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GEOLOGY AND GROUND-WATER RESOURCES OF ATASCOSA AND FRIO COUNTIES TEXAS

BY

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ABSTRACT

Atascosa and Frio Counties are in southwestern Texas and form a part of the Winter Garden district. The purpose of the investigation here recorded was to determine the source, quantity, and quality of the ground water used for irrigation and other purposes in the area.

The rock formations exposed are of Tertiary and Quaternary age and dip toward the east or southeast at a greater angle than the slope of the land surface, resulting in northeastward-trending belts of the outcropping formations. This general structure is modified by a large syncline in the western part of the area and by smaller anticlines and faults in other parts. These, however, do not affect greatly the movement of ground water. In order from oldest to youngest the exposed formations are the Indio formation (800 feet thick), of Wilcox age; the Carrizo sand (425 feet), the basal or Bigford member of the Mount Selman formation (0–500 feet), the post-Bigford beds of the Mount Selman formation (700 feet), the Cook Mountain formation (600 feet), and the Yegua formation (500 feet), all of Claiborne age; the Jackson formation (500 feet); the Catahoula tuff (600 feet), of Miocene age; the Goliad sand (20 feet), of Pliocene(?) age; and the Leona formation (75 feet), of Pleistocene age.

The chief water-bearing formations in the area are the Carrizo sand, the Mount Selman formation, and the Cook Mountain formation. The Carrizo sand crops out in the northern part of the area and furnishes shallow wells in the outcrop area and deeper flowing and nonflowing wells south and southeast of the outcrop. Water from this formation is of good quality and is used for irrigation near Pearsall, in Frio County, and Poteet, in Atascosa County. Maps accompanying the report show the outcrop of the sandstone, depths to the sandstone south and southeast of the outcrop, heights to which the water will rise, and the area in which flowing wells can be obtained.

The Mount Selman and Cook Mountain formations consist of discontinuous beds of sandstone, clay, shale, and lignite. The formations are important sources of water for domestic use and to some extent for irrigation. The waters are of variable quality, some being highly mineralized, and vary also in quantity. Water from the Mount Selman formation is used for irrigation near Pearsall and in eastern Atascosa County, and flowing wells are obtained in this formation east of Pearsall and near Pleasanton. The Cook Mountain formation yields water for irrigation near Dilley and supplies flowing wells in southeastern Frio County and southwestern Atascosa County near Hindes. The other formations of the area yield smaller amounts of water for domestic use and stock. These waters also are of variable quality, many being highly mineralized.

The investigation showed that a considerable amount of water from flowing wells is being wasted. If this water were conserved considerable additional irrigation could be carried on. Measurements of the water level in wells from the Carrizo sand (still being continued) lead to the tentative conclusion that the safe yield from this formation has not been exceeded.

INTRODUCTION

PURPOSE OF INVESTIGATION

This report covers the results of an investigation in Atascosa and Frio Counties, Tex., which was begun in 1929 under the direction of the Engineering Experiment Station of the Agricultural and Mechanical College of Texas at the joint request of the officials of the Missouri Pacific Railroad and of residents in the area. Early in 1930 an arrangement was made to incorporate the investigation into the general program of ground-water investigations which is being carried out by the State Board of Water Engineers through cooperation with the United States Geological Survey and which covers several adjacent or nearby counties, including Dimmit, Zavala, Medina, Uvalde, Duval, and Webb. This report, therefore, represents the results of a cooperative project between the Engineering Experiment Station, the Texas Board of Water Engineers, and the United States Geological Survey. The investigation was undertaken for the purpose of determining the resources of ground water in the area with special reference to the supply available for irrigation. The field work occupied June, July, and August in both 1929 and 1930, a part of December in 1931, and a part of June in 1932. During the season of 1929 an office was maintained at Pearsall, and in 1930 offices were maintained at both Pearsall and Jourdanton. During the season of 1930 the writer was ably assisted by M. T. Halbouty.

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The writer is indebted to many persons who contributed information and assistance in the field and assisted in the preparation of this report. Mr. W. B. Cook, of the Missouri Pacific Railroad, and his associates cooperated by supplying engineering and agricultural data. Mr. N. H. Hunt and Mr. L. F. Merl, secretaries respectively of the Pearsall and Dilley Chambers of Commerce, contributed data concerning wells and extended many courtesies. Well logs were supplied by Mr. W. D. Morrison, of Dilley; Mr. C. S. Young, of Jourdanton; Mr. F. M. Getzendaner and Mr. L. F. McCollum, of the Humble Oil & Refining Co.; and Mr. J. M. Dawson, of the Gulf Production Co. Mr. Getzendaner also gave freely of his store of geologic information relating to the area. Messrs. A. R. Denison and L. W. Clark, of the Amerada Petroleum Corporation, supplied information concerning Cook Mountain contacts in Frio County and oil wells drilled by the company. Miss Julia Gardner, of the United States Geological Survey, identified fossils collected by the writer and helped him to map geologic boundaries in parts of the area. Mr. W. N. White, of the Geological Survey, who is in charge of the ground-water investigation in Texas, spent several days in the field with the writer and

has reviewed and to some extent revised this report. Geologic and hydrologic data were supplied by Messrs. A. N. Sayre, T. W. Robinson, and S. F. Turner, also of the Geological Survey, who were making similar investigations in adjoining areas in Dimmit, Uvalde, and Medina Counties. Use was also made of unpublished hydrologic

FIGURE 1.—Map of Texas, showing location of Atascosa and Frio Counties.

data in the files of the United States Geological Survey collected by Messrs. Alexander Deussen and S. S. Nye. The investigation was made under the general direction of Mr. O. E. Meinzer, geologist in charge of the division of ground water in the Geological Survey.

LOCATION OF AREA

Atascosa and Frio Counties are in southwestern Texas (see fig. 1) and comprise a part of the area that is commonly called the Winter Garden district, the boundaries of which are rather loosely defined. Atascosa County has an area of 1,350 square miles and Frio County

1,124 square miles. The principal towns are Poteet, Pleasanton, North Pleasanton, Jourdanton, Lytle, Christine, and Campbellton, in Atascosa County; and Moore, Pearsall, Derby, Melon, Dilley, and Bigfoot, in Frio County.

TOPOGRAPHY AND DRAINAGE

Atascosa and Frio Counties are within the Western Gulf section of the Coastal Plain, which in this part of Texas extends from the Edwards Plateau, on the north and northwest, to the Gulf of Mexico, on the south and southeast. The general pattern of the surface is that of a uniform southeastward slope, somewhat dissected by southeastward-flowing streams. Thus Lytle, in the northwestern part of Atascosa County, has an altitude of about 730 feet above sea level, and Campbellton, in the southern part of the same county, has an altitude of only about 250 feet. In some parts the surface forms a true plain with very little relief, but in general the interstream areas are belts of relatively high land that have a southeasterly trend. In some places the more resistant beds have formed escarpments that face west or north. The greatest relief is in the northern part of the area, especially in northwestern Frio County, where the outcropping rocks contain beds of variable hardness and the streams have dissected the once uniform upland into prominent hills and valleys.

The principal streams of the area are the Frio, Atascosa, and Leona Rivers and San Miguel Creek. Minor streams of some importance are Hondo, Seco, Lagunillas, Siestadero, and Turkey Creeks. All these streams are intermittent. Floods occur during and immediately after heavy rains, but these floods subside in a few hours or at the most in a few days, and during the greater part of the time the streams either are dry or contain disconnected pools which dwindle during protracted periods of drought until little or no water remains. The channels of the Frio River in the region below Derby and of the Atascosa River below Poteet contain water nearly all the year. This is partly due to the inflow of waste water from artesian wells, that are allowed to flow continually.

The amount of standing water in the stream channels during dry times is related to the character of the underlying rocks. In sandstone areas the stream channels are usually completely dry at such times, but in shale areas they frequently contain pools of water for long periods. This difference gives a clue as to the source of some of the ground water in the sandstone formations of the area.

The larger streams are bordered by belts of alluvium, but these are narrow and poorly defined except along the Frio and Atascosa Rivers and San Miguel Creek in the southern part of the area. The alluvial deposits do not enter into the ground-water problems of the district.

VEGETATION

The native vegetation reflects to a degree the semiarid subtropical character of the climate. Nearly everywhere the uncultivated areas are covered with a growth of varying density of scrub trees or chaparral. The trees consist dominantly of mesquite in the western part of the area and of mesquite and scrub oak in the eastern part. The chaparral consists chiefly of black brush, catclaw, juahillo (wah-ee′yo), scrub mesquite, and prickly pear and other types of cactus. Near the streams are found trees of considerable size, such as the pecan, cypress, and live oak. Oaks of fairly large size also occur on the divides between the streams in the eastern part of the area. A variety of grasses flourish in open spaces among the trees and chaparral.

TRANSPORTATION

The area is crossed by branch lines of the Missouri Pacific Railroad. The International-Great Northern Railroad passes in a north-south direction through the northwestern part of Atascosa County and the central part of Frio County. Moore, Pearsall, Melon, Derby, and Dilley, in Frio County, are on this line. One branch of the San Antonio, Uvalde & Gulf division of the Missouri Pacific Railroad passes through north-central Atascosa County and another through the southern part of the county, the towns of Leming, Pleasanton, Jourdanton, Dobrowolski, Charlotte, and Hindes being on the first-named branch and Coughran, McCoy, and Campbellton on the other. A third line, the San Antonio Southern Railway, passes through Poteet and Jourdanton and terminates at Christine.

Both Atascosa and Frio Counties are provided with good trunk automobile roads. State highway 2, between San Antonio and Laredo, passes through Frio County, following the line of the International-Great Northern Railroad. State highway 85, from Dilley to Eagle Pass, crosses the southwestern part of the county. Highway 9 crosses Atascosa County from north to south through Leming, Pleasanton, and Campbellton, and a short branch of it (highway 97) extends from Pleasanton to Jourdanton. In the northern part of the county the Palo Alto road from San Antonio extends to Poteet.

All the highways converge at San Antonio, which is the supply and market point for the area. Secondary automobile roads, which are generally graded and open for travel except in very bad weather, connect all parts of the area. It should be noted that dirt roads passing over certain of the clay formations, such as the Yegua, are impassable after heavy rains.

AGRICULTURE

Atascosa and Frio Counties are to some extent in a stage of transition from stock raising to farming. Until within a comparatively few years very little farming was carried on, and practically the entire area in both counties was devoted to cattle raising. Some of the most famous early ranches in Texas were located in this area.

In recent years farming has been on the increase, much of the development having started with the building of the railroads. In most of the area dry farming is practiced. Cotton is raised extensively, and in Atascosa County it is the largest crop, but in Frio County the rainfall in many years is insufficient to mature the cotton. Corn, various sorghums, and other dry-land crops are raised.

Winter truck farming, with irrigation from wells, has become important in the area. Poteet furnishes large amounts of early strawberries and vegetables. Areas around Pearsall and Dilley furnish onions, spinach, tomatoes, and other vegetables. Large tracts still remain and probably will continue to remain as ranch land, but in general farming is being extended. According to the agricultural census of the United States, 37.9 percent of Atascosa County and 54.8 percent of Frio County were in farms in 1925. Below is a table compiled from the 1925 census showing the kinds of crops raised and the acreage devoted to each crop. The table does not include strawberries, because information was not available as to the acreage of that crop.

Farm acreage of crops raised in Atascosa and Frio Counties, Tex., in 1925

	Atascosa County	Frio County		Atascosa County	Frio County
Total area	869, 120	719, 360	Sweetpotatoes	115	4
Cotton	81, 455	73, 333	Cabbages	104	11
Corn	22, 915	22, 494	Cantaloupes	288	24
Wheat	50	54	Lettuce	75	5
Oats	107	272	Onions	37	185
Sorghums	1, 613	4, 919	Sweet corn	78	5
Peanuts	1, 807	50	Tomatoes	267	43
Hay	3, 150	522	Watermelons	3, 833	2, 179
Irish potatoes	81	12			

HISTORY

The history of Atascosa and Frio Counties is an interesting story of the winning of frontier lands from Indians, the development of ranching, the building of railroads, and finally a gradual change into a combination of ranching and farming. Only a brief summary of this history can be given here.

Venturesome stockmen established themselves in the area in the early fifties. At that time and for 25 years afterward the region was subject to Indian raids, the Frio County area being the more vulnerable because of its greater distance from San Antonio.

Atascosa County was delimited and organized in 1871. The county seat was first at Novatascosa, but later it was moved to Pleasanton and still later to Jourdanton. Until 1908 the only railroad in the county passed through the extreme northwestern part. In 1908 and 1909 two railroads, the San Antonio, Uvalde & Gulf and the San Antonio Southern, were built into the county, and Jourdanton, Poteet, and Christine were established as stations on them.

The first flowing well at Poteet, in Atascosa County, was drilled in 1904, before the advent of the railroad, and this demonstration of the availability of artesian water had much to do with the initiation of railroad building in the area. By 1910 there were 10 artesian wells, and thereafter several were drilled each year until the period of the World War, when drilling was stopped on account of the high cost of sinking the wells and providing them with pumping equipment. More recently well drilling has been resumed, and there are now more than 50 artesian wells in the Poteet area. The development of truck farming has paralleled the sinking of the artesian wells.

Frio County was also organized in 1871, with the county seat at Frio Town. In 1881 the county seat was moved to Pearsall, then a new town on the International-Great Northern Railroad, which had recently been built through the county. The original courthouse at Frio Town is still intact and is one of the historic landmarks of the region.

The first flowing well in Frio County was drilled near Pearsall in 1905. Since then, deep wells have been drilled from time to time in the Frio Valley area, west and southwest of Pearsall. Most of these wells flow and furnish water for irrigation of considerable extent.

Irrigation with water pumped from shallow wells was started in the Pearsall area in 1905, and the development reached its height about 1923. Pump-well irrigation was begun in the vicinity of Dilley about 1925 and has since gradually developed.

MAPS

Two maps accompany this report. Plate 1 shows the areal geology, the original and present areas of artesian flow, and the location of record wells and of lands irrigated with water from wells. Plate 2 shows the depths to the top of the Carrizo sand and the height above sea level to which water from the Carrizo sand would rise in 1930. The map of Frio County used as a base for showing the geologic and hydrologic data was traced from a soil map of the county prepared by M. W. Beck, of the United States Department of Agriculture, and made available through the courtesy of Mr. A. B. Conner, director of the Texas Agricultural Experiment Station. The base map of Atascosa County was prepared by M. T. Halbouty, by compilation of data from existing county and land maps and by a plane-table traverse which covered about one-third of the county.

CLIMATE

Texas is remarkable for its great variety of climate. The extreme eastern part of the State has an average annual rainfall of more than 45 inches. The precipitation decreases gradually from east to west, the annual average being less than 30 inches at San Antonio and less than 20 inches at Eagle Pass. Atascosa County on the average receives 25 to 30 inches annually as compared with 20 to 25 inches in Frio County.

There is a considerable range in temperature in the two counties. Summer temperatures are frequently higher than 100° and during the winter there is generally at least one killing frost. During the period of record the growing season has varied from 220 to 298 days. Observations made intermittently since 1908 record a minimum temperature of 13°.

In most years there is some rain every month. The heaviest precipitation usually occurs in April, May, and the early part of June and in September and October. February is also a wet month, especially in Frio County. August is the driest month. There is a tendency for the precipitation to be concentrated in heavy rains, which frequently cause floods. In many years there is a decided shortage of rainfall during the summer, especially in July and August. Crops therefore must be specially adapted to dry farming or must be irrigated.

Tables showing available records of rainfall and dates of the first killing frost in the fall and the last killing frost in the spring in the two counties, and of rainfall at Runge, in Karnes County, are given below, from reports of the United States Weather Bureau.

Climatic data for Dilley, Frio County, Tex., 1910–29

Year	Precipitation (inches)													Temperature (°)		Last killing frost in spring	First killing frost in fall
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Maximum	Minimum		
1910	0.18	0.04	1.50	3.20	1.00	1.65	1.04	1.00	1.02	--	0.70	0.99	12.32	--	--	--	
1911	.75	1.85	2.65	3.25	.90	--	--	1.00	1.80	1.55	2.50	1.00	17.25	--	--	--	
1912	--	2.05	.85	2.40	1.65	4.57	--	--	--	2.50	1.25	1.80	17.07	--	--	--	
1913	.30	1.50	.80	1.75	--	4.90	.50	--	7.60	--	2.00	3.65	23.00	--	--	--	
1914	--	1.15	.65	1.85	6.00	--	--	3.50	1.65	1.45	3.10	.85	20.20	--	--	--	
1915	.65	.40	.65	2.25	4.25	--	1.25	3.90	2.25	.75	--	--	16.35	--	--	--	
1916	1.70	--	--	.53	2.25	.62	2.47	4.90	1.11	1.86	1.15	.32	16.91	--	--	--	
1917	--	Tr.	.19	--	.25	Tr.	3.10	Tr.	1.62	--	.80	--	5.96	--	--	--	
1918	.10	.95	.45	1.96	3.52	.93	.12	.67	2.41	2.55	1.67	2.93	19.26	--	--	--	
1919	3.02	1.71	2.24	3.78	2.89	7.01	3.75	2.05	5.43	5.24	1.12	.82	39.06	--	--	--	
1920	1.72	.85	.75	1.10	6.22	5.33	4.44	2.59	.28	1.80	.83	.02	25.93	--	--	--	
1921	.49	.23	3.23	.82	2.28	1.58	.32	Tr.	3.69	1.35	.80	--	14.70	104	30	Feb. 21	Dec. 9
1922	.60	.65	4.08	1.56	8.76	2.70	3.30	.78	2.17	3.52	.46	.17	28.75	103	24	Mar. 4	Dec. 19
1923	.30	7.84	2.92	1.07	.23	.76	1.75	2.22	5.83	3.40	3.28	3.28	32.27	104	23	Mar. 20	Dec. 14
1924	.45	--	2.65	1.30	4.19	.41	.32	--	5.08	.47	--	1.36	--	--	--	Mar. 15	Dec. 19
1925	.36	--	2.91	Tr.	.88	.08	1.14	2.37	4.94	1.52	1.73	1.34	17.27	106	22	Jan. 29	Nov. 23
1926	2.65	.46	4.15	3.55	1.76	.20	.33	3.76	.49	1.39	1.10	2.12	18.92	107	25	Jan. 26	Dec. 30
1927	.89	.65	1.37	.26	1.15	5.81	.77	.02	2.65	1.73	--	1.06	16.36	110	25	--	Dec. 8
1928	.97	1.14	.17	2.24	4.73	1.62	1.05	2.16	4.62	.35	.40	1.82	21.27	104	18	Feb. 26	Dec. 23
1929	.71	.06	3.12	.44	8.95	.23	2.14	.10	.75	4.50	1.56	1.42	23.98	103	21	Feb. 13	Nov. 6
Average	1.51	3.27	1.88	1.98	3.04	2.83	2.20	1.65	2.79	2.02	1.73	1.70	22.56	--	--	--	

Climatic data for Pearsall, Frio County, Tex., 1902–29

Year	Precipitation (inches)													Last killing frost in spring	First killing frost in fall
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual		
1902	0.46	0.59	0.22	0.45	3.91	------	3.64	------	1.75	1.41	3.56	2.55	18.54	------	Dec. 4
1903	2.80	5.75	2.75	.08	2.96	2.81	7.10	0.55	1.77	.05	Tr.	.21	26.83	Feb. 18	Nov. 18
1904	Tr.	.56	------	2.45	3.00	2.25	2.85	.87	4.96	1.65	.40	.62	19.61	Feb. 21	Nov. 21
1905	.46	1.90	2.41	5.36	3.88	.81	1.40	.35	4.71	2.47	2.72	2.00	28.47	Feb. 20	Nov. 13
1909	------	------	------	------	------	------	------	.91	Tr.	3.85	Tr.	1.49	------	------	
1910	------	Tr.	.40	1.06	2.86	.60	1.55	.56	.60	2.23	.79	1.27	11.92	------	Dec. 6
1911	1.03	1.32	2.53	2.20	.48	------	.57	2.84	.09	.82	2.03	1.21	15.12	Feb. 23	Nov. 29
1912	.33	3.67	.98	1.48	1.84	3.66	.05	------	1.43	1.76	2.22	2.51	19.93	------	Nov. 28
1913	.53	1.09	1.21	1.02	.79	7.81	.27	1.46	3.50	3.64	4.96	3.77	30.05	Mar. 17	
1914	.07	1.90	1.49	2.34	5.37	.06	.08	5.80	1.65	1.49	2.35	.98	23.58	Mar. 14	
1915	.73	.31	1.14	4.40	2.41	.18	------	2.55	4.19	1.83	.17	.76	18.67	------	Nov. 15
1916	1.55	------	Tr.	1.89	2.16	1.65	3.45	3.68	1.03	3.13	1.11	.21	19.86	------	
1917	.50	.13	.08	.18	1.70	------	1.70	.24	3.23	.02	2.09	------	9.87	Mar. 3	
1918	.10	.97	1.20	3.44	3.30	1.49	.70	1.64	1.73	2.42	1.35	5.49	23.83	------	Nov. 28
1919	3.47	1.81	1.71	1.72	4.54	10.15	8.77	.84	8.21	4.60	.39	.90	47.11	------	
1920	2.31	------	.57	.75	6.26	2.73	3.48	1.02	Tr.	3.10	.90	------	21.12	------	Nov. 15
1921	.70	.16	3.60	4.17	1.95	2.02	.66	.16	2.90	1.15	1.45	------	18.92	------	
1922	1.32	.71	4.40	4.86	5.46	3.08	2.03	.06	2.52	3.59	.78	.14	28.95	------	
1923	.15	5.09	4.31	1.90	.19	1.62	1.89	2.20	5.33	5.56	3.04	3.52	34.80	Feb. 6	
1924	.59	1.06	1.14	1.30	1.78	------	------	.09	1.67	.15	------	1.31	------	------	
1925	.19	.11	2.63	.38	2.07	.91	4.36	.73	3.59	1.21	3.05	2.03	22.16	------	
1926	2.06	------	4.11	3.20	1.05	2.77	.45	.60	.50	1.71	.90	2.48	22.16	------	
1927	.82	.35	1.89	.81	1.10	7.05	.75	------	.98	1.14	------	1.02	15.91	------	
1928	.74	1.45	.86	1.94	3.10	4.47	.52	2.17	5.37	.37	.53	1.61	23.13	------	
1929	.07	.34	1.75	.29	10.05	.59	2.22	.51	1.31	1.47	1.49	1.52	21.61	------	
Average	1.51	3.27	1.88	1.98	3.04	2.83	2.20	1.65	2.79	2.02	1.73	1.70	22.56	------	

Climatic data for Rossville, Atascosa County, Tex., 1907–25

Year	Precipitation (inches)													Temperature (°)		Last killing frost in spring	First killing frost in fall
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Maximum	Minimum		
1907	------	------	------	------	------	0.22	2.38	0.51	0.58	1.74	7.24	0.64	------	------	------	------	
1908	0.36	1.84	1.59	4.93	6.68	.77	1.99	2.87	1.81	4.02	3.39	1.65	3.90	------	------	------	Nov. 15
1909	Tr.	.52	.57	.38	1.19	1.20	3.72	2.12	1.24	3.72	.14	1.79	16.59	------	------	Feb. 17	Dec. 8
1910	.94	.48	Tr.	2.52	2.23	1.14	.40	.95	.91	2.78	1.59	1.56	15.50	------	------	Feb. 19	Oct. 29
1911	.25	2.15	3.73	4.45	2.60	.05	.90	3.79	.35	1.13	2.04	1.71	23.15	------	------	Feb. 23	Nov. 13
1912	.36	6.43	1.50	1.60	1.73	4.26	1.18	.10	2.56	3.04	1.02	3.31	27.09	------	------	Feb. 27	Nov. 2
1913	.61	1.70	1.29	.51	4.31	8.25	.83	.84	7.38	9.94	5.50	4.89	46.05	------	------	Mar. 17	Oct. 27
1914	.17	1.56	2.66	5.66	4.33	.11	Tr.	2.68	.97	2.59	4.17	.92	25.82	------	------	Mar. 22	Dec. 10
1915	.60	.92	1.30	7.55	4.07	.05	.16	7.53	2.94	1.86	.21	.43	27.62	------	------	Mar. 22	Nov. 15
1916	2.07	.04	Tr.	2.46	3.80	.95	4.09	3.66	3.29	2.67	2.65	.46	26.14	------	------	Apr. 9	Nov. 14
1917	1.37	.27	.24	1.61	1.82	.27	2.88	------	.29	Tr.	.75	Tr.	9.50	------	------	Mar. 5	Oct. 30
1918	.18	1.35	1.15	4.45	3.66	2.11	.16	1.82	2.27	4.90	2.34	5.29	29.68	------	------	Feb. 3	Nov. 28
1919	6.14	1.72	1.53	5.89	2.62	1.50	11.18	3.13	13.14	10.53	2.42	1.25	61.06	------	------	Feb. 26	Dec. 10
1920	3.76	.29	.38	.26	4.70	5.15	2.44	4.93	Tr.	2.89	1.57	.05	26.42	------	------	Apr. 5	Nov. 14
1921	1.42	.54	4.71	4.14	2.69	2.42	1.22	Tr.	1.44	.41	------	------	------	108	------	Feb. 21	
1922	------	------	------	------	3.08	3.42	.08	.73	3.72	4.00	2.88	.09	------	------	------	------	Nov. 26
1923	.61	5.95	3.36	3.77	.93	.91	1.55	2.21	5.50	2.46	3.98	5.87	37.10	104	24	Mar. 20	Dec. 14
1924	.67	3.30	.90	1.42	4.36	2.28	------	.12	3.22	.02	.05	1.40	17.74	105	22	Mar. 14	Nov. 25
1925	.28	.02	1.06	.87	2.17	.57	1.55	1.23	3.41	.81	2.16	1.41	15.54	106	21	Feb. 28	Nov. 23
•Average	1.29	1.82	1.73	3.09	3.18	1.87	2.11	2.01	3.05	2.19	2.45	1.92	26.05	105	22.3	------	

Annual precipitation, in inches, at Runge, Karnes County, Tex., 1895–1929

1896	27.30	1907	25.42	1916	18.55	1925	15.43
1898	24.84	1908	31.76	1917	13.60	1926	32.28
1899	27.38	1909	18.94	1918	30.75	1927	22.29
1900	37.22	1910	28.33	1919	45.84	1928	22.91
1901	24.26	1911	27.90	1920	25.62	1929	34.90
1902	39.54	1912	22.64	1921	30.08		
1903	45.03	1913	30.73	1922	29.38	Average	28.99
1904	32.35	1914	40.39	1923	45.10		
1905	36.11	1915	20.24	1924	20.65		

GENERAL GEOLOGY

The rock formations exposed in Atascosa and Frio Counties are of Tertiary and Quaternary age, but Upper Cretaceous and Lower Cretaceous formations have been encountered in a considerable number of deep wells drilled for oil in the central and northern parts of the area, and they doubtless everywhere underlie the exposed formations. There are many problems of stratigraphy and correlation in the area, but most of them are not within the scope of this report. Plate 1 shows the outcrops of the formations except deposits of Pliocene (?) and Quaternary age. The geologic table on page 18 shows the relations and characteristics of the several formations present.

The information concerning the unexposed formations is based on their character as observed at their outcrops north of Frio and Atascosa Counties and on data obtained from the deep wells in these counties. The wells usually pass through Tertiary and Upper Cretaceous formations and end in the Lower Cretaceous a short distance below the top of the Edwards limestone. No commercial production of oil has yet been found in either of these counties except in the Somerset field, which extends from the vicinity of Somerset, in Bexar County, into the northern part of Atascosa County.

The unexposed formations are practically unavailable for water supply, because they are encountered at depths that are too great for economical development. Hence no attempt is made here to give detailed descriptions or correlations of these formations. A section which is probably more or less typical of the entire area is shown in the log of the North & Walton No. 1 C. C. Tribble well near Bigfoot, in the northeastern part of Frio County, which reached a depth of 3,560 feet. The correlation of the formations encountered in this well is given below. It should be understood that these formations will be encountered at greater depths to the south and southeast and that they may change in lithologic character and thickness. South of the latitude of Pleasanton no oil-test well has penetrated to the bottom of the Tertiary system in either of these counties. Southeast of Campbellton the Carrizo sand was reached in the C. T. Tom well at a depth of 4,500 feet.[1]

Correlation of formations encountered in the North & Walton No. 1 C. C. Tribble well, 6 miles northeast of Moore, Frio County, Tex.

		Thickness (feet)	Depth (feet)
Tertiary (Eocene):			
Mount Selman formation	Shaly clay	37	37
Carrizo sand	Sand, shale, and lignite	175	212
Indio formation	Shale, sand, and lignite	901	1,113
Midway group	Shale, greensand, sand, and limestone	354	1,467
Cretaceous:			
Upper Cretaceous:			
Navarro group	Shale; some sand	508	1,975
Taylor marl	Shale and limestone; some sand	711	2,686
Anacacho limestone	Limestone; some shale	250	2,936
Austin chalk	Chalk; some shale	245	3,181
Eagle Ford clay	Calcareous shale	176	3,357
Lower Cretaceous:			
Buda limestone	Hard white limestone	32	3,389
Del Rio clay	Dark shale	40	3,429
Georgetown limestone	Hard white limestone; some shale	58	3,487
Edwards limestone	Hard limestone	73	3,560

The general geologic structure of the area is comparatively simple. The most prominent feature is a general gulfward dip of the formations at a greater angle than the slope of the land surface. It is to this structural feature that the presence of artesian water is due.

Frio County, however, lies on the northeast edge of a regional syncline, the axis of which extends northwestward and passes near Gardendale, in La Salle County, and La Pryor, in Zavala County. The strata in the western part of Frio County are affected by this syncline and by an anticline or nose superimposed upon the northeast flank of the syncline. The axis of the anticline is approximately parallel to the course of the Leona River. Reverse dips and outliers of Cook Mountain strata northeast of the Leona River are due to the presence of this anticline or nose. In the northwestern part of Atascosa County the structure that has produced the Somerset oil field is revealed in a considerable fault affecting the strata of the Indio and Carrizo formations. In southeastern Atascosa County an anticline of some size may be present northeast of Campbellton and is indicated on the geologic map. The strata affected are those of the Yegua and Jackson formations.

Small faults have been encountered in northwestern Frio County and were mapped by A. N. Sayre. Minute faults were also found in

[1] Since the completion of the field work the Amerada Petroleum Corporation has drilled several deep wells southwest of Pearsall to test the anticlinal structure mentioned on p. 136. The deepest of the wells (Halff & Oppenheimer 2) reached a total depth of 10,050 feet. The depths to the tops of various formations were reported by the geologists of the company to be Carrizo sand 1,260 feet, Indio formation 1,500 feet, Midway group 2,620 feet, Navarro group 3,130 feet, Taylor marl 4,850 feet, Austin chalk 5,200 feet, Buda limestone 5,710 feet, Del Rio clay 5,810 feet, Georgetown limestone 5,900 feet, Edwards limestone 5,990 feet, Glen Rose limestone 6,791 feet, and Trinity group 9,771 feet. All the wells yielded small amounts of oil and gas from the Edwards limestone, and the well mentioned above was completed as an oil well with production from the Navarro group.

northeastern Frio County, north of Bigfoot, and in Atascosa County, east of Lytle, northwest of Leming, and northwest of Jourdanton. None of the faults are of sufficient magnitude to affect greatly the occurrence or movement of the ground water.

RELATION OF THE GEOLOGY TO THE GROUND-WATER CONDITIONS

SOURCE AND DISPOSAL OF THE GROUND WATER

The fundamental principles governing the occurrence and movement of ground water have been set forth in detail by Meinzer.[1a] Only essential statements will be made here, and the reader is referred to Meinzer's reports for a more detailed discussion.

The ground water is derived chiefly from water that falls as rain or snow. A part of this water runs off directly in streams to the sea, a part evaporates, a part is consumed by the plants, and a part sinks to the ground-water table and enters the zone of saturation. Most of the water in the zone of saturation is eventually returned to the surface through springs or wells or is discharged by plants or through evaporation from the soil when it approaches the surface. Some water, however, percolates directly into the sea. The water table differs in altitude from place to place and fluctuates as a result of variations in rainfall, evaporation, and other climatic conditions.

The porous rocks below the water table are as a rule saturated with water and yield water to wells sunk into them wherever the rocks are of such a texture that the water is free to move into the wells. In the more permeable rocks, such as many of the sandstones and gravel, the water is free to move under the influence of gravity, but in less permeable rocks, such as shales and fine-grained sandstones, molecular attraction tends to retard movement of the water.

GENERAL ARTESIAN CONDITIONS

The conditions governing artesian water are discussed in numerous reports of the United States Geological Survey [2] and State geological surveys and in many textbooks of geology. If a permeable stratum in an inclined position, lying between relatively impervious or watertight strata, receives water from rainfall or stream flow at its outcrop, the water entering it will move under the influence of gravity down the dip of the stratum and will tend to accumulate under hydro-

[1a] Meinzer, O. E., The occurrence of ground water in the United States, with a discussion of principles: U. S. Geol. Survey Water-Supply Paper 489, 1923; Outlines of ground-water hydrology: U. S. Geol. Survey Water-Supply Paper 494, 1923.

[2] 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.

static pressure. The general conditions governing artesian water are shown in figures 2, 3, and 4. Flowing wells may be obtained where the pressure is sufficient to raise the water to the surface. Whether flowing wells can be obtained in any given locality that is underlain by an artesian stratum will depend on the difference in altitude and the horizontal distance between that locality and the outcrop area, and also on the effectiveness of the confining beds.

In an artesian system, in general, the source of water is that entering at the outcrop of the permeable formation. The artesian system loses water through springs or other natural discharge and through wells sunk to the permeable formation. If the amount of water lost

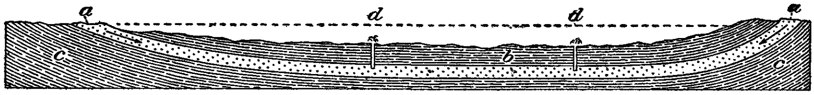


FIGURE 2.—Ideal section illustrating the chief requisite conditions for artesian wells. *a*, Permeable bed; *b*, *c*, impermeable beds below and above *a*; *d*, flowing wells from bed *a*. (After Chamberlin.)

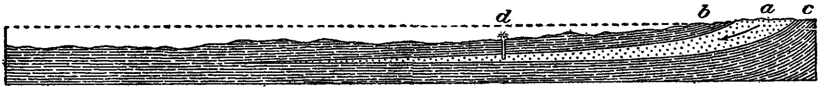


FIGURE 3.—Section illustrating the thinning out of a permeable water-bearing bed. *a*, Permeable bed enclosed between impermeable beds *b* and *c*, thus furnishing the necessary conditions for artesian fountain *d*. (After Chamberlin.)

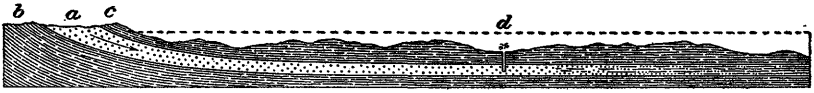


FIGURE 4.—Section illustrating the transition from a permeable water-bearing bed (*a*) into a close-textured impermeable bed. Bed *a*, being enclosed between impermeable beds *b* and *c*, furnishes the conditions for artesian flow *d*. (After Chamberlin.)

from the artesian system in any period exceeds the recharge during the same period the head will become lower. If too many wells are sunk the head may be lowered so much that not only will the wells cease to overflow but the water will have to be raised by pumping from so great a depth that the cost of pumping may become excessive. Thus there is a limit to the economical development of any artesian system. This limit is approached or may already be exceeded if the water levels in wells become lower and lower from year to year. As overdevelopment of this kind will affect unfavorably all who use water from the artesian system, it is a subject in which all users of artesian water should be interested.

ARTESIAN CONDITIONS IN ATASCOSA AND FRIO COUNTIES

The structure of the rocks in Atascosa and Frio Counties is favorable for the occurrence of artesian water. The formations are composed largely of permeable sandstones interbedded with relatively impermeable clays and shales. Except in localities where there are notable folds or faults, the rocks dip to the south or southeast, which is also the general direction in which the land surface slopes. However, the dip is nearly everywhere steeper than the surface slope, and therefore successively younger formations are encountered in crossing the area from north to south or from northwest to southeast. Each formation has an outcrop area from which it extends toward the south or southeast, below the younger formations, to progressively greater depths below the surface. (See pl. 1.) Thus the formations that appear at the surface in the northern part of the area shown on the map occur at depths of several thousand feet in the southeastern part—the Carrizo sand, for example, reaching a depth of more than 4,000 feet near Campbellton.

The Carrizo sand is the most productive artesian aquifer in the area, but certain sand members of the Mount Selman and Cook Mountain formations also furnish artesian water. The Carrizo sand possesses fairly uniform characteristics over wide areas, and the Carrizo artesian basin can therefore be accurately outlined and described. The Mount Selman and Cook Mountain formations vary considerably in lithology and stratigraphy from place to place, and the aquifers in them cannot be as accurately described as that of the Carrizo.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

A generalized section of the geologic formations that underlie this area is given in the accompanying table. The formations are listed in the order in which they lie beneath the surface, each successive formation being older than the one above it.

Generalized table of geologic formations in Atascosa and Frio Counties, Tex.

System	Series	Group	Formation	Approximate maximum thickness (feet)	Lithologic character	Water supply
Quaternary.	Recent.			25	Silt, sand, clay, and gravel. Confined to stream valleys.	No important water supply.
	Pleistocene.		Leona formation.	75	Silt, sand, and fine gravel, occurring in terraces along the larger streams.	Do.
Tertiary (?).	Pliocene (?).		Goliad sand.	20	Largely gravel, cobbles, and sand in interstream areas.	Do.
Tertiary.	Miocene.		Catahoula tuff.	600	Gray to white tuff and sandstone. Only basal beds exposed in Atascosa County. Higher beds consist of sandstone, conglomerate, and tuff. Volcanic throughout.	Do.
	Eocene.		Jackson formation.	500, [a] 1,000	Sand, sandstone, quartzite, volcanic ash, and clay. Sand is varicolored, medium to fine-grained, frequently thin-bedded. Clay is most abundant in the upper part of the formation and is largely sandy and carbonaceous. Calcareous and siliceous concretions and fossilized wood are common.	Lower sands yield domestic water supplies in southeastern Atascosa County. Water has wide range of chemical character; some water highly mineralized.
		Claiborne group.	Yegua formation.	500, [a] 900	Gray to yellowish-brown clay and slightly sandy clay. Much of it gypsiferous. Lignite and calcareous concretions common.	Generally not water-bearing. Sandy beds yield highly mineralized water.
			Cook Mountain formation.	600, [a] 900	Alternating clay and sandstone. Some glauconitic sandstone with lenses of limestone; also some lignite. Clay is in many places gypsiferous. Lower part sandy, especially in Frio County.	Furnishes considerable water. Sands in upper part of formation yield highly mineralized water. Sands in lower part yield water of good quality. Artesian wells in southwestern Atascosa County derive water from this formation.

[a] In wells.

Generalized table of geologic formations in Atascosa and Frio Counties, Tex.—Continued

System	Series	Group	Formation	Approximate maximum thickness (feet)	Lithologic character	Water supply
Tertiary.	Eocene.	Claiborne group.	Mount Selman formation.	700, [a] 500	Upper part is generally sandy, with minor amounts of shale. Many outcrops of upper part show much limonite. Lower part consists of alternating beds and lenses of sandstone and shale with lenses of impure limestone and quartzite and some lignite. Basal part (Bigford member) consists of dominantly clay beds with thin sand and limestone; calcareous concretions are common, especially near the base; a few ash beds; gypsum fairly abundant; thickest sand is near bottom.	Holds second rank as source of water. The sands of middle to upper part yield large supplies of good water. In Atascosa County the formation supplies many artesian wells; in Frio County it furnishes the water for shallow irrigation wells near Pearsall.
				150, [a] 400		Bigford member generally yields only small amounts of highly mineralized water.
			Carrizo sand.	175, [ab] 425	Dominantly coarse, porous, nonmicaceous reddish sand. Minor amounts of clay occur as beds, lenses, or lumps, and locally there are lignite beds. A few ledges of quartzitic sandstone. Cross-bedding is common.	Yields large supplies of good water to many artesian and pumped wells.
		Wilcox group.	Indio formation.	[b] 800	Thin-bedded sandstone and clay, carbonaceous, with beds of lignite. Locally gypsiferous. Not notably cross-bedded.	Furnishes small amounts of water, in places highly mineralized.
		Midway group.	(Undifferentiated.)	[b] 300	Chiefly shale with lenses and beds of clay; concretions are common.	Generally not water-bearing.
Cretaceous.	Upper Cretaceous.	Navarro group.	(Undifferentiated.)	[b] 1, 500	Shale and sand.	Encountered in oil wells but too deeply buried to be practicable for water supply in this area.
			Taylor marl.	[b] 711	Shale, limestone, and sand.	
			Anacacho limestone.	[b] 250	Limestone and shale.	
			Austin chalk.	[b] 245	Chalk and limestone.	
			Eagle Ford shale.	[b] 176	Shale.	
	Lower Cretaceous.		Buda limestone.	[b] 32	Limestone.	
			Del Rio clay.	[b] 40	Clay.	
			Georgetown limestone.	[b] 58	Limestone.	
			Edwards limestone.	[b] 300	Limestone.	

[a] In wells.

[b] See footnote 1, p. 13.

INDIO FORMATION[3]

Areal extent.—The Indio formation crops out in a small area in the vicinity of Lytle, in northwestern Atascosa County, and in the banks of the Frio River near the Hiler ranch, in northwestern Frio County (pl. 1). Only the beds in the upper part of the formation are exposed in these counties, the main outcrop area being to the north, in Medina and Bexar Counties. The formation lies unconformably beneath the Carrizo sand.

Lithology.—The Indio displays the variations in lithology that are to be expected in rocks that are dominantly nonmarine. Thin-bedded sand and sandstone, clay, laminated carbonaceous shale, and lignite are characteristic of the formation. One fairly persistent sand member about 50 feet thick occurs in the lower part of the formation and crops out in Medina County. Both calcareous and siliceous concretions are common. Many of them are elongated or biscuit-shaped, and some of them reach dimensions of several feet. Some of the sandstone beds are locally indurated to quartzite. The clays are not uncommonly gypsiferous, and in many places the thin laminated shales and sands show a yellow coating of copiapite,[4] a sulphate of iron. Photographs of exposures of the upper part of the formation are shown in plate 3, *A* and *B*.

Thickness and dip.—The formation in Frio County is about 900 feet thick, as shown by the log of the Tribble well (no. 26, pl. 1; see p. 13), and it probably has about the same thickness in Atascosa County. The dip is variable, and there is no satisfactory means of determining it accurately. In northwestern Atascosa County dips of several degrees have been observed, but these are abnormal and related to the structure of the Somerset oil field. Well records indicate that the dip in the northern half of Atascosa County is about 110 feet to the mile. In the southeastern part of the county, however, the records of deep wells seem to indicate a somewhat greater dip. In western Atascosa County and in Frio County the dip is probably about 85 feet to the mile.

Fossil plants are abundant in the Indio formation. Marine fossils are not common but have been found in cuttings from wells in the formation in Dimmit County and in surface exposures in Bexar and Wilson Counties.

Topography and vegetation.—The topography of the outcrop area of the formation is varied, and the relief is greater than that of the outcrop areas of many of the other Eocene formations in this part of

[3] Deussen, Alexander, Geology of the Coastal Plain of Texas west of the Brazos River: U. S. Geol. Survey Prof. Paper 126, pp. 47–56, 1924. Trowbridge, A. C., Tertiary and Quaternary geology of the lower Rio Grande region, Texas: U. S. Geol. Survey Bull. 837, pp. 37–52, 1932. Getzendaner, F. M., Geologic section of Rio Grande embayment, Texas, and implied history: Am. Assoc. Petroleum Geologists Bull., vol. 14, p. 1434, 1930.

[4] Determination by C. S. Ross, communicated by Julia Gardner.

Texas. As the formation is generally sandy with harder ledges intercalated, a rolling hilly topography has developed in places. The sandy areas of the Indio outcrop commonly support a growth of oak and other trees, but the shale areas are usually covered with chaparral.

Sections.—The best surface exposures of Indio strata in Atascosa County are found southeast of Lytle, in the banks of the Atascosa River. Sections in the lignite mines in Medina County near Lytle were recorded by Dumble and are still available. These mines have been closed for many years. Other mine sections have been supplied by mine owners. A number of sections of the Indio from mines and surface exposures are given below:

Sections of Indio formation

Carr mine, 1½ miles west of Lytle, Medina Connty [5]

	Feet
Brown sand with concretions of sandstone	10
Yellow laminated clay with small boulders	10
Laminated yellow-gray sand with black clay or lignitic partings; micaceous and very friable	12
Lignite	12
Gray clay, floor of mine.	

Riley mine, 2¼ miles west of Lytle, Medina County [6]

	Feet
Yellow laminated clay	15
Laminated medium-grained micaceous gray sand	20
Yellow micaceous sand with ferruginous streaks	20
Yellow-gray laminated micaceous sand with streaks of black clay or lignite	30
Lignite	5–8
Gray clay	10

0.1 mile east of Benton, Atascosa County

	Feet
Buff to reddish sandy soil	2
Calcareous cross-bedded sandstone with ferruginous laminations	4
Gray micaceous friable sand	5

In banks of Atascosa River 1.3 miles south of Benton, Atascosa County

	Feet
Ferruginous clayey soil	2
Sandy ferruginous mottled clay with seams of ferruginous gravel	11
Red ferruginous sand and gravel	2⅔
Chocolate-brown sand and clay, weathering white to yellow	6
Micaceous shaly siliceous sandstone	4
Chocolate-brown clay with copiapite stains	7

On Atascosa River 1 mile south of Benton, Atascosa County

	Feet
Red ferruginous micaceous sand	2
Grayish-yellow micaceous sand, loosely cemented	3
Cross-bedded yellow loosely cemented sand	4
Red ferruginous micaceous sand	1
Chocolate-brown clayey sand, weathering white to yellow	6
Micaceous shaly sandstone	4
Chocolate-brown gypsiferous clay with copiapite stains.	

[5] Dumble, E. T., Geology of southwestern Texas: Am. Inst. Min. Eng. Trans., vol. 33, p. 925, 1903.
[6] Communicated by J. F. Riley.

Water supply.—In the northern part of the area the Indio formation underlies the surface at depths that can readily be reached by wells. There are, however, only a few records of such wells available. According to A. N. Sayre, who has made an investigation of the geology and ground-water resources of Uvalde and Medina Counties, all wells in the Indio of which records were obtained in southeastern Medina County yield small quantities of water, some of which is highly mineralized.

CARRIZO SAND[7]

Areal extent.—The Carrizo sand crops out in the northern parts of Atascosa and Frio Counties and the southern part of Medina County. The outcrop area increases in width from west to east. In northwestern Frio County and southwestern Medina County it is about 4 miles wide, and in northern Atascosa County about 6 to 8 miles wide (pl. 1). The formation is unconformable on the Indio formation below.

Lithology and petrography.—The Carrizo sand consists almost entirely of sand but contains minor amounts of clay and lignite. The sands are on the average coarser and purer than those of any other formation in this area. The formation is generally salmon-pink, brick-red, or brown where exposed in road cuts or other openings, but it may be uncolored in fresh exposures in sand pits and is generally bleached to a yellow or white in the top soil. Usually the sand is poorly cemented, with little or no matrix, and most specimens of the formation can be pulverized between the fingers. In Atascosa and Frio Counties no one portion of the formation is persistently coarser than another. Thus near the George Blackaller ranch house, in northern Frio County, the sand at the top of the formation is very coarse, but the same is true of the sand in the basal parts of the formation in other localities. Cross-bedding is highly developed in the formation. (See pls. 4, *A*, and 5, *A*.)

The sand is in general, only slightly micaceous, but nearly every specimen will yield a small amount of mica. The mica flakes are larger than those found in other Eocene formations and seem to be more abundant in Atascosa County than in Frio County. In contrast with many of the other Eocene sands the Carrizo sand is not gypsiferous nor calcareous and contains only small amounts of iron-bearing minerals. Sand from wells in the Carrizo is usually a nearly colorless sparkling aggregate of various-sized quartz grains, at once distinctive and of an attractive appearance.

[7] For original description of Carrizo sand see Owen, J., Report of geologists for southern Texas: Texas Geol. and Min. Survey First Rept. Progress, for 1888, pp. 69–74, 1889. Additional descriptions of the formation in southwestern Texas are given by Deussen, Alexander, op. cit., pp. 56–59; Trowbridge, A.C., op. cit., pp. 52–65; Getzendaner, F. M., op. cit., pp. 1434–1435; and Vaughan, T. W., Reconnaissance in the Rio Grande coal fields of Texas: U. S. Geol. Survey Bull. 164, p. 45, 1900.

Clay is present in the formation either as thin lenticular beds or as nodular lumps surrounded by sandstone. The shale lenses are seldom seen at the surface but are recorded in well records and seen in well samples. The clay lumps can be seen in every shallow pit in the Carrizo sand in Atascosa and Frio Counties. They vary from the size of a pea up to 1 foot in diameter and consist of light-gray plastic clay or sandy clay. Much of this material is bentonitic, and it is possible that the clay lumps were originally of volcanic origin. Lignite in the Carrizo has been reported from a few oil and water wells.

The Carrizo sand has been considered nonmarine. It is composed of wind-blown sand and apparently represents a fossil sand-dune area of remarkable persistence and uniformity. The shale beds are usually nonmarine and represent lagoon or lake deposits.

Petrographic analyses of Carrizo sands are given in the table below. The samples analyzed were selected to show the variations in mechanical composition. Nos. 9 to 13 represent the very coarse sand found at a number of localities; the others represent finer-grained sands.

Petrographic analyses of samples of Carrizo sands

No.	Percentage of grains of different sizes (millimeters)							Percentage of grains of different shapes				Light minerals [a]				Heavy minerals [a]												
	More than 2	2 to 1	1 to 0.589	0.589 to 0.295	0.295 to 0.147	0.147 to 0.074	Less than 0.074	Rounded	Fairly well rounded	Subangular	Angular	Quartz	Microcline	Plagioclase	Chalcedony	Zircon	Rutile	Tourmaline	Magnetite	Cyanite	Staurolite	Apatite	Garnet	Titanite	Muscovite	Biotite	Chlorite	Xenotime (?) [b]
1	----	----	----	4.01	54.43	27.52	13.47	12	48	34	6	VA	----	R	A	A	R	C	VA	R	R	----	----	----	R	----	----	C
2	----	----	----	----	9.23	8.55	81.32	6	35	39	20	VA	----	R	A	A	R	C	C	C	C	----	----	----	----	----	----	C
3	----	----	----	11.43	51.84	27.25	9.10	6	32	44	18	VA	----	R	A	A	R	C	C	C	C	R	R	----	C	----	----	C
4	----	----	----	2.36	62.93	23.57	10.03	9	50	25	16	VA	----	R	A	A	C	C	A	C	----	R	R	----	R	----	----	C
5	----	----	----	3.84	40.88	45.59	8.22	11	46	36	7	VA	----	R	----	----	----	----	R	C	C	----	----	----	R	----	----	R
6	----	----	----	6.67	71.66	17.77	3.46	6	50	33	11	VA	----	R	A	A	C	C	R	R	R	----	R	----	C	C	----	C
7	----	----	.60	3.20	51.05	36.03	8.94	7	29	55	9	VA	----	R	A	A	C	C	R	R	R	----	----	----	R	R	----	C
8	----	----	----	1.77	54.51	34.39	8.35	8	32	40	20	VA	----	R	A	A	C	C	R	C	R	R	R	R	C	C	----	C
9	3.70	5.83	17.30	50.48	17.42	2.49	2.43	8	12	32	48	VA	R	R	A	A	R	----	A	C	----	----	----	----	C	C	R	C
10	4.30	13.05	50.33	21.41	5.19	3.17	2.48	11	40	41	8	VA	----	R	A	C	R	C	R	----	----	----	----	----	----	----	----	R
11	.44	1.40	24.22	65.94	3.96	1.11	2.52	4	23	57	16	VA	----	R	A	C	R	C	R	R	----	----	----	----	R	R	----	R
12	.23	.12	1.50	26.98	63.56	4.00	3.29	10	51	27	12	VA	----	R	A	C	R	C	C	R	R	----	----	----	R	R	----	C
13	2.78	2.95	13.86	36.04	35.84	7.50	1.00	10	40	44	6	VA	----	R	A	C	C	C	C	----	----	----	R	----	R	R	----	C

[a] VA, Very abundant; A, abundant; C, common; R, rare. Refer only to relative amounts in light or heavy concentrate. Heavy concentrate contains considerable amounts of opaque nonmetallic grains thought to be composed of minerals listed but with opaque film. Part of this material may be leucoxene.

[b] Xenotime(?), a wine-colored uniaxial mineral resembling zircon but softer, usually occurs as rounded grains.

Thickness and dip.—The Carrizo sand ranges in thickness from about 175 to 400 feet, according to well records, which, however, may not have been correlated with complete accuracy. The average thickness as estimated from surface exposures is about 325 feet. The dip is about 125 feet to the mile in southeastern Atascosa County, about 90 feet to the mile in central Frio County, and about 70 feet to the mile in western Frio County.

Topography and vegetation.—The topography developed on the Carrizo sand is distinctive. The relief is moderately high, and the general aspect is rolling. Streams are not common, and badland features result from rains. Small sand dunes occur in some localities. The excessively sandy character of parts of the outcrop area is shown in plate 5, *A*. The vegetation also is distinctive. It varies somewhat from eastern Atascosa County to western Frio County because of a material difference in the amount of rainfall. In Atascosa County and eastern Frio County live oak grows on the outcrop to the exclusion of other species except for a few mesquite and some low brush. Some hint of this type of vegetation is given in the background of plate 4, *B*. Between the trees the sandy soil supports a sparse growth of brush and grasses. In western Frio County the rainfall is materially less than in Atascosa County. Live oaks are found only near water, and the mesquite with some chaparral is dominant. The stand, however, is not dense but scattering. Consequently the area has an open park-like appearance, which is quite in contrast to that of the heavily brush-covered lands on adjacent formations. (See pl. 4, *A*.)

Sections.—Thick exposed sections of the Carrizo sand are rare, owing to the ease with which the formation is eroded. Exposures a few feet thick are found on the Atascosa River, in numerous sand pits, in road cuts, and along the Frio River. The best section noted is exposed in the bank of the Frio River 1 mile above the road crossing at the Woodward ranch (pl. 4, *B*), where 20 to 30 feet of massive cross-bedded coarse sand unconformably overlies thinner-bedded sand containing some shale and lignitic material. These beds belong to the lower part of the formation. Two sections which also represent exposures in the lower part of the formation are given below. The character of the formation as revealed in wells is shown in the well logs on pages 81–87.

