has removed most of the gravel and cut valleys into the ancient plain, leaving the gravel-capped divides as remnants. The gravel and silt capping the divides constitute the Uvalde gravel.

No wells are known to obtain water from this formation in Uvalde and Medina Counties. There are two main reasons for this lack: the formation is not thick enough to provide storage for a large quantity of water; and, because of its location on the divides between streams, water entering the formation immediately drains out of it.

QUATERNARY SYSTEM

PLEISTOCENE SERIES

LEONA FORMATION

The name "Leona" was proposed by Hill and Vaughan [85] "for the deposit making the first wide terrace of the Nueces and Leona Rivers, below the level of the Uvalde formation, and for the flood-plain deposit extending westward from Uvalde on the Leona to the Nueces River." The term has since been extended to apply to the terrace deposits lying between the Uvalde gravel and the Recent flood-plain deposits along all the streams of the area.

The Leona formation is composed of thick lenticular beds of gravel interbedded with silt. (See pl. 9, *B*.) The pebbles and boulders of the gravel are mostly limestone but some are chert or even basalt. Most of the boulders are clearly derived from the Edwards limestone. Toward the top of the formation the layers of silt increase in number and thickness. At the surface the formation is usually composed of silt which is very porous when dry. It usually contains a large number of broken or complete shells of fossil land snails and is known locally as "shell land."

The Leona formation averages about 50 feet in thickness but ranges from 93 feet to a knife edge. The thickest section of the formation observed is in a dug well in Sabinal. Good exposures of the formation are seen at numerous places along the valleys where the stream has meandered so as to cut a steep bank on one side or the other. (See pl. 9, *B*.)

[85] Hill, R. T., and Vaughan, T. W., op. cit., p. 254.

The Leona formation underlies a broad plain 4 to 5 miles wide just south of the Balcones escarpment and extends downstream as a terrace on one or both sides of each of the streams for practically their entire length. This terrace is of varying width and slopes gently toward the streamways. Near its outer margin it is about 75 to 100 feet above the level of the stream. Near the stream it is commonly about 30 feet above the water level, but where the stream is cutting against the terrace this height may be considerably greater. Most of the larger towns of this area are situated on the Leona terrace. Several Pleistocene or Recent air-breathing and fresh-water mollusks have been found in the Leona formation.[86] Trowbridge considered them as probably Pleistocene and correlated the Leona with the Beaumont. Mr. Edwards, who lives about 11½ miles south of Sabinal, reported finding large bones in the Leona formation on the Sabinal River below the Schuddemagen ranch. From his description it seems likely that these were the bones of a large mammal, probably related to the elephant family. This would seem to strengthen the belief that the Leona is of Pleistocene age. The Leona formation is not shown on the geologic map.

The deposition of the Uvalde gravel was followed by a period of erosion during which streams cut valleys into the Reynosa and then began to widen these valleys to their present width. A second uplift of the plateau or possibly a change in climatic conditions gave new life and erosive power to the streams, and again large quantities of gravel were moved along and spread out as alluvial fans just south of the Balcones escarpment and carried down the streams to cover the floors of the valleys. This gravel was largely limestone, because the period between the first uplift, which caused the deposition of the Uvalde, and the second uplift or change in climatic conditions, which caused the deposition of the Leona, was too short for weathering to produce a residual soil containing chert in the Edwards limestone area. Consequently the Edwards limestone was attacked by erosion directly, and a limestone gravel resulted. A period without uplift has followed, and streams have cut into the present terrace of Leona age and are now spreading and reworking the gravel over their flood plains.

The Leona yields more water than any other formation in the area except the Edwards limestone. (See well table, pp. 102–127.) Its outcrop area forms a wide belt extending across the two counties from east to west, and on this belt are situated practically all the towns of the two counties—Uvalde, Sabinal, D'Hanis, Hondo, and Castroville. Many of the smaller places, such as Cline and Hacienda obtain their water supplies from Leona gravel. In the town of Sabinal there are many wells in these gravels, especially in the Mexican section of the town. Most of the wells in the vicinity of

[86] Trowbridge, A. C., op. cit., p. 101.

D'Hanis and Castroville are also dug into Leona gravel. Many of the residents of Hondo still obtain their water from dug wells in the gravel, although the city waterworks obtains its water from wells drilled into the Edwards limestone. Uvalde was formerly supplied with water entirely from the Leona River and the Leona formation. The city supply was obtained from a well pit containing shallow drilled wells, which drew water from the Leona formation, and one deep well which drew from the Edwards limestone. Many private supplies also obtained water from wells in the Leona formation. Recently the level of the water in the gravel has receded until it is below the surface of the underlying rock, so that all the city water is believed at present to come from the Edwards, and at the present time there are no wells known in Uvalde which draw water from Leona gravel. However, a period of heavy rainfall might cause enough recharge to raise the water table until it is again in the Leona formation at Uvalde. South of the town, along the valley of the Leona River, there are several wells which draw rather large quantities of water from Leona gravel. On the Uvalde Pecan Plantation, about 12 miles south of the town, there are three wells that are supplied from the gravel (H–8–26, H–8–27, and H–8–30). Two of these wells are dug, and one is drilled. Their depths are 41, 53, and 63 feet. Each of these wells has been pumped at 1,500 to 2,000 gallons a minute. (See pl. 10, *A*.) Nearly everywhere in the valley south of Uvalde fairly large supplies of water may be found in the gravel. Two miles south of the town, the Vosatko brothers and F. G. Hines have wells in the Leona which yield sufficient water for irrigation (H–5–68, H–5–55, and H–5–56).

As a rule the Leona formation yields large quantities of water to wells where its contact with the underlying formation is below the water table. In the area immediately south of the Edwards Plateau, where the cavernous Edwards limestone underlies the area and where the water table is low, the Leona formation seldom contains water; but farther south, where less permeable beds underlie the Leona and where the water table is nearer the surface, fairly large supplies of water are found in it.

In the canyons of the Edwards Plateau most well water is obtained from the gravel along the rivers. As the Uvalde gravel and Leona formation converge with the stream gravel, it is not possible to say which of these formations supplies the water.

Eight samples were collected from wells drawing from the Leona formation. These waters are rather uniform in chemical character and mineral content. (See analyses, p. 36.) The total dissolved solids in these samples ranged from 280 to 515 parts per million. All the samples were predominantly calcium bicarbonate waters, but one (H–6–10) contained a rather large amount of chloride, and one

(I–5–1) contained a large amount of nitrate. These two wells are subject to pollution from the surface because of their construction. This may explain the character of the water they yield. The water from well H–8–27 is almost identical with that obtained from a spring in the Leona River (H–8–E; see analyses, p. 35). Although this well is very close to the point in the Leona River where sample H–8–C was collected the water is not as similar in chemical character to that of sample H–8–C as it is to the water from spring H–8–E. The reason for this lack of similarity to sample H–8–C may be due to the fact that the stream water loses calcium bicarbonate in passing over the travertine dams, which are very abundant in this portion of the river, and the resemblance to H–8–E indicates that the source of the spring water is in the gravel. Although the waters from Leona gravel are very similar in chemical character to those from the Edwards limestone, they are somewhat more highly mineralized. The larger mineral content is due mainly to the greater amount of calcium bicarbonate dissolved in the water of the Leona formation.

RECENT SERIES

TERRACE AND FLOOD-PLAIN DEPOSITS

Below the Leona terrace there are several smaller terraces which have been formed since Leona time. The streams are at the present time moving silt and gravel to form flood plains. These are, however, rather narrow in most places. These terraces and flood-plain deposits yield water to wells for domestic use and stock, especially along the Nueces River.

GROUND-WATER INTAKE

GENERAL CONDITIONS

The intake area of a formation is that area in which water is taken into the formation. As a rule this coincides approximately with the outcrop area. The amount of intake in the outcrop area depends upon the porosity and permeability of the formation, the amount, intensity, and distribution of the precipitation, the slope of the surface, the texture of the soil, the amount and kind of vegetation, and the height of the water table within the formation.[87]

The amount and distribution of the precipitation very obviously affect the amount of intake. The intensity of precipitation is perhaps quite as important. If no evaporation takes place and if surface water on a flat, bare surface enters the ground at a given rate and rain falls on the surface at that rate, all the rain will enter the ground. But if the rate of rainfall exceeds the rate of intake, water will enter the ground at its rate of intake only, and the excess rainfall will run

[87] For a discussion of this subject see Meinzer, O. E., The occurrence of ground water in the United States: U. S. Geol. Survey Water-Supply Paper 489, pp. 4 et seq., 1923.

off the surface. Thus, the more rapid the precipitation after the rate of intake has been exceeded the smaller will be the proportion of it which enters the ground.

On a steep slope rainfall or water from melting snow runs off rapidly; on a gentle slope the run-off is comparatively slow, and a larger proportion of the precipitation can enter the ground.

Vegetation prevents rainfall from running off so rapidly and hinders soil wash to a large extent. Where a mat of decayed vegetation is formed on the ground it acts as sponge to absorb rain water, which then percolates slowly into the ground.

On the other hand, the vegetation intercepts precipitation, and a part of the water that otherwise would reach the ground is lost by evaporation from the surfaces of the leaves and branches. Moreover, the vegetation takes up water through its roots and transpires it through its leaves and thus uses large amounts of water. The water lost through interception and transpiration by plants is probably greater than the increased amount of rain water which the presence of plants causes to enter the ground. Therefore, the principal beneficial effect of plants so far as precipitation is concerned is that they tend to prevent excessive soil erosion. Different kinds of vegetation vary in their effectiveness in preventing soil erosion and in the amount of water they transpire.

The porosity and permeability of a formation largely determine its capacity to take in and transmit water. Porosity is the ratio of total pore space to total volume of a material. The permeability is its capacity to transmit water. These properties are not directly related. Thus, materials like clay and shale have a high porosity, but because the individual pore spaces are too small to permit the movement of water through them by gravity the permeability is low. On the other hand, coarse sandstone and gravel commonly have less porosity than clay and shale, but the individual pores are large enough to permit ready movement of water through them by gravity, and therefore the material has a high permeability.

The present report deals chiefly with the capacity of formations to transmit and yield water. Therefore, the factor of chief importance is the permeability of the formations. Movement of waters (except by capillarity) through rocks takes place chiefly either by percolation, as in sandstone and gravel, where the water moves by gravity, against the forces of molecular attraction and friction, rather slowly between grains or pebbles that make up the rock, or by flow, as in limestone and other massive rocks, in which movement takes place through cracks, fissures, and solution channels rather than between grains. As the channels vary from those of microscopic size to caverns many feet in diameter, the rate of movement varies widely. However, in most limestones the rate of movement of water appears to be rapid. The difference between these two types of movement of underground water is readily understood from conditions encountered in wells drilled in search of water. A well drawing several hundred gallons a minute from sandstone would have to penetrate the formation a considerable distance, because the water moves slowly through a given section of the sandstone, and as the rate of flow cannot be increased beyond certain limits, it is necessary to draw upon a relatively large thickness of the aquifer through which the water flows in order to obtain a large amount of water. On the other hand, a well drawing from limestone might encounter a supply of several hundred gallons a minute within the space of a few inches or, on the other hand, little or no water, the result depending on whether the drill happened to encounter an opening in the limestone.

On the intake area of sandstone formations the waters falling on the surface over wide areas percolate downward into the formations. On a limestone area, however, the water must encounter an opening caused by solution, jointing, or fracturing before it can move downward, but as many of these openings are large, great quantities of water may be taken in within a comparatively short distance if the openings lead into extensive underground cavities or caverns.

If the water table stands near the surface in the intake area, the pore space in the soil and underlying formation is nearly full of water and cannot therefore receive much more. If, on the other hand, the water table is low, it is possible for the formation to take in large quantities of water before it is full.

If a formation is exposed directly at the surface (other things being equal) it will take in surface water at a rate determined by its permeability. If, on the other hand, it is covered by a thick mantle of soil or alluvium its intake may be increased or decreased according to the permeability of the mantle. If this is less than the permeability of the formation, a smaller proportion of rain water will be taken in and consequently less water will reach the underlying formation. On the other hand, if the permeability of the mantle is greater than that of the underlying formation, a larger amount of water will be taken in, and the excess of water over the rate of intake of the underlying formation will be held in storage in the soil mantle until it can enter the formation, the total amount of intake being thereby increased.

TRAVIS PEAK FORMATION

The intake area of the Travis Peak formation lies on the north side of the Edwards Plateau, many miles northeast of Uvalde and Medina Counties. Presumably water entering the Travis Peak in its outcrop area travels through the formation down the dip to the points at which it is encountered in drilled wells. A part of the water that enters the formation is derived from rain or snow falling on the outcrop area of the sandstone, and a part of it probably comes from the water lost by the streams that cross the outcrop of the sandstone.

EDWARDS LIMESTONE

The Edwards limestone occupies a large part of the Edwards Plateau. It has in many places high permeability, owing to the presence of large numbers of channels and cavities caused by solution. A relatively large amount of water enters the limestone from the rainfall on the Edwards Plateau, as is indicated by the fact that most of the streams in Uvalde and Medina Counties are fed in considerable part by springs that come from the Edwards limestone in the Edwards Plateau. There are numerous contact springs throughout the plateau area where the base of the Edwards limestone lies above the stream bed. One excellent example of such a spring is on the old Peters ranch, on Hackberry Creek, 13.5 miles north of Knippa.

The various streams that cross the Edwards limestone in this area lose large amounts of water into the formation. There is available a fairly long and comprehensive record of the flow of the Nueces River in Uvalde County, a part of which was obtained in connection with the ground-water investigation. The regimen of this stream will therefore be discussed in considerable detail.

The Nueces River enters Uvalde County near the northwest corner (see pl. 1) and flows for a distance of about 20 miles in a steep-walled, rather narrow flat-bottomed valley similar to the valleys of other streams in this part of the Edwards Plateau. It emerges from the steep-walled valley about 3 miles above the mouth of the West Nueces River. Thence downstream for a distance of about 7½ miles the river valley is bounded on the west by fairly high hills and on the east by a gently rolling plain that rises gradually from the river. About three-fourths of a mile above the Uvalde gaging station the width of the valley is reduced to a little more than a mile, and it is bounded on both sides by steep but moderately low valley walls. This constricted portion of the valley extends downstream for a distance of about 3 miles. Below this point the valley becomes gradually wider and the walls rise gently from the river.

The West Nueces is the only large tributary to the Nueces in Uvalde County, and it seldom has a flow at its mouth. The numerous smaller tributary valleys are dry most of the time, but on occasions, usually months and sometimes years apart, during and immediately after exceptionally heavy rains, these streams contribute largely to the flow of the river.

In Uvalde County bedrock is exposed in the bed of the river in some places, but in most places the bedrock is covered and the river bed and adjacent terraces are underlain by gravel. The gravel deposits in the section of the valley above the mouth of the West Nueces have a smaller areal extent and are apparently thinner than in the section between the mouth of the West Nueces and the Uvalde gaging station. In that section the maximum thickness is not known, but thicknesses of 52 and 75 feet are reported in wells H–4–26 and H–4–10.

The formations dip southward at a rate of over 100 feet to the mile, so that the stream flows on the Glen Rose limestone from the north boundary of the county for an air-line distance of about 15 miles and then on the outcrop area of the Edwards limestone for an air-line distance of about 10 miles, or a channel distance of 13 miles. The stream leaves the Edwards near the mouth of the West Nueces and flows chiefly over the outcrop area of the Austin chalk to a point just below Tom Nunn Hill, where it crosses a large fault to the outcrop area of the Escondido formation.

The river loses large amounts of water where it flows over the Edwards outcrop area, and in most stages it also loses heavily in the stretch immediately below the Edwards outcrop, between the mouth of the West Nueces and the bridge on the Uvalde-Del Rio highway, 7 miles west of Uvalde. On the other hand, there is a considerable increase in its discharge by inflow from springs between the bridge and the Uvalde-Eagle Pass road crossing, about 9 miles southwest of Uvalde. Partly in order to determine the amount of these losses and gains an extensive program of stream gaging has been carried out by the United States Geological Survey in cooperation with the State Board of Water Engineers.[88]

Gaging stations have been maintained on the river at two localities in Uvalde County for several years. The upper station is near Laguna about 23 miles northwest of Uvalde and a short distance above the outcrop of the Edwards limestone, and the lower one is at the Tom Nunn Crossing, about 7 miles southwest of Uvalde and 8 miles below the Edwards outcrop area. Continuous records showing the daily discharge of the stream are available for the Laguna station for 1924–25 to 1932–33, and for the Uvalde station for 1927–28 to 1932–33. In addition to these measurements a series of current-meter measurements have been made at several intermediate points between these stations and at intervals along the river below the Uvalde station in order to determine losses by seepage and gains from ground-water inflow in various relatively short stretches.

The following table shows the results of 12 such studies, commonly called "seepage measurements", in 1924, 1925, 1931, and 1932. The measurements were made for the most part at constant or slowly declining stages and at times when there was no inflow of surface water below the Laguna station. During declining stages, when it

[88] U. S. Geol. Survey Water-Supply Papers 588, 608, 628, 648, 668, 688, 703, 718, 733.

A. STREAM OF WATER PRODUCED BY WELL H-8-27, ON THE UVALDE PECAN PLANTATION, 7 MILES SOUTHEAST OF UVALDE, TEX.

B. FRACTURED EDWARDS LIMESTONE IN THE INTAKE AREA ON THE EAST SIDE OF THE NUECES RIVER, 11 MILES NORTHWEST OF UVALDE, TEX.

Photograph by Penn Livingston.

was practicable, the stream gagers moved in a downstream direction at a rate approximately equal to the movement of the stream. By this method a large part of the error due to changes in stage while the seepage measurements are progressing can be eliminated, and reasonably accurate estimate can be made of the losses and gains in the sections during comparable rates of river discharge.

Discharge measurements on Nueces River to determine losses from seepage and gains by ground-water inflow

Date	Location	Distance from Laguna gaging station (miles)	Discharge (second-feet)	Gain or loss in section (second-feet)	Total gain or loss (second-feet)
1924					
Mar. 23	Laguna	0	149		
24	Chalk Bluff	5.1	115	−34	−34
24	Riverview	9.1	123	+8	−26
24	Mouth of West Fork	11.6	64.7	−58.3	−84.3
25	Southern Pacific Railroad bridge	16.1	34.6	−30.1	−114.4
25	Uvalde-Del Rio crossing	18.9	[a] 1.2	−33.4	−147.8
25	Tom Nunn crossing (Uvalde gaging station)	20.9	22.8	+21.6	−126.2
25	Tom Nunn Hill dam site	22.5	23.7	+.9	−125.3
25	Uvalde-Eagle Pass crossing	26.4	37.6	+13.9	+111.2
26	San Antonio, Uvalde & Gulf Railroad bridge	29.4	29.2	−8.4	−119.6
26	La Pryor crossing	34.2	32.2	+3	−116.6
1925					
Apr. 30	Laguna	0	35.3		
30	Chalk Bluff	5.1	13.5	−21.8	−21.8
30	Cline crossing near Uvalde	18.9	0	−13.5	−35.3
30	Tom Nunn crossing	20.9	4.3	+4.3	−31.0
30	Tom Nunn Hill	22.8	1.5	−2.8	−33.8
May 1	Old Eagle Pass road crossing	26.8	9.0	+7.5	−26.3
1	San Antonio, Uvalde & Gulf Railroad crossing	29.8	2.8	−6.2	−32.5
8	Habey ranch	31.6	0	−2.8	−35.3
8	Mouth of Live Oak Creek	34.5	.5	+.5	−34.8
1	Uvalde-La Pryor crossing	34.5	.5	0	−34.8
1	Due east of La Pryor	40.7	0	−.5	−35.3
1	La Pryor ranch house	43.2	0	0	−35.3
1	4 miles below La Pryor ranch house	47.4	8.0	+8.0	−27.3
2	2 miles above Cinonia	54.9	5.4	−2.6	−29.9
1931					
May 16	Laguna	0	316		
16	Mouth of West Fork	13.0	259	−57	−57
16	Southern Pacific Railroad bridge	18.0	222	−37	−94
16	Uvalde-Del Rio road crossing	20.6	199	−23	−117
16	Gaging station near Uvalde	22.7	219	+20	−97
17	Uvalde-Eagle Pass road crossing	28.2	229	+10	−87
17	San Antonio, Uvalde & Gulf Railroad bridge	31.6	227	−2	−89
17	Old Uvalde-La Pryor road crossing	36.3	221	−6	−95
17	Gas well 5 miles northeast of La Pryor	39.6	219	−2	−97
17	La Pryor-Batesville road crossing	44.8	208	−11	−108
17	Former gaging station near Cinonia	56.5	240	+32	−76
19	Laguna	0	275		
19	6.8 miles above mouth of West Fork	6.2	279	+4	+4
19	2.6 miles above mouth of West Fork	10.4	274	−5	−1
19	Gaging station near Uvalde	22.7	196	−78	−79
June 4	Laguna, Tex	0	192		
4	2.6 miles above West Fork	10.4	187	−5	−5
4	Mouth of West Fork	13.0	157	−30	−35
4	Southern Pacific Railroad bridge	18.0	116	−41	−76
5	Uvalde-Del Rio road crossing	20.6	84.6	−31.4	−107.4
5	Gaging station near Uvalde	22.7	114	+29.4	−78
5	San Antonio, Uvalde & Gulf Railroad bridge	31.6	118	+4	−74
5	Gas well 5 miles northeast of La Pryor	39.6	111	−7	−81
6	La Pryor-Batesville road crossing	44.8	107	−4	−85
6	3½ miles above Cinonia bridge	53.0	108	+1	−84

[a] Estimated.

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Discharge measurements on Nueces River to determine losses from seepage and gains by ground-water inflow—Continued

Date	Location	Distance from Laguna gaging station (miles)	Discharge (second-feet)	Gain or loss in section (second-feet)	Total gain or loss (second-feet)
1931					
June 15	Laguna	0	156		
15	2.6 miles above West Fork	10.4	140	−16	−16
15	Mouth of West Fork	13.0	106	−34	−50
15	Southern Pacific Railroad bridge	18.0	69.7	−36.3	−86.3
15	Uvalde-Del Rio road crossing	20.6	46.6	−23.1	−109.4
16	Gaging station near Uvalde	22.7	63.7	+17.1	−92.3
16	Uvalde-Eagle Pass road crossing	28.2	81.2	+17.5	−74.8
16	San Antonio, Uvalde & Gulf Railroad bridge	31.6	75.7	−5.5	−80.3
16	Gas well 5 miles northeast of La Pryor	39.6	65.1	−10.6	−90.9
16	La Pryor-Batesville road crossing	44.8	60.4	−4.7	−95.6
17	3½ miles above Cinonia bridge	53.0	69.0	+8.6	−87.0
17	Former gaging station near Cinonia	56.5	82.4	+13.4	−73.6
22	Laguna	0	138		
22	2.6 miles above West Fork	10.4	124	−14	−14
22	Mouth of West Fork	13.0	84.1	−39.9	−53.9
22	Southern Pacific Railroad bridge	18.0	43.4	−40.7	−94.6
22	Uvalde-Del Rio road crossing	20.6	21.5	−21.9	−116.5
23	Gaging station near Uvalde	22.7	40.2	+18.7	−97.8
23	Uvalde-Eagle Pass road crossing	28.2	57.2	+17.0	−80.8
23	San Antonio, Uvalde & Gulf Railroad bridge	31.6	50.1	−7.1	−87.9
23	Gas well 5 miles northeast of La Pryor	39.6	40.9	−9.2	−97.1
23	La Pryor-Batesville road crossing	44.8	33.2	−7.7	−104.8
24	3.5 miles above Cinonia bridge	53.0	45.3	+12.1	−92.7
24	Former gaging station near Cinonia	56.5	46.1	+.8	−91.9
July 2	Laguna	0	118		
2	2.6 miles above West Fork	10.4	101	−17	−17
2	Mouth of West Fork	13.0	63.8	−37.2	−54.2
2	Southern Pacific Railroad bridge	18.0	27.5	−36.3	−90.5
2	Uvalde-Del Rio road crossing	20.6	6.31	−21.2	−111.7
3	Gaging station near Uvalde	22.7	26.9	+20.6	−91.1
3	Uvalde-Eagle Pass road crossing	28.2	43.9	+17.0	−74.1
3	San Antonio, Uvalde & Gulf Railroad bridge	31.6	39.6	−4.3	−78.4
3	Gas well 5 miles northeast of La Pryor	39.6	29.6	−10.0	−88.4
3	La Pryor-Batesville road crossing	44.8	24.2	−5.4	−93.8
4	3½ miles above Cinonia bridge	53.0	35.8	+11.6	−82.2
4	¼ mile below Cinonia bridge	56.7	35.5	−.3	−82.5
9	Laguna	0	98.9		
9	2.6 miles above West Fork	10.4	69.4	−29.5	−29.5
9	Mouth of West Fork	13.0	36.5	−32.9	−62.4
9	Southern Pacific Railroad bridge	18.0	4.6	−31.9	−94.3
9	Uvalde-Del Rio road crossing	20.6	[a] 1.5	−3.1	−97.4
9	Gaging station near Uvalde	22.7	21.6	+20.1	−77.3
13	Gaging station near Uvalde	0	17.5		
13	Uvalde-Eagle Pass road crossing	5.5	33.6	+16.1	+16.1
13	San Antonio, Uvalde & Gulf Railroad bridge	8.9	29.0	−4.6	+11.5
13	Gas well 5 miles northeast of La Pryor	16.9	17.9	−11.1	+.4
13	La Pryor-Batesville road crossing	22.1	11.5	−6.4	−6.0
13	3½ miles above Cinonia bridge	30.3	23.4	+11.9	+5.9
13	¼ mile below Cinonia bridge	33.8	21.5	−1.9	+4.0
16	Laguna	0	91.8		
16	6.8 miles above West Fork	6.2	79.9	−11.9	−11.9
16	2.6 miles above West Fork	10.4	63.8	−16.1	−28.0
16	Mouth of West Fork	13.0	25.1	−38.7	−66.7
16	Uvalde-Del Rio road crossing	20.6	0.0	−25.1	−91.8
17	Gaging station near Uvalde	22.7	18.8	+18.8	−73.0
Aug. 29	Laguna	0	119		
29	2.6 miles above West Fork	10.4	56.8	−62.2	−62.2
29	Mouth of West Fork	13.0	40.2	−16.6	−78.8
29	Southern Pacific Railroad crossing	18.0	15.2	−25.0	−103.8
30	Uvalde-Del Rio road crossing	20.6	7.8	−7.4	−111.2
30	Gaging station near Uvalde	22.7	26.9	+19.1	−92.1
30	Uvalde-Eagle Pass road crossing	28.2	36.3	+9.4	−82.7
30	San Antonio, Uvalde & Gulf Railroad crossing	31.6	38.8	+2.5	−80.2

Discharge measurements on Nueces River to determine losses from seepage and gains by ground-water inflow—Continued

Date	Location	Distance from Laguna gaging station (miles)	Discharge (second-feet)	Gain or loss in section (second-feet)	Total gain or loss (second-feet)
1931					
Nov. 14	Laguna	0	64.2		
14	6.8 miles above West Fork	6.2	43.0	−21.2	−21.2
15	2.6 miles above West Fork	10.4	14.9	−28.1	−49.3
15	Mouth of West Fork	13.0	0	−14.9	−64.2
15	Southern Pacific Railroad bridge	18.0	0	0	−64.2
15	Uvalde-Del Rio road crossing	20.6	0	0	−64.2
15	Gaging station near Uvalde	22.7	9.0	+9.0	−55.2
15	Uvalde-Eagle Pass road crossing	28.2	16.8	+7.8	−47.4
16	San Antonio, Uvalde & Gulf Railroad bridge	31.6	12.7	−4.1	−51.5
16	Gas well 5 miles northeast of La Pryor	39.6	4.0	−8.7	−60.2
1932					
Jan. 24	Laguna	0.0	64.0		
24	6.8 miles above West Fork	6.2	46.2	−17.8	−17.8
24	2.6 miles above West Fork	10.4	22.9	−23.3	−41.1
24	Mouth of West Fork	13.0	0	−22.9	−64.0
24	Southern Pacific Railroad bridge	18.0	0	0	−64.0
24	Uvalde-Del Rio road crossing	20.6	0	0	−64.0
24	Gaging station near Uvalde	22.7	8.1	+8.1	−55.9
25	Uvalde-Eagle Pass road crossing	28.2	14.4	+6.3	−49.6
25	San Antonio, Uvalde & Gulf Railroad bridge	31.6	12.8	−1.6	−51.2
25	Old Uvalde-La Pryor road crossing	36.3	8.3	−4.5	−55.7
25	Gas well 5 miles northeast of La Pryor	39.6	4.5	−3.8	−59.5

The following table shows the yearly discharge of the river at the Laguna and Uvalde gaging stations, the yearly decrease or increase in flow between stations, the estimated yearly loss on the outcrop of the Edwards limestone, and the estimated net yearly loss (loss minus ground-water inflow) between the Edwards outcrop and the Uvalde gaging station. The estimates of losses are based on studies of the seepage measurements and daily records of the discharge at the gaging stations.

