Geohydrologic Significance of Lithofacies of the Carrizo Sand of Arkansas, Louisiana, and Texas and the Meridian Sand of Mississippi

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GEOHYDROLOGY OF THE CLAIBORNE GROUP

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GEOHYDROLOGIC SIGNIFICANCE OF LITHOFACIES OF THE CARRIZO SAND OF ARKANSAS, LOUISIANA, AND TEXAS AND THE MERIDIAN SAND OF MISSISSIPPI

By J. N. Payne

ABSTRACT

The study of the Carrizo and Meridian Sands is the fourth part of an investigation of the geohydrology of the Claiborne Group.

The regional dip of the Carrizo and Meridian Sands is into the Desha basin, Mississippi embayment, and gulf coast geosyncline. Some movement of major structural features took place during Carrizo and Meridian time. Normal faulting is rather extensive in southern Arkansas and in Texas.

The thickness of the Carrizo and Meridian Sands varies from 0 in areas of nondeposition to a maximum of 700–750 feet in De Witt and Karnes Counties, Tex.

The Carrizo and Meridian Sands are lithologically almost uniform, being composed of more than 80 percent sand in about three-fourths of the area of study. In Arkansas, Louisiana, Mississippi, and part of eastern Texas, the formations were deposited as valley and channel fills and as beach sands over an irregular erosional surface. The Carrizo Sand over most of Texas was deposited as alongshore and nearshore bar and beach sands.

Aquifer tests indicate that the coefficient of permeability increases with increase in sand-unit thickness, but the range in values in the Carrizo and Meridian Sands is not as great as the range in values found in the other Claiborne aquifer formations. The areas of highest transmissivity of the formations are in west-central Mississippi and in southern Texas.

Recharge to the Carrizo and Meridian Sands takes place by infiltration of precipitation in the outcrop area and by infiltration of water from streams. Natural discharge from the Carrizo and Meridian Sands occurs primarily by leakage through the overlying confining beds. Regional flow of water in the formations is generally down the dip of the formations except where modified by long-term heavy withdrawals and in southern Texas where thick sand in the overlying Reklaw and Queen City Formations facilitates the escape of water from the Carrizo because of increased vertical permeability.

In Mississippi and Texas the dominant anion is bicarbonate in water from the Carrizo and Meridian Sands from depths of 1,700 to more than 2,500 feet. In Arkansas and Louisiana, chloride is the dominant anion below depths of 500–1,000 feet. Appreciable amounts of sulfate have been found in water from the Carrizo Sand in Texas to depths of more than 2,000 feet. Sodium is the dominant cation in water from the Carrizo and Meridian Sands of Arkansas, Louisiana, and eastern Texas. Calcium and magnesium occur in significant amounts in water from the Carrizo Sand in southern Texas to depths greater than 2,900 feet below land surface. The distribution of the dissolved-solids content of water from the Carrizo and Meridian Sands reflects the influence of geologic and hydrologic factors on water movement and the extent of flushing of the formations by fresh water.

INTRODUCTION

PURPOSE AND SCOPE

The investigation of the hydrologic significance of the lithofacies of the Carrizo and Meridian Sands constitutes the fourth part of a study of the geohydrology of the Claiborne Group of Eocene age. The report on the results of this investigation describes and evaluates the relations of stratigraphy, facies development, and depositional controls to the hydraulic characteristics of the Carrizo and Meridian Sands in parts of Arkansas, Louisiana, Mississippi, and Texas (fig. 1).

To accomplish the objectives of the investigation, data derived from electrical logs of oil, gas, and other

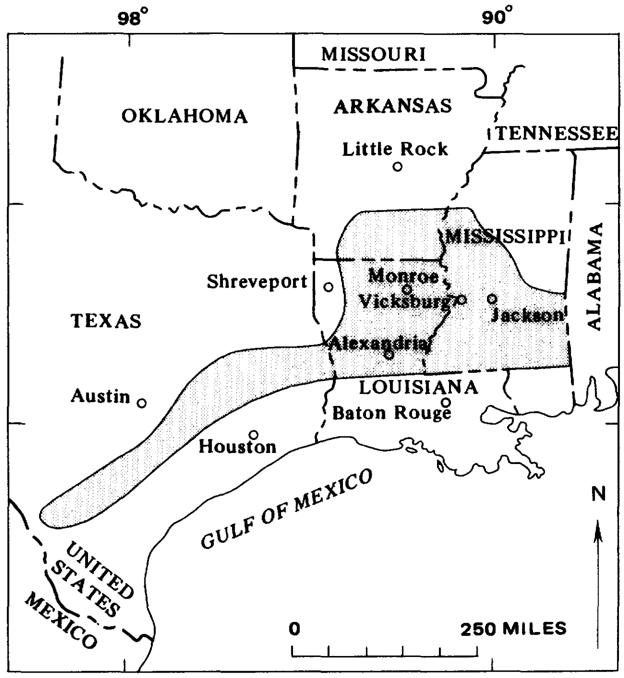

FIGURE 1.—Location of report area.

test wells, together with data from hydrologic tests, were used to prepare geologic and hydrologic maps and cross sections. The interpretation of the maps and cross sections forms the body of the report.

ACKNOWLEDGMENTS

Acknowledgment is made to the Arkansas Geological and Conservation Commission; the Louisiana Geological Survey, Department of Conservation; the Texas Water Development Board; and the Mississippi Oil and Gas Board for making available their log files.

GEOLOGY

The Carrizo Sand (Owen, 1889, p. 70) of Arkansas, Louisiana, and Texas and the equivalent Meridian Sand (Lowe, 1933, p. 1, 105–106) of Mississippi consist predominantly of fine to coarse micaceous massive-bedded quartz sands with minor amounts of interbedded clays and silts and occasional lenses of lignite. Glauconite has been found in cores from oil tests in the deeper downdip parts of the formations in Louisiana and Mississippi.

The correlation of the Carrizo and Meridian Sands as used in this report is shown on stratigraphic sections (pls. 1–4). The correlation shown on these sections is generally in agreement with that shown by Hosman (1962, p. 390–391).