Section of basal part of Carrizo sand 4 miles west of extension of lower Somerset-Benton road, Atascosa County

	Feet
Yellowish-buff sandy soil with numerous ferruginous shingles	3
Grayish-yellow coarse-grained, highly micaceous, loosely cemented sand	6
Grayish-white medium-grained well-cemented, slightly micaceous sand	5
Yellow ferruginous sand	2
Grayish-white medium-grained well-cemented, slightly micaceous sand	6
Reddish-buff coarse-grained well-cemented sand	5

Section of Carrizo sand along Atascosa River 4.1 miles south of Benton, Atascosa County

	Feet
Sandy yellow soil	8
Yellow fine-grained, slightly micaceous sand	6
Yellow compact coarse-grained micaceous sand with hard well-cemented ledges of sandstone, 6 to 8 inches in thickness	4
Coarse-grained micaceous compact sand that contains numerous different iron colors from purple to deep red	4

Many of the pits opened for road materials in Atascosa and Frio Counties afford excellent exposures of the Carrizo. The pits are shallow, as only the weathered surface sand is removed, the more firmly cemented, unweathered rock being left undisturbed. A pit on the Palo Alto road 2 miles south of the railroad crossing near Tarbutton, Atascosa County, is typical. Here a surface 100 by 100 feet is exposed in which the vertical range is not more than 18 inches. The predominating rock is a cross-bedded coarse salmon-pink sand containing irregular lumplike masses of light blue-gray sandy clay and interbedded with small amounts of flaggy to shaly sandstone. The coarse sand is loosely cemented. It shows small areas in which the quartz grains reach a maximum size of 4 millimeters, and it contains mica in large flakes. Thin layers of fine-grained light-gray sandstone are also exposed.

Well logs.—Logs of several wells that penetrate the Carrizo sand are given in the table on pages 81–87. Some of these logs are incomplete, the record of formations encountered below the Carrizo sand being omitted. A few of the logs are briefly discussed below.

162. This well is in northwestern Atascosa County 4 miles west of Rossville. It was drilled near the south boundary of the outcrop of the Carrizo sand and passed completely through it. The Carrizo is represented in the record from 83 to 485 feet, and consists entirely of sand and sandstone of variable degree of coherency. The beds encountered below 485 feet belong to the Indio formation and are composed chiefly of alternating shale and sandstone. The total depth of this well, an oil test, was 4,080 feet.

241. This well is in north-central Atascosa County 1½ miles north of Pleasanton. It gives a nearly complete section of the Mount Selman formation, as it was drilled at a point near the top of this formation. The Carrizo sand is shown from

1,200 to 1,515 feet. Here also the formation is seen to consist almost entirely of sand.

300. This well is in north-central Atascosa County, 2 miles southeast of Pleasanton, about 4 miles southeast of well 241. The Carrizo sand was encountered at 1,419 to 1,722 feet considerably deeper than in well 241. The well had a total depth of 1,722 feet. Coal was encountered at the bottom of the well, perhaps in the Indio formation but probably in the Carrizo sand, an occurrence not unknown elsewhere.

107. This well is in southern Frio County, 1¼ miles southwest of Derby. The first bed encountered in the well below surficial deposits belongs to a horizon estimated as about 100 feet below the top of the Mount Selman formation. The beds penetrated between 1,469 and 1,709 feet presumably belong to the Carrizo sand, and the shale and rock at the bottom of the well, between 1,709 and 1,760 feet may be Indio, but this is not certain. The beds logged above the Carrizo sand probably belong in part to the Bigford member of the Mount Selman formation, but the boundary between the formations is not shown.

26. An oil test well in northeastern Frio County, 6 miles northeast of Moore. This well was carefully drilled, and numerous cores were taken in the course of the drilling. The record is therefore very valuable as a basis for correlation of the many formations encountered. The Carrizo is present from 37 to 212 feet and consists largely of sand with two strata of lignite.

3. This well is in northwestern Frio County, 3 miles north of Frio Town. It was an oil test well and was drilled through the Carrizo sand into lower formations. The Carrizo was found from 65 to 248 feet and consisted largely of sand and sandstone. The well was drilled near the Carrizo-Bigford contact and passed through 65 feet of Bigford strata.

155. This well is in north-central Frio County, 4 miles southeast of Moore. It was drilled to a depth of 1,978 feet in an effort to obtain a flowing well. The beds between 530 and 931 feet, consisting of sand and sandstone, belong to the Carrizo.

22. This well is in north-central Frio County, about 3 miles southwest of Moore and 1¼ miles northwest of well 155 and was an oil test. The Carrizo sand was encountered in it between 498 and 880 feet, and the beds correspond closely in thickness and character with those found in well 155.

The logs on pages 81–87 give some idea of the variations in thickness and character of the Carrizo sand in different parts of the area. The thickness according to the well drillers ranges from 175 to 402 feet. In general the formation thickens down the dip and from west to east along the strike. The formation is composed dominantly of sand but contains thin beds of shale and lignite. Coarse white sands yield water most freely to wells.

Water supply.—The Carrizo sand, itself very permeable, is underlain by clay and shales of the Indio formation and overlain by clay of the Mount Selman formation. In the western part of Frio County the basal or Bigford member of the Mount Selman overlies the Carrizo, but farther east the Bigford has not been differentiated and the overlying beds are classed simply as Mount Selman. Partly as a result of this arrangement, water in the Carrizo sand is everywhere under artesian pressure except on the outcrop, and over a wide extent of territory the pressure is sufficient to bring the water to the surface.

A. UPPER PART OF INDIO FORMATION NEAR BENTON, ATASCOSA COUNTY.
Shows thin bedding.

B. ALTERNATING SANDS AND SHALES OF INDIO FORMATION IN BANKS OF ATASCOSA RIVER NEAR BENTON, ATASCOSA COUNTY.

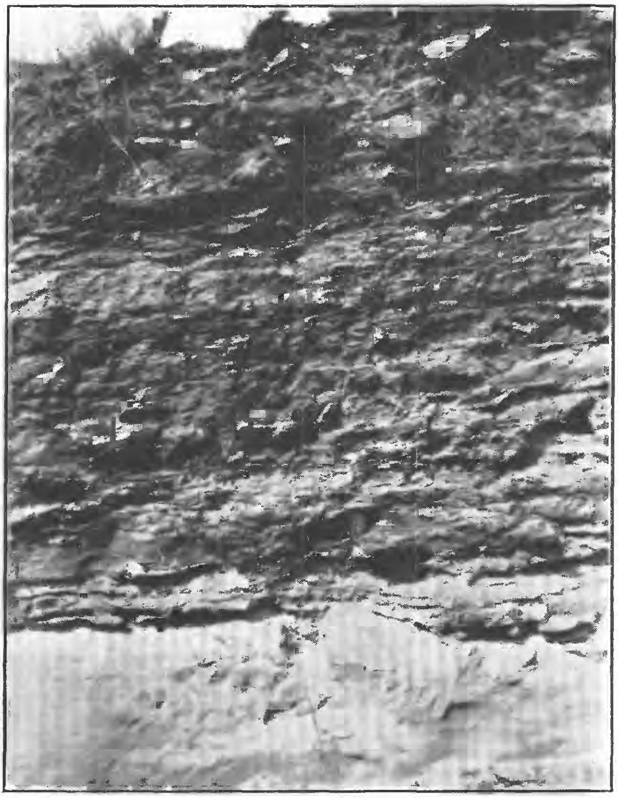
A. CROSS-BEDDED, COARSE-GRAINED CARRIZO SAND 3 MILES NORTH OF FRIO TOWN, FRIO COUNTY.

B. CONTACT OF CROSS-BEDDED CARRIZO SANDSTONE AND THIN-BEDDED UPPER PART OF INDIO FORMATION.

In bank of Frio River 1½ miles above road crossing at Woodward ranch.

A. PIT OF OSBORNE GRAVEL CO., 7 MILES NORTH OF POTEET, ATASCOSA COUNTY.

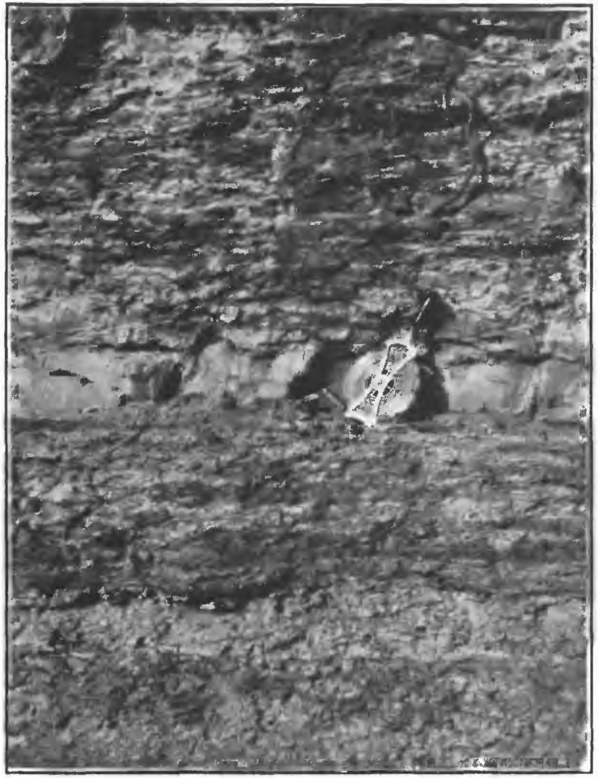
Carrizo sand is obtained from this pit for structural uses.



B. UPPER BEDS OF MOUNT SELMAN FORMATION 7½ MILES SOUTHEAST OF PEARSALL, FRIO COUNTY.

Shows a massive medium-grained porous sandstone overlain by fine thin-bedded highly ferruginous sandstones.

A. ALTERNATING BEDS OF SANDSTONE AND SHALY SANDSTONE IN LOWER PART OF MOUNT SELMAN FORMATION 1¾ MILES NORTHEAST OF ANCHORAGE, ATASCOSA COUNTY.



B. ALTERNATING SANDS AND SHALES IN LOWER PART OF COOK MOUNTAIN FORMATION ON THE BLUNTZER ROAD 5 MILES SOUTHWEST OF JOURDANTON, ATASCOSA COUNTY.

The maps show the outcrop of the Carrizo sand, the depths to the sand in localities south of the outcrop, the heights to which the water from the sand will rise, and the areas in which flowing wells can be obtained by drilling into it. Everywhere south or southeast of the outcrop the formation is encountered by wells but at greater and greater depths with increasing distance from the outcrop. The increase in the depth to the sand toward the south and southeast and the altitude above sea level to which water in the Carrizo sand would rise in 1930 are shown on plate 2. From this map it can be seen that the formation dips fairly uniformly away from the outcrop. The boundaries of the areas having the same range in depth are based on well records in which the Carrizo can be identified.

On the outcrop area water is obtained in wells at depths generally slightly more than 100 feet. These wells yield abundant supplies of water for domestic purposes. The water is essentially not under pressure in the outcrop area, because the upper surface of the saturated part of the formation is in permeable sand, where it forms a water table. A list of measured or estimated depths to the Carrizo sand in different parts of the area is given below.

Measured or estimated depths to the Carrizo sand in Atascosa and Frio Counties

	Feet
Near Leming	433
North edge of Poteet	670
3½ miles southeast of Poteet	1,077
Pleasanton	1,357
Bonita Valley orchards	1,470
3 miles southeast of Pleasanton	1,419
Jourdanton	1,635
1 mile west of Hindes	1,995
Campbellton	3,600–3,900
3 miles south of Moore	530
Pearsall	1,134
Keystone ranch	1,457
Derby	1,340
Dilley	1,975

Area of artesian flow.—The areas in which flowing wells may be obtained from the Carrizo sand are shown on plate 1. The north boundary of the area follows more or less closely the contours of surface altitude, and in the northern part of the area the flowing-well territory is restricted to the valleys. From plate 2 it is possible to determine for any locality both the approximate depth at which a well will encounter the Carrizo sand and the approximate altitude above sea level to which water in the well will rise.

Chemical character of the water.—The water from the Carrizo sand is the best in quality of all the waters of the area. The total amount of dissolved solids is generally less than 500 parts per million, except in the water drawn from the deeper wells, in which the total amount is generally less than 600 parts per million. Some of the samples from wells near the outcrop were unusually pure, containing less than 200 parts per million of total dissolved solids. The Carrizo waters generally contain some iron.

MOUNT SELMAN FORMATION [8]

In this report the Mount Selman formation is described in two sections, one on the basal or Bigford member and the other on the remainder of the formation. In previous reports the Bigford deposits have been treated as a distinct formation and included in the Wilcox group, but because of the accumulating evidence that they are of Claiborne age, they are here treated as a local member of the Mount Selman formation, with which they are included on the geologic map of Texas published in 1932. They are considered by Julia Gardner to be contemporaneous with but not exactly equivalent to the Reklaw of eastern Texas, from which they differ lithologically and with which they are not directly connected.

BIGFORD MEMBER [9]

General features.—The Bigford member of the Mount Selman formation crops out in northern Frio County. Its outcrop area is shown on plate 1 as extending from the west boundary of the county eastward to the International-Great Northern Railroad near Moore. Farther east the presence of the member is problematic, but in northeastern Frio County and in northern Atascosa County beds that are similar lithologically to those of the Bigford in other localities crop out and may belong to the member. Getzendaner [10] has stated that the Bigford is present as far east as Bigfoot, in northeastern Frio County. This statement is based on the presence of a sandstone (the Mills bed of Getzendaner), which has been definitely identified by the writer as far east in Frio County as Seco Creek. Somewhat similar sandstones occur in the Mount Selman formation in north-central Frio County, and it is felt that insufficient detailed work has been done to be certain of the correlation of the formations around Bigfoot. Accordingly east of the International-Great Northern Railroad the Bigford member is not differentiated from the rest of the Mount Selman, and statements with regard to water-supply conditions mention only the Mount Selman. The line of separation

[8] For original description see Kennedy, William, A section from Terrell, Kaufman County, to Sabine Pass on the Gulf of Mexico: Texas Geol. Survey 3d Ann. Rept., pp. 52-54, 1892. Additional descriptions of the formation in southwestern Texas are given by Deussen, Alexander, op. cit., pp. 60-64, and Trowbridge, A. C., op. cit., pp. 81-104.

[9] For original description see Trowbridge, A. C., op. cit., pp. 65-80.

[10] Getzendaner, F. M., op. cit., pp. 1436-1437.

between the Bigford member and the rest of the Mount Selman is drawn with difficulty because of similar lithologic character.

Lithology.—The Bigford is composed dominantly of dark to buff clays with thin sandstones and thin limestones, a small amount of volcanic ash, and impure lignite. Calcareous concretions are common and form good markers for the lower part of the member. The Mills bed of Getzendaner is an especially distinctive bed of the member in Zavala County and the western part of Frio County. It is unlike other sandstones in the Bigford member, though similar to certain local sandstones in the overlying beds of the Mount Selman. It is a fine-grained noncalcareous, fairly well cemented sandstone, grayish white, but showing pink, lavender, and purplish tints in hand specimens. It carries an abundance of plant remains, both leaves and stems. The stems are usually about a quarter of an inch in diameter and resemble sedges. Good outcrops of this bed are found along the Bigford escarpment in northern Frio County.

Thickness.—The thickness of the Bigford member is variable. It is difficult to recognize the member in well records. In western Frio County it is probably 300 feet thick, but it may pinch out toward the east.

Paleontology.—Fossils, except plants, are not abundant in the Bigford. Poorly preserved oysters and various mollusks are occasionally found, but no guide fossils for the member have yet been described.

Topography and vegetation.—The outcrop area of the upper part of the Bigford member is one of moderate relief, but in that of the basal part the relief is commonly stronger. In the basal part of the section resistant sandstones are present and form northward-facing escarpments. These are especially well developed in northern Frio County on the John J. Little ranch. The vegetation is the common assemblage of chaparral but is usually thicker than that on either the Carrizo or the overlying beds of the Mount Selman formation.

Water supply.—The Bigford member does not yield much water to wells, and the water is in general highly mineralized.

POST-BIGFORD BEDS

Areal extent.—The post-Bigford part of the Mount Selman formation crops out in a belt of variable width extending across both Atascosa and Frio Counties. (See pl. 1.) It rests unconformably on either the Bigford member or the Carrizo sand and is conformable beneath the Cook Mountain formation.

Lithology and petrography.—The beds are composed of gray, brown, and yellow sandstone, white, yellow, and brown clay, lignite, concretions of limonite and limestone, gypsum, altered volcanic ash, and small amounts of glauconite. The lignite beds are not important commercially in Atascosa and Frio Counties, though some mining of them has been attempted in the past. In Frio County the beds are divisible into a lower clay member and an upper sand member, but their character changes along the strike, and in Atascosa County they consist largely of alternating sand and clay beds. The sandstones are usually lenticular and are in many places indurated to quartzites. However, east of Pearsall rather persistent beds of sandstone are found in the upper part of the formation. (See pl. 5, *B.*) Some of the sandstone beds resemble fairly closely the Mills bed of Getzendaner in the Bigford member. These are found 4 miles east of Pearsall on the Charlotte road, near Navarro School in Atascosa County, and at other places. Altered volcanic ash is also present in the lower part of the beds. Exposures of this material are found 4 miles east of Pearsall and east of Leming. Glauconitic beds occur in the lower part and are usually marked by highly ferruginous outcrops and soils. Plate 6, *A*, shows alternating sandstones and shaly sandstones in the lower part of the beds.

Petrographic analyses of samples of Mount Selman sands are given in the table below.

Petrographic analyses of sandstones from Mount Selman formation

No.	Percentage of grains of different sizes (millimeters)							Percentage of grains of different shapes				Light minerals [a]			Heavy minerals [a]													
	More than 2	2 to 1	1 to 0.589	0.589 to 0.295	0.295 to 0.147	0.147 to 0.074	Less than 0.074	Rounded	Fairly well rounded	Subangular	Angular	Quartz	Plagioclase	Chalcedony	Zircon	Rutile	Tourmaline	Magnetite	Cyanite	Staurolite	Apatite	Garnet	Muscovite	Biotite	Chlorite	Xenotime (?) [b]	Pyrite
1	------	------	------	------	9.70	69.35	20.55	5	35	39	21	VA	R	A	C	R	------	R	------	------	------	------	------	------	------	R	------
2	------	------	------	------	3.96	86.40	9.01	5	40	43	27	VA	R	A	C	R	C	R	R	------	------	------	C	------	------	R	------
3	------	------	------	------	58.60	38.64	2.39	12	35	43	10	VA	R	C	C	C	C	A	C	------	R	R	C	C	R	R	------
4	0.61	0.50	0.89	1.14	22.20	64.60	9.81	12	35	39	14	VA	R	C	A	C	A	A	C	------	R	C	------	C	R	C	------
5	------	------	------	------	13.25	69.31	16.62	18	35	34	13	VA	R	C	A	C	A	C	C	R	------	R	C	C	R	C	C

[a] VA, very abundant; A, abundant; C, common; R, rare. Refer only to relative amounts in light or heavy concentrate. Heavy concentrate contains considerable amounts of opaque nonmetallic grains thought to be composed of minerals listed but with opaque film. Part of this material may be leucoxene.

[b] Xenotime (?), a wine-colored uniaxial mineral resembling zircon but softer, occurs as rounded grains.

1. Mount Selman sandstone 1¾ miles north of Anchorage, Atascosa County.
2. Mount Selman sandstone on Rossville-Poteet road 3 miles west of Palo Alto road, Atascosa County.
3. Mount Selman sandstone 4 miles west of Derby, Frio County.
4. Sample from Mrs. L. Hornsby well, 1½ miles southwest of Pearsall, Frio County.
5. Sample from F. Whitman well, 1 mile northwest of Derby, Frio County.

Thickness.—The post-Bigford beds vary in thickness along both the strike and the dip. The average thickness as determined from the outcrops in Atascosa and Frio Counties is probably around 700 feet, but a much greater thickness is indicated in wells. At Pearsall the top of the Carrizo is found at a depth of 1,134 feet in wells. Even after allowing for dip and the presence of the Bigford member, there still must be as much as 900 feet of post-Bigford Mount Selman beds in the wells. Even greater thicknesses are shown in records of wells farther down the dip.

Paleontology.—Fossils of Claiborne age are sometimes found in the post-Bigford beds of the Mount Selman formation but are not abundant. Deussen [11] has listed *Venericardia planicosta* Lamarck, *Plejona petrosa* Conrad, and *Cornulina armigera* (Conrad). Trowbridge [12] added to this list *Cytherea* sp., *Protocardia* sp., and a number of plant fossils.

Topography and vegetation.—The outcrop area exhibits a moderately well developed relief. On clayey parts of the formation the country is rather monotonously level, but on the upper part, which contains resistant sandstones, the topography is marked by numerous isolated hills. These are seen southeast of Pearsall and in much of northwestern Frio County. The vegetation is chaparral not greatly different from that developed on the Bigford member.

Sections.—Sections of the post-Bigford part of the Mount Selman formation are given below.

Sections of post-Bigford part of Mount Selman formation

1¾ miles north of Anchorage, Atascosa County

[This section is near the base of the post-Bigford part of the formation and is one of the best exposures in Atascosa County.]

	Ft.	in.
Red sandy, clayey soil	1	1
Red ferruginous concretions of sandstone		4
Red clay	1	6
Ferruginous red sand		6
Loose grayish-yellow, very fine sand	2	
Ferruginous reddish sandstone with an abundance of small clay concretions		2
Loose ferruginous sand		1
Fine-grained massive well-cemented sandstone	1	1
Loose grayish yellow, very fine sand		3
Gray gypsiferous clay	1	
Well-cemented fine-grained yellow sandstone	1	
Concealed by road	2	
Grayish-white gypsiferous clay	2	
Laminated sand, interbedded with a ferruginous gypsiferous clay	2	
Lignitic grayish brown sandy clay	1	5

[11] Deussen, Alexander, op. cit., p. 60.
[12] Trowbridge, A. C., op. cit., p. 85.

Sections of post-Bigford part of Mount Selman formation—Continued

1¾ miles north of Anchorage, Atascosa County—Continued

	Ft.	in.
White compact sand	3	6
Alternating yellow clayey sand and brown ferruginous sand 2 to 3 inches thick	2	3
Gray gypsiferous lignitic clay with ferruginous lignitic layers 2 to 3 inches thick	2	

On Poteet-Rossville road 3 miles west of Palo Alto road, Atascosa County

	Ft.	in.
Reddish-buff sandy clay soil	1	
Reddish-buff clay	1	6
Ferruginous sandstone concretions		6
Reddish-buff clay		6
Fine- to coarse-grained loosely cemented micaceous sandstone with ferruginous concretions ranging in size from 1 to 4 inches	3	
Yellowish ferruginous micaceous loose sand with silicified ferruginous bands ⅛ to ¼ inch thick	2	
Reddish-buff clay	1	
Yellow micaceous loose fine-grained sand		

At abandoned lignite mine 1½ miles south of Poteet, Atascosa County

[This section is near the middle of the formation and shows more clay than most sections.]

	Ft.	in.
Sandy yellow-white soil	1	
Yellow calcareous clay	3	
Yellow coarse-grained sand	2	
Yellow-grayish lignitic micaceous clay	4	
Lignite	3	6
Grayish clay	2	

On Frio Town road 5 miles north of Pearsall, Frio County

	Ft.	in.
Soil, caliche, and gravel	3	6
Gray fine-grained sandstone in beds as much as 8 inches thick alternating with thin sandy shale beds	8	
Gray fine-grained massive sandstone	3	

In all these sections weathering has modified the appearance of the Mount Selman strata. Fresh unweathered well samples from the middle part of the formation from a water well at Pearsall are described below.

Description of samples of drillings from F. C. Mangold well, Pearsall, Frio County

	Feet
Light-gray, very fine grained micaceous friable sandstone. Minerals present are quartz, muscovite, chalcedony, zircon, microcline, plagioclase, rutile, pyrite, xenotime?, and magnetite	22
Yellowish-buff friable fine-grained micaceous shaly sandstone with calcareous and argillaceous concretions as much as a quarter of an inch in diameter. Minerals are quartz, chalcedony, blue tourmaline, zircon, xenotime?, microcline, plagioclase, magnetite, green tourmaline, pyrite, and muscovite	42–57

Description of samples of drillings from F. C. Mangold well, Pearsall, Frio County—Continued

	Feet
Chocolate-brown to black nonplastic lignitic clay with lenses of micaceous fine-grained sandstone and pyrite concretions. The sand lenses contain same minerals as samples above	57–59
Light chocolate-brown to gray sandy plastic clay	59–69
Lignite with sand lenses	69–85
Light-gray sandy plastic clay breaking with irregular fracture. Minerals as in previous samples	90–112
Earthy-gray fine-grained friable argillaceous sandstone. Minerals as above	112–114
Earthy-gray fine-grained friable argillaceous sandstone with lenses of lignite as much as ⅛ inch thick. Minerals as above	114–119
Light grayish-green friable argillaceous and calcareous sand with calcareous concretions. Minerals include staurolite and cyanite in addition to those listed in previous samples	119–125
Earthy-gray friable fine-grained micaceous sandstone with clay concretions and small amounts of lignite. Minerals as listed in sample from 22 feet	125–180

Well logs.—The logs of four wells in the Mount Selman formation are given in the table of well logs on pages 81–87 and are briefly discussed below.

The logs of the high school well (no. 64), at Pearsall, and the H. H. Page well (no. 40), 1¾ miles north of Pearsall, illustrate the stratigraphy in the vicinity of Pearsall, where there is considerable irrigation. The greater part of the irrigation wells are about 100 feet deep and encounter water sand at depths ranging from 65 to 85 feet. The water is under small artesian pressure and rises slightly above the top of the water sand. The high school and several other wells have been drilled to depths around 200 feet. Such wells generally failed to find an adequate supply of water at the upper horizon and were carried on down. It appears that the water sand supplying the shallow wells is restricted to a small area and is present as a lens with greatest thickness north and northeast of the town. Wells put down farther east and in localities south of Pearsall, though finding sands at comparatively shallow depths, have not yielded adequate supplies for irrigation.

The Oppenheimer & Lang well (no. 83) is in the valley of San Miguel Creek east of Pearsall. The well was started near the top of the Mount Selman formation. In a total depth of 860 feet 7 water-bearing sands were found, and the 2 lower ones furnished flowing water. Of the upper 330 feet 242 feet was composed of beds of a sandy nature, if not of pure sand.

The C. S. Young well (no. 251) started in the Cook Mountain formation and was drilled nearly to the Carrizo sand. The beds between 338 and 1,428 feet, composed of alternating sandstones and shale or gumbo, have been identified as Mount Selman. Water sands were encountered at depths of 745 to 760, 810 to 820, 931 to 951, 1,113 to 1,155, and 1,188 to 1,210 feet. The well indicates the character of the geologic section around Pleasanton, where there are many artesian wells in the Mount Selman formation ranging in depth from 300 to 850 feet.

Water supply.—Usually several water-bearing sandstones are encountered by wells in the post-Bigford part of the Mount Selman formation. These sandstones are interbedded with clays, and the water in them is under artesian pressure except in localities where they appear at the surface. As the stratigraphy of the formation is not constant over large areas the artesian strata are not continuous. The upper half of the formation contains more sand than the lower half, and in parts of the area it is an important source of water. Most of the artesian water thus far developed from the Mount Selman comes from the upper part of the formation. Thinner beds in the lower part ordinarily yield artesian water of poorer quality and in smaller amounts. A few wells in Atascosa County, however, yield large flows from the lower part.

Areas of artesian flow.—Plate 1 shows the area in which flows can be obtained from wells in the Mount Selman formation. This area is in the south-central and southeastern parts of Frio County and the south-central and southwestern parts of Atascosa County. For much of the southern and southeastern parts of Atascosa County the available data are incomplete, and it is possible to give only a general outline of the artesian area.

Chemical character of the water.—The waters in the Mount Selman formation have considerable range in chemical composition. The variations within the formation are in part directly related to the horizon from which the water is drawn and in part to the depth of the wells. Some of the wells are doubtless subject to inflow of water from the overlying Cook Mountain or Yegua formation, and this affects the chemical character of the water. The post-Bigford part of the Mount Selman varies lithologically along both the strike and the dip. The water obtained from the upper sandy beds is generally suitable for domestic use, and some of it is suitable for irrigation. The lower beds contain a relatively larger amount of clay, with alternating thin sand beds. The water from the lower clayey beds is generally of poorer quality, and much of it is not suitable for any use.

The shallow water near Pearsall and in the sandy areas east and south of Pearsall is generally of good quality, containing chloride and sulphate, with relatively small amounts of sodium carbonate and sodium chloride.

COOK MOUNTAIN FORMATION[13]

Areal extent.—The Cook Mountain formation crops out in Atascosa and Frio Counties in a belt whose entire width lies within the two counties. The line of contact between the Cook Mountain formation and the underlying Mount Selman formation enters Atascosa County south of Verdi and passes south of Pleasanton, 1½ miles north of Charlotte, and through the Keystone ranch, in Frio County. It crosses the Frio River southeast of Derby and thence passes westward

[13] For original description see Kennedy, William, op. cit., pp. 54–57. Additional descriptions of the formation in southwestern Texas are given by Deussen, Alexander, op. cit., pp. 64–75, and Trowbridge, A. C., op. cit., pp. 104–129.

to the Zavala County line. (See pl. 1.) Collections of fossils from certain localities north of the Leona River in Frio County were identified as Cook Mountain by Julia Gardner. These localities are isolated outliers of the Cook Mountain and are not shown on plate 1. Such exposures are due to an anticline or nose present in this region, and most of them are on its north flank, some of them exhibiting north or reverse dip.[13a] At a point 3½ miles northeast of the Corey ranch about 60 feet of Cook Mountain beds are present with a dip of more than 2° N. This locality is highly fossiliferous. Directly south of the locality along the Leona River typical Mount Selman sand is exposed. Other Cook Mountain localities north of the Leona include Catarina Hill, Oyster Hill on the Loxton ranch, and the English Hills, in all of which the Cook Mountain strata cap the hills. Cook Mountain rocks are probably present on Berry Creek southwest of the Loxton ranch and on Little Yoledigo Creek southeast of the Taylor ranch. The formation is conformable both above and below.

Lithology and petrography.—The formation consists of sandstone, gypsiferous clay, impure limestone, and lignite. Much of the sandstone is glauconitic and contains considerable quantities of cone-in-cone concretions. The formation varies considerably in lithologic character along the strike. In eastern Atascosa County it consists largely of alternating beds of gypsiferous clay and glauconitic sandstone, with boulders of fossiliferous indurated calcareous sandstone. West of the general region of Pleasanton the lower part of the formation consists largely of glauconitic sandstone, in many places fossiliferous, with only a little clay. The greatest development of the basal glauconitic sandstone is in Frio County, where all of the Cook Mountain area except the southeast corner of the county is underlain by this rock. To the east the area underlain by the basal sandstone becomes progressively narrower until the sandstone is no longer observable near Pleasanton. Its absence east of Pleasanton is probably due to overlap or a gradation of the sandstone into the alternating clay and sandstone section above. In areas underlain by the sandstone brick-red loamy soils are developed, but where clay is the predominant constituent the formation produces black soils.

The contact of the formation with the Mount Selman in western Atascosa County is obscured by large areas of loose sand. Banks Hill, just west of the county boundary, and another area near Tobey are probably outliers of the formation and are not shown on the map.

The sandstones of the formation are generally glauconitic, though some samples are entirely free from glauconite. In some exposures the glauconitic material is calcareous and takes the character of an impure marly limestone. Petrographic analyses of sands from the formation are given below.

[13a] See footnote, p. 13.

Petrographic analyses of sandstones from Cook Mountain formation

No.	Percentage of grains of different sizes (millimeters)							Percentage of grains of different shapes				Light minerals [a]				Heavy minerals [a]											
	More than 2	2 to 1	1 to 0.589	0.589 to 0.295	0.295 to 0.147	0.147 to 0.074	Less than 0.074	Rounded	Fairly well rounded	Subangular	Angular	Quartz	Plagioclase	Glauconite	Chalcedony	Zircon	Rutile	Tourmaline	Magnetite	Cyanite	Staurolite	Garnet	Muscovite	Biotite	Chlorite	Xenotime [b]	Microcline
1	------	------	------	------	6.69	82.01	10.67	15	40	25	20	A	C	A	A	A	C	C	C	C	------	R	A	A	------	------	------
2	------	------	1.64	22.53	44.85	20.73	9.26	30	42	20	8	A	R	A	A	A	C	C	C	C	C	------	C	C	------	------	------
3	------	------	------	------	8.41	62.60	28.21	4	31	44	21	VA	C	A	A	A	C	C	C	R	R	------	R	R	------	------	------
4	------	------	------	3.41	73.94	14.43	7.30	12	45	30	12	VA	C	------	A	A	C	C	R	C	C	R	C	C	------	------	------
5	2.38	0.69	1.61	2.61	31.42	56.73	4.33	28	33	24	15	VA	C	------	A	A	C	C	VA	R	R	C	R	R	R	C	R

[a] VA, Very abundant; A, abundant; C, common; R, rare. Refer only to relative amounts in light or heavy concentrate. Heavy concentrate contains considerable amounts of opaque nonmetallic grains thought to be composed of minerals listed but with opaque film. Part of this material may be leucoxene.

[b] Xenotime (?), a wine-colored uniaxial mineral resembling zircon, but softer, usually occurs in rounded grains.

1. Cook Mountain sandstone 6.2 miles northeast of Pleasanton, Atascosa County.
2. Cook Mountain sandstone 4.7 miles southeast of Pleasanton, Atascosa County.
3. Cook Mountain sandstone half a mile south of Pleasanton, Atascosa County.
4. Cook Mountain sandstone 3 miles southeast of Derby, Frio County.
5. Sample from W. D. Morrison well, Dilley, Frio County.

Thickness and dip.—The thickness of the Cook Mountain formation ranges from 600 to 900 feet; the maximum thickness is found in wells. The beds dip southeastward at an average rate of about 115 feet to the mile.

Paleontology.—Fossils are very abundant in the formation. These are found in lenses and ledges of impure glauconitic limestone which are scattered through the formation. Detailed lists of fossils of the formation have been given by both Deussen [14] and Trowbridge [15] and are not repeated here.

Topography and vegetation.—The topographic expression of the Cook Mountain outcrop area varies with the lithology. The areas underlain by sandstone are generally rolling and have moderate relief; the less sandy parts of the formation are also rolling but have slight relief. A considerable part of the formation is sandy, and its outcrop area commonly supports open chaparral brush with scattered large live oaks. Mesquites are generally larger than those growing on other formations.

Sections.—Many small sections of the Cook Mountain formation are found throughout the area, although, in general, the formation is better exposed in Atascosa County than in Frio County. Sections from three localities in Atascosa County are given below.

Sections of Cook Mountain formation

On Pleasanton-Campbellton road half a mile south of Pleasanton, Atascosa County

[This section represents the lower 150 feet of the formation. It is compiled from a hillside section, and doubtless there are small gaps in it.]

	Ft.	in.
Brownish glauconitic sandy soil	1	3
Ledge of calcareous fossiliferous sandstone, extending laterally for 60 feet		5
Compact fossiliferous brown glauconitic sand		2
Gray gypsiferous clay with ferruginous streaks not more than a quarter of an inch thick	1	
Ledge of nonfossiliferous calcareous concretions		3
Fossiliferous brown glauconitic sand		2
Gray gypsiferous clay with numerous ferruginous streaks	1	
Yellow sand		3
Gray gypsiferous clay with numerous ferruginous streaks	4	
Yellow very fine sand		7
Gray gypsiferous clay with numerous ferruginous streaks	3	6
Yellow very fine fossiliferous glauconitic sand	1	
Gray gypsiferous clay with ten lenses of yellow sand	1	1
Yellow-purple sand, nonfossiliferous and nonglauconitic; contains many purple streaks		8
Gray gypsiferous clay with ferruginous streaks		2
Yellow laminated sand		3

[14] Deussen, Alexander, op. cit., pp. 64-65.

[15] Trowbridge, A. C., A geologic reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande: U. S. Geol. Survey Prof. Paper 131, pp. 95-96, 1923.

Sections of Cook Mountain formation—Continued

On Pleasanton-Campbellton road half a mile south of Pleasanton, Atascosa County—Continued

	Ft.	in.
Gray gypsiferous clay with a lignite layer half an inch thick		4
Yellow-grayish very fine sand		5
Lignitic layer		2
Gray gypsiferous clay		2
White very fine sand		6
Yellow very fine sand		8
Gray gypsiferous clay	2	

On Bluntzer road 5.1 miles southwest of Jourdanton, Atascosa County

	Ft.	in.
Reddish-brown clayey soil, containing numerous small pebbles and gravel	3	4
Ferruginous sandy clay containing elongated limonite concretions ½ to 1 inch in diameter		3
Brownish-red compact sand containing fossils and small clay concretions	1	4
Black lignitic clay with particles of hard lignite		8
Gray gypsiferous clay containing numerous ferruginous streaks		4
Yellow loose sand		6
Gray gypsiferous clay containing ferruginous sandy streaks		4
Gray sand		5
Gray gypsiferous clay		2
Gray sand with purple tints		6
Gypsiferous gray clay with numerous ferruginous sandy streaks		9
Ferruginous sandy lens		3
Gray gypsiferous clay with numerous ferruginous sandy streaks	1	2
Gray fine-grained sand		9
Gray gypsiferous clay with numerous ferruginous clayey streaks	5	2
Fine-grained gray sand		11
Gray gypsiferous clay with numerous ferruginous clayey streaks		3

On Pleasanton-Floresville road, 5 miles northeast of Pleasanton, Atascosa County

	Ft.	in.
Blackish-red soil	2	
Gray gypsiferous clay		10
Brownish sandy clay, highly gypsiferous; contains streaks of sand lenses 2 to 3 inches in thickness	2	
Gray gypsiferous clay		10
Reddish-brown sand		6
Gray gypsiferous clay		5
Ferruginous gypsiferous clay		3
Gray gypsiferous clay		8
Light-brown sand		4
Gray gypsiferous clay	1	2

A part of the section on the Bluntzer road is shown in plate 6, *B*. An exposure of clay with calcareous concretions from the middle part of the formation is shown in plate 7, *A*.

No good sections of the upper part of the formation are exposed in this area. In the Dilley region, southwestern Frio County, many small exposures of the upper part of the formation are found in road cuts and on hills. The predominant rock type is a brick-red sandstone containing weathered glauconite and yielding a reddish sandy-loam soil. Throughout this area thin concretionary limestone beds are also found and are usually fossiliferous. The log of the C. M. Kelley well (p. 84) shows the character of the upper part of the formation as disclosed by well cuttings.

Well logs.—Logs of wells in the Cook Mountain formation in parts of the area were obtained, including the log of the C. M. Kelley well, near Hindes, 2,390 feet deep, and logs of three wells 280 to 370 feet deep near Dilley. Unfortunately few logs of wells in the formation are available except in the Dilley area.

The C. M. Kelley well (no. 114) is in extreme southeastern Frio County. It starts near the top of the Cook Mountain formation and penetrates to the Carrizo sand. The Mount Selman contact in this well is believed to be at 965 feet, but its correct location is somewhat problematic. The formation is composed of sand, clay, sandstone, and limestone. The sands penetrated by the well between 373 and 433 feet supply the shallow flowing wells at Hindes, and sands at the same horizon but at greater depths probably supply wells near Christine. The bottom of the formation is not notably sandy, and the most sandy facies of the lower part of the Cook Mountain are found in western Frio County.

The logs of wells near Dilley (nos. 122, 133, and 136) show the character of the Cook Mountain water-bearing sands in western Frio County. According to these and other available logs the sands range from 115 to 344 feet in thickness. It is possible that some of the extreme thicknesses recorded may represent beds that are generally sandy and water-bearing but contain minor amounts of clay or shale. The records indicate quite plainly, however, that there is a thick sand member at the base of the Cook Mountain near Dilley, which thickens to the southeast.

Water supply.—The water-bearing sands of the Cook Mountain formation are generally not continuous nor very thick, and in these respects they are comparable with the sands in the Mount Selman formation. The thickest and most persistent sands are in the lower half of the formation, and it is from these sands that most of the water is obtained. The water is usually under some artesian pressure, and a few flowing wells have been obtained in Atascosa County, but in most places the wells do not flow.

Irrigation has been developed with water pumped from wells in this formation in an area around Dilley, in Frio County. The largest pumped wells and the lands irrigated from them, together with flowing wells in the formation in Atascosa County on which reliable data were obtained, are shown on plate 1.

Chemical character of the water.—The water from the Cook Mountain formation is variable in character, but on the whole it is highly mineralized. The lower sandy portions of the formation yield the best water, some of which is suitable for domestic use and for irrigation on sandy soils with good drainage. It is difficult to find suitable water for domestic use in the upper clayey parts of the formation. Much of this water is very high in dissolved solids and is objectionable to the taste.

YEGUA FORMATION[16]

Areal extent.—The Yegua formation crops out in the extreme southeastern part of Frio County and in a belt several miles wide in Atascosa County extending from the vicinity of Hindes, on the southeast, through Christine to McCoy and on to the east boundary of the county. (See pl. 1.) In some previous reports on eastern Texas this formation has been called the †Cockfield formation,[17] but that name has now been dropped.

Lithology.—The formation is composed almost entirely of gray to yellowish or light-brown clay. Some slightly sandy clay, lignite, gypsum, limestone, and limestone concretions are also found. The gypsum is rather uniformly distributed through the clay as small crystals and grains of selenite. Lignite is present in beds that range from thin seams to beds of commercial thickness. The limestone concretions are yellowish and composed of dense compact limestone with a few veins of calcite. Cone-in-cone concretions in minor amounts are also found. The clays as a whole are carbonaceous, giving brown to blackish stains and seams in nearly every exposure.

Thickness and dip.—The Yegua formation is variable in thickness. In the outcrop area it is probably not more than 700 feet thick, but the logs of wells indicate that down the dip it is materially thicker. It has an average dip of about 150 feet to the mile.

Paleontology.—Fossils are not abundant in the formation, but occasionally large oysters are found.

Topography and vegetation.—The outcrop area of the Yegua is one of little relief. The topography is therefore in some contrast to that of the Cook Mountain below and the Jackson above, in which considerable relief is common. Seen from any higher point the country underlain by the Yegua appears as nearly a plain cut by shallow stream valleys. Drainage on the whole is poor, and marshy lands are not uncommon.

The vegetation is less prolific than that of the overlying and underlying formations, though partaking of the same general character.

[16] For original description see Dumble, E. T., Report on the brown coal and lignite of Texas, pp. 124, 148-154, Texas Geol. Survey, 1892.

[17] 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.

Oaks are practically absent; mesquite and pricklypear are abundant but do not occur in dense thickets. The soils are generally deep and black, with scattered buff or reddish-buff areas.

Sections.—Few exposures of Yegua showing a greater vertical range than a few feet were found. Stream banks and road cuts yield the best exposures, and these indicate that the beds do not vary greatly in character from the bottom of the formation to the top. Sections near the base of the formation along the Pleasanton-Campbellton highway show typical brown gypsiferous clay with yellow concretions and some cone-in-cone structure. Similar exposures are found on the road from Jourdanton to Christine.

The best exposures are found along the Atascosa River for several miles above McCoy. These show only slight variation but are typical of the formation.

Section of Yegua formation on Atascosa River half a mile above bridge at McCoy, Atascosa County

	Feet
Sandy soil	2
Yellow sandy clay	3
Buff gypsiferous clay	7
Black gypsiferous clay	12
Chocolate-brown gypsiferous clay	9
Ledge of calcareous sandstone concretions	5

Section on Atascosa River 3 miles north of McCoy, Atascosa County

	Ft.	in.
Yegua formation:		
Sandy clay soil	3	
Gray gypsiferous clay	3	
Cook Mountain formation:		
Greensand		4
Brown gypsiferous sandy clay with yellow stains	7	
Black gypsiferous yellow-stained clay	3	

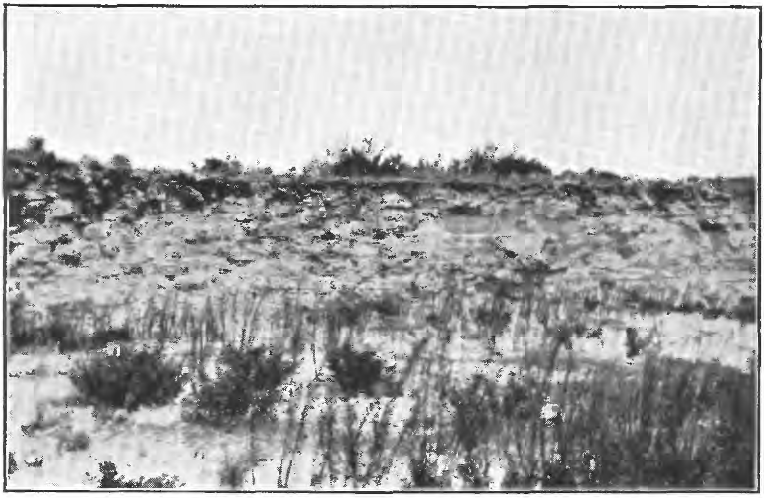
This section shows the contact between the Cook Mountain and Yegua. The greensand probably represents the top of the Cook Mountain formation.

The thickest lignite beds are found near the top of the formation. Northwest of Campbellton test pits showed several feet of the material over a considerable area. Just south of the Atascosa County line, near Cross Settlement, south of Christine, 15 feet of lignite is exposed in the bank of San Miguel Creek.

Chemical character of the water.—Most of the water from the Yegua formation is so highly mineralized that it is unsuitable for either domestic use or irrigation, though a few wells supply water that can be used. Most of the water is even unsuitable for livestock, as the stock generally refuse to drink it. Throughout the outcrop area of this formation domestic water supplies are obtained by storing rain water in cisterns or metal tanks.

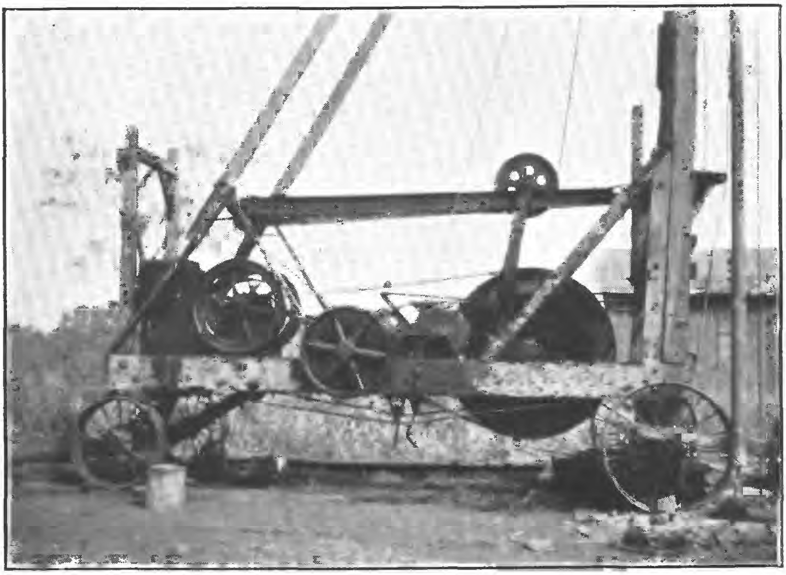
A. CLAYS WITH CALCAREOUS CONCRETIONS IN MIDDLE PORTION OF COOK MOUNTAIN FORMATION.

In bank of a creek about a fourth of a mile north of the exposure shown in plate 6, *B*.



B. THICK BEDS OF HARD JACKSON SANDSTONE IN A QUARRY AT ROCKVILLE, SOUTH OF CAMPBELLTON, ATASCOSA COUNTY.

A. ROTARY TYPE OF WATER-WELL DRILLING MACHINE.



B. PERCUSSION TYPE OF WATER-WELL DRILLING MACHINE.

JACKSON FORMATION [18]

Areal extent.—The Jackson formation appears at the surface only in southeastern and southern Atascosa County. The lower boundary line passes north of Fashing, north of Campbellton, and out of the county near Cross Settlement, in northern McMullen County. (See pl. 1.) None of the larger towns are located on the Jackson, and the area of outcrop is largely ranch country with minor amounts of farm land. The formation lies conformably on the Yegua formation and unconformably beneath the Catahoula tuff, which has overlapped the Frio clay.

Lithology and petrography.—The Jackson is composed of sandstone, quartzite, sandy clay, and volcanic ash. Much of the clay is carbonaceous or lignitic and hence chocolate-colored. The sandstone is generally gray to white, but a few beds are darker and weather to reddish soils. Many of the sandstones are thin-bedded. The beds of volcanic ash range from buff to white and are of variable thickness, the maximum being about 15 feet. They are usually partly altered to clay materials. The formation abounds in silicified wood and contains both calcareous and siliceous concretions, some of the former with cone-in-cone structure. Petrographic analyses of Jackson sands are given below.

[18] In former reports and maps issued by the U. S. Geological Survey all beds of Jackson (upper Eocene) age in Texas were included in the Fayette sandstone. It is now recognized that the beds of Jackson age in this State cannot all be appropriately assigned to the Fayette. For this reason the Survey has recently substituted Jackson formation for the beds of Jackson age in Atascosa, Frio, and other counties in southern Texas.

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Petrographic analyses of sands of Jackson formation

No.	Percentage of grains of different sizes (millimeters)				Percentage of grains of different shapes				Light minerals [a]			Heavy minerals [a]										
	0.589 to 0.295	0.295 to 0.147	0.147 to 0.074	Less than 0.074	Rounded	Fairly well rounded	Subangular	Angular	Quartz	Plagioclase	Chalcedony	Zircon	Rutile	Tourmaline	Magnetite	Cyanite	Staurolite	Apatite	Garnet	Titanite	Muscovite	Xenotime (?) [b]
1	5.72	62.05	19.30	12.25	10	55	27	8	VA	C	A	A	R	C	R	C	R	R	R	C	R	C
2	7.28	35.21	43.60	13.75	9	56	29	5	A	C	A	C	R	C	R	C	-------	C	R	R	-------	R

[a] VA, very abundant; A, abundant; C, common; R, rare. Refer only to relative amounts of light or heavy concentrate. Heavy concentrate contains considerable amounts of opaque nonmetallic grains thought to be composed of minerals listed but with opaque film. Part of this material may be leucoxene.

[b] Xenotime (?), a wine-colored uniaxial mineral resembling zircon but softer, usually occurs in rounded grains.

1, 2. Jackson formation half a mile south of C. T. Tom ranch house, Atascosa County.

Thickness and dip.—In Atascosa County the Jackson formation is about 450 feet thick, with some variation from place to place. The dip averages about 120 feet to the mile, but southeast of Campbellton much higher dips, due to local structural modifications, were observed.

Fossils.—The Jackson formation is locally fossiliferous. Many of the platy or flaggy sandstones of the lower part of the formation abound in fossils. The number of species is not great, but these are frequently present in great abundance. No detailed paleontologic studies of these fossils have been published, though *Ostrea georgiana* Conrad is commonly listed as a characteristic form. Fossil plants are likewise abundant in the formation.[18a]

Topography and vegetation.—The outcrop of resistant sandstone beds in the lower part of the formation is marked by a prominent escarpment or line of hills which is seen south of Campbellton and can be traced across Atascosa County (pl. 7, *B*). The extreme lower and upper parts of the formation are composed of softer beds, and where these appear at the surface the country is a rather featureless plain. The vegetation on the outcrop does not differ materially from that found on outcrop areas of adjacent formations.

Sections.—Excellent sections of the entire Jackson formation are found in southeastern Atascosa County. Some of the sections are given below.

Sections of Jackson formation

At Peeler ranch house, northwest of Campbellton, Atascosa County

[Basal part of formation.]

	Ft.	in.
Sandy whitish calcareous soil		2
Calcareous cone-in-cone, embedded in a coarse-grained yellow sand with numerous specimens of petrified wood	4	
Whitish-yellow coarse-grained sandstone, loosely cemented	1	6
Yellow coarse-grained sandstone, stratified with cone-in-cone	2	
Yellow sandy clay	2	

At quarry at Rockville, 6 miles south of Campbellton, Atascosa County

	Ft.	in.
Black clayey soil	1	6
Fine-grained indurated light-gray sandstone		8
Tuffaceous white shale		8
Fine-grained indurated light-gray sandstone	2	
Tuffaceous white shale		3
Fine-grained indurated light sandstone	9	
Fine-grained buff quartzite to present quarry floor	2	

[18a] A recent detailed subdivision of these beds is given in Ellisor, A. C., Jackson group of formations in Texas with notes on Frio and Vicksburg: Am. Assoc. Petroleum Geologists Bull., vol. 17, pp. 1293-1350, 1933.

Sections of Jackson formation—Continued

On prominent hill, 1¾ miles S. 40° E. of Campbellton, Atascosa County

	Ft.	in.
Fine-grained, well-cemented light-gray sandstone with ledges averaging 8 inches thick, weathering dark brownish red	20	
Tuffaceous white shale, with small ledges of nodular gray clay 1 to 2 inches thick	9	5
Fine-grained quartzitic ferruginous sandstone with ledges about 3 inches thick	12	
Tuffaceous white shale, with small ledges of nodular clay, both 2 to 4 inches thick	12	
Tuffaceous lignitic shale with a small ledge of fossiliferous sandstone	3	
Gray nodular clay		4
Loosely cemented coarse-grained yellowish-gray sandstone		6
Fine-grained ripple-marked sandstone		6
Gray nodular clay	4	
Stratified tuffaceous shale with layers of lignitic sandstone	2	
Sandstone		3
Tuffaceous chocolate-brown shale	2	
Gray nodular clay with layers of sandstone, sand, and tuff from 1 to 3 inches thick	13	

2 miles south of C. T. Tom's ranch house, Atascosa County

	Ft.	in.
Black clayey soil		8
Gray nodular chalky fossiliferous clay	2	
Gray nodular clay	4	
Fossiliferous tuffaceous sandstone		3
Gray nodular clay	4	

1¾ miles south of C. T. Tom's ranch house, Atascosa County

	Ft.	in.
Black soil		8
Laminated chocolate-brown sandy clay		4
Gray nodular clay		4
Laminated chocolate-brown lignite	1	1
Gray nodular clay	6	7

Water supply.—The water from the Jackson formation is variable in chemical quality. The sandstone from the lower part of the formation yields considerable quantities of water, some of which is suitable for use, but the higher beds generally yield water that is highly mineralized and is frequently unsuitable for use.

CATAHOULA TUFF [19]

The Catahoula tuff crops out in extreme southeastern Atascosa County, where it covers an area of about 2 square miles. It consists of creamy-gray volcanic tuff and fine tuffaceous sandstone. The thick-

[19] In accordance with present usage the term "Catahoula tuff" is applied to the dominantly volcanic series of tuffs, tuffaceous sandstones, and conglomerates overlying the Frio clay in southern Texas.

ness exposed in Atascosa County is not more than 100 feet, and the formation does not enter into the problems of water supply.

The Catahoula lies on the Jackson formation, the Frio clay having been overlapped.

GOLIAD SAND

The Goliad sand in this area is composed largely of gravel and cobbles of various kinds, with some sand and caliche. Outcrops of the formation, all of them only a few feet thick, are found sparingly southwest of Charlotte, in southwestern Atascosa County, and rather abundantly throughout Frio County. All the exposures occur on high interstream areas. The formation is not a source of water supply in Atascosa and Frio Counties and is not shown on plate 1. It is probably of Pliocene age.

LEONA FORMATION

In the valley of the Frio River, in northern Frio County, are terrace materials consisting of buff to gray silt, with minor lenses of sand or gravel, that are believed to belong to the Leona formation, of Pleistocene age. Occasional steep faces show as much as 35 feet of the material. The formation, however, is found in only small areas and is not a source of water supply.

ALLUVIUM

The stream valleys of Atascosa and Frio Counties contain Recent alluvial deposits of sand and silt, which are restricted to very narrow areas and are not of consequence as sources of water.

SANDSTONE DIKES

Two sandstone dikes are known to occur in the area—one on the E. J. Pruitt farm, 5 miles west of Charlotte, Atascosa County, on the west side of Lagunillas Creek, and the other 8½ miles east of Pearsall, Frio County, just south of the Pearsall-Charlotte road, on the west side of Black Creek.

The dike in Atascosa County crops out on the surface as a rudely wall-like mass 70 feet long and 30 feet wide with a strike of N. 52° E. It stands about 8 feet above the general land surface. Another outcrop of the same mass occurs 100 yards to the southwest, where the character is the same. The dike is jointed at right angles to the strike. The rock composing the dike is ferruginous medium- to coarse-grained well-cemented sandstone.