Discharge of Nueces River at Laguna and Uvalde gaging stations and seepage losses or gains between stations, in second-feet

Year (Oct. 1-Sept. 30)	Discharge		Decrease or increase in flow between stations	Estimated loss on outcrop of Edwards limestone	Estimated net loss between outcrop of Edwards limestone and Uvalde gaging station
	Laguna	Uvalde			
1924-25	75,300				
1925-26	99,800				
1926-27	50,900				
1927-28	51,600	6,290	−45,400	33,000	6,000
1928-29	50,900	[a] 15,900	−35,000	29,000	9,000
1929-30	69,200	[b] 61,900	−7,300	25,000	7,000
1930-31	157,000	[b] 105,000	−52,000	45,000	33,000
1931-32	210,000	[b] 509,000	+299,000	46,000	25,000
1932-33	80,000	[b] 62,800	−17,200	38,000	21,000
Total	844,100	760,890		216,000	

[a] Discharge Oct. 1 to 3, 1928, not included.
[b] Figure includes a large inflow of storm water between gaging stations.

During heavy rains storm water enters the river between the gaging stations and contributes to the discharge at the Uvalde station. On the whole such rains are infrequent and sometimes are many months apart. Usually, however, there is some surface inflow between stations each year, and the yearly loss between stations is materially greater than the figure obtained by subtracting the yearly discharge at Uvalde from that at Laguna. This is illustrated by the gaging records for 1931–32. In that year there was a large total gain between the stations due to interstation inflow, chiefly in July and September 1932. There were also large inflows between the stations in June and October 1930, May 1931, and October, November, and December 1932. The total discharge at Uvalde during these 8 months amounted to about 690,000 acre-feet, or more than four-fifths of the total discharge at that station during the 6 years in which both stations were maintained prior to 1934.

Some interesting facts are disclosed by the seepage measurements, a few of which are as follows: During nine of the series of seepage measurements, with a discharge at Laguna ranging from 92 to 316 second-feet, the losses between Laguna and the Uvalde-Del Rio road crossing ranged from 92 to 148 second-feet and averaged 112 second-feet. Of this loss an average of 60 second-feet occurred in the section between Laguna and the mouth of the West Fork, most of which is on the outcrop of the Edwards limestone, and an average of about 52 second-feet occurred between the mouth of the West Fork and the Uvalde-Del Rio bridge, below the Edwards outcrop. The measurements in 1931 indicate that the rate of loss varies more on the outcrop of the Edwards than it does in the section below it. As the discharge at Laguna declined from 192 second-feet on June 4 to 92 second-feet on July 16, the losses increased from 35 to 67 second-feet between Laguna and the mouth of the West Fork but were maintained at a relatively constant rate between the West Fork and the Del Rio bridge, at least until the discharge at the West Fork had declined to about 36 second-feet.

All the seepage measurements show a substantial increase in the flow of the river between the Del Rio bridge and the Uvalde gaging station and a further increase between the Uvalde station and the crossing of the Eagle Pass road 5½ miles below that station. The rate of pick-up in these sections was relatively constant for months after the stream ceased flowing above the Del Rio bridge in September 1931 but slowly declined during the fall, winter, and spring of 1931–32.

The apparently complicated regimen of the river indicated by the records of stream measurements at the gaging stations and intermediate points can be explained as follows: On the outcrop of the Edwards limestone the river loses large quantities of water, which first is absorbed by percolation into the gravel and then is paid out gradually from the gravel into the limestone. During floods the stream leaves its normal channel, which in places is narrow, and spreads over the adjacent bottom lands. Thereby a larger quantity of water is absorbed by the gravel than at low or moderate stages, and a temporary water table is built up, which in places is at the level of the stream bed or above it. The water thus placed in storage by the floods, sometimes called "bank storage", is gradually depleted by downward percolation into the limestone and to some extent by evaporation or transpiration, and as the water table declines percolation from the stream increases, even though the flow of the stream is decreasing.

In April 1930 the flow at Laguna was about 30 second-feet and the stream lost water rapidly after it crossed the Comanche Peak-Edwards contact. The last flowing water was near United States Geological Survey bench mark 1045. At this point the bed of the stream is formed by gravel. A well drilled several years prior to 1930 on the east side of the river near this bench mark found no water until it had passed through the gravel and 100 feet into the Edwards. This indicates that the water from the river passed through the gravel and entered the limestone.

During a large proportion of the time the discharge at Laguna is less than the intake capacity of the Edwards, and as there is, therefore, no flow in the river no recharge occurs in the section below the mouth of the West Nueces. In times of high water, however, the losses in this section are very large. It is believed that this water must enter the gravel directly. The fact that large quantities of water enter the gravel is indicated by the records of water-level fluctuations in wells H-4-8 and H-4-28 (see p. 129) which show that the water levels in these wells rose 27 and 18 feet, respectively, after floods in the spring of 1930. Well H-4-8, which was equipped with a water-stage recorder, showed a very rapid rise of 27 feet in a period of 3 weeks during and shortly after the flood of June 1930 and then declined rapidly at first and then more slowly, indicating that during the flood there was considerable loss from the river into the gravel and after the flood there was probably a gradual spreading movement both away from the river (eastward) and back toward the river. This spreading movement continued until equilibrium was reached, after which the water level remained nearly constant.

The volume of water that the gravel is capable of taking in or releasing is surprisingly large. If the gravel above the Uvalde gaging station covers an area of 5 square miles and has an average effective porosity of 25 percent it would alternately store and release 20,000 acre-feet if a thickness of 25 feet were alternately watered and unwatered.

Finally, the river alternately disappears and reappears in a similar manner in a section in the vicinity of La Pryoı, in Zavala County, 20 to 25 miles south of Uvalde, where the gravel is without question the medium of storage and release. This is explained in a report on the ground-water resources of Dimmit and Uvalde Counties and a part of Maverick County, now in preparation.

It was formerly believed that this water entered the gravel and that a part of it was paid out slowly to the river during dry periods, a part was lost from the gravel by evaporation and by transpiration from deep-rooted trees and shrubs, and the remainder increased the storage in the gravel.

However, on the basis of data now available, the computed losses into the gravel in this stretch of the stream in excess of the return flow near the Uvalde station during each year of the period from 1927–28 to 1932–33 are so great that it does not seem possible to account for them by storage, evaporation, and transpiration, and the writer believes that some but not a large amount of this water is lost by percolation from the gravel into permeable beds of the Austin chalk and a part, possibly a large part, may be lost into the Edwards immediately below the mouth of the West Nueces by downward movement along fault planes.

It is believed that the ground-water flow between the Del Rio bridge and the Eagle Pass road crossing is largely due to seepage from the gravel reservoir, although in the section below Tom Nunn Hill a part of the flow may be due to fault springs bringing water up from the Edwards. The water begins to rise a short distance above the Uvalde gaging station. The valley becomes narrower in this vicinity, thereby constricting the cross-sectional area of the gravel and producing the conditions requisite for bringing the underflow to the surface. In an earlier paper [89] it was suggested that igneous intrusions had baked and hardened the clays overlying the Edwards and permitted the Edwards limestone water to rise in this vicinity along joint cracks. There is also a large fault south of Tom Nunn Hill which may allow water from the Edwards to reach the surface. On the other hand, when the artesian head in the Edwards reservoir is high, the water levels in nearby wells that penetrate to the Edwards (see records of observation wells H–4–6, H–5–1, and H–5–51) reach altitudes that are above the river bed at the Uvalde station, but fluctuations in the flow to the river do not appear to synchronize with fluctuations in the artesian head in the Edwards. The inflow is greatest immediately after heavy floods and declines gradually with the lapse of time between floods, just as would be expected from a gravel reservoir that is filled comparatively rapidly during floods and yields water at its lower end at a rate that decreases as the water level in the reservoir declines. The head in the Edwards reservoir builds up and declines slowly and lags many months behind the fluctuations in the stream discharge.

[89] White, W. N., and others, Survey of the underground waters of Texas: U. S. Dept. Interior Press Memo. 50678, pp. 11–12, Feb. 16, 1931.

In summary it may be pointed out that the average annual loss from the Nueces into the Edwards limestone above the mouth of the West Nueces during the 6-year period was about 36,000 acre-feet. A much smaller amount was lost into the gravel below the mouth of the West Nueces. Some of this water may have entered the Edwards, some probably entered the Austin chalk, and some remained in the gravel. Of the water that remained in the gravel a part was lost by evaporation and transpiration and a part was returned to the stream.

Losses of water into the Edwards limestone also occur in other rivers crossing the formation in Uvalde and Medina Counties.

Discharge measurements on the Dry Frio River [90] on June 28, 1925, are as follows:

Discharge measurements to determine seepage on Dry Frio River from Clark ranch house to a point 9½ miles below Reagan Wells, in June 1925

Date	Stream or diversion	Location	Discharge (second-feet)		Gain or loss (second-feet)	
			Main stream	Tributary	In section	Total
June 28	Dry Frio River	Clark ranch house, 6 miles above Reagan Wells.	[a] 0.50			
28	do	3.6 miles above Reagan Wells, near Hurd School.	1.65		+1.15	+1.15
28	Mine Creek	Hurd School, 3.5 miles above Reagan Wells.		[a] 0.5		
28	Dry Frio River	½ mile below Reagan Wells	5.16		+3.01	+4.16
28	do	4½ miles below Reagan Wells	6.74		+1.58	+5.74
28	do	8 miles below Reagan Wells	9.66		+2.92	+8.66
28	do	9½ miles below Reagan Wells	0		−9.66	−1.00

[a] Estimated.

The total loss of 9.66 second-feet occurred on the Edwards limestone outcrop. On an annual basis this loss would equal 7,000 acre-feet. The stream flowed only part of the way across the Edwards outcrop, and it seems likely that if the discharge were sufficient to get farther before being completely lost a large amount of additional water would enter the limestone through cracks and solution channels. The losses are undoubtedly very heavy in time of flood or high water.

Seepage measurements on the main Frio during the same year are given below [91] and indicate a loss of 40.5 second-feet in the 7-mile stretch below Concan, all of which goes into the Edwards limestone.

Discharge measurements to determine seepage on Frio River from a point 11.8 miles above Leakey to a point 7.0 miles below Concan, Tex., in June 1925

Date	Stream or diversion	Location	Discharge (second-feet)	Gain or loss (second-feet)	
				In section	Total
June 27	Frio River	15 miles below Leakey	39.5	+13.1	+21.79
27	do	Concan, 19½ miles below Leakey	40.5	+1.0	+22.79
27	do	20½ miles below Leakey	32.5	−8.0	+14.79
27	do	23½ miles below Leakey	20.1	−12.4	+2.39
27	do	Uvalde-Concan road crossing, 26 miles below Leakey.	6.30	−13.8	−11.41
27	do	26.3 miles below Leakey	[a] 2.50	−3.8	−15.21
27	do	26.5 miles below Leakey	0.	−2.5	−17.71

[a] Estimated.

[90] U. S. Geol. Survey Water-Supply Paper 608, p. 203, 1929.

[91] Idem, p. 202.

The Frio is peculiarly well adapted for determining whether the loss shown by the above seepage measurements enters the Edwards. The lower part of the Edwards limestone crops out near Concan, and although it is not exposed at the surface in the stream bed continuously below this point but is covered by gravel in places, it is at the surface 2.3 miles below the Uvalde-Concan road crossing, and here the stream bed passes between bold walls of Edwards limestone, and the limestone also crops out in the stream bed. Even though a part of the stream water enters the gravel above the gorge, there is no flow through the gorge except during periods of high water, and the gravel does not yield water to wells, so that there can be no doubt that all the water lost from the river enters the Edwards limestone before reaching this gorge. A well in the Edwards limestone on the Florea ranch, about a mile south of this gorge, showed a depth to water of about 180 feet.

Measurements made on the Frio River at a gaging station near Concan, four-fifths of a mile below Shut-in and near Frio Town, 1½ miles below the mouth of the Sabinal River, indicate an average annual loss of 40,000 to 50,000 acre-feet between these two stations in 1923–27, a period in which the mean rainfall at Uvalde was about 6 percent below the 36-year average.

Discharge of Frio River at Concan and Frio Town and loss between stations

Year	Discharge (acre-feet)		Loss (acre-feet)	Year	Discharge (acre-feet)		Loss (acre-feet)
	Concan	Frio Town			Concan	Frio Town	
1923-24	82,600	[a] 4,470	[a] 23,300	1926-27	53,100	4,250	49,000
1924-25	24,200	1,500	23,000	1927-28	23,500		
1925-26	65,500	16,000	49,000	1928-29	23,400		

[a] April 9 to September 30.

No gaging stations have been maintained on the Sabinal River and Hondo Creek, but observations during the field season indicate that these two streams lose water in the outcrop area of the Edwards limestone. However, during 1930,[92] discharge measurements were made on the Medina River at three stations in Medina County—near Mico, 2,000 feet below the main dam of the Medina Valley Irrigation Co.; at the head of the Medina Canal; and near Riomedina, 2,000 feet below the diversion dam. The total discharge for the year at the Mico station as calculated from the daily discharge measurements was about 52,000 acre-feet, the discharge into the Medina Canal was about 21,000 acre-feet, and the discharge at the Riomedina station was 15,000 acre-feet. The loss is therefore the difference between the

[92] Surface water supply of western Gulf of Mexico basins, 1930: U. S. Geol. Survey Water-Supply Paper 703, pp. 89–94, 1932.

discharge at Mico and the sum of the discharges at the Medina Canal and Riomedina stations, or about 16,000 acre-feet. A small part of this loss, perhaps a few hundred acre-feet, is due to evaporation and transpiration by plants; most of it is due to losses into the Edwards limestone.

The computations of loss were based on the assumption that the inflow to the river due to run-off between the Mico and Riomedina stations was slight during this period. If there was notable inflow during the period, the total loss was more than the amount above given.

No accurate figures are available for the amount of water lost to the Edwards limestone from the main reservoir, but computations based on the discharge of the river above and below the reservoir indicate that the loss is heavy.

The foregoing statements indicate that the total water annually entering the Edwards limestone from the Nueces, Frio, Dry Frio, and Medina Rivers averages considerably more than 100,000 acre-feet. Including contributions from the Sabinal River and Hondo Creek the average total annual recharge to the Edwards limestone may amount to 150,000 acre-feet. The additional recharge from the smaller streams and from precipitation is unknown but must be large.

Unless there is some outlet for this water the openings in the formation must eventually become full, and the water table in the limestone would then be at or near the surface where streams cross the contact of the Edwards with younger formations. The facts that the water table at the southern margin of the outcrop area of the Edwards is more than 100 feet below the surface and that streams crossing the formation lose water indicate that there are one or more outlets down the dip. An attempt to show where these outlets are located is made on pages 86–96.

ANACACHO LIMESTONE

The Anacacho limestone is cavernous to some extent, and part of the water in the formation occurs in these caverns, but the solution channels are apparently not as extensive as those in the Edwards limestone and the Anacacho is usually not so well exposed at the surface as the Edwards. Over at least a part of the southern tip of the anticlinal nose that passes near Uvalde the Anacacho is faulted out of sight, and therefore intake at the surface in that area is not possible. From the Nueces River westward to the Uvalde County line the formation is well exposed, but porous honeycombed portions are not common, and the formation is locally impregnated with asphalt. Very little or no water is found in the Anacacho in this area. East of the Frio River the outcrop of the formation swings northward, and the town of Sabinal lies within the outcrop area. For the most part the formation is thickly covered by the Leona formation, but in a few places it is well exposed. Along the Sabinal River in the vicinity of Sabinal the limestone is a very coarse, honeycombed limestone which would doubtless be capable of taking in large amounts of water, provided the porous beds extend for a considerable distance beneath the surface. The same type of honeycombed limestone is noted in Medina County north of Castroville along the highway to Medina Lake and along Geronimo Creek near Riomedina. The water table is low, and therefore the Anacacho has good intake properties near two of the rivers that cross the area. Very little is known of the character of the outcrop in the interstream areas, because the formation is usually covered by the Leona formation, but if the honeycombed character of the outcrop at the river persists beneath the gravel in the interstream areas, there is every reason to suppose that the intake in these areas would be rather large, because rain water falling upon the surface would tend to sink to the bottom of the Leona formation and be held in it as in a reservoir, seeping slowly into the underlying formation. However, all exposures of the Anacacho in interstream areas visited by the writer consisted of massive, resistant and nonporous limestone and in some places a rather light-colored, nonresistant marl. Therefore the percolation in the interstream areas probably does not supply a great deal of water to the Anacacho.

CARRIZO SAND

It is evident from a study of the pumping records of wells in the Carrizo sand in the vicinity of La Pryor, Crystal City, and Carrizo Springs that a large amount of water is drawn from the formation annually. This water must either be replenished by recharge in the intake area or be withdrawn from storage, or both. Water in the Carrizo moves through the pore spaces between grains of sand. Consequently the rate at which water can move through the formation may be much less than the rate at which water can move through solution channels or fissures in a limestone, although the actual porosity of the sand may equal or exceed that of the limestone, and the total intake of the sand, although slower, may be as great or even greater than that of the limestone.

Water may enter the Carrizo sand directly from rainfall on the outcrop, from rivers or streams that cross the outcrop, by downward percolation of water in overlying formations, or by upward movement of water from lower formations along faults.

The total amount of water in the Carrizo and the total amount of withdrawal in Zavala and Dimmit Counties have been estimated by T. W. Robinson and S. F. Turner, and W. N. White is attempting to determine the amount of recharge to the Carrizo from various sources. Lysimeter tests made on the outcrop of the Carrizo sand during October 1930 indicated that 2 inches of rainfall had penetrated the

Carrizo sand to a depth of 8 feet. It was assumed that all water which passed to this depth would continue downward to the water table. The lithologic similarity indicates that the intake capacity of the sandstone would be very nearly the same in Uvalde and Medina Counties as in the vicinity of Carrizo Springs, where the tests were made. As the total area of the Carrizo in Uvalde and Medina Counties is about 112,000 acres, this amount of intake over the entire Carrizo outcrop in these counties would equal more than 18,000 acre-feet during the month of October.

Mr. White also made meter measurements of the discharge of the Nueces, Leona, and Frio Rivers above and below the outcrop of the Carrizo. On the Nueces River during the spring of 1930, when there was no flow at the old Uvalde-La Pryor road crossing in Zavala County, water stood in pools in the Carrizo sandstone and flowed from sand at the Carrizo-Bigford contact. These facts indicate that the water table was slightly above the river level at this point and the Carrizo water was draining from the formation into the river. However, during high water there may be some losses into the gravel that overlies the Carrizo, and some of this water may percolate through the gravel into the sand and thus raise the water level in the formation at some little distance from the river. The Carrizo outcrop on the Nueces is several miles south of the Uvalde-Zavala County line, and this matter will therefore be discussed more fully in the report on Zavala and Dimmit Counties.[94]

The Carrizo sand crops out in the valley of the Leona River only near the southern boundary of the county, along the road on the east side of the river. Elsewhere in the valley it is covered by the Leona formation, as much as 50 feet thick, through which there is apparently a large underflow, as is indicated by the large wells operating in the valley. (See pp. 68–69.) A graph of the altitude of the water levels in the gravel wells in the valley shows that the altitude declines very slowly in the area upstream from the Carrizo outcrop but declines rapidly in crossing the outcrop. This seems to indicate a loss from the gravel into the Carrizo. In February 1930 there was no apparent loss of water from the Leona River in this section, but in June 1931 a loss of 10 second-feet occurred between a point 3 miles below Kincaid Dam and Hackberry Crossing, which is about 5½ miles below the county line. This area is underlain in part by the Carrizo, and although the exact point at which the loss occurs is not known, it is believed that the loss may represent losses into the Carrizo through the gravel. In connection with the possible recharge of the Carrizo sand from the Leona River it is noteworthy that the water in the Carrizo is under greater pressure in Zavala County in the locality where the Leona River crosses its outcrop than on either side.

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[94] Robinson, T. W., and Turner, S. F., Geology and ground-water resources of Zavala and Dimmit Counties, Tex.: U. S. Geol. Survey Water-Supply Paper (in preparation).

On the Frio River conditions similar to those on the Nueces exist, and in March 1930 water was flowing from the Carrizo into the river at the Carrizo-Bigford contact near the Blackaller ranch, in Frio County, although there was no flowing water in the river above this point. Here also the water level in the Carrizo may be built up for some distance from the river during high stages, but the amount of this raising of the water level is believed to be moderate, and when the high-water stage passes, a large proportion of the water thus stored probably returns to the river as seepage. Measurements made by Mr. White on May 22, 1931, show that on the outcrop area of the Carrizo between points 2 miles northwest of the Woodward ranch and half a mile east of this ranch there was a decline in the discharge of the Frio River, from 84.4 to 80.8 second-feet. This decline is within the limits of accuracy of the measurement and may or may not indicate recharge to the Carrizo.

LEONA FORMATION

The Leona formation may receive water by rainfall penetration, by intake from streams, and by upward movement of water from lower formations. These methods of intake are discussed on pages 70–72.

GROUND-WATER MOVEMENT AND DISCHARGE

The movement of water in the Edwards limestone is indicated in several ways. (1) The streams crossing the outcrop lose water continually but the water table remains very low in the outcrop area; (2) monthly well measurements show changes in water levels which are related to periods of heavy rainfall; (3) the formation yields water to wells; (4) a contour map of the piezometric or pressure-indicating surface of the water in the Edwards limestone shows that this surface slopes toward the south or southeast from the outcrop of the formation.

As discussed on pages 73–83, the water that disappears into the cracks and cavities of the Edwards limestone from the larger streams that cross its outcrop in Uvalde and Medina Counties may amount to 150,000 acre-feet a year. Even this quantity of water entering the Edwards limestone annually over a long period would eventually fill up the underground reservoir to overflowing. The facts that all the stream beds, except the Medina, are normally dry at the downstream edge of the Edwards limestone outcrop area and that the water table in the outcrop area of the Edwards limestone is 150 to 200 feet or more below the ground surface furnish clear evidence that water moves down the dip rather freely from the intake areas. There is also doubtless a large amount of rain water that falls on the Edwards limestone and passes downward through the limestone to the water table.

Another evidence of the movement of water in the Edwards limestone is furnished by a comparison of the observations of water levels in certain wells in the area from October 1929 to October 1934. Measurements of the water level or the depth to water in selected wells were made at intervals of 1 month or as often as weather conditions and the nature of the work permitted. It would have been desirable to place water-stage recorders on some of these wells, but the fact that all were in constant use, as stock wells, prevented the installation of recorders. The fluctuations of the water level in these wells and the monthly rainfall at Uvalde are shown graphically in plate 11. The measurements are also arranged in a table showing the date, the depth to water, and the altitude of the water surface in each well at the time of each monthly measurement. (See pp. 128–132.) The wells near the outcrop or on the outcrop of the limestone were the first to show the effect of rainfall within the area. In well H–2–4 the water level receded 4.16 feet during the dry winter from November 1929 to May 1930, or from an altitude of 969.84 feet to 965.68. After the heavy rains late in May and early in June the water level rose 61.50 feet, to an altitude of 1,027.18 feet, by October 1930 and declined to 1,022.28 feet by January 1932. The water level in the Flores well (H–2–5) was variable and apparently responded very quickly to rises in the river and to short periods of pumping. The George Kennedy well (H–5–26), which is about 6 miles south by west of well H–2–4, was first measured in November 1929, when the depth to water was 186.02 feet and the altitude of the water surface was 837.16 feet. The altitude declined to 833.18 feet by the later part of May 1930 and then slowly rose to 842.93 feet by December 19, 1930, and had reached 861.78 feet in October 1931. In well H–6–1, on the Kincaid estate, the water level when first measured, in December 1929, was 103.9 feet below the surface, or at an altitude of 879.25 feet. The water level declined until the later part of May, when it began to rise, and in July 1931 it stood at 896.45 feet. The depth to water in well H–5–22 when first measured, November 20, 1929, was 78.55 feet, and the water in the well had an altitude of 855.96 feet. The water level dropped a total of 5.8 feet until June 24, 1930, when the altitude was 850.16 feet. By July 23 the water had risen to 855.76 feet, or 5.6 feet in 1 month, and by the end of October 1931 it had reached an altitude of 873.16 feet. The William Galloway well (H–5–39) was measured first on December 5, 1929, and showed a depth to water of 99.5 feet, or an altitude of 852.48 feet. By May 21, 1930, this altitude had decreased to 847.86 feet, but as the well is on the outcrop area of the Edwards limestone it felt the effect of the early June rains immediately, and on June 24 the altitude of the water surface was 850.08 feet. On October 30, 1931, the altitude of the water surface in this well was 871.43 feet. Well H–5–38 was first measured December 5, 1929, and had a depth to water of 57.93 feet. By May 21, 1930, the depth had increased to 61.07 feet, but after the rains the well immediately began to recover, and by December 19, 1930, the depth to water was only 53.72 feet. The Briscoe, Fenley & Spangler well (H-4-6) was first measured October 7, 1929. By May 22, 1930, the depth to water was 83.95 feet, and the altitude of the water surface was 869.02 feet; by June 23, 1930, the altitude of the water was 866.07 feet, and by October 1931 it was 884.97 feet. The O. T. Cardwell well (H-5-51) when first measured, October 5, 1929, had a depth to water of 52.9 feet, and on June 23, 1930, the depth to water was 56.14 feet. The water level slowly recovered from this time until January 14, 1932, when the depth was 41 feet. Other well observations show similar variations in depth to water. Some of these variations are shown graphically in plate 11.

From a study of the tables of monthly measurements it is apparent that the water level in all wells in the Edwards limestone declined during the later part of 1929 and the early part of 1930, when there was less than the normal amount of rain in the area to cause recharge. In May and June 1930 there were heavy rains within the area. The rains in May occurred north of Uvalde and are not shown on the Uvalde precipitation record; the rains in June were more general and were recorded at Uvalde. These heavy rains are reflected in the records of the wells for May and June and the following months. In general the first wells in which the water level rose as a result of the rains were on the outcrop of the Edwards limestone or near to it. The water levels in the wells farther from the outcrop did not rise as soon, but the time interval between the rise of the water levels in the outcrop wells and the rise of water in the wells down the dip was in no well more than a month, and in most wells the water level continued to rise during a period of 12 months or more, during which the rainfall was somewhat greater than normal.

It is estimated that about 2,000 acre-feet of water is drawn annually from wells in the Edwards limestone in the vicinity of Uvalde for irrigation (this includes the water pumped from the Leona gravel south of Uvalde). The city of Uvalde uses about 500,000 gallons a day, or 560 acre-feet annually. The city wells in Sabinal and Hondo also draw about 560 acre-feet of water annually from the Edwards limestone. Thus, disregarding the water drawn from the formation by stock wells, which is relatively small in amount, a total of about 3,100 acre-feet is drawn from the Edwards limestone. The water drawn from the formation must be replaced by water moving down the dip of the formation; otherwise at this rate of pumping the water in the formation would eventually be exhausted.