STRUCTURE

The structure of the top of the Carrizo and Meridian Sands is shown on plate 5.

In southern and southeastern Arkansas the regional dip is east and northeast at 20–50 feet per mile into the Desha basin. In northern, northeastern, and east-central Louisiana, the regional dip is east and southeast at 20–70 feet per mile into the Mississippi embayment. In south-central Louisiana and in Texas, the regional dip is south and southeast at 20–300 feet per mile into the gulf coast geosyncline. In northwestern and west-central Mississippi, the regional dip is west and southwest into the Desha basin and Mississippi embayment at 20–125 feet per mile. In southern Mississippi the regional dip is south and southwest at 20–150 feet per mile into the gulf coast geosyncline.

Major positive structural elements reflected on the map showing the altitude of the top of the Carrizo and Meridian Sands (pl. 5) are the Sabine arch of western Louisiana and eastern Texas, the La Salle arch in La Salle and Rapides Parishes, La., the Monroe uplift in Ouachita and Richland Parishes, La., and the Jackson dome in Mississippi. Major negative structural elements shown are the Desha basin in southeastern Arkansas, the Mississippi embayment in eastern Louisiana and western Mississippi, and the north and northwest limb of the gulf coast geosyncline in southern Louisiana, southern Mississippi, and in Texas. Thinning of the Carrizo and Meridian Sands over the Sabine and La Salle arches (pl. 1), the Wiggins arch (pl. 2), the Monroe uplift (pl. 3), and the Jackson dome (pl. 6) suggests some growth of these structures during Carrizo and Meridian time. Normal faulting is rather extensive in southern Arkansas, along the eastern flank of the Sabine arch in Louisiana, and along the north and northwest limb of the gulf coast geosyncline in Texas (pl. 5).

THICKNESS

The thickness of the Carrizo and Meridian Sands in Arkansas, Louisiana, and Mississippi is extremely variable, ranging from 0 in areas of nondeposition to between 200 and 250 feet in the Desha basin of Arkansas; the thickness is 300–450 feet in the Mississippi embayment eastward from Madison Parish, La., and northeastward to Holmes County, Miss. (pl. 6). In eastern Texas the thickness of the Carrizo Sand is nearly uniform, generally ranging between 100 and 200 feet except near the downdip limit of deposition (pl. 6). From Fayette County, Tex., southwestward through Webb County, the Carrizo Sand thickens to more than 400 feet and attains its maximum thickness of 700–750 feet in Karnes and De Witt Counties (pl. 6).

LITHOLOGIC VARIATIONS AND INTERPRETATION OF DEPOSITIONAL ENVIRONMENT

The Carrizo and Meridian Sands are almost uniform lithologically. In about three-fourths of the area underlain by the Carrizo and Meridian, the formations consist of more than 80 percent sand, and in the remaining one-fourth of the area, the formations generally consist of more than 50 percent sand except in the extreme downdip reaches of the Carrizo Sand in Texas (pl. 6, sheet 2).

The sand-percentage, formation-thickness, and maximum sand-unit-thickness maps of the Carrizo and Meridian Sands (pls. 6, 7) show marked differences between the depositional patterns in Arkansas, Louisiana, and Mississippi and the depositional patterns in most of Texas. (The method of constructing the sand-percentage and maximum sand-unit maps is given in the discussion of the Sparta Sand (Payne, 1968, p. A3–A5).)

In Arkansas, Louisiana, and Mississippi the Carrizo and Meridian nearly always contain more than 80 percent sand, even in the downdip extremities (pl. 6, sheet 1; pls. 2,3). The formation-thickness and maximum sand-unit-thickness maps (pls. 6, 7, sheet 1) show a pattern of thickening along relatively narrow sinuous bands elongated in a northerly direction, which is normal to the probable direction of orientation of the shoreline of the early Claiborne sea. The axes of thickening of the maximum sand units exhibit a well-developed anastomosing and bifurcating pattern similar to that of the present delta and fluvial plain of

Louisiana and Mississippi. The pattern of deposition of the Carrizo and Meridian Sands is believed to have resulted from the deposition of sand alongshore and nearshore during the initial advance of the Claiborne sea over an erosional surface developed on sediments of the Wilcox Group by an ancestral Mississippi River system. The elongate areas of thickening of the Carrizo and Meridian sands and the pattern of massive sand developments have resulted mainly from the filling of preexisting channels and valleys during Carrizo and Meridian time. Some massive sand units in Jones and Wayne Counties, Miss. (pl. 7, sheet 1), with easterly orientation and limited length, suggest formation as bars or beach ridges. The rather extensive areas of nondeposition (pl. 6, sheet 1) landward from the downdip depositional limits of the Carrizo and Meridian Sands are believed to have been interstream and interchannel divides that remained as islands in the early Claiborne sea throughout Carrizo and Meridian time. The lack of any marked seaward gradation of the sand-clay ratio is interpreted as reflecting the lack of any appreciable deposition on the relatively steep seaward side of the delta. In part of southern Mississippi the downdip limit of deposition may have been a result of pinchout along the north flank of the Wiggins arch.

In Texas the sand percentage of the Carrizo shows a greater degree of variation than is found in Arkansas, Louisiana, and Mississippi (pl. 6, compare sheets 1, 2). As previously stated, however, the Carrizo generally contains more than 50 percent sand except near the downdip limits of deposition. The lineation of areas of high sand concentration (more than 80 percent sand), areas of thickening of the Carrizo, and the axes of thickening of the maximum sand units has, with the exception of a relatively small area in eastern Texas, a northeasterly orientation (pls. 6, 7, sheet 2) parallel to the probable shoreline of the early Claiborne sea. The pattern of deposition is thought to be the result of the accumulation of bar and beach sands. The areas of lesser sand concentrations and thinner maximum sand units landward from the downdip or seaward depositional limits of the Carrizo are believed to represent deposition in bays and lagoons. In eastern Texas from Leon and Madison Counties eastward through Houston, Trinity, Angelina, and San Augustine Counties, the axes of thickening of the maximum sand units have northward trend and show a dendritic pattern. The pattern of deposition in this part of eastern Texas is interpreted as having resulted from deposition of the Carrizo Sand over an erosional surface developed by the ancestral Trinity and Neches Rivers during post-Wilcox, pre-Carrizo time. The thicker maximum sand units resulted from the filling of fairly deeply incised valleys and channels developed by the river systems.

