STATE EXPERIMENT STATION

BULLETIN

OF THE

LOUISIANA

GEOLOGICAL SURVEY

No. 4.

UNDERGROUND WATER RESOURCES OF
NORTHERN LOUISIANA

BATON ROUGE
1906

Bull. No. 4 Report of 1905

GEOLOGICAL SURVEY OF LOUISIANA
GILBERT D. HARRIS, Geologist-in-Charge

GEOLOGY

AND

UNDERGROUND WATER RESOURCES

OF

NORTHERN LOUISIANA

WITH

NOTES ON ADJOINING DISTRICTS

BY

A. C. VEATCH

Made under the Direction of the
STATE EXPERIMENT STATIONS
W. R. DODSON, Director
1906

LOUISIANA STATE UNIVERSITY

AND A. & M. COLLEGE

Louisiana State Board of Agriculture and Immigration

EX-OFFICIO.

GOVERNOR NEWTON C. BLANCHARD, *President.*
H. L. FUQUA, *Vice President Board Supervisors.*
CHARLES SCHULER, *Commissioner of Agriculture and Immigration.*
THOMAS D. BOYD, *President State University.*
W. R. DODSON, *Director Experiment Stations.*

MEMBERS.

JOHN DYMOND, Belair, La.
H. C. STRINGFELLOW, Howard, La.
J. SHAW JONES, Monroe, La.
C. A. TIEBOUT, Roseland, La.
FRED SEIP, Alexandria, La.

STATION STAFF.

W. R. DODSON, A. B. B. S., Director, Baton Rouge.
R. E. BLOUIN, M. S., Assistant Director, Audubon Park, New Orleans.
J. G. LEE, B. S., Assistant Director, Calhoun, La.
S. E. McCLENDON, B. S., Assistant Director, Baton Rouge, La.
H. P. AGEE, B. S., Chemist and Sugar Maker, Audubon Park, New Orleans.
A. E. DODSON, Farm Manager, Audubon Park, New Orleans.
J. K. McHUGH, Secretary and Stenographer, Audubon Park, New Orleans.
G. D. HARRIS, M. S., M. A., Geologist, Baton Rouge.
F. L. WHITNEY, Assistant Geologist, Baton Rouge.
J. E. HALLIGAN, B. S., Chemist, Baton Rouge.
J. A. HALL, JR., B. S., Chemist, Baton Rouge.
H. BARNES, Stenographer.
HOWARD J. MILKS, D. V. S., Animal Pathology.
H. R. FULTON, M. S., Vegetable Pathologist.
R. I. MENVILLE, B. S., Chemist, Baton Rouge.
A. B. JOFFRION, B. S., Chemist, Baton Rouge.
G. H. HARDIN, B. S., Assistant Chemist, Baton Rouge.
ROGER P. SWIRE, Treasurer, Baton Rouge, La.
L. O. REID, Farm Manager, Baton Rouge, La.
WILMON NEWELL, M. S., Entomologist, Baton Rouge, La.
F. H. BURNETTE, Horticulturist, Baton Rouge, La.
W. H. DALRYMPLE, M. R. C. V. S., Veterinarian, Baton Rouge, La.
E. J. WATSON, Horticulturist, Calhoun, La.
IVY WATSON, Farm Manager, Calhoun, La.
J. G. LEE, JR., Animal Husbandry, Calhoun, La.
—— ————, Dairyman and Poultryman, Calhoun, La.

The Bulletins and Reports will be sent free of charge to all farmers, by applying to the Director of the Stations, Baton Rouge, La.

LETTER OF TRANSMITTAL

BY

W. R. Dodson

State Experiment Station,
Baton Rouge, La., Aug. 1, 1906.

To His Excellency, Newton C. Blanchard, Governor of Louisiana:

Sir:—I have the honor to transmit herewith *Bulletin No. 4* of the State Geological Survey. The investigation of the underground water resources of north Louisiana discussed in a preliminary way in Bull. 1 of this Report is herewith treated exhaustively by A. C. Veatch, a former employee of the State Survey.

The desirability of the investigation must be patent to all, and the way it has been prosecuted leaves little to be desired.

Respectfully submitted,
W. R. Dodson.

LETTER OF TRANSMITTAL

BY

G. D. HARRIS

CORNELL UNIVERSITY,
ITHACA, N. Y., July 15, 1906.

DR. W. R. DODSON, DIRECTOR OF THE EXPERIMENT STATIONS OF LOUISIANA:

Sir:—I herewith transmit to you *Bulletin No. 4* of the Louisiana State Geological Survey.

The general plan and object of the investigation herewith reported upon has already been set forth in Bulletin No. 1. Though the publication has been considerably delayed, the present paper is far more complete and satisfactory than it could have been if published when Mr. Veatch first left the State Survey and proceeded to investigate the surrounding States under the auspices of the United States Geological Survey. The complete report on all these areas has been published by the National Survey as Professional Paper No. 46, entitled, "Geology and Underground Water Resources of Northern Louisiana and Southern Arkansas."* Excerpts from this elaborate paper dealing with Louisiana territory form the subject matter of this bulletin. It is believed that citizens of the state will find this bulletin amply exhaustive and much more convenient for reference than the quarto professional paper just referred to.

Respectfully submitted,
G. D. HARRIS.

CONTENTS

ILLUSTRATIONS

GEOLOGY AND UNDERGROUND WATER RESOURCES OF NORTHERN LOUISIANA WITH NOTES ON ADJOINING DISTRICTS

BY

A. C. VEATCH

CHAPTER I

GEOLOGY

INTRODUCTION

OUTLINE OF MAJOR FEATURES OF PRESENT TOPOGRAPHY

Topographically northern Louisiana and southern Arkansas form an area which is divisible into two major provinces, the Ouachita Mountains and the Gulf Coastal Plain.

The Ouachita Mountains province is a region of relatively great and rugged relief, ranging from 500 to 2,000 feet above sea level and composed of roughly parallel ridges separated by deep, flat-bottomed valleys. It is underlain by a much folded, steeply inclined, deeply eroded series of Paleozoic sandstones, shales, and limestones, and has been developed from the slightly arched surface of an old peneplain by the erosion of the softer beds.

The Gulf Coastal Plain is an area of low and rounded relief, extending in this region from 3[1] to 600 feet above sea level

[1] The elevation of extreme low water in the Mississippi at Red River Landing, November 14, 1895 (Ann. Rept. Chief of Engineers for 1900, pt. 4, 1900, pp. 2543-2544). According to the maps of the Mississippi River Commission the beds of Red, Ouachita, and Mississippi rivers and of Bayou Macon and Boeuf and Tensas rivers often extend to considerable depths below sea level; thus the Mississippi at Vicksburg (Klineston) reaches a depth of 58 feet below sea level, at Fort Adams 112 feet, and at Miles Landing, 4 miles below the mouth of Red River, 127 feet.

Geologic subdivisions.				CHARACTERISTIC Deposition. Thickness.	Character.	
				Feet.		
Quaternary.	Recent.	Alluvium.		0– 20+	Veneer of sand, silt, and clay on flood-plains.	
				0– 25	Abnormal deposits of silt in Red River Valley resulting from the obstruction by the "great raft."	
	Pleistocene.				Formation of natural mounds.	
		Port Hudson formation.		0– 200	Marine deposits on the coast and fluviatile deposits in the river valleys, partly filling the broad valleys developed in the preceding erosion cycle.	
					Rearrangement of surficial sands and gravels at new levels as erosion progressed.	
Tertiary.	Pliocene.	Lafayette formation.		10– 50	A mantle of silt, sand, and gravel spread by combined marine and river action over the relatively even surface of the Coastal Plain and in the tributary valleys.	
	Miocene.					
	Oligocene.	Fleming clay.		±260	Green calcareous clays, with a few brackish-water fossils.	
		Catahoula formation.		1,000–1,200	Near-shore deposits; sandstones occasionally quartzitic, and green clays, with fresh-water shells and land plants.	
		Vicksburg formation.		100– 200	Limestones and calcareous, somewhat lignitiferous, clays, containing marine shells.	
	Eocene.[2]	Jackson formation.	Undifferentiated Eocene.[2]	200– 550	Highly fossiliferous shallow-water marine sandy calcareous clay.	
		Cockfield member of Claiborne.[3]		400– 500	Lignitiferous sands and clays, with land plants.	Landward these formations merge into lignitiferous sands and clays without distinctive marine fossils.
		Claiborne formation.		200– 500	Fossiliferous sandy clay, containing shallow-water marine shells.	
		Sabine formation.		300– 900	Lignitiferous sands and clays, with plants and occasional beds of marine shells.	
		Midway formation.		20– 260	Limestones and black calcareous clays.	

[1] Normal thickness in northern Louisiana not known because of the widespread and irregular deposition. In southern Louisiana the beds are much thicker than here given.

[2] The Jackson, Claiborne, and Sabine formations, which are fossiliferous and distinct in central Louisiana, grade into lignitiferous beds containing no distinct fossils as they go northward. In the

northern Louisiana.

ACTIVITIES.

Degradation.	Deformation.
General degradation of the hill lands. Along Red River in Louisiana the resurrection of buried channels and the drainage of lakes produced by the "great raft." On the Sabine the partial wearing out of shoals produced by the recent movement of the Rockland-Vicksburg flexure.	A slight upward movement at the west end of the Rockland-Vicksburg flexure is producing rapids on Sabine and Angelina rivers. A recent movement of 25 feet along the line of the Red River-Alabama Landing fault has resulted in the swamping of Ouachita River Valley to a point above the mouth of Bayou Moro in Arkansas.
Partial removal of valley fillings and production of present flood-plains and principal terraces.	
Long and complex period of erosion, with the land 100 feet higher than to-day, in which the formations of the Coastal Plain were profoundly dissected and the major features of the present topography produced.	After the main development of the Angelina-Caldwell flexure the beds were faulted along a line extending from a point near Denison, Tex., through Alabama Landing, Union Parish, La. The downthrow of this fault is to the north and the break approximately 600 feet.
A period of erosion, probably composed of several stages, in which the Coastal Plain in this region was essentially base-leveled.	The low fold which extends from the vicinity of Angelina County, Tex., to a point north of Vicksburg, Miss., and which is now a line of weakness, began to develop in late Oligocene or early Miocene time. North of this line the older beds are now nearly horizontal; to the south they dip at a rate of from 35 to 150 feet per mile.
	The domes developed during late Cretaceous and early Eocene time show a slight movement in post-Claiborne time, but the amount is very small when compared with the initial movements.
Beds separated by a pronounced break in the fauna, which is, at present, the only indication of a very serious break in sedimentation.	The great north-and-south fault of the Coastal Plain of Texas (the Balcones fault) developed late in the Cretaceous. In Louisiana peculiar domes or four-sided folds were produced and reached their major development in the late Cretaceous or early Eocene. About the same time masses of igneous rocks of limited area were intruded into the Paleozoic rocks and Coastal Plain beds in southern Arkansas. In central Texas similar occurrences took place as early as the Austin epoch. The Louisiana and northeastern Texas domes are thought to be due to the upthrust of similar igneous intrusions.

region under discussion the fossiliferous Jackson limits this lignitiferous complex above. Still farther north, however, the Jackson also grows lignitiferous and merges with the rest. The Midway, likewise, in the upper embayment region shows a decidedly lignitiferous tendency and may in places merge with the lignitiferous time equivalents of the other Eocene beds.