The dike in Frio County crops out as a wall 30 to 35 feet wide and 70 feet long. The strike is N. 34° E. The general character of the material is the same as that of the dike in Atascosa County except that the ferruginous sandstone contains numerous rounded cobbles and pebbles of chert as much as 6 inches in diameter. In parts of the rock these are thė major constituents, and the rock is therefore a conglomerate. These cobbles are identical with those of the Goliad formation and probably have come from the same source. It is also likely that the materials for the dike were supplied from the erosion of Goliad gravel.

So far as can be told from the exposures near the dikes, they were not formed after faulting had opened crevices in the surface of the earth. It seems evident from the nature of the dikes that they were formed by the filling of crevices or cracks with detrital material. The structural details, however, are not available.

IRRIGATION FROM WELLS

IRRIGATION FROM WELLS IN CARRIZO SAND

General conditions.—Wells in the Carrizo sand yield abundant supplies of water for irrigation and for municipal and domestic use. The intensive development for irrigation is restricted mainly to relatively small tracts in the Frio Valley, in Frio County, and in the general locality of Poteet and Pleasanton, in Atascosa County (pl. 1). A few wells in the Carrizo sand in other parts of the area are also used for irrigation.

Frio Valley area.—Irrigation from wells in the Carrizo sand in Frio County has thus far been confined for the most part to relatively small tracts southwest of Pearsall. (See pl. 1.) The first Carrizo sand well in this area was drilled in 1905 by Halff & Oppenheimer and was a flowing well. Since that time 12 additional wells have been drilled to the Carrizo in the area for irrigation use and 2 have been drilled in Pearsall for municipal supply. All the wells once overflowed, except the municipal wells at Pearsall and the Weissinger well (no. 96), 1 mile southwest of Pearsall, but by the fall of 1929 four of them had ceased to flow. During the spring of 1930, because of unusually heavy rainfall, little water was used for irrigation. As a result, the water levels in the nonflowing wells rose perceptibly, and one well began to overflow again.

With one or two exceptions all the wells are pumped, the flowing wells being equipped with pumps so as to increase the yield of water during periods when the demands for irrigation are heaviest. When the wells in the lower (southerly) part of the area are pumped continuously or allowed to flow continuously the static level in the wells in the upper (northerly) part of the area is lowered and the yield of the wells is decreased somewhat. All the flowing wells have declined somewhat in yield since they were drilled, the lowest (most southerly) wells showing the smallest decrease. The most productive well in the area is the Bennett well, 1¼ miles south of Derby (no. 109). This well had a natural flow of 896 gallons a minute in 1928, according to a measurement by C. E. Ellsworth, of the United States Geological Survey. It yields about 2,000 gallons a minute when pumped. For many years the static level in the well stood at about 32 feet above the surface of the ground. In the pumping season of 1928–29 the well with others in the area was used intensively, and the level fell to only 12 feet above the surface. The level had risen to about 20 feet during the summer of 1930, when little water was used for irrigation. The Mills well (no. 106), 2¼ miles west of Derby, is also very productive, yielding about 800 gallons a minute. The static level in this well was 28 feet above the surface during the summer of 1930.

The water from these wells is used mostly for irrigating vegetables, especially onions, spinach, and tomatoes. There is some irrigation of cotton and corn, but during many seasons it is not necessary to irrigate these crops. In general two crops are raised on each tract of land during the year, one in summer and one in winter, and rotation of crops is employed so far as is practicable. The duty of water is variable and depends on the character of the crop and the rainfall during the growing season and to some extent on the skill of the individual farmer. For any crop the practice is to irrigate profusely until the crop is started and then to irrigate at intervals as needed to keep the plants growing vigorously in dry times. Accordingly much more water is used if the growing season is dry than if rains occur frequently.

Poteet-Pleasanton area.—The largest area irrigated from wells in the Carrizo sand in Atascosa County is in the northern part of the county around Poteet and Pleasanton. The development thus far has been restricted generally to the lower lands in the Atascosa River Valley, but a few wells have been put down on higher lands some distance from the stream. The northernmost well in this district is 5 miles west of Poteet, and the southernmost is 3 miles southeast of Pleasanton. The area thus defined is 12 miles in length but only 2 or 3 miles wide. The development of irrigation in this area is not continuous and is most intensive near Poteet. (See pl. 1.)

The wells range in depth from less than 500 feet in the northern part of this area to more than 1,600 feet in the southern part. The long dimension of the area nearly coincides with the direction of the dip of the Carrizo sand, and this accounts for the comparatively great range in the depth of the wells. In the immediate vicinity of Poteet there are more than 50 wells that are supplied by the Carrizo sand. Many of these wells are used for irrigation, but at any given time there are always many wells not being used because of change in ownership, tenancy, or agricultural conditions. Most of the wells flow, and about one-fifth of them are allowed to flow continuously. Wells near the northerly limits of the area do not flow at present, though most of them flowed originally. The artesian head in the Carrizo sandstone in the area has fallen about 25 feet since the first well was drilled, and at Poteet it is now about 500 feet above sea level.

The yield of the wells in the area by natural overflow varies considerably, according to the location of the well and the size of the casing. The average flow in the vicinity of Poteet is probably less than 200 gallons a minute. Wells in the lower (southerly) part of the area—for example, the Cunningham & Taliaferro well, 2 miles southeast of Pleasanton (no. 300), and the Anderson & Arneson well, 1 mile northeast of Jourdanton (no. 249)—have estimated yields ranging from 450 to 650 gallons a minute. Many of the wells in the northerly part of the area are equipped with pumps. About half of the pumping plants consist of turbine or centrifugal pumps driven by electric motors, but air-compressor plants and gasoline motors of several types are also used.

Irrigated tracts in this area are largely devoted to truck raising. The area is most widely known for its strawberries, to which the sandy soil is well adapted and for which high prices are commonly received. The first berries reach the market late in November or early in December, but the bulk of the crop is shipped in January, February, and March. Onions, spinach, beans, and other truck crops are also raised, and a few tracts of nursery land are irrigated. The duty of water varies materially according to the crop raised, the rainfall during the irrigation season, and the care with which the water is applied to the land.

Other areas.—Wells in the Carrizo sand are used for irrigation in other parts of the area. The well of C. M. Kelley, west of Hindes, supplies water for irrigation.

The well is 2,390 feet deep and flows about 600 gallons a minute. The Blesse well (no. 112), 1 mile southwest of Dilley, is also used for irrigation.

In the San Miguel Valley, in Frio County, several wells have been drilled to the Carrizo sand, but these wells were not used for irrigation in 1929 and 1930. The J. E. Berry well (no. 24), 4½ miles southeast of Moore, is the northernmost well in this area. It is 700 feet deep, and the water stands within 10 feet of the surface. Flowing wells of large yields at the Keystone ranch headquarters (no. 110) and the McGowen ranch headquarters (no. 111) derive their water supplies from the Carrizo sand. These wells are used for domestic supply and for stock.

IRRIGATION FROM WELLS IN MOUNT SELMAN FORMATION

Water from the Mount Selman formation is used to some extent for irrigation, mainly around Pearsall and in east-central Atascosa County. It is most widely used, however, for stock and domestic supply.

Pearsall area.—The first attempt at irrigation with water from the Mount Selman formation in the Pearsall area was in 1902, when a shallow well was drilled 1 mile north of the town. This well demonstrated that in this locality sands at comparatively shallow depths would yield sufficient water for irrigation, and soon after it was put down other wells were sunk for the same purpose, and the development has continued until the present time. The wells are from 100 to 200 feet deep and do not flow. The average pumping yield is not large, and the tracts irrigated from the wells are comparatively small. Only the best paying crops are irrigated, and the small size of the individual tracts is offset to a degree by the high returns obtained in years of good prices.

About 50 wells have been drilled and equipped with pumping plants for irrigation in an area lying for the most part north and northwest of the town. (See pl. 1.) Recently less than one-third of the pumping plants have been used for irrigation, owing chiefly to changes in land ownership, poor returns from irrigation, and inadequate funds. The largest tract irrigated in 1930 was 30 acres and the smallest 3 acres. The crops grown were tomatoes and tomato plants, beans, peas, onions, spinach, and citrus fruit. During every irrigation season many of the wells are pumped almost constantly, and between irrigation periods almost continuous pumping is also necessary to store sufficient water. The water in these wells drops to a level just above the top of the water sand soon after pumping is begun, but no other effect is noticed. After the irrigation season the water surface returns to the level it had before the irrigation season.

Eastern Atascosa County area.—North and northeast of Coughran, in eastern Atascosa County, some irrigation is carried on with waters from wells that are supplied by the Mount Selman sands. The irrigation wells range from 850 to 1,100 feet in depth, and all of them flow. The yield of the wells by natural flow ranges from a few gallons a minute near the northerly limit of the flowing-well area to several hundred gallons a minute farther south.

Irrigation thus far has been devoted largely to nursery stock and field crops. In 1930 only two tracts were irrigated, but in earlier years efforts have been made to irrigate other tracts. The water is in general highly mineralized, but the soils are exceedingly sandy, and apparently no ill effects have been experienced.

Other areas.—Flowing wells have been developed in the Mount Selman formation in several other areas. At present the water is being used for domestic purposes or for livestock, but in places it could be used for irrigation. At Pleasanton and in an area of considerable size around it many flowing wells have been drilled. These range in depth from 300 to 850 feet and are mostly of small diameter. The yields range from only a few gallons to as much as 75 gallons a minute. A part of the public supply of Pleasanton is obtained from a well (no. 262) of this character 815 feet deep, and many homes in the town are supplied from similar privately owned wells. The water is satisfactory for domestic use, and some of it could be used for irrigation. Much of the water from the formation contains appreciable amounts of hydrogen sulphide. Many of the wells yield inflammable gas, which was formerly trapped in containers and used for heating and lighting, but with the advent of natural gas from the south Texas fields this practice has been discontinued.

In San Miguel Valley, in Frio County, several flowing wells have been obtained from the Mount Selman formation. Wells on lowlands near the stream flow from depths of a few hundred feet, but on the higher land deeper sands must be tapped in order to obtain flowing wells. The flow varies, but the maximum is about 35 gallons a minute. The wells having the largest yields, of which the Oppenheimer & Lang No. 2 well (no. 84) is an example, range in depth from 790 to 860 feet. Larger yields could be obtained if wells of larger diameter were drilled. The water is used only for stock but could be used for domestic purposes and irrigation.

IRRIGATION FROM WELLS IN COOK MOUNTAIN FORMATION

Water from sands and sandstones in the Cook Mountain formation has been used to some extent for irrigation in the vicinity of Dilley. Elsewhere in the area it is used only for domestic purposes and stock.

In the vicinity of Dilley about 40 wells have been drilled to the basal sand of the Cook Mountain formation for irrigation, the first one in 1927. The wells are 8 to 10 inches in diameter and from 204 to 510 feet deep. None of the wells flow, and the distance the water must be pumped ranges from about 55 to 120 feet. They are equipped with pumps of large capacity and yield sufficient water for the irrigation of tracts of 35 acres or more. The irrigated crops include citrus fruit, spinach, onions, tomatoes, and other vegetables, and flowers.

In 1930 comparatively little land was irrigated in the area because of changes in land ownership and low prices of farm products. Irrigation practice varied widely in the Dilley area, and no accurate data are available as to the average duty of water.

MUNICIPAL WATER SUPPLIES FROM WELLS IN CARRIZO SAND

The towns of Poteet, North Pleasanton, Jourdanton, Pearsall, and Dilley obtain their public water supplies from wells drilled to the Carrizo sand. The town wells at Poteet and North Pleasanton are flowing wells. All these wells are described in the well table (pp. 64–80). Analyses of water from two of them are given in the table of analyses (pp. 60–61), as follows: Poteet, no. 218; Jourdanton, no. 250.

The water from these wells has been found to be satisfactory for municipal use. It contains a slight amount of hydrogen sulphide gas but this is removed by aeration. Iron is also present but not in amounts sufficient to affect the quality of the water seriously. Most of the towns that use the Carrizo water have modern water-supply systems operated by public-utility companies in connection with the manufacture of ice and the distribution of electric power. The usual equipment includes a modern pumping plant and standpipe or elevated tank. At Poteet the water supply is obtained from flowing wells and rises by artesian pressure into a standpipe. North Pleasanton is supplied from a well belonging to the San Antonio, Uvalde & Gulf Railroad, the water being sold to a public-utility company and distributed by it. No standpipe is needed, for the water in the well is under a static pressure of 43 pounds to the square inch.

WATER AVAILABLE FROM WELLS FOR DOMESTIC USE AND STOCK

Throughout most of Atascosa and Frio Counties water suitable for domestic use and livestock can be obtained at comparatively shallow depths. In the following pages the general ground-water conditions in various districts throughout the area are described. The conditions set forth for each district can be taken as typical for an area of considerable but indefinite size.

Extreme northern Atascosa County.—In the northernmost part of Atascosa County water for stock and family use is obtained either in the Indio formation or the Carrizo sand. In the Indio formation water supplies that have a wide range in quantity and quality are obtained in wells at depths of 125 to 300 feet It is necessary to test this water to determine if it is satisfactory for drinking. In the outcrop area of the Carrizo sand, wells are obtained at depths ranging from about 125 to 200 feet and have water levels about 105 to 140 feet below the surface. These wells yield adequate supplies of satisfactory water. Wells 166 and 167 illustrate conditions in this area. (See pl. 1 and the well table and table of analyses.) In some localities immediately south of the Carrizo outcrop area wells drilled to the Carrizo obtain water at shallower depths than in the outcrop area, because of the rather steep slope of the land surface. This is illustrated by the record of wells 169 and 170.

Anchorage and Rossville area.—In the area near Anchorage and Rossville flowing wells are obtained from the Carrizo sand in low places along the Atascosa River at depths ranging from 380 to 646 feet. In the higher areas closer to the Carrizo outcrop the wells do not flow, but good wells may be obtained at 250 feet or less. Water can be obtained in this area from wells in the Mount Selman formation at depths of less than 100 feet, but the yield of the wells is less and the water of poorer quality. The records of wells 163, 164, and 165 illustrate the conditions in this area.

Campbellton area.—The wells in Campbellton and vicinity yield bad water at shallow depths, and it is very difficult to obtain satisfactory supplies for domestic use except from very deep wells. The town obtains water from a dug well in alluvium near the Atascosa River. In the area generally dependence is placed on stored rain water for domestic purposes.

Charlotte area.—The wells in the vicinity of Charlotte range from 100 to 1,692 feet in depth, but most of them are between 100 and 300 feet deep. None of the wells flow, and the depth to water ranges from about 100 to 300 feet. The shallower wells obtain water from the lower part of the Cook Mountain formation and the deeper ones from the Mount Selman formation and the Carrizo sand. The water is variable in quality but is generally suitable for domestic use. The records of wells 293 and 294 illustrate the conditions prevailing in the shallower wells.

Christine area.—The surface rocks in the Christine area belong to the Yegua formation and are composed largely of gypsiferous clay with some beds of sand.

Wells range in depth from 155 to 1,314 feet. Flowing wells are obtained at depths greater than 950 feet, and the town is supplied from a flowing well 1,314 feet deep (no. 295). Another well in the town 950 feet deep flows, but the water is of poor quality. The shallow well waters are of variable quality, and it is often necessary to case off sands containing bad water in order to obtain a satisfactory supply.

Crown area.—Water-bearing sands are found at several depths in the Crown area. In the W. K. Shipman well (no. 337), 1 mile southeast of Crown, sands were found at 165, 357, 650 (Mount Selman), and 1,207 feet (Carrizo). Some of the upper waters are of poor quality. As a rule, however, water that is fairly satisfactory for domestic use can be obtained from shallow wells.

Dobrowolski area.—Wells in the vicinity of Dobrowolski range from 150 to 200 feet in depth. The water is of fair quality and can be used for domestic purposes, stock, and boilers. Conditions are generally similar to those around Charlotte.

Hindes area.—Flowing wells are obtained in the area round Hindes on low ground in San Miguel Valley from a sand in the Cook Mountain formation. At Hindes this sand is penetrated at depths of 380 to 440 feet. Wells are also obtained at about 150 feet, but the water is of poorer quality than that from the deeper sand. An analysis of the deeper water is given in the table on page 61 (no. 287). The Carrizo sand is encountered in this area at depths of about 1,900 feet. One well a mile southwest of the town has developed a large flow from that formation.

Jourdanton area.—The municipal supply of Jourdanton is obtained from a well 1,635 feet deep (no. 250) in which the water stands 6½ feet below the ground surface. Other wells in the area range in depth from 400 to 1,500 feet. The C. S. Young well (no. 251) encountered sands at 300, 745, 810, and 931 feet, all in the Mount Selman formation. In general the shallow ground waters throughout this area are of poorer quality than the deeper waters.

Leming area.—In and around Leming the Carrizo sand is the best available aquifer. It can be reached by wells less than 500 feet deep. Shallower wells in the Mount Selman formation yield water of variable quality, which is generally, however, fairly satisfactory for domestic use. The records of wells 170 and 171 illustrate conditions here. An analysis of water from well 171 is given in the table of water analyses.

Pleasanton, North Pleasanton, and Coughran area.—In the area including Pleasanton, North Pleasanton, and Coughran there are many shallow wells that are supplied by the Mount Selman formation, and on low ground a considerable number of the wells flow. (See pl. 1.) There are also many deeper flowing wells. The depths of all wells in regard to which information was received range from 296 to 1,925 feet. Wells 260 to 280 are examples of shallow flowing wells: wells 241, 244, 253, 254, 255, 256, 257, and 258 are deeper wells. The abundance of water-bearing sands is shown in the record of the E. R. Breaker well (no. 241), in which sands were found at 44, 200, 643, 927, and 1,206 feet. The water from the shallow and the deep wells is potable and generally suitable for domestic and irrigation uses. Analyses of water from 6 wells are given in the table of analyses.

Poteet area.—The Carrizo sand is reached by wells in the Poteet area at depths ranging from 400 to 1,000 feet and is the principal source of the ground water used in the area for domestic purposes as well as for irrigation. It is customary throughout the area to drill wells to this horizon, and most of the wells flow. Before the development of these deeper wells water of poor quality was obtained from wells ending in the Mount Selman formation at depths of 30 to 50 feet. The wells in the Carrizo sand, despite the greater cost of drilling, are the most desirable, because the water can be used for irrigation as well as for domestic purposes. Wells 175 to 238 are in this area. Analyses of water from 6 of the wells are given in the table of analyses.

Northern Frio County.—The beds that crop out in the northern part of Frio County belong to the Carrizo sand and the Mount Selman formation. Over a considerable part of the area the Carrizo either is at the surface or lies at relatively shallow depths, and wells in it yield abundant supplies of good water. The wells are from 100 to 500 feet deep. Wells 1 to 19 illustrate conditions in this area. Water can be obtained in a part of the area from the Mount Selman formation at depths of about 100 to 450 feet, but the water is of poor quality, and the wells yield much less freely than those in the Carrizo sand. In some areas in northeastern Frio County there is difficulty in obtaining potable water from the Mount Selman. Wells in the lower part of the Mount Selman formation (Bigford member) yield water of poor quality.

Derby area.—In the Derby area records were obtained of wells ranging in depth from 203 to 455 feet. These wells obtain their water from the Mount Selman formation. Wells 146, 147, 148, 149, 150, 151, 152, 153, 343, and 344 are representative.

Dilley area.—The shallow water in the area around Dilley is described in the section on water in the Cook Mountain formation (p. 40). Records were obtained of wells ranging in depth from 119 to 137 feet. West of Dilley, in the west-central part of the county, the water is found under generally similar conditions but is of more variable quality.

Pearsall area.—Shallow wells in the Pearsall area are discussed in the section on water in the Carrizo sand and Mount Selman formation (pp. 26, 34). The conditions there described prevail over a fairly wide area. Water is usually obtained in wells at depths ranging from about 100 to 250 feet. The water, though usually potable, varies considerably in mineral content. In an area east of Pearsall the sandy upper beds of the Mount Selman formation are at or near the surface and supply wells ranging from about 65 to 250 feet in depth. These wells yield the best water found in the Mount Selman formation anywhere in the area.

WELL DRILLING AND PUMPING METHODS

Most of the water wells of the area are drilled, only a few of them being dug wells. Methods of well drilling differ considerably according to the type and depth of the well and the district in which it is located. The wells drilled for domestic or ranch supply are generally shallow, averaging about 250 feet deep, and are drilled by hydraulic-rotary or cable-tool percussion-drilling machines (pl. 8). The wells range from 4 to 8 inches in diameter and are cased to variable depths. If sands yielding water of poor quality are penetrated these sands are cased off, and the remainder of the well below is uncased. In some domestic wells, however, casing is set the entire depth, or to the water-bearing sand. The domestic and ranch wells are pumped almost entirely by cylinder pumps with windmill power. Strong, fairly constant winds are common, and therefore an adequate supply of water can be obtained by this method.

Pearsall area.—The methods of drilling and pumping wells drilled for irrigation vary considerably in the Pearsall area. The wells range in depth from 100 to 2,500 feet and the pumping lift and yield is very variable. At Pearsall, in the shallow irrigation district, the greater number of wells are 100 feet deep, but a few are as much as 200 feet deep. The water-bearing sands are generally encountered at depths less than 100 or 200 feet, but the drilling contracts are usually made on the basis of drilling a well to either of these two depths.

The irrigation wells are nearly all 10 inches in diameter, though a few are only 6 or 8 inches. The wells are cased to a depth of about 10 feet, or only deep enough to exclude surface run-off and to keep the weathered rock and soil from falling into the well. Below 10 feet the holes remain open and in good shape, owing to the fact that the shales, clays, and sandstones of the Mount Selman formation do not cave readily. It is customary, in the Pearsall district, to drill two wells for each irrigation installation. These are spaced either 15 or 20 feet apart and are fitted with cylinder pumps that are operated by a walking beam connected to a crank and drive shaft. One engine or motor can then drive both pumps. There are a few single irrigation wells in the district, but most of these are used to irrigate very small tracts. One installation consists of three wells spaced 15 feet apart in a line and pumped simultaneously with one engine.

Practically all the wells in this district have been drilled with the cable-tool percussion-type drilling machine, such as is shown in plate 8, *B*. Machines of this type are suitable for sinking wells as much as 1,000 feet deep. The pumps are of the cylinder type, the cylinders being 4 to 5¾ inches in diameter. In the pumping installations in which the walking beam, crank, and pitman are used the length of stroke of the cylinder can be varied, thereby changing the yield. In certain other types of installation the stroke of the cylinder is fixed, and the yield can be varied only by changing the speed of the engine.

Power for pumping the irrigation wells at Pearsall is supplied by electric motors, stationary gasoline engines, oil engines, and converted automobile motors. If the tract of land to be irrigated covers only a few acres, an improvised power plant probably serves reasonably well. However, well operators of larger irrigation tracts use more substantial power installations, the electric motor being preferred. Some electric installations are fitted with automatic controls and hence require very little attention.

On some of the irrigated tracts at Pearsall the water is conducted directly from the wells to the land. This is not practicable except on the smaller tracts, because the yield of the wells is too small to maintain a proper irrigation head in long ditches, especially during dry, hot periods. It is customary, therefore, to build concrete storage reservoirs ranging in capacity from about 100,000 to 200,000 gallons and to store water pumped during the night in these reservoirs for use the following day. During times of most intense irrigation the wells may be pumped almost continuously for several days, but this is not the normal practice.

The cost of drilling wells in the Pearsall district is more or less standardized. At the time this investigation was made the customary cost of drilling was $1.25 a foot for the first 100 feet, including the labor of placing the casing and fitting the pump. Deep wells cost slightly more per foot of depth. As most of the wells are cased only for 10 feet the cost of casing is slight. The cost of pump pipe was 46 to 97 cents a foot, according to the quality of the pipe. The cylinder and strainer could be obtained for about $50, the exact cost depending on the size and quality. The cost of the power-plant installation varies with the type.

Dilley area.—Irrigation wells in the Dilley area range from about 250 to 400 feet in depth. The yield is considerably greater than that of the shallow wells at Pearsall, and the depth to water is greater. The wells are drilled with a hydraulic-rotary drilling machine, similar to that shown in plate 8, *A*. In the Dilley area nearly all the wells have been drilled by one driller. Most of them are 10 inches in diameter, but a few are only 6 or 8 inches. Some wells are cased to the bottom, others have only one length of casing at the surface, and still others are cased to intermediate depths. There seems to be no uniform casing practice, and frequently the cost of the casing governs the type and amount of casing used. Some of the uncased wells have caved, and it would therefore seem desirable to case the wells in this district from top to bottom.

Several types of pumps are used in the Dilley area. The deep-well cylinder pumps with geared pump jacks are perhaps more numerous than any other type. A number of wells are pumped with turbine pumps, which are operated by electric motors connected directly to the upper end of the pump shaft. A few centrifugal pumps are used. Most of the pumps are operated with electric motors, but gasoline engines, gasoline tractors, and oil engines are also used. The cost of drilling, equipping, and operating wells is greater than in the Pearsall area, because the wells are deeper and the lift greater. The drilling cost averages about $1.75 a foot for a well 10 inches in diameter; the casing costs $1.50 a foot. A typical installation, consisting of a turbine pump with a capacity of 250 gallons a minute and a 15-horsepower electric motor, costs between $600 and $1,000, depending on the make and the length of the pump setting.

In the Dilley area considerable irrigation is done directly from the wells, but on some farms earth reservoirs are used. Several concrete reservoirs are also in use. Direct irrigation is adequate for tracts of land as large as 15 acres, as the yield of the wells is sufficient to maintain an adequate irrigation head.

Poteet area.—The irrigation wells in the Poteet district illustrate another type of construction and use, as they are of intermediate depth and many of them flow. They range in depth from 550 to 1,050 feet; the shallower ones are in the northern part of the district. Most of the wells are 8 inches in diameter at the top and either 4 or 6 inches in diameter at the bottom. There is no uniform practice in this area in the amount of casing used, and many wells are insufficiently cased, simply because the owner desired to keep the initial cost of the well at a minimum. Some of the wells, however, are cased to the water-bearing sand, or for their entire depth. In such wells, the casing is set on a hard-rock layer above the sand, or it is extended into the sand and the length that penetrates the sand is perforated. In some of the wells perforated casing has been used for a considerable distance above the water-bearing sand; in others the perforated casing extends a considerable distance below the sand. Because of this practice, many of the wells yield water of inferior quality. The wells have generally been drilled with hydraulic-rotary machines of the type shown in plate 8, *A*. Some of the earlier wells, however, were drilled by the cable-tool percussion method. A few of the wells were drilled with large hydraulic-rotary machines such as are used in oil-well drilling.

Many of the wells at Poteet are flowing wells. A large number of them are not equipped with valves and are allowed to flow continuously. Reservoirs are generally used in conjunction with all the flowing wells that furnish water for irrigation. The reservoirs are made of earth and range in size from a fraction of an acre to 4 acres. Many farms, however, are irrigated directly from the wells.

Nonflowing wells and wells that yield only a small quantity by natural flow are pumped. In such wells the depth to water is not great, and therefore the pumping plants are not as elaborate as at Dilley. Centrifugal pumps, air lifts, and a few turbine pumps are used. The pumps are operated with electric motors, tractors, stationary gasoline engines, and oil engines. On the whole there has been very little electrification of pumping plants, and the installations in general are somewhat crude.

Deep wells.—The deep irrigation wells and deep wells used for municipal supply have been drilled usually with oil-well drilling equipment. Some of the wells have been drilled by oil-field contractors; others have been drilled by firms engaged only in water-well drilling. The wells are from 1,300 to 2,500 feet deep and generally obtain water from the Carrizo sand. The deep wells are cased to prevent the contamination of the Carrizo waters by mineralized water from the higher formations.

The diameter of the wells ranges from 6 to 16 inches. The diameter at the bottom is usually less than that at the top, for in most wells the casing has been reduced in size one or more times. The Pearsall city well (no. 94), which is 1,303 feet deep, has 155 feet of 16-inch casing, 806 feet of 8-inch casing, 65 feet of 6-inch casing, 104 feet of 8-inch screen, and 81 feet of 6-inch screen. The city well at Jourdanton (no. 250) is 1,635 feet deep and has 162 feet of 10-inch casing, 1,118 feet of 8-inch casing, 267 feet of 6-inch casing, and 99 feet of 6-inch screen. These wells are cited as examples of properly drilled wells in which great care was taken to insure a good finish. Some of the older irrigation wells were not so well constructed.

No exact figures are available on the cost of the deeper wells. It has been reported that one well recently drilled near Pearsall to a depth of about 1,350 feet and fitted with a pump cost $8,000. This is probably a minimum cost, for the well was drilled as economically as possible. Figures showing the cost of earlier wells are not applicable to conditions prevailing at the time the investigation was made.

QUALITY OF THE WATER

Water analyses.—The table of analyses (p. 60) shows that the waters vary widely in chemical character. This is due largely to inherent differences in the chemical character of the rocks of the various formations and perhaps in part to chemical reactions that have occurred in the waters within the rocks. In general the amount of dissolved material in water from a given formation varies directly with the depth of the formation beneath the surface. The greater the depth the longer the water has been in the formation and the greater has been its solvent action on soluble minerals present in the formation. As is to be expected, the waters from clean sandstones contain less dissolved material than those from formations containing alternating clays and impure sands.

Water analyses are of importance in determining the adaptability of water for domestic and industrial supply and for irrigation. In the area covered by this report industrial demands for water are not great, and the analyses are of chief importance as indicating whether the water is suitable for domestic use or irrigation. The analyses do not show the sanitary condition of the waters, and statements based on the analyses are made without reference to possible pollution of the waters.

The chemical character of the waters is determined by the quantities and proportions of the basic radicles calcium, magnesium, and sodium and the acid radicles bicarbonate, sulphate, and chloride. Calcium and magnesium affect the value of water for industrial uses, mainly because of the hardness that they cause. Sodium and potassium compounds may cause trouble in irrigation. If the acid radicle is carbonate or bicarbonate the resulting product is sodium carbonate or sodium bicarbonate ("black alkali"). The sulphate and chloride salts are less harmful and form "white alkali."

Requirements for domestic use.—The adaptability, in a chemical sense, of a water for domestic use is dependent to some extent on the experience of the people using it. If they have been accustomed to waters of low mineral content they will regard as bad waters in which the mineral content is only slightly higher. On the other hand, if they have lived in regions where the waters in general are somewhat heavily charged with mineral matter they will use without question water that may be rather highly mineralized. Waters of the latter type are most common in southwestern Texas. The taste of the water is important, for waters containing as much as 1,500 parts per million of dissolved materials and having a pleasant taste are still acceptable. Next to taste, softness is the most important quality of a water for domestic use. Some soft and otherwise desirable waters are rendered unpalatable by the presence of magnesium salts or sodium chloride, which give them a disagreeable taste.

Requirements for irrigation.—Water for irrigation must be of such chemical nature as not to damage the soil on which it is used. There is no fixed standard by which the quality of water for this purpose can be gaged, and it is almost impossible to construct such a standard. The type of water that can be used with safety varies greatly with the type of soil and subsoil, topography, crops, and climate. In Atascosa and Frio Counties the average annual rainfall is around 24 inches, and much of it is concentrated into violent rainstorms. The soils range from extremely porous sandy soils with very good subsurface drainage to clay soils that are almost impermeable. In the sandy soils, any accumulation of objectionable salts from irrigation waters will be largely dissolved and washed out of the soils by the torrential rains. In the clay soils the salts tend to accumulate. It is obvious that a set of standards which does not take into account the physical character of the soils would be of no value. In general, it can be stated that waters with more than 200 parts per million of sodium carbonate and a total of more than 1,000 parts per million of sodium carbonate, sodium sulphate, sodium chloride, magnesium chloride, and magnesiun sulphate should not be used on soils that do not have good subsoil drainage. Use of water with 200 to 500 parts per million of sodium carbonate is dangerous and should not be undertaken unless a careful investigation shows the drainage conditions are exceptionally good. If the water contains more than 500 parts per million of sodium carbonate its use is certain to result in serious damage to all except the most sandy soils with ideal drainage conditions. In addition it should be kept in mind that the total of the salts previously mentioned should not exceed 2,000 parts per million and that waters with 1,000 to 2,000 parts per million of these constituents demand careful handling.

It should be understood that this general outline of standards for use of irrigation waters is not universally applicable. Examples are known, in Atascosa and Frio Counties, of water with dissolved mineral matter in excess of the limits given that has been used for years with no apparent ill effects. The conditions of drainage, however, were ideal, and the soil very sandy. At the same time one tract of land irrigated with water containing less than 250 parts per million of total dissolved constituents and less than 100 parts of sodium carbonate showed distinct, progressive damage. The soil was of a clayey type, the irrigation was excessive, and the drainage was very poor. Users of water for irrigation should keep in mind constantly the fact that the matter of drainage is of the utmost importance.

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Analyses of ground waters in Atascosa and Frio Counties, Tex.

[Analyzed by Margaret D. Foster. Parts per million. For records of wells see corresponding numbers in well table, pp. 64-80]

No.	Location	Depth (feet)	Date of collection	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)
	Frio County														
25	Moore, 4½ miles southeast of	190	June 18, 1932	[a] 482		1.5	63	22	[a] 95		388	47	62	1.0	248
29	Bigford (cotton gin)	115	do	330	51	.21	34	8.6	53	9.3	149	45	54	.60	120
41	Pearsall, 1¾ miles north of	130	do	[a] 1,247		.12	152	23	[a] 269		234	259	415	14	474
44	Pearsall, 1¼ miles north of	110	do	[a] 800		.26	145	18	[a] 128		331	114	228	2.5	436
75	Pearsall, 6 miles east of	46	May 26, 1932	2,868	46	.10	354	150	289	44	356	554	470	810	1,500
84	Pearsall, 12 miles east of	860	do	987	20	3.4	90	40	199	21	374	172	258	.0	389
93	Divot, ¼ mile west of	173	June 17, 1932	[a] 2,620		.27	42	22	[a] 878		362	712	755	2.6	195
97	Pearsall, 3½ miles southwest of	1,350	do	414	22	4.0	99	18	22	6.2	331	59	25	.05	321
105	Derby, 2¾ miles northwest of	1,672	do	[a] 349		.15	83	16	[a] 26		295	58	18	2.7	273
109	Derby, 1¼ miles south of	1,700	do	349	23	.22	70	13	36	6.1	284	47	18	.57	228
111	Pearsall, 12½ miles southeast of	1,700	May 26, 1932	308	17	.17	66	14	25	7.8	270	38	15	.0	222
113	Dilley, about ½ mile from Dilley on Laredo Highway	2,010	Jan. 1, 1928	350	27	.24	32	11	80	4.6	282	45	18	.42	125
121	Dilley, 2½ miles northwest of	305	June 17, 1932	1,090	27	.31	102	36	221	9.6	341	254	248	.38	403
130	Dilley, ¾ mile south of	200	do	[a] 672		2.5	88	39	[a] 107		349	131	135	.0	380
132	Dilley	307	Jan. 20, 1928	1,747	22	2.4	166	65	305	18	292	650	325	.45	682
133	do	370	June 17, 1932	[a] 1,803		.57	120	55	[a] 427		245	730	350	.25	526
146	Melon, 1½ miles southeast of	228	June 18, 1932	[a] 662		.45	94	19	[a] 118		273	79	148	69	313
148	Melon	242	do	1,954	14	.55	127	57	438	20	301	676	408	2.6	551
152-a	Derby, ½ mile southwest of	285	do	[a] 1,652		.36	149	82	[a] 323		345	436	460	32	709
152-c	Divot, 2½ miles southwest of	210	June 17, 1932	[a] 4,321		7.8	176	34	[a] 1,347		390	1,182	1,385	4.5	579
154-a	Pearsall, ½ mile west of	40	June 18, 1932	[a] 899		.15	118	61	[a] 131		446	121	228	20	545
154-c	Pearsall, 2 miles east of	200	do	[a] 1,936		3.7	312	65	[a] 302		284	273	838	5.4	1,046
158-a	Dilley, 4 miles northwest of	250	June 17, 1932	[a] 1,054		1.2	104	39	[a] 214		328	377	158	.50	420
	Atascosa County														
163	Rossville, 5½ miles southwest of	380	Feb. 22, 1928	227	18	1.1	31	6.2	28	5.1	52	50	51	.10	103
166	Poteet, 8½ miles north of	175	June 18, 9132	[a] 107		.23	[b] 10		[a] 27		31	21	32	.42	[c] 34
172	Leming	120	June 19, 9132	[a] 767		1.1	130	31	[a] 110		286	120	235	.0	452
177	Rossville, 4½ miles south of	640	June 18, 1932	[a] 196		1.4	40	7.9	[a] 20		84	41	45	.0	132
197	Poteet, 3¾ miles west of, Locke Nursery	600	May 26, 1932	199	19	1.1	29	6.0	21	7.4	60	36	43	0	97
216	Poteet	840	Feb. 22, 1928	180	18	.58	23	4.8	23	4.3	43	33	46	.21	77
218	do	835	May 26, 1932	193	16	11	28	6.1	21	7.0	55	32	47	.0	95
220	Poteet, ¼ mile south of	840	do	253	15	6.7	50	9.3	21	8.7	166	32	32	.0	163

241	Pleasanton, 1½ miles north of	1,925	Feb. 20, 1928	292	20	.52	59	8.5	28	3.5	189	39	34	.0	182
248	Jourdanton, 1½ miles west of	1,040	June 18, 1932	[a] 442		1.7	48	23	[a] 88		272	73	75	.50	214
249	Jourdanton, 1 mile northeast of	1,505	Feb. 21, 1928	331	22	.96	77	12	28	4.3	264	37	34	.0	242
250	Jourdanton (ice plant)	1,635	June 18, 1932	[a] 333		.90	68	15	[a] 39		278	41	33	.0	232
255	Coughran, 1½ miles north of	1,050	June 19, 1932	[a] 583			[b] 5		[a] 249		543	[a] 1	81	.0	[c] 18
262a	Pleasanton	815	Feb. 20, 1928	484	20	.09	6.8	3.7	173	3.0	356	2.2	90	.10	32
263	Pleasanton (hotel)	380	June 19, 1932	[a] 917		1.2	[b] 5		[a] 380		455	[b] 1	335	.0	[c] 20
274	Pleasanton	340	do	[a] 969			[b] 3		[a] 398		528	109	235	.0	[c] 12
279	do	630	do	[a] 458		.23	[b] 7		[a] 185		363	[b] 1	92	.0	[c] 26
287	Hiudes	450	do	[a] 1,699			[b] 9		[a] 639		324	547	412	2.7	[c] 28
295	Christine	1,314	do	[a] 1,652			[b] 3		[a] 672		781	153	475	.68	[c] 9
296	do	956	do	1,718	21	.10	4.8	2.3	643	14	769	152	460	2.5	21
300	Pleasanton, 2 miles southeast of	1,722	do	[a] 334		.69	82	12	[a] 28		268	47	33	.0	254
303	McCoy	900	do	[a] 2,980			[b] 3		[a] 1,255		1,671	163	850	.0	[c] 10

[a] Calculated.
[b] By turbidity.
[c] Determined.

CONSERVATION OF THE WATER SUPPLY

In the season of 1929–30 the discharge of the irrigation wells and of the flowing wells used for other purposes was measured or estimated, the land irrigated with water from wells was mapped (pl. 1), the kind of crops raised was recorded, the amount of water used for each crop was studied, and the quantity of water wasted from each well was computed. This survey revealed the facts that although some of the wells are shut down when the water is not needed, a considerable number in both counties are allowed to flow continuously, and a surprisingly large quantity of water is completely wasted or used to only a minor extent for watering livestock or maintaining fish ponds. Waste occurs from all three of the sandstones that furnish water for irrigation, but attention was given especially to the Carrizo sand, from which the greatest quantities of water are wasted.

The flow of the wells was ascertained approximately by weir measurements, rough volumetric or float measurements, or estimates. On the basis of all data obtained it was estimated that in 1929–30 water was being discharged by wells in the Carrizo sand at the rate of about 16,000 acre-feet a year—about 9,500 acre-feet by wells in Atascosa County and about 6,500 acre-feet by wells in Frio County.

The results of the survey, as presented in plate 1, show that the total area irrigated in 1929–30 with water obtained from the Carrizo sand was 2,085 acres—1,350 acres in Atascosa County and 735 acres in Frio County.

In 1929–30 there was more rainfall than normal, and therefore the quantity of water used for irrigation was less than usual. On the basis of the studies that were made the average annual duty of water was placed at 2.4 acre-feet to the acre in Atascosa County and 2.8 acre-feet in Frio County, although it is recognized that with the best irrigation practice somewhat smaller amounts would probably be adequate. It was therefore computed that, with the acreage irrigated in 1929–30, the quantity of water from the Carrizo sand that is beneficially used for irrigation in a year of average rainfall amounts to about 5,300 acre-feet—3,200 acre-feet in Atascosa County and 2,100 acre-feet in Frio County. These computations lead to the startling conclusion that in each county about two-thirds of the water withdrawn from the underground reservoir formed by the Carrizo sand is virtually wasted.

In both the Pearsall area and the Poteet area there has been some decline in artesian head and a corresponding decline in discharge from each well. The decline has not been great, but nevertheless it has been sufficient to cause some of the wells to cease flowing. If the waste of artesian water were eliminated there would doubtless be an appreciable restoration of head, such as occurred during the winter of 1929–30, when, because of heavy rainfall, only a small amount of water was used for irrigation and wells resumed flowing that had ceased to flow in 1928. It is estimated that by eliminating the waste it will be possible to put under irrigation about 4,000 acres of additional land in the two counties without making any additional draft upon the underground reservoir.

Frequent measurements are being made of depths to water level in selected wells for both counties. This program of water-level measurements is to be continued, and a partial resurvey of the discharge and use of ground water is to be made. The records of depth to water thus far obtained indicate that in both counties there has been a small net decline in the head of the water in the Carrizo sand since the investigation was begun in 1929, while the head in the Mount Selman formation has remained practically unchanged. A longer record of water levels and correlative rates of discharge must be obtained before a close estimate of safe yield can be made. The data at hand, however, lead to the conclusion that the present beneficial use is not in excess of the safe yield and that further irrigation developments can safely be made to utilize all or most of the total discharge as shown by the survey of 1929–30, provided effective steps are taken to eliminate the waste.

RECORDS OF WELLS

Data on wells in Atascosa and Frio Counties are given in the following tables. All the wells listed are shown on plate 1.

Records of wells in Frio County, Tex.

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power [a]	Use [b]	Remarks
1	Frio Town, 7 miles northwest of, at ranch headquarters.	Louis Vest			698.89		5		Carrizo sand	−84.4		C, W	D, S	
2	Frio Town, 4 miles north of.	G. A. Blackaller			656.66		5		do	−60		C, W	D	
3	Frio Town, 3 miles north of.	do	Lefevre & Story		688		12							Abandoned oil test.
3a	Frio Town, 2½ miles north of.	Lou Blackaller				52	6		Carrizo sand	−41.4				
4	Frio Town, 4½ miles west of.	C. Woodward			661.66	400	6		do	−78		C, W	S	
5	Frio Town, 2½ miles west of.	Mrs. D. Little				210	6		do	−65		C, W	S	No water above 200 feet.
6	Frio Town, 6 miles northeast of.	J. J. Little			697.7		5		do	−100		C, W	S	
7	Frio Town, 3 miles northeast of, Swamp Farm.	do			635.02	52	5⅝		do	−41		C, W	D, S	
8	Frio Town	Mrs. W. A. Roberts			627.77	208			do	−52		C, W	D	
9	do	do		1909	629.29	197	6		do	−52		C, W	D	
10	Moore, 10 miles west of	H. W., A. C., and R. L. Eshenberger.	F. B. Lefevre	1930	638	3,478	8							Abandoned oil test.
11	do	do					5		Carrizo sand	−102		C, W	D	
12	Moore, 9 miles west of	F. Fasler				160	5		do	−109		C, W	D, S	
13	Moore, 4 miles northwest of.	P. M. Crane				110	5⅜		do	−103		C, W	D, S	A little scale on boiling.
14	Moore, 3.5 miles west of	B. Conover			670.09	200	5⅜		do	−110		C, W	D, S	Soft.
15	do	S. E. Edwards	Lain & Brown		679	2,607								Abandoned oil test.
17	Moore, ½ mile west of	Martin Ellison	B. Young	1909	675.98	108	4		Bigford (?) member of Mount Selman formation.	−61		C, W	D, S	Heavy draw-down when pumping.
18	Moore	Moore School			661.87	200	4		Carrizo sand	−98		C, W	D	
19	do	J. W. Winters	A. Doodlestadt		662.27	200	6		do	−101		C, W	D, I	Some iron stain on vessels; some scale on boiling.
20	Moore, ⅓ mile southeast of.	A. Obits				38	40		Bigford (?) member of Mount Selman formation.	−32		None	D	Dug.
21	Moore, 1½ miles south of	A. Dunlap	B. Conover	1914		117	4			−75		C, W	D, S	

22	Moore, 3 miles southwest of.	W. O. Brown	Donaldson Oil & Gas Co.		704	2,846								Abandoned oil test.
23	Moore, 4½ miles southeast of, ranch headquarters.	J. E. Berry		1900		150	6		Mount Selman formation.	−20		C, W	D, S	
24	do	do	N. Graham	1910	573.71	720	8	300–600	Carrizo sand	−10	900	A, G	N	
[c]25	Moore, 4½ miles southeast of.	Siebert & Nelms	A. Mann	1926		190	5¼	190	do.(?)	−44		C, W	D	
26	Moore, 6 miles northeast of.	C. C. Tribble	North & Walton	1930		3,554	10							Do.
27	Bigfoot, 2 miles north of.	Burns	E. H. Wray	1930										Oil test; gas.
28	Moore, 6 miles southeast of.	A. Johnson				560	8		Carrizo sand	−5		None	N	
[c]29	Bigfoot, cotton gin	G. E. Thomas and C. W. Frazier.		1919		115	4		Mount Selman formation.	−100		C, W	B	
30	Bigfoot	Louis Ross		1915		76			do	−70		C, W	D	Dug.
31	do	A. A. Whittaker	V. Hamilton	1905		110			do	−100		C, W	D	Do.
32	Bigfoot, 1 mile south of.	G. W. Couser	Shubar			200	4		do	−138		C, W	S	Bitter taste.
33	Pearsall, 13 miles west of ranch headquarters.	J. Loxton		1913		500	5½		do.(?)	−200		C, W	D	Fine white sand at bottom.
34	Loxton, 5 miles southwest of ranch headquarters.	do				260	5½		do	−150		C, W	S	
35	Pearsall, 8 miles northwest of.	B. I. Gillman	L. Whitley			157	6	147–157	do	−150	7	C, W	D	
36	Pearsall, 3 miles north of railroad underpass 0.6 mile west of.	Claude McCauley	C. McKinley	1926–1930		1,245	10	1,000–1,300(?)	Carrizo sand	−139	600	T, G	I	
37	Pearsall, 2¼ miles north of.	do		1927	669.60		10		Mount Selman formation.	−87		C, G	N	2 wells 20 feet apart.
38	Pearsall, 2 miles north of.	do		1927		130		115–126	do	−88	500(?)	T, G		Do.
39	do	Thomas Young	Layne Texas Co.	1918		115	8	85–115	do	−76	50	C, G	I	Temperature 96° F.
40	do	H. H. Page	D. Upton	1927		110	8	90–110	do	−56	120	C, E	I	2 wells 20 feet apart; temperature 86° F.
[c]41	Pearsall, 1¾ miles north of.	A. R. Strong	do	1918		130	8	60–80	do	−78.3	120	C, E	I	2 wells 20 feet apart.
42	Pearsall, 1 mile north of.	E. Strong		1918		100	8	65–85	do	−40	120	C, E	I	Do.
43	Pearsall, 1¼ miles north of.	A. M. Vanderwert		1927		116	8	90–116	do	−45	60	C, E	I	
[c]44	do	R. W. Brown	E. Braton	1916		110	8	85–110	do	−50	100	C, G	I	2 wells 20 feet apart; temperature 90° F.
45	Pearsall, 1 mile north of.	J. E. Fields	F. Saunders			100	8	80–100	do	−40		C, G	I	
46	Pearsall, 1½ miles northwest of.	W. Hanson	J. D. Owings	1927	628.68	120	8	85–115	do	−51		C, G	I	
47	Pearsall, 1¼ miles northwest of.	E. D. Bonner	J. E. Owings	1928		120	8	90–120	do	−45	40	C, G	I	

[a] Pumps: C, Cylinder pump; D, duplex cylinder pump; A, air lift; T, turbine centrifugal pump; E, rotary pump; Cent., ordinary centrifugal pump. Power: W, Windmill; H, hand; G, gasoline or oil engine; S, steam engine; E, electric motor; K, kerosene engine.

[b] C, Cooking; D, domestic; S, stock; I, irrigation, B, boiler; N, not used; M, municipal.

[c] For analysis see table on pp. 60–61.

Records of wells in Frio County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power	Use	Remarks
48	Pearsall, 1¼ miles north of.	H. G. Rylander		1920		125	8	90–125	Mount Selman formation.	–72	110	C, E	I	2 wells 20 feet apart.
49	Pearsall, 1 mile north of railroad station.	Mason Maney	L. Upton	1918	637.41	100	8	80–100	do	–62	120	C, G	I	Do.
50	do	J. S. Wickware	D. Upton			125	8	92–124	do	–70			I	Do.
51	do	C. C. Vaughan	do			115			do			C, E		Do.
52	Pearsall, 1 mile north of.	T. Cage	L. Upton	1918		135	8	115–130	do	–45	100	C, E		2 wells 20 feet apart; water also at 80–90 feet.
53	Pearsall, ¾ mile north of.	H. J. Bilhartz				90	8		do	–45	60	C, E	I	Temperature 90° F.
54	do	E. M. Howard	L. Upton	1917		100	8	80–100	do	–40	120	C, G	I	2 wells 20 feet apart.
55	do	E. Mattews	W. M. Higdon	1927		135	8	115–130	do			C, E	I	2 wells 20 feet apart; water also at 80–90 feet.
56	do	C. Rylander		1920		110	8	80–110	do	–45	120	C	I	2 wells 20 feet apart.
57	Pearsall, 1½ miles northwest of.	F. W. Reichert	J. D. Owings	1928		176	8	130–176	do	–45	140	C, G	I	
58	Pearsall, 1¼ miles northwest of.	L. C. Dennis	do	1927		205	8	165–205	do	–45	50	C, G	I	
59	Pearsall, 1¼ miles northwest of railroad station.	F. A. Hall	do	1927		205	8	165–205	do	–45	120	C, G	I	
60	Pearsall, 1¾ miles northwest of.	D. Landis		1926		140	8	110–140	do	–45	50	C, G	I	
61	Pearsall, 1¼ miles northwest of.	Thurman Barrett	J. D. Owings	1928		171	8	140–171	do	–45	50	C, G	I	
62	Pearsall, ½ mile north of.	J. E. Beall	J. Gray	1920		160	8	80–110	do	–40	100	C, G	I	Do.
63	do	G. Arnold				160	8	80–100	do	–40	100	C, G	I	Do.
64	Pearsall, ½ mile northeast of.	Pearsall High School	W. M. Higdon			237	8	210–214	do		60			
65	Pearsall, ½ mile south of.	D. S. Beck		1928		116	8	90–116	do	–45	50	C, G	I	
66	Pearsall, ¾ mile south of.	Roy Woodward	W. M. Higdon	1928		175	6	140–175	do		12	C, G	I	
67	Pearsall, 1 mile southwest of.	H. G. Wright	J. D. Owings			160		90–130	do		120	C, G		Water also at 65–80 feet.
68	Pearsall, 2 miles southwest of.	E. M. Hodge	T. P. Nixon	1930		128	8	112–125	do	–50		C, E	I	
69	do	A. Dearberg	do	1930		146	8	120–125	do	–50				

70	Pearsall, 1¾ miles southwest of.	L. Hornsby	J. D. Owings	1930		135	8	130-135	do			C, E	I	Bitter taste; two wells 20 feet apart.
71	Pearsall, 2 miles southwest of.	F. C. Mangold	T. P. Nixon	1930		200	8	180-183	do	−48		C, E	I	Three wells equipped; water also at 120-123 and 160-163 feet.
72	Pearsall, 1¼ miles southwest of.	F. A. Bredthauer	D. Upton		601.93		8		do	−48		C, E	I	Two wells 20 feet apart.
73	Pearsall, 1½ miles east of.	F. T. Malone		1900		50			do	−40		C, W	D	Dug.
74	Pearsall, 5½ miles east of.	W. M. Fain			569.50	1,265	8		do	−61				Abandoned oil test.
[a]75	Pearsall, 6 miles east of.	Mrs. H. C. Parramore.				46				−41		C, W	D	Dug.
76	Pearsall, 6½ miles east of.	do			584.57	237			Mount Selman formation.	−100		C, W	S	
77	Pearsall, 7 miles east of.	A. M. Woolsey	E. Doodlestadt	1905		160	6		do	−70		C, W	D, S	
78	Schattel, gin yard	Weiser & Raschke	S. Stussey	1929		145	5	143-145		−135		C, W	B	
79	Miguel, 1½ miles southwest of.	R. B. Kelly	A. Mann	1926	581.53	150	4			−116		C, W	S	Salty, bitter.
80	Miguel, 4 miles south of.	J. C. Nation	O. Z. Boone	1929		751	4½	460-480	Mount Selman formation.	−165		C, W	S	Water also at 70, 105, and 245-265 feet.
81	Pearsall, 9 miles east of, Simms Lake.	Oppenheimer & Lang.		1928			4½		do	+10	15		S	Flows.
82	Pearsall, 11 miles east of.	Oppenheimer & Lang, no. 1.	O. Z. Boone	1928		650	4½	600-650	do	+10	15		S	Flows; water also at 50 feet.
83	Goldfinch, 2½ miles west of.	Oppenheimer & Lang, no. 3.	do	1929		600	4½	510-600	do	+15	15		S	Flows; water also at 60-65 feet.
[a]84	Goldfinch, 1½ miles west of.	Oppenheimer & Lang, no. 2.	do	1929		860	4½	790-860	do	+32	22		S	Flows; water also at 30-32, 50-55, 71-80, 85-100, 310-330, and 500-600 feet.
85	Goldfinch, 1¼ miles west of.	O. Cox	do	1929		650	4½	590-650	do	−2			S	
86	Pearsall, 20 miles southwest of, near Zavala County line.	M. Taylor estate		1913		114	6		do			C, W	D	
87	Pearsall, 19 miles southwest of, ranch headquarters.	J. Loxton				250	6		do	−150		C, W	S	
88	Dilley, 13½ miles northwest of.	F. Doering				250	6		do	−50		C, W	D, S	
89	do	do				146	4½		do	−77		C, W	S	Pumped dry by windmill; bitter taste.
90	Dilley, 12 miles northwest of.	F. Kolos	W. Whitley	1922		175	6		do	−155		C, W	D, S	
91	Dilley, 11½ miles northwest of.	D. D. Harrigan				6	6		do	−57		C, W	S	Bitter, milky.
92	Divot, 2 miles west of.	L. Burnett	W. P. Alley			250	6		do	−44		C, W	S	

[a] For analysis see table on p. 60.