HYDROLOGY

The Carrizo and Meridian Sands are important aquifers in Mississippi and Texas. The Carrizo Sand of Arkansas and Louisiana is of lesser importance as a source of water largely because of its erratic distribution.

PERMEABILITY[1] AND TRANSMISSIBILITY[2] IN RELATION TO GEOLOGIC FACTORS

The Carrizo and Meridian Sands are the most uniform lithologically of the Claiborne aquifers; consequently, the range in values of the coefficients of permeability is not as great as the range of values found in the previously described Claiborne formations (Payne, 1968, p. A5–A6; 1970, p. B4; 1973). There is, however, an increase in permeability with increase in thickness of the maximum sand units (see Payne, 1968, p. A5) shown in the following tabulation of average coefficients of permeability determined from the results of 45 aquifer tests:

Sand thickness (ft)	*Coefficient of permeability (gal/d/ft²)*	*Hydraulic conductivity (ft/d)*
25– 100	220	29
100– 200	300	40
200–>300	400–450	53–60

The preceding permeability values were used to calculate the transmissibility of the cumulative thickness of sand in the Carrizo Sand of Arkansas, Louisiana, and Texas and the Meridian Sand of Mississippi (pl. 8).

The highest transmissibility values, over 150,000 gal/d/ft (gallons per day per foot) (transmissivity of 20,000 ft² per day), in the Carrizo Sand are found in Atascosa, Frio, Gonzales, and Karnes Counties, Tex. (pl. 8, sheet 2). In these areas the Carrizo Sand is generally more than 400 feet thick, and the maximum sand units are in excess of 200 feet thick. The highest transmissibility values in the Meridian Sand, over 150,000 gpd per ft (20,000 ft² per day) are in Hinds, Madison, Warren, and Yazoo Counties, Miss., where the Meridian is generally over 350 feet thick and where individual sand units are more than 250 feet thick (pl. 8, sheet 1). Transmissibility values of the Carrizo Sand of

[1]The coefficient of permeability is defined as the rate of flow of water, in gallons per day, through a cross-sectional area of the aquifer 1 foot square under a hydraulic gradient of 100 percent, or 1 foot per foot at a temperature of 60°F (16°C). The field coefficient of permeability is the same rate of flow under the prevailing conditions of water temperature (Meinzer and Wenzel, 1942, p. 452). It has been recommended that the term "field coefficient of permeability" be replaced by the term "hydraulic conductivity," which expresses the rate of flow in units of feet per day (Lohman and others, 1972, p. 4–5). Both values are shown in the text.

[2]The coefficient of transmissibility is the field coefficient of permeability multiplied by the thickness, in feet, of the aquifer (Theis, 1935, p. 520). Bredehoeft (1964, p. D168) elaborated this definition to account for an aquifer made up of layers of differing permeabilities as

$$T = \sum K_i m_i,$$

where

i =1, 2, 3. . . n layers of differing permeability,
T =transmissibility,
Ki =permeability of the i layer, and
mi =thickness of the i layer.

It has been recommended that the term "coefficient of transmissibility" be replaced by the term "transmissivity" in which the units are feet squared per day (Lohman and others, 1972, p. 13). Both values are given in the text and on maps.

Texas and the Meridian Sand of Mississippi are generally higher than the transmissibility values of the Carrizo in Arkansas and Louisiana, reflecting the thicker and more continuous development of the formations in Mississippi and Texas (compare pls. 6–8).

RECHARGE AND DISCHARGE

Recharge of the Carrizo Sand of Arkansas and Louisiana and the Meridian Sand of Mississippi is principally by infiltration of precipitation in the outcrop area. There is a minor amount of infiltration from streams. The Carrizo Sand of Texas receives recharge from infiltration of precipitation in the outcrop area and infiltration of water from streams.

Discharge from the Carrizo and Meridian Sands occurs by withdrawals from wells and by natural discharge. The largest withdrawals from wells in the Meridian Sand have been in Leflore County, Miss., where long-term withdrawals resulted in an extensive cone of depression in Bolivar, Leflore, and Sunflower Counties (Brown, 1947, p. 39, pl. 12; Hosman and others, 1968, p. D13, pl. 5). The largest withdrawals from wells in the Carrizo Sand have been in the heavily irrigated area of Dimmit, Frio, and Zavala Counties, Tex., where withdrawals have caused a pronounced decline in water levels (Alexander and White, 1966, p. 50–51, figs. 17, 19, 22; Harris, 1965, p. 33, figs. 9–10; Mason, 1960, p. 36–37, 42, figs. 8–9, pl. 8). Natural discharge from the Carrizo and Meridian Sands takes place primarily by leakage through the overlying confining beds. A lesser amount of natural discharge is to streams incised into the formations.

REGIONAL FLOW

Except in the outcrop area, water in the Carrizo and Meridian Sands is under artesian conditions, and the regional flow is generally down the dip of the formations. The regional flow of water in the Meridian Sand in northwestern and west-central Mississippi is to the west-southwest toward the axes of the Desha basin and Mississippi embayment, except where altered by the cone of depression in Bolivar, Leflore, and Sunflower Counties. In southern Mississippi the regional flow is to the south and southwest toward the gulf coast geosyncline. In Arkansas and northern and eastern Louisiana, the regional flow of water in the Carrizo Sand is to the east and southeast into the Desha basin and Mississippi embayment. In southern Louisiana and in Texas, the regional flow is to the south-southeast and southeast into the gulf coast geosyncline. In Dimmit, Frio, Zavala, and adjoining parts of Atascosa and La Salle Counties, Tex., the regional flow has been modified by the cone of depression developed by large withdrawals of water from the Carrizo Sand for use in irrigation. In parts of Atascosa, Frio, Karnes, La Salle, and McMullen Counties, Tex., the regional flow is diverted in directions tangential to the dip direction toward areas of thick sand in the overlying Reklaw and Queen City Formations where the head of water in the Carrizo Sand is higher than the head in the overlying formations and where escape of water from the Carrizo is facilitated by increased vertical permeability. It is also possible that water velocities in the Carrizo may be increased in these areas of thick sand in the Reklaw and Queen City as compared with areas where the Reklaw and Queen City Formations are composed of thinner bedded sands and a larger percentage of clay.[3] An upward component of flow occurs throughout much of the area where the head of water in the Carrizo and the Meridian Sands exceeds that in the overlying formations.