3 A group without distinctive marine fossils, probably almost wholly of Claiborne age.

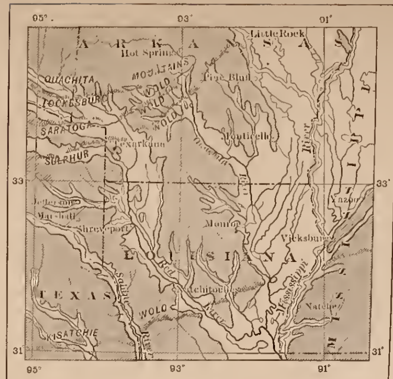
(Pl. XXVII). It is underlain by a series of relatively soft strata, dipping on the whole gently seaward, in which the present topography has been formed entirely by the profound dissection of an old plain level. The surface of this old plain has now been almost completely destroyed (Pl. XXV, C and D), and the region presents two principal topographic divisions— (1) the hill lands and (2) the flood-plain and terrace areas (Pl.XXV, B); the former representing the uplands formed of rolling hills, composed largely of the older beds of the Coastal Plain, and the latter the lowlands, flat or benchlike in character, composed of redeposited sediments of rather recent fluviatile origin.

In the flood-plain region three features of very recent origin are to be noted— (1) the greater depth of Ouachita River Valley in southern Arkansas as compared with the Mississippi Valley at the same latitude (Pl. XXV, C); (2) the shoals and rapids which are found in the midst of strips of mature topography on Angelina River near its mouth, along Sabine River from Pendleton to Burrs Ferry, particularly near Columbus (Pl. XXXV, on Red River near Alexandria, and on numerous small tributary and distributary channels in the Red River flood-plain between latitude 32° and 33°, and on Ouachita River at Catahoula Shoals (figs. 24, 25), and (3) the lakes which occur or which formerly occurred in the lower part of each of the streams tributary to Red River between Alexandria and the Arkansas-Louisiana State line (fig 18). These lakes are the most important recent topographic features of this region, having been formed since the fifteenth century, but now the cause of their formation having passed, they are returning to their normal status as tributary streams. Several no longer exist, though stili represented on maps because of the lack of recent detailed surveys.

In the hill lands the general character of the topography is irregular and rolling, the hills rising 100 to 200 feet above the flat-bottomed stream channels which extend in every direction, but the unequal hardness of the underlying beds has given rise to several transverse ranges of hills, which are more or less persistent for many miles and follow the general strike of the formations producing them. Of these the Kisatchie Wold[2] (Pl. XXV, A), which is produced by the hard sandstone layers in the

A

The Lockesburg, Saratoga, Sulphur, and Kisatchie wolds.



B

Hill lands.

Flood-plain and terrace areas.

C

Areas less than 100 feet above gulf level.

D

Areas more than 400 feet above gulf level.

SALIENT TOPOGRAPHIC FEATURES OF THE GULF COASTAL PLAIN IN NORTHERN LOUISIANA AND SOUTHERN ARKANSAS.

BY

A.C.VEATCH.

Scale

0 50 100 200 300 miles

1905

From U. S. Geol. Surv.

Catahoula (Grand Gulf) formation, is perhaps the most important. Others are the Sulphur Wold, formed by the sandy beds of the lower Eocene, and the Saratoga and Locksburg Wolds, by Cretaceous formations. The transverse valley or vale[2] to the

From U. S. Geol. Surv.
FIG. 18.—The lakes of Red River Valley in Louisiana at their fullest development.

north of the Sulphur Wold, though not very well marked, has determined the location of the Iron Mountain Railway between Little Rock and Texarkana.

Over all the Coastal Plain, except in the steeper hill areas and the most recent flood plains, are low, circular, mound-like elevations that are in themselves of minor significance, but are relatively important because of their persistence and wide distribution. They are from 20 to 100 feet in diameter and attain a

[2] For definition and derivation of the terms wold and vale see Prof. Paper U. S. Geol. Survey No. 44, 1906, p. 29.

maximum elevation of 6 feet. They are particularly abundant in the terrace areas, where in wet weather they form low, sandy islands in the midst of a water-covered clay country. Their origin is one of the most interesting and perplexing problems of the region.

HISTORICAL GEOLOGY

CRETACEOUS

INLYING AREAS OF THE UPPER CRETACEOUS IN NORTHERN LOUISIANA AND EASTERN TEXAS

Disturbances during the late Cretaceous or very early Eocene resulted in the formation of a number of steep domes or four-sided folds (quaquaversals) on the sea bottom in what is now northern Louisiana and eastern Texas (Pl. XXXVIII).

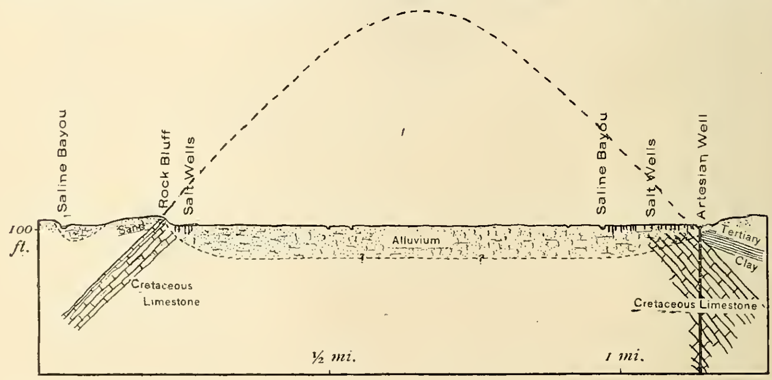
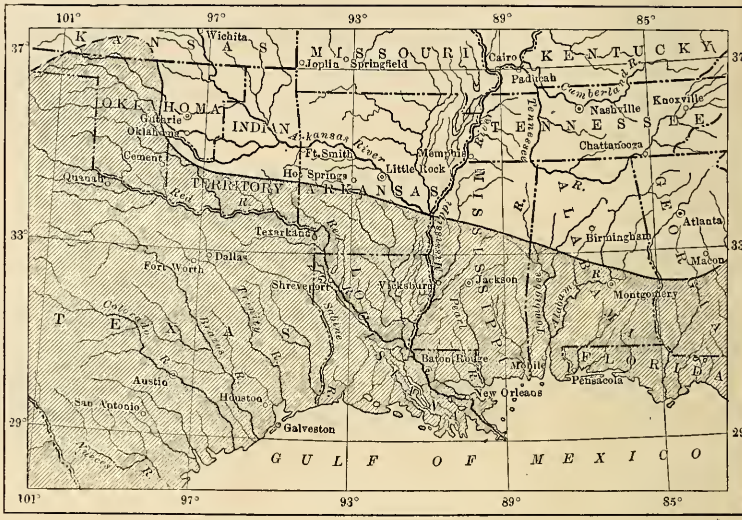


FIG. 19.—Cross section at Drakes Salt Works, Louisiana, showing locationof shallow brine wells and symmetrical truncated character of dome.

Whether the forces producing these unique domes were in any way associated with those producing intrusions farther north it is as yet impossible to say; but the irregularity of their distribution, the great symmetry of all the domes which have been carefully studied[3], the difficulty of explaining this symmetry by any manner of folding not associated with igneous intrusions, and the suggestion which this symmetry carries of force applied at

[3] See Veatch, A. C., The salines of northern Louisiana: Geol. Survey Louisiana, Rept. of 1902, pp. 41–100; Pls. XVIII–XXII.

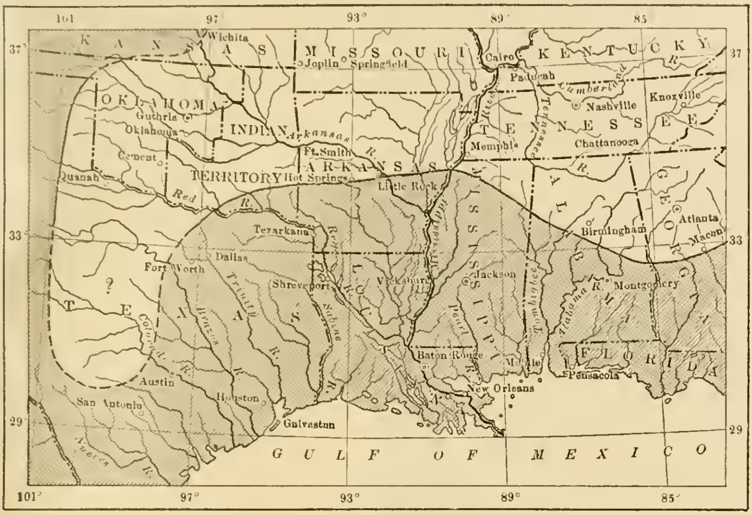


(A) EARLY LOWER CRETACEOUS

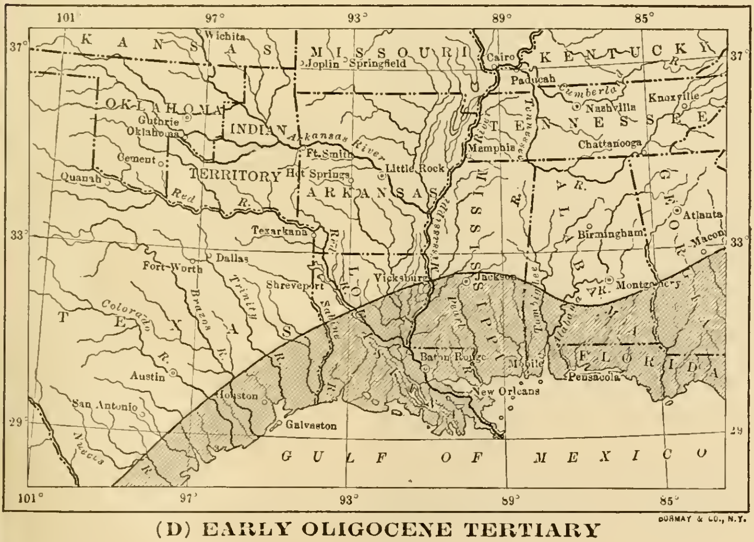
(C) LATE CRETACEOUS AND EARLY TERTIARY

100 0 100 Sca

Relative positions of land and water areas in the south-central U. du
and all shaded areas. Land: Unshaded portions of present land.



(B) EARLY UPPER CRETACEOUS



DURMAY & CO., N.Y.

(D) EARLY OLIGOCENE TERTIARY

le 300 400 500 600 MILES

ıring the Cretaceous Tertiary epochs. Water: Present Gulf of Mexico

From U. S. Geol. Surv.

PRELIMINARY GEOLOGICAL MAP OF NORTHREN LOUISIANA
Abridged from Veatch's map. Pl. III., professional paper No. 46.

one point from below, just as a sharp-pointed little dome might be formed in a sheet of dough by pushing upward with a blunt pencil, indicate similar igneous intrusions beneath these great thicknesses of relatively plastic, recently deposited Cretaceous sediments as the cause of these domes.[4]

Whatever their true origin, the sea floor showed, near the close of the Cretaceous, or in the early Tertiary, a series of steep-sided, more or less circular elevations. These elevations would naturally modify the conditions existing in the portions of the sea where they were sufficiently contiguous to materially interrupt the oceanic circulation, and it is perhaps to such an interruption by the Texas group of domes that the salt deposits of Grand Saline, Tex., are due.

These domes were entirely buried by the Eocene sediments, and as the twelve which have thus far been found in northern Louisiana and eastern Texas (Pl. XXXVII) all occur in valleys (Pls. XXVII, XXXVIII, sec. F) flanked by hills of Tertiary strata and their exposure is due to more or less accidental conditions of erosion, it is quite probable that others will be encountered when the country is more thoroughly prospected. This probability introduces a decided element of uncertainty into the artesian-well prospects of this region.