Plate 2 shows that the piezometric surface of the water in the Edwards limestone is very irregular. In most parts of the area the slope is gentle, but in no part of the area is the surface flat. In the area just east of the Frio River the slope is more than 100 feet to the mile. This surface would be flat if the Edwards water were static and therefore the piezometric contour map indicates that the Edwards water is moving away from the recharge areas.

From a study of the well data in the area where the piezometric surface slopes steeply it appears that the steep slope is due to unusually low permeability of the Edwards in this area. The wells yield only small amounts of water and have a much larger drawdown than in the Uvalde area where the piezometric surface is gently sloping. Therefore, it seems proper to point out here that the amount of slope of this surface cannot be directly correlated with the amount of movement of ground water in a limestone formation.

In the vicinity of Uvalde the piezometric surface is decidedly high, but east of Uvalde, between the Frio and Sabinal Rivers, it is lower. It is thought that the high area in the vicinity of Uvalde is accounted for by the presence of a large fault south of the town, which has brought impermeable formations at higher horizons down against the Edwards limestone, causing the water of the Edwards to be dammed and backed up at this place while eastward movement is retarded by the area of low permeability between the Frio and Sabinal Rivers.

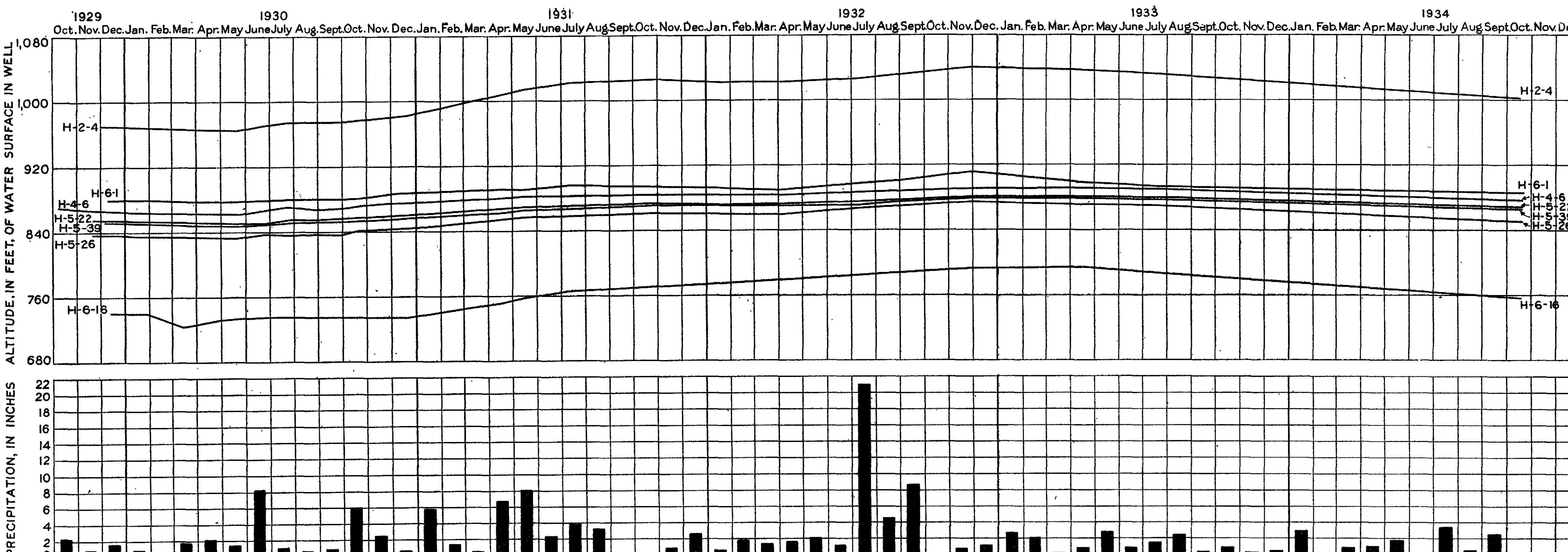
The surface of the water in the Edwards limestone along a line running from a point about 7 miles northwest of Uvalde through Uvalde and thence southward and eastward down the valley of the Leona River slopes at a rate of about 5 feet to the mile until the vicinity of North Uvalde is reached, where the slope is less than 5 feet in 6 miles. This flat portion of the piezometric surface lies immediately under the town of Uvalde and continues southward in the Leona Valley to approximately the location of the east-west fault that crosses the area about 2 or 3 miles south of Uvalde. From this profile it appears certain that water from the Edwards limestone in the vicinity of the Nueces River at the outcrop of the formation has sufficient head to cause it to move from the outcrop area southward and eastward to Uvalde. South of the location of the fault the profile of the piezometric surface becomes that of the Leona formation, and a rather steep decline is shown from this point to the outcrop of the Carrizo sand, near the Uvalde-Zavala county line.

The combined withdrawal of water from the Edwards limestone by all wells is not more than about one-fortieth of the 150,000 acre-feet which, according to the records obtained in 1930, enters the formation annually in the two counties from the streams in or near the Edwards Plateau, to say nothing of the water that enters the limestone directly from precipitation on the outcrop. Plants have been shown to draw heavily upon the ground water in some areas, but in the outcrop area of the Edwards limestone very little effect can be assigned to the transpiration of plants, because the water table is below the reach of even the most energetic of the water-using plants.

It must be supposed, therefore, that this water comes to the surface elsewhere either in springs or in wells.

It is pointed out on page 80 that there is a large fault south of Tom Nunn Hill which may provide a conduit from the Edwards to the surface. In addition, the fractures in the igneous rocks west of the Nueces may possibly, although not probably, provide a conduit to the surface. Water levels in such Edwards wells as are found in the area indicate that the altitude to which the Edwards water would rise is more than sufficient to bring this water to the surface in the bed of the Nueces River near Tom Nunn Hill. The altitude of the water level in well H–4–6, 6 miles northeast of Tom Nunn Hill, ranged during the period of observation from 861.59 to 890.87 feet. According to Munroe Fenley, the water in the oil test Pulliam no. 6 (H–7–5), on the Pulliam ranch, which penetrated to the Edwards limestone, flowed over the top of the casing. The Smythe Bros.' well (H–7–2), which penetrated to the Edwards, is about 3 miles southwest of the point at which water begins to appear in the Nueces River. According to Hans Smythe, the water in this well ordinarily rises to the top of the casing and overflows after the pump has been idle for about a week. On May 5, 1930, the water in this well was 17.6 feet below the surface. The altitude of the well is about 900 feet, and the altitude of the water surface is therefore about 882 feet. The bed of the Nueces River near Tom Nunn Hill has an altitude of 860 feet. Thus the Edwards water is under sufficient pressure to force it to the surface near Tom Nunn Hill, even at times when the water level is lower than normal, providing a suitable conduit from the Edwards to the surface is present. When the water level in the Edwards is high there is sufficient pressure to cause the water to flow at a point nearly as far north as the present Del Rio bridge. The amount of water returning to the surface from the Edwards in this manner will depend to a large extent on the size of the conduit and the hydrostatic head.

The regimen of the Nueces River is discussed rather fully on pages 73–83, where it is shown that a large part of the return flow of the river between the Del Rio bridge and the Eagle Pass road is seepage of water stored in the gravel between the mouth of the West Nueces and the Uvalde gaging station during high-water stages. If any water returns to the stream from the Edwards in this area the amount is not large, because the fluctuations in the flow of the river do not appear to synchronize with fluctuations in the water level in the Edwards. However, if the contribution from the Edwards is relatively small, fluctuations in this flow would probably be obscured by the fluctuation in the flow coming from the gravel reservoir above. In any case, the total amount of water returned to the river from the Edwards limestone can represent only a small



FLUCTUATIONS OF WATER LEVEL IN WELLS DRAWING FROM THE EDWARDS LIMESTONE AND RAINFALL FROM OCTOBER 1929 TO OCTOBER 1934.

portion of the total amount of water lost into the Edwards limestone in its outcrop area above the mouth of the West Fork. It is believed, therefore, that the remaining Edwards water must return to the surface elsewhere in springs and wells. A part of the water that enters the Edwards from the Nueces River above the mouth of the West Nueces probably comes to the surface in the valley of the Leona River below the town of Uvalde.

The Leona River is the only stream in the area that flows continuously and has its source south of the Edwards Plateau. In this respect it is similar to the San Antonio River at San Antonio and Las Moras Creek near Brackettville, both of which are fed by water emerging along faults from the Edwards limestone. It is believed that the Leona is also fed by water coming from the Edwards along faults that are buried under thick deposits of Leona gravels and that the water moving upward along the faults enters the gravels and thence enters the stream channel. The following table [95] shows the discharge of the Leona at various dates:

Discharge measurements of Leona River near Uvalde, Tex.

Date	Location	Discharge (second-feet)	Remarks
1885	Road crossing 1.7 miles below Uvalde		Flowed.
1893	do		Did not flow.
Dec. 1895	do	11	
June 1899	do		Do.
Sept. 1900	do	5	
Mar. 1904	do	22	
Apr. 1906	do	13	
1911	do		Do.
Apr. 4, 1925	Leona Valley Livestock & Irrigation Co.'s canal	5.6	
Do	Leona River 500 feet below canal	2.9	
1928	Road crossing 1.7 miles below Uvalde	.87	

Seepage measurements made by the United States Geological Survey in cooperation with the Texas State Board of Water Engineers in 1931 [96] are given below.

Discharge measurements to determine seepage on Leona River near Uvalde, Tex., 1931

Date	Location	Approximate distance below initial starting point (miles)	Discharge (second-feet)		
			Measured	Gain or loss in section	Total gain or loss
June 11	Highway bridge 1.7 miles southeast of Uvalde	0	3.1		
11	Below Leona Valley livestock and irrigation canal	2.1	8.0	+4.9	+4.9
11	Crossing at White's place above Kincaid Dam	6.6	16.4	+8.4	+13.3
11	Below Kincaid Dam	8.1	7.2	−9.2	+4.1
11	3 miles below Kincaid Dam	11	19.1	+11.9	+16.0
12	Hackberry Crossing	17.0	9.5	−9.6	+4.1

[95] U. S. Geol. Survey Water-Supply Papers 210, 308, 608, and 668.

[96] Surface water supply of the western Gulf of Mexico basins, 1931: U. S. Geol. Survey Water-Supply Paper 718, p. 108, 1933.

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The measurements indicate that in general the flow of the stream increased to a point 8 miles below Uvalde.

The Leona River Valley has its head about 15 miles north of Uvalde and is cut into the bedrock as far south as the Southern Pacific Railroad. Below this point the valley becomes much wider and is partly filled with gravel of the Leona formation, which, in the vicinity of Uvalde, has a thickness of 60 to 90 feet. In normal years the stream flows constantly at the bridge 1.7 miles southeast of Uvalde, but the point at which flow begins moves upstream or downstream, apparently with fluctuation of the water table in the Leona formation. The possible sources of the water in the Leona formation in this area are direct recharge from precipitation and flood waters, underflow from the gravel along the Nueces, and recharge from the Edwards limestone along the faults that cross the valley under the gravel south of Uvalde. (See pl. 1.)

The gravel reservoir in the Leona Valley is comparable in size to the gravel reservoir in the Nueces River Valley between the mouth of the West Nueces River and the Uvalde gaging station. It has been shown that much of the water stored in the gravel by floods on the Nueces was drained out rather rapidly, and within a few months after the floods the discharge at the Uvalde station ranged from a fraction of a second-foot to a few second-feet. The Leona River, on the other hand, reaches flood stages for a short period immediately after heavy rains and then declines to its normal flow. This flow persists or increases for months afterward. In addition, the valley is notable for the great number of live oak, pecan, and large mesquite trees that grow in it. The live oaks and pecans are especially heavy users of ground water, and the amount of ground water lost from the reservoir by the transpiration of these trees is very large. Several large irrigation wells also draw considerable amounts of water from the gravel.

During the period from 1926 to May 1930 the rainfall at Uvalde was below normal and the water level in the Edwards limestone near Uvalde had declined so that its altitude was about 851 feet in May 1930, and the first running water in the Leona River was near the White farm, where the altitude, as indicated on the map of the Uvalde quadrangle, is a little less than 850 feet. When the water levels in Edwards wells began to rise in the later part of May 1930 the Leona began to flow at progressively higher points, and in December 1930, according to T. G. Hines, water began to seep into the stream under the bridge south of Uvalde, where the altitude is about 860 feet. At that time the water level in nearby wells was estimated to be about 860 feet. In February 1931 the stream began to flow under the bridge.

The Leona passed through a similar cycle in 1893–1900, according to an earlier report,[97] which states:

In former years there was located in the southern suburbs of Uvalde a large spring with constant flow, known as "Leona Spring." This spring was dry but once between 1870 and 1893—namely, in 1885. It soon revived, however, and continued flowing up to 1893, when the discharge stopped, and no water has issued from it since that date. The water in the wells in the vicinity in 1884 was 25 feet below the surface of the ground, but in 1899 the level was about 50 feet below the surface. A pumping station was located on the banks of Leona River near Leona Spring in 1893, but after 1 or 2 years the river failed to such an extent that the entire pumping plant was moved to within 150 yards of the courthouse at Uvalde. At the new station a 15- by 15-foot pit was excavated 24 feet deep, and the pumps were placed at the bottom of this pit, and then a well 4 by 7 feet square was sunk from this level to a depth of 16 feet, out of which the water was pumped into a standpipe. The water at first rose in this well to within 35 feet of the ground surface. In December 1897 it was noticed that the supply was failing, and this continued until May 1898, when a second pit, 10 by 10 feet and 9 feet deep, was excavated on the southwest side of the first pit, and the well was also lowered until its bottom was 63 feet below the ground surface; when the pumps were finally lowered, their new position was 33 feet below the surface. In January 1899 it was found necessary to sink three small drill wells in the bottom of the main pump well to a depth of 30 to 35 feet, reaching a total depth of 98 feet from the surface of the ground.

Leona River, in 1895, was found by Cyrus C. Babb to be dry under the railroad bridge, but at the crossing 1½ miles south of the town a discharge of 11 second-feet was found. The river ceased flowing at this crossing in January 1898. About June 15, 1899, heavy rains fell over Uvalde and Kinney Counties, raising the Leona River to a flowing depth of 6 to 8 feet. Notwithstanding this, on June 28, 1899, when visited by Thomas U. Taylor, the river was dry at the crossing above referred to. The bed of the stream was followed to the head of the upper irrigation ditch, about 4 miles below the town of Uvalde, but no flowing water was found. The only irrigation along Leona River in 1899 was done through the agency of a steam pump 10 or 12 miles below Uvalde.

Another paper [98] states:

In June 1899, after the heavy rains over southwest Texas, known as the "Brackett flood", the water was standing at about the 93-foot level and was slowly rising. On September 16, 1900, the water had risen to within 2 feet of the pumps, or to the 35-foot level—that is, the water had risen about 58 feet in 15 months, or nearly 4 feet a month, and on December 1, 1900, it had reached the pumps, and arrangements were made to raise them. Accurate measurements during September 1900 showed that the water in the wells was at that time rising at the rate of 4 inches a month.

Between Leona Spring and the brickyard crossing on the road from Uvalde to Pearsall there are several small springs, the largest being Mulberry Spring, which during the early part of 1900 was flowing; in September 1900 its flow had ceased, and on December 1, 1900, it had a flow of about 1 second-foot. * * * On September 17, 1900, Mr. Taylor found a flow at the brickyard crossing of 5 second-feet.

The slow steady rise of water in the wells at Uvalde, which at that time were supplied by the Leona gravel, is very similar to the rise of

[97] U. S. Geol. Survey Water-Supply Paper 37, p. 276, 1900.
[98] U. S. Geol. Survey Water-Supply Paper 50, p. 342, 1901.

water levels in the Edwards limestone wells in 1930 and 1931. It does not have the rapid fluctuations characteristic of the wells drawing from the gravel in the Nueces River Valley.

A further indication of the probability that the Leona River is fed by fault springs is found in the fact that the piezometric surface of the Edwards water converges toward the water table in the gravel at Uvalde. In the Leona Valley the two surfaces practically coincide. Therefore, the water in the Edwards limestone is under sufficient hydrostatic head to cause it to enter the Leona formation, provided a suitable conduit exists.

Generally when heavy rains fall in the Edwards Plateau area and cause heavy recharge into the Edwards, rainfall is also heavy at Uvalde, and there is opportunity for direct recharge to the gravel from the rainfall. This recharge, however, is believed to be small in comparison with the recharge from the Edwards.

The only other possible discharges of the waters entering the Edwards limestone in this area appear to be in Bexar County and Kinney County. At San Antonio there are large springs fed by the Edwards that, like the spring at Uvalde, were dry in 1897, 1898, and 1899 but had a flow of more than 200 second-feet in 1919.[99] The city of San Antonio and many homes, ranches, and irrigated farms in the surrounding area are supplied with water from wells drawing from the Edwards. A part of this supply undoubtedly comes from the Edwards in eastern Medina County, for the piezometric surface slopes eastward rapidly in this area, indicating that the ground water is moving eastward. But a part may enter the Edwards limestone farther west in Medina and Uvalde Counties. The Las Moras Springs,[100] in Kinney County, have an average discharge of 34 second-feet. Very few wells have been drilled to the Edwards limestone for water in Uvalde County west of the Nueces River, but the piezometric surface in this area, as indicated in two wells, does not slope westward, and therefore it appears likely that the springs near Brackett do not draw water from the Edwards in Uvalde County.

If the foregoing interpretation of the movement and discharge of water in the Edwards limestone is correct, there should be a chemical similarity between the waters of the Edwards limestone and those of the Nueces and Leona Rivers.

Three samples of water were taken from the Leona River—one (H–8–D) at the beginning of the permanent water in the river, about 4 miles south of Uvalde; another (H–8–C) 2 miles farther downstream, where the water flows constantly; and a third (H–8–E) about 4 miles still farther downstream. Below H–8–C there is a dam which was constructed to impound water for irrigation and

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[99] Meinzer, O. E., Large springs in the United States: U. S. Geol. Survey Water-Supply Paper 557, p. 37, 1927.

[100] Idem, p. 38.

which has served to back up the water of the Leona River to form a long, deep pool. Springs at H–8–C supply a part of its flow below this point. Between points D and C there is a large travertine dam.

The Leona River carries calcium bicarbonate water similar to the normal waters of the Leona gravels. At point H–8–D it shows a higher concentration, which may be due in part to stagnation. In passing over the travertine dam between H–8–D and H–8–C the water loses a part of its calcium bicarbonate in the dam. At H–8–D the water apparently comes directly from the Leona gravels, as indicated by its chemical similarity to the water from well H–8–27. From the analyses (see p. 35) it is seen that the Leona River water is also very much like the water of the Edwards limestone.

Three samples of water were taken from the Nueces River and labeled H–1–H, H–7–F, and H–7–G from north to south. H–1–H was taken just within the border of the Edwards Plateau, opposite Chalk Bluff, where the Nueces River flows a goodly stream. H–7–F was taken about 15 miles downstream, where the river bed begins to carry water again, and H–7–G was taken at the Pulliam bridge, about 5 miles farther south. H–1–H is a calcium bicarbonate water containing 203 parts per million of total dissolved solids, with a relatively low content of other constituents. H–7–F has the same mineral content as H–1–H, but it carries a little less calcium bicarbonate and a correspondingly greater amount of calcium sulphate. The other constituents remain about the same in all three samples. H–7–G is similar to H–7–F, except for a slight increase in calcium bicarbonate, and contains 221 parts per million of total dissolved solids.

Sample H–1–H is very similar to the normal type of Edwards water. The similarity in the water of the Nueces above and below that portion of the stream which is nearly always dry suggests that the water of the Nueces disappears near the plateau edge only to reappear later in the stream.

The water entering the Edwards limestone in Uvalde and Medina Counties from the larger streams that cross its outcrop may average 150,000 acre-feet a year. In addition, a considerable quantity of water probably enters the formation directly from precipitation. A part of this water, coming from the Nueces River and possibly from the Frio River, returns to the surface in fault springs south of Uvalde. A small part of the water from the Nueces may return to the river in fault springs in the Nueces below Tom Nunn Hill, although this statement cannot be supported by conclusive evidence. About 3,100 acre-feet annually is brought to the surface in Uvalde and Medina Counties in municipal, irrigation, industrial, and stock wells. The total amount of Edwards limestone water returned to the surface in these counties is less than one-fourth of the water entering the formation from streams. South of these counties the Edwards is commonly less pervious and the water is highly mineralized, indicating that there is not free circulation down the dip and the water that enters the formation does not pass freely into the area south of these counties. For these reasons it is believed that a considerable part of the recharge to the Edwards moves laterally either to the east or to the west.

GROUND-WATER UTILIZATION

Ground water in Uvalde and Medina Counties is used most commonly for domestic purposes and stock. Probably the largest amounts of ground water are used for municipal supplies, industrial processes, and irrigation. The table of well records (pp. 102–127) includes all the wells visited by the writer except a few on which no information was available and shows the water level and the purpose for which the well water is used. Plate 2 shows the location of the wells and irrigated areas. The vicinity of Uvalde is the only part of these counties in which conditions are suitable for the use of ground water for irrigation. A total of 1,902 acres was irrigated in 1929—717 acres with water from the Edwards limestone, 1,040 acres from the Leona formation, and 145 acres from a source that is not definitely known but was either the Leona or the Edwards.

WELL-DRILLING METHODS

Practically all the wells in Uvalde and Medina Counties are drilled with cable tools operated from a portable drilling rig. The wells that are used for irrigation and the municipal wells are commonly 8 to 12 inches in diameter, but most of the wells are drilled for domestic or stock water, and 4 to 6 inch wells are large enough to meet the owners' needs. Many of the older wells are poorly cased because either casing of poor quality was used or the well was cased to a very shallow depth. As a result, many of the older casings are badly corroded and in some wells are completely disintegrated. Many of the wells have caved in, so that it is practically impossible to pull the cylinders to make repairs. Fortunately within the last few years it is becoming more generally recognized that wells should be cased with standard heavy-gage casings fitted together with couplings and that the casing should be extended through all caving formations and properly seated and sealed to prevent contamination either from the surface or from leakage from formations containing highly mineralized water. Most of the wells in the area are equipped with plunger pumps operated by windmills. Electric power is available near Uvalde and near power lines, and some of the irrigation wells and the municipal wells are pumped by turbine pumps electrically operated. Some of the irrigation wells are pumped with power supplied by gasoline engines or Diesel engines, usually with turbine pumps.

SANITARY CONDITIONS

In connection with the geologic and hydrologic studies in this area and in Zavala, Dimmit, and Maverick Counties, to the south, studies were made by Chester Cohen, sanitary engineer, Texas State Department of Health, in regard to the sanitary quality of the ground-water supplies. More than 200 dug and drilled wells were examined with respect to their location and construction, to determine the possibilities of pollution of the ground water before it reaches the wells or by the entrance of contaminating materials into the wells at the top. Samples collected from these wells were sent to the laboratory of the Texas State Department of Health, at Austin, for examination, and the data obtained by Mr. Cohen are filed in the office of that department, for use in public-health administration.

In considering the sanitary quality of any ground-water supply consideration must be given to the purification of such waters through the processes of underground storage and natural filtration. The minimum distance that should exist between a cesspool or a pit privy and a water well is still open to question and depends largely upon the direction of ground-water movement and the permeability of the soil and water-bearing material. To study these and allied problems investigations were made by Mr. Cohen in several localities. Determination of the presence or absence of pollution was largely based on tests for *Bacillus coli.* These bacteria are probably not in themselves harmful, but they are commonly associated with the fecal discharges of man and other animals, and therefore if they are found in a water supply, that supply may also be contaminated by bacteria of the intestinal diseases, such as typhoid, dysentery, and diarrhea.

The results of the investigations indicate that in general the bacteria are not carried far through soil, sand, or other fine-grained material, and that the water in the sand formations is generally safe, especially where these formations are protected by overlying impervious beds. The water in the crevices of the limestone formations was also generally found to be free from pollution, probably in part because of the filtering effects of the overlying soil. However, the water in honeycombed or cavernous limestone is obviously in greater danger of pollution than that in the fine-grained materials.

The results of the investigations also indicate that in most of the wells that yield polluted water the pollution is introduced into the wells at the top, and therefore that the problem of pure water supplies in this area is largely a problem of proper well construction. In one town a bacteriologic examination was made of the water from 26 drilled wells and 16 dug wells. None of the drilled wells gave any evidence of pollution, but 12 of the dug wells showed the presence of *Bacillus coli.* Further investigation of two of the dug wells indicated that the ground water was not polluted before it entered the wells but was polluted after it had percolated into the wells by material that entered the wells from the top. All these wells are rather close to privies, horse and cow lots, or other sources of pollution. Thus air-borne contamination may find its way into the wells through the uncovered tops; contaminated storm water may flow into the wells at the surface or seep into them a short distance below the surface; the repeated lowering of a bucket, rope, or chain into a well may introduce contamination from the hands of the operator; and the priming of a pump with surface water may also introduce pollution. It is probable that dug wells would generally be free from pollution if they were provided with durable water-tight curbing to the water table, substantial water-tight covers, and pumps that were kept free from pollution. Nevertheless, there is more safety in drilled wells if they are provided with heavy casings seated on a water-tight confining bed or carried a considerable depth below the water table, and if they are tightly sealed at the top and provided with pumps.

Some of the defects of the wells in the area are summarized by Cohen in the following paragraphs. Fortunately these defects do not invariably result in contamination of the water supply, but they are, nevertheless, objectionable because they are conducive to contamination.

Numerous sanitary defects of varying degrees of seriousness were noted during the investigation. Many of the wells were improperly located with respect to topography, being located in low areas in which the drainage was toward the well. Such areas serve as collecting basins for surface water, which may find its way into the well either by percolation downward along the sides of the casing or by actually flowing over the top of the casing or curbing into the well and thus contaminate the supply. In many wells the casing has become so corroded as to permit the entrance of surface water through the casing walls. Commonly the casing is open at the top, permitting entrance of small animals to the well, especially in windmill wells.

In many cases the drill hole is left open and unprotected during the interval between the completion of the well and the setting of the pump, allowing contamination by entrance of surface water, small animals, or air-borne fecal material. Polluted surface water is sometimes used in drilling operations and serves to contaminate the water-bearing bed. Materials introduced into the well, such as casings and screens, gravel packing, leather plungers and valves, pump bowls, sucker rods, and canvas seals, should be disinfected either before or immediately after being set in place. Often these materials are not disinfected and serve as seeding media for bacterial development.

Many of the deep-well turbine pumps have openings in the pump base which permit oil and pump seepage from the packing glands, as well as dust infection and surface pollution, to enter the well. Inasmuch as it is often necessary and desirable to test the static level of the water in the well, the opening used for this purpose should be closed with a threaded plug when not in use. A further continuous source of pollution is the oil or grease lubrication used in the lower bearings of the pump. This is a point that should receive some study, because in practically every well supply it was noted that the oil passes directly from the oil tubing into the water just below the pump bowls. During the last several years we have had a number of complaints of tastes and odors where an oversupply of oil was fed into the pump for lubrication.

Where a supply is used only for irrigation purposes there is no particular objection to these defects in construction, but inasmuch as practically every supply examined in the area is used also for drinking purposes, it becomes important that proper attention be paid to these sanitary items. Of course, during prolonged dry periods there is less likelihood of surface pollution entering a well than during rainy seasons. However, many of the avenues which permit the entrance of surface wash also permit the entrance of air-borne contamination and pollution directly through human and animal agencies.

In wells having deep-well turbine pumps the most satisfactory construction consists of mounting the pump on a concrete block base and so setting the pump as to form a perfectly tight seal at the casing top and exclude all possible exterior contamination.