Records of wells in Frio County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power [a]	Use [b]	Remarks
[c]93	Divot, ¼ mile west of	J. F. Burdwell	W. P. Alley	1928		173	6		Mount Selman formation.	−71		C, W	S, D	
94	Pearsall, ice plant	Central Power & Light Co.	Layne Texas Co.	1926	622	1,303	16–6		Carrizo sand	−60	125		City supply.	Temperature 92° F.
95	Pearsall, 0.1 mile southwest of ice plant.	do		1908		2,300	8–6	1,150–1,500	do	−60			N	"Old city well."
96	Pearsall, 1 mile southwest of.	W E. Weissinger	J M. Sorrel	1928	601.93	1,337	8	1,070–1,330	do	−96	672	T, E	I	
[c]97	Pearsall, 3½ miles southwest of.	P. S. Tschirhard			553.21	1,350	8		do	−17	1,000	R, E	I	Flowed 100 gallons a minute when drilled.
98	Pearsall, 4½ miles southwest of.	Halff & Oppenheimer.		1905		1,473	8–4	1,200–1,473	do	−14	350	R, E	I	Flowed for 10 years temperature 96° F.
99	Pearsall, 5 miles southwest of.	J. N. Long	J. N. Long	1909	537.63	1,324	8	1,214–1,324	do	−9	860	R, G	I	Originally flowed.
100	Pearsall, 6 miles southwest of.	C. A. Davies	Gulf Coast Drilling Co.	1912	526	1,419	6		do	+1	25		I	Flows; temperature 98° F.
101	Pearsall, 5½ miles south of.	J. H. Evans		1911	526.41	1,540	8¼	1,200–1,540	do	−10	700	T, E	I	Flowed until 1928; temperature 98° F.
102	Pearsall, 11½ miles southwest of.	E. N. Corey		1910	540	1,408	10–8	1,204–1,408	do				N	Originally flowed 450 gallons a minute.
103	Dilley, 8½ miles northwest of.	C. W. Witherspoon		1927	505	1,514	8	1,324–1,502	do		750		I	Flows.
104	do	do		1917	515	1,515	8		do		600		I	Flows; temperature 96° F.
[c]105	Derby, 2¾ miles northwest of.	S. S. Searcy	J. W. Ward	1912	493.22	1,672	6	1,375–1,672	do	+25	400		I	Flows.
106	Derby, 2¼ miles west of.	A. L. Mills		1918	492.94	1,750	8–6		do	+28	800		I	Flows; temperature 98° F.
107	Derby, 1¼ miles southwest of, known as Lilley No. 2.	E. Hohenberg		1914		1,761	8–6	1,485–1,699	do	+16	250	R, E	I	Flows; yields 450 gallons a minute when pumped.
108	Derby, 1½ miles southwest of, known as Lilley No. 1.	do		1913	484.71	1,760	8–6		do	+12	450	R, E	I	Flows; yields 750 gallons a minute when pumped.

[a]109	Derby, 1¼ miles south of.	John Bennett	Dodd	1915	484.66	1,700	10–8	1,440–1,700	do	+10	890	Cent., E	I	Flows; yields 2,000 gallons a minute when pumped.
110	Pearsall, 12 miles southeast of, Keystone ranch headquarters.	Oppenheimer & Lang.	I. U. Bettison	1912		1,757	12–6	1,485–1,757	do	+58	300		S	Flows; temperature 96° F.; water also at 100, 150, 580, 720, and 880 feet.
[a]111	Pearsall, 12½ miles southeast of, ranch headquarters.	F. McGowen				1,700	10		do		500		D, S	Flows; temperature 98½° F.
112	Dilley, ½ mile southwest of.	F. Blesse	G. Karsch	1913	564	2,410	6–4¾	1,836–2,180	do	−54	325	T, E	I	
[a]113	Dilley	International-Great Northern R. R.	McMaster & Pomeroy.	1924		2,010	8–6	1,923–1,990	do	−45	450	A, S	M	
114	Hindes, ¾ mile southwest of.	C. M. Kelly			396	2,114	10		do	+80	600		I	Flows.
115	Dilley, 12 miles west of	Mrs. C. T. Hardy	H. Rummel	1913		125	6		Cook Mountain formation.	−52		C, W	I, D	Brackish taste.
116	Dilley, 10½ miles west of.	Mrs. M. Melms	W. D. Morrison	1927		199	10		do	−97		C, W	C, S	Bitter taste.
117	Covey Chapel, store	J. P. Weatherford	H. Rummel	1924		165	4½		do	−99		C, W	D	Flat taste.
118	Covey Chapel	G. Mudd				22			do	−20		None	D	Dug.
119	Dilley, 2½ miles west of	H. N. Beekley		1927		343	8	240–340	do	−130	350	T, E	I	Water also at 145–225 feet; 2 wells.
120	Dilley, 3¼ miles northwest of.	Hauser Bros	W. D. Morrison	1927	564.33	303	10		do	−117	150	C, G	I	
[a]121	Dilley, 2½ miles northwest of.	do	do	1927		305	10		do	−95	175	T, G	I	
122	Dilley, 1 mile northwest of.	R. C. Jacobs	do	1928		336	10	268–336	do	−120		T, G	I	
123	Dilley	T. A. Raiford	do	1929		330	10	130–325	do	−120	180	T, E	I	
124	Dilley, 2½ miles north of.	D. D. Harrigan	do	1928	503.39	204	10	120–185	Mount Selman formation.	−60		None		
125	Dilley, 3 miles northwest of.	do	do	1928		200	10	185–200	do	−88	90	D, G		
126	Dilley, 2½ miles northwest of.	do	do	1928		358	10	135–195	do	−78		None		
127	Dilley, 3½ miles northwest of.	do	do		550.94	259	10	125–202	do	−105				
128	Dilley	C. D. Parker				200			Cook Mountain formation.	−120	180	C, E	I	
129	Dilley, 1 mile southwest of.	Ross & Avant			564.67	375	10	360–375	do	−133	200	T, E	I	
[a]130	Dilley, ¾ mile south of	do				200			do			C, E	D	
131	Dilley	R. A. White	W. D. Morrison			300	10		do			C, E	I	
[a]132	do	G. B. Nauermann	do	1927	540.62	307	10	120–302	do	−110		D, E	I	
[a]133	do	W. D. Morrison	do	1929		370	12½	122–365	do	−110		T, E	I	
134	Dilley, 1½ miles southeast of.	C. W. Rogers	do			358	10		do	−80?		T, G	I	

[a] For analysis see table on pp. 60–61.

Records of wells in Frio County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed		Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power [a]	Use [b]	Remarks
								Depth (feet)	Geologic horizon					
135	Dilley, 2 miles southeast of.	T. D. Fulmer	Hamilton	1929		200	8		Cook Mountain formation.	−60		C, G	I, D, S	
136	Dilley, ½ mile north of	W. C. Haynes	W. D. Morrison	1927	531.93	280	10	95–272	do	−97		None		
137	Dilley, 2 miles east of	G. V. Sellers	W. Alley	1926		119	6		do	−63		C, W	S only	
138	Goldfinch, gin	J. Cox	O. Z. Boone	1925		1,232	6	860–900	Mount Selman formation.	−24		C, W, S	B, D	
139	Goldfinch	J. C. Nation	do	1926	513	424	6	370–424	do			C, W	D	Water also at 50, 100–125, and 285–300 feet.
140	1.1 miles northeast of headquarters of Keystone ranch on west bank of San Miguel Creek.	Oppenheimer & Lang.		1894	455	390		375–390	do		10		S	Flows.
141	Dilley, 5 miles west of	E. W. Sanford	W. D. Morrison	1928		357	10		Cook Mountain formation.	−120	125	T, E		Water also at 203–354 feet.
142	Pearsall, 6 miles southeast of.	T. W. Foster	D. Upton	1915		175	4½		Mount Selman formation.	−160		C, W	S only	
143	Pearsall, 8 miles southeast of.	G. H. Nitschmann	G. Dietzman	1930		66		64–66	do	−53			D	Water also at 52 feet.
144	Pearsall, 11 miles southeast of.	D. A. Oppenheimer				75			do	−52		C, W		Dug.
145	Pearsall, 10 miles southeast of, ¾ mile west of Shallow Wells School.	W. Trickey					6		do	−115		C, W	S only	Bitter taste.
[c]146	Melon, 1½ miles southeast of.	W. J. Watkins		1912		228	6		do	−58		C, W	D, S	
147	Melon, 8 miles southeast of, ranch headquarters.	Mrs. M. Shiner				165	4		do.(?)	−58		C, W	D, S	
[c]148	Melon	C. McKinley	D. Upton	1926		242	6		do	−99		C, W	D	
149	do	Burden estate	J. Gray	1902		196	4½	150–196	do	−80		C, W	D	Pumps down in 45 minutes; water also at 80 feet.
150	Melon, gin	Frio Cotton Oil Co.	F. Wadzick	1906		350	5		do			C, S	B	
151	Melon	Melon Well Co.	D. Upton	1915		420	6	320?	do	−103		C, W	D	
152	Derby, ¼ mile northwest of.	F. Whitman	W. D. Morrison	1927			10		do	−72	45	C, E	I	

[c]152a	Derby, ½ mile southwest of.	H. Bennett				285	7		do	−45.8		C, W	D	
152b	do	do				455	5		do	−34		C, W	D	
[c]152c	Divot, 2½ miles southwest of.	R. S. Parks		1910		210	5	185–210	do	−65		C, W	D	
153	Derby	John Bennett	W. E. Smith	1910		306	6¼	280–306	do	−71		C, E	D	
154	Pearsall, 2½ miles southeast of.	R. E. Malone				80	4½		do	−72		C, W	D	
[c]154a	Pearsall, ½ mile west of.	J. L. Hammett				40			do	−12		C, W	D	
154b	Pearsall, 1 mile north of.	E. H. Shaw					4½		do	62.5		C, W	D	
[c]154c	Pearsall, 2 miles east of.	R. T. Barnhart				200	5⁷⁄₁₆		do	−50		C, W	D	
155	Moore, 4 miles southeast of.	W. D. Syers	I. U. Bettison		566	1,978								
156	Moore, 3¾ miles southeast of.	do				100		42–100	Mount Selman formation.	−35	60			
157	Dilley, 1¾ miles west of.	Mrs. O. E. Flato	W. D. Morrison	1927		365	8	325–360	Cook Mountain formation.	−143		D, E		
158	Dilley, 2 miles north of.	J. L. Hill	do			235	10	100–235	do	−65		D, G		
[c]158a	Dilley, 4 miles northwest of.	M. C. Powers		1926		250	4½	210–250	Mount Selman formation.	−130		C, W	S	Salty.
159	Dilley	H. W. Fay	W. D. Morrison			395	12		Cook Mountain formation.	−73				

[c] For analysis see table on pp. 60-61.

Records of wells in Atascosa County, Tex.

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power [a]	Use [b]	Remarks
160	Rossville, 3¼ miles north of.	C. E. Dillon			637	136	4		Carrizo sand	−108		C, W	D, S	
161	Rossville, 2½ miles north of.	G. W. Beachman			636	125	2½		do	−105		C, W	D, S	
162	Rossville, 4 miles west of	A. Cortinas	Rio Bravo Oil Co.		543	4,080	8-6-4							Abandoned oil test.
[c]163	Rossville, 5½ miles southwest of.	R. Ross	T. Byram	1927	517	380	6	280-380	Carrizo sand	+12	80	Cent., K.		Water also at 180 feet. Flows; yields 250 gallons a minute when pumped.
164	Rossville, 6 miles southwest of.	do	do	1926		420	6	400-420	do	+17				
165	Anchorage	H. E. Whittet	H. E. Whittet	1910	547.9	250	4		do	−34.5		C, W	D, S	
[c]166	Poteet, 8½ miles north of	W. K. Hamilton			676	175	4		do	−140		C, G	D, S	
167	Poteet, 7½ miles north of	Osborne Gravel Co.	Osborne Gravel Co.	1928		187	4		do	−142		C, G	D,	2 wells 15 feet apart. Used also to wash gravel.
168	Poteet, 5½ miles north of	Mrs. L. Brockley			558	120	4		do	−90		C, G	D, S	
169	Leming, 4 miles north of	R. L. Bruce		1925		104	4	100-104	do	−69		C, W	D, S	Lignite at 60 feet.
170	do	Schultze Bros		1922		76	5	50-76	do	−28		C, W	D, S	Lignite at 38 feet.
171	Leming, ¾ mile south of	W. McKenzie				70	4		Mount Selman formation.	−40		C, G	D	
[c]172	do	D. McKenzie				120	3		do	−90		C, G	D	
173	Leming, 3¾ miles northeast of.	F. Jaksik	W. G. French	1916		4,004								Abandoned oil test.
174	Pleasanton, 10 miles northeast of, Black Hill store.	C. A. Moehrig				455	4½		Mount Selman formation.	−82		C, W	D, S	
175	Rossville, 5 miles south of.	Escalara	T. Byram			531	6-5		Carrizo sand					Flows; drilling in 1930.
176	Rossville, 4½ miles south, slightly west of.	J. D. Eldridge	do	1926		620	5¾	535-620	do	+12	150		I	Flows; water also at 390 feet.
[c]177	Rossville, 4½ miles south of.	do	do	1928		640	6	550-640	do	+5	25		I	Flows; water also at 400 feet.
178	Rossville, 5½ miles south of.	J. McDonald	do	1928		707	6	680-707	do	+11	50		I	Flows.
179	Rossville, 6 miles south of.	J. Campain	do	1927		578	6-4	558-578	do	+18	100	Cent., G.	I	Do.
180	Rossville, 5½ miles south of.	T. Byram	do	1926	475	558	5	550-558	do	+37	350		I	Do.

181	Rossville, 4½ miles south of.	do	do	1927	512	620	6	600–620	do	+9	120	I	Do
182	Rossville, 3½ miles south of.	J. McDonald	do	1927		680	6–4½		do	+10		I	Do.
183	Rossville, 3 miles south of.	A. N. Simmons	do	1926		468	6		(?)	−18	750 T	I	
184	Rossville, 3 miles southeast of.	E. Layer		1924		535	10	500–535	Carrizo sand	−12	450 Cent., G	I	
185	Rossville, 2½ miles southeast of.	L. S. Martinez	T. Byram	1927	535	560	6		do	−57		D, S	
186	Poteet, 3½ miles northwest of.	M. Rogers	do		513	422	8	210–250	do	−22	None		
187	Poteet, 3 miles northwest of.	A. Forge	J. Wolfe		515	666	8	490	do	−32	900 Cent.	I	
188	do	do	do		515	525	8	375	do	−12	200	I	
189	Poteet, 4½ miles west of.	C. Layer				380			do			I	
190	do	do				380			do			I	
191	do	H. E. McKinney									400 Cent.	I	
192	Poteet, 3½ miles west of.	S. Solomon		1915		714	6		Carrizo sand	−10	30 Cent., G	I	
193	Poteet, 4 miles west of	C. E. Simmons		1928		627		490–627	do	−13	600 T	I	
194	Poteet, 3¾ miles west of.	A. C. Zigmond		1914		707	6	600	do	−1?	A, G	I	
195	Poteet, 3½ miles west of.	do				715	3–6	610–715	do	−5	A, G	I	
196	Poteet, 3¾ miles west of.	F. Hohberg		1914		600	6		do	+3	Cent., G	I	Slight flow.
197[e]	Poteet, 3¾ miles west of, Locke Nursery.	Locke Bros		1914		600	6		do	+23	350	I	Flows.
198	Poteet, 2¼ miles west of.	G. Jambers	G. P. Rainery	1911		1,000	8		do		Cent., G	I	
199	Poteet, 2 miles west of	T. Lozana	Holder	1924			6		do		A, G	I	
200	Poteet, 2½ miles west of.	H. T. Mumme	H. T. Mumme	1909		600	6		do	+1	5	S	Flows; once flowed 250 gallons a minute.
201	Poteet, 2½ miles southwest of.	J. W. Wilburn	T. Byram	1929		642	6–4½		do	+15	250	I	Flows.
202	Poteet, 1½ miles northwest of.	W. B. Wofford	G. Gilland	1926	505.4	1,040	8–6	985–1,040	do	−27.75	350 T, G	D, S	Water also at 810–887 feet.
203	Poteet, 1½ miles north of	S. Wall	do	1926		600	6		do	+5	50 Cent., G	I	Flows.
204	Poteet, 1 mile north of	C. E. Hurley		1926		918	6	700–918	do	+1	10 Cent., G	I	Do.
205	do	L. Scoggin	G. Gilland	1926		881	6	600–281	do	+28	250	I	Do.
206	Poteet	H. T. Mumme		1904		850	8	700–850	do	−5	500 Cent., E	I	Water also at 430 feet; originally flowed 216 gallons a minute.

[a] Pumps: C, Cylinder pump; D, duplex cylinder pump; A, air lift; T, turbin centrifugal pump; E, rotary pump; Cent., ordinary centrifugal pump. Power: W, Windmill; H, hand; G, gasoline or oil engine; E, electric motor; Kerosene engine.

[b] C, Cooking; D, domestic; S, stock; I, irrigation; B, boiler; N, not used; Kerosene engine.

[e] For analysis see table on pp. 60–61.

Records of wells in Atascosa County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power	Use	Remarks
207	Poteet, ¾ mile northwest of.	W. M. Slimm					6		Carrizo sand			A, E	I	Formerly flowed.
208	Poteet, ½ mile west of	J. L. Burd		1910		840	6		do		400	Cent., G	I	
209	Poteet, ½ mile northwest of.	J. Ward					4-6		do	−28		A, E	I	
210	Poteet, ½ mile north of	C. A. Reed		1911			4-8		do	+5	50	Cent., E	R. R., I	Flows; original head +30 feet.
211	Poteet, ¾ mile north of	S. Hughes	T. Byram	1928		720	6	670-720	do	+1	600	Cent., E	I	Flows.
212	do	H. L. Ulbrich	Brown	1926		800	4		do	+5		E	I	Small flow.
213	Poteet, 2½ miles northeast of.	L. F. Brown				850			do	−5			I	
214	Poteet, 1 mile northeast of.	J. Howard					8		do	−25				
215	Poteet	W. J. Hallmark et al.					8		do	+6	100	Cent., E	I	Flows.
[c]216	do	H. T. Mumme	H. T. Mumme	1910		840	6		do	+20	250		D	Do.
217	do	do	do	1912		840	6		do	+28	400	Cent., E	D	150 houses; flows.
[c]218	do	City of Poteet	J. Wolfe	1928		835	6		do	+30	50	Cent., E	M	Flows.
219	do	H. T. Mumme	H. T. Mumme	1917		840	6		do	+20	500		I	Do.
[c]220	Poteet, ¼ mile south of	do	do	1909		840	4½		do	+10	50		I	Do.
221	Poteet, ¾ mile southwest of.	P. Redish		1926			6		do	+42	350		I	Flows; originally flowed 250 gallons a minute.
222	Poteet, hotel	Mrs. E. Ernst		1910		840	6	750-840	do		50	A	I	Flows.
223	Poteet	W. M. Smelley		1927		927	4		do	+7	100	Cent., E	I	Do.
224	do	H. T. Mumme	H. T. Mumme	1914		840	4		do	+9	45	Cent., G	I	Do.
225	Poteet, ½ mile east of, south side of Pleasanton Road.	M. Myers		1911			6-4			+10			I	Do.
226	Poteet, ½ mile southeast of.	J. H. Hildreth et al.		1911			6		do	+15	75		I	Do.
227	Poteet, 1 mile south of	C. M. Rice		1925			6		do	+7	100	Cent., E	I	Do.

•228	Poteet, 1½ miles south of.	F. Hicks	G. Gilland	1926			6		do		350		I	Do.
229	Poteet, ¾ mile east of	C. L. Spence			460	840			do	−5		A	I	
230	do	E. A. Gomez				1,000	6–4		do	+6	60	T, G	I	Do.
231	do	A. R. Bailey				934	8–6	710–934	do	+15	250		I	Do.
232	Poteet, 2½ miles southeast of.	J. A. Burger	I. U. Bettison	1912	445	1,245	8–6		do	+5	25		I	Do.
233	Poteet, 2 miles southeast of.				409				do	+35	400		I	Do.
234	Poteet, 1¾ miles southeast of.	E. H. Shearer			426	1,001			do	+50	250		I	Do.
235	Poteet, 2 miles southeast of.	F. Cook				990			do	+35	300		I	Do.
236	Poteet, 3 miles southeast of.	I. R. Adams			425	1,000			do	+5	35			Do.
237	Poteet, 1 mile north of	Grayson & Manry		1926					do				I	
238	Poteet, ½ mile southeast of.	M. Myers				1,080	8		do		100		I	Do.
239	Leming, 1¾ miles southeast of.	M. F. Childress	Leming Oil & Refining Co.		454	2,600	8	850–1,150	Indio formation.	+5	15			Flows; abandoned oil test.
240	do	do				300	5		Carrizo sand (?)	−20				
ᶜ241	Pleasanton, 1½ miles north of.	E. R. Breaker	Evans et al	1911	412	1,925	8–4	927–1,200	Carrizo sand	+80	250?		I	Flows; water also at 1,206–1,515 feet.
242	Pleasanton, 1½ miles northeast of.	Richter et al	Gulf Production Co.		425				do					Abandoned oil test.
243	Pleasanton, 1 mile north of.	I. A. Eakins		1906		208	4		Mount Selman formation.	+10	40		D	Flows.
244	North Pleasanton, railroad shop.	San Antonio, Uvalde & Gulf R. R.			390	1,552		1,464–1,552	Carrizo sand	+96	500		R.R., D	Do.
245	Crown, 1½ miles southeast of.			1927		160	4		Mount Selman formation.	−130		C, W	S	Sulphur.
246	Charlotte, 1½ miles east of.	A. E. Beckman		1928	512	1,692	7–4	1,632–1,692	Carrizo sand	−12			D, S	
247	Jourdanton, 7 miles southwest of.	J. W. Madden				1,465	6		Mount Selman formation (?).	−34.5		C, H	D, S	
ᶜ248	Jourdanton, 1½ miles west of.	C. A. Robertson	I. U. Bettison			1,040	8–6	940–1,040	Mount Selman formation.	−80		C, W	D, S	
ᶜ249	Jourdanton, 1 mile northeast of.	Anderson & Arneson.		1925	403	1,505	6–6	1,412–1,505	Carrizo sand	−55	450		I	Flows.
ᶜ250	Jourdanton, ice plant	Central Power & Light Co.	Layne Texas Co.	1930		1,635	10–6	1,604–1,635	do	−6.5	270	T, E	M	Water also at 1,192–1,243 feet.
251	Jourdanton, 1½ miles northeast of.	C. S. Young	C. S. Young	1919	403	1,428		1,113–1,155	Mount Selman formation.	−10		C, G	D	Water also at 931–950, 810–820, 745–760, and 300–303 feet.
252	North Pleasanton, ¾ mile east of.	J. W. Siefried	W. Brown	1924		499	5–6		do	+4	25		I, D	Flows.
253	North Pleasanton, 3½ miles northeast of.	P. Wiseman			407	1,429		1,411	Carrizo sand	+2	10		D	Do.

ᶜ For analysis see table on pp. 60-61.

Records of wells in Atascosa County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power	Use	Remarks
254	North Pleasanton, 3 miles east of.	Hunter & Barber	B. T. Spradley	1909		482	5–4	400–482	Mount Selman formation.	+8	35		D	Flows; water also at 213 feet; originally flowed 125 gallons a minute.
[c]255	Coughran, 1½ miles north of.	W. J. Allerkamp	W. Brown		382	1,050	6–4	950–1,050	do	+12	100		D, S, I	Flows.
256	Coughran, 1 mile north east of.	J. A. Clopton	do			927	6		do	+35	350		I	Do.
257	Coughran, ½ mile north of.	do	do			903	6		do	+53	350		I	Do.
258	Coughran, east of gin	Coughran town site			344	800	6	700–800	do	+75	200		Town supply	Flows; water also at 500–506 feet.
259	Coughran, 5 miles north east of.	J. A. Brown	W. Brown			1,157	6		do	+40	200		I	Flows.
260	Pleasanton, courthouse yard.	Atascosa County	A. J. Parchman	1900		666	3	600–666	do	+25	65		D	Flows; gas; temperature 78° F.; water also at 150–165 feet.
261	Pleasanton	Mrs. J. F. Spence	A. Fuente	1909		470	3–2	430–470	do	+23	18		D	Temperature 77° F.; flows.
[c]262	do	J. R. Daughtry	W. Cook	1913		505	4–3	480–500	do	+9	20		D	Flows; coal at bottom; water also at 340 feet.
[c]262a	do	City of Pleasanton				815	8–4	640–800	do	−20				
[c]263	Pleasanton, hotel	T. Bright	W. Cook	1904		380	4–3	250	do	+16	4		D	Flows; water also at 200 feet; temperature 72° F.
264	Pleasanton	E. S. Ferris	B. T. Spradley	1910		563	3	500–513	do	+25	25		D	Flows; water also at 400–412 feet.
265	do	E. H. Burmeister, Sr.	A. Fuente	1909		676	3	600–676	do	+25	118		D	Flows; water also at 350 feet; temperature 80° F.; gas for lights, engine, and gas plant.

266	do	M. M. Mansfield	B. T. Spradley	1910		639	3	500–550	do	+22	150		D	Flows; water also at 400–412 feet; temperature 80° F.; gas for lighting and cooking in 2 houses and lighting additional house.
267	do	P. A. Vance	do	1912		686	5⅜ 3	628–686	do	+18	300		D	Flows; water also at 550–570 and 610–618 feet; temperature 81° F.
268	do	R. L. Gross estate	J. Mills	1912		708	3¾ 2	579–708	do	+30	70		D, I	Flows; water also at 220–250, 330–360, and 540–564 feet; temperature 80° F.
269	do	W. A. McCoy estate		1913		280	5–2		do	+20	5		D	Flows; temperature 70° F.; sulphur.
270	do	M. Royal	Allen & Wilson	1908		406	2–1¼		do	+5	15		D	Flows; temperature 77° F.
271	do	G. Long	A. Fuente	1909		720	4–3–2	670–720	do	+10	3		D	Flows; temperature 77½° F.
272	do	J. L. Akeridge and W. N. Meeks.	W. Cook	1902		610	3–2	510–530	do	+30	75		D	Flows; water also at 340 feet; 3 feet of coal at 500 feet.
273	do	C. W. Herzel	B. T. Spradley	1910		560	5	500–560	do	+11	70		D	Flows.
[c]274	do	A. B. Gillete	J. T. Mills	1897		340	4	334–340	do	+5	12		D	Flows; water also at 240–244 feet.
275	do	L. Thomason	W. Cook	1912		600	2		do	+18	50		D	Flows; water also at 400–570 feet; temperature 80½° F., gas sufficient for cooking, lighting, and heating.
276	do	Mrs. K. C. Ormand	do	1902		640	2	600–640	do	+12	30		D	Flows; temperature 74° F.; water also at 340 and 500–550 feet.
277	do	J. R. Cook		1902		640	2	600–640	do	+20	30		D	Flows.
278	Pleasanton, north edge of	R. H. Blanch		1920		372	3		do	+13	60		D, I	Do.
[c]279	Pleasanton	C. W. Kenley				630	3		do	+23	200		D	Do.
280	Pleasanton, south edge of	N. A. McCoy	L. Devilbiss	1912		708	3¾	580–780	do	+5	5		D	Do.
281	Jourdanton, 5¼ miles southwest of, at La Parita store.	R. C. Thurmand		1909		707	5³⁄₁₆	677–707	Cook Mountain formation (?).	+2	3		D, S	Flows; sulphur.
282	do	J. Matocha				1,504	6	1,504	Mount Selman formation.		175		D	Flows; sulphur; salt water at 300 and 700 feet; good water at 1,050 feet.
283	Jourdanton, 5 miles southwest of.	H. McCollum	W. Cook	1929		1,100	6		do	−10			D	

[c] For analysis see table on pp. 60–61.

Records of wells in Atascosa County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons per minute)	Pump and power	Use o	Remarks
284	Charlotte, 5½ miles southwest of, Davis-town gin.	M. M. Davis				132	4		Cook Mountain formation.	−30		C, G	B, D	
285	Hindes, 2½ miles north of.	W. M. Hindes		1909		440	4		do.(?)	−5		C, W	S	
286	Hindes, ¼ mile north of	Atascosa State Bank		1915		350	4¼		do	+20	10			Flows.
•287	Hindes, opposite railroad station.	Hindes, Inc	W. Cook			450	4¼		do	+35	42		D, R. R.	Do.
288	Hindes, ½ mile east of	J. D. Romberg	C. Edwards			400	4¼		do	+20	35		D	Do.
289	Hindes, ¼ mile southeast of.	S. Williams	do	1895		445	4¼		do	+15	10			Do.
290	Hindes, ½ mile southeast of.	do	do	1918		450	4¼		do	+20	80		D	Do.
291	Charlotte, 6 miles southeast of.	M. N. Davis		1900		304	5⅝		do.(?)	+15	25		D, S, I	Do.
292	Charlotte 7 miles south of.	Y. D. Coleman				180			do	−30				Bitter taste.
293	Charlotte, 2½ miles southwest of.	J. W. Chamberlain		1929		105	4		do.(?)	−70		C, W	D	
294	Charlotte, ½ mile southeast of.	J. M. Couser	W. Favor	1912		200	4		do.(?)	−15		C, W	D	
295	Christine, north edge of	Town of Christine		1917	342	1,314	6–4	1,280–1,314	Mount Selman formation.	+25	300		Town supply.	Flows.
•296	Christine	do		1911	342	956	8	951–956	do		250			Flows; salty.
297	Christine, 4½ miles east of.	J. Campbell		1906		2,000	8	1,422–1,563	do		75			Flows.
298	Campbellton, 4½ miles northwest of.	J. Dupuy			357	2,938	10	1,640–1,698	do.(?)		300		I	Do.
299	Poteet, 1¾ miles northwest of.	E. J. Fasler		1911		1,000	6		Carrizo sand	−27.5		C, W	D, S	
•300	Pleasanton, 2 miles southeast of.	Cunningham & Taliferro.		1927	365	1,722	6–5$\frac{7}{16}$	1,435–1,722	do	+98	650		I	Flows; water also at 70–80, 170–178, 305–335, 625–715, and 910–961 feet.
301	Christine, 5½ miles west of.	R. Lauderdale				1,500	4	900–1,200	Mount Selman formation.	+60 originally.	60		D	Flows.

302	Pleasanton, 11 miles southeast of.	J. Dupuy			307	1,200			do				I	Do.
[a]303	McCoy	McCoy store			344	900			do		50		D	Do.
304	McCoy, 5 miles east of, King's School.	E. Albert	W. Stempel	1927		100	4		Yegua formation (?).	−55		C, W	D	Slightly salty
305	McCoy, 5½ miles east of	W. Taush	do	1927		109	4		do. (?)	−45		C, W	S	Salty.
306	McCoy, 5 miles east of	R. Smith	do	1929		148	4		do	−65		C, W	S	Do.
307	McCoy, 4½ miles east of	do	do	1929		138	4		do	−60		C, W	S	Do.
308	McCoy, 3 miles east of	Parkhill	do	1929		99	4		do	−50		C, W	S	Do.
309	McCoy, 3 miles southeast of.	T. Smith	do	1929		147	4		do	−55		C, W	S	Do.
310	McCoy, 5 miles east of	W. Taush	do			57	4		do	−50		C, W	D	
311	Campbellton, 8 miles northeast of.	J. W. Smith	do	1927		187	4		do	−70		C, W	S	Sulphur.
312	Campbellton, 7½ miles northeast of.	L. Mayer	do	1926		187	4		do	−98		C, W	S	Salty.
313	Campbellton, 8 miles northeast of.	L. Brister	do	1928		323	4		Yegua formation.	−80		C, W	D	Slightly salty.
314	Fashing, 4 miles northwest of.	F. Ruckman	do	1929		383	4		do. (?)	−85		C, W	S	Do.
315	Fashing, 3½ miles northwest of.	B. Hearhausler	do	1928		168	4		Jackson. (?)	−68		C, W	S	Salty.
316	Fashing, 2½ miles northwest of.	W. Hearhausler	do	1928		268	4		Jackson	−68		C. W	S	Do.
317	Fashing, 1¼ miles north of.	H. Kilner	D. P. Paschal	1923		110	4¼		do	−70		C, W	D	
318	Fashing, ½ mile north of.	F. Frenzil	do	1923		110	4¼		do	−40		C, W	S	Bitter taste.
319	Fashing, 1 mile northeast of.	J. Seiler	do	1923		91½	4¼		do	−30		C, W	S	
320	Fashing	J. Weigang	Schaffer	1929		198	4¼		do	−60		C, W	S	Salty.
321	Fashing, 1 mile southwest of.	H. Kelner	D. P. Paschal	1924		160	4¼		do			C, W	S	Sulphur.
322	Fashing	Fashing Mercantile Co.		1927		150	4		do	−50		C, W	S	Do.
323	Fashing, 2½ miles south of.	Essy Bros	D. P. Paschal	1923		160	4¼		do	−48		C, W	D	
324	Fashing, 4 miles southwest of.	do	do	1923		155	4¼		do	−50		C, W	S	
325	Campbellton, 3 miles northwest of.	A. N. Peller		1925		300	4		Yegua formation (?).	−100		C, W	S	Salty.
326	Campbellton, 2¾ miles northwest of.	do		1928		1,600	4		Mount Selman formation (?).		50		S	Flows; salty.
327	Campbellton	C. A. Struve		1928		2,000	8		do	+40	200			Do.
328	Campbellton, 4¼ miles southeast of.	Douglas	W. Stempel	1927		249	4		Jackson	−135		C, W	S	Salty.
329	Campbellton, 5½ miles southeast of.	Oldenoff	do	1927		247	4		do	−140		C, W	S	Do.

[a] For analysis see table on pp. 60-61.

Records of wells in Atascosa County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons per minute)	Pump and power	Use	Remarks
330	Campbellton, 4 miles northeast of.	R. T. Eshenberg	W. Stemple	1930		387	4		Yegua formation (?).	−80		C, W	D	Slightly salty.
331	McCoy, 5 miles west of	A. Smith	do	1930		138	4		Yegua or Cook Mountain formation.	−70		C, W	S	Salty.
332	McCoy, 4¼ miles west of.	do	do	1928		148	4		do	−70		C, W	S	Do.
333	McCoy, 5 miles west of	do	do	1929		144	4		do	−70		C, W	S	Do.
334	Campbellton, 1½ miles northeast of.	F. Allen	do	1926		248	4		Yegua formation.	−10		C, W	S	Do.
335	Fashing, 1¾ miles northwest of.	J. Weigang	Schaffer	1930		285	4		Jackson					Gas only.
336	Coughran, 8 miles northeast of.	S. Houston	W. Stempel	1928		247	4		Cook Mountain formation (?).	−60		C, W	S	Salty.
337	Charlotte, 5 miles north of.	W. K. Shipman		1908		1,207	5–3½	1,140–1,207	Carrizo sand	−60		C, W	D, S	Water also at 360–375 feet.
338	Charlotte, 4½ miles northwest of.	E. J. Pruitt				376	4	349–376	Mount Selman formation.	−8		C, W		Slight taste.
339	Campbellton, 4 miles southeast of.	Mrs. C. T. Tom	De Lange Eiser & Co.			4,644								Abandoned oil test.
340	do	do	Pantex Oil Co	1915	352	2,440		2,440	Cook Mountain formation (?).					Salty; abandoned oil test; water also at 1,200 feet.
341	Pleasanton, 2½ miles southeast of.	T. H. Harrison	Geo. Boone			244	4	234–244	do	−54		C, W	S	Salty.
342	Poteet, 4 miles east of	H. Shearer		1930		909	4½	735–909	Carrizo sand	+15	150			Flows.
343	Charlotte, west edge of	Chamberlain							Mount Selman formation.				D	

Partial log of well of L. E. Blackallar, Lefevre & Story no. 1, 3 miles north of Frio Town, Frio County (no. 3)

	Thickness (feet)	Depth (feet)
Mount Selman formation (Bigford member):		
Clay and sand	10	10
Sandrock and hard shale	55	65
Carrizo sand:		
Water sand	5	70
Hard sandrock	30	100
Clay and gravel	35	135
Sand and gravel; probably water	15	150
Sandrock	10	160
Sand and gravel	25	185
Hard sand and gravel	25	210
Sand; probably water	38	248
Indio formation:		
Hard blue rock	7	255
Hard sandy shale	15	248
Rock	4	274
Shale and sand	8	282
Hard blue rock	25	307
Sandy shale	13	320
Yellow clay	30	350
Rock	10	360
Clay and boulders	30	390
Yellow clay	10	400
Rock	2	402

Log of Donaldson Oil & Gas Co. well 1, W. O. Brown, 3 miles southwest of Moore, Frio County (no. 22)

	Thickness (feet)	Depth (feet)
Mount Selman formation:		
Surface soil	10	10
Gravel and sand	42	52
Hard rock with streaks of sand and boulders	48	100
Hard rock inlaid with sand	46	146
Rock	24	170
Shale	50	220
Hard sand	6	226
Sand and shale with gas	14	240
Sand with water	27	267
Packed sand and lime shells	184	451
Shale	47	498
Carrizo sand:		
Sand (cored; water)	160	658
Hard packed sand streaked with rock	122	880
Indio formation:		
Hard packed sand with layers of rock	380	1,260
Hard sandy shale	8	1,268
Gumbo and lignite	20	1,288
Hard sandy shale	26	1,314
Rock	2	1,316
Pack sand with layers of shale	434	1,750
Gumbo and boulders	16	1,766
Limerock	4	1,770
Sandy shale	23	1,793
Lime and shell	17	1,810
Blue sand core	5	1,815
Gumbo	44	1,859
Limerock	5	1,864
Sand core	4	1,868
Shale	29	1,897
Sandrock	3	1,900

Log of North & Walton well 1, C. C. Tribble, 6 miles northeast of Moore, Frio County (no. 26)

	Thickness (feet)	Depth (feet)
Mount Selman formation:		
Sand	14	14
Gray shaly clay	23	37
Carrizo sand:		
Hard sand	11	48
Sand and shale	16	64
Lignite	1	65
Sand	75	140
Lignite	1	141
Sand with streaks of lignite	71	212
Indio formation:		
Brown shale	8	220
Sand with shale breaks	50	270
Brown shale	20	290
Sandrock	2	292
Shale	5	297
Sand and lignite	27	324
Sandrock	5	329
Shale	56	385
Sand	53	458
Shale	43	501
Indio formation—Continued.		
Sandrock	3	504
Shale and sand	35	539
Sandrock	2	541
Shale	7	548
Shale and boulders	46	594
Hard sand and rock	14	608
Brown shale	72	680
Sand and shale	9	689
Brown shale and boulders	34	723
Sandrock	5	728
Shale and boulders	72	800
Sand and shale	28	828
Shale and boulders	22	850
Hard sand	4	854
Shale and boulders	42	896
Hard sand and shale	70	966
Hard sandrock	8	974
Shale	28	1,002
Hard sand	4	1,006
Shale	25	1,031

Log of North & Walton well 1, C. C. Tribble, 6 miles northeast of Moore, Frio County (no. 26)—Continued

	Thickness (feet)	Depth (feet)
Indio formation—Continued.		
Hard sand	6	1,037
Shale and boulders	38	1,075
Hard sand	15	1,090
Sandy shale	21	1,111
Sandrock	2	1,113
Midway formation:		
Shale and greensand	21	1,134
Greensand and sticky shale	6	1,140
Shale and sand	83	1,223
Shale	57	1,280
Hard limy sand (greensand and shell)	29	1,309
Shale	7	1,316
Hard sandy shale (greensand and fossil shell fragments)	42	1,358
Sandrock	2	1,360
Shale and sand	28	1,388
Hard and sticky shale	10	1,398
Hard sand	7	1,405
Shale	13	1,418
Sand	2	1,420
Shale	10	1,430
Greensand	8	1,438
Sandy shale	27	1,465
Hard sand	2	1,467
Navarro formation:		
Gray sticky shale	10	1,477
Hard shale and boulders	36	1,513
Sandrock	2	1,515
Sticky shale with hard sand breaks	35	1,550
Sticky shale and boulders	61	1,611
Sticky shale with sand breaks	82	1,693
Sticky shale with hard sand	42	1,735
Hard shale	18	1,753
Sticky shale and hard shale with sand streaks	222	1,975
Navarro formation—Continued.		
Sticky shale and shale	310	2,285
Sand	12	2,297
Sand and sticky shale	39	2,336
Sand	11	2,347
Sand and sticky shale	22	2,369
Hard shale	20	2,389
Sand	8	2,397
Sticky shale	53	2,450
Sand	6	2,456
Sticky shale	30	2,486
Shale and sand	34	2,520
Sticky shale	6	2,526
Gumbo and sticky shale	10	2,536
Shale and sticky shale	50	2,586
Shale and sandy shale	66	2,652
Shale and sticky shale	34	2,686
Taylor marl:		
Lime and shale	13	2,699
Lime	3	2,702
Lime and shale	144	2,846
Hard and sticky shale	15	2,861
Hard sand	31	2,892
Anacacho limestone: Lime and shale	44	2,936
Austin chalk: Hard chalk with breaks of gummy chalk	145	3,181
Eagle Ford shale:		
Shale	9	3,190
Shale and lime	22	3,212
Limy shale	145	3,357
Buda limestone: Hard white lime	32	3,389
Del Rio clay: Dark shale	40	3,429
Georgetown limestone:		
Hard white lime	58	3,487
Soft gummy lime	4	3,491
Edwards limestone: Hard lime	41	3,534

Log of well 2 of Oppenheimer & Lang, 2½ miles west of Goldfinch, Frio County (no. 83)

	Thickness (feet)	Depth (feet)
Mount Selman formation:		
Yellow sand	30	30
Water sand	2	32
Yellow clay	18	50
Water sand	5	55
Yellow gumbo	15	70
Rock	1.8	71.8
Water sand	8.2	80
Blue shale	5	85
Water sand	15	100
Sandy shale; some rock	100	200
Mud	50	250
Mount Selman formation—Contd.		
Sandy shale	60	310
Water sand; no flow	20	330
Shale	90	420
Mud	60	480
Shale	20	500
Water sand; some lignite; flow of water	100	600
Shale	55	655
Mud	45	700
Shale	90	790
Water sand; flows	70	860

Log of well of H. H. Page, 2 miles north of Pearsall, Frio County (no. 40)

	Thickness (feet)	Depth (feet)
Mount Selman formation:		
Clay	42	42
Rock	4	46
Yellow gumbo	12	58
Mount Selman formation—Contd.		
Reddish clay	7	65
Water sand	41	106

Log of high school well at Pearsall, Frio County (no. 64)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Mount Selman formation—Contd.		
Red sand	2	2	Blue shale	34	120
Sand and clay	38	40	Shale and lignite	10	130
Blue gumbo	10	50	Gumbo	20	150
Yellow clay	5	55	Blue shale	20	170
Yellow sand; some water	10	65	Sandrock	1	171
Hard sandrock	5	70	Blue shale	39	210
Blue shale	15	85	Water sand	4	214
Sandrock	1	86	Sand and shale with water	23	237

Log of well of E. Hohenberg, Lilley no. 2, 1¼ miles southwest of Derby, Frio County (no. 107)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Reynosa formation:			Mount Selman formation—Contd.		
Surface soil	4	4	Shale	3	383
White hard caliche	4	8	Sand	12	395
Gravel	10	18	Hard blue shale	15	410
Mount Selman formation:			Rock	17	427
Hard sandrock	21	39	Blue shale boulders	3	430
Yellow sand	2	41	Coal	105	535
Hard sand	3	44	Shale, etc., boulders	5	540
Hard rock	18	62	Hard smooth rock	775	1,315
Brown soil	3	65	Brown shale	1	1,316
Wet sand; very little water	5	70	Brown shale; little show of oil and gas	82	1,398
Hard brown soil	5	75			
Blue sand; water	10	85	Carrizo sand:		
Soft blue shale	15	100	Coarse gray sand; artesian flow	71	1,469
Gravel	13	113	Soft brown shale; gas	16	1,485
Soft brown shale	5	118	Hard gray shale	10	1,495
Sand	22	140	Hard gray fine sand	135	1,630
Hard shale and boulders	4	144	Shale	15	1,645
Rock	91	235	Rock	2	1,647
Shale	3	238	Hard shale and rock	21	1,668
Hard sandrock	52	290	Gray sand; artesian flow	26	1,694
Blue shale	10	300	Gumbo	5	1,699
Blue sand; water	25	325	Sand; artesian flow	10	1,709
Soft blue gumbo	10	335	Shale	51	1,760
Coal	35	370	Rock	1	1,761
Hard rock	10	380			

Partial log of well of C. M. Kelley, three-fourths mile southwest of Hindes, Atascosa County (no. 114)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil and clay	20	20	Cook Mountain formation—Cont.		
Fine white sand	10	30	Shale	18	312
Gravel	8	38	Gumbo	15	327
Cook Mountain formation:			Hard rock	3	330
Blue clay	10	48	Shale	27	357
Blue pack sand	39	87	Gumbo	5	362
Blue gumbo	4	91	Pack sand	11	373
Blue pack sand	36	127	Coarse white sand; small flow	60	433
Light-blue gumbo	30	157	Soapstone	3	436
Very hard rock	2	159	Shale	20	456
Black gumbo and boulders	35	194	Gumbo	6	462
Gray pack sand	20	214	Shale	14	476
Very hard rock	1	215	Coarse sand; show of oil	12	488
Shale	18	233	Gumbo and boulders	27	515
Boulders	4	237	Soft blue rock	11	526
Gumbo	10	247	Gumbo	10	536
Blue pack sand	31	278	Shale and shells	32	568
Gravel	1	279	Hard rock	1	569
Shale	6	285	Gumbo	15	584
Gumbo	9	294	Shale	20	604

Partial log of well of C. M. Kelley, three-fourths mile southwest of Hindes, Atascosa County (no. 114)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Cook Mountain formation—Cont.			Cook Mountain formation—Cont.		
Hard rock	1	605	Sand	15	844
Gumbo	3	608	Hard rock	24	868
Gray sand	5	613	Gumbo	5	873
Gumbo	6	619	Hard rock	2	875
Hard rock	1	620	Hard sand	10	885
Hard sand	5	625	Hard sandy shale	35	920
Hard rock	2	627	Gumbo	15	935
Fine blue sand	14	641	Shale	10	945
Gumbo	3	644	Gumbo	4	949
Hard rock	1	645	Shale	5	954
Porous rock	6	651	Gumbo with hard shells	11	965
Gumbo	36	687	Mount Selman formation (?):		
Shale	20	707	Porous rock; 8-inch casing set	7	972
Porous rock; second flow	18	725	Gumbo	4	976
Gumbo	15	740	Shale	15	991
Shale	8	748	Gumbo	4	995
Gumbo	10	758	Shale	35	1,030
Hard rock	1	759	Fine blue sand	11	1,041
Blue shale and shells	10	769	Shale	21	1,062
Fine gray sand	13	782	Gumbo	21	1,083
Hard sand and shale	35	817	Hard sand	8	1,091
Gumbo	12	829	Gumbo and boulders	4	1,095

Log of well of R. C. Jacobs, 1 mile northwest of Dilley, Frio County (no. 122)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	4	4	Water sand	168	290
Sandy clay	21	25	Gumbo	25	315
Yellow sand	40	65	Sandy shale	5	320
Gray sand	57	122	Gumbo	16	336

Log of well of W. D. Morrison, Dilley, Frio County (no. 133)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	4	4	Sandstone	20	95
Clay	11	15	Blue shale	27	122
Sandstone	20	35	Water sand	243	365
Sandy clay	35	70	Blue shale	5	370
Limestone	5	75			

Log of well of W. C. Haynes (nursery well), half a mile north of Dilley, Frio County (no. 136)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil and clay	45	45	Water sand	177	272
Blue shale	5	50	Sandy gray shale	8	280
Blue sandy shale	45	95			

Partial log of well of W. D. Syers, 4 miles southeast of Moore, Frio County (no. 155)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Carrizo sand:		
Soil and clay	25	25	Coarse white sand	30	560
Sand	3	28	Medium white sand	176	736
Yellow gumbo	20	48	Porous rock	54	790
Yellow sand	35	83	Very hard rock	2	792
Lignite	3	86	Coarse white sand; good water	20	812
Shale	7	93	Very hard rock	6	818
Rock	1	94	Porous rock	57	875
Sand	10	104	Hard rock	1	876
Rock	1	105	Porous rock	14	890
Blue sand gas	27	132	Very hard rock	4	894
Gumbo	11	143	Coarse hard water sand	37	931
Rock and boulders	12	155	Indio formation:		
Gray sand; gas	40	195	Very hard rock	3	934
Rock	1	196	Hard sand and shells; water	58	992
Soft shale; gas and oil	31	227	Very hard rock	1	993
Rock	3	230	Fine black sand	17	1,010
Fine sand	10	240	Hard rock	1	1,011
Soft rock; gas	22	262	Fine black sand	53	1,064
Sand	50	312	Very hard rock	3	1,067
Sand and shale	88	400	Fine blue sand	20	1,087
Soft gumbo	13	413			
Very hard rock	10	423			
Fine white sand	106	529			
Shale rock	1	530			

Partial log of well of Rio Bravo Oil Co., no. 2 Cortinas, 4 miles west of Rossville, Atascosa County (no. 162)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Indio formation:		
Hard sand	25	25	Black gumbo	15	500
Yellow clay	57	82	Rock	5	505
Rock	1	83	Gumbo and shale	27	532
Carrizo sand:			Pyrite	11	543
Hard sand	131	214	Sand and boulders	44	587
Sandrock	12	226	Rock	3	590
Hard rock	134	360	Gumbo	37	627
Sandrock	4	364	Hard rock	3	630
Hard sand	121	485			

Log of well of E. R. Breaker, 1½ miles north of Pleasanton, Atascosa County (no. 241)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Mount Selman formation—Contd.		
Surface sand	2	2	Pyrite	1	495
Yellow clay	22	24	Shale and sand	10	505
Gray clay	14	38	Hard rock	4	509
Blue clay	6	44	Shale and sand	14	523
Water sand	64	108	Hard limerock	2	525
Soft sandrock	92	200	Shale and sand	8	533
Water sand	24	224	Gumbo	23	556
Rock sand	11	235	Sand, shale, and slate	33	589
Shale	15	250	Brown rock	3	592
Soft asphalt rock and fine sand	14	264	Hard sand	22	614
Brown shale mixed with gumbo	22	286	Rock	4	618
			Shale	25	643
Brown shale and sand	23	409	Hard sand; water show	16	659
Sandrock	3	412	Soft shale and gumbo	21	680
Brown shale	27	439	Blue and brown shale and sand	37	717
Rock	1	440	Rock	1	718
Brown shale and sand	44	484	Shale and sand	38	756
Hard rock	1	485	Gumbo	14	770
Lignite	2	487	Rock	1	771
Shale and sand	7	494	Shale and sand	11	782

Log of well of E. R. Breaker, 1½ miles north of Pleasanton, Atascosa County (no. 241)—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation—Contd.			Indio formation:		
Brown rock	4	786	Pyrite	3	1,518
Soft shale and sand	4	790	Lignite	4	1,522
Hard gumbo	14	804	Black gumbo	78	1,600
Limerock	2	806	Packed sand	12	1,612
Sand; oil show	4	810	Black gumbo	88	1,700
Porous rock; oil show	22	832	Limestone	20	1,720
Shale and sand	24	856	Shell and shale	20	1,740
Gumbo	12	868	Gray blue gumbo	25	1,765
Rock	1	869	Sand; water show	25	1,790
Shale and sand	31	900	Shale	15	1,805
Gumbo	25	925	Rock	4	1,809
Rock	2	927	Hard shale	102	1,911
Water sand	273	1,200	Soft shale; gas show	6	1,917
Carrizo sand:			Rock (lime formation)	8	1,925
Rock	6	1,206			
Water sand	309	1,515			

Log of well of C. S. Young, 1½ miles northeast of Jourdanton, Atascosa County (no. 251)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Cook Mountain formation:			Mount Selman formation—Contd.		
Yellow sand	2	2	Blue sandstone	3	993
Red clay	3	5	Hard pack sand	7	1,000
Gravel, pyrite, and gypsum	5	10	Blue sandstone	3	1,003
Black sand	10	20	Blue shale	4	1,007
Gravel and pyrite	30	50	Blue sandstone	3	1,010
Yellow rock	20	70	Hard blue sand	10	1,020
Black sand	5	75	Hard rough red rock	4	1,024
Black shale	7	82	Hard sandstone	11	1,035
Gray sand	38	120	Blue sandstone	3	1,038
Oil showing	20	140	Hard blue shale	30	1,068
Water sand	22	162	Blue sandstone	3	1,071
Rock sand	140	300	Shale and sand; oil and gas	1	1,072
Water sand	3	303	Hard sandstone	8	1,080
Sandstone and shell	32	335	Water sand	10	1,090
Pack sand	3	338	Blue sandstone	2	1,092
Mount Selman formation:			Blue gumbo	18	1,110
Hard, rough sandstone	202	540	Blue sandstone	3	1,113
Sand; oil showing	3	543	Water sand	42	1,155
Red gumbo	7	550	Blue sandstone	5	1,160
Hard sandstone	12	562	Blue shale	25	1,185
Sandstone	6	568	Blue sandstone	3	1,188
Hard sandstone	3	571	Water sand	22	1,210
Black sand	14	585	Hard blue shale; oil show	9	1,219
Blue gumbo	20	605	Blue sandstone	3	1,222
Black shale	25	630	Hard blue shale	6	1,228
Blue gumbo	15	645	Hard blue sandstone	2	1,230
Black shale	35	680	Blue shale	6	1,236
Pack sand	25	705	Hard blue sandstone	4	1,240
Blue gumbo	10	715	Blue shale	20	1,260
Sand and shale; oil show	7	722	Blue sandstone; oil show	3	1,263
Sand; oil show	8	730	Hard blue shale	9	1,272
Blue gumbo	15	745	Blue sandstone	3	1,275
Water sand	15	760	Soft blue shale	15	1,290
Blue sandstone	10	770	Blue sandstone	4	1,294
Hard blue shale	12	782	Blue gumbo	18	1,312
Gumbo and boulders	13	795	Blue shale	13	1,325
Hard blue gumbo	15	810	Blue sandstone	4	1,329
Water sand	10	820	Blue shale	11	1,340
Blue shale	50	870	Blue sandstone	5	1,345
Hard sand	12	882	Blue shale	5	1,350
Hard blue shale	18	900	Blue sandstone	4	1,354
Blue gumbo	10	910	Blue shale	16	1,370
Blue shale	21	931	Blue sandstone	3	1,373
Water sand	19	950	Blue shale	7	1,380
Hard sandstone	4	954	Blue sandstone	4	1,384
Gumbo and pyrites	16	970	Blue shale	11	1,395
Sandstone	4	974	Blue sandstone	5	1,400
Soft blue shale	8	982	Hard blue shale	10	1,410
Hard rough sandstone	3	985	Brown shale	8	1,418
Hard blue shale	5	990	Hard blue sandstone	10	1,428

Log of well of Cunningham & Taliferro, 2 miles southeast of Pleasanton, Atascosa County (no. 300)

	Thickness (feet)	Depth (feet)
Cook Mountain and Mount Selman formations:		
Yellow soil and clay	50	50
Dark-blue clay	25	75
Sandrock	2	77
Water sand	3	80
Blue clay	90	170
Blue water sand	8	178
Blue clay	127	305
Blue water sand	30	335
Blue clay	290	625
Blue water sand	90	715
Blue clay	89	804
Sandrock	106	910
Blue water sand	51	961
Cook Mountain and Mount Selman formations—Continued.		
Sand and clay, hard	44	1,005
Gray water sand	40	1,045
Hard sand and shale	168	1,213
Gray water sand	29	1,242
Hard sandy shale	138	1,380
Shale and gumbo	39	1,419
Carrizo sand:		
White hard rock	16	1,435
White water sand	75	1,510
Blue hard rock	17	1,530
White water sand	54	1,590
Blue hard rock	30	1,620
White water sand and coal	102	1,722

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GEOLOGY AND GROUND-WATER RESOURCES OF ATASCOSA AND FRIO COUNTIES, TEXAS

By John T. Lonsdale

ABSTRACT

Atascosa and Frio Counties are in southwestern Texas and form a part of the Winter Garden district. The purpose of the investigation here recorded was to determine the source, quantity, and quality of the ground water used for irrigation and other purposes in the area.