In determining the amount of deformation represented it is necessary to ascertain with some degree of accuracy the age or stratigraphic position of the beds exposed in these domes. At the Anderson[5] and Brooks[6] salines in Texas and at the Bisteneau, Kings, and Rayburns salt works in Louisiana[7] fossil shells, such as *Exogyra costata*, *Gryphæa vesicularis*,[8] *Ostrea larva*, and other forms representing an uppermost Cretaceous fauna, have been found in limestone or chalk-marl deposits. These beds are the

---

[4] See footnote p. 66.

[5] Dumble, E. T., Second Ann. Rept. Geol. Survey Texas, 1891, pp. 304, 305.

[6] Herndon, J. H., Second Ann. Rept. Geol. Survey Texas, 1891, p. 223.

[7] Veatch, A. C., Geol. Survey Louisiana, Rept. of 1902 [1902], pp. 73, 74, 78, 86–87.

[8] The variety which Taff figures as characteristic, in Arkansas, of the base of the Saratoga or mid-Marlbrook formation: Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pls., 51, 52.

lithologic and paleontologic counterparts of the Marlbrook division of the Arkansas section, and may be tentatively referred to it. If of Marlbrook age the displacement to the present top of the dome is 1,100 feet (Pl. XXXVIII, sec. D) The original height of the top of the dome is not known, but the present truncated top is 1¼ miles in diameter, and the removed portion must have had a thickness of many hundred feet. The known displacement at Kings and Rayburns is about the same, but the total displacement was probably somewhat less, as is indicated by the smaller area of their truncated tops.

The beds exposed in the Winnfield dome are nonfossiliferous, light-colored, porous crystalline limestone in which the cavities are filled with sharp calcite crystals. Similar porous limestones of great thickness have been encountered in wells at Drakes (904, 994) and Cedar Lick, two miles south of Winnfield (999), and as the structure in all these cases is the same as that at the localities carrying Cretaceous fossils, and as the limestones are totally different from any of the Tertiary sediments in this region, they are regarded as Cretaceous deposits which have been altered by the pressure and heat produced in forming the domes. These marbles could not have been formed from any of the beds above the Marlbrook, and they are therefore regarded as Marlbrook or older. The deformation represented is therefore in the neighborhood of 2,000 feet (Pl. XXXVIII, sec. C).

At Coochie Brake, Drakes, and Prices Salt Works very arenaceous limestones, containing leaf impressions, are found in the domed areas. These, if Cretaceous—and it is difficult to see how they may be Tertiary—represent either the Nacatoch or the Bingen. At Drakes the diameter of the truncated dome is about a mile, and the observed angle of slope on one side is 45°. This indicates that the strata removed may have had a thickness of as much as 2,000 feet and that the total deformation may be 3,000 or 4,000 feet.

The deformation at the Many dome, which is capped with Midway limestone, is almost the total thickness of the Sabine in this region, or between 800 and 1,000 feet.

The greater part of the movements represented in these domes took place in late Cretaceous or early Tertiary time, certainly before the deposition of the Sabine sediments, which show no signs of deformation of this magnitude. However, it seems probable that these points have been the loci of slight movements since that time, and that the relatively great dip of the Claiborne beds immediately surrounding the Winnfield dome is due to such a slight movement rather than entirely to deposition on a highly inclined surface.

TERTIARY

EOCENE

CONDITIONS OF DEPOSITION

The change from the Cretaceous to the Tertiary in this region is much more of a paleontologic than a stratigraphic break; many of the genera and all of the species of mollusks inhabiting the Cretaceous sea disappeared at the close of the Cretaceous, as if by magic, to be replaced by the entirely new fauna which inhabited the Eocene ocean.

No stratigraphic break at all commensurate with the paleontologic break has been discovered in this region, and the abrupt change in the animal life is, as Dana suggests,[9] perhaps due more to an alteration in the direction and character of the ocean currents, with the consequent change in temperature and food supply, and to the destructive effects of earthquake waves resulting from the gigantic disturbances which produced the Rocky Mountains, than to a time lapse.

Midway epoch.—Certainly the earliest Eocene deposits, the Midway formation, are sediments indicating depths and distribution of water which are but the normal continuation of the Cretaceous conditions to which cycle of deposition they seem more properly to belong. This fact, with the presence of the Midway on the top of two of the domes, at Kings and Many, suggests that the domes were formed as late as the beginning of the Sabine.

The shore line of this early Eocene ocean was roughly parallel to that of the late Cretaceous sea, and the slight deepening of the water which permitted the formation of the Midway limestone,

[9] Manual of Geology, 4th ed., 1895, pp. 877–878.

together with a slight warping, allowed the ocean to advance farther up the Mississippi embayment than before, and made possible the deposition of marine fossils in southern Illinois,[10] while marine Cretaceous fossils have not been found north of northern Tennesee.[11]

Sabine epoch.—The Mississippi embayment at this time was relatively shallow and flat-bottomed—its present depth of perhaps 3,000 feet at Memphis being the result of very gradual warping accompanied by a deposition which kept pace with the lowering and which extended through the whole Eocene—and a slight elevation was sufficient to convert it into a great low-lying swamp, or marsh, occasionally submerged by the ocean. The conditions were favorable for the growth of shallow-water marine mollusca only as far north as Sabine Parish in Louisiana, about 30° north latitude, and in eastern Alabama about the latitude of Meridian, Miss., and even here there was an alternation of marine near-shore and swampy conditions. These deposits constitute the Sabine formation. Above these swamps, or out of the shallow-water sea, the domes projected as a unique series of circular hills, and as the progressive subsidence continued they were gradually buried beneath the swamp, estuarine, and shallow-water marine deposits, doubtless undergoing in the process more or less erosion from atmospheric agencies and ocean waves.

Claiborne epoch.—A slight depression, or perhaps it would be better to say a slight excess of the rate of depression over the rate of sedimentation, in eastern Texas and along the embayment caused the marine fauna to extend farther northward and to reach in the embayment region a point a little north of the thirty-third parallel. Still farther north, where the water was not deep enough, or river sediments prevented the growth of marine forms, the deposition of the lignitiferous sands and clays containing no marine fossils, which had begun at the close of the Midway, continued. A slight elevation, greater in Louisiana and Texas than

[10] Worthen, Geol. Survey Illinois, vol. 1, 1866, pp. 44–46; Loughridge, Geol. Survey Kentucky, Rept. on Jackson's Purchase Region, 1888. pp. 41–52; Harris, Geol. Survey Louisiana, Rept. of 1902 [1902], p. 9.

[11] Loughridge, Geol. Survey Kentucky, Rept. on Jackson's Purchase Region, 1888, p. 32.

in Alabama, converted the shallow, flat sea bottom of the early portion of the Claiborne epoch into a coastal or estuarine marsh, and in western Mississippi, Louisiana and Texas from 200 to 500 feet of lignitiferous clays and sands with no marine fossils were laid down before the gradual oscillation of this region or changes in climatic conditions again permitted a northward transgression of the marine fauna. This group of sediments is called the Cockfield member of the Claiborne.

Jackson epoch.—Following the Cockfield deposition, conditions were favorable for the growth of marine forms to a point somewhat north of Memphis. This, the Jackson epoch, completed the main filling of the embayment area.

In the succeeding Oligocene and Miocene time the shore line retreated gulfward, and there is no evidence that during these ages there was more than a gentle curve in the coast line in the region of the old Mississippi embayment (Pl. XXVI, D).

MAJOR DIVISIONS OF THE EOCENE

The Eocene about latitude 31° 30′ north is composed of the following major paleontologic subdivisions: (1) The Midway, characterized by fossiliferous limestone, but containing some blue clay; (2) the Sabine, composed of lignitiferous sands and clays, with marine fossils in the seaward or southern portions; (3) the Claiborne, composed of very fossiliferous calcareous clay in its lower portion and lignitiferous sands and clays, with no marine fossils, in its upper (Cockfield member); and (4) the Jackson, composed of fossiliferous calcareous clays. In the upper portion of the embayment all the beds become lignitiferous and lose to a greater or less extent their distinctive marine fossils. This lignitiferous complex, which can be separated only on purely stratigraphic grounds, is discussed and mapped in this report as "undifferentiated Eocene" (p. 35).

MIDWAY FORMATION [12]

This formation, which was named by Smith and Johnson in 1887 from a landing on the west side of the Alabama River in

[12] Synonymy of the Midway formation:

≡ Midway stage, Harris (Bull. Am. Pal., vol. 1, 1896, pp. 11-13).

≡ Midwayan stage, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey 1898, table opp. p. 334.

Wilcox County, Ala.,[13] and redefined by Harris[14] to include a paleontologic group bounded below by the Cretaceous and above by the Nanafalia beds of the Sabine (Lignitic), has been traced more or less intermittently along the southern edge of the Cretaceous outcrops—or where they are missing, as in the uppermost and western parts of the Mississippi embayment, along the Paleozoic rocks—from Georgia to Colorado River in Texas and perhaps to the Rio Grande.

As already indicated, its lithologic characters are more similar to the underlying calcareous Cretaceous clays and marls than to the overlying lignitiferous beds of the Sabine. Although this formation is composed of irregularly bedded dark-colored calcareous clays with more or less sand, it is generally characterized by the absence of the lignitic material so common in the overlying Sabine formation and by a bed or beds of impure white limestone 10 to 25 feet thick, which, because of its lithologic resemblance, was for a long time correlated with the Cretaceous. In common with other beds of the Eocene, it contains *Venericardia planicosta*,

---

=Basal or Wills Point clays, Penrose (First Ann. Rept. Geol. Survey Texas, 1890, pp. 19-22).

≡Midway (or Clayton)+Sucarnochee or Black Bluff+Naheola or Matthews Landing, Smith *et al.* (Bull. U.S. Geol. Survey No. 43, 1887, p.18; Geology of the Coastal Plain of Alabama Geol. Survey Alabama, 1894, p. 27).

>Porter Creek group, Safford (Am. Jour. Sci., 2d ser., vol. 37, 1864, p.368).

>Flatwoods clays, Hilgard (Agriculture and Geology of Mississippi, 1860, pp. 110, 111: Proc. Am. Assoc, Adv. Sci., vol. 20, 1871, p. 222; Am. Jour. Sci., 3d ser., vol. 2, 1871, p. 391).

=Middleton formation, Safford (Bull. Geol. Soc. America, vol. 3, 1892, pp. 511, 512).

NOTE.—In this and the several syononym tables following, the symbols used have the following meanings:

≡Equal to in every respect.

=Equal in a general way.

>Less than.

<Greater than.

≠Not equal to.

[13] Bull. U. S. Geol. Survey No. 43, 1887, p. 62.

[14] Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, 1894, pp. 8, 9, 22; Bull. Am. Pal., vol. 1, 1896, pp. 11-13.