WELL TABLES

In the following tables the figures given for "Altitude" have either been determined by levels run from previously established bench marks by E. E. Harris, of the United States Geological Survey, or by the Messrs. Coble, or estimated from the topographic map. The error in the altitudes estimated from the Uvalde quadrangle is probably not more than 10 feet. On the Hondo quadrangle, however, the altitudes may be as much as 25 feet in error. At most wells the bench mark from which depth to water was measured was located at the top of the water-pipe clamp. At a few wells the clamps consisted of two 4- by 4-inch timbers, one placed on each side of the drop pipe (the pipe through which water is delivered to the surface), bolted together. This clamp holds the pipe tightly and is so adjusted that it rests on top of the casing and supports the water pipe in the well. The type of clamp commonly used in Uvalde and Medina Counties consists of an iron collar with a flange on the lower side (fig. 3). This flange is placed on top of the casing, and the drop pipe passes through the collar. When the drop pipe is in the correct position 3 or 4 iron wedges are inserted into the slots prepared for them and driven home to hold the pipe firmly in place. This leaves a section of an annular opening between the pipe and the collar and any two wedges, through which a tape weighted with lead may be inserted for measuring depth to water. Where wooden clamps were used it was not always possible to get the tape into the casing for making a measurement.

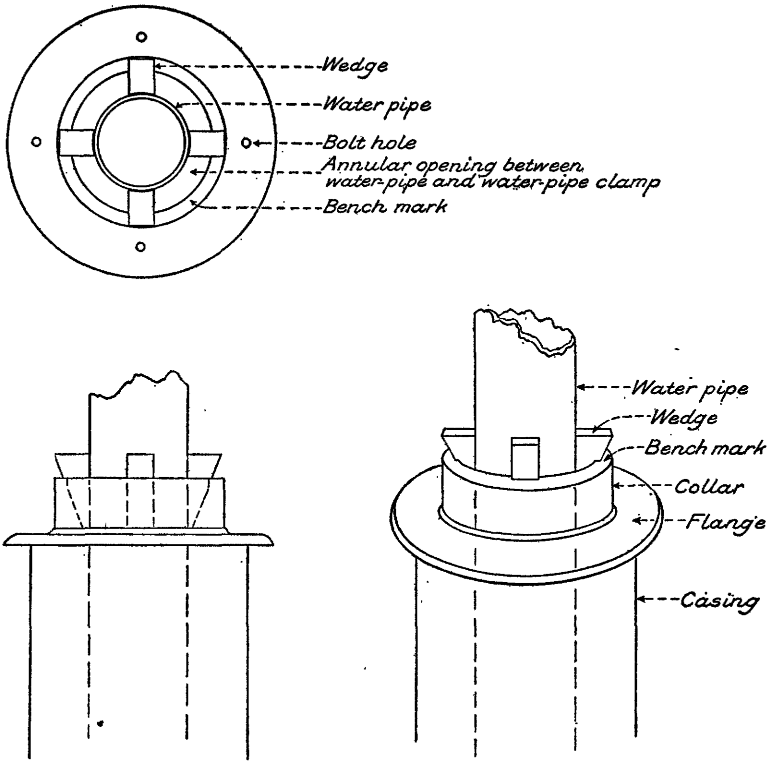

FIGURE 3.—A type of drop-pipe supporting clamp commonly used in wells in Uvalde and Medina Counties, Tex.

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet) [a]	Type of well [b]
A-9-1	4 miles west of Montell	Cloudt	Phantom Oil Co.		1,450±	D
B-8-1	24 miles north of Uvalde	Patterson Bros.	Transcontinental Oil Co.	1920		D
G-6-1	1 mile north of Carbondale	J. B. Smythe	Gulf Production Co.	1916	950	D
G-9-1	20 miles southwest of Uvalde.	J. B. & W. A. Smythe.	Pure Oil Co.		1,200	D
G-9-2	do	do	do		1,150	D
D-7-1 [f]	3 miles southwest of Medina Dam.	Max Boehme		Old		D
D-7-2 [f]	1 mile east of Habŷ crossing	A. Haby			928.50	D
D-7-3 [f]	3 miles east of Medina Dam	do			1,147.52	D
D-7-4 [f]	2.7 miles east of Medina Dam.	do			1,156.19	D
D-7-5 [f]	4 miles east of Medina Dam	do			1,153.75	D
D-7-6 [f]	1.2 miles west of cliff	Schuchart estate				D
D-8-1 [f]	At cliff	do				D
H-2-1	9.2 miles north of Uvalde	Meyer	M. L. Hale	1925	1,059	D
H-2-3	10.2 miles north of Uvalde	C. L. Farrish	G. C. Sanderlin	1916		D
H-2-4 [h]	13.7 miles north of Uvalde	J. H. Desmuke		1894	1,155.68	D
H-2-5 [h]	17.8 miles north of Uvalde	Judge Flores			1,176.32	D
H-2-6	12 miles northeast of Uvalde.	L. L. Gilleland	G. C. Sanderlin	1913	1,074.0	D
H-2-7	do	do	do	1909	1,070	D
H-2-8 [h i]	12.5 miles northeast of Uvalde.	F. C. Brigman		1895	1,074.01	D
H-3-1 [i]	13 miles northeast of Uvalde.	G. C. Sanderlin	G. C. Sanderlin	1910	1,068.78	D
H-3-2	15 miles northeast of Uvalde.	Mark Upson	—— Brumley	1917	1,070	D
H-3-3	18 miles northeast of Uvalde.	Mrs. Pearl Scott	G. C. Sanderlin		1,100	D
H-3-4 [h]	do	Rimkus		1909	1,131.95	D

See footnotes at end of table.

Medina Counties, Tex.

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed		Height of bench mark above ground level (feet)	Water level		Use of water [d]	Remarks
		Character of material	Geologic horizon		Below bench mark (feet) [c]	Date of measurement		
[e]1,635	15½						N	Oil test; water at 260, 275, 845, 1,056, 1,095, 1,175, 1,230, 1,310, 1,340, 1,377, 1,392, 1,425, 1,505, 1,549, 1,569, and 1,610 feet. (See log, p. 133.)
3,930	15						N	Oil test; water at 11-85, 775, 1,330, and 1,627 feet; salt water at 2,800 feet. (See log, p. 133.)
2,625	12½							Oil test; water at 63 feet; sulphur water at 1,426, 1,494, and 1,994 feet. (See log, p. 134.)
4,810							N	Oil test; water at 1,920, 2,100, 2,122, 2,465, 3,570, and 3,880 feet. (See log, p. 135.)
2,445							N	Turbine pump and electric motor; yields about 280 gallons a minute, according to driller. (See log, p. 136.)
600		Limestone	Edwards and Glen Rose.		[g]300±	Jan. 15, 1934	D, S	Owner reports that well has caved below 300 feet.
444	6	do	Edwards	1.5	148.28	Jan. 8, 1934	D, S	
500	8	do	Edwards and Glen Rose.	.5	213.70	do	S	Principal water supply from Glen Rose.
586	8	do	do	1	221.43	do	S	Do.
500	8	do	do	1.5	94.58	do	N	
400−		do	Edwards			Jan. 11, 1934	D	
520	7	do	do		301+	do		
500	6	do	do	1.0	221	Nov. 22, 1929	D, S	Owner reported depth to water as being 90 feet originally.
386	6	do	do		249	Nov. 30, 1929	D, S	Owner reported 190 feet to water.
190+	6	do	do	2.1	185.84	do	D, S	
100+	5	do	do	1.5	89.87	do	D, S	A gasoline engine is used as an auxiliary source of power in case of failure of wind.
270	6	do	do	.3	210.90	Dec. 3, 1929	D, S	
250	6	do	do	.5	220.8	do	D, S	
300	6	do	do	2.7	236.49	do	D, S	A gasoline engine is used for power. Temperature 69.5.[e f]
440	6	do	do	0	345		D, S	
398	5	do	do	0	340	1917	D, S	Gasoline engine is used as an auxiliary source of power in case of failure of wind.
	6	do	do		240+	Dec. 24, 1929	D, S	Do.
	6	do	do (?)	.7	233.43	Dec. 3, 1929	S	

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
H-3-5	13.5 miles northwest of Sabinal.	Santleben			1,200	D
H-3-6	15.5 miles northwest of Sabinal.	Sid Bates			1,350	H
H-3-7	11 miles northwest of Sabinal.	Glotch		1925	115	D
H-3-8	8.5 miles northwest of Sabinal.	K. Trulo			1,055	D
H-3-9	3.5 miles northwest of Sabinal.	H. M. Waldrip	Charley Tyler	1925	998.82	D
H-3-10	5 miles west by north of Sabinal.	Spence estate			1,001.05	D
H-3-11	6 miles west by north of Sabinal.	Mrs. W. A. Kelly		1912	1,028.65	D
H-3-12 [h]	8 miles west by north of Sabinal.				1,011.82	D
H-3-13	16 miles east by northeast of Uvalde.	Alexander	—— Niemeyer	1904	1,006.5	D
H-4-1	5 miles northwest of Uvalde.	Joe Richarz	G. C. Sanderlin		940	D
H-4-2	58 miles northwest by west of Uvalde.	E. Gray	John Roberts	1928	985.02	D
H-4-3 [i]	75 miles west-northwest of Uvalde.	Harper			1,009.96	D
H-4-4	7.5 miles northwest by west of Uvalde.	Patterson		1904	1,025	D
H-4-5	9 miles northwest by north of Uvalde.				1,040.49	D
H-4-6 [h]	4.5 miles west-northwest of Uvalae.	Briscoe, Fenley & Spangler.			952.97	D
H-4-7	6 miles west-northwest of Uvalde.				967.81	D
H-4-8 [h]	7.6 miles west-northwest Uvalde.	J. T. Hall		1912	939.83	H, D
H-4-9	do	do			952	D
H-4-10	do	R. L. Herrington			935	H, D
H-4-11	7.5 miles west-northwest of Uvalde.	DeHood Barber			939.22	D
H-4-12	7.5 miles west by north of Uvalde.	Lewis Stearns			900	D
H-4-13 [h]	4 miles west by north of Uvalde.	B. B. Dunbar		1929	949	D
H-4-14	do	do			949.02	D
H-4-15	3.5 miles north of Uvalde	Witts			934.88	D
H-4-16	3.4 miles north of Uvalde	Young			936.90	D
H-4-17	3 miles west of Uvalde	Witts			928.08	D
H-4-18 [h]	do	do			926.89	D
H-4-19	2.5 miles west by south of Uvalde.				935.15	D
H-4-20	3 miles west by south of Uvalde.	Ashur			910.0	H
H-4-21 [h]	4 miles west of Uvalde				938.14	D
H-4-22	4.8 miles west of Uvalde	Meacham			941.96	D
H-4-23	6 miles west by south of Uvalde.	A. Milam			920	D
H-4-24	7 miles southwest by south of Uvalde.	Smith			915	D
H-4-25	6.5 miles west of Uvalde	Monguam	Munroe Fenley		907.06	D
H-4-26	7 miles west of Uvalde				900	H
H-4-27	do	Meacham			899.50	D
H-4-28 [h i]	7.4 miles west of Uvalde	J. R. Ingraham			898.54	H, D
H-4-29	8 miles west of Uvalde	do			900	D
H-4-30	11 miles west of Uvalde				955	D
H-4-31	3.5 miles west-southwest of Uvalde.	R. S. Edmonds		1909	960	D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
	6	Limestone	Edwards	1.3	200	Jan. 4, 1930	S	
21	4	do	do	1.5	18.55	do	N	
450	8	do (?)	do (?)	.5	447(?)	Dec. 17, 1929	S	Blowing well.
	5				300+	do	D, S	Small yield.
	8			1.3	175.52	Dec. 10, 1929	D, S	Do.
275+	6			.5	240.87	Dec. 11, 1929	D, S	Do.
400+	6	Limestone	Edwards		300+	do	D, S	Large yield.
	6			1.1	263.30	do	S	
520	5	Limestone	Edwards	.9	346	Dec. 4, 1929	D, S	Small yield.
200	6	do	do	1.2	109.5	Nov. 22, 1929	D, S	Owner measured depth to water of 60 feet in 1928.
206	6	do	do	1.2	116.75	do	D, S	
	6	do	do	.5	140	do	D, S	
185	6	do	do			Nov. 23, 1929	D, S	Obstruction in casing; no measurement of depth to water possible.
	6	do	do (?)	.5	159.7	do	D, S	
100+	8			2.4	83.95	Oct. 7, 1929	S	
	6			2.6	94.4	Oct. 9, 1929	D	Abandoned.
135	8	Gravel	Leona	1.5	65.10	do	D	75 feet of casing; rope and bucket lift.
119	8			1.0	84	do	D, S	
		Gravel	Leona	0	72	Apr. 10, 1930	D, S	
	6	do	do	2.5	55.15	Oct. 9, 1929	D, S	
	6	do	do	1.0	44.9	do	D, S	Gasoline engine used as source of power.
500	10	Limestone	Edwards	0	70	Oct. 7, 1929	I	
400	8	do	do. (?)	1.4	83.3	do	D, S	
	6			3.0	75.2	do	N	
	6			3.0	76.85	do	S	
	8			.5	100+	do	D, S	
250	6	Limestone	Austin (?)	.5	91.90	do	D, S	Small yield.
199	6		do		73.8	Oct. 2, 1929	D, S	
150	72	Chalk	do				D, S	Do.
	6		do. (?)	2.7	77.3	Oct. 2, 1929	D, S	
	4		do. (?)	.7	81.63	do	S	Auxiliary gasoline engine used for power when wind fails.
	6	Chalk (?)	Austin	1.3	40.78	Oct. 4, 1929	D, S	
	6	Gravel	Leona	2.0	41.26	do	D, S	
160	4	Chalk	Austin		42.3	Sept. 23, 1929	D, S	Small yield.
	48	Gravel	Lower terrace	3.0	51.90	Oct. 3, 1929	N	
	6	do	do	2.5	35.12	Oct. 2, 1929	D, S	Large yield.
	5	do	do	1.5	29.99	Oct. 3, 1929	D, S	Auxiliary gasoline engine.
	6	do. (?)	do. (?)	.3	45.95	do	S	
	6			1.5	59.20	Nov. 14, 1929	S	
96	6			1.6	63.5	Oct. 18, 1929	D, S	63 feet of casing.

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
H-4-32	7 miles west-southwest of Uvalde.	A. Milam			920	H
H-4-33	7.5 miles west by south of Uvalde.	W. A. Allen			890	D
H-5-1	Uvalde	City of Uvalde			904.85	D
H-5-2	do	Uvalde Electric & Ice Co.	G. P. Laird	1919	910	D
H-5-3 [i]	Northwest of Uvalde	Luis Borgas		1925	908	H, D
H-5-4	West of Uvalde	Canales			909	H
H-5-5	1.5 miles west by south of Uvalde.	Jesus DeLeon	Munroe Fenley		910	D
H-5-6	2.3 miles west by south of Uvalde.	Lane's Rock Hill Dairy.			910	D
H-5-7	2.5 miles west by south of Uvalde.	Hagood			920	D
H-5-8	1.7 miles west-southwest of Uvalde.	R. P. Rainey			900	D
H-5-9	2 miles west-southwest of Uvalde.	W. J. Malarkey	J. W. Roberts	1929	900	D
H-5-10	2.5 miles west-southwest of Uvalde.	Brashier			910	D
H-5-11	3 miles west-southwest of Uvalde.	G. L. James		1912	915	D
H-5-12	1.5 miles west by north of Uvalde.	T. H. McNelley			920	D
H-5-13 [i]	2.5 miles west-northwest of Uvalde.	John Monigan	Munroe Fenley	1927	925	D
H-5-14	2.6 miles west-northwest of Uvalde.	Charles Bowman	do	1929	930	D
H-5-15	2.3 miles northwest of Uvalde.	C. S. Bowman	do		930	D
H-5-16	2 miles north by west of Uvalde.	E. H. Barber		1915		D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
	36	Chalk	Austin	3.0	41.85	Oct. 4, 1929	D, S	
84	6	Limestone	do. (?)			do	D, S	
350	12	do	Edwards		48.73	Nov. 7, 1929	M	There are 5 drilled wells in bottom of a sump—4 shallow wells less than 100 feet deep and 8 inches in diameter and the deep well here listed. It is thought that most of the water comes from the deep well. Two horizontal centrifugal electrically operated pumps deliver 750 gallons a minute each and develop a draw-down of about 8 inches.
403		Limestone	do				M	
64	48	Gravel	Leona	2.5	63.6	May 19, 1930	D	Rope and bucket.
48	48	do	do	3.0	48.03	Sept. 23, 1929	D	Well dry. Rope and bucket lift.
101	6	Limestone	Edwards		52.73	Oct. 2, 1929	D	
		do	do. (?)	.8	47	do	D, S	
81	8				53.71	Sept. 23, 1929	D, S	
	8			2.1	48.5	Oct. 18, 1929	D, S	
598	10	Limestone	Edwards		*a* 45	do	I	
	6			1.2	51.80	do	S	
120	6⅝			1.4	53.9	do	S	
	5			1.0	54.85	Oct. 22, 1929	D	Plunger pump with gasoline engine.
475	10	Limestone	Edwards		66.4	Oct. 21, 1929	I	Turbine pump with 25-horsepower electric motor delivers 650 gallons a minute to irrigate 150 acres of feed crops. Draw-down is 0.3 foot. (See log, p. 136.)
107	12	do	do		69.5	do	I	Turbine pump with gasoline engine delivers 1,175 gallons a minute to irrigate 200 acres of feed crops.
540		do	do				N	Turbine pump and electric motor. Well yields about 280 gallons a minute, according to driller. (See log, p. 137.)
110	(?)	do	do	1.5	73±		D	

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
H-5-17	2.3 miles north-northwest of Uvalde.	George Clark		1909	926.34	D
H-5-18	2.4 miles north-northwest of Uvalde.	Mrs. F. F. Spires			927.65	D
H-5-19	3.3 miles north-northwest of Uvalde.	J. D. Scott			935.58	D
H-5-20	3.8 miles west by north of Uvalde.	Moos			947.28	D
H-5-21	4.4 miles northwest of Uvalde.	J. G. Finch				D
H-5-22 [h]	2 miles north of Uvalde	Jack Dean			934.51	D
H-5-23	do	Frank McKenzie		1913	928.00	D
H-5-24	4.7 miles north-northeast of Uvalde.	M. E. Walker		1914	992.05	D
H-5-25	5.1 miles north-northeast of Uvalde.	George Kennedy		1905	984.73	D
H-5-26 [h, i]	7.2 miles north-northeast of Uvalde.	do		1905	1,023.18	D
H-5-27	8 miles north-northeast of Uvalde.	William Higley	G. C. Sanderlin	1908	1,041.42	D
H-5-28	9.5 miles north-northeast of Uvalde.	George Kennedy			1,070.0	D
H-5-29	10.2 miles northeast by north of Uvalde.	Nellie Hairston	——Crawford	1925	1,065.0	D
H-5-30	East Uvalde	Juan B. Reyes	——Moore		902.48	H, D
H-5-31	4 miles east of courthouse at Uvalde.	W. H. Hill		1903	899.99	H, D
H-5-32	0.7 mile east by north of Uvalde.	J. M. Pile		1922	918	D
H-5-33	1.2 miles east of Uvalde	J. E. Pucini		1905	907	D
H-5-34 [i]	2.5 miles east of Uvalde	Houston	Century Oil & Gas Co.		950	D
H-5-35	3.5 miles east by north of Uvalde.	Hooper			962	D
H-5-36	6.3 miles east by north of Uvalde.	Houston		1909	958	D
H-5-37	1 mile east by north of Uvalde.	John Allison	Munroe Fenley	1930	950	D
H-5-38 [h]	1.7 miles east-northeast of Uvalde.				913.67	D
H-5-39 [h]	2.5 miles east-northeast of Uvalde.	William Galloway	Munroe Fenley	1926	951.98	D
H-5-40	5 miles northeast of Uvalde	Walcott	Bell Oil & Gas Corporation.		1,000	D
H-5-41	6.9 miles northeast of Uvalde.	J. D. Mahaffey			962.11	D
H-5-42 [h]	6.6 miles northeast of Uvalde.	do	——Saunders		945.77	D
H-5-43	8.9 miles northeast of Uvalde.	W. H. Cramer		1925	979.42	H, D
H-5-44	1 mile south by west of Uvalde.	J. H. Zackary		1929	908.69	D
H-5-45	do	W. R. Tate		1899	905	D
H-5-46	1 mile south of Uvalde					D
H-5-47	do	W. H. Petty				D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
138	4	Limestone	Edwards	1.2	66.85	Nov. 21, 1929	D	
142	6	do	do	2.5	68.30	Nov. 22, 1929	D	
110		do	do	.5	78.75	do	D, S	
100+	6	do	do	.4	89.90	do	D, S	
	6					do		
190	6	do	Edwards	.65	78.55	Nov. 20, 1929	D	
100+	(?)	do	do	.5	84.50	do	D	1.5-horsepower gasoline engine and plunger pump.
200	5	do	do	2.0	140.80	do	D, S	
200	6	do	do	2.0	135.95	do	D, S	
200	7	do	do	1.8	186.02	do	S	
221	4	do	do		198.5	Nov. 21, 1929	D, S	
520	6	do	do	.7	250.0	do	S	
254	6	do	do	1.0	200+	do	D, S	Obstruction in well due to lack of casing below first joint.
100+	6	do	do	2.9	47.70	Feb. 5, 1930	D	Rise in Leona due to rains has no immediate effect on well, according to owner.
63	60	do	do. (?)	4.1	46.09	Feb. 6, 1930	D	
180	5	do	do	1.3	59.15	Nov. 7, 1929	D	
79	8	Gravel	Leona	.7	56.20	do	D, S	
713		Limestone	Edwards (?)					Oil test; water in Edwards at 275 feet.
	8	do	Edwards	.3	94.77	Nov. 26, 1929	S	
100	6	Gravel (?)	Leona (?)	1.2	54.28	do	D, S	
120+		Limestone	Edwards				D	
	6	do	do	3.8	57.93	Dec. 5, 1929	N	
135		do	do	1.2	99.50	do	D, I	Gasoline engine with plunger pump irrigates 2 acres of onions.
3,030	15	Sand	Paleozoic				N	Oil test; water at 210–675 feet. (See log, p. 137.)
700(?)	6	(?)	(?)	.7	97.25	Dec. 5, 1929	D, S	Small yield; depth may be 700 feet, according to F. M. Getzendaner.
250+	4	Limestone	Edwards (?)	.5	87.60	Jan. 27, 1930	S	
200(?)	36		Probably Austin.	2.6	104.58	Dec. 9, 1929	D, S	
60(?)	6	Limestone	Edwards (?)	1.5	51	Oct. 5, 1929	D	
85	6	do	do			do		Could not measure depth to water.
	6					do		
	6					do	D	Obstructions in casing prevented measuring depth to water.

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
H-5-48	1.5 miles southwest of Uvalde.	Mrs. John Laird	——Laird	1909	895	H, D
H-5-49	do	do	do	1908	895	H, D
H-5-50	1.5 miles south-southwest of Uvalde.	San Antonio, Uvalde & Gulf R. R.	Munroe Fenley		895	D
H-5-51 [h] [i]	2.5 miles south-southwest of Uvalde.	O. T. Cardwell			909.54	D
H-5-52 [i]	1.3 miles south of Uvalde	Ingraham & Jenkins.	Munroe Fenley	1927	901.38	D
H-5-53	1.6 miles south by east of Uvalde.	W. R. Sweringen	——Sweringen	1928	898.42	D
H-5-54	do	Mrs. L. M. Burge			893.89	D
H-5-55	1.5 miles south-southeast of Uvalde.	T. G. Hines		1927	882.48	H
H-5-56 [i]	1.7 miles south-southeast of Uvalde.	do		1928	885.08	H
H-5-57	1.8 miles south-southeast of Uvalde.	W. R. Sweringen	—— Sweringen	1924	880.42	H, D
H-5-58	2 miles southeast by east of Uvalde.				915	H
H-5-59	2.4 miles east-southeast of Uvalde.	W. M. Bearers		1906	925	D
H-5-60	2.1 miles southeast by south of Uvalde.	J. W. Boggus		Old	895	D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
80	6	Gravel	Leona	0.8	44.7	Oct. 8, 1929	D	
80	60	do	do			do	I	A turbine pump driven by a crude oil engine supplies 600 gallons a minute and irrigates 80 acres of spinach and feed crops. No draw-down reported by owner. Well is dug to 40 feet and drilled from 40 to 80 feet.
75	6	do	do	.6	33.9	Oct. 5, 1929	S	
85	6	Limestone	Edwards		52.90	do	S	
600	10	do	do		35	Oct. 25, 1929	I	Could not measure. Figure given is driller's measure when well was drilled. A turbine pump and electric motor delivers 250 gallons a minute to irrigate 20 acres of truck produce. (See log, p. 137.)
650.0	12	do	do	.6	41.60	Oct. 24, 1929	I	Turbine pump and 25-horsepower gasoline engine delivers at capacity 1,000 gallons a minute; irrigates 100 acres of food stuffs.[a]
		Gravel (?)	Leona	1.5	38.7	do	D, S	
31	50	do	do	.5	27.6	do	I	Turbine pump with 10-horsepower gasoline engine delivers at capacity 500 gallons a minute to irrigate 10 acres.[a]
33	50	do	do		31.4	do	I	Turbine pump with 15-horsepower gasoline engine delivers at capacity 500 gallons a minute to irrigate 40 acres of corn, maize, alfalfa, and spinach.
270	*8	{Gravel Limestone	do Edwards	} 1.0	26.2	do	I	Lots of water in the gravel; perforated casing through gravel. Do not know if there was any water in the Edwards. Turbine pump with gasoline engine delivers 600 gallons a minute and irrigates 25 acres of spinach and alfalfa in a pecan grove.[a]
55.8	4	Gravel	Leona	.5	52.7	Oct. 7, 1929	N	Plunger pump with gasoline engine.
100	6	do	do	.85	60.6	do	D, S	
80	5					Oct. 31, 1929	D, S	Could not measure.