CHEMICAL QUALITY OF WATER AND RELATIONS TO GEOLOGIC AND HYDROLOGIC FACTORS

Data from chemical analyses in the files of the U.S. Geological Survey and in published reports, together with calculations of dissolved-solids content of water from electrical-log data, were used to prepare a map showing some of the important chemical characteristics of water in the Carrizo and Meridian Sands (pl. 9). Stiff-type diagrams of selected chemical analyses have been used to construct geohydrologic sections showing the variations in amounts of major constituents (sections *E–E'* through *K–K'*, pl. 9).

VARIATIONS IN CHEMICAL QUALITY OF WATER

In the more uniformly developed and generally more transmissive Meridian Sand of Mississippi, bicarbonate is probably the dominant anion to greater depths and to higher concentrations of dissolved solids than in the erratically developed and generally less transmissive Carrizo Sand of Arkansas and Louisiana, where flushing by fresh water has been less extensive. Water from the Meridian Sand in Mississippi is generally of the bicarbonate type at depths ranging from 1,500 to 2,000 feet and at dissolved-solids concentrations ranging from 1,500 to 2,000 mg/1 (milligrams per liter). (See pl. 9, sections *E–E'*, *F–F'*; Hosman and others, 1968, pl. 5.) In Arkansas and Louisiana, bicarbonate water is less extensive, and chloride may become the dominant anion at depths of less than 500 feet and at dissolved-solids concentrations of less than 1,000 mg/1 (well LC–2, table 1; Hosman and others, 1968, pl. 5). Bicarbonate-type water in the Carrizo Sand in Texas generally extends to more than 2,500 feet below sea level. The depth of bicarbonate-type water is particularly striking in Karnes, Live Oak, and McMullen Counties, Tex., where the transmissibility of the Carrizo Sand and the overlying Reklaw and Queen City Formations is relatively high. Here the bicarbonate-type water extends to depths of more than 4,800 feet (wells TK–2, TLO–1, TMm–3, table 1; sections *J–J'*,

[3]Pearson and White (1967, p. 251, 260, fig. 6) estimated from C^{14} data that the water velocities in the Carrizo Sand in Atascosa County, Tex., are about 8 feet per year 10 miles from the outcrop and 5.3 feet per year 31 miles from the outcrop.

K–K', pl. 9). The sulfate content of water from the Meridian Sand of Mississippi and the Carrizo Sand of Arkansas and Louisiana is generally low (table 1; sections *E–E'*, *F–F'*, pl. 9). In Texas, appreciable amounts of sulfate are found in water from wells in the Carrizo Sand to depths of 1,500–2,000 feet. In deeper wells the sulfate content is generally low (table 1; pl. 9, sheet 2).

Sodium is the dominant cation in water from wells in the Meridian Sand of Mississippi and the Carrizo Sand of Arkansas, Louisiana, and eastern Texas (table 1; pl. 9); consequently, the waters are generally soft (less than 60 mg/l $CaCO_3$). Calcium and magnesium are found in significant concentrations in only a few wells in and a short distance downdip from the outcrop area. From Gonzales County, Tex., southwestward through Dimmit County, wells in the Carrizo Sand to depths of as much as 2,900 feet yield hard waters (over 60 mg/l $CaCO_3$), which show relatively high concentrations of calcium and magnesium (table 1, wells TAt–4, TDm–1, TF–4, TGz–2, TWn–3). Generally, however, sodium is the dominant cation in waters from the Carrizo beyond depths of about 1,500 feet below sea level (pl. 9, sheet 2, sections *H–H'*, *J–J'*, *K–K'*).

DISSOLVED SOLIDS

The relation of dissolved-solids content to the specific conductance of water from the Carrizo and Meridian Sands is constant to concentrations of about 10,000 mg/l (fig. 2). Based on this relationship, a satisfactory method for calculating the dissolved-solids content of water in an aquifer from the long-normal resistivity curve of electrical logs was described by Turcan (1966, p. 3–13): This method is based on the equation

$$Ff=\frac{Ro}{Rw},$$

where

Ff = the field formation resistivity factor,
Ro = the resistivity read from the long-normal curve corrected to 77°F (25°C), and
Rw = the resistivity of the water at 77°F (25°C)