The rock formations exposed are of Tertiary and Quaternary age and dip toward the east or southeast at a greater angle than the slope of the land surface, resulting in northeastward-trending belts of the outcropping formations. This general structure is modified by a large syncline in the western part of the area and by smaller anticlines and faults in other parts. These, however, do not affect greatly the movement of ground water. In order from oldest to youngest the exposed formations are the Indio formation (800 feet thick), of Wilcox age; the Carrizo sand (425 feet), the basal or Bigford member of the Mount Selman formation (0–500 feet), the post-Bigford beds of the Mount Selman formation (700 feet), the Cook Mountain formation (600 feet), and the Yegua formation (500 feet), all of Claiborne age; the Jackson formation (500 feet); the Catahoula tuff (600 feet), of Miocene age; the Goliad sand (20 feet), of Pliocene(?) age; and the Leona formation (75 feet), of Pleistocene age.

The chief water-bearing formations in the area are the Carrizo sand, the Mount Selman formation, and the Cook Mountain formation. The Carrizo sand crops out in the northern part of the area and furnishes shallow wells in the outcrop area and deeper flowing and nonflowing wells south and southeast of the outcrop. Water from this formation is of good quality and is used for irrigation near Pearsall, in Frio County, and Poteet, in Atascosa County. Maps accompanying the report show the outcrop of the sandstone, depths to the sandstone south and southeast of the outcrop, heights to which the water will rise, and the area in which flowing wells can be obtained.

The Mount Selman and Cook Mountain formations consist of discontinuous beds of sandstone, clay, shale, and lignite. The formations are important sources of water for domestic use and to some extent for irrigation. The waters are of variable quality, some being highly mineralized, and vary also in quantity. Water from the Mount Selman formation is used for irrigation near Pearsall and in eastern Atascosa County, and flowing wells are obtained in this formation east of Pearsall and near Pleasanton. The Cook Mountain formation yields water for irrigation near Dilley and supplies flowing wells in southeastern Frio County and southwestern Atascosa County near Hindes. The other formations of the area yield smaller amounts of water for domestic use and stock. These waters also are of variable quality, many being highly mineralized.

The investigation showed that a considerable amount of water from flowing wells is being wasted. If this water were conserved considerable additional irrigation could be carried on. Measurements of the water level in wells from the Carrizo sand (still being continued) lead to the tentative conclusion that the safe yield from this formation has not been exceeded.

INTRODUCTION

PURPOSE OF INVESTIGATION

This report covers the results of an investigation in Atascosa and Frio Counties, Tex., which was begun in 1929 under the direction of the Engineering Experiment Station of the Agricultural and Mechanical College of Texas at the joint request of the officials of the Missouri Pacific Railroad and of residents in the area. Early in 1930 an arrangement was made to incorporate the investigation into the general program of ground-water investigations which is being carried out by the State Board of Water Engineers through cooperation with the United States Geological Survey and which covers several adjacent or nearby counties, including Dimmit, Zavala, Medina, Uvalde, Duval, and Webb. This report, therefore, represents the results of a cooperative project between the Engineering Experiment Station, the Texas Board of Water Engineers, and the United States Geological Survey. The investigation was undertaken for the purpose of determining the resources of ground water in the area with special reference to the supply available for irrigation. The field work occupied June, July, and August in both 1929 and 1930, a part of December in 1931, and a part of June in 1932. During the season of 1929 an office was maintained at Pearsall, and in 1930 offices were maintained at both Pearsall and Jourdanton. During the season of 1930 the writer was ably assisted by M. T. Halbouty.

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The writer is indebted to many persons who contributed information and assistance in the field and assisted in the preparation of this report. Mr. W. B. Cook, of the Missouri Pacific Railroad, and his associates cooperated by supplying engineering and agricultural data. Mr. N. H. Hunt and Mr. L. F. Merl, secretaries respectively of the Pearsall and Dilley Chambers of Commerce, contributed data concerning wells and extended many courtesies. Well logs were supplied by Mr. W. D. Morrison, of Dilley; Mr. C. S. Young, of Jourdanton; Mr. F. M. Getzendaner and Mr. L. F. McCollum, of the Humble Oil & Refining Co.; and Mr. J. M. Dawson, of the Gulf Production Co. Mr. Getzendaner also gave freely of his store of geologic information relating to the area. Messrs. A. R. Denison and L. W. Clark, of the Amerada Petroleum Corporation, supplied information concerning Cook Mountain contacts in Frio County and oil wells drilled by the company. Miss Julia Gardner, of the United States Geological Survey, identified fossils collected by the writer and helped him to map geologic boundaries in parts of the area. Mr. W. N. White, of the Geological Survey, who is in charge of the ground-water investigation in Texas, spent several days in the field with the writer and

has reviewed and to some extent revised this report. Geologic and hydrologic data were supplied by Messrs. A. N. Sayre, T. W. Robinson, and S. F. Turner, also of the Geological Survey, who were making similar investigations in adjoining areas in Dimmit, Uvalde, and Medina Counties. Use was also made of unpublished hydrologic

FIGURE 1.—Map of Texas, showing location of Atascosa and Frio Counties.

data in the files of the United States Geological Survey collected by Messrs. Alexander Deussen and S. S. Nye. The investigation was made under the general direction of Mr. O. E. Meinzer, geologist in charge of the division of ground water in the Geological Survey.

LOCATION OF AREA

Atascosa and Frio Counties are in southwestern Texas (see fig. 1) and comprise a part of the area that is commonly called the Winter Garden district, the boundaries of which are rather loosely defined. Atascosa County has an area of 1,350 square miles and Frio County

1,124 square miles. The principal towns are Poteet, Pleasanton, North Pleasanton, Jourdanton, Lytle, Christine, and Campbellton, in Atascosa County; and Moore, Pearsall, Derby, Melon, Dilley, and Bigfoot, in Frio County.

TOPOGRAPHY AND DRAINAGE

Atascosa and Frio Counties are within the Western Gulf section of the Coastal Plain, which in this part of Texas extends from the Edwards Plateau, on the north and northwest, to the Gulf of Mexico, on the south and southeast. The general pattern of the surface is that of a uniform southeastward slope, somewhat dissected by southeastward-flowing streams. Thus Lytle, in the northwestern part of Atascosa County, has an altitude of about 730 feet above sea level, and Campbellton, in the southern part of the same county, has an altitude of only about 250 feet. In some parts the surface forms a true plain with very little relief, but in general the interstream areas are belts of relatively high land that have a southeasterly trend. In some places the more resistant beds have formed escarpments that face west or north. The greatest relief is in the northern part of the area, especially in northwestern Frio County, where the outcropping rocks contain beds of variable hardness and the streams have dissected the once uniform upland into prominent hills and valleys.

The principal streams of the area are the Frio, Atascosa, and Leona Rivers and San Miguel Creek. Minor streams of some importance are Hondo, Seco, Lagunillas, Siestadero, and Turkey Creeks. All these streams are intermittent. Floods occur during and immediately after heavy rains, but these floods subside in a few hours or at the most in a few days, and during the greater part of the time the streams either are dry or contain disconnected pools which dwindle during protracted periods of drought until little or no water remains. The channels of the Frio River in the region below Derby and of the Atascosa River below Poteet contain water nearly all the year. This is partly due to the inflow of waste water from artesian wells, that are allowed to flow continually.

The amount of standing water in the stream channels during dry times is related to the character of the underlying rocks. In sandstone areas the stream channels are usually completely dry at such times, but in shale areas they frequently contain pools of water for long periods. This difference gives a clue as to the source of some of the ground water in the sandstone formations of the area.

The larger streams are bordered by belts of alluvium, but these are narrow and poorly defined except along the Frio and Atascosa Rivers and San Miguel Creek in the southern part of the area. The alluvial deposits do not enter into the ground-water problems of the district.

VEGETATION

The native vegetation reflects to a degree the semiarid subtropical character of the climate. Nearly everywhere the uncultivated areas are covered with a growth of varying density of scrub trees or chaparral. The trees consist dominantly of mesquite in the western part of the area and of mesquite and scrub oak in the eastern part. The chaparral consists chiefly of black brush, catclaw, juahillo (wah-ee′yo), scrub mesquite, and prickly pear and other types of cactus. Near the streams are found trees of considerable size, such as the pecan, cypress, and live oak. Oaks of fairly large size also occur on the divides between the streams in the eastern part of the area. A variety of grasses flourish in open spaces among the trees and chaparral.

TRANSPORTATION

The area is crossed by branch lines of the Missouri Pacific Railroad. The International-Great Northern Railroad passes in a north-south direction through the northwestern part of Atascosa County and the central part of Frio County. Moore, Pearsall, Melon, Derby, and Dilley, in Frio County, are on this line. One branch of the San Antonio, Uvalde & Gulf division of the Missouri Pacific Railroad passes through north-central Atascosa County and another through the southern part of the county, the towns of Leming, Pleasanton, Jourdanton, Dobrowolski, Charlotte, and Hindes being on the first-named branch and Coughran, McCoy, and Campbellton on the other. A third line, the San Antonio Southern Railway, passes through Poteet and Jourdanton and terminates at Christine.

Both Atascosa and Frio Counties are provided with good trunk automobile roads. State highway 2, between San Antonio and Laredo, passes through Frio County, following the line of the International-Great Northern Railroad. State highway 85, from Dilley to Eagle Pass, crosses the southwestern part of the county. Highway 9 crosses Atascosa County from north to south through Leming, Pleasanton, and Campbellton, and a short branch of it (highway 97) extends from Pleasanton to Jourdanton. In the northern part of the county the Palo Alto road from San Antonio extends to Poteet.

All the highways converge at San Antonio, which is the supply and market point for the area. Secondary automobile roads, which are generally graded and open for travel except in very bad weather, connect all parts of the area. It should be noted that dirt roads passing over certain of the clay formations, such as the Yegua, are impassable after heavy rains.

AGRICULTURE

Atascosa and Frio Counties are to some extent in a stage of transition from stock raising to farming. Until within a comparatively few years very little farming was carried on, and practically the entire area in both counties was devoted to cattle raising. Some of the most famous early ranches in Texas were located in this area.

In recent years farming has been on the increase, much of the development having started with the building of the railroads. In most of the area dry farming is practiced. Cotton is raised extensively, and in Atascosa County it is the largest crop, but in Frio County the rainfall in many years is insufficient to mature the cotton. Corn, various sorghums, and other dry-land crops are raised.

Winter truck farming, with irrigation from wells, has become important in the area. Poteet furnishes large amounts of early strawberries and vegetables. Areas around Pearsall and Dilley furnish onions, spinach, tomatoes, and other vegetables. Large tracts still remain and probably will continue to remain as ranch land, but in general farming is being extended. According to the agricultural census of the United States, 37.9 percent of Atascosa County and 54.8 percent of Frio County were in farms in 1925. Below is a table compiled from the 1925 census showing the kinds of crops raised and the acreage devoted to each crop. The table does not include strawberries, because information was not available as to the acreage of that crop.

Farm acreage of crops raised in Atascosa and Frio Counties, Tex., in 1925

	Atascosa County	Frio County		Atascosa County	Frio County
Total area	869,120	719,360	Sweetpotatoes	115	4
Cotton	81,455	73,333	Cabbages	104	11
Corn	22,915	22,494	Cantaloupes	288	24
Wheat	50	54	Lettuce	75	5
Oats	107	272	Onions	37	185
Sorghums	1,613	4,919	Sweet corn	78	5
Peanuts	1,807	50	Tomatoes	267	43
Hay	3,150	522	Watermelons	3,833	2,179
Irish potatoes	81	12			

HISTORY

The history of Atascosa and Frio Counties is an interesting story of the winning of frontier lands from Indians, the development of ranching, the building of railroads, and finally a gradual change into a combination of ranching and farming. Only a brief summary of this history can be given here.

Venturesome stockmen established themselves in the area in the early fifties. At that time and for 25 years afterward the region was subject to Indian raids, the Frio County area being the more vulnerable because of its greater distance from San Antonio.

Atascosa County was delimited and organized in 1871. The county seat was first at Novatascosa, but later it was moved to Pleasanton and still later to Jourdanton. Until 1908 the only railroad in the county passed through the extreme northwestern part. In 1908 and 1909 two railroads, the San Antonio, Uvalde & Gulf and the San Antonio Southern, were built into the county, and Jourdanton, Poteet, and Christine were established as stations on them.

The first flowing well at Poteet, in Atascosa County, was drilled in 1904, before the advent of the railroad, and this demonstration of the availability of artesian water had much to do with the initiation of railroad building in the area. By 1910 there were 10 artesian wells, and thereafter several were drilled each year until the period of the World War, when drilling was stopped on account of the high cost of sinking the wells and providing them with pumping equipment. More recently well drilling has been resumed, and there are now more than 50 artesian wells in the Poteet area. The development of truck farming has paralleled the sinking of the artesian wells.

Frio County was also organized in 1871, with the county seat at Frio Town. In 1881 the county seat was moved to Pearsall, then a new town on the International-Great Northern Railroad, which had recently been built through the county. The original courthouse at Frio Town is still intact and is one of the historic landmarks of the region.

The first flowing well in Frio County was drilled near Pearsall in 1905. Since then, deep wells have been drilled from time to time in the Frio Valley area, west and southwest of Pearsall. Most of these wells flow and furnish water for irrigation of considerable extent.

Irrigation with water pumped from shallow wells was started in the Pearsall area in 1905, and the development reached its height about 1923. Pump-well irrigation was begun in the vicinity of Dilley about 1925 and has since gradually developed.

MAPS

Two maps accompany this report. Plate 1 shows the areal geology, the original and present areas of artesian flow, and the location of record wells and of lands irrigated with water from wells. Plate 2 shows the depths to the top of the Carrizo sand and the height above sea level to which water from the Carrizo sand would rise in 1930. The map of Frio County used as a base for showing the geologic and hydrologic data was traced from a soil map of the county prepared by M. W. Beck, of the United States Department of Agriculture, and made available through the courtesy of Mr. A. B. Conner, director of the Texas Agricultural Experiment Station. The base map of Atascosa County was prepared by M. T. Halbouty, by compilation of data from existing county and land maps and by a plane-table traverse which covered about one-third of the county.

CLIMATE

Texas is remarkable for its great variety of climate. The extreme eastern part of the State has an average annual rainfall of more than 45 inches. The precipitation decreases gradually from east to west, the annual average being less than 30 inches at San Antonio and less than 20 inches at Eagle Pass. Atascosa County on the average receives 25 to 30 inches annually as compared with 20 to 25 inches in Frio County.

There is a considerable range in temperature in the two counties. Summer temperatures are frequently higher than 100° and during the winter there is generally at least one killing frost. During the period of record the growing season has varied from 220 to 298 days. Observations made intermittently since 1908 record a minimum temperature of 13°.

In most years there is some rain every month. The heaviest precipitation usually occurs in April, May, and the early part of June and in September and October. February is also a wet month, especially in Frio County. August is the driest month. There is a tendency for the precipitation to be concentrated in heavy rains, which frequently cause floods. In many years there is a decided shortage of rainfall during the summer, especially in July and August. Crops therefore must be specially adapted to dry farming or must be irrigated.

Tables showing available records of rainfall and dates of the first killing frost in the fall and the last killing frost in the spring in the two counties, and of rainfall at Runge, in Karnes County, are given below, from reports of the United States Weather Bureau.

Climatic data for Dilley, Frio County, Tex., 1910–29

Year	Precipitation (inches)													Temperature (°)		Last killing frost in spring	First killing frost in fall
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Maximum	Minimum		
1910	0.18	0.04	1.50	3.20	1.00	1.65	1.04	1.00	1.02	------	0.70	0.99	12.32	------	------	------	
1911	.75	1.85	2.65	3.25	.90	------	------	1.00	1.80	1.55	2.50	1.00	17.25	------	------	------	
1912	------	2.05	.85	2.40	1.65	4.57	------	------	------	2.50	1.25	1.80	17.07	------	------	------	
1913	.30	1.50	.80	1.75	------	4.90	.50	------	7.60	------	2.00	3.65	23.00	------	------	------	
1914	------	1.15	.65	1.85	6.00	------	------	3.50	1.65	1.45	3.10	.85	20.20	------	------	------	
1915	.65	.40	.65	2.25	4.25	------	1.25	3.90	2.25	.75	------	------	16.35	------	------	------	
1916	1.70	------	------	.53	2.25	.62	2.47	4.90	1.11	1.86	1.15	.32	16.91	------	------	------	
1917	------	Tr.	.19	------	.25	Tr.	3.10	Tr.	1.62	------	.80	------	5.96	------	------	------	
1918	.10	.95	.45	1.96	3.52	.93	.12	.67	2.41	2.55	1.67	2.93	19.26	------	------	------	
1919	3.02	1.71	2.24	3.78	2.89	7.01	3.75	2.05	5.43	5.24	1.12	.82	39.06	------	------	------	
1920	1.72	.85	.75	1.10	6.22	5.33	4.44	2.59	.28	1.80	.83	.02	25.93	------	------	------	
1921	.49	.23	3.23	.82	2.28	1.58	.32	Tr.	3.69	1.35	.80	------	14.70	104	30	Feb. 21	Dec. 9
1922	.60	.65	4.08	1.56	8.76	2.70	3.30	.78	2.17	3.52	.46	.17	28.75	103	24	Mar. 4	Dec. 19
1923	.30	7.84	2.92	1.07	.23	.76	1.75	2.22	5.83	3.40	3.28	3.28	32.27	104	23	Mar. 20	Dec. 14
1924	.45	------	2.65	1.30	4.19	.41	.32	------	5.08	.47	------	1.36	------	------	------	Mar. 15	Dec. 19
1925	.36	------	2.91	Tr.	.88	.08	1.14	2.37	4.94	1.52	1.73	1.34	17.27	106	22	Jan. 29	Nov. 23
1926	2.65	.46	4.15	3.55	1.76	.20	.33	3.76	.49	1.39	1.10	2.12	18.92	107	25	Jan. 26	Dec. 30
1927	.89	.65	1.37	.26	1.15	5.81	.77	.02	2.65	1.73	------	1.06	16.36	110	25	------	Dec. 8
1928	.97	1.14	.17	2.24	4.73	1.62	1.05	2.16	4.62	.35	.40	1.82	21.27	104	18	Feb. 26	Dec. 23
1929	.71	.06	3.12	.44	8.95	.23	2.14	.10	.75	4.50	1.56	1.42	23.98	103	21	Feb. 13	Nov. 6
Average	1.51	3.27	1.88	1.98	3.04	2.83	2.20	1.65	2.79	2.02	1.73	1.70	22.56	------	------	------	

Climatic data for Pearsall, Frio County, Tex., 1902–29

Year	Precipitation (inches)													Last killing frost in spring	First killing frost in fall
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual		
1902	0.46	0.59	0.22	0.45	3.91	----	3.64	----	1.75	1.41	3.56	2.55	18.54	----	Dec. 4
1903	2.80	5.75	2.75	.08	2.96	2.81	7.10	0.55	1.77	.05	Tr.	.21	26.83	Feb. 18	Nov. 18
1904	Tr.	.56	----	2.45	3.00	2.25	2.85	.87	4.96	1.65	.40	.62	19.61	Feb. 21	Nov. 21
1905	.46	1.90	2.41	5.36	3.88	.81	1.40	.35	4.71	2.47	2.72	2.00	28.47	Feb. 20	Nov. 13
1909		----	----	----	----	----	----	.91	Tr.	3.85	Tr.	1.49	----	----	
1910	----	Tr.	.40	1.06	2.86	.60	1.55	.56	.60	2.23	.79	1.27	11.92	----	Dec. 6
1911	1.03	1.32	2.53	2.20	.48	----	.57	2.84	.09	.82	2.03	1.21	15.12	Feb. 23	Nov. 29
1912	.33	3.67	.98	1.48	1.84	3.66	.05	----	1.43	1.76	2.22	2.51	19.93	----	Nov. 28
1913	.53	1.09	1.21	1.02	.79	7.81	.27	1.46	3.50	3.64	4.96	3.77	30.05	Mar. 17	
1914	.07	1.90	1.49	2.34	5.37	.06	.08	5.80	1.65	1.49	2.35	.98	23.58	Mar. 14	
1915	.73	.31	1.14	4.40	2.41	.18	----	2.55	4.19	1.83	.17	.76	18.67		Nov. 15
1916	1.55	----	Tr.	1.89	2.16	1.65	3.45	3.68	1.03	3.13	1.11	.21	19.86	----	
1917	.50	.13	.08	.18	1.70	----	1.70	.24	3.23	.02	2.09	----	9.87	Mar. 3	
1918	.10	.97	1.20	3.44	3.30	1.49	.70	1.64	1.73	2.42	1.35	5.49	23.83	----	Nov. 28
1919	3.47	1.81	1.71	1.72	4.54	10.15	8.77	.84	8.21	4.60	.39	.90	47.11	----	
1920	2.31	----	.57	.75	6.26	2.73	3.48	1.02	Tr.	3.10	.90	----	21.12	----	Nov. 15
1921	.70	.16	3.60	4.17	1.95	2.02	.66	.16	2.90	1.15	1.45	----	18.92	----	
1922	1.32	.71	4.40	4.86	5.46	3.08	2.03	.06	2.52	3.59	.78	.14	28.95	----	
1923	.15	5.09	4.31	1.90	.19	1.62	1.89	2.20	5.33	5.56	3.04	3.52	34.80	Feb. 6	
1924	.59	1.06	1.14	1.30	1.78	----	----	.09	1.67	.15	----	1.31	----	----	
1925	.19	.11	2.63	.38	2.07	.91	4.36	.73	3.59	1.21	3.05	2.03	22.16	----	
1926	2.06	----	4.11	3.20	1.05	2.77	.45	.60	.50	1.71	.90	2.48	22.16	----	
1927	.82	.35	1.89	.81	1.10	7.05	.75	----	.98	1.14	----	1.02	15.91	----	
1928	.74	1.45	.86	1.94	3.10	4.47	.52	2.17	5.37	.37	.53	1.61	23.13	----	
1929	.07	.34	1.75	.29	10.05	.59	2.22	.51	1.31	1.47	1.49	1.52	21.61	----	
Average	1.51	3.27	1.88	1.98	3.04	2.83	2.20	1.65	2.79	2.02	1.73	1.70	22.56	----	

Climatic data for Rossville, Atascosa County, Tex., 1907–25

Year	Precipitation (inches)													Temperature (°)		Last killing frost in spring	First killing frost in fall
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Maximum	Minimum		
1907						0.22	2.38	0.51	0.58	1.74	7.24	0.64					
1908	0.36	1.84	1.59	4.93	6.68	.77	1.99	2.87	1.81	4.02	3.39	1.65	3.90				Nov. 15
1909	Tr.	.52	.57	.38	1.19	1.20	3.72	2.12	1.24	3.72	.14	1.79	16.59			Feb. 17	Dec. 8
1910	.94	.48	Tr.	2.52	2.23	1.14	.40	.95	.91	2.78	1.59	1.56	15.50			Feb. 19	Oct. 29
1911	.25	2.15	3.73	4.45	2.60	.05	.90	3.79	.35	1.13	2.04	1.71	23.15			Feb. 23	Nov. 13
1912	.36	6.43	1.50	1.60	1.73	4.26	1.18	.10	2.56	3.04	1.02	3.31	27.09			Feb. 27	Nov. 2
1913	.61	1.70	1.29	.51	4.31	8.25	.83	.84	7.38	9.94	5.50	4.89	46.05			Mar. 17	Oct. 27
1914	.17	1.56	2.66	5.66	4.33	.11	Tr.	2.68	.97	2.59	4.17	.92	25.82			Mar. 22	Dec. 10
1915	.60	.92	1.30	7.55	4.07	.05	.16	7.53	2.94	1.86	.21	.43	27.62			Mar. 22	Nov. 15
1916	2.07	.04	Tr.	2.46	3.80	.95	4.09	3.66	3.29	2.67	2.65	.46	26.14			Apr. 9	Nov. 14
1917	1.37	.27	.24	1.61	1.82	.27	2.88		.29	Tr.	.75	Tr.	9.50			Mar. 5	Oct. 30
1918	.18	1.35	1.15	4.45	3.66	2.11	.16	1.82	2.27	4.90	2.34	5.29	29.68			Feb. 3	Nov. 28
1919	6.14	1.72	1.53	5.89	2.62	1.50	11.18	3.13	13.14	10.53	2.42	1.25	61.06			Feb. 26	Dec. 10
1920	3.76	.29	.38	.26	4.70	5.15	2.44	4.93	Tr.	2.89	1.57	.05	26.42			Apr. 5	Nov. 14
1921	1.42	.54	4.71	4.14	2.69	2.42	1.22	Tr.	1.44	.41				108		Feb. 21	
1922					3.08	3.42	.08	.73	3.72	4.00	2.88	.09					Nov. 26
1923	.61	5.95	3.36	3.77	.93	.91	1.55	2.21	5.50	2.46	3.98	5.87	37.10	104	24	Mar. 20	Dec. 14
1924	.67	3.30	.90	1.42	4.36	2.28		.12	3.22	.02	.05	1.40	17.74	105	22	Mar. 14	Nov. 25
1925	.28	.02	1.06	.87	2.17	.57	1.55	1.23	3.41	.81	2.16	1.41	15.54	106	21	Feb. 28	Nov. 23
• Average	1.29	1.82	1.73	3.09	3.18	1.87	2.11	2.01	3.05	2.19	2.45	1.92	26.05	105	22.3		

Annual precipitation, in inches, at Runge, Karnes County, Tex., 1895–1929

1896	27.30	1907	25.42	1916	18.55	1925	15.43
1898	24.84	1908	31.76	1917	13.60	1926	32.28
1899	27.38	1909	18.94	1918	30.75	1927	22.29
1900	37.22	1910	28.33	1919	45.84	1928	22.91
1901	24.26	1911	27.90	1920	25.62	1929	34.90
1902	39.54	1912	22.64	1921	30.08		
1903	45.03	1913	30.73	1922	29.38	Average	28.99
1904	32.35	1914	40.39	1923	45.10		
1905	36.11	1915	20.24	1924	20.65		

GENERAL GEOLOGY

The rock formations exposed in Atascosa and Frio Counties are of Tertiary and Quaternary age, but Upper Cretaceous and Lower Cretaceous formations have been encountered in a considerable number of deep wells drilled for oil in the central and northern parts of the area, and they doubtless everywhere underlie the exposed formations. There are many problems of stratigraphy and correlation in the area, but most of them are not within the scope of this report. Plate 1 shows the outcrops of the formations except deposits of Pliocene (?) and Quaternary age. The geologic table on page 18 shows the relations and characteristics of the several formations present.

The information concerning the unexposed formations is based on their character as observed at their outcrops north of Frio and Atascosa Counties and on data obtained from the deep wells in these counties. The wells usually pass through Tertiary and Upper Cretaceous formations and end in the Lower Cretaceous a short distance below the top of the Edwards limestone. No commercial production of oil has yet been found in either of these counties except in the Somerset field, which extends from the vicinity of Somerset, in Bexar County, into the northern part of Atascosa County.

The unexposed formations are practically unavailable for water supply, because they are encountered at depths that are too great for economical development. Hence no attempt is made here to give detailed descriptions or correlations of these formations. A section which is probably more or less typical of the entire area is shown in the log of the North & Walton No. 1 C. C. Tribble well near Bigfoot, in the northeastern part of Frio County, which reached a depth of 3,560 feet. The correlation of the formations encountered in this well is given below. It should be understood that these formations will be encountered at greater depths to the south and southeast and that they may change in lithologic character and thickness. South of the latitude of Pleasanton no oil-test well has penetrated to the bottom of the Tertiary system in either of these counties. Southeast of Campbellton the Carrizo sand was reached in the C. T. Tom well at a depth of 4,500 feet.[1]

Correlation of formations encountered in the North & Walton No. 1 C. C. Tribble well, 6 miles northeast of Moore, Frio County, Tex.

		Thickness (feet)	Depth (feet)
Tertiary (Eocene):			
Mount Selman formation	Shaly clay	37	37
Carrizo sand	Sand, shale, and lignite	175	212
Indio formation	Shale, sand, and lignite	901	1,113
Midway group	Shale, greensand, sand, and limestone	354	1,467
Cretaceous:			
Upper Cretaceous:			
Navarro group	Shale; some sand	508	1,975
Taylor marl	Shale and limestone; some sand	711	2,686
Anacacho limestone	Limestone; some shale	250	2,936
Austin chalk	Chalk; some shale	245	3,181
Eagle Ford clay	Calcareous shale	176	3,357
Lower Cretaceous:			
Buda limestone	Hard white limestone	32	3,389
Del Rio clay	Dark shale	40	3,429
Georgetown limestone	Hard white limestone; some shale	58	3,487
Edwards limestone	Hard limestone	73	3,560

The general geologic structure of the area is comparatively simple. The most prominent feature is a general gulfward dip of the formations at a greater angle than the slope of the land surface. It is to this structural feature that the presence of artesian water is due.

Frio County, however, lies on the northeast edge of a regional syncline, the axis of which extends northwestward and passes near Gardendale, in La Salle County, and La Pryor, in Zavala County. The strata in the western part of Frio County are affected by this syncline and by an anticline or nose superimposed upon the northeast flank of the syncline. The axis of the anticline is approximately parallel to the course of the Leona River. Reverse dips and outliers of Cook Mountain strata northeast of the Leona River are due to the presence of this anticline or nose. In the northwestern part of Atascosa County the structure that has produced the Somerset oil field is revealed in a considerable fault affecting the strata of the Indio and Carrizo formations. In southeastern Atascosa County an anticline of some size may be present northeast of Campbellton and is indicated on the geologic map. The strata affected are those of the Yegua and Jackson formations.

Small faults have been encountered in northwestern Frio County and were mapped by A. N. Sayre. Minute faults were also found in

[1] Since the completion of the field work the Amerada Petroleum Corporation has drilled several deep wells southwest of Pearsall to test the anticlinal structure mentioned on p. 136. The deepest of the wells (Halff & Oppenheimer 2) reached a total depth of 10,050 feet. The depths to the tops of various formations were reported by the geologists of the company to be Carrizo sand 1,260 feet, Indio formation 1,500 feet, Midway group 2,620 feet, Navarro group 3,130 feet, Taylor marl 4,850 feet, Austin chalk 5,200 feet, Buda limestone 5,710 feet, Del Rio clay 5,810 feet, Georgetown limestone 5,900 feet, Edwards limestone 5,990 feet, Glen Rose limestone 6,791 feet, and Trinity group 9,771 feet. All the wells yielded small amounts of oil and gas from the Edwards limestone, and the well mentioned above was completed as an oil well with production from the Navarro group.

northeastern Frio County, north of Bigfoot, and in Atascosa County, east of Lytle, northwest of Leming, and northwest of Jourdanton. None of the faults are of sufficient magnitude to affect greatly the occurrence or movement of the ground water.

RELATION OF THE GEOLOGY TO THE GROUND-WATER CONDITIONS

SOURCE AND DISPOSAL OF THE GROUND WATER

The fundamental principles governing the occurrence and movement of ground water have been set forth in detail by Meinzer.[1a] Only essential statements will be made here, and the reader is referred to Meinzer's reports for a more detailed discussion.

The ground water is derived chiefly from water that falls as rain or snow. A part of this water runs off directly in streams to the sea, a part evaporates, a part is consumed by the plants, and a part sinks to the ground-water table and enters the zone of saturation. Most of the water in the zone of saturation is eventually returned to the surface through springs or wells or is discharged by plants or through evaporation from the soil when it approaches the surface. Some water, however, percolates directly into the sea. The water table differs in altitude from place to place and fluctuates as a result of variations in rainfall, evaporation, and other climatic conditions.

The porous rocks below the water table are as a rule saturated with water and yield water to wells sunk into them wherever the rocks are of such a texture that the water is free to move into the wells. In the more permeable rocks, such as many of the sandstones and gravel, the water is free to move under the influence of gravity, but in less permeable rocks, such as shales and fine-grained sandstones, molecular attraction tends to retard movement of the water.

GENERAL ARTESIAN CONDITIONS

The conditions governing artesian water are discussed in numerous reports of the United States Geological Survey [2] and State geological surveys and in many textbooks of geology. If a permeable stratum in an inclined position, lying between relatively impervious or water-tight strata, receives water from rainfall or stream flow at its outcrop, the water entering it will move under the influence of gravity down the dip of the stratum and will tend to accumulate under hydro-

[1a] Meinzer, O. E., The occurrence of ground water in the United States, with a discussion of principles: U. S. Geol. Survey Water-Supply Paper 489, 1923; Outlines of ground-water hydrology: U. S. Geol. Survey Water-Supply Paper 494, 1923.

[2] 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.

static pressure. The general conditions governing artesian water are shown in figures 2, 3, and 4. Flowing wells may be obtained where the pressure is sufficient to raise the water to the surface. Whether flowing wells can be obtained in any given locality that is underlain by an artesian stratum will depend on the difference in altitude and the horizontal distance between that locality and the outcrop area, and also on the effectiveness of the confining beds.

In an artesian system, in general, the source of water is that entering at the outcrop of the permeable formation. The artesian system loses water through springs or other natural discharge and through wells sunk to the permeable formation. If the amount of water lost

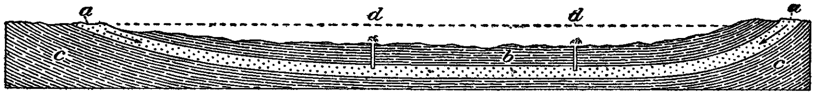


FIGURE 2.—Ideal section illustrating the chief requisite conditions for artesian wells. *a*, Permeable bed; *b*, *c*, impermeable beds below and above *a*; *d*, flowing wells from bed *a*. (After Chamberlin.)

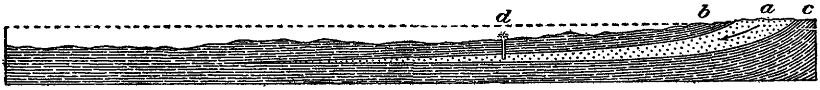


FIGURE 3.—Section illustrating the thinning out of a permeable water-bearing bed. *a*, Permeable bed enclosed between impermeable beds *b* and *c*, thus furnishing the necessary conditions for artesian fountain *d*. (After Chamberlin.)

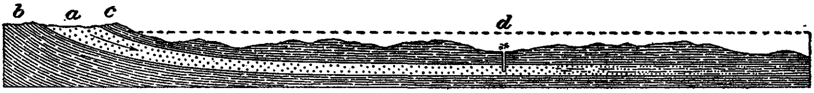


FIGURE 4.—Section illustrating the transition from a permeable water-bearing bed (*a*) into a close-textured impermeable bed. Bed *a*, being enclosed between impermeable beds *b* and *c*, furnishes the conditions for artesian flow *d*. (After Chamberlin.)

from the artesian system in any period exceeds the recharge during the same period the head will become lower. If too many wells are sunk the head may be lowered so much that not only will the wells cease to overflow but the water will have to be raised by pumping from so great a depth that the cost of pumping may become excessive. Thus there is a limit to the economical development of any artesian system. This limit is approached or may already be exceeded if the water levels in wells become lower and lower from year to year. As overdevelopment of this kind will affect unfavorably all who use water from the artesian system, it is a subject in which all users of artesian water should be interested.

ARTESIAN CONDITIONS IN ATASCOSA AND FRIO COUNTIES

The structure of the rocks in Atascosa and Frio Counties is favorable for the occurrence of artesian water. The formations are composed largely of permeable sandstones interbedded with relatively impermeable clays and shales. Except in localities where there are notable folds or faults, the rocks dip to the south or southeast, which is also the general direction in which the land surface slopes. However, the dip is nearly everywhere steeper than the surface slope, and therefore successively younger formations are encountered in crossing the area from north to south or from northwest to southeast. Each formation has an outcrop area from which it extends toward the south or southeast, below the younger formations, to progressively greater depths below the surface. (See pl. 1.) Thus the formations that appear at the surface in the northern part of the area shown on the map occur at depths of several thousand feet in the southeastern part—the Carrizo sand, for example, reaching a depth of more than 4,000 feet near Campbellton.

The Carrizo sand is the most productive artesian aquifer in the area, but certain sand members of the Mount Selman and Cook Mountain formations also furnish artesian water. The Carrizo sand possesses fairly uniform characteristics over wide areas, and the Carrizo artesian basin can therefore be accurately outlined and described. The Mount Selman and Cook Mountain formations vary considerably in lithology and stratigraphy from place to place, and the aquifers in them cannot be as accurately described as that of the Carrizo.

GEOLOGIC FORMATIONS AND THEIR WATER-BEARING PROPERTIES

A generalized section of the geologic formations that underlie this area is given in the accompanying table. The formations are listed in the order in which they lie beneath the surface, each successive formation being older than the one above it.

Generalized table of geologic formations in Atascosa and Frio Counties, Tex.

System	Series	Group	Formation	Approximate maximum thickness (feet)	Lithologic character	Water supply
Quaternary.	Recent.			25	Silt, sand, clay, and gravel. Confined to stream valleys.	No important water supply.
	Pleistocene.		Leona formation.	75	Silt, sand, and fine gravel, occurring in terraces along the larger streams.	Do.
Tertiary (?).	Pliocene (?).		Goliad sand.	20	Largely gravel, cobbles, and sand in interstream areas.	Do.
Tertiary.	Miocene.		Catahoula tuff.	600	Gray to white tuff and sandstone. Only basal beds exposed in Atascosa County. Higher beds consist of sandstone, conglomerate, and tuff. Volcanic throughout.	Do.
	Eocene.		Jackson formation.	500, [a] 1,000	Sand, sandstone, quartzite, volcanic ash, and clay. Sand is varicolored, medium to fine-grained, frequently thin-bedded. Clay is most abundant in the upper part of the formation and is largely sandy and carbonaceous. Calcareous and siliceous concretions and fossilized wood are common.	Lower sands yield domestic water supplies in southeastern Atascosa County. Water has wide range of chemical character; some water highly mineralized.
		Claiborne group.	Yegua formation.	500, [a] 900	Gray to yellowish-brown clay and slightly sandy clay. Much of it gypsiferous. Lignite and calcareous concretions common.	Generally not water-bearing. Sandy beds yield highly mineralized water.
			Cook Mountain formation.	600, [a] 900	Alternating clay and sandstone. Some glauconitic sandstone with lenses of limestone; also some lignite. Clay is in many places gypsiferous. Lower part sandy, especially in Frio County.	Furnishes considerable water. Sands in upper part of formation yield highly mineralized water. Sands in lower part yield water of good quality. Artesian wells in southwestern Atascosa County derive water from this formation.

[a] In wells.

Generalized table of geologic formations in Atascosa and Frio Counties, Tex.—Continued

System	Series	Group	Formation	Approximate maximum thickness (feet)	Lithologic character	Water supply
Tertiary.	Eocene.	Claiborne group.	Mount Selman formation.	700, [a] 500	Upper part is generally sandy, with minor amounts of shale. Many outcrops of upper part show much limonite. Lower part consists of alternating beds and lenses of sandstone and shale with lenses of impure limestone and quartzite and some lignite. Basal part (Bigford member) consists of dominantly clay beds with thin sand and limestone; calcareous concretions are common, especially near the base; a few ash beds; gypsum fairly abundant; thickest sand is near bottom.	Holds second rank as source of water. The sands of middle to upper part yield large supplies of good water. In Atascosa County the formation supplies many artesian wells; in Frio County it furnishes the water for shallow irrigation wells near Pearsall.
				150, [a] 400		Bigford member generally yields only small amounts of highly mineralized water.
			Carrizo sand.	175, [a b] 425	Dominantly coarse, porous, nonmicaceous reddish sand. Minor amounts of clay occur as beds, lenses, or lumps, and locally there are lignite beds. A few ledges of quartzitic sandstone. Cross-bedding is common.	Yields large supplies of good water to many artesian and pumped wells.
		Wilcox group.	Indio formation.	[b] 800	Thin-bedded sandstone and clay, carbonaceous, with beds of lignite. Locally gypsiferous. Not notably cross-bedded.	Furnishes small amounts of water, in places highly mineralized.
		Midway group.	(Undifferentiated.)	[b] 300	Chiefly shale with lenses and beds of clay; concretions are common.	Generally not water-bearing.
Cretaceous.	Upper Cretaceous.	Navarro group.	(Undifferentiated.)	[b] 1,500	Shale and sand.	Encountered in oil wells but too deeply buried to be practicable for water supply in this area.
			Taylor marl.	[b] 711	Shale, limestone, and sand.	
			Anacacho limestone.	[b] 250	Limestone and shale.	
			Austin chalk.	[b] 245	Chalk and limestone.	
			Eagle Ford shale.	[b] 176	Shale.	
	Lower Cretaceous.		Buda limestone.	[b] 32	Limestone.	
			Del Rio clay.	[b] 40	Clay.	
			Georgetown limestone.	[b] 58	Limestone.	
			Edwards limestone.	[b] 300	Limestone.	

[a] In wells.

[b] See footnote 1, p. 13.

INDIO FORMATION[3]

Areal extent.—The Indio formation crops out in a small area in the vicinity of Lytle, in northwestern Atascosa County, and in the banks of the Frio River near the Hiler ranch, in northwestern Frio County (pl. 1). Only the beds in the upper part of the formation are exposed in these counties, the main outcrop area being to the north, in Medina and Bexar Counties. The formation lies unconformably beneath the Carrizo sand.

Lithology.—The Indio displays the variations in lithology that are to be expected in rocks that are dominantly nonmarine. Thin-bedded sand and sandstone, clay, laminated carbonaceous shale, and lignite are characteristic of the formation. One fairly persistent sand member about 50 feet thick occurs in the lower part of the formation and crops out in Medina County. Both calcareous and siliceous concretions are common. Many of them are elongated or biscuit-shaped, and some of them reach dimensions of several feet. Some of the sandstone beds are locally indurated to quartzite. The clays are not uncommonly gypsiferous, and in many places the thin laminated shales and sands show a yellow coating of copiapite,[4] a sulphate of iron. Photographs of exposures of the upper part of the formation are shown in plate 3, *A* and *B*.

Thickness and dip.—The formation in Frio County is about 900 feet thick, as shown by the log of the Tribble well (no. 26, pl. 1; see p. 13), and it probably has about the same thickness in Atascosa County. The dip is variable, and there is no satisfactory means of determining it accurately. In northwestern Atascosa County dips of several degrees have been observed, but these are abnormal and related to the structure of the Somerset oil field. Well records indicate that the dip in the northern half of Atascosa County is about 110 feet to the mile. In the southeastern part of the county, however, the records of deep wells seem to indicate a somewhat greater dip. In western Atascosa County and in Frio County the dip is probably about 85 feet to the mile.

Fossil plants are abundant in the Indio formation. Marine fossils are not common but have been found in cuttings from wells in the formation in Dimmit County and in surface exposures in Bexar and Wilson Counties.

Topography and vegetation.—The topography of the outcrop area of the formation is varied, and the relief is greater than that of the outcrop areas of many of the other Eocene formations in this part of

[3] Deussen, Alexander, Geology of the Coastal Plain of Texas west of the Brazos River: U. S. Geol. Survey Prof. Paper 126, pp. 47-56, 1924. Trowbridge, A. C., Tertiary and Quaternary geology of the lower Rio Grande region, Texas: U. S. Geol. Survey Bull. 837, pp. 37-52, 1932. Getzendaner, F. M., Geologic section of Rio Grande embayment, Texas, and implied history: Am. Assoc. Petroleum Geologists Bull., vol. 14, p. 1434, 1930.

[4] Determination by C. S. Ross, communicated by Julia Gardner.

Texas. As the formation is generally sandy with harder ledges intercalated, a rolling hilly topography has developed in places. The sandy areas of the Indio outcrop commonly support a growth of oak and other trees, but the shale areas are usually covered with chaparral.

Sections.—The best surface exposures of Indio strata in Atascosa County are found southeast of Lytle, in the banks of the Atascosa River. Sections in the lignite mines in Medina County near Lytle were recorded by Dumble and are still available. These mines have been closed for many years. Other mine sections have been supplied by mine owners. A number of sections of the Indio from mines and surface exposures are given below:

Sections of Indio formation

Carr mine, 1½ miles west of Lytle, Medina Connty [5]

	Feet
Brown sand with concretions of sandstone	10
Yellow laminated clay with small boulders	10
Laminated yellow-gray sand with black clay or lignitic partings; micaceous and very friable	12
Lignite	12
Gray clay, floor of mine.	

Riley mine, 2¼ miles west of Lytle, Medina County [6]

	Feet
Yellow laminated clay	15
Laminated medium-grained micaceous gray sand	20
Yellow micaceous sand with ferruginous streaks	20
Yellow-gray laminated micaceous sand with streaks of black clay or lignite	30
Lignite	5–8
Gray clay	10

0.1 mile east of Benton, Atascosa County

	Feet
Buff to reddish sandy soil	2
Calcareous cross-bedded sandstone with ferruginous laminations	4
Gray micaceous friable sand	5

In banks of Atascosa River 1.3 miles south of Benton, Atascosa County

	Feet
Ferruginous clayey soil	2
Sandy ferruginous mottled clay with seams of ferruginous gravel	11
Red ferruginous sand and gravel	2⅔
Chocolate-brown sand and clay, weathering white to yellow	6
Micaceous shaly siliceous sandstone	4
Chocolate-brown clay with copiapite stains	7

On Atascosa River 1 mile south of Benton, Atascosa County

	Feet
Red ferruginous micaceous sand	2
Grayish-yellow micaceous sand, loosely cemented	3
Cross-bedded yellow loosely cemented sand	4
Red ferruginous micaceous sand	1
Chocolate-brown clayey sand, weathering white to yellow	6
Micaceous shaly sandstone	4
Chocolate-brown gypsiferous clay with copiapite stains.	

[5] Dumble, E. T., Geology of southwestern Texas: Am. Inst. Min. Eng. Trans., vol. 33, p. 925, 1903.
[6] Communicated by J. F. Riley.

Water supply.—In the northern part of the area the Indio formation underlies the surface at depths that can readily be reached by wells. There are, however, only a few records of such wells available. According to A. N. Sayre, who has made an investigation of the geology and ground-water resources of Uvalde and Medina Counties, all wells in the Indio of which records were obtained in southeastern Medina County yield small quantities of water, some of which is highly mineralized.

CARRIZO SAND [7]

Areal extent.—The Carrizo sand crops out in the northern parts of Atascosa and Frio Counties and the southern part of Medina County. The outcrop area increases in width from west to east. In northwestern Frio County and southwestern Medina County it is about 4 miles wide, and in northern Atascosa County about 6 to 8 miles wide (pl. 1). The formation is unconformable on the Indio formation below.

Lithology and petrography.—The Carrizo sand consists almost entirely of sand but contains minor amounts of clay and lignite. The sands are on the average coarser and purer than those of any other formation in this area. The formation is generally salmon-pink, brick-red, or brown where exposed in road cuts or other openings, but it may be uncolored in fresh exposures in sand pits and is generally bleached to a yellow or white in the top soil. Usually the sand is poorly cemented, with little or no matrix, and most specimens of the formation can be pulverized between the fingers. In Atascosa and Frio Counties no one portion of the formation is persistently coarser than another. Thus near the George Blackaller ranch house, in northern Frio County, the sand at the top of the formation is very coarse, but the same is true of the sand in the basal parts of the formation in other localities. Cross-bedding is highly developed in the formation. (See pls. 4, *A*, and 5, *A*.)

The sand is in general, only slightly micaceous, but nearly every specimen will yield a small amount of mica. The mica flakes are larger than those found in other Eocene formations and seem to be more abundant in Atascosa County than in Frio County. In contrast with many of the other Eocene sands the Carrizo sand is not gypsiferous nor calcareous and contains only small amounts of iron-bearing minerals. Sand from wells in the Carrizo is usually a nearly colorless sparkling aggregate of various-sized quartz grains, at once distinctive and of an attractive appearance.

[7] For original description of Carrizo sand see Owen, J., Report of geologists for southern Texas: Texas Geol. and Min. Survey First Rept. Progress, for 1888, pp. 69–74, 1889. Additional descriptions of the formation in southwestern Texas are given by Deussen, Alexander, op. cit., pp. 56–59; Trowbridge, A.C., op. cit., pp. 52–65; Getzendaner, F. M., op. cit., pp. 1434–1435; and Vaughan, T. W., Reconnaissance in the Rio Grande coal fields of Texas: U. S. Geol. Survey Bull. 164, p. 45, 1900.

Clay is present in the formation either as thin lenticular beds or as nodular lumps surrounded by sandstone. The shale lenses are seldom seen at the surface but are recorded in well records and seen in well samples. The clay lumps can be seen in every shallow pit in the Carrizo sand in Atascosa and Frio Counties. They vary from the size of a pea up to 1 foot in diameter and consist of light-gray plastic clay or sandy clay. Much of this material is bentonitic, and it is possible that the clay lumps were originally of volcanic origin. Lignite in the Carrizo has been reported from a few oil and water wells.

The Carrizo sand has been considered nonmarine. It is composed of wind-blown sand and apparently represents a fossil sand-dune area of remarkable persistence and uniformity. The shale beds are usually nonmarine and represent lagoon or lake deposits.

Petrographic analyses of Carrizo sands are given in the table below. The samples analyzed were selected to show the variations in mechanical composition. Nos. 9 to 13 represent the very coarse sand found at a number of localities: the others represent finer-grained sands.

Petrographic analyses of samples of Carrizo sands

No.	Percentage of grains of different sizes (millimeters)							Percentage of grains of different shapes				Light minerals [a]				Heavy minerals [a]												
	More than 2	2 to 1	1 to 0.589	0.589 to 0.295	0.295 to 0.147	0.147 to 0.074	Less than 0.074	Rounded	Fairly well rounded	Subangular	Angular	Quartz	Microcline	Plagioclase	Chalcedony	Zircon	Rutile	Tourmaline	Magnetite	Cyanite	Staurolite	Apatite	Garnet	Titanite	Muscovite	Biotite	Chlorite	Xenotime (?) [b]
1	------	--------	--------	4.01	54.43	27.52	13.47	12	48	34	6	VA	-----	R	A	A	R	C	VA	R	R	----	----	----	R	----	----	C
2	------	--------	--------	--------	9.23	8.55	81.32	6	35	39	20	VA	-----	R	A	A	R	C	C	C	C	----	----	----	----	----	----	C
3	------	--------	--------	11.43	51.84	27.25	9.10	6	32	44	18	VA	-----	R	A	A	R	C	C	C	C	R	R	----	C	----	----	C
4	------	--------	--------	2.36	62.93	23.57	10.03	9	50	25	16	VA	-----	R	A	A	C	C	A	C	----	R	R	----	R	----	----	C
5	------	--------	--------	3.84	40.88	45.59	8.22	11	46	36	7	VA	-----	R	----	----	----	----	R	C	C	----	----	----	R	----	----	R
6	------	--------	--------	6.67	71.66	17.77	3.46	6	50	33	11	VA	-----	R	A	A	C	C	R	R	R	----	R	----	C	C	----	C
7	------	--------	.60	3.20	51.05	36.03	8.94	7	29	55	9	VA	-----	R	A	A	C	C	R	R	R	----	----	----	R	R	----	C
8	------	--------	--------	1.77	54.51	34.39	8.35	8	32	40	20	VA	-----	R	A	A	C	C	R	C	R	R	R	R	C	C	----	C
9	3.70	5.83	17.30	50.48	17.42	2.49	2.43	8	12	32	48	VA	R	R	A	A	R	----	A	C	----	----	----	----	C	C	R	C
10	4.30	13.05	50.33	21.41	5.19	3.17	2.48	11	40	41	8	VA	-----	R	A	C	R	C	R	----	----	----	----	----	----	----	----	R
11	.44	1.40	24.22	65.94	3.96	1.11	2.52	4	23	57	16	VA	-----	R	A	C	R	C	R	R	----	----	----	----	R	R	----	R
12	.23	.12	1.50	26.98	63.56	4.00	3.29	10	51	27	12	VA	-----	R	A	C	R	C	C	R	R	----	----	----	R	R	----	C
13	2.78	2.95	13.86	36.04	35.84	7.50	1.00	10	40	44	6	VA	-----	R	A	C	C	C	C	-----	-----	----	R	----	R	R	----	C

[a] VA, Very abundant; A, abundant; C, common; R, rare. Refer only to relative amounts in light or heavy concentrate. Heavy concentrate contains considerable amounts of opaque nonmetallic grains thought to be composed of minerals listed but with opaque film. Part of this material may be leucoxene.

[b] Xenotime(?), a wine-colored uniaxial mineral resembling zircon but softer, usually occurs as rounded grains.

Thickness and dip.—The Carrizo sand ranges in thickness from about 175 to 400 feet, according to well records, which, however, may not have been correlated with complete accuracy. The average thickness as estimated from surface exposures is about 325 feet. The dip is about 125 feet to the mile in southeastern Atascosa County, about 90 feet to the mile in central Frio County, and about 70 feet to the mile in western Frio County.

Topography and vegetation.—The topography developed on the Carrizo sand is distinctive. The relief is moderately high, and the general aspect is rolling. Streams are not common, and badland features result from rains. Small sand dunes occur in some localities. The excessively sandy character of parts of the outcrop area is shown in plate 5, *A*. The vegetation also is distinctive. It varies somewhat from eastern Atascosa County to western Frio County because of a material difference in the amount of rainfall. In Atascosa County and eastern Frio County live oak grows on the outcrop to the exclusion of other species except for a few mesquite and some low brush. Some hint of this type of vegetation is given in the background of plate 4, *B*. Between the trees the sandy soil supports a sparse growth of brush and grasses. In western Frio County the rainfall is materially less than in Atascosa County. Live oaks are found only near water, and the mesquite with some chaparral is dominant. The stand, however, is not dense but scattering. Consequently the area has an open park-like appearance, which is quite in contrast to that of the heavily brush-covered lands on adjacent formations. (See pl. 4, *A*.)

Sections.—Thick exposed sections of the Carrizo sand are rare, owing to the ease with which the formation is eroded. Exposures a few feet thick are found on the Atascosa River, in numerous sand pits, in road cuts, and along the Frio River. The best section noted is exposed in the bank of the Frio River 1 mile above the road crossing at the Woodward ranch (pl. 4, *B*), where 20 to 30 feet of massive cross-bedded coarse sand unconformably overlies thinner-bedded sand containing some shale and lignitic material. These beds belong to the lower part of the formation. Two sections which also represent exposures in the lower part of the formation are given below. The character of the formation as revealed in wells is shown in the well logs on pages 81–87.

Section of basal part of Carrizo sand 4 miles west of extension of lower Somerset-Benton road, Atascosa County

	Feet
Yellowish-buff sandy soil with numerous ferruginous shingles	3
Grayish-yellow coarse-grained, highly micaceous, loosely cemented sand	6
Grayish-white medium-grained well-cemented, slightly micaceous sand	5
Yellow ferruginous sand	2
Grayish-white medium-grained well-cemented, slightly micaceous sand	6
Reddish-buff coarse-grained well-cemented sand	5

Section of Carrizo sand along Atascosa River 4.1 miles south of Benton, Atascosa County

	Feet
Sandy yellow soil	8
Yellow fine-grained, slightly micaceous sand	6
Yellow compact coarse-grained micaceous sand with hard well-cemented ledges of sandstone, 6 to 8 inches in thickness	4
Coarse-grained micaceous compact sand that contains numerous different iron colors from purple to deep red	4

Many of the pits opened for road materials in Atascosa and Frio Counties afford excellent exposures of the Carrizo. The pits are shallow, as only the weathered surface sand is removed, the more firmly cemented, unweathered rock being left undisturbed. A pit on the Palo Alto road 2 miles south of the railroad crossing near Tarbutton, Atascosa County, is typical. Here a surface 100 by 100 feet is exposed in which the vertical range is not more than 18 inches. The predominating rock is a cross-bedded coarse salmon-pink sand containing irregular lumplike masses of light blue-gray sandy clay and interbedded with small amounts of flaggy to shaly sandstone. The coarse sand is loosely cemented. It shows small areas in which the quartz grains reach a maximum size of 4 millimeters, and it contains mica in large flakes. Thin layers of fine-grained light-gray sandstone are also exposed.