Pseudoliva vetusta, and forms of *Calyptraphorus velatus* and *Turritella mortoni*. Among other forms which are peculiar to this formation and which are, therefore, marks of identification are *Enclimotoceras ulrichi* White, *Ostrea crenulimarginata* Gabb, *Ostrea pulaskansis* Harris, and *Volutilithes limopsis* Conrad.[15]

In Arkansas the Midway limestone outcrops along the edge of the Paleozoic rocks from Bayou Departe, Independence County, to below Rockport, on Ouachita River near Malvern, Hot Springs County (Pl. XXVII). It is particularly well developed around and south of Little Rock, where the total thickness of the beds exposed is not known to be greater than 20 feet. Between the outcrops near Malvern and southwestern Travis County, Tex., no exposures are known, but from the latter point southward to Brazos River the limestone and marls form a narrow belt having a maximum width of 13 miles near Wills Point.[16] The total thickness in this section is estimated by Kennedy at 260 feet,[17] which is but a little greater than that found in this formation in western Alabama by Harris (210 feet).[18] It therefore seems probable that the thickness of the Midway beds underlying Louisiana is about 200 feet.

In Louisiana limited outcrops of the Midway have been found in connection with two of the domes, Many and Kings (Pl. XXVII), and the report of "*Nautilus dekayi* Morton" (probably *Enclimotoceras ulrichi* White) between Hendersons Mills and Albany, in Caddo Parish,[19] together with the irregularity of the

---

[15] For a detailed discussion of the paleontology of the Midway formation see Harris, G. D., The Midway stage: Bull. Am. Pal., vol. 1, 1896, pp. 117-270.

[16] Kennedy, William, Proc. Philadelphia Acad. Nat. Sci. for 1895, 1896, pp. 144-149.

[17] Third Ann. Rept. Geol. Survey Texas, 1892, p. 49.

[18] Harris, G. D., Bull. Am. Pal., vol. 1, 1896, p. 145.

[19] Collins, H. C., Ann. Rept. Chief of Engineers for 1873, vol. 1, 1873, pp. 651–654; also House Ex. Doc., 43 Cong., 1st sess., vol. 2, pt. 2, 1873, pp. 651–664. A careful examination of this locality by the writer failed to confirm this report. Collins' statement, however, bears so many earmarks of careful observations faithfully recorded, that the results of this examination are not felt to be conclusive.

section of a well sunk near the mouth of Cottonwood Bayou, which obtained brine, suggests that there may be another dome area in this region (Pl. XXXVIII, sec. F). None of the fossils have been examined, but it seems probable from the structure of the region that the shell marls reported in wells at Uni (835, 836) and at Furrh, La. (802), are Midway, as are likewise the shells found in the well at Waldo, Ark., (Pl. XXXVIII, secs. F, H, I).

SABINE FORMATION[20]

Overlying the Midway limestones and calcareous clays is a series of dark, finely laminated sands and clays containing much vegetable matter, either scattered through the mass or accumulated in lignite beds, and occasional layers containing marine shells. It commonly differs from the underlying Midway in the

---

[20] Synonymy of the Sabine formation :

≡Lignitic stage, Harris (Am. Jour. Sci., 3d ser., vol. 47, 1894, p. 304; Bull. Am. Pal., vol. 2, No. 9, 1897).

≡Chickasawan stage, Dall (not Hilgard) (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, table opp. p. 334).

<Lignitic, Smith *et al.* (Bull. U. S. Geol. Survey No. 43, 1887, pp. 18, 38; Geol. Survey Alabama, Bull. No. 2, 1892, p. 47; Geology of Coastal Plain of Alabama, Alabama Geol. Survey, 1894, pp. 147, 198, 488), which includes the Midway.

>Mansfield group, Hilgard (Am. Jour. Sci., 2d ser., vol. 48, 1869, p 340), which includes all the Sabine formation except the fossiliferous beds.

<Mansfield group, Hopkins (First Ann. Rept. Geol. Survey Louisiana, 1869, 1870, pp. 78, 83), which includes the nonfossiliferous portion of the Sabine and the Claiborne (Cockfield).

<Camden series, Hill (Geol. Survey Arkansas, Rept. for 1888, vol. 2, 1888, pp. 49-53), which includes fossiliferous Jackson, the Lagrange, and a portion of the Cretaceous.

>Lignitic, Kennedy (Third Ann. Rept. Geol. Survey Texas, 1892, p. 50 ; Proc. Philadelphia Acad. Sci. for 1895, 1896, p. 92), which includes all the Sabine except the fossiliferous beds.

<Lagrange group, Safford (Am. Jour. Sci. 2d ser., vol. 37, 1864, pp. 369-370; Rept. Memphis Waterworks for 1898), which includes portions of all the Eocene beds above the Midway.

<Timber belt or Sabine River beds, Penrose (First Ann. Rept. Geol. Survey Texas, 1890, pp. 22-47, 117), which in eastern Texas included also the lower Claiborne, Cockfield, and Jackson.

presence of lignitic material and fossil leaves and when containing marine fossils is readily distinguished from both the Midway and the overlying Claiborne. Toward the coast, where it is overlain by the very calcareous, argillaceous, fossiliferous lower Claiborne beds, its upper limit can be fixed with exactness, but farther inland, where estuarine and swamp conditions persisted until Jackson time, no separation is possible except on a purely stratigraphic basis. (See Pl. XXXVIII).

On the whole, the formation is predominantly sandy, and while the sand beds are not so regular or so coarse as some of the beds in the Cretaceous, they are the most important water-bearing strata in Louisiana and Arkansas north of the outcrop of the Catahoula formation (Pl. XXVII), and south of the Eocene-Cretaceous boundary.

In Alabama this formation, which has long been called the Lignitic, contains several fossiliferous horizons that are closely related from a paleontologic standpoint, but show faunal differences which have led to the recognition of four substages, named as follows, beginning with the lowest: (1) Nanafalia, (2) Bells and Greggs Landing (Tuscahoma), (3) Woods Bluff, and (4) Hatchetigbee. The first two are sometimes collectively called the Bells Landing substage and the second two the Bashi substage.[21] No distinctive marine fossils have yet been found in the lignitiferous time equivalents of this formation in Mississippi, Arkansas, and the upper embayment region, but along Sabine River in Louisiana and Texas, in the same position relative to the embayment as the Alabama deposits, are developed fossiliferous beds showing the same facies. *Ostrea thirsæ*, an oyster common in the Nanafalia horizon in Alabama, occurs in abundance at Marthaville, La., and the fossils from Pendleton and Sabinetown bluffs on Sabine River, in Sabine County, Tex., show very close affinities to the Greggs Landing and Woods Bluff horizons of Alabama.[22] These beds are limited above by a well-

[21] Smith, E. A., and Johnson, L. C., Bull. U. S. Geol. Survey, No. 43, 1887, p. 18; Smith, E. A., Johnson, L. C., and Langdon, D. W., Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, p. 27; Harris, G. D., Bull. Am. Pal., vol. 2, 1897, p. 196.

[22] Harris, G. D., Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 65-72, 299-309; Geol. Survey Louisiana, Rept. of 1902, pp. 123-125.

preserved and abundant lower Claiborne fauna, and below by the Midway (Wills Point) fossiliferous clays and limestones.

The name Lignitic formation, derived from the lithologic character of the beds, is not in accordance with the rules of geologic nomenclature, and it is therefore necessary to give to this formation the name of some locality at or near which the beds are typically exposed. As the name Chickasaw formation[23] or stage, which has been used by Dall as an exact synonym for Lignitic, is neither stratigraphically nor historically appropriate in this sense, and as the name Lagrange (Safford, 1864), has been applied to the lignitiferous complex above the Midway, and as the doubtful definition and the lack of marine fossils at the type localities of the Mansfield group (Hilgard, 1873) and Camden formation (Hill, 1888) make them unavailable, the name Sabine has been suggested and adopted, from the typical development of the formation along Sabine River in Sabine County, Tex., and Sabine Parish, La., and from noteworthy exposures at Sabinetown Bluff.

The Sabine formation and its equivalent beds in the undifferentiated Eocene underlie the whole of Louisiana, except the limited areas occupied by the outcrops of the Cretaceous and Midway

[23] This name was suggested by Hilgard as an appropriate equivalent for his Northern Lignitic (which is defined in Geology of Mississippi, 1860, pp. 110-123; Am. Jour. Sci., 3d ser., vol. 2, 1871, pp. 394-396), for the very sufficient reason that the "entire Northern Lignitic is within the Chickasaw Purchase, and its most characteristic and conspicuous outcrops are on the four Chickasaw bluffs, of which the Memphis bluff is the last" (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, pp. 344-345). Dall, however, assumed that Hilgard's Northern Lignitic was the exact equivalent of the Lignitic defined by paleozoologic criteria in the Alabama section, and so used it. As a matter of fact the Northern Lignitic is a lignitiferous complex, containing representatives of all the beds between the Midway and the Jackson (see p. 33), and therefore represents the swamp and estuarine deposits of the Sabine, Claiborne, and Jackson epochs. The strata exposed in the Chickasaw bluff, the type locality (see Pl. XXXVIII A,) are stratigraphically either Jackson or the underlying Cockfield, which is uppermost Claiborne. In the whole of the Chickasaw Purchase (about 20,000 square miles) no locality of the Sabine (Lignitic) containing typical marine fossils has been found, and it is necessary to go 100 miles from its border for such a locality. It therefore appears necessary either to use the name Chickasaw formation in the sense in which Hilgard defined it or to abandon it.

domes, and all of Arkansas south and east of the Cretaceous and Midway outcrops (Pl. XXVII). Its thickness, as shown by carefully constructed sections in which local irregularities are reduced to their proper minor importance, ranges from 300 feet in northern Bossier Parish to from 800 to 900 feet near Natchitoches and on Sabine River (Pl. XXXVIII).

CLAIBORNE FORMATION [24]

This formation, which overlies the Sabine, contains the most persistent and widely developed marine beds of the Coastal Plain, and is known to extend from Maryland to the Rio Grande. Its extremely fossiliferous character early attracted attention, and it was from collections from Claiborne Bluff, on Alabama River, in Alabama, that the presence of beds of Eocene age in the Gulf States was first proved by Conrad.[25] He named it the Claiborne formation and, with Lea,[26] described and figured many of the fossils found in a relatively thin sand bed which outcrops in the bluff at Claiborne Landing, Ala. Subsequent work has shown that this bed, which is generally referred to as the Claiborne sand, is but a very local development, paleontologically, of one of the larger divisions of the Eocene. It is to this large division that the name Claiborne formation or Claiborne group is now applied. (See synonymy.)

In central Louisiana the Claiborne formation is divisible into a lower fossiliferous member, which has been called the "Lower Claiborne" in this area, and an upper lignitiferous member, called the Cockfield, which contains no marine fossils. The lower portion is much more calcareous, glauconitic, and clayey than the underlying Sabine beds, and where typically developed contains no lignitic nor lignitiferous matter, though to the north it changes to lignitiferous sands and clays and merges into the undifferentiated Eocene group. Thus, while across San Augustine and Sabine counties, Tex., and on Sabine River it is extremely calcareous and fossiliferous and is sharply limited both above and

[24] Synonymy of the Claiborne formation:

=Claibornian stage, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, pp. 342-343), except the White Bluff beds.

below by the lignitiferous beds of the Cockfield and the Sabine, and while it maintains this calcareous, fossiliferous character northward in Louisiana to about the Vicksburg, Shreveport and Pacific Railway (Pl. XXVII), yet north of that line the beds are pronouncedly lignitiferous in character. A few small, poorly preserved Claiborne fossils have been found in northern Bossier Parish,[27] and stratigraphic relations suggest that the fossils

---

=Claiborne (sand)+Lower Claiborne, Harris (Am. Jour. Sci., 3d ser., vol. 47, 1894, p. 304), except the White Bluff beds.

≡Claiborne sand+*Ostrea sellæformis* beds+Lisbon beds+Buhrstone, Harris (Am. Jour. Sci., 3d ser., vol. 47, 1894, p. 304).