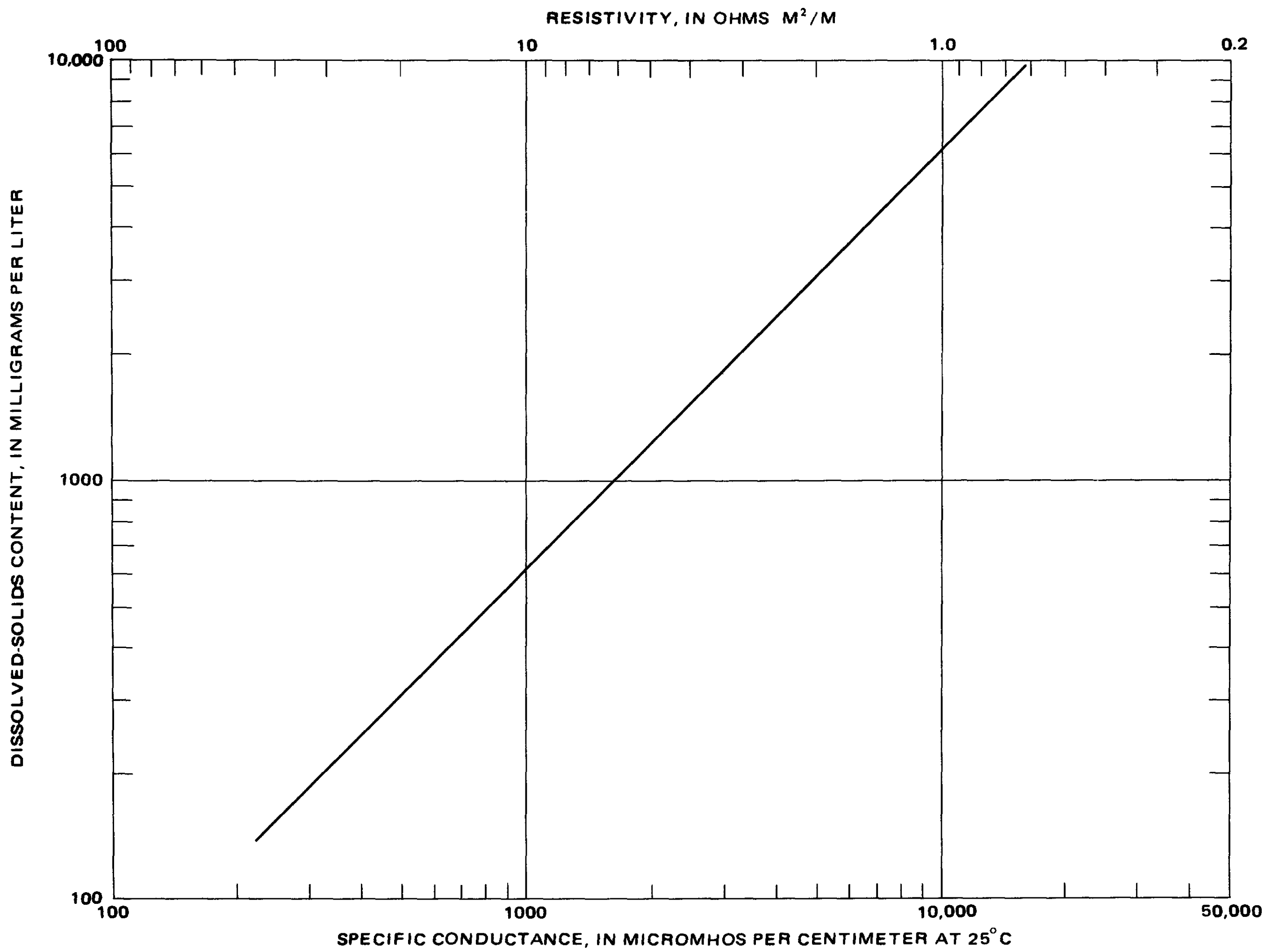

FIGURE 2.—Relation of specific conductance and resistivity to dissolved-solids content of water from the Carrizo Sand of Arkansas, Louisiana, and Texas and the Meridian Sand of Mississippi.

TABLE 1.—*Descriptions and analyses of water from wells in the Carrizo*

[Analyses by U.S. Geological

Well number[1] and location	Owner or well designation	Date of collection	Depth of well (ft)	Analyses, in: Silica	Iron	Calcium	Magnesium	Sodium (*Calculated as sodium)	Potassium
Arkansas									
Miller County:									
AM-1	Mrs. E. L. Bradham	10- 7-64	400	14	0.06	2.6	0.8	153	2.3
AM-2	R. E. Ransdell	10- 6-64	560	11	.13	.5	.6	106	1.0
Nevada County:									
AN-1	Hubert Knight	10- 6-64	196	12	1.1	3.0	.7	54	2.6
Louisiana									
Bienville Parish:									
LBi-1	Louisiana Dept. Public Works	4- 4-68	540	18	4.5	18	4.9	30	7.1
Bossier Parish:									
LB-1	J. F. Strayhan	8-16-61	560	8.2	.02	5	1.3	216	4.1
Caddo Parish:									
LC-1	Wayne Norton	8-16-61	460	8.7	.14	1.5	.1	94	1.3
LC-2	R. Westbrook	8-16-61	230	8.5	.01	15	1.6	363	8.2
Natchitoches Parish:									
LN-1	City of Natchitoches	9-10-43	228	----	.09	2.6	1.3	*221	
LN-2	do	8-13-44	549	15	.09	2.6	.8	276	3.7
Webster Parish:									
LW-1	Louisiana Dept. Public Works	4-15-68	201	12	1.1	14	3.6	370	10
LW-2	do	9-29-70	342	25	.35	1.4	.1	66	2.4
Mississippi									
Attala County:									
MA-1	City of Kosciusko, well 4	1- 5-57	436	27	0.28	13	4.6	3.8	4.2
Bolivar County:									
MB-1[2]	Town of Gunnison	4-16-59	1,738	5.2	.0	3.21	.3	*524.17	
MB-2[2]	Town of Beulah	4-16-59	1,760	7.6	Trace	2.41	.0	*250.93	
MB-3[2]	Town of Boyle	2-24-60	1,555	17.2	Trace	1.52	.0	*176.41	
Carroll County:									
MC-1[2]	Town of North Carrollton	5-19-61	430	1.2	1.0	14.42	6.12	*34.50	
Clarke County:									
MCK-1	Town of Enterprise	11-30-67	250	18	.02	2	.0	102	1.2
MCK-2	Ray Smith	8-14-68	340	46	1.1	9.9	.8	23	1.3
MCK-3	Bill Anderson	8-15-68	400	23	1.0	3.6	.0	75	.6
Grenada County:									
MG-1	City of Grenada	5-23-51	172	28	.24	10	4.3	64	7
Holmes County:									
MH-1	Town of West	1- 4-57	412	----	1.9	16	4.1	17	4.1
MH-2	Town of Tchula	4-13-64	1,246	18	.55	.5	.2	68	.7
MH-3	Town of Goodman	11-12-63	980	14	.03	.4	.0	69	.9
Lauderdale County:									
MLd-1	W. P. Brown	9-19-68	336	22	.04	4.1	.4	61	1.4
Leflore County:									
MLf-1	City of Greenwood	2-25-40	835	15	.04	1.2	.2	84	2.7
MLf-2[2]	Town of Ita Bena	3-18-60	1,107	.0	.0	1.36	.87	*100.16	
Newton County:									
MN-1	City of Union	11-28-67	323	43	2.9	12	4.9	4.0	2.6
MN-2	Conehatta School	4-21-69	634	26	.1	3.3	.2	75	2.5
MN-3	Mississippi Experiment Station	11-15-66	440	39	1.6	6.2	1.7	42	3.8
Scott County:									
MSc-1	H.& H. Water Assoc	4-15-67	945	14	.04	1.0	.0	104	1.6
MSc-2	Steele-Ringold	10-17-68	918	12	.12	.4	.2	76	1.0
Sharkey County:									
MS-1	Bill Klaus	2- 1-56	1,900	----	.26	5.1	.6	1,060	13
Sunflower County:									
MSf-1[2]	Town of Ruleville	10-17-60	1,406	7.6	.0	.89	.0	*144.21	
MSf-2	R. N. Sheffield	1- 4-62	1,541	9.5	.32	.0	.0	119	1.0
MSf-3	Town of Inverness	3-14-40	1,749	17	.15	1.6	.4	178	7.4
Tallatchie County:									
MT-1[2]	Town of Sumner	2-27-61	783	16	Trace	5.13	.0	*126.96	
Washington County:									
MW-1	Dow Chemical Co	11- 1-63	1,990	14	2.1	1.4	.0	424	2.0
MW-2	Mrs. John Minyard	3-15-40	1,786	17	.08	2.6	.7	628	14
Yazoo County:									
MY-1	Town of Eden	7-26-55	1,735	----	.4	1.2	.5	141	----
MY-2	C. C. Swayze	5-29-58	1,682	----	.02	.3	1.4	122	5.4