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
H-5-61	21 miles southeast dy south of Uvale.	J. W. Roggus	—— Roberts	1929	896	D
H-5-62	2.2 miles southeast by south of Uvalde.	Ramon Rodriquez		1929	894.64	H
H-5-63	3.2 miles southeast by south of Uvalde.				892	D
H-5-64	4.1 miles southeast by south of Uvalde.				878	H
H-5-65	1.7 miles south of Uvalde	W. R. Sweringen	—— Sweringen	1924	900	D
H-5-66	2.1 miles south-southeast of Uvalde.	Mrs. L. M. Burge		1926	890	D
H-5-67	1.8 miles south-southeast of Uvalde.	do		1927	875	H, D
H-5-68	2 miles south by east of Uvalde.	Vosatko Bros		1924	858	H
H-5-69	2.3 miles south of Uvalde				880	D
H-5-70	2.5 miles south by east of Uvalde.	W. H. Godball		1911	878	H
H-5-71	2.9 miles south by east of Uvalde.				870	H
H-5-72	7.2 miles east-southeast of Uvalde.	Mrs. M. Connor		1908	890	D
H-5-73	1.7 miles south-southeast of Uvalde.	Mrs. L. M. Burge		1927	878.0	H
H-6-1[h]	9.2 miles northeast by east of Uvalde.	Kincaid estate		Very old	981.15	D
H-6-2	10 miles northeast by east of Uvalde.	Texas Trap Rock Co.		1926	978.17	D
H-6-3	0.7 mile west by south of Knippa.	Decideria Diaz		1922	982.59	D
H-6-4	1 mile northeast of Knippa	Bob Harring	—— Sanderlin		987	D
H-6-5	9 miles west by north of Sabinal.	F. J. Niemeyer	—— Niemeyer	1910	1,010	D
H-6-6	7.8 miles west of Sabinal	E. F. Martin		1917	990	D
H-6-7	8.8 miles west by south of Sabinal.	I. J. Sharey			978.33	D
H-6-8[h]	1.5 miles east by north of Knippa.	Jones & Son		1929	978.32	H
H-6-9	6.1 miles west of Sabinal	Albright				D, H
H-6-10[hi]	2.9 miles west of Sabinal	Herbert Stevens				D, H
H-6-11	3.3 miles southwest by west of Sabinal.	A. J. Owen		1904	950	D
H-6-12	3.2 miles southwest of Sabinal.	do		1909	921	D
H-6-13	5.5 miles southwest by west of Sabinal.	Fred Peters			916.38	D
H-6-14	6.5 miles southwest by west of Sabinal.				929.53	D
H-6-15	7 miles southwest by west of Sabinal.	Bailey		1906	924.1	D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
800	-----	Gravel				Nov. 1, 1929	N	Water encountered in gravel but not in sufficient amount for irrigation.
47	60	do	Leona	0	43.9	do	D	Rope and bucket lift.
	6				39.05	do	D, S	
35.5	36	Gravel	Leona	.5	34.1	do	N	Rope and bucket.
	8	do	do	1.8	41	Oct. 24, 1929	D, S	
300	6	Gravel (?) Limestone	Leona (?) Edwards	2.4	44.6	do	D, S	
325	([1])	Gravel Limestone	Leona Edwards	1.0	18.75	Oct. 28, 1929	I	Centrifugal pump with 10-horsepower electric motor delivers 500 gallons a minute to irrigate about 25 acres.[g]
30	-----	Gravel	Leona	.9	16.55	Jan. 15, 1930	I	Centrifugal pump and crude-oil engine delivers 1,650 gallons a minute to irrigate 55 acres (20 acres of pecans, 35 acres of spinach, corn, etc.).[g]
	12			1.7	28.9	Oct. 24, 1929	D, S	Ford motor and plunger pump.
39.1	40	Gravel	Leona	.5	34.0	Oct. 22, 1929	D, S	Plunger pump with gasoline engine.
23	72	do	River		10.40	Oct. 25, 1929	I	Centrifugal pump with gasoline engine.
350	7	Limestone	Edwards(?)	2.7	67.5	Dec. 5, 1929	S	Drawdown 133.2 feet in 2 weeks.
26	-----	Gravel	Leona			Oct. 28, 1929	I	Turbine pump and 10-horsepower electric motor delivers 750 gallons a minute to irrigate 35 acres of vegetables.
300	6	Limestone	Edwards(?)	1.9	103.90	Dec. 9, 1929	D, S	
946	-----	do	do		[i]139.0	Sept. 20, 1929	M	Air lift and steam compressor. (See log, p. 138.)
97	-----	Gravel	Leona	.8	75.75	Dec. 9, 1929	D	
	6			.7	121.25	do	S	
488	6	Limestone	Edwards	.8	276.27	Dec. 4, 1929	D, S	
180+	-----			.7	124.32	do	D, S	No casing in well.
120	5	Tuff	Austin	1.2	77.93	do	D, S	
89	40	do	do	1.3	78.26	Dec. 9, 1929	S	
160	6	Limestone	Anacacho	2.0	63.40	Dec. 11, 1929	D, S	
77	4	Silt, soil	Leona	.35	68.81	Dec. 10, 1929	D, S	Rope and bucket.
130	7	Limestone	Anacacho	2.9	74.72	do	D, S	
124	8	do	do	2.2	54.80	Nov. 26, 1929	D, S	
67.7	6	Gravel(?)	Leona(?)	1.8	47.4	do	D, S	
110	6			.5	62.78	do	D, S	
96	7	Gravel(?)	Leona	3.0	58.17	do	D, S	

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
H-6-16[h, i]	3.1 miles southeast of Knippa.	Illinois Pipe Line Co.	—— Holderman	1928	934.94	D
H-7-17	10 miles southwest by west of Sabinal.	J. Davis		1929	945	D
H-6-18	11 miles east by north of Uvalde.	Houston			950	D
H-6-19	7.5 miles east-northeast of Uvalde.				940	D
H-6-20	8.7 miles east by south of Uvalde.	Mrs. Connor		1899	860	H
H-6-21[h, i]	9.2 miles east by south of Uvalde.	do			834.5	H
H-7-1	5.5 miles west-southwest of Uvalde.					D
H-7-2[i]	10.8 miles west-southwest of Uvalde.	Smythe Bros			920	D
H-7-3	9.4 miles southwest of Uvalde.	Anderson no. 1	Union Oil Co		800	D
H-7-4	9.5 miles south-southwest of Uvalde.	Pulliam no. 1			795	D
H-7-5	9.7 miles south-southwest of Uvalde.	Pulliam no. 6	Munroe Fenley		805	D
H-7-6	8.3 miles south-southwest of Uvalde.	N. B. Pulliam, Jr.		1909		D
H-8-1	3.3 miles south-southwest of Uvalde.				960	D
H-8-2	4.1 miles south-southwest of Uvalde.	Hines & Monagin			950	D
H-8-3	4.6 miles south-southwest of Uvalde.	Dr. B. M. Hines				D
H-8-4	4.8 miles south-southwest of Uvalde.	Dr. Roberts		Very old.	950	D
H-8-5	3.2 miles south by east of Uvalde.	R. M. Simmonds	Sam Bunting	1917		D
H-8-6	do	Sam Jones		Before 1912.		D
H-8-7	3.5 miles south by east of Uvalde.	do	Sam Bunting	1915		D
H-8-8	3.8 miles south by east of Uvalde.	do	do	1915		D
H-8-9	3.5 miles south-southeast of Uvalde.					H
H-8-10	4.6 miles southeast by south of Uvalde.	Aten		1929	831	H
H-8-11	do	Will White		1925	830	H
H-8-12	4.5 miles southeast by south of Uvalde.	do		1925	828	H
H-8-13[h, i]	5.2 miles southeast by south of Uvalde.	Lee		1907	869.97	H
H-8-14	5.8 miles southeast by south of Uvalde.	do		1924	862.89	H

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
1,330	6	Limestone	Edwards	0.06	194.29	Dec. 11, 1929	I	Plunger pump and electric motor; draw-down over 100 feet at 8 to 10 gallons a minute in 7 hours; temperature 86°.
	6			3.8	71.74	Nov. 27, 1929	D	Probably draws water from the Austin chalk.
997		Limestone(?)	Edwards(?)				S	Drilled as an oil test well but is now used as a stock well.
66.45	6	Gravel	Leona	1.1	66.45	Nov. 26, 1929	D, S	
66	72	do	do	2.2	63.05	Nov. 6, 1929	D, S	
32.5	60	do	do	2.0	26.55	do	D, S	
					100+	Oct. 18, 1929	D, S	
2,000	6	Limestone	Edwards		17.62	May 5, 1930	S	Well has large draw-down, 118 feet 30 minutes after pumping.
3,147							N	Drilled as an oil test well; water not reported. (See log, p. 138.)
1,305							N	Drilled as an oil test well; water at 361–399, 520, and 910 feet.
2,454		Limestone	Edwards				N	Drilled as an oil test; snlphur water flowed over top of casing from Edwards limestone.
	6			1.3	154.6	Nov. 18, 1929	S	
	6				100+	Oct. 5, 1929	S	
	6	Limestone(?)	Edwards (?)	.7	83.6	Nov. 15, 1929	S	
300	6	Trap rock		1.7	94.4	Oct. 8, 1929	D, S	
150	5			1.8	80.90	Oct. 7, 1929	S	
200	8			.5	38.3	Oct. 22, 1929	D, S	
75	4			1.0	46.35	Oct. 24, 1929	D, S	
180	6			.5			S	
180	6				45.00	Oct. 24, 1929	D, S	
37	48	Gravel	Leona	2.1	33.00	Oct. 25, 1929	D, S	Rope and bucket lift.
39.2	60	do	do	1.0	37.6	do	D, S	
39.5	48	do	do	0	36.35	do	I	Turbine pump with gasoline engine irrigates 20 acres of cane and corn.
39.7	48	do	do	3.3	35.85	do	D, I	Do.
41	36	do	do	.5	39.54	Oct. 26, 1929	S	
40	36	do	do	3.0	35.6	do	D	

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
H-8-15	6.5 miles southeast by south of Uvalde.	Taylor		1907	854.62	H
H-8-16	6 miles southeast by south of Uvalde.	T. P. Lee			120	D
H-8-17	7.3 miles southeast by south of Uvalde.	do				D
H-8-18	7.7 miles southeast by south of Uvalde.	do				D
H-8-19[h, i]	8.8 miles south-southeast of Uvalde.	A. W. West				D
H-8-20	4.7 miles southeast of Uvalde.					D
H-8-21	4.5 miles southeast by south of Uvalde.	Blankenship				H
H-8-22	6.3 miles southeast by south of Uvalde.	J. R. Baylor				H
H-8-23	7.7 miles southeast of Uvalde.	S. T. Gilbert				H
H-8-24	do	do				H
H-8-25	6.6 miles southeast of Uvalde.	Uvalde Pecan Plantation.		1929	847.01	H
H-8-26	7 miles south by southeast of Uvalde.	do				D
H-8-27[i]	7.5 miles southeast of Uvalde.	do			838.83	H
H-8-28	7.8 miles southeast of Uvalde.	do		1899	837.88	H
H-8-29	8.2 miles southeast of Uvalde.	do			834.51	D
H-8-30	8.5 miles southeast of Uvalde.	Mrs. Mayberry		1893	829.26	H
H-8-31	8.2 miles southeast of Uvalde.	Uvalde Pecan Plantation.		1927	831.14	H
H-8-32	9.9 miles southeast of Uvalde.	Ed Downs				H
H-9-1	10 miles southeast of Uvalde.					D
H-9-2	10.2 miles southeast of Uvalde.	Kincaid				H
H-9-3	10.2 miles southeast of Uvalde.	R. T. Brewton				H
H-9-4	10.7 miles southeast of Uvalde.	Brooks				D
H-9-5[h]	11.5 miles southeast of Uvalde.	Kincaid Bros			795	H
H-9-6[h]	13 miles southeast of Uvalde.	do				D
H-9-7	11.5 miles east-southeast of Uvalde.	Uvalde Pecan Plantation.	Mission Drilling Co.	1930	900	D
H-9-8[h, i]	12.2 miles east-southeast of Uvalde.	Kincaid estate				D
H-9-9	13.7 miles east-southeast of Uvalde.	do	Humble Oil & Refining Co.	1924		D
H-9-10	16.5 miles east-southeast of Uvalde.	do	do			D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
38	48	Gravel	Leona	2.7	35.05	Oct. 26, 1929	D	Rope and bucket lift.
120	5	Sand		2.1	91.3	Oct. 29, 1929	S	
	6			.9	67.20	do	S	
	6			.5	86.55	do	S	
400	6	Sandstone	Indio	2.4	85.60	do	S	
57.5	6			.3	37.8	Nov. 1, 1929	D, S	
33.5	48	Gravel	Leona	2.4	31.45	do	D	Do.
60	5	do	do	2.0	40.50	do	D, S	
52.5	72	do	do	0	52.3	do	S	
40.29	60	do	do	3.0	36.75	do	D	Do.
51.5	60	do	do	.5	33.75	do	N	
63	12	do	do			Nov. 2, 1929	I	Turbine pump with gasoline engine delivers 1,800 gallons a minute to irrigate 300 acres of pecans.
41.5	55	do	do	0	32.8	do	I	Turbine pump and Diesel engine delivers 2,000 gallons a minute to irrigate 400 acres; draw-down is 8 feet in 7 hours.
37.5	30	do	do	1.4	31.85	do	D, S	
135	8			2.3	45.05	do	D, S	Water reported alkaline.
34.9	48	Gravel	Leona	3.4	32.9	Nov. 4, 1929	D	
53.8	55	do	do	0	30.4	Nov. 2, 1929	I	Turbine pump with gasoline engine; capacity of pump 2,200 gallons a minute to irrigate 200 acres.
41.90	55	do	do	2.9	38.15	Nov. 4, 1929	D, S	
42.8	7			0	34.25	do	D	Rope and bucket lift.
37	36	Gravel	Leona	3.2	33.05	do	D	
70.3	96			2.0	65.70	do	D, S	
100+	6			2.6	65.20	do	D, S	
41.90	48	Sand	Carrizo	3.5	36.15	do	D	Do.
160	6	do	do.(?)	.8	101.20	Nov. 9, 1929	S	Plunger pump and gasoline engine.
1,160	10						N	Oil test; water at 270, 428, and 838 feet.
150(?)	6	Sand	Indio(?)	.6	108.90	Nov. 4, 1929	S	
1,775					0	1924	N	Oil test; water at 285, 870, 970, 1,680, and 1,706 feet; flowed while bailing. (See log, p. 139.)
2,324	12½						N	Oil test; water at 470, 590, 840, and 1,620 feet.

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
H-9-11	15.5 miles southeast of Uvalde.	Kincaid Bros	Ballard & Underwood.	1924	833	D
I-1-1[h]	1.8 miles north-northwest of Sabinal.	Maynard Fowkes		1909		H
I-1-2[m]	2.5 miles north of Sabinal	Heep		1929		D
I-1-3[i]	4 miles north of Sabinal	E. B. Kincaid			1,010.16	D
I-1-4	4.7 miles east by north of Sabinal.	R. D. Hallern		1917		D
I-1-5	6 miles northwest of D'Hanis.	Rothe no. 1	California Medina Association.	1927		D
I-1-6[f]	8.5 miles northeast of Sabinal.	Walter Albrecht	John Roberts		1,039.59	D
I-1-7[f]	6 miles east of Sabinal	M. T. Schuchart	do	1932	996.99	D
I-2-1[g i]	7.8 miles north of D'Hanis	W. A. Weynand	C. W. Bohnet	1913	993.15	D
I-2-2	5.2 miles north of D'Hanis	Carl Rothe		Very old		D
I-2-4	2.5 miles east of D'Hanis					H
I-2-5	3 miles west by south of Hondo.					H
I-2-6	6 miles north-northwest of Hondo.	E. W. Lacey		Very old	972.73	D
I-2-7[i]	8.2 miles north-northwest of Hondo.	Alfred Schlentz		1918	972.73	D
I-2-8[f]	4.5 miles north by east of D'Hanis.	Joseph Lutz	Peters & Schilling		952.55	D
I-2-9	3.5 miles northeast of D'Hanis.	Robert Zerr	Schweitzer		921.15	D
I-3-1[i]	Hondo	Wilson			887.77	D
I-3-2[i]	do	do	—— Lindholm	1909	887.53	D
I-3-3	4.7 miles north of Hondo	Gus Britch			935.14	D
I-3-4	7.2 miles north by east of Hondo.	H. W. McClain	—— Wiemeis		945.87	D
I-3-5[i]	6 miles north by east of Hondo.	L. H. Heyen		1900	915.9	D
I-3-6[f]	3 miles north of Hondo. Hondo.	Willie Britch	Peters & Schilling	1926	938.51	D
I-3-7[f]	3.5 miles north of Hondo	Hugo Mumme	do	1915	948.88	D
I-4-1[i]	Sabinal	L. F. Heard		1895	957.9	D
I-4-2	West Sabinal	Porfio Flores		1929	949.3	H
I-4-3	do	Gabriel Barda			948.2	H
I-4-4[i]	City well at Sabinal	City of Sabinal		1919	953	D
I-4-5	West Sabinal	José Martínez		1920	950	H
I-4-6	do	Alberto Contrérez			932.2	H
I-4-7[m]	do	Southern Pacific Co.			902.3	H
I-4-8	1.8 miles west-southwest of Sabinal.	W. C. Crews		1910		D
I-4-9	Southwest of Sabinal	M. E. Giffin	Eph Mills	1921	975.04	D
I-4-10[m]	South of Sabinal	Dr. Wood			959.2	D
I-4-11[m]	do	Fowler			948.5	D
I-4-12[m]	Sabinal	Arthur Wood			956.6	D
I-4-13[m]	do	M. A. Gooding			952.7	D
I-4-14[m]	do	Central Power & Light Co.			961.7	H, D
I-4-15[m]	do	Cullins				D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
1,164(?)							N	Oil test.
36	48	Gravel	Leona	1.5	29.97	Dec. 10, 1929	S	Plunger pump and gasoline engine.
89.3		do	do		57.5	Feb. 27, 1930	D	
1,000		Limestone	Edwards	.7	190.22	Feb. 21, 1930	D, S	Large yield.
500	6	do	Anacacho	.2	125.1	Feb. 19, 1930	D, S	
3,213	10		Paleozoic	0	0			
585	5 3/16	Limestone	Edwards	1.5	283.5	Oct. 3, 1934	S	
995	5 3/64	do	do	1.5	256.37	do	S	
285	8	do	do	.6	236.8	May 17, 1930	D, S	
540	6	do	do			do	D, I	
43.5	48	Gravel	Leona	2.6	43.5	Feb. 19, 1930	D, S	
63	48	Sandy lime	Escondido		51.9	do	N	
341		Limestone	Edwards	.4	225	May 17, 1930	D, S	
400	7 5/8	do	do	.8	244.8	do	D, S	Plunger pump and gasoline engine; top of Edwards, 247 feet.
804½	6 5/8	do	do	1.3	205.4	Oct. 3, 1934	D, S	
3,500	12	do	do	1.5	150.74	Oct. 2, 1934	D, S	Drilled as an oil test. Plugged back to 1,100 feet.
1,500		do	do	0	181.37	Feb. 20, 1930	M	Plunger pump.
1,600	12	do	do	0	196.7	do	M	Turbine pump and Diesel engine.
300	6	do	do	1.9	215.8	do	D, S	
237	6	do	do	1.7	219	do	D, S	
278	6	do	do	1.2	189.5	do	D, S	
805	5 3/16	do	do	.8	208.2	do	D, S	
462	10	do	do	.8	205	Oct. 3, 1934	D, S	
130	4	do	Anacacho	1.1	85.25	Feb. 12, 1930	D	
93	36	Gravel	Leona	2.9	88.1	do	D	Rope and bucket lift.
61	36	do	do	2.5	40.6	do	D	Do.
2,700	10	Limestone	Edwards		215.0		M	Two wells, one 1,330 feet deep, the other 2,700 feet deep; turbine pumps with electric motors both draw from the Edwards limestone and deliver 150 to 300 gallons a minute. (See log, p. 139.)
63	36	Gravel Limestone	Leona Anacacho	2.8	55.37	Feb. 12, 1930	D	Rope and bucket lift.
47	36	Gravel	Leona	2.8	43.4	do	D	Do.
	72	Limestone	Anacacho		15.7	Mar. 10, 1930	M	
165	6	do	do	.8	77.72	Dec. 10, 1929	D, S	
970	6	do	Edwards	.65	257.4	Dec. 11, 1929	D	
164		do	Anacacho		91.0	Feb. 26, 1930	D	
70		do	do			Feb. 27, 1930	D	
60		do	do		57.8	Feb. 23, 1930	D	
57.4		do	do		54.0	Mar. 13, 1930	D	
67.2		do	do		54.7	do	M	
62.4		do	do	1.0	57.55	Feb. 19, 1930	D	

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
I-4-16[m]	Sabinal				946.8	D
I-4-17[m]	East of Sabinal					D
I-4-18	3.7 miles east by north of Sabinal.	Ross Kennedy estate.			968.82	D
I-4-19	1.6 miles south by west of Sabinal.	R. D. Garteaser		1900		H
I-4-20	1.9 miles south by east of Sabinal.					D
I-4-21	1.8 miles south of Sabinal	Turner		1929		D
I-4-22	2.7 miles south of Sabinal	Ross Kennedy		Before 1910		D
I-4-23	4.3 miles south of Sabinal	Lee Braden		Very old		H
I-4-24	5 miles south by east of Sabinal.	W. O. Shane		1905		D
I-4-25	7 miles south of Sabinal	Robert Shane		1916		D
I-4-26	8.6 miles south by east of Sabinal.	George Kennedy				D
I-4-27	9 miles south of Sabinal	Lee Braden		1918		D
I-4-28[i]	6.7 miles southwest by west of D'Hanis.					D
I-4-29	6.3 miles southwest of D'Hanis.	Illinois Pipe Line Co.	—— Holdeman		950.76	D
I-4-30[i]	12 miles southeast by south of Sabinal.	Virgil Johnson			788.44	D
I-4-31[f]	8 miles south-southeast of Sabinal.	George Rehm	Rehm et al	1933	870.58	D
I-4-32[f]	4 miles south-southwest of Sabinal.	Quinn Braden			866.35	D
I-5-1[i]	1.2 miles east of D'Hanis					H
I-5-2	9.5 miles south by east of D'Hanis.	Newton no. 1	Mid-Kansas Co	1930		D
I-5-3	11 miles south by west of Hondo.	P. S. Ward no. 1	Grayburg Oil Co			D
I-5-4	7 miles south-southwest of Hondo.	A. L. Haegelin	Medina Oil Co			D
I-5-5	5.6 miles south-southwest of Hondo.					D
I-5-6	5 miles south by west of Hondo.	Taylor no. 1	United North & South Development Co.	1926	845.8	D
I-5-7	5 miles south-southwest of Hondo.	R. J. Taylor	Pruitt & Van Demen.		850	D
I-6-1	3.5 miles southwest of Dunlay.	Neuman no. 1	Maxwell & Turman.			D
I-6-2	10 miles south-southeast of Hondo.	Blackburn no. 1	Ina Oil Co			D
I-6-3	10.5 miles south-southeast of Hondo.	Regina Schmidt	Magnolia Petroleum Co.			D
I-6-4	12 miles south-southeast of Hondo.	L. J. Schmidt no. 1	Witherspoon Oil Co.			D
I-6-5	13.5 miles south-southeast of Hondo.	Jos. Keller no. 1	Magnolia Petroleum Co.			D
I-6-6	12 miles south by east of Hondo.	M. M. Adams no. 6	Henderson & Holden.	1926		D
I-6-7	12.5 miles south by east of Hondo.	J. P. Nixon	Mid-Kansas Oil & Gas Co.	1927		D
I-6-8	3 miles north-northeast of Yancey.	do	Green-Foster	1921		D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed		Height of bench mark above ground level (feet)	Water level		Use of water	Remarks
		Character of material	Geologic horizon		Below bench mark (feet)	Date of measurement		
86					46	Feb. 27, 1930		
						do	D	
1,600	8	Limestone	Edwards	1.5	249.7	Feb. 19, 1930	D, S	
53	60	Gravel	Leona	1.2	49.6	Feb. 12, 1930	D, S	
99+	6	Limestone	Anacacho	1.0	59.03	Feb. 11, 1930	D, S	
120		Basalt	do	0	[a]45			
80+		Limestone	do	.4	55.1	Feb. 12, 1930	D	
50	48	Gravel	Leona	2.3	45.15	do	D, S	
142	48	Limestone	Anacacho	.3	56.4	Feb. 11, 1930	N	
148	6	do	do	1.2	64.45	Feb. 5, 1930	D, S	
175		do	Escondido	.2	130.7	Feb. 11, 1930	D, S	
160	6	do	do		49.1	do	S	
450	7	do	Anacacho		232	May 21, 1930	S	Bad water for drinking.
1,303		do	Edwards	.75	237.5	Apr. 21, 1930	D, I	Electric motor and plunger pump.
2,000	8	do	do	4.35	77.24	Apr. 30, 1930	D, S	Oil test; 1,600 feet to top of Edwards limestone.
1,350	6⅝	do	do	3.1	134.9	do	N	
1,165	10	do	do	0	157.0	Oct. 5, 1934	N	
30	72	Gravel	Leona	2.9	26.7	Feb. 19, 1930	D	
1,990								Oil test; water at 85 and 1,990 feet; driller reported hole full of water at 1,990 feet. (See log p. 140.)
2,196								Oil test; no report on water.
1,950								Oil test; water at 62, 1,097 (salt), 1,837 (sulphur), and 1,873 (fresh) feet. (See log, p. 141.)
211+	6			1.1	132	Feb. 22, 1930	S	
1,425							N	Oil test; now plugged.
1,225	12½				[a]100			Oil test; water at 240 and 1,193 feet.
1,468							N	
2,006							N	Oil test; water at 36, 126, and 1,895 feet; fresh water at 1,895 feet. (See log, p. 141.)
2,048							N	Oil test; water in Edwards at 2,040 feet.
2,262							N	Oil test; no water reported.
1,029	10							Gas well; 2,000,000 cubic feet of gas.
944	10							Gas well; 15,533,480 cubic feet of gas.
946	10							Gas well; 16,000,000 cubic feet of gas.
1,500	8					Feb. 17, 1930	S	Flows with gas; oil test.

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
I-7-1	16 miles south by east of Sabinal.					D
I-8-1	5 miles north-northeast of Frio Town.	G. A. Blackaller	Joe Gray			D
I-8-2	15 miles south of D'Hanis	do	Medfrio Oil Corporation.			D
I-8-3	do	Little				D
I-8-4	5 miles west by south of Yancey.	Martin	—— Swartz			D
I-8-5	4.1 miles southwest of Yancey.	John Little			669.15	H
I-8-6	4.6 miles southwest of Yancey.	do			658.70	H
I-8-7	3.1 miles southwest of Yancey.					H
I-8-8	1.7 miles west-northwest of Yancey.	M. W. McCaughan		1910		D
I-8-9	2 miles west-northwest of Yaucey.	W. P. Ward		1900		D
I-8-10[i]	3 miles west-northwest of Yancey.	Frank Martin				D
I-9-1	1.5 miles south-southwest of Yancey.	John Faseler	John Weiners		690.75	D
I-9-2	3 miles southeast of Yancey.				647.32	D
I-9-3	4 miles southeast of Yancey.	Wilson			676.16	D
I-9-4[i]	4.5 miles northwest of Moore.	Crane			663.83	D
I-9-5	2 miles east of Yancey				670	D
I-9-6	2.3 miles east of Yancey	Fritz Falder		Old		H
I-9-7	3 miles east of Yancey	Henry Faseler		Old	664.39	D
I-9-8	4.9 miles east of Yancey	Aldo McAnelly			693.4	H
I-9-9	2 miles northeast of Yancey.	Fritz Fuchs				D
I-9-10	3 miles northeast of Yancey	Faseter no. 1	Witherspoon Oil Co.			D
J-1-1	7.2 miles west of Castroville.	S. H. Steinle	B. C. Weiners	1925		D
J-1-2	7 miles west of Castroville	John Bohlen		Very old		D
J-1-3	6 miles northwest by west of Castroville.	Anton Burger	Wheless Peters			D
J-1-4	3 miles southwest of Castroville.	J. Courand	Golden West Oil Co.	1927	861.47	D
J-1-5[n]	1 mile southwest of Castroville.	Joe Bodder	Jagge Bros	1923		D
J-1-6[n]	Castroville	Inter-Diocesan Seminary for Mexicans.		1923		D
J-1-7[n]	2.3 miles east-northeast of Castroville.	Robert Halty	Henry Loessberg	Very old.		D
J-1-8[n]	2 miles north of Castroville	L. W. Burell		1910		D
J-1-9[i, n]	1.7 miles north by east of Castroville.	do	Jagge & Tacherhart.		820.17	D
J-1-10[n]	2.5 miles north of Castroville.	A. F. Jagge	—— Jagge	1925	844.69	D
J-1-11[i, n]	3.4 miles north of Castroville.	L. W. Burell	L. W. Burell	1907		D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
100+	7(?)	Sand	Carrizo	2.3	58.7	Apr. 19, 1930	D	
240	6	Sandstone	Carrizo(?)		36.5	Mar. 1, 1930		
3,500							N	Oil test.
250	6	Sand	Indio	1.6			S	
190	5⅝	Sandstone	Carrizo	1.0	34.5	Mar. 1, 1930	D, S	
100+	60	do	do		86.18	Mar. 4, 1930	D, S	
100+	60	do	do	2.0	34.5	Mar. 1, 1930	D, S	
91	60	do	do	3.0	71.8	Feb. 22, 1930	N	
120		do	Indio	.5	50.7	Feb. 27, 1930	D, S	Brown settling on bucket; cakes and wears out teakettle.
80		do	do	.5	80	do	D, S	
300	5	do	do	0	78.5	Feb. 22, 1930	D, S	
223	5⅝	do	Carrizo	.9	81.46	do	D, S	
121	12	do	do		64.75	Feb. 28, 1930	D, S	
119		do	do	1.0	102.3	do	D, S	
110	5⅝	do	do	2.0	103.3	Mar. 1, 1930	D, S	
83±	4	do	Carrizo	.2	43.9	Feb. 28, 1930	N	
56	60	do	Indio	3.0	49.5	Feb. 27, 1930	D	Rope and bucket lift.
130	4	do	do	1.0	44.8	Feb. 28, 1930	D, S	Great deal of iron; kills roses after a year or two.
86	60	do	Carrizo	.9	75.5	do	D, S	
1,800	10					Feb. 17, 1928	S	Oil test.
2,270	10							Oil test; no water reported.
120	6		Escondido	2.0	70.37	Feb. 19, 1930	D, S	
100	6		do	2.0	87	do	D, S	
1,315							N	Oil test; sulphur water in Edwards limestone at 1,300 feet. (See log, p. 142.)
1,714	6			10.5	175.09	Jan. 4, 1934	S	Oil test; still cased and could be used; water in Edwards. (See log, p. 142.)
275			Escondido					Unsuccessful well.
700		Limestone	Edwards			Feb. 19, 1930	M	
225	10	do	Anacacho(?)	2	91.57	do	S	Cased to 200 feet.
217	6	do	do			do	N	Well caved recently.
565	5$\frac{5}{16}$	do	Edwards		[f]122.56	Jan. 8, 1934	D, S	
562	6	do	do		[f]146.59	Feb. 19, 1930	D, S	
180	6	do	Anacacho	7	52.45	Feb. 20, 1930	D, S	Water from 65 feet; plunger pump with gas engine acts as auxiliary to windmill.