≡Claiborne (sand)+Buhrstone, Smith and Johnson (Bull. U. S. Geol. Survey No. 43, 1887, p. 18).

≡Claiborne proper (including the Claiborne sand and *Ostrea sellæformis* beds)+Buhrstone, Smith, Johnson, and Langdon (Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, pp. 27, 122, 124, geologic map of Alabama, 1894).

>or=Claiborne stage or Claiborne group (siliceous Claiborne+calcareous Claiborne), Hilgard (Geology of Mississippi, 1860, pp. 108, 123-128).

>Claibornian, Heilprin (Proc. Philadelphia Acad. Nat. Sci., 1882, p. 184; Contributions to Tertiary geology and palentology of the United States, Philadelphia, 1884, p. 30), which is exactly equivalent to Claiborne sand.

<Lower Claiborne, Kennedy (Proc. Philadelphia, Acad. Nat. Sci. for 1895, p. 92), which includes portions of Jackson and basal Oligocene beds.

<and>Cooks Mountain beds+Mount Selman beds (Marine deposits or Marine beds), Kennedy (Third Ann. Rept. Geol. Survey Texas, 1892, p. 45; Bull. U. S. Geol. Survey No. 212, pl. 2, 1903), which include also the portion of the Sabine which contains marine fossils.

=Lower Claiborne+Cockfield Ferry beds, Vaughan (Bull. U. S. Geol. Survey No. 142, 1896, p. 21).

=Lower Claiborne, Harris and Veatch (Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 73-89, geologic map).

=Lower Claiborne+Cockfield, Harris (Geol. Survey Louisiana, Rept. of 1902 [1902], pp. 17-21).

[25] Conrad, T. A., Eocene fossils of the Claiborne, with observations on this formation in the United States: Fossil Shells of the Tertiary Formation of North America, vol. 1. No. 3, 1835, pp. 29-36. (See Harris's republication of Conrad's Fossil Shells, 1893, pp. 75-84).

[26] Lea, Isaac, Tertiary formation of Alabama: Contributions to Geology, Philadelphia, 1833, pp. 9-209, pls. 1-6.

found in the wells at Buckner, Ark., and Dubach, La. (889), and at Walnut Bluff, below Camden, on Ouachita River,[28] are also Claiborne, but the general character of the beds in this region indicates nearshore or swamp conditions very different from the deeper water conditions farther south.

In Louisiana and Texas the commonest and most readily recognized fossils of this formation are *Ostrea sellæformis* and *Anomia ephippoides*. The oysters are particularly abundant, often forming "oyster prairies," which are bald spots covered with oysters.

The thickness of this lower fossiliferous portion of the Claiborne formation is 250 to 300 feet in the region about Monroe, but increases to over 500 feet at Winnfield. On Sabine River the thickness, calculated from dip observations, is 550 feet,[29] and the section of a well recently put down near Robinsons Ferry which obtained fossils at a depth of 1,250 feet, that Dr. W. H. Dall regards as Claiborne, indicates that it is as much as 700 feet.

COCKFIELD MEMBER OF THE CLAIBORNE[30]

The lignitiferous sands and clays which occur in central Louisiana between the marine portions of the Claiborne and Jackson formations are extremely similar in lithologic character to the Sabine beds, and were at first confused with them. They contain no marine mollusks and are characterized by thin, impure lignite beds and clays, often containing plant remains in an excellent state of preservation. They are identical in appearance with the lignitiferous complex to the north (undifferen-

[27] Harris, G. D., Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, 1894, pp. 178–180.

[28] Ibid., pp. 141–142.

[29] Geol. Survey Louisiana, Rept. 1902, p. 120.

[30] Synonymy of the Cockfield member:

=Upper Lignitic beds, Lerch (Preliminary report on the hills of Louisiana south of the Vicksburg, Shreveport and Pacific Railway to Alexandria, 1893, pp. 82–85).

≡Cockfield Ferry beds, Vaughan (Am. Geol., vol. 15, 1895, p. 220; Bull. U. S. Geol. Survey No. 142, 1896, p. 21).

<Lower Claiborne, Harris and Veatch (Geol. Survey Louisiana, Rept. 1899 [1900], pp. 80–82), which inclndes also the fossiliferous portion of the Claiborne in Louisiana.

tiated Eocene) of which they form a part, and can be definitely differentiated only when fixed between fossiliferous Claiborne and Jackson beds or by structural data.

They were first definitely separated from the other Eocene nonmarine strata by Lerch, who called them the upper Lignitic in distinction from the lower Lignitic (Sabine) which occurred below the lower Claiborne formation. Later Vaughan found these beds typically exposed at Cockfield Ferry,[31] on Red River, halfway between the very fossiliferous Claiborne beds at St. Maurice and the Jackson beds at Montgomery, and named them the "Cocksfield Ferry beds."

At Jackson, Miss., the Cockfield beds have a thickness of about 400 feet.[32] In Louisiana the thickness ranges from 400 to 500 feet. (See Pl. XXXVIII.)

≡Cockfield beds, Harris (Geol. Survey Louisiana, Rept. of 1902 [1902], p. 21.

≡Cockfield Ferry beds or Cocksfield, Veatch (Geol. Survey Louisiana, Rept. of 1902, pp. 120, 130–131, 141, 158, 160–163).

=?Yégua, Dumble (Report on Brown Coal, Geol. Survey Texas, 1892, pp. 148–154; Science, new ser., vol. 16, 1902, pp. 670–671).

<Yégua clays, Kennedy (Proc. Philadelphia Acad. Nat. Sci., vol. 47, 1895, p. 92), which includes part of the fossiliferous marine Jackson.

<Lufkin or Angelina County beds, Kennedy (Third Ann. Rept. Geol. Survey Texas, 1892, pp. 45, 58–60), which includes part of the fossiliferous marine Jackson.

<Mansfield group, Hopkins (First Ann. Rept. Geol. Survey Louisiana, 1869, 1870, pp. 78–83), which includes the unfossiliferous Sabine.

<Northern Lignitic, Hilgard (Geology of Mississippi, 1860, pp. 110–123; Am. Jour. Sci., 3d ser., vol. 2, 1871, pp, 394–396), which includes also lignitiferous portions of the Sabine and lower Claiborne.

[31] This was spelled by Vaughan "Cocksfield Ferry." The maps of the Red River Survey (MS. sheet No. 37, Red River Survey, U.S. Eng'rs., 1889–1890, scale 1 : 10,000) gave two plantations at this point belonging to "A. P. Cockfield" and "W. J. Cockfield." The ferry name should naturally be spelled in the same way as the name of the owners. The section at "Cocksfield Ferry," published by Vaughan (Am. Geol., vol. 15, 1895, pl. 9; Bull. U. S. Geol. Survey No. 142, 1896, pl. 1), is really a section of Petite Ecore, or, as it has been improperly anglicized, "Petite Ecore Bluff."

[32] Based on well section given in Geology and Agriculture of Mississippi, 1860, p. 191.

The sandy, near-shore character of these beds makes them of greater importance as water carriers than the Claiborne and Jackson. In central Louisiana they commonly contain great amounts of soluble salts and the water is generally not so good as that from the Sabine. In Arkansas and Mississippi a sand bed at about the same stratigraphic position as the basal Cockfield water horizon yields good potable water.

Regarding the relation of the Cockfield to the Jackson and Claiborne time divisions the data at hand, as has been pointed out by Vaughan,[33] indicate that they are late Claiborne rather than early Jackson. In central Louisiana they are limited below, at St. Maurice, by fossils which belong low in the Claiborne, and above, at Montgomery, by fossils, which, while not basal Jackson, are low in the Jackson; and while the Cockfield may contain a small amount of the Jackson, it is to be regarded as almost wholly of Claiborne age. In southern Arkansas, where basal Jackson fossils are developed, the Cockfield is clearly of Claiborne age. In central Texas, as pointed out by Dumble,[34] the Yégua of Dumble (not Kennedy) presents many points of resemblance to the Cockfield, and is here clearly a portion of the Claiborne.

JACKSON FORMATION[35]

The Jackson group was named by Conrad[36] in 1856, from

[33] Bull. U. S. Geol. Survey No. 142, 1896, p. 22.

[34] Science, new ser., vol. 16, 1902, pp. 670–671.

[35] Synonymy of the Jackson formation:

≡Jacksonian stage, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, p. 342.

≡Jackson stage, Harris and Veatch (Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 89–93; Geol. Survey Louisiana, Rept. of 1902, pp. 22–23, 131–132, 141, 158, 164–167).

<Jackson group, Hopkins (Second Ann. Rept. Geol. Survey Louisiana, 1871, pp. 7–15, map), which includes the Sabine, Cockfield, lower Claiborne, and a part of the Jackson; the remainder of the Jackson is included in his Vicksburg group.

<White limestone, Johnson (Report on the iron region of northern Louisiana and eastern Texas; House Ex. Doc., 50th Cong. 1st sess. No. 195, 1888, map, pp. 14–15), which includes lower Claiborne (in part), Cockfield, Jackson, and Vicksburg (?).

<Yégua clays, Kennedy (Proc. Philadelphia Acad. Nat. Sci. vol. 47, 1895, p. 92), which includes the Cockfield.

Jackson, the capital of Mississippi, where the beds are typically exposed. It consists of a series of fossiliferous, somewhat gypseous, calcareous clays which have been traced from eastern Alabama to eastern Texas. It extends farther up the Mississippi embayment than any other of the Tertiary beds containing marine fossils except the Midway, having been found in wells at Hays Landing, La. (872), near Arkansas City, Ark. (144), and at Helena, Ark. (644). It is exposed at Crowleys Ridge, west of Memphis, and, south of Arkansas River in Arkansas, extends from near Little Rock to Hamburg. (See Pls. XXVII and XXXVIII, sec. A). At Crowleys Ridge it shows a marked tendency to change into lignitiferous clays—a tendency which is quite like that of the Claiborne and the Sabine farther south.

In this region it is the most fossiliferous marine bed of the Eocene, with the possible exception of the Claiborne in Louisiana and the Midway in Arkansas, from both of which it may be distinguished by its characteristic fossils and stratigraphic position. One of the noted outcrops in Louisiana is shown in Pl. XXVIII.

≠Yégua, Dumble (Report on Brown Coal, Geol. Survey Texas, 1892, pp. 148–154; Science, new ser., vol. 16, 1902, pp. 670–671), which is regarded as a portion of the Claiborne.

<White limestone, Smith (Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, pp. 107, 232, 376, 492, 495; see also Casey, Proc. Philadelphia Acad. Nat. Sci. for 1901, 1901, pp. 513-518).

<Fayette sands, Kennedy (Proc. Philadelphia Acad. Nat. Sci. for 1895, 1896, pp. 92, 95–99; Bull. U. S. Geol. Survey No. 212, 1903, p. 20, pl. 2). These, as defined by Kennedy, are largely Catahoula (Grand Gulf), but include, near the base, Jackson fossils. (See Harris, Geol. Survey Louisiana, Rept. of 1902, p. 25; Veatch, ibid., p. 133).

<Vicksburg, Hilgard (Am. Jour. Sci., 2d ser., vol. 48, 1869, pp. 340–341; Supplement and Final Report of a Geological Reconnaissance of Louisiana, New Orleans, 1873, pp. 18–19), which includes all the Jackson and Claiborne beds in Louisiana along Sabine River and a number of Jackson localities in eastern Louisiana.