Well logs.—Logs of several wells that penetrate the Carrizo sand are given in the table on pages 81–87. Some of these logs are incomplete, the record of formations encountered below the Carrizo sand being omitted. A few of the logs are briefly discussed below.

162. This well is in northwestern Atascosa County 4 miles west of Rossville. It was drilled near the south boundary of the outcrop of the Carrizo sand and passed completely through it. The Carrizo is represented in the record from 83 to 485 feet, and consists entirely of sand and sandstone of variable degree of coherency. The beds encountered below 485 feet belong to the Indio formation and are composed chiefly of alternating shale and sandstone. The total depth of this well, an oil test, was 4,080 feet.

241. This well is in north-central Atascosa County 1½ miles north of Pleasanton. It gives a nearly complete section of the Mount Selman formation, as it was drilled at a point near the top of this formation. The Carrizo sand is shown from

1,200 to 1,515 feet. Here also the formation is seen to consist almost entirely of sand.

300. This well is in north-central Atascosa County, 2 miles southeast of Pleasanton, about 4 miles southeast of well 241. The Carrizo sand was encountered at 1,419 to 1,722 feet considerably deeper than in well 241. The well had a total depth of 1,722 feet. Coal was encountered at the bottom of the well, perhaps in the Indio formation but probably in the Carrizo sand, an occurrence not unknown elsewhere.

107. This well is in southern Frio County, 1¼ miles southwest of Derby. The first bed encountered in the well below surficial deposits belongs to a horizon estimated as about 100 feet below the top of the Mount Selman formation. The beds penetrated between 1,469 and 1,709 feet presumably belong to the Carrizo sand, and the shale and rock at the bottom of the well, between 1,709 and 1,760 feet may be Indio, but this is not certain. The beds logged above the Carrizo sand probably belong in part to the Bigford member of the Mount Selman formation, but the boundary between the formations is not shown.

26. An oil test well in northeastern Frio County, 6 miles northeast of Moore. This well was carefully drilled, and numerous cores were taken in the course of the drilling. The record is therefore very valuable as a basis for correlation of the many formations encountered. The Carrizo is present from 37 to 212 feet and consists largely of sand with two strata of lignite.

3. This well is in northwestern Frio County, 3 miles north of Frio Town. It was an oil test well and was drilled through the Carrizo sand into lower formations. The Carrizo was found from 65 to 248 feet and consisted largely of sand and sandstone. The well was drilled near the Carrizo-Bigford contact and passed through 65 feet of Bigford strata.

155. This well is in north-central Frio County, 4 miles southeast of Moore. It was drilled to a depth of 1,978 feet in an effort to obtain a flowing well. The beds between 530 and 931 feet, consisting of sand and sandstone, belong to the Carrizo.

22. This well is in north-central Frio County, about 3 miles southwest of Moore and 1¼ miles northwest of well 155 and was an oil test. The Carrizo sand was encountered in it between 498 and 880 feet, and the beds correspond closely in thickness and character with those found in well 155.

The logs on pages 81–87 give some idea of the variations in thickness and character of the Carrizo sand in different parts of the area. The thickness according to the well drillers ranges from 175 to 402 feet. In general the formation thickens down the dip and from west to east along the strike. The formation is composed dominantly of sand but contains thin beds of shale and lignite. Coarse white sands yield water most freely to wells.

Water supply.—The Carrizo sand, itself very permeable, is underlain by clay and shales of the Indio formation and overlain by clay of the Mount Selman formation. In the western part of Frio County the basal or Bigford member of the Mount Selman overlies the Carrizo, but farther east the Bigford has not been differentiated and the overlying beds are classed simply as Mount Selman. Partly as a result of this arrangement, water in the Carrizo sand is everywhere under artesian pressure except on the outcrop, and over a wide extent of territory the pressure is sufficient to bring the water to the surface.

A. UPPER PART OF INDIO FORMATION NEAR BENTON, ATASCOSA COUNTY.
Shows thin bedding.

B. ALTERNATING SANDS AND SHALES OF INDIO FORMATION IN BANKS OF ATASCOSA RIVER NEAR BENTON, ATASCOSA COUNTY.

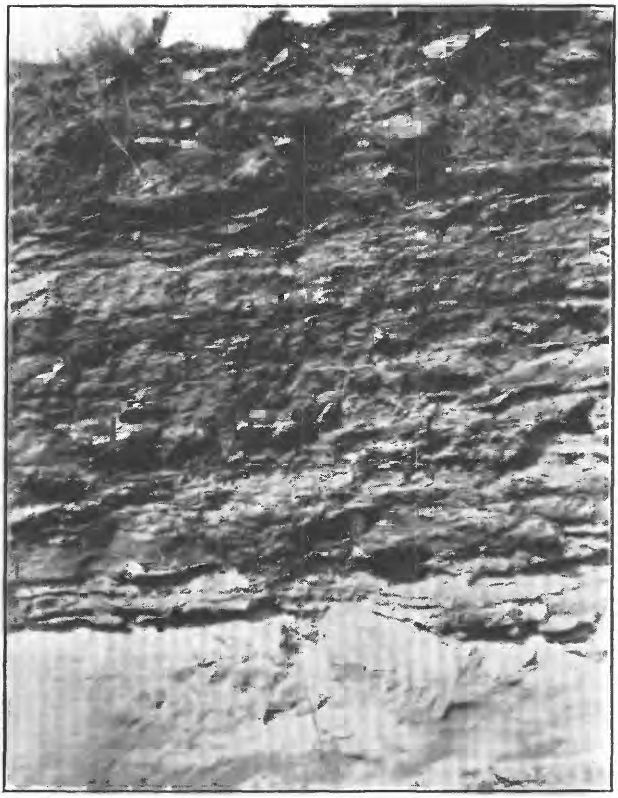
A. CROSS-BEDDED, COARSE-GRAINED CARRIZO SAND 3 MILES NORTH OF FRIO TOWN, FRIO COUNTY.

B. CONTACT OF CROSS-BEDDED CARRIZO SANDSTONE AND THIN-BEDDED UPPER PART OF INDIO FORMATION.

In bank of Frio River 1½ miles above road crossing at Woodward ranch.

A. PIT OF OSBORNE GRAVEL CO., 7 MILES NORTH OF POTEET, ATASCOSA COUNTY.

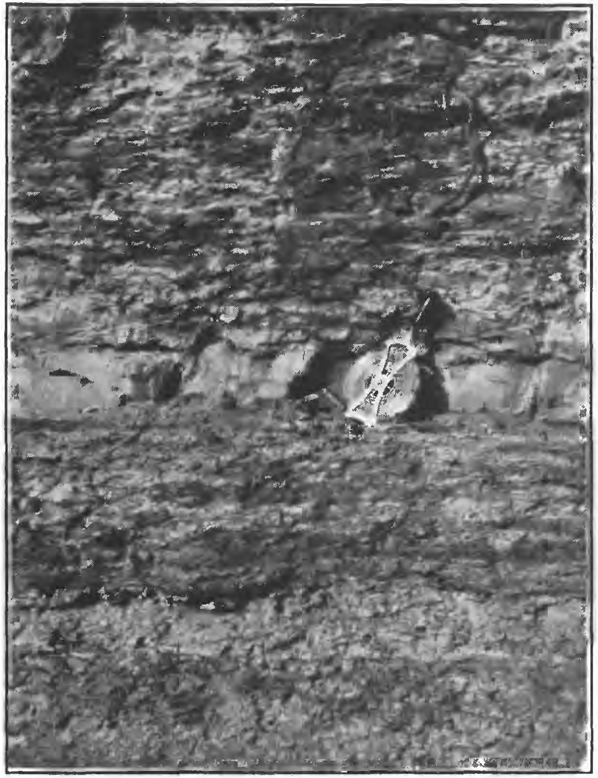
Carrizo sand is obtained from this pit for structural uses.



B. UPPER BEDS OF MOUNT SELMAN FORMATION 7½ MILES SOUTHEAST OF PEARSALL, FRIO COUNTY.

Shows a massive medium-grained porous sandstone overlain by fine thin-bedded highly ferruginous sandstones.

A. ALTERNATING BEDS OF SANDSTONE AND SHALY SANDSTONE IN LOWER PART OF MOUNT SELMAN FORMATION 1¾ MILES NORTHEAST OF ANCHORAGE, ATASCOSA COUNTY.



B. ALTERNATING SANDS AND SHALES IN LOWER PART OF COOK MOUNTAIN FORMATION ON THE BLUNTZER ROAD 5 MILES SOUTHWEST OF JOURDANTON, ATASCOSA COUNTY.

The maps show the outcrop of the Carrizo sand, the depths to the sand in localities south of the outcrop, the heights to which the water from the sand will rise, and the areas in which flowing wells can be obtained by drilling into it. Everywhere south or southeast of the outcrop the formation is encountered by wells but at greater and greater depths with increasing distance from the outcrop. The increase in the depth to the sand toward the south and southeast and the altitude above sea level to which water in the Carrizo sand would rise in 1930 are shown on plate 2. From this map it can be seen that the formation dips fairly uniformly away from the outcrop. The boundaries of the areas having the same range in depth are based on well records in which the Carrizo can be identified.

On the outcrop area water is obtained in wells at depths generally slightly more than 100 feet. These wells yield abundant supplies of water for domestic purposes. The water is essentially not under pressure in the outcrop area, because the upper surface of the saturated part of the formation is in permeable sand, where it forms a water table. A list of measured or estimated depths to the Carrizo sand in different parts of the area is given below.

Measured or estimated depths to the Carrizo sand in Atascosa and Frio Counties

	Feet
Near Leming	433
North edge of Poteet	670
3½ miles southeast of Poteet	1, 077
Pleasanton	1, 357
Bonita Valley orchards	1, 470
3 miles southeast of Pleasanton	1, 419
Jourdanton	1, 635
1 mile west of Hindes	1, 995
Campbellton	3, 600–3, 900
3 miles south of Moore	530
Pearsall	1, 134
Keystone ranch	1, 457
Derby	1, 340
Dilley	1, 975

Area of artesian flow.—The areas in which flowing wells may be obtained from the Carrizo sand are shown on plate 1. The north boundary of the area follows more or less closely the contours of surface altitude, and in the northern part of the area the flowing-well territory is restricted to the valleys. From plate 2 it is possible to determine for any locality both the approximate depth at which a well will encounter the Carrizo sand and the approximate altitude above sea level to which water in the well will rise.

Chemical character of the water.—The water from the Carrizo sand is the best in quality of all the waters of the area. The total amount of

101044—35——3

dissolved solids is generally less than 500 parts per million, except in the water drawn from the deeper wells, in which the total amount is generally less than 600 parts per million. Some of the samples from wells near the outcrop were unusually pure, containing less than 200 parts per million of total dissolved solids. The Carrizo waters generally contain some iron.

MOUNT SELMAN FORMATION [8]

In this report the Mount Selman formation is described in two sections, one on the basal or Bigford member and the other on the remainder of the formation. In previous reports the Bigford deposits have been treated as a distinct formation and included in the Wilcox group, but because of the accumulating evidence that they are of Claiborne age, they are here treated as a local member of the Mount Selman formation, with which they are included on the geologic map of Texas published in 1932. They are considered by Julia Gardner to be contemporaneous with but not exactly equivalent to the Reklaw of eastern Texas, from which they differ lithologically and with which they are not directly connected.

BIGFORD MEMBER [9]

General features.—The Bigford member of the Mount Selman formation crops out in northern Frio County. Its outcrop area is shown on plate 1 as extending from the west boundary of the county eastward to the International-Great Northern Railroad near Moore. Farther east the presence of the member is problematic, but in northeastern Frio County and in northern Atascosa County beds that are similar lithologically to those of the Bigford in other localities crop out and may belong to the member. Getzendaner [10] has stated that the Bigford is present as far east as Bigfoot, in northeastern Frio County. This statement is based on the presence of a sandstone (the Mills bed of Getzendaner), which has been definitely identified by the writer as far east in Frio County as Seco Creek. Somewhat similar sandstones occur in the Mount Selman formation in north-central Frio County, and it is felt that insufficient detailed work has been done to be certain of the correlation of the formations around Bigfoot. Accordingly east of the International-Great Northern Railroad the Bigford member is not differentiated from the rest of the Mount Selman, and statements with regard to water-supply conditions mention only the Mount Selman. The line of separation

[8] For original description see Kennedy, William, A section from Terrell, Kaufman County, to Sabine Pass on the Gulf of Mexico: Texas Geol. Survey 3d Ann. Rept., pp. 52–54, 1892. Additional descriptions of the formation in southwestern Texas are given by Deussen, Alexander, op. cit., pp. 60–64, and Trowbridge, A. C., op. cit., pp. 81–104.

[9] For original description see Trowbridge, A. C., op. cit., pp. 65–80.

[10] Getzendaner, F. M., op. cit., pp. 1436–1437.

between the Bigford member and the rest of the Mount Selman is drawn with difficulty because of similar lithologic character.

Lithology.—The Bigford is composed dominantly of dark to buff clays with thin sandstones and thin limestones, a small amount of volcanic ash, and impure lignite. Calcareous concretions are common and form good markers for the lower part of the member. The Mills bed of Getzendaner is an especially distinctive bed of the member in Zavala County and the western part of Frio County. It is unlike other sandstones in the Bigford member, though similar to certain local sandstones in the overlying beds of the Mount Selman. It is a fine-grained noncalcareous, fairly well cemented sandstone, grayish white, but showing pink, lavender, and purplish tints in hand specimens. It carries an abundance of plant remains, both leaves and stems. The stems are usually about a quarter of an inch in diameter and resemble sedges. Good outcrops of this bed are found along the Bigford escarpment in northern Frio County.

Thickness.—The thickness of the Bigford member is variable. It is difficult to recognize the member in well records. In western Frio County it is probably 300 feet thick, but it may pinch out toward the east.

Paleontology.—Fossils, except plants, are not abundant in the Bigford. Poorly preserved oysters and various mollusks are occasionally found, but no guide fossils for the member have yet been described.

Topography and vegetation.—The outcrop area of the upper part of the Bigford member is one of moderate relief, but in that of the basal part the relief is commonly stronger. In the basal part of the section resistant sandstones are present and form northward-facing escarpments. These are especially well developed in northern Frio County on the John J. Little ranch. The vegetation is the common assemblage of chaparral but is usually thicker than that on either the Carrizo or the overlying beds of the Mount Selman formation.

Water supply.—The Bigford member does not yield much water to wells, and the water is in general highly mineralized.

POST-BIGFORD BEDS

Areal extent.—The post-Bigford part of the Mount Selman formation crops out in a belt of variable width extending across both Atascosa and Frio Counties. (See pl. 1.) It rests unconformably on either the Bigford member or the Carrizo sand and is conformable beneath the Cook Mountain formation.

Lithology and petrography.—The beds are composed of gray, brown, and yellow sandstone, white, yellow, and brown clay, lignite, concretions of limonite and limestone, gypsum, altered volcanic ash, and small amounts of glauconite. The lignite beds are not important commercially in Atascosa and Frio Counties, though some mining of them has been attempted in the past. In Frio County the beds are divisible into a lower clay member and an upper sand member, but their character changes along the strike, and in Atascosa County they consist largely of alternating sand and clay beds. The sandstones are usually lenticular and are in many places indurated to quartzites. However, east of Pearsall rather persistent beds of sandstone are found in the upper part of the formation. (See pl. 5, *B*.) Some of the sandstone beds resemble fairly closely the Mills bed of Getzendaner in the Bigford member. These are found 4 miles east of Pearsall on the Charlotte road, near Navarro School in Atascosa County, and at other places. Altered volcanic ash is also present in the lower part of the beds. Exposures of this material are found 4 miles east of Pearsall and east of Leming. Glauconitic beds occur in the lower part and are usually marked by highly ferruginous outcrops and soils. Plate 6, *A*, shows alternating sandstones and shaly sandstones in the lower part of the beds.

Petrographic analyses of samples of Mount Selman sands are given in the table below.

Petrographic analyses of sandstones from Mount Selman formation

No.	Percentage of grains of different sizes (millimeters)							Percentage of grains of different shapes				Light minerals [a]			Heavy minerals [a]												
	More than 2	2 to 1	1 to 0.589	0.589 to 0.295	0.295 to 0.147	0.147 to 0.074	Less than 0.074	Rounded	Fairly well rounded	Subangular	Angular	Quartz	Plagioclase	Chalcedony	Zircon	Rutile	Tourmaline	Magnetite	Cyanite	Staurolite	Apatite	Garnet	Muscovite	Biotite	Chlorite	Xenotime (?) [b]	Pyrite
1	------	------	------	------	9.70	69.35	20.55	5	35	39	21	VA	R	A	C	R	------	R	------	------	------	------	------	------	------	R	------
2	------	------	------	------	3.96	86.40	9.01	5	40	43	27	VA	R	A	C	R	C	R	R	------	------	------	C	------	------	R	------
3	------	------	------	------	58.60	38.64	2.39	12	35	43	10	VA	R	C	C	C	C	A	C	------	R	R	C	C	R	R	------
4	0.61	0.50	0.89	1.14	22.20	64.60	9.81	12	35	39	14	VA	R	C	A	C	A	A	C	------	R	C	------	C	R	C	------
5	------	------	------	------	13.25	69.31	16.62	18	35	34	13	VA	R	C	A	C	A	C	C	R	------	R	C	C	R	C	C

[a] VA, very abundant; A, abundant; C, common; R, rare. Refer only to relative amounts in light or heavy concentrate. Heavy concentrate contains considerable amounts of opaque nonmetallic grains thought to be composed of minerals listed but with opaque film. Part of this material may be leucoxene.

[b] Xenotime (?), a wine-colored uniaxial mineral resembling zircon but softer, occurs as rounded grains.

1. Mount Selman sandstone 1¾ miles north of Anchorage, Atascosa County.
2. Mount Selman sandstone on Rossville-Poteet road 3 miles west of Palo Alto road, Atascosa County.
3. Mount Selman sandstone 4 miles west of Derby, Frio County.
4. Sample from Mrs. L. Hornsby well, 1½ miles southwest of Pearsall, Frio County.
5. Sample from F. Whitman well, 1 mile northwest of Derby, Frio County.

Thickness.—The post-Bigford beds vary in thickness along both the strike and the dip. The average thickness as determined from the outcrops in Atascosa and Frio Counties is probably around 700 feet, but a much greater thickness is indicated in wells. At Pearsall the top of the Carrizo is found at a depth of 1,134 feet in wells. Even after allowing for dip and the presence of the Bigford member, there still must be as much as 900 feet of post-Bigford Mount Selman beds in the wells. Even greater thicknesses are shown in records of wells farther down the dip.

Paleontology.—Fossils of Claiborne age are sometimes found in the post-Bigford beds of the Mount Selman formation but are not abundant. Deussen [11] has listed *Venericardia planicosta* Lamarck, *Plejona petrosa* Conrad, and *Cornulina armigera* (Conrad). Trowbridge [12] added to this list *Cytherea* sp., *Protocardia* sp., and a number of plant fossils.

Topography and vegetation.—The outcrop area exhibits a moderately well developed relief. On clayey parts of the formation the country is rather monotonously level, but on the upper part, which contains resistant sandstones, the topography is marked by numerous isolated hills. These are seen southeast of Pearsall and in much of northwestern Frio County. The vegetation is chaparral not greatly different from that developed on the Bigford member.

Sections.—Sections of the post-Bigford part of the Mount Selman formation are given below.

Sections of post-Bigford part of Mount Selman formation

1¾ miles north of Anchorage, Atascosa County

[This section is near the base of the post-Bigford part of the formation and is one of the best exposures in Atascosa County.]

	Ft.	in.
Red sandy, clayey soil	1	1
Red ferruginous concretions of sandstone		4
Red clay	1	6
Ferruginous red sand		6
Loose grayish-yellow, very fine sand	2	
Ferruginous reddish sandstone with an abundance of small clay concretions		2
Loose ferruginous sand		1
Fine-grained massive well-cemented sandstone	1	1
Loose grayish yellow, very fine sand		3
Gray gypsiferous clay	1	
Well-cemented fine-grained yellow sandstone	1	
Concealed by road	2	
Grayish-white gypsiferous clay	2	
Laminated sand, interbedded with a ferruginous gypsiferous clay	2	
Lignitic grayish brown sandy clay	1	5

[11] Deussen, Alexander, op. cit., p. 60.
[12] Trowbridge, A. C., op. cit., p. 85.

Sections of post-Bigford part of Mount Selman formation—Continued

1¾ miles north of Anchorage, Atascosa County—Continued

	Ft.	in.
White compact sand	3	6
Alternating yellow clayey sand and brown ferruginous sand 2 to 3 inches thick	2	3
Gray gypsiferous lignitic clay with ferruginous lignitic layers 2 to 3 inches thick	2	

On Poteet-Rossville road 3 miles west of Palo Alto road, Atascosa County

	Ft.	in.
Reddish-buff sandy clay soil	1	
Reddish-buff clay	1	6
Ferruginous sandstone concretions		6
Reddish-buff clay		6
Fine- to coarse-grained loosely cemented micaceous sandstone with ferruginous concretions ranging in size from 1 to 4 inches	3	
Yellowish ferruginous micaceous loose sand with silicified ferruginous bands ⅛ to ¼ inch thick	2	
Reddish-buff clay	1	
Yellow micaceous loose fine-grained sand		

At abandoned lignite mine 1½ miles south of Poteet, Atascosa County

[This section is near the middle of the formation and shows more clay than most sections.]

	Ft.	in.
Sandy yellow-white soil	1	
Yellow calcareous clay	3	
Yellow coarse-grained sand	2	
Yellow-grayish lignitic micaceous clay	4	
Lignite	3	6
Grayish clay	2	

On Frio Town road 5 miles north of Pearsall, Frio County

	Ft.	in.
Soil, caliche, and gravel	3	6
Gray fine-grained sandstone in beds as much as 8 inches thick alternating with thin sandy shale beds	8	
Gray fine-grained massive sandstone	3	

In all these sections weathering has modified the appearance of the Mount Selman strata. Fresh unweathered well samples from the middle part of the formation from a water well at Pearsall are described below.

Description of samples of drillings from F. C. Mangold well, Pearsall, Frio County

	Feet
Light-gray, very fine grained micaceous friable sandstone. Minerals present are quartz, muscovite, chalcedony, zircon, microcline, plagioclase, rutile, pyrite, xenotime?, and magnetite	22
Yellowish-buff friable fine-grained micaceous shaly sandstone with calcareous and argillaceous concretions as much as a quarter of an inch in diameter. Minerals are quartz, chalcedony, blue tourmaline, zircon, xenotime?, microcline, plagioclase, magnetite, green tourmaline, pyrite, and muscovite	42–57

Description of samples of drillings from F. C. Mangold well, Pearsall, Frio County—Continued

	Feet
Chocolate-brown to black nonplastic lignitic clay with lenses of micaceous fine-grained sandstone and pyrite concretions. The sand lenses contain same minerals as samples above	57–59
Light chocolate-brown to gray sandy plastic clay	59–69
Lignite with sand lenses	69–85
Light-gray sandy plastic clay breaking with irregular fracture. Minerals as in previous samples	90–112
Earthy-gray fine-grained friable argillaceous sandstone. Minerals as above	112–114
Earthy-gray fine-grained friable argillaceous sandstone with lenses of lignite as much as ⅛ inch thick. Minerals as above	114–119
Light grayish-green friable argillaceous and calcareous sand with calcareous concretions. Minerals include staurolite and cyanite in addition to those listed in previous samples	119–125
Earthy-gray friable fine-grained micaceous sandstone with clay concretions and small amounts of lignite. Minerals as listed in sample from 22 feet	125–180

Well logs.—The logs of four wells in the Mount Selman formation are given in the table of well logs on pages 81–87 and are briefly discussed below.

The logs of the high school well (no. 64), at Pearsall, and the H. H. Page well (no. 40), 1¾ miles north of Pearsall, illustrate the stratigraphy in the vicinity of Pearsall, where there is considerable irrigation. The greater part of the irrigation wells are about 100 feet deep and encounter water sand at depths ranging from 65 to 85 feet. The water is under small artesian pressure and rises slightly above the top of the water sand. The high school and several other wells have been drilled to depths around 200 feet. Such wells generally failed to find an adequate supply of water at the upper horizon and were carried on down. It appears that the water sand supplying the shallow wells is restricted to a small area and is present as a lens with greatest thickness north and northeast of the town. Wells put down farther east and in localities south of Pearsall, though finding sands at comparatively shallow depths, have not yielded adequate supplies for irrigation.

The Oppenheimer & Lang well (no. 83) is in the valley of San Miguel Creek east of Pearsall. The well was started near the top of the Mount Selman formation. In a total depth of 860 feet 7 water-bearing sands were found, and the 2 lower ones furnished flowing water. Of the upper 330 feet 242 feet was composed of beds of a sandy nature, if not of pure sand.

The C. S. Young well (no. 251) started in the Cook Mountain formation and was drilled nearly to the Carrizo sand. The beds between 338 and 1,428 feet, composed of alternating sandstones and shale or gumbo, have been identified as Mount Selman. Water sands were encountered at depths of 745 to 760, 810 to 820, 931 to 951, 1,113 to 1,155, and 1,188 to 1,210 feet. The well indicates the character of the geologic section around Pleasanton, where there are many artesian wells in the Mount Selman formation ranging in depth from 300 to 850 feet.

Water supply.—Usually several water-bearing sandstones are encountered by wells in the post-Bigford part of the Mount Selman formation. These sandstones are interbedded with clays, and the water in them is under artesian pressure except in localities where they appear at the surface. As the stratigraphy of the formation is not constant over large areas the artesian strata are not continuous. The upper half of the formation contains more sand than the lower half, and in parts of the area it is an important source of water. Most of the artesian water thus far developed from the Mount Selman comes from the upper part of the formation. Thinner beds in the lower part ordinarily yield artesian water of poorer quality and in smaller amounts. A few wells in Atascosa County, however, yield large flows from the lower part.

Areas of artesian flow.—Plate 1 shows the area in which flows can be obtained from wells in the Mount Selman formation. This area is in the south-central and southeastern parts of Frio County and the south-central and southwestern parts of Atascosa County. For much of the southern and southeastern parts of Atascosa County the available data are incomplete, and it is possible to give only a general outline of the artesian area.

Chemical character of the water.—The waters in the Mount Selman formation have considerable range in chemical composition. The variations within the formation are in part directly related to the horizon from which the water is drawn and in part to the depth of the wells. Some of the wells are doubtless subject to inflow of water from the overlying Cook Mountain or Yegua formation, and this affects the chemical character of the water. The post-Bigford part of the Mount Selman varies lithologically along both the strike and the dip. The water obtained from the upper sandy beds is generally suitable for domestic use, and some of it is suitable for irrigation. The lower beds contain a relatively larger amount of clay, with alternating thin sand beds. The water from the lower clayey beds is generally of poorer quality, and much of it is not suitable for any use.

The shallow water near Pearsall and in the sandy areas east and south of Pearsall is generally of good quality, containing chloride and sulphate, with relatively small amounts of sodium carbonate and sodium chloride.

COOK MOUNTAIN FORMATION[13]

Areal extent.—The Cook Mountain formation crops out in Atascosa and Frio Counties in a belt whose entire width lies within the two counties. The line of contact between the Cook Mountain formation and the underlying Mount Selman formation enters Atascosa County south of Verdi and passes south of Pleasanton, 1½ miles north of Charlotte, and through the Keystone ranch, in Frio County. It crosses the Frio River southeast of Derby and thence passes westward

[13] For original description see Kennedy, William, op. cit., pp. 54–57. Additional descriptions of the formation in southwestern Texas are given by Deussen, Alexander, op. cit., pp. 64–75, and Trowbridge, A. C., op. cit., pp. 104–129.

to the Zavala County line. (See pl. 1.) Collections of fossils from certain localities north of the Leona River in Frio County were identified as Cook Mountain by Julia Gardner. These localities are isolated outliers of the Cook Mountain and are not shown on plate 1. Such exposures are due to an anticline or nose present in this region, and most of them are on its north flank, some of them exhibiting north or reverse dip.[13a] At a point 3½ miles northeast of the Corey ranch about 60 feet of Cook Mountain beds are present with a dip of more than 2° N. This locality is highly fossiliferous. Directly south of the locality along the Leona River typical Mount Selman sand is exposed. Other Cook Mountain localities north of the Leona include Catarina Hill, Oyster Hill on the Loxton ranch, and the English Hills, in all of which the Cook Mountain strata cap the hills. Cook Mountain rocks are probably present on Berry Creek southwest of the Loxton ranch and on Little Yoledigo Creek southeast of the Taylor ranch. The formation is conformable both above and below.

Lithology and petrography.—The formation consists of sandstone, gypsiferous clay, impure limestone, and lignite. Much of the sandstone is glauconitic and contains considerable quantities of cone-in-cone concretions. The formation varies considerably in lithologic character along the strike. In eastern Atascosa County it consists largely of alternating beds of gypsiferous clay and glauconitic sandstone, with boulders of fossiliferous indurated calcareous sandstone. West of the general region of Pleasanton the lower part of the formation consists largely of glauconitic sandstone, in many places fossiliferous, with only a little clay. The greatest development of the basal glauconitic sandstone is in Frio County, where all of the Cook Mountain area except the southeast corner of the county is underlain by this rock. To the east the area underlain by the basal sandstone becomes progressively narrower until the sandstone is no longer observable near Pleasanton. Its absence east of Pleasanton is probably due to overlap or a gradation of the sandstone into the alternating clay and sandstone section above. In areas underlain by the sandstone brick-red loamy soils are developed, but where clay is the predominant constituent the formation produces black soils.

The contact of the formation with the Mount Selman in western Atascosa County is obscured by large areas of loose sand. Banks Hill, just west of the county boundary, and another area near Tobey are probably outliers of the formation and are not shown on the map.

The sandstones of the formation are generally glauconitic, though some samples are entirely free from glauconite. In some exposures the glauconitic material is calcareous and takes the character of an impure marly limestone. Petrographic analyses of sands from the formation are given below.

[13a] See footnote, p. 13.

Petrographic analyses of sandstones from Cook Mountain formation

No.	Percentage of grains of different sizes (millimeters)							Percentage of grains of different shapes				Light minerals [a]				Heavy minerals [a]											
	More than 2	2 to 1	1 to 0.589	0.589 to 0.295	0.295 to 0.147	0.147 to 0.074	Less than 0.074	Rounded	Fairly well rounded	Subangular	Angular	Quartz	Plagioclase	Glauconite	Chalcedony	Zircon	Rutile	Tourmaline	Magnetite	Cyanite	Staurolite	Garnet	Muscovite	Biotite	Chlorite	Xenotime [b]	Microcline
1	-----	-----	-----	-----	6.69	82.01	10.67	15	40	25	20	A	C	A	A	A	C	C	C	C	-----	R	A	A	-----	-----	-----
2	-----	-----	1.64	22.53	44.85	20.73	9.26	30	42	20	8	A	R	A	A	A	C	C	C	C	C	-----	C	C	-----	-----	-----
3	-----	-----	-----	-----	8.41	62.60	28.21	4	31	44	21	VA	C	A	A	A	C	C	C	R	R	-----	R	R	-----	-----	-----
4	-----	-----	-----	3.41	73.94	14.43	7.30	12	45	30	12	VA	C	-----	A	A	C	C	R	C	C	R	C	C	-----	-----	-----
5	2.38	0.69	1.61	2.61	31.42	56.73	4.33	28	33	24	15	VA	C	-----	A	A	C	C	VA	R	R	C	R	R	R	C	R

[a] VA, Very abundant; A, abundant; C, common; R, rare. Refer only to relative amounts in light or heavy concentrate. Heavy concentrate contains considerable amounts of opaque nonmetallic grains thought to be composed of minerals listed but with opaque film. Part of this material may be leucoxene.

[b] Xenotime (?), a wine-colored uniaxial mineral resembling zircon, but softer, usually occurs in rounded grains.

1. Cook Mountain sandstone 6.2 miles northeast of Pleasanton, Atascosa County.
2. Cook Mountain sandstone 4.7 miles southeast of Pleasanton, Atascosa County.
3. Cook Mountain sandstone half a mile south of Pleasanton, Atascosa County.
4. Cook Mountain sandstone 3 miles southeast of Derby, Frio County.
5. Sample from W. D. Morrison well, Dilley, Frio County.

Thickness and dip.—The thickness of the Cook Mountain formation ranges from 600 to 900 feet; the maximum thickness is found in wells. The beds dip southeastward at an average rate of about 115 feet to the mile.

Paleontology.—Fossils are very abundant in the formation. These are found in lenses and ledges of impure glauconitic limestone which are scattered through the formation. Detailed lists of fossils of the formation have been given by both Deussen [14] and Trowbridge [15] and are not repeated here.

Topography and vegetation.—The topographic expression of the Cook Mountain outcrop area varies with the lithology. The areas underlain by sandstone are generally rolling and have moderate relief; the less sandy parts of the formation are also rolling but have slight relief. A considerable part of the formation is sandy, and its outcrop area commonly supports open chaparral brush with scattered large live oaks. Mesquites are generally larger than those growing on other formations.

Sections.—Many small sections of the Cook Mountain formation are found throughout the area, although, in general, the formation is better exposed in Atascosa County than in Frio County. Sections from three localities in Atascosa County are given below.

Sections of Cook Mountain formation

On Pleasanton-Campbellton road half a mile south of Pleasanton, Atascosa County

[This section represents the lower 150 feet of the formation. It is compiled from a hillside section, and doubtless there are small gaps in it.]

	Ft.	in.
Brownish glauconitic sandy soil	1	3
Ledge of calcareous fossiliferous sandstone, extending laterally for 60 feet		5
Compact fossiliferous brown glauconitic sand		2
Gray gypsiferous clay with ferruginous streaks not more than a quarter of an inch thick	1	
Ledge of nonfossiliferous calcareous concretions		3
Fossiliferous brown glauconitic sand		2
Gray gypsiferous clay with numerous ferruginous streaks	1	
Yellow sand		3
Gray gypsiferous clay with numerous ferruginous streaks	4	
Yellow very fine sand		7
Gray gypsiferous clay with numerous ferruginous streaks	3	6
Yellow very fine fossiliferous glauconitic sand	1	
Gray gypsiferous clay with ten lenses of yellow sand	1	1
Yellow-purple sand, nonfossiliferous and nonglauconitic; contains many purple streaks		8
Gray gypsiferous clay with ferruginous streaks		2
Yellow laminated sand		3

[14] Deussen, Alexander, op. cit., pp. 64-65.

[15] Trowbridge, A. C., A geologic reconnaissance in the Gulf Coastal Plain of Texas near the Rio Grande: U. S. Geol. Survey Prof. Paper 131, pp. 95-96, 1923.

Sections of Cook Mountain formation—Continued

On Pleasanton-Campbellton road half a mile south of Pleasanton, Atascosa County—Continued

	Ft.	in.
Gray gypsiferous clay with a lignite layer half an inch thick		4
Yellow-grayish very fine sand		5
Lignitic layer		2
Gray gypsiferous clay		2
White very fine sand		6
Yellow very fine sand		8
Gray gypsiferous clay	2	

On Bluntzer road 5.1 miles southwest of Jourdanton, Atascosa County

	Ft.	in.
Reddish-brown clayey soil, containing numerous small pebbles and gravel	3	4
Ferruginous sandy clay containing elongated limonite concretions ½ to 1 inch in diameter		3
Brownish-red compact sand containing fossils and small clay concretions	1	4
Black lignitic clay with particles of hard lignite		8
Gray gypsiferous clay containing numerous ferruginous streaks		4
Yellow loose sand		6
Gray gypsiferous clay containing ferruginous sandy streaks		4
Gray sand		5
Gray gypsiferous clay		2
Gray sand with purple tints		6
Gypsiferous gray clay with numerous ferruginous sandy streaks		9
Ferruginous sandy lens		3
Gray gypsiferous clay with numerous ferruginous sandy streaks	1	2
Gray fine-grained sand		9
Gray gypsiferous clay with numerous ferruginous clayey streaks	5	2
Fine-grained gray sand		11
Gray gypsiferous clay with numerous ferruginous clayey streaks		3

On Pleasanton-Floresville road, 5 miles northeast of Pleasanton, Atascosa County

	Ft.	in.
Blackish-red soil	2	
Gray gypsiferous clay		10
Brownish sandy clay, highly gypsiferous; contains streaks of sand lenses 2 to 3 inches in thickness	2	
Gray gypsiferous clay		10
Reddish-brown sand		6
Gray gypsiferous clay		5
Ferruginous gypsiferous clay		3
Gray gypsiferous clay		8
Light-brown sand		4
Gray gypsiferous clay	1	2

A part of the section on the Bluntzer road is shown in plate 6, *B*. An exposure of clay with calcareous concretions from the middle part of the formation is shown in plate 7, *A*.

No good sections of the upper part of the formation are exposed in this area. In the Dilley region, southwestern Frio County, many small exposures of the upper part of the formation are found in road cuts and on hills. The predominant rock type is a brick-red sandstone containing weathered glauconite and yielding a reddish sandy-loam soil. Throughout this area thin concretionary limestone beds are also found and are usually fossiliferous. The log of the C. M. Kelley well (p. 84) shows the character of the upper part of the formation as disclosed by well cuttings.

Well logs.—Logs of wells in the Cook Mountain formation in parts of the area were obtained, including the log of the C. M. Kelley well, near Hindes, 2,390 feet deep, and logs of three wells 280 to 370 feet deep near Dilley. Unfortunately few logs of wells in the formation are available except in the Dilley area.

The C. M. Kelley well (no. 114) is in extreme southeastern Frio County. It starts near the top of the Cook Mountain formation and penetrates to the Carrizo sand. The Mount Selman contact in this well is believed to be at 965 feet, but its correct location is somewhat problematic. The formation is composed of sand, clay, sandstone, and limestone. The sands penetrated by the well between 373 and 433 feet supply the shallow flowing wells at Hindes, and sands at the same horizon but at greater depths probably supply wells near Christine. The bottom of the formation is not notably sandy, and the most sandy facies of the lower part of the Cook Mountain are found in western Frio County.

The logs of wells near Dilley (nos. 122, 133, and 136) show the character of the Cook Mountain water-bearing sands in western Frio County. According to these and other available logs the sands range from 115 to 344 feet in thickness. It is possible that some of the extreme thicknesses recorded may represent beds that are generally sandy and water-bearing but contain minor amounts of clay or shale. The records indicate quite plainly, however, that there is a thick sand member at the base of the Cook Mountain near Dilley, which thickens to the southeast.

Water supply.—The water-bearing sands of the Cook Mountain formation are generally not continuous nor very thick, and in these respects they are comparable with the sands in the Mount Selman formation. The thickest and most persistent sands are in the lower half of the formation, and it is from these sands that most of the water is obtained. The water is usually under some artesian pressure, and a few flowing wells have been obtained in Atascosa County, but in most places the wells do not flow.

Irrigation has been developed with water pumped from wells in this formation in an area around Dilley, in Frio County. The largest pumped wells and the lands irrigated from them, together with flowing wells in the formation in Atascosa County on which reliable data were obtained, are shown on plate 1.

Chemical character of the water.—The water from the Cook Mountain formation is variable in character, but on the whole it is highly mineralized. The lower sandy portions of the formation yield the best water, some of which is suitable for domestic use and for irrigation on sandy soils with good drainage. It is difficult to find suitable water for domestic use in the upper clayey parts of the formation. Much of this water is very high in dissolved solids and is objectionable to the taste.

YEGUA FORMATION[16]

Areal extent.—The Yegua formation crops out in the extreme southeastern part of Frio County and in a belt several miles wide in Atascosa County extending from the vicinity of Hindes, on the southeast, through Christine to McCoy and on to the east boundary of the county. (See pl. 1.) In some previous reports on eastern Texas this formation has been called the †Cockfield formation,[17] but that name has now been dropped.

Lithology.—The formation is composed almost entirely of gray to yellowish or light-brown clay. Some slightly sandy clay, lignite, gypsum, limestone, and limestone concretions are also found. The gypsum is rather uniformly distributed through the clay as small crystals and grains of selenite. Lignite is present in beds that range from thin seams to beds of commercial thickness. The limestone concretions are yellowish and composed of dense compact limestone with a few veins of calcite. Cone-in-cone concretions in minor amounts are also found. The clays as a whole are carbonaceous, giving brown to blackish stains and seams in nearly every exposure.

Thickness and dip.—The Yegua formation is variable in thickness. In the outcrop area it is probably not more than 700 feet thick, but the logs of wells indicate that down the dip it is materially thicker. It has an average dip of about 150 feet to the mile.

Paleontology.—Fossils are not abundant in the formation, but occasionally large oysters are found.

Topography and vegetation.—The outcrop area of the Yegua is one of little relief. The topography is therefore in some contrast to that of the Cook Mountain below and the Jackson above, in which considerable relief is common. Seen from any higher point the country underlain by the Yegua appears as nearly a plain cut by shallow stream valleys. Drainage on the whole is poor, and marshy lands are not uncommon.

The vegetation is less prolific than that of the overlying and underlying formations, though partaking of the same general character.

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[16] For original description see Dumble, E. T., Report on the brown coal and lignite of Texas, pp. 124, 148-154, Texas Geol. Survey, 1892.

[17] 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.

Oaks are practically absent; mesquite and pricklypear are abundant but do not occur in dense thickets. The soils are generally deep and black, with scattered buff or reddish-buff areas.

Sections.—Few exposures of Yegua showing a greater vertical range than a few feet were found. Stream banks and road cuts yield the best exposures, and these indicate that the beds do not vary greatly in character from the bottom of the formation to the top. Sections near the base of the formation along the Pleasanton-Campbellton highway show typical brown gypsiferous clay with yellow concretions and some cone-in-cone structure. Similar exposures are found on the road from Jourdanton to Christine.

The best exposures are found along the Atascosa River for several miles above McCoy. These show only slight variation but are typical of the formation.

Section of Yegua formation on Atascosa River half a mile above bridge at McCoy, Atascosa County

	Feet
Sandy soil	2
Yellow sandy clay	3
Buff gypsiferous clay	7
Black gypsiferous clay	12
Chocolate-brown gypsiferous clay	9
Ledge of calcareous sandstone concretions	5

Section on Atascosa River 3 miles north of McCoy, Atascosa County

	Ft.	in.
Yegua formation:		
Sandy clay soil	3	
Gray gypsiferous clay	3	
Cook Mountain formation:		
Greensand		4
Brown gypsiferous sandy clay with yellow stains	7	
Black gypsiferous yellow-stained clay	3	

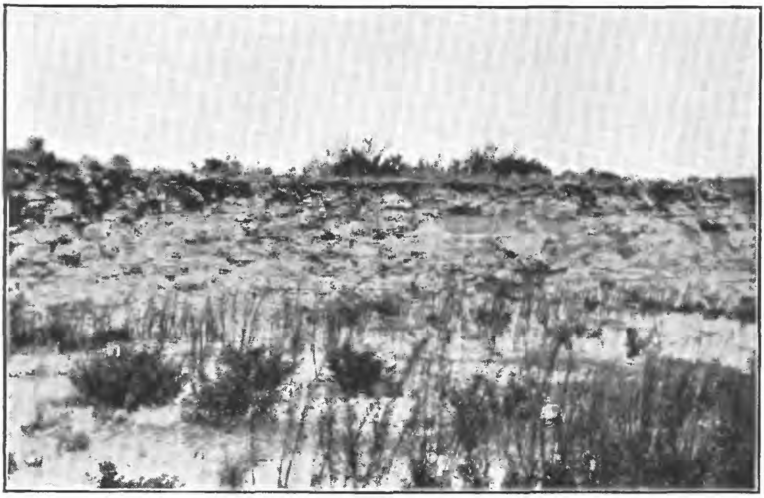
This section shows the contact between the Cook Mountain and Yegua. The greensand probably represents the top of the Cook Mountain formation.

The thickest lignite beds are found near the top of the formation. Northwest of Campbellton test pits showed several feet of the material over a considerable area. Just south of the Atascosa County line, near Cross Settlement, south of Christine, 15 feet of lignite is exposed in the bank of San Miguel Creek.

Chemical character of the water.—Most of the water from the Yegua formation is so highly mineralized that it is unsuitable for either domestic use or irrigation, though a few wells supply water that can be used. Most of the water is even unsuitable for livestock, as the stock generally refuse to drink it. Throughout the outcrop area of this formation domestic water supplies are obtained by storing rain water in cisterns or metal tanks.

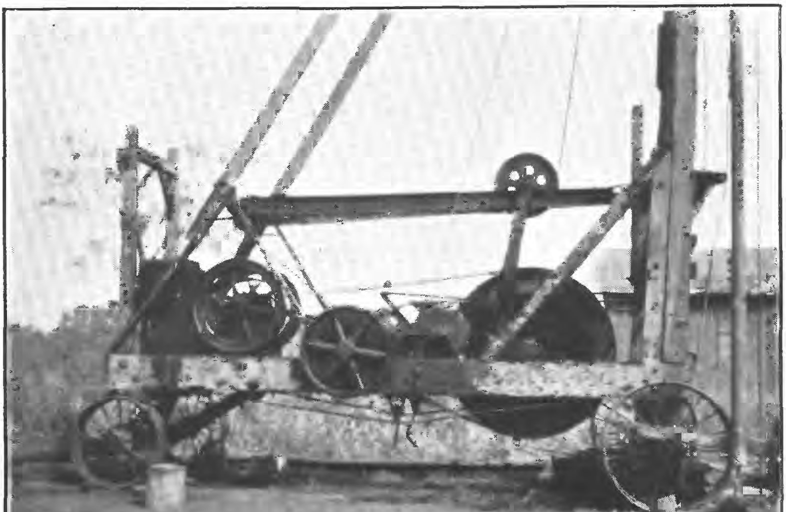
A. CLAYS WITH CALCAREOUS CONCRETIONS IN MIDDLE PORTION OF COOK MOUNTAIN FORMATION.

In bank of a creek about a fourth of a mile north of the exposure shown in plate 6, *B*.



B. THICK BEDS OF HARD JACKSON SANDSTONE IN A QUARRY AT ROCKVILLE, SOUTH OF CAMPBELLTON, ATASCOSA COUNTY.

A. ROTARY TYPE OF WATER-WELL DRILLING MACHINE.



B. PERCUSSION TYPE OF WATER-WELL DRILLING MACHINE.

JACKSON FORMATION[18]

Areal extent.—The Jackson formation appears at the surface only in southeastern and southern Atascosa County. The lower boundary line passes north of Fashing, north of Campbellton, and out of the county near Cross Settlement, in northern McMullen County. (See pl. 1.) None of the larger towns are located on the Jackson, and the area of outcrop is largely ranch country with minor amounts of farm land. The formation lies conformably on the Yegua formation and unconformably beneath the Catahoula tuff, which has overlapped the Frio clay.

Lithology and petrography.—The Jackson is composed of sandstone, quartzite, sandy clay, and volcanic ash. Much of the clay is carbonaceous or lignitic and hence chocolate-colored. The sandstone is generally gray to white, but a few beds are darker and weather to reddish soils. Many of the sandstones are thin-bedded. The beds of volcanic ash range from buff to white and are of variable thickness, the maximum being about 15 feet. They are usually partly altered to clay materials. The formation abounds in silicified wood and contains both calcareous and siliceous concretions, some of the former with cone-in-cone structure. Petrographic analyses of Jackson sands are given below.

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[18] In former reports and maps issued by the U. S. Geological Survey all beds of Jackson (upper Eocene) age in Texas were included in the Fayette sandstone. It is now recognized that the beds of Jackson age in this State cannot all be appropriately assigned to the Fayette. For this reason the Survey has recently substituted Jackson formation for the beds of Jackson age in Atascosa, Frio, and other counties in southern Texas.

Petrographic analyses of sands of Jackson formation

No.	Percentage of grains of different sizes (millimeters)				Percentage of grains of different shapes				Light minerals [a]			Heavy minerals [a]										
	0.589 to 0.295	0.295 to 0.147	0.147 to 0.074	Less than 0.074	Rounded	Fairly well rounded	Subangular	Angular	Quartz	Plagioclase	Chalcedony	Zircon	Rutile	Tourmaline	Magnetite	Cyanite	Staurolite	Apatite	Garnet	Titanite	Muscovite	Xenotime (?) [b]
1	5.72	62.05	19.30	12.25	10	55	27	8	VA	C	A	A	R	C	R	C	R	R	R	C	R	C
2	7.28	35.21	43.60	13.75	9	56	29	5	A	C	A	C	R	C	R	C	------	C	R	R	------	R

[a] VA, very abundant; A, abundant; C, common; R, rare. Refer only to relative amounts of light or heavy concentrate. Heavy concentrate contains considerable amounts of opaque nonmetallic grains thought to be composed of minerals listed but with opaque film. Part of this material may be leucoxene.

[b] Xenotime (?), a wine-colored uniaxial mineral resembling zircon but softer, usually occurs in rounded grains.

1, 2. Jackson formation half a mile south of C. T. Tom ranch house, Atascosa County.

Thickness and dip.—In Atascosa County the Jackson formation is about 450 feet thick, with some variation from place to place. The dip averages about 120 feet to the mile, but southeast of Campbellton much higher dips, due to local structural modifications, were observed.

Fossils.—The Jackson formation is locally fossiliferous. Many of the platy or flaggy sandstones of the lower part of the formation abound in fossils. The number of species is not great, but these are frequently present in great abundance. No detailed paleontologic studies of these fossils have been published, though *Ostrea georgiana* Conrad is commonly listed as a characteristic form. Fossil plants are likewise abundant in the formation.[18a]

Topography and vegetation.—The outcrop of resistant sandstone beds in the lower part of the formation is marked by a prominent escarpment or line of hills which is seen south of Campbellton and can be traced across Atascosa County (pl. 7, *B*). The extreme lower and upper parts of the formation are composed of softer beds, and where these appear at the surface the country is a rather featureless plain. The vegetation on the outcrop does not differ materially from that found on outcrop areas of adjacent formations.

Sections.—Excellent sections of the entire Jackson formation are found in southeastern Atascosa County. Some of the sections are given below.

Sections of Jackson formation

At Peeler ranch house, northwest of Campbellton, Atascosa County

[Basal part of formation.]

	Ft.	in.
Sandy whitish calcareous soil		2
Calcareous cone-in-cone, embedded in a coarse-grained yellow sand with numerous specimens of petrified wood	4	
Whitish-yellow coarse-grained sandstone, loosely cemented	1	6
Yellow coarse-grained sandstone, stratified with cone-in-cone	2	
Yellow sandy clay	2	

At quarry at Rockville, 6 miles south of Campbellton, Atascosa County

	Ft.	in.
Black clayey soil	1	6
Fine-grained indurated light-gray sandstone		8
Tuffaceous white shale		8
Fine-grained indurated light-gray sandstone	2	
Tuffaceous white shale		3
Fine-grained indurated light sandstone	9	
Fine-grained buff quartzite to present quarry floor	2	

[18a] A recent detailed subdivision of these beds is given in Ellisor, A. C., Jackson group of formations in Texas with notes on Frio and Vicksburg: Am. Assoc. Petroleum Geologists Bull., vol. 17, pp. 1293–1350, 1933.

Sections of Jackson formation—Continued

On prominent hill, 1¾ miles S. 40° E. of Campbellton, Atascosa County

	Ft.	in.
Fine-grained, well-cemented light-gray sandstone with ledges averaging 8 inches thick, weathering dark brownish red	20	
Tuffaceous white shale, with small ledges of nodular gray clay 1 to 2 inches thick	9	5
Fine-grained quartzitic ferruginous sandstone with ledges about 3 inches thick	12	
Tuffaceous white shale, with small ledges of nodular clay, both 2 to 4 inches thick	12	
Tuffaceous lignitic shale with a small ledge of fossiliferous sandstone	3	
Gray nodular clay		4
Loosely cemented coarse-grained yellowish-gray sandstone		6
Fine-grained ripple-marked sandstone		6
Gray nodular clay	4	
Stratified tuffaceous shale with layers of lignitic sandstone	2	
Sandstone		3
Tuffaceous chocolate-brown shale	2	
Gray nodular clay with layers of sandstone, sand, and tuff from 1 to 3 inches thick	13	

2 miles south of C. T. Tom's ranch house, Atascosa County

	Ft.	in.
Black clayey soil		8
Gray nodular chalky fossiliferous clay	2	
Gray nodular clay	4	
Fossiliferous tuffaceous sandstone		3
Gray nodular clay	4	

1¾ miles south of C. T. Tom's ranch house, Atascosa County

	Ft.	in.
Black soil		8
Laminated chocolate-brown sandy clay		4
Gray nodular clay		4
Laminated chocolate-brown lignite	1	1
Gray nodular clay	6	7

Water supply.—The water from the Jackson formation is variable in chemical quality. The sandstone from the lower part of the formation yields considerable quantities of water, some of which is suitable for use, but the higher beds generally yield water that is highly mineralized and is frequently unsuitable for use.

CATAHOULA TUFF [19]

The Catahoula tuff crops out in extreme southeastern Atascosa County, where it covers an area of about 2 square miles. It consists of creamy-gray volcanic tuff and fine tuffaceous sandstone. The thick-

[19] In accordance with present usage the term "Catahoula tuff" is applied to the dominantly volcanic series of tuffs, tuffaceous sandstones, and conglomerates overlying the Frio clay in southern Texas.

ness exposed in Atascosa County is not more than 100 feet, and the formation does not enter into the problems of water supply.

The Catahoula lies on the Jackson formation, the Frio clay having been overlapped.

GOLIAD SAND

The Goliad sand in this area is composed largely of gravel and cobbles of various kinds, with some sand and caliche. Outcrops of the formation, all of them only a few feet thick, are found sparingly southwest of Charlotte, in southwestern Atascosa County, and rather abundantly throughout Frio County. All the exposures occur on high interstream areas. The formation is not a source of water supply in Atascosa and Frio Counties and is not shown on plate 1. It is probably of Pliocene age.

LEONA FORMATION

In the valley of the Frio River, in northern Frio County, are terrace materials consisting of buff to gray silt, with minor lenses of sand or gravel, that are believed to belong to the Leona formation, of Pleistocene age. Occasional steep faces show as much as 35 feet of the material. The formation, however, is found in only small areas and is not a source of water supply.

ALLUVIUM

The stream valleys of Atascosa and Frio Counties contain Recent alluvial deposits of sand and silt, which are restricted to very narrow areas and are not of consequence as sources of water.

SANDSTONE DIKES

Two sandstone dikes are known to occur in the area—one on the E. J. Pruitt farm, 5 miles west of Charlotte, Atascosa County, on the west side of Lagunillas Creek, and the other 8½ miles east of Pearsall, Frio County, just south of the Pearsall-Charlotte road, on the west side of Black Creek.

The dike in Atascosa County crops out on the surface as a rudely wall-like mass 70 feet long and 30 feet wide with a strike of N. 52° E. It stands about 8 feet above the general land surface. Another outcrop of the same mass occurs 100 yards to the southwest, where the character is the same. The dike is jointed at right angles to the strike. The rock composing the dike is ferruginous medium- to coarse-grained well-cemented sandstone.