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of well
J-1-12 [n]	4.6 miles north of Castroville.	F. C. Stinson	Jess Rogers	1929		D
J-1-13 [n]	6 miles north of Castroville.	Max Boehme	—— Grove	1914		D
J-1-14 [f]	5 miles north of Castroville.	I. C. Stinson			873.27	D
J-1-15 [f]	3.4 miles south-southwest of Cliff.	A. C. Wurzbach	A. E. Goforth	1918	924.67	D
J-1-16 [f]	3 miles southwest of Cliff	Alfred Bourgum	do	1915	928.78	D
J-1-17 [f]	2 miles east of Haby's Crossing.	A. Haby			925.59	D
J-1-18 [f]	3 miles south of Medina Dam.	Joe Schott			1,046.35	D
J-1-19 [f]	4 miles south of Medina Dam.	do		1930	970.20	D
J-1-20 [f]	4.3 miles south of Medina Dam.	do			976.14	D
J-1-21 [f]	4 miles south by west of Medina Dam.	A. A. Haby	Jules Jagge	1920	1,003.49	D
J-1-22 [f]	4.4 miles south by west of Medina Dam.	John Schuehle	A. E. Goforth		1,001.25	D
J-1-23 [f]	5.8 miles south of Medina Dam.	F. Youngman	John Crowder	1927	948.30	D
J-1-24 [f]	5.2 miles south southwest of Medina Dam.	Robert Groff			1,003.26	D
J-1-25 [f]	5.3 miles south southwest of Medina Dam.	Henry Schuehle			1,044.09	D
J-2-1 [n]	2.5 miles east-northeast of Castroville.	Annie Weiblen		Old		D
J-2-2 [n]	2.6 miles east-northeast of Castroville.	Fritz Weiblen	—— Burkett	1926	797.33	D
J-2-3 [n]	3.2 miles east of Castroville.	Max. H. Bippert	—— Burkett	1929		D
J-2-4 [f]	6 miles northeast of Castroville.	C. T. Wurzbach			997.74	D
J-2-5 [f]	2.5 miles south of Cliff	A. A. Haby	A. E. Goforth		950.02	D
J-2-6 [f]	1.7 miles south of Cliff	Mrs. Joe Haby	do		967.74	D
J-4-1	3.7 miles south of Dunlay	Jake Haby	Mid-Kansas Oil & Gas Co.	1925	955	D
J-4-2	4 miles south of Dunlay	L. A. Haby	do		957	D
J-4-3	3 miles west of Noonan	Emil Bendele	Stovers & May		775	D
J-4-4	0.5 mile west of Noonan	Suburban Irrigated Farm.	Pearson Oil Co.			D
J-4-5	1.7 miles south of Noonan	Medina Irrigation Co.	Schermerhorn Oil Co.			D
J-4-6	2 miles south of Noonan	Jungman	do	1926	779	D
J-4-7 [n]	0.75 mile east by south of Natalia.	San Antonio Suburban Irrigation Farms Co.	A. H. Dudenstadt		752	D
J-4-8	6 miles northwest of Devine.	Keller	—— Lewis	1927	794	D
J-4-9 [f]	3 miles south-southwest of Castroville.	Wm. Edgar	F. M. Burkett & Sons.	1916	851.78	D
J-5-1 [i] [n]	Lacoste	Southern Pacific Co.		1905-10	725.01	D
J-7-1 [n]	2.2 miles northeast by north of Devine.	Adkins			671.6	H
J-7-2 [n]	1.2 miles northeast by north of Devine.	Evergreen Cemetery Assoc.		Very old	696.94	D
J-7-3 [n]	1 mile north of Devine	D. L. Sollock			657.68	D

See footnotes at end of table.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
641	6	Limestone	Edwards	0	161	Feb. 20, 1930	D	
300		Chalk	Austin(?)			Feb. 19, 1930	N	Small yield of sulphur water.
501	6	Limestone	Edwards		175.16	Jan. 8, 1934		
775±	5	do	do	2	201.80	Aug. 29, 1934	D, S	
769	8	do	do	2	174.73	Jan. 9, 1934	D, S	
260		do	do		60.28	Oct. 10, 1934	D, S	
190±	6½	do	do	2	179.24	Jan. 15, 1934	S	
220±	5½	do	do	1.5	150.95	do	S	
297	5	do.(?)	do.(?)	2	154.09	Jan. 10, 1934	D, S	
275±	8	do	do	0	153.81	Jan. 12, 1934	D, S	
275±	8	do	do		154.10	do	D, S	
880±	8	do	do	1	219.70	do	D, S	
332		do	do	1	161.8	do	D, S	
350±		do	do	1.5	220.79	do	S	
225	8	do	Anacacho(?)	.3	95.30	do	D, S	
560	6	do	Austin	.5	119.50	do	D, S	
1,180	8	do	do	0	91.00	do	D, S	Depth to water not measured.
440		do	Edwards		307.75	Oct. 11, 1934		
740	6	do	do	.5	236.24	Aug. 29, 1934	S	
740	6	do	do	1	229.92	do	D,S	
1,616	6⅝						N	Oil test; sulphur water at 1,507-1,508 feet. (See log, p. 143.)
1,604							N	Oil test; encountered cavity in Edwards limestone.
1,672							N	Oil test; no water reported in Edwards limestone. (See log, p. 143.)
1,414							N	Oil test; no water reported.
1,625							N	Oil test; no water reported; location not exact.
1,645							N	Oil test; location not exact.
75	8	Sandstone	Carrizo	1.0	51.73	Feb. 22, 1930	N	
2,372	10						N	Oil test; no report on water.
1,502	8	Limestone	Edwards	−.5	166.80	Jan. 5, 1934	D, S	
1,450		do	do		50.50		M	
100	36	Sandstone	Carrizo	1.0	61.90	Feb. 21, 1930	D, S	
146	6	do	do	2.0	132.0	do	N	
495		do	do	1.0	44.76	do		Large supply of water found.

Records of wells in Uvalde and

[Unless otherwise noted all wells are equipped with

No.	Location	Owner or name	Driller	Date completed	Altitude of bench mark above sea level (feet)	Type of wall
J-7-4 [n]	1 mile north of Devine	N A. Briscoe			656.91	D
J-7-5 [n]	1 mile west-northwest of Devine.	A. D. Whitfield	W. B. Hamilton	1922	653.31	D
J-7-6 [n]	2 miles west of Devine	Foster Robert	—— King		667.45	D
J-7-7 [n]	2.5 miles northwest of Devine.	Noonan	—— Witherspoon		707	D
J-7-8 [n]	do	J. R. McCaldin			696	D
J-7-9 [n]	3 miles west of Devine				750	H
J-7-10 [i] [n]	4.2 miles west of Devine	Miss Lou Crawford.	—— Hamilton		692.57	D
J-7-11 [n]	1.2 miles southeast by south of Devine.	A. A. Lilly		1923	659.57	D
J-7-12 [n]	1 mile southwest of Devine	J. R. Hester	George Hester	1905	655	D
J-7-13 [i]	2.5 miles southwest of Devine.			1930		D
J-7-14 [n]	do	Adams Co	Donaldson Oil Co			D
J-7-15 [n]	2.7 miles southwest of Devine.	Emil Schmidt estate.			663.24	D
J-7-16 [n]	2.8 miles southwest of Devine.	International-Great Northern R. R.	—— Night			D
J-7-17 [n]	3.6 miles southeast by south of Devine.	J. J. Wipff	—— Johnson	1900	639.25	D
J-7-18 [n]	3.7 miles southeast by south of Devine.	do			640	H
J-7-19 [n]	1.3 miles southeast of Devine.	Bob Teel		Very old	660	D
J-7-20 [n]	2.1 miles east-southeast of Devine.				662.64	H
J-7-21 [n]	3 miles east-southeast of Devine.	D. J. Bartlett	Martin Crouch	1918	650	D
J-7-22 [n]	3.2 miles east-southeast of Devine.				660	D
J-7-23 [i] [n]	4 miles east-southeast of Devine.	Josephine Haegelin			640	D, H
J-8-1 [n]	5.3 miles east-southeast of Devine.			1897	641.24	H

[a] Altitudes of wells indicated with decimals were established by level. All others were estimated from topographic maps.
[b] D, drilled; H, dug.
[c] The bench mark or point from which this measurement was taken is the top of the water-pipe clamp (See text.)
[d] D, domestic; S, stock; I, irrigation; M, municipal or industrial; N, not in use or abandoned.
[e] Well not completed.
[f] Data furnished by Penn P. Livingston.
[g] Reported by owner.
[h] Observation well; depth to water measured about once a month.
[i] Sample of water collected for chemical analysis.
[j] Depth to water as reported in October 1929.
[k] 48 inches for 30 feet; 8-inch casing, 30 to 235 feet.
[l] 48 inches to a depth of 25 feet.
[m] Data furnished by Chester Cohen.
[n] Data furnished by S. F. Turner.

Medina Counties, Tex.—Continued

deep-well plunger lift pumps operated by windmills]

Depth (feet)	Diameter (inches)	Principal water-bearing bed: Character of material	Principal water-bearing bed: Geologic horizon	Height of bench mark above ground level (feet)	Water level: Below bench mark (feet)	Water level: Date of measurement	Use of water	Remarks
132	-----	Sandstone	Carrizo	0	88.38	Feb. 21, 1930	D, S	
132	8	do	do	.3	86.50	do	N	
114	5⁹⁄₁₆	do	do				D, S	
2,710							N	Oil test; flows sulphur water from the Edwards, according to Mr. Armstrong.
3,012		Sandstone	Carrizo				N	Oil test. (See log, p. 144.)
152+	36	do	do				D, S	
135	6	do	do	2.5	85.40	Feb. 21, 1930	D, S	Gasoline engine and plunger pump.
150	10	do	do	2.0	103.75	do	D, S	
140		do	do				D, S	
		do	do				N	Drilled to supply water for an oil test.
3,125		Limestone	Edwards				N	Oil test; no water in Edwards limestone.
103	5	Sandstone	Carrizo				S	
127	10	do	do			Feb. 21, 1930	M	Diesel engine and plunger pump.
92	4	do	do	1.5	85.76	do	N	
90		do	do			do	D, S	Large yield.
		do	do	2.0	120.1	Feb. 22, 1930	D, S	
140	48	do	do	1.0	107.55	Feb. 21, 1930	D, S	
105	4	do	do		96.47	Feb. 22, 1930	D, S	
105	8	do	do	2.0	104.5	do	D, S	
82		do	do		75 (?)	do	D, S	Dug 70 feet and drilled 12 feet farther.
96	48	do	do	1.5	94.67	do	D, S	

WELL-MEASUREMENT RECORDS

[For description of wells see preceding table]

H-2-4. Reference point, top of pump-support clamp, 2.1 feet above ground; altitude 1,155.68 feet. Well ends in Edwards limestone.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Nov. 30, 1929	185.84	969.84	
Dec. 24, 1929	186.70	968.98	
Jan. 20, 1930	187.40	968.28	
Mar. 13, 1930	188.36	967.32	
May 21, 1930	190	965.68	Wind blowing.
June 24, 1930	184.25	971.43	
July 23, 1930	180.90	974.78	
Aug. 28, 1930	-------	---------	Pumping.
Sept. 30, 1930	180	975.68	
Oct. 22, 1930	178	977.68	Pumping slowly.
Dec. 19, 1930	172.90	982.78	
May 14, 1931	139.70	1,015.98	
July 11, 1931	132.60	1,023.08	
Oct. 30, 1931	128.50	1,027.18	
Jan. 14, 1932	133.40	1,022.28	
Feb. 16, 1932	132.00	1,023.68	
Apr. 1, 1932	132.80	1,022.68	
July 8, 1932	128.70	1,026.98	
Nov. 30, 1932	115.11	1,040.57	
Apr. 10, 1933	118.10	1,037.58	
July 19, 1933	122.95	1,032.73	
Oct. 16, 1934	153.81	1,001.87	

H-2-5. Reference point, top of pump-support clamp, 1.5 feet above ground; altitude 1,176.32 feet. Well ends in Edwards limestone.

Nov. 30, 1929	89.87	1,086.45	
Jan. 20, 1930	62.94	1,113.38	
Mar. 13, 1930	85.40	1,090.92	
May 21, 1930	62.4	1,113.92	
June 24, 1930	64.00	1,112.32	
July 23, 1930	71.35	1,104.97	Shut down 15 minutes.
Aug. 28, 1930	81.20	1,095.12	
Sept. 30, 1930	93.25	1,083.07	Shut down 10 minutes.
Oct. 22, 1930	53.66	1,122.66	Do.
Dec. 19, 1930	57.75	1,118.57	
May 14, 1931	--------	---------	
July 11, 1931	55.30	1,121.02	
Oct. 30, 1931	57.25	1,119.07	
Jan. 14, 1932	60.95	1,115.37	
Feb. 16, 1932	60.05	1,116.27	
Apr. 1, 1932	58.80	1,117.52	
July 9, 1932	38.00	1,138.32	
Nov. 30, 1932	54.55	1,121.77	
Apr. 10, 1933	57.80	1,118.52	
July 19, 1933	58.00	1,118.32	
Oct. 16, 1934	94.62	1,081.70	

H-2-8. Reference point, top of pump-support clamp, 18 inches above ground; altitude 1,074.01 feet. Well ends in Edwards limestone.

Dec. 3, 1929	236.49	837.52	
Jan. 20, 1930	238	836.01	
Nov. 30, 1932	153.35	920.66	

H-3-4. Reference point, top of pump-support clamp; altitude 1,131.95 feet. Well ends in Glen Rose limestone.

Dec. 3, 1929	223.43	908.52	
Dec. 23, 1929	233.44	898.51	
Jan. 27, 1930	233.56	898.39	
Mar. 13, 1930	234.93	897.02	
May 21, 1930	233.4	898.55	

H-3-4—Continued.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
June 24, 1930	237.90	894.05	
July 23, 1930	251.10	880.85	
Aug. 28, 1930	233.70	898.25	
Sept. 30, 1930	233.45	898.50	
Oct. 22, 1930	236.75	895.20	Not pumping.
Dec. 19, 1930	233.40	898.55	Do.
May 14, 1931	233.30	898.65	
July 11, 1931	225.60	906.35	
Oct. 29, 1931	237.50	894.45	
Jan. 14, 1932	236.05	895.90	
Feb. 16, 1932	236.70	895.25	
Mar. 31, 1932	-------	---------	Below 232-foot tape.
Apr. 1, 1932	232.+	---------	
July 9, 1932	237.15	894.80	
Nov. 30, 1932	204.90	927.05	
Apr. 10, 1933	236.30	895.65	
July 19, 1933	252.80	879.15	
Oct. 16, 1934	237.10	894.85	

H-3-12. Reference point, top of pump-support clamp, 1.1 feet above ground; altitude 1,011.82 feet. Well ends in serpentine (Eagle Ford shale).

Dec. 11, 1929	263.30	748.52	
Jan. 27, 1930	264.52	747.30	
Mar. 13, 1930	264.35	747.47	
Apr. 10, 1930	264.55	747.27	
May 21, 1930	265.13	746.69	
June 24, 1930	257.30	754.52	
July 23, 1930	261.80	750.02	
Aug. 28, 1930	262.75	779.07	
Sept. 30, 1930	300.+	---------	
Dec. 19, 1930	288	723.82	
Apr. 15, 1931	260.20	751.62	
May 14, 1931	247.50	764.32	
July 11, 1931	248.50	763.32	
Oct. 30, 1931	246.65	765.17	
Jan. 14, 1932	249.70	762.12	
Feb. 16, 1932	250.70	761.12	
Apr. 1, 1932	238.+	---------	
July 9, 1932	241.75	770.07	
Nov. 30, 1932	220.+	---------	
Oct. 23, 1934	275.93	735.89	

H-4-6. Reference point, top of pump-support clamp, 2.4 feet above ground; altitude 952.97 feet. Well ends in Edwards limestone.

Oct. 7, 1929	83.95	869.02	
Nov. 14, 1929	85.05	867.92	
Dec. 7, 1929	86.23	866.74	
Jan. 16, 1930	88.13	864.84	
Mar. 10, 1930	89.52	863.45	
May 22, 1930	91.4	861.57	
June 23, 1930	86.90	866.07	
July 22, 1930	82.40	870.57	
Aug. 29, 1930	85.40	867.57	
Sept. 29, 1930	84.75	868.22	
Oct. 22, 1930	81.50	871.47	Windmill shut down 15 minutes.
Nov. 25, 1930	78.10	874.87	Windmill shut down 5 minutes.
Dec. 17, 1930	77.50	875.47	Not pumping.
Apr. 15, 1931	72.35	880.62	Cut off 10 minutes.
May 14, 1931	70.35	882.62	
Oct. 29, 1931	68.00	884.97	
Jan. 14, 1932	69.05	883.92	

H-4-6—Continued.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Feb. 16, 1932	69.45	883.52	
Apr. 1, 1932	69.70	883.27	
Nov. 30, 1932	62.10	890.87	
Apr. 10, 1933	61.45	891.52	
July 18, 1933	63.10	889.87	
Oct. 16, 1934	76.01	876.96	

H-4-8. Reference point, top of casing, 1.5 feet above ground; altitude 939.83 feet. Well in Leona formation.

Oct. 9, 1929	65.10	874.73	
Nov. 23, 1929	67.40	872.43	
Dec. 5, 1929	68.45	871.38	
Jan. 8, 1930	70.60	869.23	
Feb. 6, 1930	71.65	868.18	
Mar. 10, 1930	72.59	867.24	
Apr. 5, 1930	73.35	866.48	
May 4, 1930	74.35	865.48	
June 9, 1930	75.24	864.59	
June 23, 1930	49.21	890.62	
July 2, 1930	48.19	891.64	
Aug. 4, 1930	61.15	878.68	
Aug. 27, 1930	64.00	875.83	
Sept. 29, 1930	66.40	873.43	
Oct. 22, 1930	47.08	892.75	
May 13, 1931	40.84	898.99	
July 10, 1931	41.34	898.49	
Oct. 29, 1931	46.18	893.65	Top of casing moved down 10 inches.
Jan. 13, 1932	48.64	891.19	
Feb. 16, 1932	49.23	890.60	
Apr. 1, 1932	49.40	890.43	
Dec. 1, 1932	37.35	902.48	
Apr. 10, 1933	37.90	901.93	
July 18, 1933	41.10	898.73	
Oct. 15, 1934	58.12	881.71	

H-4-18. Reference point, top of pump-support clamp, 2 feet above ground. Well ends in Austin chalk.

Oct. 7, 1929	91.90	---------	
Nov. 14, 1929	92.20	---------	
Dec. 7, 1929	91.86	---------	
Jan. 17, 1930	91.89	---------	
Feb. 14, 1930	91.87	---------	
Mar. 10, 1930	91.93	---------	
June 23, 1930	92.35	---------	
July 22, 1930	91.80	---------	
Aug. 29, 1930	92.10	---------	
Sept. 30, 1930	92.00	---------	
Oct. 22, 1930	92.25	---------	
Nov. 25, 1930	91.95	---------	
Dec. 17, 1930	92.20	---------	
May 14, 1931	84.40	---------	
July 11, 1931	87.35	---------	Pumping slowly.
Oct. 30, 1931	100.+	---------	Pumping.
Jan. 13, 1932	143.30	---------	Not pumping.
Feb. 16, 1932	88.10	---------	
Apr. 1, 1932	92.90	---------	
July 8, 1932	75.00	---------	
Dec. 1, 1932	91.55		
Apr. 10, 1933	74.85	---------	
July 18, 1933	92.40	---------	
Oct. 15, 1934	82.03	---------	

H-4-28. Reference point, top of pump-support clamp, 1.5 feet above ground; altitude 898.54 feet. Well in Leona formation.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Oct. 3, 1929	30.00	868.54	
Nov. 14, 1929	31.25	867.29	
Dec. 7, 1929	32.68	865.86	
Jan. 16, 1930	34.20	864.34	
Feb. 14, 1930	35.22	863.32	
Mar. 10, 1930	35.72	862.82	
May 22, 1930	37.5	861.04	
June 23, 1930	19.55	878.99	
July 22, 1930	24.75	873.79	Shut down 15 minutes.
Aug. 29, 1930	29.40	869.14	
Sept. 30, 1930	30.90	867.64	
Oct. 22, 1930	20.55	877.99	
Nov. 25, 1930	23.40	875.14	
Dec. 17, 1930	25.40	873.14	Not pumping.
May 14, 1931	17.40	881.14	
July 10, 1931	19.10	879.44	Do.
Oct. 29, 1931	22.60	875.94	Do.
Jan. 13, 1932	24.30	874.24	Do.
Feb. 16, 1932	24.55	873.99	
Mar. 31, 1932	24.70	873.84	
July 8, 1932	14.50	884.04	Bench mark lowered about 1 foot.
Dec. 1, 1932	14.03	884.51	
Apr. 10, 1933	15.25	883.29	
July 18, 1933	19.35	879.19	

H-5-1. Reference point, top of sump on east side; altitude 904.85 feet.

Nov. 7, 1929	48.73	856.12	
Dec. 5, 1929	49.54	855.31	
Jan. 8, 1930	50.61	854.24	
Feb. 6, 1930	51.42	853.43	
Mar. 10, 1930	52.33	852.52	
Apr. 5, 1930	52.9	851.95	
May 18, 1930	53.9	850.95	
Aug. 29, 1930	49.45	855.40	
Oct. 22, 1930	48.30	856.55	
May 14, 1931	37.35	867.50	
July 10, 1931	34.95	869.90	
Oct. 30, 1931	33.24	871.61	
Dec. 1, 1932	27.40	877.45	
Oct. 15, 1934	38.24	866.61	

H-5-22. Reference point, top of pump-support clamp; altitude 934.51 feet. Well ends in Edwards limestone.

Nov. 20, 1929	78.55	855.96	
Dec. 24, 1929	79.70	854.81	
Jan. 17, 1930	80.60	853.91	
Mar. 13, 1930	81.92	852.59	
May 21, 1930	83.57	850.94	
June 24, 1930	84.35	850.16	
July 23, 1930	78.75	855.76	Not pumping.
Aug. 28, 1930	78.60	855.91	
Nov. 25, 1930	75.10	859.41	Do.
Dec. 19, 1930	74.20	860.31	Pumping slowly.
May 14, 1931	65.50	869.01	
July 13, 1931	------	----------	Pumping.
Oct. 30, 1931	61.35	873.16	
Jan. 14, 1932	62.75	871.76	
Feb. 16, 1932	62.75	871.76	
Apr. 1, 1932	62.20	872.31	
July 8, 1932	60.50	874.01	
Dec. 1, 1932	54.12	880.39	
Apr. 10, 1933	53.60	880.91	
July 20, 1933	55.00	879.51	
Oct. 15, 1934	67.20	867.31	

H-5-26. Reference point, top of pump-support clamp, 1.8 feet above ground; altitude 1,023.18 feet. Well ends in Edwards limestone.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Nov. 20, 1929	186.02	837.16	
Dec. 24, 1929	187.07	836.11	Still day.
Jan. 16, 1930	187.67	835.51	Do.
Mar. 13, 1930	188.89	834.29	Fairly still.
May 21, 1930	190	833.18	Blowing.
June 24, 1930	186.10	837.08	
July 23, 1930	187.25	835.93	Pump running slowly.
Aug. 28, 1930	185.40	837.78	
Sept. 30, 1930	186.60	836.58	
Oct. 21, 1930	181.90	841.28	
Dec. 19, 1930	180.15	843.03	
May 14, 1931	165.60	857.58	
July 11, 1931	164.70	858.48	
Oct. 30, 1931	161.40	861.78	
Jan. 14, 1932	162.95	860.23	
Feb. 16, 1932	163.25	859.93	
Apr. 1, 1932	163.85	859.33	
July 8, 1932	156.50	866.68	
Nov. 30, 1932	149.17	874.01	
Apr. 10, 1933	151.80	871.38	
July 19, 1933	152.70	870.48	
Oct. 16, 1934	169.45	853.73	

H-5-38. Reference point, top of pump-support clamp, 3.8 feet above ground; altitude 913.67 feet. Well ends in Edwards limestone.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Dec. 5, 1929	57.93	855.72	
Jan. 27, 1930	59.58	854.09	
Mar. 12, 1930	60.78	852.89	
May 21, 1930	61.07	852.60	
June 24, 1930	59.75	853.92	
July 23, 1930	59.95	853.72	
Aug. 28, 1930	57.45	856.22	
Sept. 30, 1930	58.00	855.67	
Oct. 23, 1930	56.75	856.92	
Dec. 3, 1930	54.15	859.52	
Dec. 19, 1930	53.72	859.95	
Apr. 15, 1931	48.35	865.32	
May 14, 1931	45.25	868.42	
July 11, 1931	43.10	870.57	
Oct. 30, 1931	41.15	872.52	
Jan. 14, 1932	41.50	872.17	
Feb. 16, 1932	41.70	871.97	
Apr. 1, 1932	42.05	871.62	
July 9, 1932	39.30	874.37	
Aug. 31, 1932	38.45	875.22	
Dec. 1, 1932	34.61	879.06	
Apr. 11, 1933	34.15	879.52	
July 20, 1933	35.50	878.17	

H-5-39. Reference point, top of pump-support clamp, 1.2 feet above ground; altitude 951.98 feet. Well ends in Edwards limestone.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Dec. 5, 1929	99.50	852.48	
Jan. 27, 1930	101.00	850.98	
Mar. 12, 1930	102.27	849.71	
Apr. 22, 1930	103.50	848.48	
May 21, 1930	104.12	847.86	
June 24, 1930	102.90	849.08	
July 23, 1930	100.15	851.83	
Aug. 28, 1930	99.25	852.73	
Sept. 30, 1930	99.70	852.28	
Oct. 23, 1930	98.65	853.33	
Dec. 3, 1930	96.10	855.88	
Dec. 19, 1930	95.30	856.68	
Apr. 15, 1931	89.40	862.58	
May 14, 1931	86.20	865.78	
July 11, 1931	83.00	868.98	

H-5-39—Continued.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Oct. 30, 1931	80.55	871.43	
Jan. 14, 1932	80.85	871.13	
Feb. 16, 1932	81.10	870.88	
Apr. 1, 1932	81.50	870.48	
July 9, 1932	81.10	870.88	
Aug. 31, 1932	77.40	874.28	
Dec. 1, 1932	72.75	879.23	
Apr. 11, 1933	72.40	879.58	
July 20, 1933	73.60	878.38	
Oct. 16, 1934	86.20	865.78	

H-5-42. Reference point, top of pump-support clamp, 0.5 foot above ground; altitude 945.77 feet. Well ends in Edwards limestone.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Jan. 1, 1930	87.60	858.17	
May 21, 1930	91.20	854.57	
June 24, 1930	83.50	862.27	
July 23, 1930	88.70	857.07	Not pumping.
Aug. 28, 1930	83.90	861.87	
Sept. 30, 1930	88.80	856.97	
Dec. 3, 1930	80.90	864.87	
Dec. 19, 1930	81.00	864.77	
Apr. 15, 1931	99.20	846.57	Shut down 15 minutes.
May 14, 1931	72.40	873.37	
July 11, 1931	70.15	875.62	
Oct. 30, 1931	70.00	875.77	
Jan. 14, 1932	70.95	874.82	
Apr. 1, 1932	81.30	864.47	Pump shut off 10 minutes.
July 9, 1932	71.67	874.10	
Dec. 1, 1932	62.69	883.08	
Apr. 10, 1933	64.75	881.02	
July 20, 1933	67.05	878.72	

H-5-51. Reference point, top of pump-support clamp, 0.6 foot above ground; altitude 909.54 feet. Well ends in Edwards limestone.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Oct. 5, 1929	52.90	856.64	
Nov. 13, 1929	53.15	856.39	
Dec. 19, 1929	53.78	855.76	
Jan. 16, 1930	54.47	855.07	
Mar. 10, 1930	55.73	853.81	
Apr. 15, 1930	56.5	853.04	
June 23, 1930	56.14	853.40	
July 22, 1930	55.55	853.99	
Aug. 27, 1930	54.45	855.09	
Oct. 1, 1930	54.50	855.04	
Dec. 17, 1930	51.30	858.24	
May 14, 1931	43.90	865.64	
July 11, 1931	42.60	866.94	Shut off.
Oct. 29, 1931	41.30	868.24	
Jan. 14, 1932	41.00	868.54	Do.
Mar. 31, 1932	41.10	868.44	
July 8, 1932	39.59	869.95	
Aug. 31, 1932	39.85	869.69	
Dec. 1, 1932	37.35	872.19	
Apr. 11, 1933	36.70	845.49	
July 21, 1933	38.20	833.99	
Oct. 16, 1934	44.23	865.31	

H-5-53. Reference point, top of pump base; altitude 898.42 feet.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Oct. 24, 1929	41.65	856.77	
Nov. —, 1930	41.65	856.77	
Apr. 5, 1931	34.80	863.62	

H-5-53—Continued.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
May 13, 1931	32.80	865.62	
July 10, 1931	31.20	867.22	
Oct. 29, 1931	30.10	868.32	
Jan. 14, 1932	--------	----------	Pumping.
Apr. 1, 1932	30.30	868.12	
July 8, 1932	29.20	869.22	
Aug. 31, 1932	28.90	869.52	
Dec. 1, 1932	26.63	871.79	
Apr. 10, 1933	26.00	872.42	
July 21, 1933	27.20	871.22	
Oct. 16, 1934	33.35	865.07	

H-6-1. Reference point, top of pump-support clamp, 1.9 feet above ground; altitude 983.15 feet. Well ends in Edwards limestone.