≠Jackson group, Lerch (The hills of Louisiana south of the Vicksburg, Shreveport and Pacific Railway [1893], pp. 88–91), which includes only a portion of the lower Claiborne.

[36] Conrad, T. A., Proc. Philadelphia Acad. Nat. Sci., vol. 7, 1856, p. 257.

Noted Fossiliferous Jackson Outcrop at Montgomery, La.

UNDIFFERENTIATED EOCENE[37]

The Eocene beds, which in central Louisiana, Mississippi and Alabama are fossiliferous, all become lignitiferous in the upper portion of the embayment. The marine fossils of the Sabine, lower Claiborne, and Jackson epochs each extend farther northward than those of the preceding epochs, but in each case the beds bearing marine fossils grade into lignitiferous clays and sands containing no distinctive marine fossils.

The first name given to this lignitiferous group, which can not be separated except on structural grounds, was the Lagrange. This included all the Eocene beds in Tennessee above the Midway, and was afterwards quite logically extended by its author, Prof. J. M. Safford, State geologist of Tennessee, to include the lignitiferous sands and clays of Crowleys Ridge,[38] which are of

[37] Synonymy of the undifferentiated Eocene:

=Northern lignitic, Hilgard (Geology of Mississippi, 1860 pp. 110–123; Am. Jour. Sci., 3d ser,, vol. 2, 1871, pp. 394–396), except the Flatwoods clays, which are Midway.

≡Lagrange, including Bluff lignite, Safford (Am. Jour. Sci., 2d ser., vol. 37, 1864, pp. 369–370).

≡Lagrange+Bluff lignite, Safford (Geology of Tennessee, 1869, pp. 424–428).

≡Lagrange, Safford (Agricultural and Geological Map of Tennessee, 1874, Taintor Brothers, New York, publishers).

≡Lagrange, Safford (Agricultural and Geological Map of Tennessee, Tavel, Eastman & Howell, Nashville, Tenn., 1875).

≡Lagrange, Safford and Killbrew (Elementary Geology of Tennessee, Nashville, 1876, pp. 165–166).

≡Lagrange, Safford (Agricultural and Geological Map of Tennessee, 1888, 1896, 1899).

≡Lagrange, Safford (Rept. Memphis Water Works, 1898, p. 16).

≡Lagrange, Safford (Elements of the Geology of Tennessee, Nashville, 1900, pp. 104, 160–161).

<Camden series, Hill (Ann. Rept. Geol. Survey Arkansas for 1888, vol. 2, 1888, pp. 188–189), which includes the Jackson and a portion of the Cretaceous.

=(?)or>Camden beds, Hill (Ann. Rept. Geol. Survey Arkansas for 1888, vol. 2, 1888, pp. 188–189).

>Chickasaw stage, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, pp. 344–345), which is restricted to the Lignitic (Harris, 1894) or Sabine formation.

[38] Lundie, John, Rept. on Waterworks System of Memphis, Tenn., 1898, p. 16.

lower Jackson age and are the stratigraphic equivalents of the beds in the upper Chickasaw Bluffs. This formation grows more sandy to the north, where at Memphis essentially continuous sand beds 800 feet thick have been penetrated.[39]

OLIGOCENE

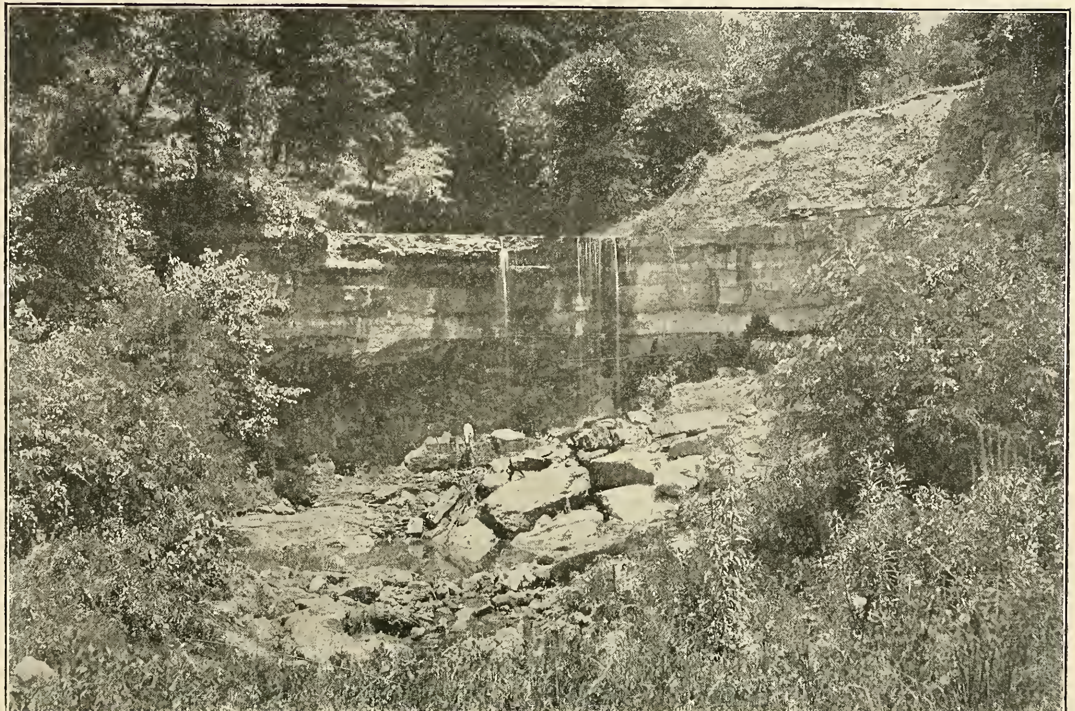
CONDITIONS OF DEPOSITION

The change from the Eocene to the Oligocene in this area is, like the change from the Cretaceous to the Eocene, much more a paleontologic than a stratigraphic break, and while beds of lignitiferous strata separate the Jackson from the basal Oligocene or Vicksburg beds, they are of no greater importance as an indication of a time break than half a dozen beds within the Eocene. No pronounced unconformity or discordance of the strata has been observed. However, such characteristic and abundant Eocene forms as *Venericardia*, *Pseudoliva*, *Volutilithes*, and *Calyptraphorus* abruptly terminate in the Jackson, and are replaced in the basal Oligocene by a distinctly different fauna. Of the 122 species known in the basal Oligocene, but 10 are found in the Claiborne and Jackson.[40]

The lowest Oligocene beds in the Mississippi Valley, like the basal Eocene, are lithologically more like the topmost beds of the preceding series than the succeeding beds of the larger time division which they initiate. They represent conditions of deposition and distribution of ocean water which are but the continuation of those of the previous period, while the succeeding beds are indicative of more or less radical changes. The basal Oligocene beds, the Vicksburg formation, are overlain by near-shore deposits consisting of coarse sandstones interstratified with greenish-gray clays very different from the underlying calcareous and lignitiferous strata and entirely devoid of marine remains, though containing land plants and fresh-water shells. This group of beds, which is called the Catahoula formation, is in turn overlain by greenish calcareous clays, containing a very few

[39] Safford, J. M., Bulletin State Board of Health, vol. 5, pt. 7, Feb. 20, 1890, pp. 98–106 ; Ann. Rept. Geol. Survey Arkansas for 1889, vol. 2, 1891, pp. 28–29.

[40] Dall, W. H., Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, 1903, p. 1553.



VICKSBURG LIMESTONE, MINT SPRING BAYOU, JUST ABOVE VICKSBURG, MISS.

brackish-water shells and called the Fleming formation. Indeed, if physical rather than biological changes were made the basis of the broader geologic divisions, the dividing lines between the Cretaceous and Eocene and the Eocene and Oligocene in this region would be drawn above the base of the deposits of these larger time units.

During the Eocene the Mississippi embayment was almost, if not completely, filled, and in the Oligocene, except possibly in early Vicksburg time, the coast line was a simple broad curve reaching from eastern Georgia to Mexico with no pronounced indentations (Pl. XXVI D).

VICKSBURG FORMATION[41]

The Vicksburg formation, which was named by Conrad in 1846[42] from its very fossiliferous exposure in the bluffs at Vicksburg, Miss. (Pl XXIX), where it has a total thickness of 120 feet,[43] is the lithological counterpart of the underlying Jackson, from which it can be distinguished by its characteristic fossils. The

[41] Synonymy of the Vicksburg formation:

≡ Vicksburg, Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, 1903, p. 1553).

≠ Vicksburg, Hilgard (Am. Jour. Sci., 2d ser., vol. 48, 1869, pp. 340–341; Supplemental and Final Report of a Geological Reconnaissance of Louisiana, New Orleans, 1873, pp. 18–19). All the localities at which Hilgard reported Vicksburg in Louisiana have proved to be Claiborne or Jackson.

< Vicksburg group, Hopkins (First Ann. Rept. Geol. Survey Louisiana, 1869, 1870, pp. 94–98; Second Ann. Rept. Geol. Survey Louisiana, 1870, 1871, pp. 15–18). Includes portions of the Claiborne and Jackson.

≠ White limestone, Johnson (Iron Region of Northern Louisiana and Eastern Texas, 1888, pp. 14–16). As described, this includes only Jackson and Claiborne fossils.

< St. Stephens White limestone, Smith (Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, pp. 107, 232, 376, 492, 495), which includes the Jackson. According to Casey, it has not yet been definitely proved that the White limestones contain any true Vicksburg (Proc. Philadelphia Acad. Nat. Sci. for 1901, pp. 513–518).

[42] Conrad, T. A., Proc., Philadelphia Acad. Nat. Sci., vol. 3, 1846, pp. 280–281.

[43] Hilgard, E. W., Am. Jour. Sci. 3d ser., vol. 2, 1871, map facing p. 391.

known extent of the typical Vicksburg is very limited. West of Mississippi River it has been definitely proved to occur only in a limited region in northern Catahoula Parish, La.[44] (Pl. XXVII), though it may extend westward to the vicinity of Little River. To the east certain beds in eastern Mississippi and Alabama, particularly the great Orbitoidal limestone of the Florida peninsula, have been correlated with this formation, but the recent work of Dall[45] renders this correlation somewhat doubtful, and Casey has suggested that the true Vicksburg beds represent but a local development in a remnant of the old Mississippi embayment.[46]

CATAHOULA FORMATION[47]

Overlying the fossiliferous Vicksburg clays and limestones is a series of sandstones and greenish clays which are generally quite

[44] The outcrops of the Vicksburg beds 3 miles south of Rosefield were first described by Hopkins, who correctly referred them to the Vicksburg (First Ann. Rept. Geol. Survey Louisiana for 1869, 1870, p. 97 ; Second Ann. Rept. Geol. Survey Louisiana for 1870, 1871, p. 16). They were, however, first definitely proved to belong to this stage by Vaughan (Bull. U. S. Geol. Survey No. 142, 1896, p. 52).

[45] Dall, W. H., Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, 1903, p. 1553.

[46] Casey, T. L., On the probable age of the Alabama White limestone; Proc. Philadelphia Acad. Nat. Sci. for 1901, pp. 513–518.