See footnotes at end of table.

and Meridian Sands in Arkansas, Louisiana, Mississippi, and Texas

Survey unless otherwise indicated]

milligrams per liter														
Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Nitrate	Boron	Dissolved solids	Hardness, as $CaCO_3$	Percent sodium	Sodium-adsorption-ratio	Specific conductance, in micromhos at 25°C	pH	Color, in cobalt units	Temperature, in degrees Celsius
							Arkansas—Continued							
344	7	0.0	34	0.2	0.1	----	383	10	------	------	692	8.4	8	-----
256	.0	.2	15	.7	.7	----	262	4	------	------	452	8.1	10	-----
132	.0	12	5.8	.3	.0	----	156	10	------	------	257	7.8	3	18
							Louisiana—Continued							
100	0.0	5	33	0.1	0.6	----	166	65	------	------	320	6.5	10	26
456	----	92	19	2.2	2.1	1.3	623	18	95	22	986	7.7	10	22
249	----	3.2	4	.2	.3	.31	251	4	97	20	417	7.6	30	21
635	----	.0	239	1.5	.1	1.04	979	44	94	24	1,690	7.6	10	21
566	4	2	15	----	.0	----	525	12	------	------	------	----	------	21
592	32	.9	53	.2	.5	----	677	10	98	38	1,130	8.3	------	23
412	.0	.0	361	.9	.2	----	975	50	------	------	1,790	8.1	10	21
168	.0	.0	7	.2	.0	----	185	4	------	------	270	7.7	10	22
							Mississippi—Continued							
58	----	11	3	0.1	0.2	----	132	51	------	------	130	6.6	10	19
570	----	.0	409.5	.6	----	----	1,285.19	10	------	------	------	7.9	<5	29
526	----	.0	18	.0	----	----	594.74	6	------	------	------	8.0	70	------
350	----	Trace	18	.5	----	----	431.77	3.8	------	------	------	8.5	15	28
124	----	9.38	3	.0	----	----	144.35	61.2	------	------	------	7.3	------	------
273	0.0	7.8	2	.1	.3	----	267	5	------	------	436	7.7	40	------
86	.0	10	1.3	.1	.0	----	134	28	------	1.89	169	7.1	10	------
168	.0	34	2	.2	.1	----	222	9	------	------	346	7.0	10	------
204	----	7.4	11	.0	1.8	----	252	43	------	------	361	7.4	8	19
104	----	6.6	2.5	.0	1.5	----	148	57	------	------	183	7.4	7	19
168	----	12	2.1	.5	.2	----	195	2	------	------	283	7.6	50	------
167	----	12	2.8	.1	1.0	----	165	1	------	------	289	7.8	4	24
165	.0	11	1.6	.1	.8	----	183	12	------	7.7	283	8.1	5	19
218	----	5.8	2.8	.4	.0	----	217	------	------	------	------	----	10	------
281	----	1.48	10	.2	----	----	240.03	7	------	------	------	8.4	0	26
47	.0	15	3.2	.2	.1	----	108	50	------	.26	131	5.9	0	18
186	.0	18	1.7	.1	.3	----	219	9	------	10.84	322	7.5	5	22
118	.0	14	3.6	.0	1.2	----	170	22	------	3.87	215	7.1	5	------
267	.0	4	3.1	.3	.2	----	260	3	------	------	415	7.7	20	22
184	.0	13	2.7	.1	.2	----	197	2	------	24.50	306	7.9	15	24
1,300	----	3.8	860	4.0	1.5	----	2,680	15	------	------	4,490	7.9	40	34
281	----	.0	23	.3	----	----	346.56	2.2	------	------	------	8.4	10	27
316	----	.0	2.2	.3	1.0	----	327	0	------	------	481	7.8	20	------
478	----	.5	7.2	----	.0	----	446	5.6	------	------	------	----	25	31
221	----	.0	48	.1	----	----	329.38	12.8	------	------	------	7.6	15	22
784	----	.2	144	1.3	.5	----	1,040	4	------	------	1,740	8.5	45	------
1,177	----	.8	309	[3]2.4	.32	----	1,571	9.4	------	------	------	----	45	37
343	----	2.2	4	----	.1	----	358	5	------	------	578	8.8	22	34
308	8	1.2	4	.3	1.2	----	329	6	------	------	471	8.5	19	27

TABLE 1.—*Descriptions and analyses of water from wells in the Carrizo Mississippi, and*