The dike in Frio County crops out as a wall 30 to 35 feet wide and 70 feet long. The strike is N. 34° E. The general character of the material is the same as that of the dike in Atascosa County except that the ferruginous sandstone contains numerous rounded cobbles and pebbles of chert as much as 6 inches in diameter. In parts of the rock these are the major constituents, and the rock is therefore a conglomerate. These cobbles are identical with those of the Goliad formation and probably have come from the same source. It is also likely that the materials for the dike were supplied from the erosion of Goliad gravel.

So far as can be told from the exposures near the dikes, they were not formed after faulting had opened crevices in the surface of the earth. It seems evident from the nature of the dikes that they were formed by the filling of crevices or cracks with detrital material. The structural details, however, are not available.

IRRIGATION FROM WELLS

IRRIGATION FROM WELLS IN CARRIZO SAND

General conditions.—Wells in the Carrizo sand yield abundant supplies of water for irrigation and for municipal and domestic use. The intensive development for irrigation is restricted mainly to relatively small tracts in the Frio Valley, in Frio County, and in the general locality of Poteet and Pleasanton, in Atascosa County (pl. 1). A few wells in the Carrizo sand in other parts of the area are also used for irrigation.

Frio Valley area.—Irrigation from wells in the Carrizo sand in Frio County has thus far been confined for the most part to relatively small tracts southwest of Pearsall. (See pl. 1.) The first Carrizo sand well in this area was drilled in 1905 by Halff & Oppenheimer and was a flowing well. Since that time 12 additional wells have been drilled to the Carrizo in the area for irrigation use and 2 have been drilled in Pearsall for municipal supply. All the wells once overflowed, except the municipal wells at Pearsall and the Weissinger well (no. 96), 1 mile southwest of Pearsall, but by the fall of 1929 four of them had ceased to flow. During the spring of 1930, because of unusually heavy rainfall, little water was used for irrigation. As a result, the water levels in the nonflowing wells rose perceptibly, and one well began to overflow again.

With one or two exceptions all the wells are pumped, the flowing wells being equipped with pumps so as to increase the yield of water during periods when the demands for irrigation are heaviest. When the wells in the lower (southerly) part of the area are pumped continuously or allowed to flow continuously the static level in the wells in the upper (northerly) part of the area is lowered and the yield of the wells is decreased somewhat. All the flowing wells have declined somewhat in yield since they were drilled, the lowest (most southerly) wells showing the smallest decrease. The most productive well in the area is the Bennett well, 1¼ miles south of Derby (no. 109). This well had a natural flow of 896 gallons a minute in 1928, according to a measurement by C. E. Ellsworth, of the United States Geological Survey. It yields about 2,000 gallons a minute when pumped. For many years the static level in the well stood at about 32 feet above the surface of the ground. In the pumping season of 1928–29 the well with others in the area was used intensively, and the level fell to only 12 feet above the surface. The level had risen to about 20 feet during the summer of 1930, when little water was used for irrigation. The Mills well (no. 106), 2¼ miles west of Derby, is also very productive, yielding about 800 gallons a minute. The static level in this well was 28 feet above the surface during the summer of 1930.

The water from these wells is used mostly for irrigating vegetables, especially onions, spinach, and tomatoes. There is some irrigation of cotton and corn, but during many seasons it is not necessary to irrigate these crops. In general two crops are raised on each tract of land during the year, one in summer and one in winter, and rotation of crops is employed so far as is practicable. The duty of water is variable and depends on the character of the crop and the rainfall during the growing season and to some extent on the skill of the individual farmer. For any crop the practice is to irrigate profusely until the crop is started and then to irrigate at intervals as needed to keep the plants growing vigorously in dry times. Accordingly much more water is used if the growing season is dry than if rains occur frequently.

Poteet-Pleasanton area.—The largest area irrigated from wells in the Carrizo sand in Atascosa County is in the northern part of the county around Poteet and Pleasanton. The development thus far has been restricted generally to the lower lands in the Atascosa River Valley, but a few wells have been put down on higher lands some distance from the stream. The northernmost well in this district is 5 miles west of Poteet, and the southernmost is 3 miles southeast of Pleasanton. The area thus defined is 12 miles in length but only 2 or 3 miles wide. The development of irrigation in this area is not continuous and is most intensive near Poteet. (See pl. 1.)

The wells range in depth from less than 500 feet in the northern part of this area to more than 1,600 feet in the southern part. The long dimension of the area nearly coincides with the direction of the dip of the Carrizo sand, and this accounts for the comparatively great range in the depth of the wells. In the immediate vicinity of Poteet there are more than 50 wells that are supplied by the Carrizo sand. Many of these wells are used for irrigation, but at any given time there are always many wells not being used because of change in ownership, tenancy, or agricultural conditions. Most of the wells flow, and about one-fifth of them are allowed to flow continuously. Wells near the northerly limits of the area do not flow at present, though most of them flowed originally. The artesian head in the Carrizo sandstone in the area has fallen about 25 feet since the first well was drilled, and at Poteet it is now about 500 feet above sea level.

The yield of the wells in the area by natural overflow varies considerably, according to the location of the well and the size of the casing. The average flow in the vicinity of Poteet is probably less than 200 gallons a minute. Wells in the lower (southerly) part of the area—for example, the Cunningham & Taliaferro well, 2 miles southeast of Pleasanton (no. 300), and the Anderson & Arneson well, 1 mile northeast of Jourdanton (no. 249)—have estimated yields ranging from 450 to 650 gallons a minute. Many of the wells in the northerly part of the area are equipped with pumps. About half of the pumping plants consist of turbine or centrifugal pumps driven by electric motors, but air-compressor plants and gasoline motors of several types are also used.

Irrigated tracts in this area are largely devoted to truck raising. The area is most widely known for its strawberries, to which the sandy soil is well adapted and for which high prices are commonly received. The first berries reach the market late in November or early in December, but the bulk of the crop is shipped in January, February, and March. Onions, spinach, beans, and other truck crops are also raised, and a few tracts of nursery land are irrigated. The duty of water varies materially according to the crop raised, the rainfall during the irrigation season, and the care with which the water is applied to the land.

Other areas.—Wells in the Carrizo sand are used for irrigation in other parts of the area. The well of C. M. Kelley, west of Hindes, supplies water for irrigation.

The well is 2,390 feet deep and flows about 600 gallons a minute. The Blesse well (no. 112), 1 mile southwest of Dilley, is also used for irrigation.

In the San Miguel Valley, in Frio County, several wells have been drilled to the Carrizo sand, but these wells were not used for irrigation in 1929 and 1930. The J. E. Berry well (no. 24), 4½ miles southeast of Moore, is the northernmost well in this area. It is 700 feet deep, and the water stands within 10 feet of the surface. Flowing wells of large yields at the Keystone ranch headquarters (no. 110) and the McGowen ranch headquarters (no. 111) derive their water supplies from the Carrizo sand. These wells are used for domestic supply and for stock.

IRRIGATION FROM WELLS IN MOUNT SELMAN FORMATION

Water from the Mount Selman formation is used to some extent for irrigation, mainly around Pearsall and in east-central Atascosa County. It is most widely used, however, for stock and domestic supply.

Pearsall area.—The first attempt at irrigation with water from the Mount Selman formation in the Pearsall area was in 1902, when a shallow well was drilled 1 mile north of the town. This well demonstrated that in this locality sands at comparatively shallow depths would yield sufficient water for irrigation, and soon after it was put down other wells were sunk for the same purpose, and the development has continued until the present time. The wells are from 100 to 200 feet deep and do not flow. The average pumping yield is not large, and the tracts irrigated from the wells are comparatively small. Only the best paying crops are irrigated, and the small size of the individual tracts is offset to a degree by the high returns obtained in years of good prices.

About 50 wells have been drilled and equipped with pumping plants for irrigation in an area lying for the most part north and northwest of the town. (See pl. 1.) Recently less than one-third of the pumping plants have been used for irrigation, owing chiefly to changes in land ownership, poor returns from irrigation, and inadequate funds. The largest tract irrigated in 1930 was 30 acres and the smallest 3 acres. The crops grown were tomatoes and tomato plants, beans, peas, onions, spinach, and citrus fruit. During every irrigation season many of the wells are pumped almost constantly, and between irrigation periods almost continuous pumping is also necessary to store sufficient water. The water in these wells drops to a level just above the top of the water sand soon after pumping is begun, but no other effect is noticed. After the irrigation season the water surface returns to the level it had before the irrigation season.

Eastern Atascosa County area.—North and northeast of Coughran, in eastern Atascosa County, some irrigation is carried on with waters from wells that are supplied by the Mount Selman sands. The irrigation wells range from 850 to 1,100 feet in depth, and all of them flow. The yield of the wells by natural flow ranges from a few gallons a minute near the northerly limit of the flowing-well area to several hundred gallons a minute farther south.

Irrigation thus far has been devoted largely to nursery stock and field crops. In 1930 only two tracts were irrigated, but in earlier years efforts have been made to irrigate other tracts. The water is in general highly mineralized, but the soils are exceedingly sandy, and apparently no ill effects have been experienced.

Other areas.—Flowing wells have been developed in the Mount Selman formation in several other areas. At present the water is being used for domestic purposes or for livestock, but in places it could be used for irrigation. At Pleasanton and in an area of considerable size around it many flowing wells have been drilled. These range in depth from 300 to 850 feet and are mostly of small diameter. The yields range from only a few gallons to as much as 75 gallons a minute. A part of the public supply of Pleasanton is obtained from a well (no. 262) of this character 815 feet deep, and many homes in the town are supplied from similar privately owned wells. The water is satisfactory for domestic use, and some of it could be used for irrigation. Much of the water from the formation contains appreciable amounts of hydrogen sulphide. Many of the wells yield inflammable gas, which was formerly trapped in containers and used for heating and lighting, but with the advent of natural gas from the south Texas fields this practice has been discontinued.

In San Miguel Valley, in Frio County, several flowing wells have been obtained from the Mount Selman formation. Wells on lowlands near the stream flow from depths of a few hundred feet, but on the higher land deeper sands must be tapped in order to obtain flowing wells. The flow varies, but the maximum is about 35 gallons a minute. The wells having the largest yields, of which the Oppenheimer & Lang No. 2 well (no. 84) is an example, range in depth from 790 to 860 feet. Larger yields could be obtained if wells of larger diameter were drilled. The water is used only for stock but could be used for domestic purposes and irrigation.

IRRIGATION FROM WELLS IN COOK MOUNTAIN FORMATION

Water from sands and sandstones in the Cook Mountain formation has been used to some extent for irrigation in the vicinity of Dilley. Elsewhere in the area it is used only for domestic purposes and stock.

In the vicinity of Dilley about 40 wells have been drilled to the basal sand of the Cook Mountain formation for irrigation, the first one in 1927. The wells are 8 to 10 inches in diameter and from 204 to 510 feet deep. None of the wells flow, and the distance the water must be pumped ranges from about 55 to 120 feet. They are equipped with pumps of large capacity and yield sufficient water for the irrigation of tracts of 35 acres or more. The irrigated crops include citrus fruit, spinach, onions, tomatoes, and other vegetables, and flowers.

In 1930 comparatively little land was irrigated in the area because of changes in land ownership and low prices of farm products. Irrigation practice varied widely in the Dilley area, and no accurate data are available as to the average duty of water.

MUNICIPAL WATER SUPPLIES FROM WELLS IN CARRIZO SAND

The towns of Poteet, North Pleasanton, Jourdanton, Pearsall, and Dilley obtain their public water supplies from wells drilled to the Carrizo sand. The town wells at Poteet and North Pleasanton are flowing wells. All these wells are described in the well table (pp. 64–80). Analyses of water from two of them are given in the table of analyses (pp. 60–61), as follows: Poteet, no. 218; Jourdanton, no. 250.

The water from these wells has been found to be satisfactory for municipal use. It contains a slight amount of hydrogen sulphide gas but this is removed by aeration. Iron is also present but not in amounts sufficient to affect the quality of the water seriously. Most of the towns that use the Carrizo water have modern water-supply systems operated by public-utility companies in connection with the manufacture of ice and the distribution of electric power. The usual equipment includes a modern pumping plant and standpipe or elevated tank. At Poteet the water supply is obtained from flowing wells and rises by artesian pressure into a standpipe. North Pleasanton is supplied from a well belonging to the San Antonio, Uvalde & Gulf Railroad, the water being sold to a public-utility company and distributed by it. No standpipe is needed, for the water in the well is under a static pressure of 43 pounds to the square inch.

WATER AVAILABLE FROM WELLS FOR DOMESTIC USE AND STOCK

Throughout most of Atascosa and Frio Counties water suitable for domestic use and livestock can be obtained at comparatively shallow depths. In the following pages the general ground-water conditions in various districts throughout the area are described. The conditions set forth for each district can be taken as typical for an area of considerable but indefinite size.

Extreme northern Atascosa County.—In the northernmost part of Atascosa County water for stock and family use is obtained either in the Indio formation or the Carrizo sand. In the Indio formation water supplies that have a wide range in quantity and quality are obtained in wells at depths of 125 to 300 feet It is necessary to test this water to determine if it is satisfactory for drinking. In the outcrop area of the Carrizo sand, wells are obtained at depths ranging from about 125 to 200 feet and have water levels about 105 to 140 feet below the surface. These wells yield adequate supplies of satisfactory water. Wells 166 and 167 illustrate conditions in this area. (See pl. 1 and the well table and table of analyses.) In some localities immediately south of the Carrizo outcrop area wells drilled to the Carrizo obtain water at shallower depths than in the outcrop area, because of the rather steep slope of the land surface. This is illustrated by the record of wells 169 and 170.

Anchorage and Rossville area.—In the area near Anchorage and Rossville flowing wells are obtained from the Carrizo sand in low places along the Atascosa River at depths ranging from 380 to 646 feet. In the higher areas closer to the Carrizo outcrop the wells do not flow, but good wells may be obtained at 250 feet or less. Water can be obtained in this area from wells in the Mount Selman formation at depths of less than 100 feet, but the yield of the wells is less and the water of poorer quality. The records of wells 163, 164, and 165 illustrate the conditions in this area.

Campbellton area.—The wells in Campbellton and vicinity yield bad water at shallow depths, and it is very difficult to obtain satisfactory supplies for domestic use except from very deep wells. The town obtains water from a dug well in alluvium near the Atascosa River. In the area generally dependence is placed on stored rain water for domestic purposes.

Charlotte area.—The wells in the vicinity of Charlotte range from 100 to 1,6[illegible]2 feet in depth, but most of them are between 100 and 300 feet deep. None of the wells flow, and the depth to water ranges from about 100 to 300 feet. The shallower wells obtain water from the lower part of the Cook Mountain formation and the deeper ones from the Mount Selman formation and the Carrizo sand. The water is variable in quality but is generally suitable for domestic use. The records of wells 293 and 294 illustrate the conditions prevailing in the shallower wells.

Christine area.—The surface rocks in the Christine area belong to the Yegua formation and are composed largely of gypsiferous clay with some beds of sand.

Wells range in depth from 155 to 1,314 feet. Flowing wells are obtained at depths greater than 950 feet, and the town is supplied from a flowing well 1,314 feet deep (no. 295). Another well in the town 950 feet deep flows, but the water is of poor quality. The shallow well waters are of variable quality, and it is often necessary to case off sands containing bad water in order to obtain a satisfactory supply.

Crown area.—Water-bearing sands are found at several depths in the Crown area. In the W. K. Shipman well (no. 337), 1 mile southeast of Crown, sands were found at 165, 357, 650 (Mount Selman), and 1,207 feet (Carrizo). Some of the upper waters are of poor quality. As a rule, however, water that is fairly satisfactory for domestic use can be obtained from shallow wells.

Dobrowolski area.—Wells in the vicinity of Dobrowolski range from 150 to 200 feet in depth. The water is of fair quality and can be used for domestic purposes, stock, and boilers. Conditions are generally similar to those around Charlotte.

Hindes area.—Flowing wells are obtained in the area round Hindes on low ground in San Miguel Valley from a sand in the Cook Mountain formation. At Hindes this sand is penetrated at depths of 380 to 440 feet. Wells are also obtained at about 150 feet, but the water is of poorer quality than that from the deeper sand. An analysis of the deeper water is given in the table on page 61 (no. 287). The Carrizo sand is encountered in this area at depths of about 1,900 feet. One well a mile southwest of the town has developed a large flow from that formation.

Jourdanton area.—The municipal supply of Jourdanton is obtained from a well 1,635 feet deep (no. 250) in which the water stands 6½ feet below the ground surface. Other wells in the area range in depth from 400 to 1,500 feet. The C. S. Young well (no. 251) encountered sands at 300, 745, 810, and 931 feet, all in the Mount Selman formation. In general the shallow ground waters throughout this area are of poorer quality than the deeper waters.

Leming area.—In and around Leming the Carrizo sand is the best available aquifer. It can be reached by wells less than 500 feet deep. Shallower wells in the Mount Selman formation yield water of variable quality, which is generally, however, fairly satisfactory for domestic use. The records of wells 170 and 171 illustrate conditions here. An analysis of water from well 171 is given in the table of water analyses.

Pleasanton, North Pleasanton, and Coughran area.—In the area including Pleasanton, North Pleasanton, and Coughran there are many shallow wells that are supplied by the Mount Selman formation, and on low ground a considerable number of the wells flow. (See pl. 1.) There are also many deeper flowing wells. The depths of all wells in regard to which information was received range from 296 to 1,925 feet. Wells 260 to 280 are examples of shallow flowing wells: wells 241, 244, 253, 254, 255, 256, 257, and 258 are deeper wells. The abundance of water-bearing sands is shown in the record of the E. R. Breaker well (no. 241), in which sands were found at 44, 200, 643, 927, and 1,206 feet. The water from the shallow and the deep wells is potable and generally suitable for domestic and irrigation uses. Analyses of water from 6 wells are given in the table of analyses.

Poteet area.—The Carrizo sand is reached by wells in the Poteet area at depths ranging from 400 to 1,000 feet and is the principal source of the ground water used in the area for domestic purposes as well as for irrigation. It is customary throughout the area to drill wells to this horizon, and most of the wells flow. Before the development of these deeper wells water of poor quality was obtained from wells ending in the Mount Selman formation at depths of 30 to 50 feet. The wells in the Carrizo sand, despite the greater cost of drilling, are the most desirable, because the water can be used for irrigation as well as for domestic purposes. Wells 175 to 238 are in this area. Analyses of water from 6 of the wells are given in the table of analyses.

Northern Frio County.—The beds that crop out in the northern part of Frio County belong to the Carrizo sand and the Mount Selman formation. Over a considerable part of the area the Carrizo either is at the surface or lies at relatively shallow depths, and wells in it yield abundant supplies of good water. The wells are from 100 to 500 feet deep. Wells 1 to 19 illustrate conditions in this area. Water can be obtained in a part of the area from the Mount Selman formation at depths of about 100 to 450 feet, but the water is of poor quality, and the wells yield much less freely than those in the Carrizo sand. In some areas in northeastern Frio County there is difficulty in obtaining potable water from the Mount Selman. Wells in the lower part of the Mount Selman formation (Bigford member) yield water of poor quality.

Derby area.—In the Derby area records were obtained of wells ranging in depth from 203 to 455 feet. These wells obtain their water from the Mount Selman formation. Wells 146, 147, 148, 149, 150, 151, 152, 153, 343, and 344 are representative.

Dilley area.—The shallow water in the area around Dilley is described in the section on water in the Cook Mountain formation (p. 40). Records were obtained of wells ranging in depth from 119 to 137 feet. West of Dilley, in the west-central part of the county, the water is found under generally similar conditions but is of more variable quality.

Pearsall area.—Shallow wells in the Pearsall area are discussed in the section on water in the Carrizo sand and Mount Selman formation (pp. 26, 34). The conditions there described prevail over a fairly wide area. Water is usually obtained in wells at depths ranging from about 100 to 250 feet. The water, though usually potable, varies considerably in mineral content. In an area east of Pearsall the sandy upper beds of the Mount Selman formation are at or near the surface and supply wells ranging from about 65 to 250 feet in depth. These wells yield the best water found in the Mount Selman formation anywhere in the area.

WELL DRILLING AND PUMPING METHODS

Most of the water wells of the area are drilled, only a few of them being dug wells. Methods of well drilling differ considerably according to the type and depth of the well and the district in which it is located. The wells drilled for domestic or ranch supply are generally shallow, averaging about 250 feet deep, and are drilled by hydraulic-rotary or cable-tool percussion-drilling machines (pl. 8). The wells range from 4 to 8 inches in diameter and are cased to variable depths. If sands yielding water of poor quality are penetrated these sands are cased off, and the remainder of the well below is uncased. In some domestic wells, however, casing is set the entire depth, or to the water-bearing sand. The domestic and ranch wells are pumped almost entirely by cylinder pumps with windmill power. Strong, fairly constant winds are common, and therefore an adequate supply of water can be obtained by this method.

Pearsall area.—The methods of drilling and pumping wells drilled for irrigation vary considerably in the Pearsall area. The wells range in depth from 100 to 2,500 feet and the pumping lift and yield is very variable. At Pearsall, in the shallow irrigation district, the greater number of wells are 100 feet deep, but a few are as much as 200 feet deep. The water-bearing sands are generally encountered at depths less than 100 or 200 feet, but the drilling contracts are usually made on the basis of drilling a well to either of these two depths.

The irrigation wells are nearly all 10 inches in diameter, though a few are only 6 or 8 inches. The wells are cased to a depth of about 10 feet, or only deep enough to exclude surface run-off and to keep the weathered rock and soil from falling into the well. Below 10 feet the holes remain open and in good shape, owing to the fact that the shales, clays, and sandstones of the Mount Selman formation do not cave readily. It is customary, in the Pearsall district, to drill two wells for each irrigation installation. These are spaced either 15 or 20 feet apart and are fitted with cylinder pumps that are operated by a walking beam connected to a crank and drive shaft. One engine or motor can then drive both pumps. There are a few single irrigation wells in the district, but most of these are used to irrigate very small tracts. One installation consists of three wells spaced 15 feet apart in a line and pumped simultaneously with one engine.

Practically all the wells in this district have been drilled with the cable-tool percussion-type drilling machine, such as is shown in plate 8, *B*. Machines of this type are suitable for sinking wells as much as 1,000 feet deep. The pumps are of the cylinder type, the cylinders being 4 to 5¾ inches in diameter. In the pumping installations in which the walking beam, crank, and pitman are used the length of stroke of the cylinder can be varied, thereby changing the yield. In certain other types of installation the stroke of the cylinder is fixed, and the yield can be varied only by changing the speed of the engine.

Power for pumping the irrigation wells at Pearsall is supplied by electric motors, stationary gasoline engines, oil engines, and converted automobile motors. If the tract of land to be irrigated covers only a few acres, an improvised power plant probably serves reasonably well. However, well operators of larger irrigation tracts use more substantial power installations, the electric motor being preferred. Some electric installations are fitted with automatic controls and hence require very little attention.

On some of the irrigated tracts at Pearsall the water is conducted directly from the wells to the land. This is not practicable except on the smaller tracts, because the yield of the wells is too small to maintain a proper irrigation head in long ditches, especially during dry, hot periods. It is customary, therefore, to build concrete storage reservoirs ranging in capacity from about 100,000 to 200,000 gallons and to store water pumped during the night in these reservoirs for use the following day. During times of most intense irrigation the wells may be pumped almost continuously for several days, but this is not the normal practice.

The cost of drilling wells in the Pearsall district is more or less standardized. At the time this investigation was made the customary cost of drilling was $1.25 a foot for the first 100 feet, including the labor of placing the casing and fitting the pump. Deep wells cost slightly more per foot of depth. As most of the wells are cased only for 10 feet the cost of casing is slight. The cost of pump pipe was 46 to 97 cents a foot, according to the quality of the pipe. The cylinder and strainer could be obtained for about $50, the exact cost depending on the size and quality. The cost of the power-plant installation varies with the type.

Dilley area.—Irrigation wells in the Dilley area range from about 250 to 400 feet in depth. The yield is considerably greater than that of the shallow wells at Pearsall, and the depth to water is greater. The wells are drilled with a hydraulic-rotary drilling machine, similar to that shown in plate 8, *A*. In the Dilley area nearly all the wells have been drilled by one driller. Most of them are 10 inches in diameter, but a few are only 6 or 8 inches. Some wells are cased to the bottom, others have only one length of casing at the surface, and still others are cased to intermediate depths. There seems to be no uniform casing practice, and frequently the cost of the casing governs the type and amount of casing used. Some of the uncased wells have caved, and it would therefore seem desirable to case the wells in this district from top to bottom.

Several types of pumps are used in the Dilley area. The deep-well cylinder pumps with geared pump jacks are perhaps more numerous than any other type. A number of wells are pumped with turbine pumps, which are operated by electric motors connected directly to the upper end of the pump shaft. A few centrifugal pumps are used. Most of the pumps are operated with electric motors, but gasoline engines, gasoline tractors, and oil engines are also used. The cost of drilling, equipping, and operating wells is greater than in the Pearsall area, because the wells are deeper and the lift greater. The drilling cost averages about $1.75 a foot for a well 10 inches in diameter; the casing costs $1.50 a foot. A typical installation, consisting of a turbine pump with a capacity of 250 gallons a minute and a 15-horsepower electric motor, costs between $600 and $1,000, depending on the make and the length of the pump setting.

In the Dilley area considerable irrigation is done directly from the wells, but on some farms earth reservoirs are used. Several concrete reservoirs are also in use. Direct irrigation is adequate for tracts of land as large as 15 acres, as the yield of the wells is sufficient to maintain an adequate irrigation head.

Poteet area.—The irrigation wells in the Poteet district illustrate another type of construction and use, as they are of intermediate depth and many of them flow. They range in depth from 550 to 1,050 feet; the shallower ones are in the northern part of the district. Most of the wells are 8 inches in diameter at the top and either 4 or 6 inches in diameter at the bottom. There is no uniform practice in this area in the amount of casing used, and many wells are insufficiently cased, simply because the owner desired to keep the initial cost of the well at a minimum. Some of the wells, however, are cased to the water-bearing sand, or for their entire depth. In such wells, the casing is set on a hard-rock layer above the sand, or it is extended into the sand and the length that penetrates the sand is perforated. In some of the wells perforated casing has been used for a considerable distance above the water-bearing sand; in others the perforated casing extends a considerable distance below the sand. Because of this practice, many of the wells yield water of inferior quality. The wells have generally been drilled with hydraulic-rotary machines of the type shown in plate 8, *A*. Some of the earlier wells, however, were drilled by the cable-tool percussion method. A few of the wells were drilled with large hydraulic-rotary machines such as are used in oil-well drilling.

Many of the wells at Poteet are flowing wells. A large number of them are not equipped with valves and are allowed to flow continuously. Reservoirs are generally used in conjunction with all the flowing wells that furnish water for irrigation. The reservoirs are made of earth and range in size from a fraction of an acre to 4 acres. Many farms, however, are irrigated directly from the wells.

Nonflowing wells and wells that yield only a small quantity by natural flow are pumped. In such wells the depth to water is not great, and therefore the pumping plants are not as elaborate as at Dilley. Centrifugal pumps, air lifts, and a few turbine pumps are used. The pumps are operated with electric motors, tractors, stationary gasoline engines, and oil engines. On the whole there has been very little electrification of pumping plants, and the installations in general are somewhat crude.

Deep wells.—The deep irrigation wells and deep wells used for municipal supply have been drilled usually with oil-well drilling equipment. Some of the wells have been drilled by oil-field contractors; others have been drilled by firms engaged only in water-well drilling. The wells are from 1,300 to 2,500 feet deep and generally obtain water from the Carrizo sand. The deep wells are cased to prevent the contamination of the Carrizo waters by mineralized water from the higher formations.

The diameter of the wells ranges from 6 to 16 inches. The diameter at the bottom is usually less than that at the top, for in most wells the casing has been reduced in size one or more times. The Pearsall city well (no. 94), which is 1,303 feet deep, has 155 feet of 16-inch casing, 806 feet of 8-inch casing, 65 feet of 6-inch casing, 104 feet of 8-inch screen, and 81 feet of 6-inch screen. The city well at Jourdanton (no. 250) is 1,635 feet deep and has 162 feet of 10-inch casing, 1,118 feet of 8-inch casing, 267 feet of 6-inch casing, and 99 feet of 6-inch screen. These wells are cited as examples of properly drilled wells in which great care was taken to insure a good finish. Some of the older irrigation wells were not so well constructed.

No exact figures are available on the cost of the deeper wells. It has been reported that one well recently drilled near Pearsall to a depth of about 1,350 feet and fitted with a pump cost $8,000. This is probably a minimum cost, for the well was drilled as economically as possible. Figures showing the cost of earlier wells are not applicable to conditions prevailing at the time the investigation was made.

QUALITY OF THE WATER

Water analyses.—The table of analyses (p. 60) shows that the waters vary widely in chemical character. This is due largely to inherent differences in the chemical character of the rocks of the various formations and perhaps in part to chemical reactions that have occurred in the waters within the rocks. In general the amount of dissolved material in water from a given formation varies directly with the depth of the formation beneath the surface. The greater the depth the longer the water has been in the formation and the greater has been its solvent action on soluble minerals present in the formation. As is to be expected, the waters from clean sandstones contain less dissolved material than those from formations containing alternating clays and impure sands.

Water analyses are of importance in determining the adaptability of water for domestic and industrial supply and for irrigation. In the area covered by this report industrial demands for water are not great, and the analyses are of chief importance as indicating whether the water is suitable for domestic use or irrigation. The analyses do not show the sanitary condition of the waters, and statements based on the analyses are made without reference to possible pollution of the waters.

The chemical character of the waters is determined by the quantities and proportions of the basic radicles calcium, magnesium, and sodium and the acid radicles bicarbonate, sulphate, and chloride. Calcium and magnesium affect the value of water for industrial uses, mainly because of the hardness that they cause. Sodium and potassium compounds may cause trouble in irrigation. If the acid radicle is carbonate or bicarbonate the resulting product is sodium carbonate or sodium bicarbonate ("black alkali"). The sulphate and chloride salts are less harmful and form "white alkali."

Requirements for domestic use.—The adaptability, in a chemical sense, of a water for domestic use is dependent to some extent on the experience of the people using it. If they have been accustomed to waters of low mineral content they will regard as bad waters in which the mineral content is only slightly higher. On the other hand, if they have lived in regions where the waters in general are somewhat heavily charged with mineral matter they will use without question water that may be rather highly mineralized. Waters of the latter type are most common in southwestern Texas. The taste of the water is important, for waters containing as much as 1,500 parts per million of dissolved materials and having a pleasant taste are still acceptable. Next to taste, softness is the most important quality of a water for domestic use. Some soft and otherwise desirable waters are rendered unpalatable by the presence of magnesium salts or sodium chloride, which give them a disagreeable taste.

Requirements for irrigation.—Water for irrigation must be of such chemical nature as not to damage the soil on which it is used. There is no fixed standard by which the quality of water for this purpose can be gaged, and it is almost impossible to construct such a standard. The type of water that can be used with safety varies greatly with the type of soil and subsoil, topography, crops, and climate. In Atascosa and Frio Counties the average annual rainfall is around 24 inches, and much of it is concentrated into violent rainstorms. The soils range from extremely porous sandy soils with very good subsurface drainage to clay soils that are almost impermeable. In the sandy soils, any accumulation of objectionable salts from irrigation waters will be largely dissolved and washed out of the soils by the torrential rains. In the clay soils the salts tend to accumulate. It is obvious that a set of standards which does not take into account the physical character of the soils would be of no value. In general, it can be stated that waters with more than 200 parts per million of sodium carbonate and a total of more than 1,000 parts per million of sodium carbonate, sodium sulphate, sodium chloride, magnesium chloride, and magnesiun sulphate should not be used on soils that do not have good subsoil drainage. Use of water with 200 to 500 parts per million of sodium carbonate is dangerous and should not be undertaken unless a careful investigation shows the drainage conditions are exceptionally good. If the water contains more than 500 parts per million of sodium carbonate its use is certain to result in serious damage to all except the most sandy soils with ideal drainage conditions. In addition it should be kept in mind that the total of the salts previously mentioned should not exceed 2,000 parts per million and that waters with 1,000 to 2,000 parts per million of these constituents demand careful handling.

It should be understood that this general outline of standards for use of irrigation waters is not universally applicable. Examples are known, in Atascosa and Frio Counties, of water with dissolved mineral matter in excess of the limits given that has been used for years with no apparent ill effects. The conditions of drainage, however, were ideal, and the soil very sandy. At the same time one tract of land irrigated with water containing less than 250 parts per million of total dissolved constituents and less than 100 parts of sodium carbonate showed distinct, progressive damage. The soil was of a clayey type, the irrigation was excessive, and the drainage was very poor. Users of water for irrigation should keep in mind constantly the fact that the matter of drainage is of the utmost importance.

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Analyses of ground waters in Atascosa and Frio Counties, Tex.

[Analyzed by Margaret D. Foster. Parts per million. For records of wells see corresponding numbers in well table, pp. 64-80]

No.	Location	Depth (feet)	Date of collection	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)
	Frio County														
25	Moore, 4½ miles southeast of	190	June 18, 1932	[a] 482		1.5	63	22	[a] 95		388	47	62	1.0	248
29	Bigford (cotton gin)	115	do	330	51	.21	34	8.6	53	9.3	149	45	54	.60	120
41	Pearsall, 1¾ miles north of	130	do	[a] 1,247		.12	152	23	[a] 269		234	259	415	14	474
44	Pearsall, 1¼ miles north of	110	do	[a] 800		.26	145	18	[a] 128		331	114	228	2.5	436
75	Pearsall, 6 miles east of	46	May 26, 1932	2,868	46	.10	354	150	289	44	356	554	470	810	1,500
84	Pearsall, 12 miles east of	860	do	987	20	3.4	90	40	199	21	374	172	258	.0	389
93	Divot, ¼ mile west of	173	June 17, 1932	[a] 2,620		.27	42	22	[a] 878		362	712	755	2.6	195
97	Pearsall, 3½ miles southwest of	1,350	do	414	22	4.0	99	18	22	6.2	331	59	25	.05	321
105	Derby, 2¾ miles northwest of	1,672	do	[a] 349		.15	83	16	[a] 26		295	58	18	2.7	273
109	Derby, 1¼ miles south of	1,700	do	349	23	.22	70	13	36	6.1	284	47	18	.57	228
111	Pearsall, 12½ miles southeast of	1,700	May 26, 1932	308	17	.17	66	14	25	7.8	270	38	15	.0	222
113	Dilley, about ½ mile from Dilley on Laredo Highway	2,010	Jan. 1, 1928	350	27	.24	32	11	80	4.6	282	45	18	.42	125
121	Dilley, 2½ miles northwest of	305	June 17, 1932	1,090	27	.31	102	36	221	9.6	341	254	248	.38	403
130	Dilley, ¾ mile south of	200	do	[a] 672		2.5	88	39	[a] 107		349	131	135	.0	380
132	Dilley	307	Jan. 20, 1928	1,747	22	2.4	166	65	305	18	292	650	325	.45	682
133	do	370	June 17, 1932	[a] 1,803		.57	120	55	[a] 427		245	730	350	.25	526
146	Melon, 1½ miles southeast of	228	June 18, 1932	[a] 662		.45	94	19	[a] 118		273	79	148	69	313
148	Melon	242	do	1,954	14	.55	127	57	438	20	301	676	408	2.6	551
152-a	Derby, ½ mile southwest of	285	do	[a] 1,652		.36	149	82	[a] 323		345	436	460	32	709
152-c	Divot, 2½ miles southwest of	210	June 17, 1932	[a] 4,321		7.8	176	34	[a] 1,347		390	1,182	1,385	4.5	579
154-a	Pearsall, ½ mile west of	40	June 18, 1932	[a] 899		.15	118	61	[a] 131		446	121	228	20	545
154-c	Pearsall, 2 miles east of	200	do	[a] 1,936		3.7	312	65	[a] 302		284	273	838	5.4	1,046
158-a	Dilley, 4 miles northwest of	250	June 17, 1932	[a] 1,054		1.2	104	39	[a] 214		328	377	158	.50	420
	Atascosa County														
163	Rossville, 5½ miles southwest of	380	Feb. 22, 1928	227	18	1.1	31	6.2	28	5.1	52	50	51	.10	103
166	Poteet, 8½ miles north of	175	June 18, 9132	[a] 107		.23	[b] 10		[a] 27		31	21	32	.42	[c] 34
172	Leming	120	June 19, 9132	[a] 767		1.1	130	31	[a] 110		286	120	235	.0	452
177	Rossville, 4½ miles south of	640	June 18, 1932	[a] 196		1.4	40	7.9	[a] 20		84	41	45	.0	132
197	Poteet, 3¾ miles west of, Locke Nursery	600	May 26, 1932	199	19	1.1	29	6.0	21	7.4	60	36	43	0	97
216	Poteet	840	Feb. 22, 1928	180	18	.58	23	4.8	23	4.3	43	33	46	.21	77
218	do	835	May 26, 1932	193	16	11	28	6.1	21	7.0	55	32	47	.0	95
220	Poteet, ¼ mile south of	840	do	253	15	6.7	50	9.3	21	8.7	166	32	32	.0	163

241	Pleasanton, 1½ miles north of	1,925	Feb. 20, 1928	292	20	.52	59	8.5	28	3.5	189	39	34	.0	182
248	Jourdanton, 1½ miles west of	1,040	June 18, 1932	[a] 442		1.7	48	23	[a] 88		272	73	75	.50	214
249	Jourdanton, 1 mile northeast of	1,505	Feb. 21, 1928	331	22	.96	77	12	28	4.3	264	37	34	.0	242
250	Jourdanton (ice plant)	1,635	June 18, 1932	[a] 333		.90	68	15	[a] 39		278	41	33	.0	232
255	Coughran, 1½ miles north of	1,050	June 19, 1932	[a] 583			[b] 5		[a] 249		543	[a] 1	81	.0	[c] 18
262a	Pleasanton	815	Feb. 20, 1928	484	20	.09	6.8	3.7	173	3.0	356	2.2	90	.10	32
263	Pleasanton (hotel)	380	June 19, 1932	[a] 917		1.2	[b] 5		[a] 380		455	[b] 1	335	.0	[c] 20
274	Pleasanton	340	do	[a] 969			[b] 3		[a] 398		528	109	235	.0	[c] 12
279	do	630	do	[a] 458		.23	[b] 7		[a] 185		363	[b] 1	92	.0	[c] 26
287	Hiudes	450	do	[a] 1,699			[b] 9		[a] 639		324	547	412	2.7	[c] 28
295	Christine	1,314	do	[a] 1,652			[b] 3		[a] 672		781	153	475	.68	[c] 9
296	do	956	do	1,718	21	.10	4.8	2.3	643	14	769	152	460	2.5	21
300	Pleasanton, 2 miles southeast of	1,722	do	[a] 334		.69	82	12	[a] 28		268	47	33	.0	254
303	McCoy	900	do	[a] 2,980			[b] 3		[a] 1,255		1,671	163	850	.0	[c] 10

[a] Calculated.
[b] By turbidity.
[c] Determined.

CONSERVATION OF THE WATER SUPPLY

In the season of 1929–30 the discharge of the irrigation wells and of the flowing wells used for other purposes was measured or estimated, the land irrigated with water from wells was mapped (pl. 1), the kind of crops raised was recorded, the amount of water used for each crop was studied, and the quantity of water wasted from each well was computed. This survey revealed the facts that although some of the wells are shut down when the water is not needed, a considerable number in both counties are allowed to flow continuously, and a surprisingly large quantity of water is completely wasted or used to only a minor extent for watering livestock or maintaining fish ponds. Waste occurs from all three of the sandstones that furnish water for irrigation, but attention was given especially to the Carrizo sand, from which the greatest quantities of water are wasted.

The flow of the wells was ascertained approximately by weir measurements, rough volumetric or float measurements, or estimates. On the basis of all data obtained it was estimated that in 1929–30 water was being discharged by wells in the Carrizo sand at the rate of about 16,000 acre-feet a year—about 9,500 acre-feet by wells in Atascosa County and about 6,500 acre-feet by wells in Frio County.

The results of the survey, as presented in plate 1, show that the total area irrigated in 1929–30 with water obtained from the Carrizo sand was 2,085 acres—1,350 acres in Atascosa County and 735 acres in Frio County.

In 1929–30 there was more rainfall than normal, and therefore the quantity of water used for irrigation was less than usual. On the basis of the studies that were made the average annual duty of water was placed at 2.4 acre-feet to the acre in Atascosa County and 2.8 acre-feet in Frio County, although it is recognized that with the best irrigation practice somewhat smaller amounts would probably be adequate. It was therefore computed that, with the acreage irrigated in 1929–30, the quantity of water from the Carrizo sand that is beneficially used for irrigation in a year of average rainfall amounts to about 5,300 acre-feet—3,200 acre-feet in Atascosa County and 2,100 acre-feet in Frio County. These computations lead to the startling conclusion that in each county about two-thirds of the water withdrawn from the underground reservoir formed by the Carrizo sand is virtually wasted.

In both the Pearsall area and the Poteet area there has been some decline in artesian head and a corresponding decline in discharge from each well. The decline has not been great, but nevertheless it has been sufficient to cause some of the wells to cease flowing. If the waste of artesian water were eliminated there would doubtless be an appreciable restoration of head, such as occurred during the winter of 1929–30, when, because of heavy rainfall, only a small amount of water was used for irrigation and wells resumed flowing that had ceased to flow in 1928. It is estimated that by eliminating the waste it will be possible to put under irrigation about 4,000 acres of additional land in the two counties without making any additional draft upon the underground reservoir.

Frequent measurements are being made of depths to water level in selected wells for both counties. This program of water-level measurements is to be continued, and a partial resurvey of the discharge and use of ground water is to be made. The records of depth to water thus far obtained indicate that in both counties there has been a small net decline in the head of the water in the Carrizo sand since the investigation was begun in 1929, while the head in the Mount Selman formation has remained practically unchanged. A longer record of water levels and correlative rates of discharge must be obtained before a close estimate of safe yield can be made. The data at hand, however, lead to the conclusion that the present beneficial use is not in excess of the safe yield and that further irrigation developments can safely be made to utilize all or most of the total discharge as shown by the survey of 1929–30, provided effective steps are taken to eliminate the waste.

RECORDS OF WELLS

Data on wells in Atascosa and Frio Counties are given in the following tables. All the wells listed are shown on plate 1.

Records of wells in Frio County, Tex.

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power [a]	Use [b]	Remarks
1	Frio Town, 7 miles northwest of, at ranch headquarters.	Louis Vest			698.89		5		Carrizo sand	−84.4		C, W	D, S	
2	Frio Town, 4 miles north of.	G. A. Blackaller			656.66		5		do	−60		C, W	D	
3	Frio Town, 3 miles north of.	do	Lefevre & Story		688		12							Abandoned oil test.
3a	Frio Town, 2½ miles north of.	Lou Blackaller				52	6		Carrizo sand	−41.4				
4	Frio Town, 4½ miles west of.	C. Woodward			661.66	400	6		do	−78		C, W	S	
5	Frio Town, 2½ miles west of.	Mrs. D. Little				210	6		do	−65		C, W	S	No water above 200 feet.
6	Frio Town, 6 miles northeast of.	J. J. Little			697.7		5		do	−100		C, W	S	
7	Frio Town, 3 miles northeast of, Swamp Farm.	do			635.02	52	5⅝		do	−41		C, W	D, S	
8	Frio Town	Mrs. W. A. Roberts			627.77	208			do	−52		C, W	D	
9	do	do		1909	629.29	197	6		do	−52		C, W	D	
10	Moore, 10 miles west of	H. W., A. C., and R. L. Eshenberger.	F. B. Lefevre	1930	638	3,478	8							Abandoned oil test.
11	do	do					5		Carrizo sand	−102		C, W	D	
12	Moore, 9 miles west of	F. Fasler				160	5		do	−109		C, W	D, S	
13	Moore, 4 miles northwest of.	P. M. Crane				110	5⅜		do	−103		C, W	D, S	A little scale on boiling.
14	Moore, 3.5 miles west of	B. Conover			670.09	200	5⅜		do	−110		C, W	D, S	Soft.
15	do	S. E. Edwards	Lain & Brown		679	2,607								Abandoned oil test.
17	Moore, ½ mile west of	Martin Ellison	B. Young	1909	675.98	108	4		Bigford (?) member of Mount Selman formation.	−61		C, W	D, S	Heavy draw-down when pumping.
18	Moore	Moore School			661.87	200	4		Carrizo sand	−98		C, W	D	
19	do	J. W. Winters	A. Doodlestadt		662.27	200	6		do	−101		C, W	D, I	Some iron stain on vessels; some scale on boiling.
20	Moore, ⅓ mile southeast of.	A. Obits				38	40		Bigford (?) member of Mount Selman formation.	−32		None	D	Dug.
21	Moore, 1½ miles south of	A. Dunlap	B. Conover	1914		117	4			−75		C, W	D, S	

22	Moore, 3 miles southwest of.	W. O. Brown	Donaldson Oil & Gas Co.		704	2,846								Abandoned oil test.
23	Moore, 4½ miles southeast of, ranch headquarters.	J. E. Berry		1900		150	6		Mount Selman formation.	−20		C, W	D, S	
24	do	do	N. Graham	1910	573.71	720	8	300–600	Carrizo sand	−10	900	A, G	N	
[c]25	Moore, 4½ miles southeast of.	Siebert & Nelms	A. Mann	1926		190	5¼	190	do.(?)	−44		C, W	D	
26	Moore, 6 miles northeast of.	C. C. Tribble	North & Walton	1930		3,554	10							Do.
27	Bigfoot, 2 miles north of.	Burns	E. H. Wray	1930										Oil test; gas.
28	Moore, 6 miles southeast of.	A. Johnson				560	8		Carrizo sand	−5		None	N	
[c]29	Bigfoot, cotton gin	G. E. Thomas and C. W. Frazier.		1919		115	4		Mount Selman formation.	−100		C, W	B	
30	Bigfoot	Louis Ross		1915		76			do	−70		C, W	D	Dug.
31	do	A. A. Whittaker	V. Hamilton	1905		110			do	−100		C, W	D	Do.
32	Bigfoot, 1 mile south of.	G. W. Couser	Shubar			200	4		do	−138		C, W	S	Bitter taste.
33	Pearsall, 13 miles west of ranch headquarters.	J. Loxton		1913		500	5½		do.(?)	−200		C, W	D	Fine white sand at bottom.
34	Loxton, 5 miles southwest of ranch headquarters.	do				260	5½		do	−150		C, W	S	
35	Pearsall, 8 miles northwest of.	B. I. Gillman	L. Whitley			157	6	147–157	do	−150	7	C, W	D	
36	Pearsall, 3 miles north of railroad underpass 0.6 mile west of.	Claude McCauley	C. McKinley	1926–1930		1,245	10	1,000–1,300(?)	Carrizo sand	−139	600	T, G	I	
37	Pearsall, 2¼ miles north of.	do		1927	669.60		10		Mount Selman formation.	−87		C, G	N	2 wells 20 feet apart.
38	Pearsall, 2 miles north of.	do		1927		130		115–126	do	−88	500(?)	T, G		Do.
39	do	Thomas Young	Layne Texas Co.	1918		115	8	85–115	do	−76	50	C, G	I	Temperature 96° F.
40	do	H. H. Page	D. Upton	1927		110	8	90–110	do	−56	120	C, E	I	2 wells 20 feet apart; temperature 86° F.
[c]41	Pearsall, 1¾ miles north of.	A. R. Strong	do	1918		130	8	60–80	do	−78.3	120	C, E	I	2 wells 20 feet apart.
42	Pearsall, 1 mile north of.	E. Strong		1918		100	8	65–85	do	−40	120	C, E	I	Do.
43	Pearsall, 1¼ miles north of.	A. M. Vanderwert		1927		116	8	90–116	do	−45	60	C, E	I	
[c]44	do	R. W. Brown	E. Braton	1916		110	8	85–110	do	−50	100	C, G	I	2 wells 20 feet apart; temperature 90° F.
45	Pearsall, 1 mile north of.	J. E. Fields	F. Saunders			100	8	80–100	do	−40		C, G	I	
46	Pearsall, 1½ miles northwest of.	W. Hanson	J. D. Owings	1927	628.68	120	8	85–115	do	−51		C, G	I	
47	Pearsall, 1¼ miles northwest of.	E. D. Bonner	J. E. Owings	1928		120	8	90–120	do	−45	40	C, G	I	

[a] Pumps: C, Cylinder pump; D, duplex cylinder pump; A, air lift; T, turbine centrifugal pump; E, rotary pump; Cent., ordinary centrifugal pump. Power: W, Windmill; H, hand; G, gasoline or oil engine; S, steam engine; E, electric motor; K, kerosene engine.

[b] C, Cooking; D, domestic; S, stock; I, irrigation, B, boiler; N, not used; M, municipal.

[c] For analysis see table on pp. 60–61.

Records of wells in Frio County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power	Use	Remarks
48	Pearsall, 1¼ miles north of.	H. G. Rylander		1920		125	8	90–125	Mount Selman formation.	−72	110	C, E	I	2 wells 20 feet apart.
49	Pearsall, 1 mile north of railroad station.	Mason Maney	L. Upton	1918	637.41	100	8	80–100	do	−62	120	C, G	I	Do.
50	do	J. S. Wickware	D. Upton			125	8	92–124	do	−70			I	Do.
51	do	C. C. Vaughan	do			115			do			C, E		Do.
52	Pearsall, 1 mile north of.	T. Cage	L. Upton	1918		135	8	115–130	do	−45	100	C, E		2 wells 20 feet apart; water also at 80–90 feet.
53	Pearsall, ¾ mile north of.	H. J. Bilhartz				90	8		do	−45	60	C, E	I	Temperature 90° F.
54	do	E. M. Howard	L. Upton	1917		100	8	80–100	do	−40	120	C, G	I	2 wells 20 feet apart.
55	do	E. Mattews	W. M. Higdon	1927		135	8	115–130	do			C, E	I	2 wells 20 feet apart; water also at 80–90 feet.
56	do	C. Rylander		1920		110	8	80–110	do	−45	120	C	I	2 wells 20 feet apart.
57	Pearsall, 1½ miles northwest of.	F. W. Reichert	J. D. Owings	1928		176	8	130–176	do	−45	140	C, G	I	
58	Pearsall, 1¼ miles northwest of.	L. C. Dennis	do	1927		205	8	165–205	do	−45	50	C, G	I	
59	Pearsall, 1¼ miles northwest of railroad station.	F. A. Hall	do	1927		205	8	165–205	do	−45	120	C, G	I	
60	Pearsall, 1¾ miles northwest of.	D. Landis		1926		140	8	110–140	do	−45	50	C, G	I	
61	Pearsall, 1¼ miles northwest of.	Thurman Barrett	J. D. Owings	1928		171	8	140–171	do	−45	50	C, G	I	
62	Pearsall, ½ mile north of.	J. E. Beall	J. Gray	1920		160	8	80–110	do	−40	100	C, G	I	Do.
63	do	G. Arnold				160	8	80–100	do	−40	100	C, G	I	Do.
64	Pearsall, ½ mile northeast of.	Pearsall High School	W. M. Higdon			237	8	210–214	do		60			
65	Pearsall, ½ mile south of.	D. S. Beck		1928		116	8	90–116	do	−45	50	C, G	I	
66	Pearsall, ¾ mile south of.	Roy Woodward	W. M. Higdon	1928		175	6	140–175	do		12	C, G	I	
67	Pearsall, 1 mile southwest of.	H. G. Wright	J. D. Owings			160		90–130	do		120	C, G		Water also at 65–80 feet.
68	Pearsall, 2 miles southwest of.	E. M. Hodge	T. P. Nixon	1930		128	8	112–125	do	−50		C, E	I	
69	do	A. Dearberg	do	1930		146	8	120–125	do	−50				

70	Pearsall, 1¾ miles southwest of.	L. Hornsby	J. D. Owings	1930		135	8	130-135	do			C, E	I	Bitter taste; two wells 20 feet apart.
71	Pearsall, 2 miles southwest of.	F. C. Mangold	T. P. Nixon	1930		200	8	180-183	do	−48		C, E	I	Three wells equipped; water also at 120-123 and 160-163 feet.
72	Pearsall, 1¼ miles southwest of.	F. A. Bredthauer	D. Upton		601.93		8		do	−48		C, E	I	Two wells 20 feet apart.
73	Pearsall, 1½ miles east of.	F. T. Malone		1900		50			do	−40		C, W	D	Dug.
74	Pearsall, 5½ miles east of.	W. M. Fain			569.50	1,265	8		do	−61				Abandoned oil test.
[a]75	Pearsall, 6 miles east of.	Mrs. H. C. Parramore.				46				−41		C, W	D	Dug.
76	Pearsall, 6½ miles east of.	do			584.57	237			Mount Selman formation.	−100		C, W	S	
77	Pearsall, 7 miles east of.	A. M. Woolsey	E. Doodlestadt	1905		160	6		do	−70		C, W	D, S	
78	Schattel, gin yard	Weiser & Raschke	S. Stussey	1929		145	5	143-145		−135		C, W	B	
79	Miguel, 1½ miles southwest of.	R. B. Kelly	A. Mann	1926	581.53	150	4			−116		C, W	S	Salty, bitter.
80	Miguel, 4 miles south of.	J. C. Nation	O. Z. Boone	1929		751	4½	460-480	Mount Selman formation.	−165		C, W	S	Water also at 70, 105, and 245-265 feet.
81	Pearsall, 9 miles east of, Simms Lake.	Oppenheimer & Lang.		1928			4½		do	+10	15		S	Flows.
82	Pearsall, 11 miles east of.	Oppenheimer & Lang, no. 1.	O. Z. Boone	1928		650	4½	600-650	do	+10	15		S	Flows; water also at 50 feet.
83	Goldfinch, 2½ miles west of.	Oppenheimer & Lang, no. 3.	do	1929		600	4½	510-600	do	+15	15		S	Flows; water also at 60-65 feet.
[a]84	Goldfinch, 1½ miles west of.	Oppenheimer & Lang, no. 2.	do	1929		860	4½	790-860	do	+32	22		S	Flows; water also at 30-32, 50-55, 71-80, 85-100, 310-330, and 500-600 feet.
85	Goldfinch, 1¼ miles west of.	O. Cox	do	1929		650	4½	590-650	do	−2			S	
86	Pearsall, 20 miles southwest of, near Zavala County line.	M. Taylor estate		1913		114	6		do			C, W	D	
87	Pearsall, 19 miles southwest of, ranch headquarters.	J. Loxton				250	6		do	−150		C, W	S	
88	Dilley, 13½ miles northwest of.	F. Doering				250	6		do	−50		C, W	D, S	
89	do	do				146	4½		do	−77		C, W	S	Pumped dry by windmill; bitter taste.
90	Dilley, 12 miles northwest of.	F. Kolos	W. Whitley	1922		175	6		do	−155		C, W	D, S	
91	Dilley, 11½ miles northwest of.	D. D. Harrigan				6	6		do	−57		C, W	S	Bitter, milky.
92	Divot, 2 miles west of.	L. Burnett	W. P. Alley			250	6		do	−44		C, W	S	

[a] For analysis see table on p. 60.