[47] Synonymy of the Catahoula formation:

- < Grand Gulf sandstone, Wailes (Agriculture and Geology of Mississippi, 1857, pp. 216–219). Includes typical Grand Gulf sandstone and (erroneously) some consolidated Claiborne and Lafayette.
- < Grand Gulf group, Hilgard (Report on Geology and Agriculture of Mississippi, 1860, pp. 147–154), which includes the Catahoula, Fleming, and Pascagoula formations.
- = Typical Grand Gulf, Dall (Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1898, table facing p. 334).
- ≡ Grand Gulf proper, Harris (Geol. Survey Louisiana, Rept. of 1902, p. 28).
- < Grand Gulf beds, Harris (ibid.).
- ≡ Grand Gulf, Veatch (Geol. Survey Louisiana, Rept. of 1902, pp. 120, 132–135).
- < Fayette beds, Penrose (First Ann. Rept. Geol. Survey Texas, 1890, pp. 47–58), which are a composite including Claiborne beds in their type locality and Catahoula and Fleming beds in east Texas.
- ≠ Fayette beds, Dumble (Jour. Geol., vol 2, 1894, pp. 552–554; Science, new ser., vol. 16, 1902, p. 671), which are Claiborne.

From U. S. Geol. Surv. Photograph by G. D. Harris

On Texas and Pacific Railway, Near Lena, La.

different, lithologically, from any of the older beds of the Tertiary series in Louisiana and Arkansas. The sandstones which are the characteristic feature of this formation range in thickness from a few inches to 50 or 60 feet (Pl. XXX, wells 859, 938, 939), and thickness of as much as 140 feet (well 855) have been reported.[48] These sand beds are often cemented by silica into very hard quartzites, but such occurrences are essentially local, and the quartzitic beds pass laterally in very short distances into soft sandstones or even unconsolidated sands. These sandstones and quartzitic layers have resisted erosion more than the underlying clays and unconsolidated sands of the Eocene and so have formed a line of rocky hills, the Kisatchie Wold (Pl. XXV), extending across Louisiana, into Texas on the one hand and into Mississippi on the other.

These beds contain no indications of marine life, but land plants are abundant and fresh-water shells have been found in several places. The change from the conditions existing in the Vicksburg is very marked and indicates an elevation during which the region where the oceanic conditions were favorable for the growth of marine life was considerably south of the present outcrop of the formation (see Pl. XXVII).

These beds were observed at Grand Gulf, on Mississippi River, in Claiborne County, Miss., by Wailes, the first State geologist of Mississippi, who referred to them as the "Grand Gulf sandstones."[49] Later Hilgard[50] used the name "Grand Gulf group" to include the beds exposed in southern Mississippi between the Vicksburg and the relatively recent coastal clays (Port Hudson),

---

< Fayette sands, Kennedy (Third Ann. Rept. Geol. Survey Texas, 1892, pp. 60–62; Bull. U. S. Geol. Survey No. 212, 1903, pp. 20, 21–22), which includes a portion of the Jackson. (See Geol. Survey Louisiana, Rept. of 1902, pp. 25, 132–133.)

= Oakville, Dumble (Science, new ser., vol. 16, 1902, pp. 670–671). This correlation, while suggestive, needs further evidence to verify it.

[48] Kennedy, William, Third Ann. Rept. Geol. Survey, Texas, 1892, p. 63.

[49] Wailes, B. C. L., Agriculture and Geology of Mississippi, 1857, pp. 216–219.

[50] Hilgard, E. W., Rept. on Agriculture and Geology of Mississippi, 1860, pp. 147–154.

and the name has been used with varying shades of meaning by different authors since that time.[51]

In view of this confusion and in order to furnish a name not likely to be misunderstood, the name Catahoula formation is used in this paper as a synonym for the "typical Grand Gulf" or the "Grand Gulf proper." This new name is from Catahoula Parish, La.,[52] which is directly across the Mississippi Valley from Grand Gulf and where there are many outcrops which are lithologically and stratigraphically counterparts of the beds of the old type locality. From this place the beds have been traced eastward through Mississippi into Alabama, where they apparently grade into a series of fossiliferous sands and calcareous clays known as the "Chattahoochee group." To the west they extend in a very pronounced line across Louisiana into eastern Texas, and, according to Dumble, are continued across that State in his Oakville beds.[53] The thickness of this formation, as shown by comparative cross sections based on wells at Alexandria (933, 939) and Boyce (944) and on dip observations on Sabine River,[54] is about 1,100 feet (Pl. XXXVIII).

The country in which this formation outcrops is, as a rule, poor in everything but long-leaf pine. The sand beds are, however, important water carriers, and in places (as near Harrisonburg, Lena, and Christie, La., and about Rockland, Tex.) the quartzitic layers have been quarried for riprap work and ballast (Pl. XXIV).

FLEMING CLAY[55]

The Fleming clay, which was so named by Kennedy in 1892[56] from Fleming siding on the Missouri, Kansas and Texas Railway

[51] In this connection see the following; Smith, E. A., and Aldrich, T. H., Science, new ser., vol. 16, 1902, pp. 835–837; Idem, vol. 18, 1903, pp. 20–26; Dall, W. H., Science, new ser., vol. 16, 1902, pp. 946–947; Idem, vol. 18, 1903, pp. 83–85; Hilgard, E. W., Science, new ser., vol. 18, 1903, pp. 180–182.

[52] It may be of historic interest to note that one of the first mentions of the outcrops of this formation refers to the exposures at Catahoula shoals, in Catahoula Parish, which were even at that early day correctly correlated with the exposures east of the Mississippi (see Darby, William, A Geological Description of the State of Louisiana, Philadelphia, 1816, pp. 45–46).

[53] Science, new ser., vol. 16, 1902, pp. 670–671.

[54] Geol. Survey Louisiana, Rept. of 1902, pp. 120, 132–135. pl. 37.

[55] Synonymy of Fleming clay:

near the line between Tyler and Polk counties, Tex., consists of green or bluish green calcareous clays, differing from the underlying Catahoula beds in the presence of numerous small white calcareous nodules and the absence of the characteristic Catahoula sandstone layers. Near its base it often contains a bed of bright-red clay, which forms a convenient line of parting.[57] These beds produce a stiff, heavy soil that is often black and resembles the soils of the Cretaceous prairies. Except where deeply covered with the surficial sands and gravels, these are commonly quite distinct from the coarse, sandy soils of the Catahoula formation.

Although these deposits represent less truly littoral sediments than the Catahoula beds, extended search has failed to reveal any marine remains except near Burkville, Newton County, Tex., where a brackish-water Oligocene fauna [58] has been found in a local development of limestone 3 to 4 inches thick. These beds are particularly well developed on Neches River in the vicinity of Townbluff and extend east and west from that point in a belt 5 to 15 miles wide.

The thickness of the Fleming beds is not well known, though

=Fleming beds, Kennedy (Third Ann. Rept. Geol. Survey Texas, 1891, pp. 62–63).

≠Frio clays, Dumble (Jour. Geol., vol. 2, 1894, pp. 554–555; Science, new ser., vol. 16, 1902, pp. 670–671), which are regarded as Claiborne.

≡Frio clays, Kennedy (Proc. Acad. Nat. Sci. Philadelphia for 1895, 1896, pp. 93–95; Bull, U. S. Geol. Survey No. 212, 1903, pp. 20, 22–23, pl. 2).

≡Frio Clays, Veatch (Geol. Survey Louisiana, Rept. of 1902, pp. 120, 135–137, 141–144, pl. 37).

≡Frio clays, Harris (Geol. Survey Louisiana, Rept. of 1902, pp. 28–32).

≡Frio clays, Maury (Bull. Am. Pal., vol. 3, 1902, pp. 353, 390, pl. 25).

[56] Kennedy, W., Third Ann. Rept. Geol. Survey Texas, 1892, pp. 62–63.

[57] Ibid., p. 63; Harris, G. D., Geol. Survey Louisiana, Rept. of 1902, p. 31.

[58] Geol. Survey Louisiana, Rept. of 1902, p. 136; Bull. Am. Pal., No. 15, vol. 3, 1902, p. 80. Kennedy (Bull. U. S. Geol. Survey No. 212, 1903, p. 53) reports a number of lower Claiborne (Eocene) species from this locality, but the collection made by the writer in 1902, which was by far the largest made at this point, showed none of the species listed by Kennedy. Dr. T. W. Vaughan l ter visited the outcrop and states that the fragmentary material which he was able to obtain was regarded by both himself and Dr. W. H. Dall as having a decidedly Oligocene aspect.

it has been estimated by Kennedy at 260 feet and by Veatch at 200 + feet.[59]

Along Sabine River the dip of the Fleming formation is much less than that of the basal Catahoula beds, though it is apparently the same as that of the uppermost Catahoula, which is from 25 to 35 feet per mile.

MIOCENE AND EARLY PLIOCENE

After the deposition of the Fleming beds a general elevation of this region, accentuated locally by the further development of the low Angelina-Caldwell monoclinal flexure (Pl. XXXVII), caused the sea to retreat southward to a point between the present outcrop of the Catahoula and Fleming formations and the Gulf shore. This retreat was but one of the steps in the gradual growth of this portion of the American continent, which, with minor retrogressions, such as occurred in the late Pliocene, has resulted in moving the shore line of the southern sea, now the Gulf of Mexico, from a line, as yet unfixed, north of the southern edge of the Ouachita Mountains to the present coast.

The effect of this late Oligocene, Miocene, and early Pliocene uplift and the very slow and gradual tilting which accompanied it was to permit the formation in the coast region of Louisiana of very thick post-Oligocene deposits, which, with the beds that were formed in the late Pliocene and Quaternary, have a thickness in that region of much more than 3,000 feet.[60] The region north of this shore line was by this elevation subjected to more or less profound erosion, by which this new Coastal Plain, underlain by Oligocene, Eocene, and Cretaceous sediments, was reduced to a level, in Louisiana and Arkansas, of from 500 to 700 feet above the present sea level. North of this Coastal Plain, in the region of the older rocks, where erosion had been active since the first arching and tilting of the great Jurassic peneplain in the

[59] Geol. Survey Louisiana, Rept. of 1902, p. 120.

[60] The Galveston, Tex., well at a depth of 2,920 feet reached only the upper part of the Miocene (Harris, Fourth Ann. Rept. Geol. Survey Texas, for 1892, 1893, p. 118; Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7, 1901, pp. 402–406).

early Cretaceous, the erosion of the Miocene and early Pliocene completed the formation of a plain lying below the level of the old Jurassic peneplain and containing many protruding remnants of the older surface. This lower, partially developed Tertiary peneplain was essentially continuous with the eroded Coastal Plain.

LATE PLIOCENE

LAFAYETTE FORMATION

CONDITIONS OF DEPOSITION

In the late Pliocene a considerable change in elevation occurred, which caused the sea to advance from its position a little north of the present Gulf coast and to cover much of the eroded Coastal Plain and in places to extend over the bordering rocks. The sea, in its advance and retreat, spread over this plain a sheet of littoral deposits, and the rivers flowing into it filled up the valleys with similar materials.

This great blanket of silts, sands, and gravels of near-shore and fluviatile origin, which, from its exposures in Lafayette County, Miss., has been named the Lafayette formation by Hilgard,[61] and which has been described at length by McGee,[62] was, in northern Louisiana and southern Arkansas, largely worn away and redeposited in the succeeding periods of erosion. Its remnants or redeposited remnants are, however, very common throughout the Coastal Plain in Arkansas and Louisiana, though the exact relation of the different deposits and the succession of events involved in their redeposition can be exactly determined only by a very detailed study after large-scale topographic maps have been prepared.

PRESENT DISTRIBUTION

South of the Catahoula and Fleming formations these sands and gravels form the surface for miles and then pass southward beneath the more recent clays of the Quaternary (fig. 20), forming there the water bearing beds which furnish a portion of the

[61] Hilgard, E. W., Am. Geol., vol. 8, 1891, p. 130.