Well number[1] and location	Owner or well designation	Date of collection	Depth of well (ft)	Analyses, in					
				Silica	Iron	Calcium	Magnesium	Sodium	Potassium
								*Calculated as sodium	
Texas									
Angelina County:									
TAn–1	Gulf Oil Co	8– 2–49	955	14	0.34	0.2	0.2	118	1.6
Atascosa County:									
TAt–1	M. W. Parchman	7– 29–63	166	19	4.5	35	7	43	7.3
TAt–2	City of Poteet, well 4	8– 5–64	956	17	1.1	26	4.2	22	7.3
TAt–3	City of Pleasanton	8– 14–45	1,550	13	.89	64	7.8	27	10
TAt–4	R. D. Quillian	8– 19–64	2,993	17	.98	65	12	29	8.3
TAt–5	Allen Hime	7– 18–56	2,150	18	------	65	13	31	9.7
TAt–6	Lower Nueces River Water Supply District, well 5.	3– 14–51	3,992	30	.19	3.6	.7	244	2.0
Burleson County:									
TB–1	John E. Newman	11– 11–59	2,500	18	------	4.5	.9	652	3.8
Dimmit County:									
TDm–1	Jack Bowman	12– 30–48	1,300	20	------	30	16	*110	
TDm–2	R. W. Briggs	12– 12–48	1,800	53	------	5.5	2.6	*245	
Frio County:									
TF–1	O. W. Machen, well 1	8– 19–52	260	24	------	119	16	*18	
TF–2	Oppenheimer & Lang	8– 13–64	1,700	16	1.0	74	13	28	6.8
TF–3	F. J. Avant	8– 26–64	1,622	11	3.2	61	14	27	5.9
TF–4	City of Dilley	8– (?)–59	2,082	----	16	26	8	*66	
Gonzales County:									
TGz–1	M. C. Butcher	4– 27–62	740	30	.42	37	5.8	*33	
TGz–2	City of Nixon, well 1	5– 15–59	1,387	14	.0	46	6	26	8.8
TGz–3	Jack Wheat	3– 12–63	2,225	20	------	5.5	3.3	*291	
Houston County:									
TH–1	R. E. Smith	8– 22–63	452	12	.52	2.5	.7	*108	
TH–2	A. E. Murray	7– 18–61	350	11	.79	.0	.6	*114	
TH–3	G. L. Potter	7– 27–63	1,230	13	2.5	3.5	.4	162	1.4
TH–4	Seven J Stock Farm, Inc	7– 25–61	1,500	15	.14	.2	.2	*195	
Karnes County:									
TK–1	Joe Bartosh, well 1	2– 15–55	4,711	36	.12	3.2	.6	277	4.0
TK–2	Fred Klingeman, well 1	4– 26–56	[4]8,004	50	.05	3.0	.6	454	6.6
La Salle County:									
TLs–1	McNair Bros	10– (?)–42	2,763	25	.02	2.4	1.2	*207	
TLs–2	City of Cotulla, well 1	9– 15–42	2,300	26	.02	2.2	1.1	*214	
TLs–3	South Texas Syndicate, well 17	4– 23–59	3,606	24	------	3.5	.1	*301	
TLs–4	H. Coquat Estate	4– 2–59	3,500	26	------	3.5	.2	576	4.5
TLs–5	K. C. Miller	5– 5–59	4,280	15	------	1.2	.0	473	3.9
Lee County:									
TL–1	C. G. Glasscock	7– 22–64	455	12	------	27	7.9	*20	
TL–2	Erhart	5– 5–64	109	20	8.0	3.5	2.7	*22	
Leon County:									
TLn–1	A. A. Schweinle	9– 9–58	450	13	2.7	9	2.7	*40	
TLn–2	D. F. Jones	9– 5–58	400	13	.6	50	15	*28	
TLn–3	City of Normangee	4– 20–43	1,209	14	.1	.4	.3	*99.8	
Live Oak County:									
TLO–1	Humble Oil & Refining Co	8– 8–56	4,842	39	.13	2.8	.3	422	4.5
Madison County:									
TMd–1	Joe Tinkle	6– 21–61	1,650	4.7	------	1.0	.0	*178	
McMullen County:									
TMm–1	Adolph Poenish	3– 23–59	3,600	26	------	2.2	.7	*309	
TMm–2	South Texas Syndicate	10– (?)–42	4,150	36	.06	.6	1.1	*591	
TMm–3	A. J. Flowers	3– 26–59	5,050	40	------	2.8	.1	826	7.5
Webb County:									
TWb–1	John Long	7– 21–65	2,450	19	------	1.8	.4	*331	
Wilson County:									
TWn–1	J. Neyland	6– 20–55	140	26	------	3.2	1.3	*15	
TWn–2	L. G. Arnold	6– 22–55	1,121	16	------	4.9	2.5	*254	
TWn–3	R. A. Popham	6– 22–55	1,104	15	------	38	6.1	24	7.4

[1]Numbers do not correspond to county numbers of the various district offices.
[2]Analyses by Mississippi State Board of Health.