Dec. 9, 1929	103.90	879.25	
Jan. 27, 1930	103.95	879.20	
Mar. 12, 1930	104.80	878.35	
Apr. 29, 1930	105.5	877.65	
May 20, 1930	105.5	877.65	
June 24, 1930	104.65	878.50	
July 23, 1930	103.80	879.35	Not pumping.
Aug. 28, 1930	102.40	880.75	
Sept. 30, 1930	103.25	879.90	
Oct. 23, 1930	101.40	881.75	Do.
Dec. 3, 1930	98.15	885.00	Do.
Dec. 19, 1930	98.03	885.12	
Apr. 15, 1931	91.60	891.55	Not pumping for 10 minutes; showed no recovery.
May 14, 1931	92.40	890.75	
July 11, 1931	86.70	896.45	
Oct. 30, 1931	88.80	894.35	
Jan. 14, 1932	90.80	892.35	
Feb. 16, 1932	92.00	891.15	
Apr. 1, 1932	93.30	889.85	
July 9, 1932	85.25	897.90	
Aug. 30, 1932	81.20	901.95	
Dec. 1, 1932	70.98	912.17	
Apr. 10, 1933	83.80	899.35	
July 19, 1933	89.50	893.65	
Oct. 24, 1934	97.40	885.75	

H-6-8. Reference point, top of pump-support clamp, 1.3 feet above ground; altitude 978.32 feet. Well ends in Austin chalk.

Dec. 9, 1929	78.26	900.06	
Jan. 27, 1930	77.40	900.92	
Mar. 12, 1930	77.92	900.40	
Apr. 21, 1930	79.65	898.67	
May 21, 1930	78.09	900.23	
June 24, 1930	78.00	900.32	
July 23, 1930	79.45	898.87	
Aug. 28, 1930	79.00	899.32	
Sept. 30, 1930	78.30	900.02	
Oct. 23, 1930	77.85	900.47	
Dec. 19, 1930	77.90	900.42	
Apr. 15, 1931	77.65	900.67	
May 14, 1931	77.35	900.97	
July 11, 1931	76.75	901.57	
Oct. 30, 1931	77.70	900.62	
Jan. 14, 1932	76.70	901.62	
Feb. 16, 1932	78.90	899.42	
Apr. 1, 1932	78.90	899.42	
July 9, 1932	76.10	902.22	
Aug. 31, 1932	76.15	902.17	
Nov. 30, 1933	76.35	901.97	
Apr. 10, 1933	74.00	904.32	
July 19, 1933	74.05	904.27	

H-6-9. Reference point, top of pump-support clamp, 2 feet above ground. Well in Leona formation.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Dec. 11, 1929	63.40	---------	
Jan. 27, 1930	61.18	---------	
Mar. 13, 1930	62.90	---------	
June 24, 1930	46.20	---------	
July 23, 1930	43.25	---------	
Aug. 28, 1930	46.30	---------	
Sept. 30, 1930	50.20	---------	
Dec. 19, 1930	47.10	---------	
Apr. 15, 1931	43.15	---------	
May 14, 1931	41.60	---------	
July 11, 1931	42.70	---------	
Oct. 30, 1931	46.65	---------	
Jan. 14, 1932	46.25	---------	
Feb. 16, 1932	46.30	---------	
Apr. 1, 1932	46.10	---------	
July 9, 1932	42.82	---------	
Aug. 31, 1932	42.10	---------	
Nov. 30, 1932	40.30	---------	
Apr. 10, 1933	41.20	---------	
July 20, 1933	43.00	---------	

H-6-10. Reference point, top of well curb, 0.35 foot above ground. Well in Leona formation.

Dec. 12, 1929	68.81	---------	
Jan. 27, 1930	68.85	---------	
Mar. 12, 1930	69.04	---------	
May 21, 1930	69.25	---------	
June 24, 1930	68.70	---------	
July 23, 1930	68.60	---------	
Aug. 28, 1930	68.80	---------	
Sept. 30, 1930	68.95	---------	
Oct. 23, 1930	68.70	---------	
Dec. 3, 1930	68.50	---------	
Dec. 19, 1930	69.40	---------	
Apr. 15, 1931	67.65	---------	
May 14, 1931	67.70	---------	
July 11, 1931	67.70	---------	
Oct. 30, 1931	68.15	---------	
Jan. 4, 1932	68.25	---------	
Feb. 16, 1932	68.45	---------	
Apr. 1, 1932	68.60	---------	
July 9, 1932	67.15	---------	
Aug. 31, 1932	67.10	---------	
Nov. 30, 1932	65.70	---------	
Apr. 10, 1933	66.85	---------	
July 19, 1933	67.05	---------	

H-6-16. Reference point, top of pump-support clamp, 0.6 foot above ground; altitude 934.94 feet. Well ends in Edwards limestone.

Dec. 11, 1929	194.29	740.65	
Jan. 27, 1930	194.75	740.19	
Mar. 13, 1930	210.95	723.99	Pumped heavily for 15 days, but not pumped for 13 hours before measurement.
Apr. 29, 1930	202.9	732.04	
May 21, 1930	200.40	734.54	
June 24, 1930	199.65	735.29	
Aug. 28, 1930	-------	---------	Pumping.
Sept. 30, 1930	199.15	735.79	
Dec. 19, 1930	190.75	744.19	
Apr. 15, 1931	183.00	751.94	
May 14, 1931	177.80	757.14	
July 10, 1931	168.50	766.44	
Oct. 30, 1931	-------	---------	Do.
Jan. 14, 1932	159.60	775.34	
Feb. 16, 1932	-------	---------	Do.
Mar. 31, 1932	-------	---------	Do.
July 9, 1932	-------	---------	Do.
Nov. 30, 1932	141.87	793.07	
Apr. 11, 1933	141.20	793.74	
July 20, 1933	147.80	787.14	
Oct. 24, 1934	178.60	756.34	

H-6-21. Reference point, top of well curb, 2 feet above ground; altitude 834.5 feet. Well ends in Leona formation.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Nov. 6, 1929	26.55	807.95	
Dec. 23, 1929	27.12	807.38	
Jan. 14, 1930	27.28	807.22	
Mar. 14, 1930	27.60	806.90	
Apr. 10, 1930	28.1	806.40	
July 24, 1930	23.30	811.20	
Aug. 29, 1930	25.05	809.45	
Oct. 1, 1930	26.25	808.25	
Dec. 20, 1930	22.70	811.80	Measurements discontinued.

H-8-4. Reference point, top of pump-support clamp, 1.8 feet above ground. Well ends in Indio formation.

Oct. 7, 1929	80.90	---------	
Nov. 13, 1929	80.85	---------	
Dec. 17, 1929	80.69	---------	
Jan. 16, 1930	79.58	---------	
Mar. 10, 1930	80.18	---------	
Apr. 14, 1930	80.75	---------	
May 20, 1930	80.91	---------	
June 28, 1930	80.00	---------	
July 22, 1930	80.70	---------	
Aug. 27, 1930	85.60	---------	Measurements discontinued.

H-8-13. Reference point, top of pump-support clamp; altitude 869.97 feet. Well in Leona formation.

Oct. 26, 1929	39.54	830.43	
Nov. 8, 1929	39.65	830.32	
Dec. 23, 1929	39.90	830.07	
Jan. 15, 1930	39.87	830.10	
Apr. 8, 1930	40.08	829.89	
May 22, 1930	40.53	829.44	
June 23, 1930	40.03	829.94	
July 23, 1930	40.30	829.67	
Aug. 29, 1930	40.70	829.27	
Oct. 1, 1930	40.90	829.07	
Oct. 21, 1930	40.31	829.66	
Dec. 19, 1930	39.60	830.37	
May 13, 1931	37.60	832.37	
July 10, 1931	37.85	832.12	
Oct. 29, 1931	37.84	832.13	
Jan. 13, 1932	38.38	831.59	
Feb. 16, 1932	-------	---------	Rain.
Apr. 2, 1932	36.96	833.01	
July 8, 1932	35.55	834.42	
Dec. 1, 1932	36.78	833.19	
Apr. 10, 1933	36.85	833.12	
July 21, 1933	37.43	832.54	

H-8-19. Reference point, top of pump-support clamp, 2 4 feet above ground. Well ends in Indio formation.

Date	Depth to water (feet)	Altitude of water surface (feet)	Remarks
Oct. 28, 1927	85.60	---------	
Dec. 23, 1929	64.19	---------	
Jan. 14, 1930	61.05	---------	
June 25, 1930	57.75	---------	
July 24, 1930	62.55	---------	Not pumping.
Aug. 29, 1930	66.85	---------	
Oct. 1, 1930	69.75	---------	
Dec. 20, 1930	70.85	---------	
May 13, 1931	68.55	---------	Measurements discontinued.

H-9-5. Reference point, top of curb, 3.5 feet above ground; altitude 795 feet. Well ends in Indio formation.

Dec. 23, 1929	37.50	---------	
Jan. 15, 1930	38.13	---------	
Apr. 11, 1930	39.12	---------	
May 22, 1930	39.24	---------	
June 25, 1930	39.80	---------	
July 24, 1930	38.75	---------	
Aug. 29, 1930	39.30	---------	
Oct. 1, 1930	38.65	---------	
Nov. 2, 1930	38.95	---------	
Dec. 20, 1930	39.20	---------	Measurements discontinued.

H-9-6. Reference point, top of pump-support clamp, 0.8 foot above ground. Well ends in Indio formation.

Nov. 9, 1929	101.20	---------	
Dec. 21, 1929	100.05	---------	
Jan. 14, 1930	94.90	---------	
July 24, 1930	129.80	---------	
Aug. 29, 1930	95.80	---------	Measurements discontinued.

H-9-8. Reference point, top of pump-support clamp, 0.6 foot above ground. Well ends in Indio formation.

Nov. 5, 1929	108.90	---------	
Dec. 21, 1929	110.10	---------	
Jan. 14, 1930	104.94	---------	
June 25, 1930	116.80	---------	
July 24, 1930	113.75	---------	Windmill shut off 45 minutes; rise 0.1 foot a minute.
Aug. 29, 1930	106.15	---------	
Oct. 1, 1930	124.00	---------	Windmill shut down 15 minutes.
Dec. 20, 1930	108.60	---------	Measurements discontinued.

WELL LOGS

A-9-1. *Phantom Oil Co.'s well Cloudt no. 1, southwest corner of sec. 661, Gulf, Colorado & Santa Fe Ry. Co. survey, Uvalde County*

[Commenced drilling Feb. 20, 1930. To be drilled 4,000 feet. Carl G. Cromwell, contractor]

	Thickness (feet)	Depth (feet)
Edwards and Comanche Peak limestones:		
Lime	70	70
Hard lime	70	140
Glen Rose limestone:		
Shale	90	230
Shelly lime	26	256
Water sand; 4 bailers an hour	4	260
Hard lime	10	270
Water sand; hole full of water	5	275
Blue shale	30	305
Hard lime	48	353
Blue shale	17	370
Hard lime	110	480
Blue and gray shale	45	525
Sandy shale	10	535
Gray shale	30	565
Lime; setting 15½-inch casing	15	580
White shale	65	645
Lime shells	50	695
Sandy lime	10	705
White lime	75	780
Broken lime	45	825
Water sand; 8 bailers an hour	20	845
Lime shells	30	875
Hard lime	60	935
Hard gray sandy lime	30	965
Sand	35	1,000
Broken lime	20	1,020
Sand	5	1,025
Hard sandy lime	5	1,030
Lime	13	1,043
Water sand; hole full of water	13	1,056
White hard lime	19	1,075
Water sand	15	1,090
Hard lime	5	1,095
Medium sand	25	1,120
Lime; running 1,148 feet of 12½-inch casing	28	1,148
White lime	17	1,165
Slate and lime shells; hole full of water	20	1,185
Slate	10	1,195
Lime	3	1,198
Travis Peak formation:		
Slate; bailing hole dry; hole full of water, caving	32	1,230
Gray shale	7	1,237
Red rock	4	1,241
Hard sand	6	1,247
Sandy shale	23	1,270
Red rock	7	1,277
Slate	1	1,278
Lime	3	1,281
Sandy shale	7	1,288
Hard sand	12	1,300
Water sand; hole full of water	13	1,313
Hard sand	24	1,337
Water sand; hole full of water	8	1,345
Hard sand	15	1,360
Soft sand	9	1,369
Water sand; hole full of water	8	1,377
Sand	8	1,385
Water sand	7	1,392
Red rock	7	1,399
Sand	19	1,418
Water sand; hole full of water	7	1,425
Sand	5	1,430
Water sand	18	1,448
White lime	1	1,449
Red sandy shale	8	1,457
Sand	28	1,485
Water sand; hole full of fresh water	20	1,505
Fine gravel	20	1,525
Hard red sand	10	1,535
White lime	2	1,537
Pink water sand	12	1,549
Fine sand and fine gravel	7	1,556
Water sand	13	1,569
Hard sand	4	1,573
Coarse gravel	12	1,585
Very hard sand	15	1,600
Hard sand	3	1,603
Water sand	7	1,610
Sand and gravel	20	1,630
Hard gray sand	5	1,635

Total 12½-inch casing 1,633 feet 9 inches.

B-8-1. *Transcontinental Oil Co.'s well Patterson Bros. no. 1, I. K. Henry survey no. 934, Uvalde County*

	Thickness (feet)	Depth (feet)
Edwards limestone:		
Gravel	11	11
Hard lime; water	84	95
Hard lime	155	250
Glen Rose limestone:		
Blue clay	5	255
Hard lime	195	450
Blue clay	10	460
Hard lime	60	520
Blue clay	8	528
Hard lime	242	770
Loose brown lime	5	775
Loose brown lime; water	5	780
Hard and soft lime	272	1,052
Blue clay	8	1,060
Glen Rose limestone—Con.		
Soft pink sand; gyp crystal	12	1,072
Hard lime	118	1,190
Blue clay	20	1,210
Soft sand	6	1,216
Blue clay	8	1,224
Soft lime	7	1,231
Blue mud	39	1,270
Soft lime	5	1,275
Slate and shale	15	1,290
Travis Peak formation:		
Red rock	10	1,300
Shale and sand	30	1,330
Soft sand; water	5	1,335
Red boulders	10	1,345

B-8-1. *Transcontinental Oil Co.'s well Patterson Bros. no. 1, I. K. Henry survey no. 934, Uvalde County*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Travis Peak formation—Contd.			Paleozoic rocks—Continued.		
Lime	10	1,355	Black lime; salt water at 2,827		
Blue shale	25	1,380	feet	45	2,845
Pink sand	45	1,425	Slate	95	2,940
Red rock	5	1,430	Black lime	7	2,947
Pink sand	22	1,452	Gray lime, gritty	5	2,952
Blue clay	12	1,464	Slate and shells	83	3,035
Pink sand	46	1,510	Black lime	8	3,043
Lime and shale	10	1,520	Brown sand	4	3,047
Lime shells, hard	10	1,530	Slate and shells	23	3,070
Pink sand	22	1,552	Black lime, gritty	48	3,118
Lime shells	8	1,560	Slate and shells	87	3,205
Water sand	10	1,570	Black lime	47	3,252
Lime shells	5	1,575	Slate and shells	18	3,270
Gray sand (pebbles)	52	1,627	Black lime, sandy	30	3,300
Fine water sand	7	1,634	Gray sand	15	3,315
Coarse sand	23	1,657	Slate and shells	422	3,737
Red rock	3	1,660	Black lime	6	3,743
Coarse sand	18	1,678	White lime	13	3,756
Brown clay	38	1,716	Gray sand	12	3,768
Sand; 8-inch casing	7	1,723	Slate and shells	138	3,906
Paleozoic rocks:			Lime	9	3,915
Slate	1,077	2,800	Slate and shells	15	3,930

G-6-1. *Gulf Production Co.'s well Smythe no. 1, Uvalde County*

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Anacacho formation and Austin			Anacacho formation and Austin		
chalk:			chalk—Continued.		
Soil and gravel	20	20	Brown shale	20	900
Yellow clay	40	60	Black shale	140	1,040
Lime shell; fresh water	3	63	Lime	8	1,048
Blue slate	5	68	Eagle Ford shale:		
Sharp sand	20	88	Black shale	77	1,125
Blue slate	4	92	Buda limestone:		
Lime	68	160	White lime	5	1,130
Shell, pyrites, and shale	5	165	Pink lime	30	1,160
Lime, hard	5	170	White lime	45	1,205
Lime	75	245	Del Rio clay:		
Blue slate	8	253	Blue slate	120	1,325
Lime, hard	11	264	Georgetown limestone:		
White lime	10	274	Sandy lime	61	1,386
Blue shale	6	280	Edwards limestone:		
Lime	40	320	Black sand; sulphur water	40	1,426
Slate	5	325	White water sand	69	1,495
Lime	35	360	White lime	8	1,503
Blue slate	5	365	Sandy lime	172	1,675
Lime	20	385	Iron pyrites and slate	13	1,688
Blue slate	6	391	Lime	22	1,710
White lime	40	431	Slate	8	1,718
Slate	4	435	Black sand and iron	12	1,730
Lime	30	465	Black sandy lime	82	1,812
Slate	2	467	Gray lime; water	182	1,994
Lime	20	487	Comanche Peak limestone:		
Slate	5	492	White lime	14	2,008
Lime	16	508	Light shale	70	2,078
Slate	8	516	Walnut clay and Glen Rose lime-		
White lime	29	545	stone:		
Slate	15	560	White lime	424	2,502
White lime	300	860	Brown shale	4	2,506
Black slate	10	870	Lime	14	2,520
White lime	5	875	Shale	90	2,610
Brown sand	5	880	Lime	15	2,625

G-9-1. *Pure Oil Co.'s well J. B. & W. A. Smythe no. 1, Uvalde*

	Thickness (feet)	Depth (feet)
Anacacho limestone, Austin chalk, and Eagle Ford shale:		
Hard rock	3	3
Hard sandy lime	48	51
Crystallized rock	31	82
Blue sandy lime	3	85
Blue putty shale and asphalt	13	98
Rock asphalt	10	108
Blue gumbo	47	155
Gray lime	17	172
Blue gumbo	3	175
Gray lime	40	215
Blue sandy	10	225
Gray lime	10	235
Blue shale and lime shells	3	238
Blue and gray shale	22	260
Gray shale and gumbo	110	370
Gray shale	70	440
Gray lime, broken	12	452
Blue shale	48	500
Blue sandy shale and gumbo	28	528
Gray shale	7	535
Sandy lime	15	550
Hard lime shells	30	580
Gray sandy lime	5	585
Hard gray lime	5	590
Gray shale	20	610
Hard lime	2	612
Gray shale	23	635
Gray shale and lime, broken	3	638
Gray broken lime	15	653
Gray shale	77	730
Lime	60	790
Lime and blue shale	80	870
Lime and shale	70	940
Broken lime	45	985
Broken lime and shale	35	1,020
Shale and asphalt	20	1,040
Shale	5	1,045
Broken lime and shale	60	1,105
Cement-colored shale	65	1,170
White hard shale	4	1,174
Cement-colored shale	56	1,230
Lime	3	1,233
Gray hard lime	105	1,338
Gray shale	42	1,380
Shale and slate	31	1,411
Gray lime	79	1,490
Shale	8	1,498
Gray lime	12	1,510
Lime	7	1,517
Lime and sandy shale	33	1,550
Sandy shale; showing of oil	17	1,567
Black and gray sandy lime	5	1,572
Formation not given	3	1,575
Black and gray sandy lime	15	1,590
Gray and white lime	15	1,605
Buda limestone:		
Gray and white lime	5	1,610
White lime	100	1,710
Del Rio clay:		
Blue shale	5	1,715
Soft blue shale	55	1,770
Caving some	30	1,800
Soft blue shale	15	1,815
Blue shale	20	1,835
Broken lime and shale	12	1,847
Georgetown limestone:		
White lime; caving some	12	1,859
White lime	50	1,910
Edwards limestone:		
Soft brown lime	10	1,920
White lime 5 bailers an hour	127	2,047
Hard white sand and lime	28	2,075
Brown sand	5	2,080
Dark sandy lime	20	2,100
Gray sand; hole full of water at 2,107 feet	22	2,122
Edwards limestone—Continued.		
White sand; water	33	2,155
White sand	2	2,157
White lime	58	2,215
Gray soft sand	12	2,227
White lime; show of soft coal at 2,260 to 2,265 feet	63	2,290
Hard white lime; hole caving somewhat	15	2,305
White lime	10	2,315
Hard black lime	19	2,334
Black lime	36	2,370
Black lime; show of oil	8	2,378
Corrected measurement	8	2,386
Gray sandy lime	29	2,415
Black lime	33	2,448
Black lime and white shell	17	2,465
Black lime; from 2,470 to 2,474 feet half full of water	9	2,474
Black lime	32	2,506
Black sandy lime and gravel	8	2,514
Black lime and gravel	16	2,530
Gray sandy lime	14	2,544
Gray lime	461	3,005
Lime and shale	15	3,020
Broken lime and shale	43	3,063
Broken lime	24	3,087
Broken gray lime	58	3,145
Glen Rose limestone and Travis Peak formation:		
Broken gray lime	11	3,155
Hard gray lime	14	3,170
Broken lime	64	3,234
Blue shale and gray lime	2	3,236
Gray lime	24	3,260
Blue shale and gray lime	12	3,272
Gray lime	298	3,570
Brown water sand	22	3,592
Brown sandy lime; lost returns 3,608 to 3,640 feet	118	3,710
Hard gray lime	12	3,722
Gray lime	16	3,738
Gray water sand	22	3,760
Soft gray sandy lime	27	3,787
Broken gray lime	18	3,805
Cannot catch sample; more water, sand	22	3,827
Cannot catch sample	7	3,834
Gray sandy lime	23	3,857
Gray lime	18	3,875
Hard gray lime	5	3,880
Brown water sand	3	3,883
Broken lime	10	3,893
Gray lime	13	3,906
Lime	19	3,925
Hard lime and shale	11	3,936
Soft lime	11	3,947
Gray lime and shale	24	3,971
Light shale and lime shell	45	4,016
Broken lime	4	4,020
Lime and shale	6	4,026
Hard gray lime	2	4,028
Hard black sandy lime	26	4,054
Gray sandy lime	2	4,056
Brown sandy lime	2	4,058
Hard lime	2	4,060
Lime	8	4,068
Lime shells and shale	9	4,077
Hard gray lime	62	4,139
Sandy gray lime	11	4,150
Gray shale	3	4,153
Hard gray sandy lime	4	4,157
Hard gray lime	7	4,164
Light-blue shale	11	4,175
Blue shale	12	4,187
Gray lime	27	4,214
Blue shale	10	4,224
Gray sandy lime	15	4,239

G-9-1. *Pure Oil Co.'s well J. B. & W. A. Smythe no. 1, Uvalde*—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Glen Rose limestone and Travis Peak formation—Continued.			Glen Rose limestone and Travis Peak formation—Continued.		*Feet*
Black lime shell	2	4,241	Hard gray lime	11	4,713
Gray lime	13	4,254	Gray lime	45	4,758
Shale and lime shells	16	4,270	Gray lime and blue shale	45	4,803
Blue shell	6	4,276	Gray sandy lime	7	4,810
Blue shale and lime	3	4,279	Paleontologic determinations:		
Dark gray lime	14	4,293	Eagle Ford		1,560
Gray lime	15	4,308	Top of Buda		1,605
Gray sandy lime	25	4,333	Top of Del Rio		1,710
Gray lime	27	4,360	Top of Georgetown		1,847
Gray lime and shale	240	4,600	Top of Edwards		1,910
Hard gray lime	26	4,626	Top of Glen Rose		3,145
Gray lime	76	4,702			

G-9-2. *Pure Oil Co.'s well J. B. & W. A. Smythe no. 2, Uvalde County*

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Anacacho limestone and Austin chalk:			Anacacho limestone and Austin chalk—Continued.		
Hard sandy lime	20	20	Shale, asphalt, and lime shells	42	1,235
Lime	7	27	Eagle Ford shale:		
Asphalt	28	55	Asphalt and lime shells	115	1,350
Lime	20	75	Shale, asphalt, and lime shells	43	1,393
Gray lime; water	25	100	Black shale and lime shells	43	1,436
Blue shale	20	120	Black shale	14	1,450
Hard gray lime	6	126	Hard gray lime	16	1,466
Gray lime and shale	6	132	Gray lime	29	1,495
Shale and lime	23	155	Black shale	20	1,515
White mud	10	165	Buda limestone:		
Blue gumbo	5	170	White lime	100	1,615
Hard gray lime; water	20	190	Del Rio clay:		
Shale and lime	15	205	Gray shale	70	1,685
White mud	12	217	Slate	22	1,707
Blue gumbo mud	13	230	Gray shale	58	1,765
Gray lime shell	3	233	Georgetown limestone:		
Blue gumbo mud	11	244	Gray shale	8	1,773
Shale and lime shells	30	274	White lime	42	1,815
Gray shale	26	300	Edwards limestone; water at 1,820 to 1,830 feet	200	2,015
Blue shale and lime shells	89	389	Brown lime	10	2,025
Blue shale	36	425	White lime; more sulphur water at 2,203 feet	238	2,263
Blue shale and lime	10	435	Black lime	4	2,267
White shale	84	519	Water sand, gray	28	2,295
White lime	42	561	Black lime	45	2,340
Light sandy lime	19	580	Black sandy lime; very small show of oil at 2,355 feet	44	2,384
Sandy lime	5	585	Hard black lime	36	2,420
White sandy lime	43	628	Black lime	25	2,445
Gray lime	10	638			
White shale and lime shells	35	673			
Gray lime	235	908			
Soft gray lime; water at 995 feet	285	1,193			

H-5-13. *John Monagin well, Uvalde County*

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Austin chalk and Eagle Ford shale:			Del Rio clay	90	263
Black soil	2	2	Georgetown limestone:		
Red clay	10	12	Yellow limestone; some water	22	285
Yellow rotten clay	6	18	Edwards limestone:		
Loose gravel	24	42	Hard white limestone	15	300
Yellow clay and boulders	48	90	White limestone with yellow streaks	65	365
Buda limestone:			Hard white limestone with layers of flint; 2 or 3 breaks	25	390
Lime; water	40	130	Flint ledges; water	10	400
Lime broken	25	155			
Softer white lime	10	165			
Lime with blue specks	3	168			
Lime nearly blue	5	173			

H-5-15. *C. S. Bowman well, Uvalde County*

	Thickness (feet)	Depth (feet)
Austin chalk and Eagle Ford shale:		
Soil	3	3
White clay	22	25
Loose gravel	20	45
Hard limestone	15	60
Rotten yellow basalt	10	70
Hard blue basalt	10	80
Rotten yellow basalt	10	90
Blue rotten basalt	75	165
Hard yellow lime	7	172
Soft yellow lime and clay	11	183
Austin chalk and Eagle Ford shale—Continued.		
Brown shale	7	190
Rotten yellow clay and boulders	30	220
Buda limestone:		
Lime	65	285
Lime, with blue specks	23	308
Del Rio clay	99	407
Georgetown and Edwards limestones; water at 446-515 feet	133	540

Total depth, 655 feet.