Records of wells in Frio County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power [a]	Use [b]	Remarks
[c] 93	Divot, ¼ mile west of	J. F. Burdwell	W. P. Alley	1928		173	6		Mount Selman formation.	−71		C, W	S, D	
94	Pearsall, ice plant	Central Power & Light Co.	Layne Texas Co.	1926	622	1,303	16-6		Carrizo sand	−60	125		City supply.	Temperature 92° F.
95	Pearsall, 0.1 mile southwest of ice plant.	do		1908		2,300	8-6	1,150-1,500	do	−60			N	"Old city well."
96	Pearsall, 1 mile southwest of.	W E. Weissinger	J M. Sorrel	1928	601.93	1,337	8	1,070-1,330	do	−96	672	T, E	I	
[c] 97	Pearsall, 3½ miles southwest of.	P. S. Tschirhard			553.21	1,350	8		do	−17	1,000	R, E	I	Flowed 100 gallons a minute when drilled.
98	Pearsall, 4½ miles southwest of.	Halff & Oppenheimer.		1905		1,473	8-4	1,200-1,473	do	−14	350	R, E	I	Flowed for 10 years temperature 96° F.
99	Pearsall, 5 miles southwest of.	J. N. Long	J. N. Long	1909	537.63	1,324	8	1,214-1,324	do	−9	860	R, G	I	Originally flowed.
100	Pearsall, 6 miles southwest of.	C. A. Davies	Gulf Coast Drilling Co.	1912	526	1,419	6		do	+1	25		I	Flows; temperature 98° F.
101	Pearsall, 5½ miles south of.	J. H. Evans		1911	526.41	1,540	8¼	1,200-1,540	do	−10	700	T, E	I	Flowed until 1928; temperature 98° F.
102	Pearsall, 11½ miles southwest of.	E. N. Corey		1910	540	1,408	10-8	1,204-1,408	do				N	Originally flowed 450 gallons a minute.
103	Dilley, 8½ miles northwest of.	C. W. Witherspoon		1927	505	1,514	8	1,324-1,502	do		750		I	Flows.
104	do	do		1917	515	1,515	8		do		600		I	Flows; temperature 96° F.
[c] 105	Derby, 2¾ miles northwest of.	S. S. Searcy	J. W. Ward	1912	493.22	1,672	6	1,375-1,672	do	+25	400		I	Flows.
106	Derby, 2¼ miles west of.	A. L. Mills		1918	492.94	1,750	8-6		do	+28	800		I	Flows; temperature 98° F.
107	Derby, 1¼ miles southwest of, known as Lilley No. 2.	E. Hohenberg		1914		1,761	8-6	1,485-1,699	do	+16	250	R, E	I	Flows; yields 450 gallons a minute when pumped.
108	Derby, 1½ miles southwest of, known as Lilley No. 1.	do		1913	484.71	1,760	8-6		do	+12	450	R, E	I	Flows; yields 750 gallons a minute when pumped.

[a]109	Derby, 1¼ miles south of.	John Bennett	Dodd	1915	484.66	1,700	10-8	1,440-1,700	do	+10	890	Cent., E	I	Flows; yields 2,000 gallons a minute when pumped.
110	Pearsall, 12 miles southeast of, Keystone ranch headquarters.	Oppenheimer & Lang.	I. U. Bettison	1912		1,757	12-6	1,485-1,757	do	+58	300		S	Flows; temperature 96° F.; water also at 100, 150, 580, 720, and 880 feet.
[a]111	Pearsall, 12½ miles southeast of, ranch headquarters.	F. McGowen				1,700	10		do		500		D, S	Flows; temperature 98½° F.
112	Dilley, ½ mile southwest of.	F. Blesse	G. Karsch	1913	564	2,410	6-4¾	1,836-2,180	do	−54	325	T, E	I	
[a]113	Dilley	International-Great Northern R. R.	McMaster & Pomeroy.	1924		2,010	8-6	1,923-1,990	do	−45	450	A, S	M	
114	Hindes, ¾ mile southwest of.	C. M. Kelly			396	2,114	10		do	+80	600		I	Flows.
115	Dilley, 12 miles west of	Mrs. C. T. Hardy	H. Rummel	1913		125	6		Cook Mountain formation.	−52		C, W	I, D	Brackish taste.
116	Dilley, 10½ miles west of.	Mrs. M. Melms	W. D. Morrison	1927		199	10		do	−97		C, W	C, S	Bitter taste.
117	Covey Chapel, store	J. P. Weatherford	H. Rummel	1924		165	4½		do	−99		C, W	D	Flat taste.
118	Covey Chapel	G. Mudd				22			do	−20		None	D	Dug.
119	Dilley, 2½ miles west of	H. N. Beekley		1927		343	8	240-340	do	−130	350	T, E	I	Water also at 145-225 feet; 2 wells.
120	Dilley, 3¼ miles northwest of.	Hauser Bros	W. D. Morrison	1927	564.33	303	10		do	−117	150	C, G	I	
[a]121	Dilley, 2½ miles northwest of.	do	do	1927		305	10		do	−95	175	T, G	I	
122	Dilley, 1 mile northwest of.	R. C. Jacobs	do	1928		336	10	268-336	do	−120		T, G	I	
123	Dilley	T. A. Raiford	do	1929		330	10	130-325	do	−120	180	T, E	I	
124	Dilley, 2½ miles north of.	D. D. Harrigan	do	1928	503.39	204	10	120-185	Mount Selman formation.	−60		None		
125	Dilley, 3 miles northwest of.	do	do	1928		200	10	185-200	do	−88	90	D, G		
126	Dilley, 2½ miles northwest of.	do	do	1928		358	10	135-195	do	−78		None		
127	Dilley, 3½ miles northwest of.	do	do		550.94	259	10	125-202	do	−105				
128	Dilley	C. D. Parker				200			Cook Mountain formation.	−120	180	C, E	I	
129	Dilley, 1 mile southwest of.	Ross & Avant			564.67	375	10	360-375	do	−133	200	T, E	I	
[a]130	Dilley, ¾ mile south of	do				200			do			C, E	D	
131	Dilley	R. A. White	W. D. Morrison			300	10		do			C, E	I	
[a]132	do	G. B. Nauermann	do	1927	540.62	307	10	120-302	do	−110		D, E	I	
[a]133	do	W. D. Morrison	do	1929		370	12½	122-365	do	−110		T, E	I	
134	Dilley, 1½ miles southeast of.	C. W. Rogers	do			358	10		do	−80?		T, G	I	

[a] For analysis see table on pp. 60-61.

Records of wells in Frio County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power [a]	Use [b]	Remarks
135	Dilley, 2 miles southeast of.	T. D. Fulmer	Hamilton	1929		200	8		Cook Mountain formation.	−60		C, G	I, D, S	
136	Dilley, ½ mile north of	W. C. Haynes	W. D. Morrison	1927	531.93	280	10	95–272	do	−97		None		
137	Dilley, 2 miles east of	G. V. Sellers	W. Alley	1926		119	6		do	−63		C, W	S only	
138	Goldfinch, gin	J. Cox	O. Z. Boone	1925		1,232	6	860–900	Mount Selman formation.	−24		C, W, S	B, D	
139	Goldfinch	J. C. Nation	do	1926	513	424	6	370–424	do			C, W	D	Water also at 50, 100–125, and 285–300 feet.
140	1.1 miles northeast of headquarters of Keystone ranch on west bank of San Miguel Creek.	Oppenheimer & Lang.		1894	455	390		375–390	do		10		S	Flows.
141	Dilley, 5 miles west of	E. W. Sanford	W. D. Morrison	1928		357	10		Cook Mountain formation.	−120	125	T, E		Water also at 203–354 feet.
142	Pearsall, 6 miles southeast of.	T. W. Foster	D. Upton	1915		175	4½		Mount Selman formation.	−160		C, W	S only	
143	Pearsall, 8 miles southeast of.	G. H. Nitschmann	G. Dietzman	1930		66		64–66	do	−53			D	Water also at 52 feet.
144	Pearsall, 11 miles southeast of.	D. A. Oppenheimer				75			do	−52		C, W		Dug.
145	Pearsall, 10 miles southeast of, ¾ mile west of Shallow Wells School.	W. Trickey					6		do	−115		C, W	S only	Bitter taste.
[c]146	Melon, 1½ miles southeast of.	W. J. Watkins		1912		228	6		do	−58		C, W	D, S	
147	Melon, 8 miles southeast of, ranch headquarters.	Mrs. M. Shiner				165	4		do.(?)	−58		C, W	D, S	
[c]148	Melon	C. McKinley	D. Upton	1926		242	6		do	−99		C, W	D	
149	do	Burden estate	J. Gray	1902		196	4½	150–196	do	−80		C, W	D	Pumps down in 45 minutes; water also at 80 feet.
150	Melon, gin	Frio Cotton Oil Co.	F. Wadzick	1906		350	5		do			C, S	B	
151	Melon	Melon Well Co.	D. Upton	1915		420	6	320?	do	−103		C, W	D	
152	Derby, ¼ mile northwest of.	F. Whitman	W. D. Morrison	1927			10		do	−72	45	C, E	I	

[c]152a	Derby, ½ mile southwest of.	H. Bennett				285	7		do	−45.8		C, W	D	
152b	do	do				455	5		do	−34		C, W	D	
[c]152c	Divot, 2½ miles southwest of.	R. S. Parks		1910		210	5	185–210	do	−65		C, W	D	
153	Derby	John Bennett	W. E. Smith	1910		306	6¼	280–306	do	−71		C, E	D	
154	Pearsall, 2½ miles southeast of.	R. E. Malone				80	4½		do	−72		C, W	D	
[c]154a	Pearsall, ½ mile west of.	J. L. Hammett				40			do	−12		C, W	D	
154b	Pearsall, 1 mile north of.	E. H. Shaw					4½		do	62.5		C, W	D	
[c]154c	Pearsall, 2 miles east of.	R. T. Barnhart				200	5⅞		do	−50		C, W	D	
155	Moore, 4 miles southeast of.	W. D. Syers	I. U. Bettison		566	1,978								
156	Moore, 3¾ miles southeast of.	do				100		42–100	Mount Selman formation.	−35	60			
157	Dilley, 1¾ miles west of.	Mrs. O. E. Flato	W. D. Morrison	1927		365	8	325–360	Cook Mountain formation.	−143		D, E		
158	Dilley, 2 miles north of.	J. L. Hill	do			235	10	100–235	do	−65		D, G		
[c]158a	Dilley, 4 miles northwest of.	M. C. Powers		1926		250	4½	210–250	Mount Selman formation.	−130		C, W	S	Salty.
159	Dilley	H. W. Fay	W. D. Morrison			395	12		Cook Mountain formation.	−73				

[c] For analysis see table on pp. 60–61.

Records of wells in Atascosa County, Tex.

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power [a]	Use [b]	Remarks
160	Rossville, 3¼ miles north of.	C. E. Dillon			637	136	4		Carrizo sand	−108		C, W	D, S	
161	Rossville, 2½ miles north of.	G. W. Beachman			636	125	2½		do	−105		C, W	D, S	
162	Rossville, 4 miles west of	A. Cortinas	Rio Bravo Oil Co.		543	4,080	8-6-4							Abandoned oil test.
[c]163	Rossville, 5½ miles southwest of.	R. Ross	T. Byram	1927	517	380	6	280–380	Carrizo sand	+12	80	Cent., K.		Water also at 180 feet. Flows; yields 250 gallons a minute when pumped.
164	Rossville, 6 miles southwest of.	do	do	1926		420	6	400–420	do	+17				
165	Anchorage	H. E. Whittet	H. E. Whittet	1910	547.9	250	4		do	−34.5		C, W	D, S	
[c]166	Poteet, 8½ miles north of	W. K. Hamilton			676	175	4		do	−140		C, G	D, S	
167	Poteet, 7½ miles north of	Osborne Gravel Co.	Osborne Gravel Co.	1928		187	4		do	−142		C, G	D,	2 wells 15 feet apart. Used also to wash gravel.
168	Poteet, 5½ miles north of	Mrs. L. Brockley			558	120	4		do	−90		C, G	D, S	
169	Leming, 4 miles north of	R. L. Bruce		1925		104	4	100–104	do	−69		C, W	D, S	Lignite at 60 feet.
170	do	Schultze Bros		1922		76	5	50–76	do	−28		C, W	D, S	Lignite at 38 feet.
171	Leming, ¾ mile south of	W. McKenzie				70	4		Mount Selman formation.	−40		C, G	D	
[c]172	do	D. McKenzie				120	3		do	−90		C, G	D	
173	Leming, 3¾ miles northeast of.	F. Jaksik	W. G. French	1916		4,004								Abandoned oil test.
174	Pleasanton, 10 miles northeast of, Black Hill store.	C. A. Moehrig				455	4½		Mount Selman formation.	−82		C, W	D, S	
175	Rossville, 5 miles south of.	Escalara	T. Byram			531	6-5		Carrizo sand					Flows; drilling in 1930.
176	Rossville, 4½ miles south, slightly west of.	J. D. Eldridge	do	1926		620	5¾	535–620	do	+12	150		I	Flows; water also at 390 feet.
[c]177	Rossville, 4½ miles south of.	do	do	1928		640	6	550–640	do	+5	25		I	Flows; water also at 400 feet.
178	Rossville, 5½ miles south of.	J. McDonald	do	1928		707	6	680–707	do	+11	50		I	Flows.
179	Rossville, 6 miles south of.	J. Campain	do	1927		578	6-4	558–578	do	+18	100	Cent., G.	I	Do.
180	Rossville, 5½ miles south of.	T. Byram	do	1926	475	558	5	550–558	do	+37	350		I	Do.

181	Rossville, 4½ miles south of.	do	do	1927	512	620	6	600-620	do	+9	120	I	Do
182	Rossville, 3½ miles south of.	J. McDonald	do	1927		680	6-4½		do	+10		I	Do.
183	Rossville, 3 miles south of.	A. N. Simmons	do	1926		468	6		(?)	-18	750 T	I	
184	Rossville, 3 miles southeast of.	E. Layer		1924		535	10	500-535	Carrizo sand	-12	450 Cent., G	I	
185	Rossville, 2½ miles southeast of.	L. S. Martinez	T. Byram	1927	535	560	6		do	-57		D, S	
186	Poteet, 3½ miles northwest of.	M. Rogers	do		513	422	8	210-250	do	-22	None.		
187	Poteet, 3 miles northwest of.	A. Forge	J. Wolfe		515	666	8	490	do	-32	900 Cent.	I	
188	do	do	do		515	525	8	375	do	-12	200	I	
189	Poteet, 4½ miles west of.	C. Layer				380			do			I	
190	do	do				380			do			I	
191	do	H. E. McKinney									400 Cent.	I	
192	Poteet, 3½ miles west of.	S. Solomon		1915		714	6		Carrizo sand	-10	30 Cent., G	I	
193	Poteet, 4 miles west of	C. E. Simmons		1928		627		490-627	do	-13	600 T	I	
194	Poteet, 3¾ miles west of.	A. C. Zigmond		1914		707	6	600	do	-1?	A, G	I	
195	Poteet, 3½ miles west of.	do				715	8-6	610-715	do	-5	A, G	I	
196	Poteet, 3¾ miles west of.	F. Hohberg		1914		600	6		do	+3	Cent., G	I	Slight flow.
[c]197	Poteet, 3¾ miles west of, Locke Nursery.	Locke Bros		1914		600	6		do	+23	350	I	Flows.
198	Poteet, 2¼ miles west of.	G. Jambers	G. P. Rainery	1911		1,000	8		do		Cent., G	I	
199	Poteet, 2 miles west of	T. Lozana	Holder	1924			6		do		A, G	I	
200	Poteet, 2½ miles west of.	H. T. Mumme	H. T. Mumme	1909		600	6		do	+1	5	S	Flows; once flowed 250 gallons a minute.
201	Poteet, 2½ miles southwest of.	J. W. Wilburn	T. Byram	1929		642	6-4½		do	+15	250	I	Flows.
202	Poteet, 1½ miles northwest of.	W. B. Wofford	G. Gilland	1926	505.4	1,040	8-6	985-1,040	do	-27.75	350 T, G	D, S	Water also at 810-887 feet.
203	Poteet, 1½ miles north of	S. Wall	do	1926		600	6		do	+5	50 Cent., G	I	Flows.
204	Poteet, 1 mile north of	C. E. Hurley		1926		918	6	700-918	do	+1	10 Cent., G	I	Do.
205	do	L. Scoggin	G. Gilland	1926		881	6	600-281	do	+28	250	I	Do.
206	Poteet	H. T. Mumme		1904		850	8	700-850	do	-5	500 Cent., E	I	Water also at 430 feet; originally flowed 216 gallons a minute.

[a] Pumps: C, Cylinder pump; D, duplex cylinder pump; A, air lift; T, turbin centrifugal pump; E, rotary pump; Cent., ordinary centrifugal pump. Power: W, Windmill; H, hand; G, gasoline or oil engine; E, electric motor; Kerosene engine.
[b] C, Cooking; D, domestic; S, stock; I, irrigation; B, boiler; N, not used; Kerosene engine.
[c] For analysis see table on pp. 60-61.

Records of wells in Atascosa County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power	Use	Remarks
207	Poteet, ¾ mile northwest of.	W. M. Slimm					6		Carrizo sand			A, E	I	Formerly flowed.
208	Poteet, ½ mile west of	J. L. Burd		1910		840	6		do		400	Cent., G	I	
209	Poteet, ½ mile northwest of.	J. Ward					4–6		do	−28		A, E	I	
210	Poteet, ½ mile north of	C. A. Reed		1911			4–8		do	+5	50	Cent., E	R. R., I	Flows; original head +30 feet.
211	Poteet, ¾ mile north of	S. Hughes	T. Byram	1928		720	6	670–720	do	+1	600	Cent., E	I	Flows.
212	do	H. L. Ulbrich	Brown	1926		800	4		do	+5		E	I	Small flow.
213	Poteet, 2½ miles northeast of.	L. F. Brown				850			do	−5			I	
214	Poteet, 1 mile northeast of.	J. Howard					8		do	−25				
215	Poteet	W. J. Hallmark et al.					8		do	+6	100	Cent., E	I	Flows.
c216	do	H. T. Mumme	H. T. Mumme	1910		840	6		do	+20	250		D	Do.
217	do	do	do	1912		840	6		do	+28	400	Cent., E	D	150 houses; flows.
c218	do	City of Poteet	J. Wolfe	1928		835	6		do	+30	50	Cent., E	M	Flows.
219	do	H. T. Mumme	H. T. Mumme	1917		840	6		do	+20	500		I	Do.
c220	Poteet, ¼ mile south of	do	do	1909		840	4½		do	+10	50		I	Do.
221	Poteet, ¾ mile southwest of.	P. Redish		1926			6		do	+42	350		I	Flows; originally flowed 250 gallons a minute.
222	Poteet, hotel	Mrs. E. Ernst		1910		840	6	750–840	do		50	A	I	Flows.
223	Poteet	W. M. Smelley		1927		927	4		do	+7	100	Cent., E	I	Do.
224	do	H. T. Mumme	H. T. Mumme	1914		840	4		do	+9	45	Cent., G	I	Do.
225	Poteet, ½ mile east of, south side of Pleasanton Road.	M. Myers		1911			6–4			+10			I	Do.
226	Poteet, ½ mile southeast of.	J. H. Hildreth et al.		1911			6		do	+15	75		I	Do.
227	Poteet, 1 mile south of	C. M. Rice		1925			6		do	+7	100	Cent., E	I	Do.

[a]228	Poteet, 1½ miles south of.	F. Hicks	G. Gilland	1926			6		do		350		I	Do.
229	Poteet, ¾ mile east of	C. L. Spence			460	840			do	−5		A	I	
230	do	E. A. Gomez				1,000	6-4		do	+6	60	T, G	I	Do.
231	do	A. R. Bailey				934	8-6	710-934	do	+15	250		I	Do.
232	Poteet, 2½ miles southeast of.	J. A. Burger	I. U. Bettison	1912	445	1,245	8-6		do	+5	25		I	Do.
233	Poteet, 2 miles southeast of.				409				do	+35	400		I	Do.
234	Poteet, 1¾ miles southeast of.	E. H. Shearer			426	1,001			do	+50	250		I	Do.
235	Poteet, 2 miles southeast of.	F. Cook				990			do	+35	300		I	Do.
236	Poteet, 3 miles southeast of.	I. R. Adams			425	1,000			do	+5	35			Do.
237	Poteet, 1 mile north of	Grayson & Manry		1926					do				I	
238	Poteet, ½ mile southeast of.	M. Myers				1,080	8		do		100		I	Do.
239	Leming, 1¾ miles southeast of.	M. F. Childress	Leming Oil & Refining Co.		454	2,600	8	850-1,150	Indio formation.	+5	15			Flows; abandoned oil test.
240	do	do				300	5		Carrizo sand (?)	−20				
[c]241	Pleasanton, 1½ miles north of.	E. R. Breaker	Evans et al	1911	412	1,925	8-4	927-1,200	Carrizo sand	+80	250?		I	Flows; water also at 1,206-1,515 feet.
242	Pleasanton, 1½ miles northeast of.	Richter et al	Gulf Production Co.		425				do					Abandoned oil test.
243	Pleasanton, 1 mile north of.	I. A. Eakins		1906		208	4		Mount Selman formation.	+10	40		D	Flows.
244	North Pleasanton, railroad shop.	San Antonio, Uvalde & Gulf R. R.			390	1,552		1,464-1,552	Carrizo sand	+96	500		R.R., D	Do.
245	Crown, 1½ miles southeast of.			1927		160	4		Mount Selman formation.	−130		C, W	S	Sulphur.
246	Charlotte, 1½ miles east of.	A. E. Beckman		1928	512	1,692	7-4	1,632-1,692	Carrizo sand	−12			D, S	
247	Jourdanton, 7 miles southwest of.	J. W. Madden				1,465	6		Mount Selman formation (?).	−34.5		C, H	D, S	
[c]248	Jourdanton, 1½ miles west of.	C. A. Robertson	I. U. Bettison			1,040	8-6	940-1,040	Mount Selman formation.	−80		C, W	D, S	
[c]249	Jourdanton, 1 mile northeast of.	Anderson & Arneson.		1925	403	1,505	6-6	1,412-1,505	Carrizo sand	−55	450		I	Flows.
[c]250	Jourdanton, ice plant	Central Power & Light Co.	Layne Texas Co.	1930		1,635	10-6	1,604-1,635	do	−6.5	270	T, E	M	Water also at 1,192-1,243 feet.
251	Jourdanton, 1½ miles northeast of.	C. S. Young	C. S. Young	1919	403	1,428		1,113-1,155	Mount Selman formation.	−10		C, G	D	Water also at 931-950, 810-820, 745-760, and 300-303 feet.
252	North Pleasanton, ¾ mile east of.	J. W. Siefried	W. Brown	1924		499	5-6		do	+4	25		I, D	Flows.
253	North Pleasanton, 3½ miles northeast of.	P. Wiseman			407	1,429		1,411	Carrizo sand	+2	10		D	Do.

[a] For analysis see table on pp. 60-61.

Records of wells in Atascosa County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons a minute)	Pump and power	Use	Remarks
254	North Pleasanton, 3 miles east of.	Hunter & Barber	B. T. Spradley	1909		482	5–4	400–482	Mount Selman formation.	+8	35		D	Flows; water also at 213 feet; originally flowed 125 gallons a minute.
[c]255	Coughran, 1½ miles north of.	W. J. Allerkamp	W. Brown		382	1,050	6–4	950–1,050	do	+12	100		D, S, I	Flows.
256	Coughran, 1 mile north east of.	J. A. Clopton	do			927	6		do	+35	350		I	Do.
257	Coughran, ½ mile north of.	do	do			903	6		do	+53	350		I	Do.
258	Coughran, east of gin	Coughran town site			344	800	6	700–800	do	+75	200		Town supply	Flows; water also at 500–506 feet.
259	Coughran, 5 miles north east of.	J. A. Brown	W. Brown			1,157	6		do	+40	200		I	Flows.
260	Pleasanton, courthouse yard.	Atascosa County	A. J. Parchman	1900		666	3	600–666	do	+25	65		D	Flows; gas; temperature 78° F.; water also at 150–165 feet.
261	Pleasanton	Mrs. J. F. Spence	A. Fuente	1909		470	3–2	430–470	do	+23	18		D	Temperature 77° F.; flows.
[c]262	do	J. R. Daughtry	W. Cook	1913		505	4–3	480–500	do	+9	20		D	Flows; coal at bottom; water also at 340 feet.
[c]262a	do	City of Pleasanton				815	8–4	640–800	do	−20				
[c]263	Pleasanton, hotel	T. Bright	W. Cook	1904		380	4–3	250	do	+16	4		D	Flows; water also at 200 feet; temperature 72° F.
264	Pleasanton	E. S. Ferris	B. T. Spradley	1910		563	3	500–513	do	+25	25		D	Flows; water also at 400–412 feet.
265	do	E. H. Burmeister, Sr.	A. Fuente	1909		676	3	600–676	do	+25	118		D	Flows; water also at 350 feet; temperature 80° F.; gas for lights, engine, and gas plant.

266	do	M. M. Mansfield	B. T. Spradley	1910		639	3	500–550	do	+22	150		D	Flows; water also at 400–412 feet; temperature 80° F.; gas for lighting and cooking in 2 houses and lighting additional house.
267	do	P. A. Vance	do	1912		686	5⅜ 3	628–686	do	+18	300		D	Flows; water also at 550–570 and 610–618 feet; temperature 81° F.
268	do	R. L. Gross estate	J. Mills	1912		708	3¾ 2	579–708	do	+30	70		D, I	Flows; water also at 220–250, 330–360, and 540–564 feet; temperature 80° F.
269	do	W. A. McCoy estate		1913		280	5–2		do	+20	5		D	Flows; temperature 70° F.; sulphur.
270	do	M. Royal	Allen & Wilson	1908		406	2–1¼		do	+5	15		D	Flows; temperature 77° F.
271	do	G. Long	A. Fuente	1909		720	4–3–2	670–720	do	+10	3		D	Flows; temperature 77½° F.
272	do	J. L. Akeridge and W. N. Meeks.	W. Cook	1902		610	3–2	510–530	do	+30	75		D	Flows; water also at 340 feet; 3 feet of coal at 500 feet.
273	do	C. W. Herzel	B. T. Spradley	1910		560	5	500–560	do	+11	70		D	Flows.
[c]274	do	A. B. Gillete	J. T. Mills	1897		340	4	334–340	do	+5	12		D	Flows; water also at 240–244 feet.
275	do	L. Thomason	W. Cook	1912		600	2		do	+18	50		D	Flows; water also at 400–570 feet; temperature 80½° F., gas sufficient for cooking, lighting, and heating.
276	do	Mrs. K. C. Ormand	do	1902		640	2	600–640	do	+12	30		D	Flows; temperature 74° F.; water also at 340 and 500–550 feet.
277	do	J. R. Cook		1902		640	2	600–640	do	+20	30		D	Flows.
278	Pleasanton, north edge of	R. H. Blanch		1920		372	3		do	+13	60		D, I	Do.
[c]279	Pleasanton	C. W. Kenley				630	3		do	+23	200		D	Do.
280	Pleasanton, south edge of	N. A. McCoy	L. Devilbiss	1912		708	3¾	580–780	do	+5	5		D	Do.
281	Jourdanton, 5¼ miles southwest of, at La Parita store.	R. C. Thurmand		1909		707	5³⁄₁₆	677–707	Cook Mountain formation (?).	+2	3		D, S	Flows; sulphur.
282	do	J. Matocha				1,504	6	1,504	Mount Selman formation.		175		D	Flows; sulphur; salt water at 300 and 700 feet; good water at 1,050 feet.
283	Jourdanton, 5 miles southwest of.	H. McCollum	W. Cook	1929		1,100	6		do	−10			D	

[c] For analysis see table on pp. 60–61.

Records of wells in Atascosa County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons per minute)	Pump and power	Use o	Remarks
284	Charlotte, 5½ miles southwest of, Davistown gin.	M. M. Davis				132	4		Cook Mountain formation.	−30		C, G	B, D	
285	Hindes, 2½ miles north of.	W. M. Hindes		1909		440	4		do. (?)	−5		C, W	S	
286	Hindes, ¼ mile north of	Atascosa State Bank		1915		350	4¼		do	+20	10			Flows.
•287	Hindes, opposite railroad station.	Hindes, Inc	W. Cook			450	4¼		do	+35	42		D, R. R.	Do.
288	Hindes, ½ mile east of	J. D. Romberg	C. Edwards			400	4¼		do	+20	35		D	Do.
289	Hindes, ¼ mile southeast of.	S. Williams	do	1895		445	4¼		do	+15	10			Do.
290	Hindes, ½ mile southeast of.	do	do	1918		450	4¼		do	+20	80		D	Do.
291	Charlotte, 6 miles southeast of.	M. N. Davis		1900		304	5⅝		do. (?)	+15	25		D, S, I	Do.
292	Charlotte 7 miles south of.	Y. D. Coleman				180			do	−30				Bitter taste.
293	Charlotte, 2½ miles southwest of.	J. W. Chamberlain		1929		105	4		do. (?)	−70		C, W	D	
294	Charlotte, ½ mile southeast of.	J. M. Couser	W. Favor	1912		200	4		do. (?)	−15		C, W	D	
295	Christine, north edge of	Town of Christine		1917	342	1,314	6–4	1,280–1,314	Mount Selman formation.	+25	300		Town supply.	Flows.
•296	Christine	do		1911	342	956	8	951–956	do		250			Flows; salty.
297	Christine, 4½ miles east of.	J. Campbell		1906		2,000	8	1,422–1,563	do		75			Flows.
298	Campbellton, 4½ miles northwest of.	J. Dupuy			357	2,938	10	1,640–1,698	do. (?)		300		I	Do.
299	Poteet, 1¾ miles northwest of.	E. J. Fasler		1911		1,000	6		Carrizo sand	−27.5		C, W	D, S	
•300	Pleasanton, 2 miles southeast of.	Cunningham & Taliferro.		1927	365	1,722	6–5$\frac{7}{16}$	1,435–1,722	do	+98	650		I	Flows; water also at 70–80, 170–178, 305–335, 625–715, and 910–961 feet.
301	Christine, 5½ miles west of.	R. Lauderdale				1,500	4	900–1,200	Mount Selman formation.	+60 originally.	60		D	Flows.

302	Pleasanton, 11 miles southeast of.	J. Dupuy			307	1,200			do				I	Do.
[a]303	McCoy	McCoy store			344	900			do		50		D	Do.
304	McCoy, 5 miles east of, King's School.	E. Albert	W. Stempel	1927		100	4		Yegua formation (?).	−55		C, W	D	Slightly salty
305	McCoy, 5½ miles east of	W. Taush	do	1927		109	4		do. (?)	−45		C, W	S	Salty.
306	McCoy, 5 miles east of	R. Smith	do	1929		148	4		do	−65		C, W	S	Do.
307	McCoy, 4½ miles east of	do	do	1929		138	4		do	−60		C, W	S	Do.
308	McCoy, 3 miles east of	Parkhill	do	1929		99	4		do	−50		C, W	S	Do.
309	McCoy, 3 miles southeast of.	T. Smith	do	1929		147	4		do	−55		C, W	S	Do.
310	McCoy, 5 miles east of	W. Taush	do			57	4		do	−50		C, W	D	
311	Campbellton, 8 miles northeast of.	J. W. Smith	do	1927		187	4		do	−70		C, W	S	Sulphur.
312	Campbellton, 7½ miles northeast of.	L. Mayer	do	1926		187	4		do	−98		C, W	S	Salty.
313	Campbellton, 8 miles northeast of.	L. Brister	do	1928		323	4		Yegua formation.	−80		C, W	D	Slightly salty.
314	Fashing, 4 miles northwest of.	F. Ruckman	do	1929		383	4		do. (?)	−85		C, W	S	Do.
315	Fashing, 3½ miles northwest of.	B. Hearhausler	do	1928		168	4		Jackson. (?)	−68		C, W	S	Salty.
316	Fashing, 2½ miles northwest of.	W. Hearhausler	do	1928		268	4		Jackson	−68		C. W	S	Do.
317	Fashing, 1¼ miles north of.	H. Kilner	D. P. Paschal	1923		110	4¼		do	−70		C, W	D	
318	Fashing, ½ mile north of.	F. Frenzil	do	1923		110	4¼		do	−40		C, W	S	Bitter taste.
319	Fashing, 1 mile northeast of.	J. Seiler	do	1923		91½	4¼		do	−30		C, W	S	
320	Fashing	J. Weigang	Schaffer	1929		198	4¼		do	−60		C, W	S	Salty.
321	Fashing, 1 mile southwest of.	H. Kelner	D. P. Paschal	1924		160	4¼		do			C, W	S	Sulphur.
322	Fashing	Fashing Mercantile Co.		1927		150	4		do	−50		C, W	S	Do.
323	Fashing, 2½ miles south of.	Essy Bros	D. P. Paschal	1923		160	4¼		do	−48		C, W	D	
324	Fashing, 4 miles southwest of.	do	do	1923		155	4¼		do	−50		C, W	S	
325	Campbellton, 3 miles northwest of.	A. N. Peller		1925		300	4		Yegua formation (?).	−100		C, W	S	Salty.
326	Campbellton, 2¾ miles northwest of.	do		1928		1,600	4		Mount Selman formation (?).		50		S	Flows; salty.
327	Campbellton	C. A. Struve		1928		2,000	8		do	+40	200			Do.
328	Campbellton, 4¼ miles southeast of.	Douglas	W. Stempel	1927		249	4		Jackson	−135		C, W	S	Salty.
329	Campbellton, 5½ miles southeast of.	Oldenoff	do	1927		247	4		do	−140		C, W	S	Do.

[a] For analysis see table on pp. 60–61.

Records of wells in Atascosa County, Tex.—Continued

No.	Location	Owner	Driller	Date completed	Altitude above sea level (feet)	Depth (feet)	Diameter (inches)	Principal water-bearing bed: Depth (feet)	Principal water-bearing bed: Geologic horizon	Water level above or below surface (feet)	Yield (gallons per minute)	Pump and power	Use	Remarks
330	Campbellton, 4 miles northeast of.	R. T. Eshenberg	W. Stemple	1930		387	4		Yegua formation (?).	−80		C, W	D	Slightly salty.
331	McCoy, 5 miles west of	A. Smith	do	1930		138	4		Yegua or Cook Mountain formation.	−70		C, W	S	Salty.
332	McCoy, 4¼ miles west of.	do	do	1928		148	4		do	−70		C, W	S	Do.
333	McCoy, 5 miles west of	do	do	1929		144	4		do	−70		C, W	S	Do.
334	Campbellton, 1½ miles northeast of.	F. Allen	do	1926		248	4		Yegua formation.	−10		C, W	S	Do.
335	Fashing, 1¾ miles northwest of.	J. Weigang	Schaffer	1930		285	4		Jackson					Gas only.
336	Coughran, 8 miles northeast of.	S. Houston	W. Stempel	1928		247	4		Cook Mountain formation (?).	−60		C, W	S	Salty.
337	Charlotte, 5 miles north of.	W. K. Shipman		1908		1, 207	5–3½	1, 140–1, 207	Carrizo sand	−60		C, W	D, S	Water also at 360–375 feet.
338	Charlotte, 4½ miles northwest of.	E. J. Pruitt				376	4	349–376	Mount Selman formation.	−8		C, W		Slight taste.
339	Campbellton, 4 miles southeast of.	Mrs. C. T. Tom	De Lange Eiser & Co.			4, 644								Abandoned oil test.
340	do	do	Pantex Oil Co	1915	352	2, 440		2, 440	Cook Mountain formation (?).					Salty; abandoned oil test; water also at 1, 200 feet.
341	Pleasanton, 2½ miles southeast of.	T. H. Harrison	Geo. Boone			244	4	234–244	do	−54		C, W	S	Salty.
342	Poteet, 4 miles east of	H. Shearer		1930		909	4½	735–909	Carrizo sand	+15	150			Flows.
343	Charlotte, west edge of	Chamberlain							Mount Selman formation.				D	

Partial log of well of L. E. Blackallar, Lefevre & Story no. 1, 3 miles north of Frio Town, Frio County (no. 3)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation (Bigford member):			Indio formation:		
Clay and sand	10	10	Hard blue rock	7	255
Sandrock and hard shale	55	65	Hard sandy shale	15	248
Carrizo sand:			Rock	4	274
Water sand	5	70	Shale and sand	8	282
Hard sandrock	30	100	Hard blue rock	25	307
Clay and gravel	35	135	Sandy shale	13	320
Sand and gravel; probably water	15	150	Yellow clay	30	350
Sandrock	10	160	Rock	10	360
Sand and gravel	25	185	Clay and boulders	30	390
Hard sand and gravel	25	210	Yellow clay	10	400
Sand; probably water	38	248	Rock	2	402

Log of Donaldson Oil & Gas Co. well 1, W. O. Brown, 3 miles southwest of Moore, Frio County (no. 22)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Indio formation:		
Surface soil	10	10	Hard packed sand with layers of rock	380	1,260
Gravel and sand	42	52	Hard sandy shale	8	1,268
Hard rock with streaks of sand and boulders	48	100	Gumbo and lignite	20	1,288
Hard rock inlaid with sand	46	146	Hard sandy shale	26	1,314
Rock	24	170	Rock	2	1,316
Shale	50	220	Pack sand with layers of shale	434	1,750
Hard sand	6	226	Gumbo and boulders	16	1,766
Sand and shale with gas	14	240	Limerock	4	1,770
Sand with water	27	267	Sandy shale	23	1,793
Packed sand and lime shells	184	451	Lime and shell	17	1,810
Shale	47	498	Blue sand core	5	1,815
Carrizo sand:			Gumbo	44	1,859
Sand (cored; water)	160	658	Limerock	5	1,864
Hard packed sand streaked with rock	122	880	Sand core	4	1,868
			Shale	29	1,897
			Sandrock	3	1,900

Log of North & Walton well 1, C. C. Tribble, 6 miles northeast of Moore, Frio County (no. 26)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Indio formation—Continued.		
Sand	14	14	Sandrock	3	504
Gray shaly clay	23	37	Shale and sand	35	539
Carrizo sand:			Sandrock	2	541
Hard sand	11	48	Shale	7	548
Sand and shale	16	64	Shale and boulders	46	594
Lignite	1	65	Hard sand and rock	14	608
Sand	75	140	Brown shale	72	680
Lignite	1	141	Sand and shale	9	689
Sand with streaks of lignite	71	212	Brown shale and boulders	34	723
Indio formation:			Sandrock	5	728
Brown shale	8	220	Shale and boulders	72	800
Sand with shale breaks	50	270	Sand and shale	28	828
Brown shale	20	290	Shale and boulders	22	850
Sandrock	2	292	Hard sand	4	854
Shale	5	297	Shale and boulders	42	896
Sand and lignite	27	324	Hard sand and shale	70	966
Sandrock	5	329	Hard sandrock	8	974
Shale	56	385	Shale	28	1,002
Sand	53	458	Hard sand	4	1,006
Shale	43	501	Shale	25	1,031

Log of North & Walton well 1, C. C. Tribble, 6 miles northeast of Moore, Frio County (no. 26)—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Indio formation—Continued.			Navarro formation—Continued.		
Hard sand	6	1,037	Sticky shale and shale	310	2,285
Shale and boulders	38	1,075	Sand	12	2,297
Hard sand	15	1,090	Sand and sticky shale	39	2,336
Sandy shale	21	1,111	Sand	11	2,347
Sandrock	2	1,113	Sand and sticky shale	22	2,369
Midway formation:			Hard shale	20	2,389
Shale and greensand	21	1,134	Sand	8	2,397
Greensand and sticky shale	6	1,140	Sticky shale	53	2,450
Shale and sand	83	1,223	Sand	6	2,456
Shale	57	1,280	Sticky shale	30	2,486
Hard limy sand (greensand and shell)	29	1,309	Shale and sand	34	2,520
Shale	7	1,316	Sticky shale	6	2,526
Hard sandy shale (greensand and fossil shell fragments)	42	1,358	Gumbo and sticky shale	10	2,536
Sandrock	2	1,360	Shale and sticky shale	50	2,586
Shale and sand	28	1,388	Shale and sandy shale	66	2,652
Hard and sticky shale	10	1,398	Shale and sticky shale	34	2,686
Hard sand	7	1,405	Taylor marl:		
Shale	13	1,418	Lime and shale	13	2,699
Sand	2	1,420	Lime	3	2,702
Shale	10	1,430	Lime and shale	144	2,846
Greensand	8	1,438	Hard and sticky shale	15	2,861
Sandy shale	27	1,465	Hard sand	31	2,892
Hard sand	2	1,467	Anacacho limestone: Lime and shale	44	2,936
Navarro formation:			Austin chalk: Hard chalk with breaks of gummy chalk	145	3,181
Gray sticky shale	10	1,477	Eagle Ford shale:		
Hard shale and boulders	36	1,513	Shale	9	3,190
Sandrock	2	1,515	Shale and lime	22	3,212
Sticky shale with hard sand breaks	35	1,550	Limy shale	145	3,357
Sticky shale and boulders	61	1,611	Buda limestone: Hard white lime	32	3,389
Sticky shale with sand breaks	82	1,693	Del Rio clay: Dark shale	40	3,429
Sticky shale with hard sand	42	1,735	Georgetown limestone:		
Hard shale	18	1,753	Hard white lime	58	3,487
Sticky shale and hard shale with sand streaks	222	1,975	Soft gummy lime	4	3,491
			Edwards limestone: Hard lime	41	3,534

Log of well 2 of Oppenheimer & Lang, 2½ miles west of Goldfinch, Frio County (no. 83)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Mount Selman formation—Contd.		
Yellow sand	30	30	Sandy shale	60	310
Water sand	2	32	Water sand; no flow	20	330
Yellow clay	18	50	Shale	90	420
Water sand	5	55	Mud	60	480
Yellow gumbo	15	70	Shale	20	500
Rock	1.8	71.8	Water sand; some lignite; flow of water	100	600
Water sand	8.2	80	Shale	55	655
Blue shale	5	85	Mud	45	700
Water sand	15	100	Shale	90	790
Sandy shale; some rock	100	200	Water sand; flows	70	860
Mud	50	250			

Log of well of H. H. Page, 2 miles north of Pearsall, Frio County (no. 40)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Mount Selman formation—Contd.		
Clay	42	42	Reddish clay	7	65
Rock	4	46	Water sand	41	106
Yellow gumbo	12	58			

Log of high school well at Pearsall, Frio County (no. 64)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Mount Selman formation—Contd.		
Red sand	2	2	Blue shale	34	120
Sand and clay	38	40	Shale and lignite	10	130
Blue gumbo	10	50	Gumbo	20	150
Yellow clay	5	55	Blue shale	20	170
Yellow sand; some water	10	65	Sandrock	1	171
Hard sandrock	5	70	Blue shale	39	210
Blue shale	15	85	Water sand	4	214
Sandrock	1	86	Sand and shale with water	23	237

Log of well of E. Hohenberg, Lilley no. 2, 1¼ miles southwest of Derby, Frio County (no. 107)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Reynosa formation:			Mount Selman formation—Contd.		
Surface soil	4	4	Shale	3	383
White hard caliche	4	8	Sand	12	395
Gravel	10	18	Hard blue shale	15	410
Mount Selman formation:			Rock	17	427
Hard sandrock	21	39	Blue shale boulders	3	430
Yellow sand	2	41	Coal	105	535
Hard sand	3	44	Shale, etc., boulders	5	540
Hard rock	18	62	Hard smooth rock	775	1,315
Brown soil	3	65	Brown shale	1	1,316
Wet sand; very little water	5	70	Brown shale; little show of oil and gas	82	1,398
Hard brown soil	5	75			
Blue sand; water	10	85	Carrizo sand:		
Soft blue shale	15	100	Coarse gray sand; artesian flow	71	1,469
Gravel	13	113	Soft brown shale; gas	16	1,485
Soft brown shale	5	118	Hard gray shale	10	1,495
Sand	22	140	Hard gray fine sand	135	1,630
Hard shale and boulders	4	144	Shale	15	1,645
Rock	91	235	Rock	2	1,647
Shale	3	238	Hard shale and rock	21	1,668
Hard sandrock	52	290	Gray sand; artesian flow	26	1,694
Blue shale	10	300	Gumbo	5	1,699
Blue sand; water	25	325	Sand; artesian flow	10	1,709
Soft blue gumbo	10	335	Shale	51	1,760
Coal	35	370	Rock	1	1,761
Hard rock	10	380			

Partial log of well of C. M. Kelley, three-fourths mile southwest of Hindes, Atascosa County (no. 114)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil and clay	20	20	Cook Mountain formation—Cont.		
Fine white sand	10	30	Shale	18	312
Gravel	8	38	Gumbo	15	327
Cook Mountain formation:			Hard rock	3	330
Blue clay	10	48	Shale	27	357
Blue pack sand	39	87	Gumbo	5	362
Blue gumbo	4	91	Pack sand	11	373
Blue pack sand	36	127	Coarse white sand; small flow	60	433
Light-blue gumbo	30	157	Soapstone	3	436
Very hard rock	2	159	Shale	20	456
Black gumbo and boulders	35	194	Gumbo	6	462
Gray pack sand	20	214	Shale	14	476
Very hard rock	1	215	Coarse sand; show of oil	12	488
Shale	18	233	Gumbo and boulders	27	515
Boulders	4	237	Soft blue rock	11	526
Gumbo	10	247	Gumbo	10	536
Blue pack sand	31	278	Shale and shells	32	568
Gravel	1	279	Hard rock	1	569
Shale	6	285	Gumbo	15	584
Gumbo	9	294	Shale	20	604

Partial log of well of C. M. Kelley, three-fourths mile southwest of Hindes, Atascosa County (no. 114)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Cook Mountain formation—Cont.			Cook Mountain formation—Cont.		
Hard rock	1	605	Sand	15	844
Gumbo	3	608	Hard rock	24	868
Gray sand	5	613	Gumbo	5	873
Gumbo	6	619	Hard rock	2	875
Hard rock	1	620	Hard sand	10	885
Hard sand	5	625	Hard sandy shale	35	920
Hard rock	2	627	Gumbo	15	935
Fine blue sand	14	641	Shale	10	945
Gumbo	3	644	Gumbo	4	949
Hard rock	1	645	Shale	5	954
Porous rock	6	651	Gumbo with hard shells	11	965
Gumbo	36	687	Mount Selman formation (?):		
Shale	20	707	Porous rock; 8-inch casing set	7	972
Porous rock; second flow	18	725	Gumbo	4	976
Gumbo	15	740	Shale	15	991
Shale	8	748	Gumbo	4	995
Gumbo	10	758	Shale	35	1,030
Hard rock	1	759	Fine blue sand	11	1,041
Blue shale and shells	10	769	Shale	21	1,062
Fine gray sand	13	782	Gumbo	21	1,083
Hard sand and shale	35	817	Hard sand	8	1,091
Gumbo	12	829	Gumbo and boulders	4	1,095

Log of well of R. C. Jacobs, 1 mile northwest of Dilley, Frio County (no. 122)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	4	4	Water sand	168	290
Sandy clay	21	25	Gumbo	25	315
Yellow sand	40	65	Sandy shale	5	320
Gray sand	57	122	Gumbo	16	336

Log of well of W. D. Morrison, Dilley, Frio County (no. 133)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil	4	4	Sandstone	20	95
Clay	11	15	Blue shale	27	122
Sandstone	20	35	Water sand	243	365
Sandy clay	35	70	Blue shale	5	370
Limestone	5	75			

Log of well of W. C. Haynes (nursery well), half a mile north of Dilley, Frio County (no. 136)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Soil and clay	45	45	Water sand	177	272
Blue shale	5	50	Sandy gray shale	8	280
Blue sandy shale	45	95			

Partial log of well of W. D. Syers, 4 miles southeast of Moore, Frio County (no. 155)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Carrizo sand:		
Soil and clay	25	25	Coarse white sand	30	560
Sand	3	28	Medium white sand	176	736
Yellow gumbo	20	48	Porous rock	54	790
Yellow sand	35	83	Very hard rock	2	792
Lignite	3	86	Coarse white sand; good water	20	812
Shale	7	93	Very hard rock	6	818
Rock	1	94	Porous rock	57	875
Sand	10	104	Hard rock	1	876
Rock	1	105	Porous rock	14	890
Blue sand gas	27	132	Very hard rock	4	894
Gumbo	11	143	Coarse hard water sand	37	931
Rock and boulders	12	155	Indio formation:		
Gray sand; gas	40	195	Very hard rock	3	934
Rock	1	196	Hard sand and shells; water	58	992
Soft shale; gas and oil	31	227	Very hard rock	1	993
Rock	3	230	Fine black sand	17	1,010
Fine sand	10	240	Hard rock	1	1,011
Soft rock; gas	22	262	Fine black sand	53	1,064
Sand	50	312	Very hard rock	3	1,067
Sand and shale	88	400	Fine blue sand	20	1,087
Soft gumbo	13	413			
Very hard rock	10	423			
Fine white sand	106	529			
Shale rock	1	530			

Partial log of well of Rio Bravo Oil Co., no. 2 Cortinas, 4 miles west of Rossville, Atascosa County (no. 162)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Indio formation:		
Hard sand	25	25	Black gumbo	15	500
Yellow clay	57	82	Rock	5	505
Rock	1	83	Gumbo and shale	27	532
Carrizo sand:			Pyrite	11	543
Hard sand	131	214	Sand and boulders	44	587
Sandrock	12	226	Rock	3	590
Hard rock	134	360	Gumbo	37	627
Sandrock	4	364	Hard rock	3	630
Hard sand	121	485			

Log of well of E. R. Breaker, 1½ miles north of Pleasanton, Atascosa County (no. 241)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation:			Mount Selman formation—Contd.		
Surface sand	2	2	Pyrite	1	495
Yellow clay	22	24	Shale and sand	10	505
Gray clay	14	38	Hard rock	4	509
Blue clay	6	44	Shale and sand	14	523
Water sand	64	108	Hard limerock	2	525
Soft sandrock	92	200	Shale and sand	8	533
Water sand	24	224	Gumbo	23	556
Rock sand	11	235	Sand, shale, and slate	33	589
Shale	15	250	Brown rock	3	592
Soft asphalt rock and fine sand	14	264	Hard sand	22	614
Brown shale mixed with gumbo	22	286	Rock	4	618
			Shale	25	643
Brown shale and sand	23	409	Hard sand; water show	16	659
Sandrock	3	412	Soft shale and gumbo	21	680
Brown shale	27	439	Blue and brown shale and sand	37	717
Rock	1	440	Rock	1	718
Brown shale and sand	44	484	Shale and sand	38	756
Hard rock	1	485	Gumbo	14	770
Lignite	2	487	Rock	1	771
Shale and sand	7	494	Shale and sand	11	782

Log of well of E. R. Breaker, 1½ miles north of Pleasanton, Atascosa County (no. 241)—Continued

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Mount Selman formation—Contd.			Indio formation:		
Brown rock	4	786	Pyrite	3	1,518
Soft shale and sand	4	790	Lignite	4	1,522
Hard gumbo	14	804	Black gumbo	78	1,600
Limerock	2	806	Packed sand	12	1,612
Sand; oil show	4	810	Black gumbo	88	1,700
Porous rock; oil show	22	832	Limestone	20	1,720
Shale and sand	24	856	Shell and shale	20	1,740
Gumbo	12	868	Gray blue gumbo	25	1,765
Rock	1	869	Sand; water show	25	1,790
Shale and sand	31	900	Shale	15	1,805
Gumbo	25	925	Rock	4	1,809
Rock	2	927	Hard shale	102	1,911
Water sand	273	1,200	Soft shale; gas show	6	1,917
Carrizo sand:			Rock (lime formation)	8	1,925
Rock	6	1,206			
Water sand	309	1,515			

Log of well of C. S. Young, 1½ miles northeast of Jourdanton, Atascosa County (no. 251)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Cook Mountain formation:			Mount Selman formation—Contd.		
Yellow sand	2	2	Blue sandstone	3	993
Red clay	3	5	Hard pack sand	7	1,000
Gravel, pyrite, and gypsum	5	10	Blue sandstone	3	1,003
Black sand	10	20	Blue shale	4	1,007
Gravel and pyrite	30	50	Blue sandstone	3	1,010
Yellow rock	20	70	Hard blue sand	10	1,020
Black sand	5	75	Hard rough red rock	4	1,024
Black shale	7	82	Hard sandstone	11	1,035
Gray sand	38	120	Blue sandstone	3	1,038
Oil showing	20	140	Hard blue shale	30	1,068
Water sand	22	162	Blue sandstone	3	1,071
Rock sand	140	300	Shale and sand; oil and gas	1	1,072
Water sand	3	303	Hard sandstone	8	1,080
Sandstone and shell	32	335	Water sand	10	1,090
Pack sand	3	338	Blue sandstone	2	1,092
Mount Selman formation:			Blue gumbo	18	1,110
Hard, rough sandstone	202	540	Blue sandstone	3	1,113
Sand; oil showing	3	543	Water sand	42	1,155
Red gumbo	7	550	Blue sandstone	5	1,160
Hard sandstone	12	562	Blue shale	25	1,185
Sandstone	6	568	Blue sandstone	3	1,188
Hard sandstone	3	571	Water sand	22	1,210
Black sand	14	585	Hard blue shale; oil show	9	1,219
Blue gumbo	20	605	Blue sandstone	3	1,222
Black shale	25	630	Hard blue shale	6	1,228
Blue gumbo	15	645	Hard blue sandstone	2	1,230
Black shale	35	680	Blue shale	6	1,236
Pack sand	25	705	Hard blue sandstone	4	1,240
Blue gumbo	10	715	Blue shale	20	1,260
Sand and shale; oil show	7	722	Blue sandstone; oil show	3	1,263
Sand; oil show	8	730	Hard blue shale	9	1,272
Blue gumbo	15	745	Blue sandstone	3	1,275
Water sand	15	760	Soft blue shale	15	1,290
Blue sandstone	10	770	Blue sandstone	4	1,294
Hard blue shale	12	782	Blue gumbo	18	1,312
Gumbo and boulders	13	795	Blue shale	13	1,325
Hard blue gumbo	15	810	Blue sandstone	4	1,329
Water sand	10	820	Blue shale	11	1,340
Blue shale	50	870	Blue sandstone	5	1,345
Hard sand	12	882	Blue shale	5	1,350
Hard blue shale	18	900	Blue sandstone	4	1,354
Blue gumbo	10	910	Blue shale	16	1,370
Blue shale	21	931	Blue sandstone	3	1,373
Water sand	19	950	Blue shale	7	1,380
Hard sandstone	4	954	Blue sandstone	4	1,384
Gumbo and pyrites	16	970	Blue shale	11	1,395
Sandstone	4	974	Blue sandstone	5	1,400
Soft blue shale	8	982	Hard blue shale	10	1,410
Hard rough sandstone	3	985	Brown shale	8	1,418
Hard blue shale	5	990	Hard blue sandstone	10	1,428

Log of well of Cunningham & Taliferro, 2 miles southeast of Pleasanton, Atascosa County (no. 300)

	Thickness (feet)	Depth (feet)		Thickness (feet)	Depth (feet)
Cook Mountain and Mount Selman formations:			Cook Mountain and Mount Selman formations—Continued.		
Yellow soil and clay	50	50	Sand and clay, hard	44	1,005
Dark-blue clay	25	75	Gray water sand	40	1,045
Sandrock	2	77	Hard sand and shale	168	1,213
Water sand	3	80	Gray water sand	29	1,242
Blue clay	90	170	Hard sandy shale	138	1,380
Blue water sand	8	178	Shale and gumbo	39	1,419
Blue clay	127	305	Carrizo sand:		
Blue water sand	30	335	White hard rock	16	1,435
Blue clay	290	625	White water sand	75	1,510
Blue water sand	90	715	Blue hard rock	17	1,530
Blue clay	89	804	White water sand	54	1,590
Sandrock	106	910	Blue hard rock	30	1,620
Blue water sand	51	961	White water sand and coal	102	1,722

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