and Meridian Sands in Arkansas, Louisiana, Texas—Continued

milligrams per liter														
Bicarbonate	Carbonate	Sulfate	Chloride	Fluoride	Nitrate	Boron	Dissolved solids	Hardness, as $CaCO_3$	Percent sodium	Sodium-adsorption-ratio	Specific conductance, in micromhos at 25°C	pH	Color, in cobalt units	Temperature, in degrees Celsius
Texas—Continued														
201	6	67	10	0.1	1.8	0.59	333	2	99.4	------	519	8.7	10	31
38	----	41	102	.2	.0	.05	274	116	43	1.7	487	5.6	------	------
51	----	32	44	.2	.0	.07	178	82	34	1.1	317	6.2	------	28
206	----	40	36	1.0	.0	----	300	192	23	.8	509	7.5	------	33
272	----	29	25	.4	.0	.13	320	212	22	.9	541	7.2	------	39
271	----	42	22	----	.0	.13	334	215	23	.9	553	7.4	------	------
504	----	65	44	.6	.0	----	675	12	97	32	1,010	8.1	------	------
702	----	2.4	620	----	.2	1.6	1,650	14	99	76	2,880	8.0	------	------
300	----	61	50	----	.0	----	442	141	63	4	723	----	------	------
282	----	131	133	----	2.0	----	711	24	96	22	1,120	----	------	------
391	----	26	26	.4	2.0	.01	430	363	10	.4	724	7.2	------	------
282	----	44	22	.5	.0	.14	344	238	20	.8	573	7.2	------	------
260	----	33	18	.3	.0	.03	298	210	21	.8	513	7.4	------	------
-----	----	72	5	.4	.4	----	341	98	------	------	568	7.8	------	------
163	----	24	20	.2	.0	----	230	116	38	1.3	369	7.0	------	27
157	----	30	31	.1	.2	.16	249	139	27	1.0	422	7.0	------	33
636	----	6.8	91	.9	.0	----	767	27	96	24	1,220	7.5	------	43
236	----	35	8.3	.3	1.0	----	284	9	96	16	470	7.7	------	23
248	----	31	9.5	.2	.0	----	288	2	99	35	453	7.3	------	23
328	----	66	21	.3	.2	.24	429	10	97	22	681	7.8	------	24
430	----	33	26	.4	.0	----	481	2	100	60	773	8.1	------	28
573	----	44	70	.8	.0	.38	725	10	97	37	1,170	8.7	------	59
997	----	31	108	2.4	.2	.74	1,150	10	98	62	1,810	8.0	------	80
334	----	87	68	.1	.0	----	555	11	------	------	------	8.4	------	45
341	----	79	81	.1	.0	----	571	10	------	------	------	8.4	------	40
439	----	82	153	.6	.2	----	794	9	99	44	1,310	8.2	------	52
1,120	----	103	176	----	.0	.65	1,140	10	99	81	2,340	8.6	------	52
924	----	35	171	----	.0	.45	1,150	3	99	119	1,930	8.8	------	------
120	----	32	8.5	.0	.0	.09	166	100	30	.9	288	7.1	------	23
24	----	17	21	.2	1.0	----	103	20	71	2.1	160	6.1	------	23
102	----	22	9.8	----	.0	----	143	34	72	3.0	240	6.8	------	------
204	----	64	9.5	----	.5	----	286	186	25	.9	466	7.2	------	------
220	----	12	14	.4	1.0	----	250	2	------	------	------	8.2	------	------
918	----	11	110	1.3	.0	.39	1,040	8	98	65	1,680	8.2	------	65
384	24	.0	39	.5	.0	.4	436	2	94	55	752	8.5	------	------
601	----	76	76	1.0	.0	----	787	8	99	46	1,100	8.7	------	49
1,282	----	2.6	168	.4	.0	----	1,433	6	------	------	------	8.2	------	------
1,790	----	.6	228	----	.8	1.2	1,990	8	99	131	3,130	8.5	------	65
470	.0	162	121	.9	.0	----	867	6	99	59	1,400	7.7	------	------
14	----	9.5	17	----	.0	----	84	13	71	------	109	6.5	------	23
582	----	18	56	.5	.2	.49	639	22	96	------	1,060	7.9	------	36
126	----	34	33	.1	.2	.48	218	120	29	------	382	7.2	------	31

[3]Fluoride run on sample collected 8–16–39.
[4]Oil test converted to water well; 8-in. casing to 8,004 ft; perforated from 5,290- to 5,355-ft depth.

and was used to calculate the dissolved-solids content of water in the sands of the Carrizo and Meridian. The resulting values, together with data from chemical analyses, were used in preparing a map showing the regional variations in maximum and minimum dissolved-solids content of water in the Carrizo and Meridian Sands (pl. 9).

The effects of geologic and hydrologic factors on water movement and extent of flushing by fresh water are reflected in the distribution of the dissolved-solids content of water in the Carrizo and Meridian Sands. In Mississippi, many of the areas of thickened, massive sand units and high transmissibility are elongated parallel to the direction of flow, and the lines showing low concentrations of dissolved solids are deflected in the downflow or downdip direction so that water of low salinity is found at greater depth along the paths of thick, massive sand-unit development than in the areas of thin sand-unit development (compare pls. 5, 7–9). The orientation of the long dimension of massive sand bodies and areas of high transmissivity in Arkansas and Louisiana is, in general, normal to the direction of flow. This unfavorable orientation of the massive sand bodies with respect to the direction of flow, coupled with the presence of large areas of nondeposition of the Carrizo Sand across the flow path, has retarded movement of water through the Carrizo and limited the extent of flushing of the formation by fresh water (compare pls. 7–9). The pattern of distribution of dissolved-solids content of water in the Carrizo Sand of Texas shows a rather orderly increase in concentration of dissolved solids in the downflow or downdip direction. This orderly pattern is largely a reflection of the uniformity of sand-unit development. The axes of maximum sand-unit development are generally normal to the direction of flow, but over most of the area underlain by the Carrizo Sand in Texas the sand bodies are in excess of 50 feet thick and transmissibility values are more than 45,000 gal/d/ft. These geologic and hydrologic conditions, together with relatively high heads of water in the Carrizo, have been favorable to water movement; flushing of the Carrizo by fresh water to depths in excess of 2,000 feet below land surface has occurred over much of the Texas area (pls. 5, 7–9). Of particular note is the presence of fresh water in the Carrizo to depths of more than 5,000 feet in parts of Karnes, Live Oak, and McMullen Counties where high transmissibility of the Carrizo and of the overlying formations has offered particularly favorable paths for water movement.

CONCLUSIONS

1. The mode of deposition is an important controlling factor in the hydrology of the Carrizo and Meridian Sands. Those areas in which thick, massive sands were extensively developed as channel and valley fills and bar and beach deposits offer the best potentials as sources of ground water.
2. The most extensive flushing of the Carrizo and Meridian Sands by fresh water has taken place in Texas where sand units are generally thick and transmissibility values are high, particularly in those areas showing high sand concentrations in the overlying formations.
3. The Carrizo and Meridian Sands are the most uniform lithologically of any of the aquifer formations in the Claiborne Group.
4. Mapping of the dissolved-solids content of water is an effective aid in determining the relation of lithology and depositional pattern to extent of flushing and water movement.
5. The geologic and hydrologic maps of the Carrizo and Meridian Sands form a basis for the quantitative evaluation and description of the Carrizo-Meridian aquifer system.

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