H-5-40. *Bell Oil & Gas Corporation's well Walcott no. 1, Alex Moore survey no. 374, 1,000 feet east of Ange siding on Southern Pacific Railroad, Uvalde County*

[Compiled by F. M. Getzendaner. Altitude of curb, almost exactly 1,000 feet above sea level]

	Thickness (feet)	Depth (feet)
Soil, gravel, etc	2	2
Eagle Ford shale:		
Yellow gritty shale	70	72
Light-gray calcareous shale	8	80
Dark-brown petroliferous shale; considerable oil showing around 90 feet	40	120
Buda limestone:		
Hard milk-white limestone	45	165
Del Rio clay:		
Blue sticky clay	45	210
Georgetown and Edwards limestones:		
Hard and softer gray limestone; much water. (Drill cuttings are missing between 675 and 1,355 feet)	465	675
Gray limestone	45	720
Glen Rose limestone:		
Alternating gray limestone and blue shale	860	1,580
Travis Peak formation:		
Alternating gray limestone and sandstone. (From memory; samples missing from this collection)	200	1,780
Paleozoic rocks:		
Blue, brown, and black shales and clays. (Many fossils taken from cavings from this series by writer. Some looked like *Productus*. Collection turned over to Mr. Henninger, of Gulf Produc-		
Paleozoic rocks—Continued.		
tion Co., for determination. He reported them lost in transit to paleontologist. Formation uncertain)	960	2,740
Pink sandy shale	28	2,768
White fine-grained siliceous sand; last 15 feet a "pack" sand. Cuttings entirely separated; grains almost "powder" fine, all white and perfectly transparent	30	2,798
Slightly coarser sands, stained pink and reddish brown	22	2,820
Minutely fine-grained, slightly argillaceous sands, light-brown or tan-colored	16	2,836
White to slightly stained fine-grained sandstone. One bed here does not separate to individual grains in cuttings but comes out in sandstone fragments	9	2,845
Dark-blue shale and clay	30	2,875
Gray (white under the lens), minutely fine grained, poorly consolidated sands	25	2,900
Coarser-grained white sands. Sample from last 10 feet is half shale, evidently cavings	52	2,952
Fine-grained white (under lens), poorly consolidated sands	78	3,030

Well supposed to be 3,100 feet deep. Samples of last 70 feet missing. Saw one piece of gray limestone said to have come from near bottom.

H-5-52. *Ingraham & Jenkins well, south of Uvalde, Uvalde County*

	Thickness (feet)	Depth (feet)
Leona formation, yellow clay	60	60
Austin chalk, chalky lime	7	67
Eagle Ford shale	65	132
Buda limestone	90	222
Del Rio clay	73	295
Georgetown limestone	50	345
Edwards limestone:		
Broken yellow rock; water	10	355
Hard white lime	120	475
Edwards limestone—Continued.		
Hard white lime, flint beds and layers	20	495
Broken yellow lime; lots of water	10	505
Hard flint and flint beds	60	565
Pinkish lime	10	575
Yellow rotten lime	10	585
Yellow sandy (?) lime	15	600

Top of water at 35 feet, lowered to 42 feet at 450 gallons a minute.

H-6-2. *Texas Trap Rock Co.'s well, Knippa, Uvalde County*

	Thickness (feet)	Depth (feet)
Leona formation, gravel	46	46
Austin chalk and Eagle Ford shale:		
First limestone	132	178
Soft slaty material	29	207
Limestone	68	275
Soft black rock; trace of water	23	298
Blue mud	27	325
Blue mud and hard layers	34	359
Harder blue mud	14	373
Whitish clay	20	393
Slate and blue mud	9	402
Buda limestone:		
Solid white limestone	8	410
Solid white limestone, thin, hard	6	416
Solid white limestone, thicker, soft layer	27	443
Limestone	33	476
Del Rio clay:		
Blue clay with oyster and iron pyrites	9	485
Blue clay	80	565
Georgetown limestone:		
Blue clay and limestone, becoming whiter	2	567
Limestone	32	599
Thin veins of water-deposited lime	10	609
Limestone	3	612
Edwards limestone:		
Limestone	13	625
Whitish clay; water	5	630
Potter's clay	135	765
Soft white limestone	20	785
Light colored limestone	14	799
Very hard limestone; water at about 810 feet	8	807
Very hard limestone	20	827
White sandy lime	5	832
Brownish milky limestone	48	880
Whiter, harder, gritty limestone	55	935
Whiter, harder, gritty limestone, becoming darker	11	946

Test run for 20 hours at 35 gallons a minute. Driller thought he struck some water at this level.

H-7-3. *Union Oil Co.'s well Anderson no. 1, Uvalde County*

	Thickness (feet)	Depth (feet)
Escondido formation:		
Coarse sand	21	21
Blue rock	9	30
Hard shell	22	52
Blue rock and hard shells	50	102
Saturated sandrock; oil 11 feet	56	158
Blue rock with iron pyrites	21	179
Anacacho limestone:		
Saturated sand	5	184
Blue rock	5	189
Blue rock and iron pyrites	123	312
Hard blue rock	18	330
Saturated rock	40	370
White limestone	56	426
Gas	10	436
Saturated sand	38	474
Gray lime	43	517
White sandy shale	158	675
Austin chalk:		
Blue sandy shale	415	1,090
Black shale	10	1,100
Some iron pyrites	70	1,170
Eagle Ford shale: White shale	130	1,300
Buda limestone: White lime	30	1,330
Del Rio clay:		
Oil sands 15 feet (driller's log)	5	1,335
Blue shale	75	1,410
Georgetown limestone: White shale	90	1,500
Edwards limestone:		
White lime	50	1,550
Gray lime	75	1,625
"Oil sand"	75	1,700
White lime	50	1,750
Blue lime	100	1,850
White lime	140	1,990
Sandy lime	12	2,002
Comanche Peak limestone: Blue sandy lime	28	2,039
Glen Rose limestone:		
White sand 5 feet	15	2,045
Gas sand	105	2,150
Oil 10 feet	50	2,200
Blue sandy lime	70	2,270
Gas 2 feet	10	2,280
Pink lime 3 feet	686	2,966
Black shale 11 feet	181	3,147

Total depth, 3,775 feet.

H-9-9. *Humble Oil & Refining Co.'s well Kincaid no. 1, Uvalde County*

[Correlation by F. M. Getzendaner]

	Thickness (feet)	Depth (feet)
Escondido formation:		
Loose sand	25	25
Gravel	25	50
Yellow clay	11	61
Blue shale	119	180
Blue sandy shale; water	5	185
Blue shale	30	215
Blue lime	20	235
White lime	25	260
Gray gritty lime	10	270
White shale	7	277
Gray shale	8	285
Anacacho limestone:		
Gray sand; hole full of water	10	295
Brown fine sand; considerable gas and dead oil-asphalt	25	320
Blue shale	10	330
Gray shale	10	340
White lime	30	370
White broken lime	15	385
Sandy shale	8	393
Blue shale	32	425
White lime	30	455
Blue shale	20	475
Gray shale	70	545
Blue shale	40	585
Gray shale	10	595
Gray sandy shale	10	605
Gray lime	25	630
Blue sandy shale	10	640
Blue shale	30	670
Gray lime	25	695
Blue shale	50	745
Blue sandy shale	5	750
Blue shale	120	870
Austin chalk, Eagle Ford shale, and Buda limestone:		
Blue sandy shale; water	3	873
Blue shale	87	960
White lime	10	970
Blue sandy shale; more water at 1,000 feet	60	1,030
Blue shale	260	1,290
Blue sandy shale	60	1,350
Blue shale	228	1,578
Blue sandy shale	22	1,600
Blue shale and lime shells	30	1,630
Del Rio clay:		
Blue shale and lime shells	34	1,661
Gray broken lime and shale; ran casing and corrected depth	16	1,680
Georgetown and Edwards limestones:		
Gray sandy lime; sulphur water at 1,680 feet rose nearly to top	26	1,706
Gray hard lime; flowed while bailing	19	1,725
Gray hard lime	7	1,732
Gray lime and sand	6	1,738
White lime	11	1,749
Gray sand	3	1,752
White pure lime	7	1,759
Gray lime and sand	5	1,764
White lime	6	1,770
White sandy lime	5	1,775

I-4-4. *Sabinal deep well, Sabinal, Uvalde County, Tex.*

[The first part of the log (to 1,478 feet) was made by the drillers as the well progressed. The rest was made by the Bureau of Economic Geology of the State University from drillings sent by Mayor W. D. Heard]

	Thickness (feet)	Depth (feet)
Anacacho limestone:		
Soil	3	3
Yellow clay	32	35
Gravel	5	40
Yellow clay	25	65
Gravel	5	70
Yellow clay	12	82
Lime	8	90
Blue shale	30	120
Lime	5	125
Black shale	5	130
Lime	55	185
Blue shale	5	190
Lime	20	210
Blue shale	10	220
Lime	5	225
Blue shale	40	265
Green shale	15	280
Shell	2	282
Blue shale	18	300
Austin chalk:		
White shale	10	310
Blue shale	25	335
White shale	30	365
Blue shale	10	375
White shale	31	406
Lime	24	430
White slate	15	445
Lime; water at 515 feet	70	515
Austin chalk—Continued.		
Slate and lime	75	590
Brown shale	20	610
Lime	20	630
White slate	20	650
Lime	35	685
Eagle Ford shale:		
Black slate	15	700
Brown shale	65	765
Buda limestone:		
Hard lime	10	775
Chalky lime	13	788
Hard lime	54	842
Del Rio clay: Shale	73	915
Georgetown limestone: Sand; water at 915 feet	25	940
Edwards limestone:		
White lime	110	1,050
Gray lime	10	1,060
White lime	10	1,170
Gray lime and sand	10	1,180
Hard lime	140	1,320
Limerock	150	1,470
Sandrock	8	1,478
Crystalline limestone	12	1,490
Crystalline grayish-brown limestone	35	1,525
Grayish-brown and white limestone	20	1,545

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I-4-4. *Sabinal deep well, Sabinal, Uvalde County, Tex.*—Continued

	Thickness (feet)	Depth (feet)
Edwards limestone—Continued.		
Gray limestone	30	1,575
Light-gray chalky limestone	42	1,617
Gray limestone	11	1,628
Gray limestone and marl	19	1,647
Comanche Peak limestone, Walnut clay, and Glen Rose limestone:		
Light bluish-gray limestone	23	1,670
White limestone	8	1,678
White limestone and light-blue marl	17	1,695
Gray limestone and light-blue soft marl	5	1,700
Gray limestone	10	1,710
Light-gray limestone and blue marl containing some gypsum	18	1,728
White limestone and blue marl	36	1,764
Gray and bluish limestone and blue marl	56	1,820
Light-gray limestone and light-blue marl	92	1,912
Dark bluish-gray limestone and some white limestone	56	1,968
Gray marl and light-gray limestone	4	1,972
Grayish-blue marl	8	1,980
Gray limestone and gray marl	20	2,000
Gray organic fragmental limestone	80	2,080
Gray limestone and bluish-gray shale	18	2,098
Gray organic fragmental limestone	9	2,107
Comanche Peak, etc.—Contd.		
Dark bluish-gray marly shale and light-gray limestone	13	2,120
Light-gray limestone and bluish-gray marly shale	15	2,135
Bluish-gray marly shale and light-gray limestone	25	2,160
Light-gray limestone	15	2,175
Gray marly shale	10	2,185
Soft bluish-gray marly shale	25	2,210
Light-gray limestone	20	2,230
Light-gray limestone and bluish-gray marly shale	30	2,260
Gray limestone	25	2,285
Light-gray limestone and some gray marly shale	35	2,320
Light-gray porous limestone and some gray shale	15	2,335
Light-gray limestone and dark-gray marly shale	20	2,355
Light-gray limestone	98	2,453
Light-buff limestone	50	2,503
Light-buff crystalline limestone	25	2,528
Grayish-buff crystalline limestone	50	2,578
Gray organic fragmental and partly crystalline limestone	27	2,605
Gray limestone	28	2,633
Gray organic fragmental limestone	22	2,655
Gray limestone	25	2,680
Gray organic fragmental limestone	20	2,700

Dr. J. A. Udden, of the Bureau of Economic Geology and Technology, University of Texas, under whose direction the work was done, writes as follows: "The highest sample submitted was 1,478 feet to 1,490 feet below the surface. This sample and the next following three samples I believe, have come from the lower part of the Edwards limestone formation. From about 1,640 feet to somewhere near 2,500 feet is the Comanche Peak limestone, the Walnut clays, and the Glen Rose formation. Below this the well seems to have gone into the Travis Peak formation some 200 feet. This formation has not been penetrated wholly, and it is evident that the drilling has stopped before reaching the Trinity sands and has not yet entered probable underlying Pennsylvania."

I-5-2. *Mid-Kansas Co.'s well Jesse Newton no. 1, Maxime Bendel survey 762, Medina County*

	Thickness (feet)	Depth (feet)
Escondido, Navarro, Taylor, and Anacacho formations:		
Surface soil	3	3
Clay	11	14
Gravel	4	18
Yellow clay and sand	47	65
Black water sand	20	85
Sandy shale	16	101
Hard rock and sand	5	106
Sandy limerock	27	133
Hard blue shale	7	140
Bedrock	1	141
Soft white shale	32	173
Hard limerock	4	177
Shale and hard lime	21	198
Hard broken lime	7	205
Shale and hard lime	12	217
Sandy shale and lime	25	242
Shale and lime	20	262
Bedrock	1	263
Shale	59	322
Slate rock	16	338
?	1	339
Shale	8	347
Blue shale	5	352
Hard rock and hard shale	10	362
Sand; oil showing	5	367
Shale	53	420
Rock	2	422
Shale	35	457
Escondido, Navarro, Taylor, and Anacacho formations—Contd.		
Hard rock	1	458
Sticky shale	8	466
Gumbo	22	488
Sticky shale and boulders	14	502
Shale and boulders	68	570
Hard rocks	2	572
Shale and boulders	176	748
Hard limerock	2	750
Shale and lime shells	31	781
Shale and boulders	64	845
Sticky shale	83	928
Sandy shale; gas show	12	940
Sticky shale	51	991
Lime	164	1,155
Sandy shale	8	1,163
Shale and hard lime	5	1,168
Hard lime	7	1,175
Sandy shale	29	1,204
Sandy shale and hard lime	38	1,242
Limerock	6	1,248
Broken lime	17	1,265
Austin chalk	347	1,612
Eagle Ford shale	60	1,672
Buda limestone	85	1,757
Del Rio clay	67	1,824
Georgetown limestone	116	1,940
Edwards limestone; hole full of water	50	1,990

I–5–4. *Medina Oil Co.'s well A. L. Haegelin, 7 miles south-southwest of Hondo, Medina County*

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Escondido, Navarro, and Anacacho formations, Taylor marl, and Austin chalk:			Escondido, Navarro, and Anacacho formations, Taylor marl, and Austin chalk—Contd.		
Surface soil	10	10	Sandy lime	12	1,230
Clay	28	38	Hard blue clay	40	1,270
Rock	4	42	Sand and gravel	3	1,273
Gravel and water	20	62	Lime (Anacacho)	19	1,292
Boulders and gumbo	174	236	Blue shale	5	1,297
Gumbo and sand	173	409	Unknown formation	297	1,594
Gumbo and shale	251	660	Eagle Ford shale:		
Sandy gumbo	30	690	Gray shale	16	1,610
Sandy shale	15	705	Shale	35	1,645
Gumbo	255	960	Buda limestone	78	1,723
Blue shale	13	973	Del Rio clay	77	1,800
Gumbo	66	1,039	Georgetown limestone:		
Lime (Anacacho)	53	1,092	Lime; sulphur water	37	1,837
Salt water and salt	5	1,097	Lime and sand; water	24	1,861
Water gas	6	1,103	Edwards limestone:		
Blue azurite shale	59	1,162	Strong fresh water	12	1,873
Lime (Anacacho) and gumbo	38	1,200	Showing H_2S and oil	33	1,906
Lime (Anacacho)	18	1,218	Limestone	44	1,950

I–6–2. *Ina Oil Co.'s well Blackburn no. 1, Medina County*

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Indio, Midway, Escondido, Navarro, and Anacacho formations, Taylor marl, and Austin chalk:			Indio, Midway, Escondido, Navarro, and Anacacho formations, Taylor marl, and Austin chalk—Continued.		
Sand, gravel, and yellow clay	23	23	Gray sandy shale, very hard streaks, thin layers of rock	132	784
Water sand	13	36	Hard sandy shale	54	838
Lignite	9	45	Gray sticky shale; at 862 feet reamed from 9¼ to 5¾ inches	24	862
Shale	37	82	Rock	8	870
Rock pyrite	4	86	Oil sand, estimated at 5 barrels	34	904
Sandy shale	19	105	Hard gray sandy shale	156	1,060
Sandrock	2	107	Hard limestone	40	1,100
Sandy shale	18	125	Lime with breaks of shale	50	1,150
Hard sandstone	1	126	Limestone	50	1,200
Packed sand; water	10	136	Anacacho limestone	114	1,314
Sandy shale	46	182	Austin chalk:		
Very hard rock	3	185	Sticky clay	40	1,354
Gray sandy shale	45	230	Chalk	294	1,648
Limerock	2	232	Eagle Ford shale	52	1,700
Shale	13	245	Buda limestone	80	1,780
Rock	2	247	Del Rio clay: Sandy clay	50	1,830
Gray shale	18	265	Georgetown limestone:		
Hard limerock	8	273	Limestone	20	1,850
Gray sandy shale	20	293	Core saturated with oil; strong odor	1	1,851
Sticky shale	21	314	Another core; more heavy show of oil	2	1,853
Rock	1	315	Georgetown	40	1,893
Gumbo	75	390	Edwards limestone:		
Sandrock	2	392	Core, top of Edwards	2	1,895
Blue sandy shale	53	445	Edwards—fresh water	111	2,006
Sandrock	2	447			
Gumbo	83	530			
Limerock	3	533			
Blue sandy shale; hard streaks	117	650			
Limerock	2	652			

J-1-3. *Wheless-Peters well Anton Burger no. 1, William Teer survey no. 341, Medina County*

	Thickness (feet)	Depth (feet)
Escondido, Navarro, Taylor, and Anacacho formations and Austin chalk:		
Black earth	3	3
Gravel	41	44
Yellow clay	190	234
Blue shale	2	236
Blue lime	9	245
Blue shale	19	264
Blue shale and thin sand lenses	1	265
Blue lime	5	270
Blue shale and thin sand lenses	2	272
Blue shale	118	390
Blue lime	3	393
Blue shale	59	452
Blue lime	202	654
Escondido, Navarro, Taylor, and Anacacho formations and Austin chalk—Continued.		
White limestone; some marly limestone	168	822
Dark shale	6	828
Austin chalk	267	1,095
Eagle Ford shale: Lignitic shale	41	1,136
Buda limestone: Hard creamy-white limestone	62	1,198
Del Rio clay: Blue mud	60	1,285
Georgetown limestone:		
Gray limestone	32	1,290
Hard yellowish-white limestone	10	1,300
Edwards limestone: Porous sandy limestone; sulphur water	15	1,315

J-1-4. *Golden West Oil Co.'s well Courand no. 1, 3 miles southwest of Castroville, Medina County*

	Thickness (feet)	Depth (feet)
Upper Cretaceous:		
Gravel	10	10
Shale	200	210
Lime	15	225
Shale	172	397
Sand	35	432
Shale	35	467
Lime	113	580
Shale	80	660
Lime	140	800
Shale	5	805
Sand	15	820
Lime	83	903
Sand	17	920
Shale	12	932
Buda limestone	71	1,003
Del Rio clay:		
Clay	29	1,032
Sand	2	1,034
Shale	18	1,052
Georgetown limestone:		
Sand; water at 1,066 feet	15	1,067
Lime	32	1,099
Edwards limestone:		
Sand; water at 1,099 feet	23	1,122
Sandy lime	5	1,127
Hard lime; water at 1,147 feet	20	1,147

J-4-1. *Mid-Kansas Oil & Gas Co.'s well Jake Haby no. 1, Medina County school-land survey no. 292*

	Thickness (feet)	Depth (feet)
Escondido and Navarro formations, Taylor marl, Austin chalk, and Anacacho limestone:		
Surface sand	10	10
Gray rock	4	14
Gray sand	6	20
White gravel	20	40
Rock	4	44
Gravel and clay	10	54
Rock	1	55
Blue clay	5	60
Shale and boulders	200	260
Sticky shale	125	385
Blue shale	15	400
Shale; show of gas and oil	35	435
Shale and boulders	79	514
Rock	2	516
Shale and boulders	284	800
Limerock	31	831
Gray sand	1	832
Gray sand and rock	44	876
Sandy shale and shell; light show of oil at 912 feet	66	942
Escondido and Navarro formations, Taylor marl, Austin chalk, and Anacacho limestone—Continued.		
Blue sandy shale	58	1,000
Rock	14	1,014
Chalky shale	45	1,059
Chalk	1	1,060
Blue shale	16	1,076
Gray lime	38	1,114
White chalk	32	1,146
Chalk	189	1,335
Eagle Ford shale	35	1,370
Buda limestone	54	1,424
Del Rio clay	60	1,484
Georgetown limestone	23	1,507
Edwards limestone:		
Limestone; sulphur water	35	1,542
Yellow sand and clay	6	1,548
Yellow clay	44	1,592
Limestone	24	1,616

J-4-3. *Stovers & May well Emil Bendele no. 1, Medina County*

	Thickness (feet)	Depth (feet)
Midway, Escondido, and Navarro formations, Taylor marl, Austin chalk, and Anacacho limestone:		
Black soil	10	10
Gravelly clay	6	16
Pack sand	4	20
Clay	20	40
Pack sand	6	46
Water sand	4	50
Rock	3	53
Sand with water	17	70
Sandy shale	5	75
Rock	32	107
Sand	8	115
Rock	3	118
Shale and boulders	42	160
Chalk	2	162
Shale	11	173
Rock	5	178
Shale	12	190
Water sand	10	200
Rock	3	203
Shale and boulders	42	245
Rock	2	247
Sand	15	262
Shale	123	385
Shale and boulders	50	435
Shale	35	470
Pack sand	10	480
Shale	20	500
Rock	3	503
Shale	17	520
Rock	5	525
Shale and boulders	25	550
Shale	20	570
Rock	2	572
Sticky shale	28	600
Rock	4	604
Shale and shell; showing of oil	8	612
Midway, Escondido, and Navarro formations, Taylor marl, Austin chalk, and Anacacho limestone:—Continued.		
Hard shale	28	640
Shale	15	655
Rock	3	658
Gumbo	22	680
Gray-blue hard shale	50	730
Hard shale	60	790
Gumbo	30	820
Sticky shale	20	840
Rock	2	842
Gumbo	33	875
Shale	20	895
Anacacho	25	920
Lime and shale	40	960
Shale	90	1,050
Sandy lime	35	1,085
Red clay; top of chalk	15	1,100
Hard chalk	25	1,125
Chalk	87	1,212
Hard dry chalk	58	1,270
Hard chalk	80	1,350
Chalk	15	1,365
Black shale	10	1,375
Chalk	17	1,392
Eagle Ford shale	23	1,415
Buda limestone	45	1,460
Del Rio clay	60	1,520
Georgetown limestone	2	1,522
Broken limestone	13	1,535
Hard limestone	15	1,550
Limestone	6	1,556
Edwards limestone:		
Hard dry lime	29	1,585
Hard broken lime	50	1,635
Hard dry brown lime	21	1,656
Hard brown lime, black streaks	16	1,672

J-7-8. *J. R. McCaldin well W. A. Thompson no. 1, San Antonio Ditch Co. survey no. 402, Medina County*

	Thickness (feet)	Depth (feet)
Carrizo sand	210	210
Indio formation:		
Brown shale	38	248
Rock	1	249
Shale and sand	19	268
Rock	2	270
Sand	15	285
Gumbo	14	299
Rock	3	302
Brown shale	28	330
Rock	4	334
Shale	10	344
Gumbo	6	350
Shale	15	365
Rock	1	366
Shale	4	370
Rock	2	372
Shale	13	385
Rock	4	389
Shale	10	399
Rock	1	400
Shale	26	426
Packed sand; show of gas	7	433
Rock	5	438
Sandy shale	12	450
Gumbo	15	465
Shale	40	505
Rock	6	511
Shale and boulders	36	547
Rock	1	548
Shale	3	551
Rock	5	556
Shale with streaks of sand	59	615
Gumbo	49	664
Gummy and sandy shale with boulders	51	715
Gumbo	15	730
Shale	35	765
Gumbo	10	775
Rock	4	779
Shale	27	806
Rock	2	808
Shale	48	856
Rock	5	861
Gumbo	4	865
Rock	7	872
Shale	8	880
Midway formation:		
Broken lime with shale	25	905
Midway formation—Continued.		
Shale	49	954
Rock	8	962
Shale	23	985
Gumbo	10	995
Gray shale and boulders	83	1,078
Lime	1	1,079
Shale and boulders	36	1,115
Lime	2	1,117
Shale	5	1,122
Lime	4	1,126
Escondido and Navarro formations, Taylor marl, Anacacho limestone, and Austin chalk:		
Shale with streaks of sandy lime and pyrite boulders	13	1,139
Shale and boulders	112	1,251
Rock	2	1,253
Shale and boulders	142	1,395
Gumbo	8	1,403
Shale and boulders	167	1,570
Gumbo	15	1,585
Shale with streaks of lime	22	1,607
Lime	13	1,620
Gumbo	10	1,630
Hard shale	10	1,640
Shale	10	1,650
Gumbo	15	1,665
Shale and boulders	47	1,712
Sandy shale; show of gas	18	1,730
Gummy shale	20	1,750
Hard lime	14	1,764
Shale with streaks of sand	72	1,836
Sandy shale	13	1,849
Gumbo	11	1,860
Shale	65	1,925
Gumbo	50	1,975
Gummy shale	49	2,024
Sandy shale with streaks of lime	30	2,054
Gummy shale with shell boulders	81	2,135
Lime with gummy streaks	253	2,388
Hard lime	222	2,610
Eagle Ford shale	34	2,644
Buda limestone: Hard lime	146	2,790
Del Rio clay	53	2,843
Georgetown limestone	65	2,908
Edwards limestone	104	3,012

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