[62] McGee, W. J., The Lafayette formation; Twelfth Ann. Rept. U. S. Geol. Survey, pt. 1, 1891, pp. 347-521.

waters used in the irrigation of that region. North of the Catahoula sandstone their occurrence is essentially fragmentary, and they appear and disappear in an extremely irregular manner. As shown by wells, they are commonly thickest in the large valleys, where they have been concentrated by erosion subsequent to their original deposition, but they do not normally outcrop on the surface of the present river flood plains and on the adjoining terraces, though they are frequently exposed in the base of the river banks at low water and are generally abundant where the terraces grade into the adjacent hills.

They are notably absent in regions of very calcareous clays, as in the Jackson area in Louisiana and the regions underlain by the more calcareous beds of the Cretaceous,[63] a peculiarity of distribution due to two factors: (1) The clayey

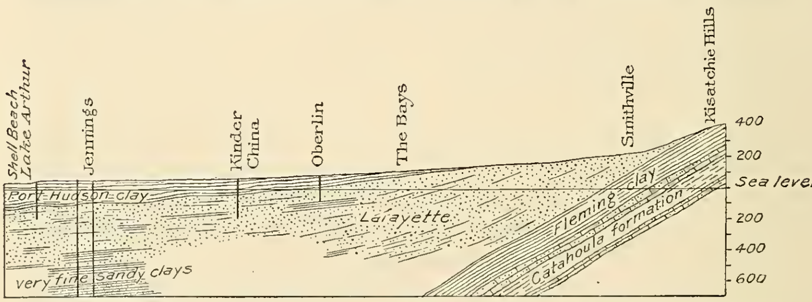


FIG. 20.—North-south section showing Lafayette and younger gravels passing beneath the clays of the Port Hudson and supplying artesian wells in southern Louisiana.

layers of a gently sloping unconsolidated Coastal Plain series are generally more easily eroded than the sandy beds, and the surficial beds are therefore really more completely removed along the outcrops of the clay layers; (2) it is not always possible to state positively that these Lafayette and younger beds are absent from the weathered outcrops of the sandy layers of the older Coastal Plain series, and it often happens, because of the absence of pronounced lithologic differences, that the Lafayette beds are

[63] Also observed in Mississippi and Alabama (Geology of the Coastal Plain of Alabama, Geol. Survey Alabama, 1894, p. 63; Agriculture and Geology of Mississippi, 1860, p. 5; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 105–106).

assumed to be present in great thickness, when in fact they are almost or entirely absent. Thus, in Arkansas, portions of the weathered outcrops of the Bingen and Nacatoch sands[64] have been mistaken for these surficial beds. Outcrops of a bed of littoral sediments, probably Cretaceous, lying below the Midway at Little Rock,[65] and ferruginous deposits in Louisiana belonging to the lower Claiborne[66] have also been improperly classed as Lafayette.

The gravel deposits are particularly abundant along Ouachita and Little Missouri rivers, and on the eastern side of the old course of Red River, along Bayou Dorcheat and Black Bayou. The bowlders along this line are often of extreme size; thus at Bisteneau Salt Works large masses of quartzite, containing 8 to 10 cubic feet, were observed in 1899 and were then thought to be local,[67] but similar bowlders have subsequently been found at many points to the north between this locality and the novaculite outcrops in the Ouachita Mountains. Similar bowlders have been found on Ouachita River near Monroe[68], and it is difficult, in the absence of any known glacial action, to imagine how they could have been transported 100 to 150 miles from their source, unless it were by floating ice. Call, however, has made the suggestion that somewhat similar bowlders on Crowleys Ridge were carried by roots of floating trees.[69] This, while possible in some cases, is not believed to be the true explanation of all the occurrences observed in southern Arkansas and northern Louisiana. These large gravel deposits belong more properly to the period of erosion and readjustment which followed the Lafayette than to the Lafayette submergence itself.

---

[64] Ann. Rept. Geol. Survey Arkansas for 1888, vol. 2, 1888, pp. 28-42, map; Twenty-second Ann. Rept. U. S. Geol. Survey, pt. 3, 1902, pl. 47.

[65] Twelfth Ann. Rept. U. S. Geol. Survey, pt. 1, 1891, p. 470; Ann. Rept. Geol. Survey Arkansas for 1892, vol. 2, 1894, p. 7.

[66] Second Ann. Rept. Geol. Survey Louisiana for 1870, 1871, pp. 22–23; Bull. Louisiana State Exper. Sta.; Preliminary report on the hills of Louisiana north of the Vicksburg, Shreveport and Pacific Railway, 1893, pp. 24-26; Bull. U. S. Geol. Survey No. 142, 1896, pp. 20-22; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 100–101.

[67] Geol. Survey Louisiana, Rept. of 1902, p. 88.

[68] Ibid., p. 169.

[69] Call, R. E., Ann. Rept. Geol. Survey Arkansas for 1889, vol. 2.

QUATERNARY

PLEISTOCENE

LATE TERTIARY AND EARLY QUATERNARY EROSION

A gradual elevation marked the close of the Lafayette epoch and the sea retreated southward over the deposits laid down in its former advance, reassorted them, and carried back into the ocean some of the finer materials of the upper layers. The streams following the sea across this newly emerged coastal plain, in courses determined by its slight irregularities, began at once to trench its surface and incidentally to form the major topographic features of to-day. As this slow elevation continued the streams cut deeper and deeper into the underlying beds and, while at first the valleys were deep and narrow and the major streams were separated by large flat-topped areas representing the old plain level, the tributary streams gradually wore back into these level regions, divided them, and carved them into hills. When at last the land came to rest, at a height of about 100 feet above the present level, the streams, unable to cut below the very low slopes necessary to carry their waters seaward, began to cut from side to side and in time made broad valleys somewhat larger than the present flood plains, which occupy the depressions produced by these older rivers, but which are now restricted by the unremoved portions of the Port Hudson deposits forming terraces. The bottom lands along the larger streams, the ancient Mississippi, Arkansas, Ouachita, and Red rivers, were about 100 feet below the present flood plains (see bottom of gravel layer, (Pl. XXXVIII,) and like the latter were trenched still deeper by the streams traversing them (see stream cuts in present destructional flood plains, shown in fig. 23), p. 51). Thus the bed of the Mississippi of today has an extreme depth of 150 feet below its banks at Vicksburg, 165 feet at Fort Adams, and 175 feet 4 miles below the mouth of Red River,[70] and the abnormal depths of the redeposited Lafayette and Quaternary materials encountered in some of the wells given in the following tables are, in part, thought to be due to such occurrences, though they may be the effect of a slight uplift toward the close of this erosion period.

[70] Mississippi River Comm., Survey of Mississippi River, charts Nos. 48, 60 and 61.

Table showing thickness of Port Hudson and redeposited Lafayette and Quaternary beds in the Red River Valley, and indicating the position of the old land surface.

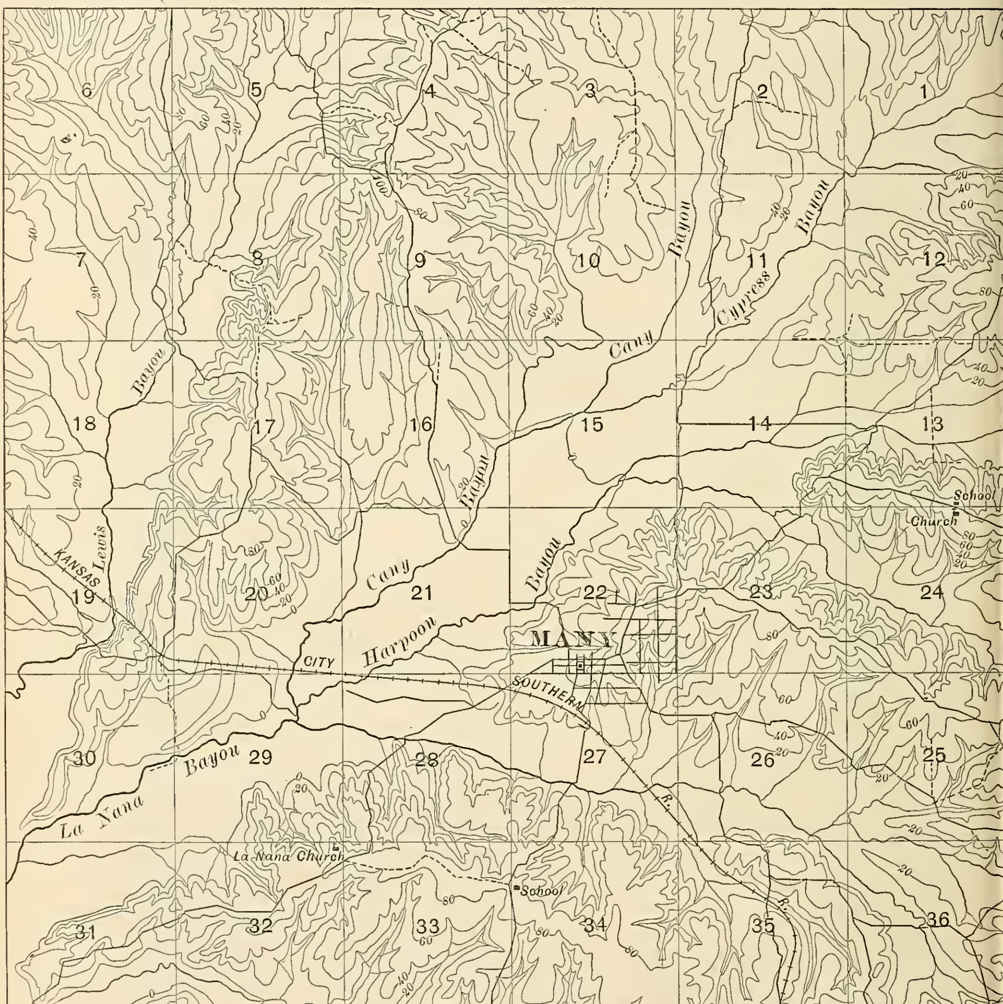
Well No.[71]	Location	Thickness of deposits
	LOUISIANA	
	Bossier Parish:	*Feet.*
788	Lake Point	120
783	Bossier City (3 miles north of)	130
784	Bossier City (2½ miles north of)	76
785	Bossier City	80
786	Bossier City	195?
794	Pool	111?
	Caddo Parish:	
803	Missionary	130
796	Belcher	96
797	Belcher (3 miles northeast of)	125
799	Dixie	60
800	Dixie (2½ miles east of)	85
801	Dixie (3 miles southwest of)	121
835	Uni	70
804	Below Shreveport	69–110
805	Robson	106
832	Bayou Pierre	70
	Natchitoches Parish:	
906	Luella	300?
908	Montrose	180
	Grant Parish:	
877	Colfax	130
	Rapides Parish:	
953	Rapides (average of 5 wells)	108
937	Alexandria	90
938	Alexandria	155
940	Alexandria	110+
950	Pineville	200?
950	Pineville	230?
947	Lamothe	105+

Table showing thickness of Port Hudson and redeposited Lafayette beds in the Mississippi Valley, and indicating the position of the old land surface

Well No[72]	Location	Thickness of deposits
	LOUISIANA	*Feet.*
873	Lake Providence	248?
872	Hays Landing.	109
894	Mound	135+
922	Monroe	95
923	Monroe	80
867	Fish Pond	145+

[71] Numbers correspond to those used in Chapter V.

[72] Numbers correspond to those used in Chapter V.

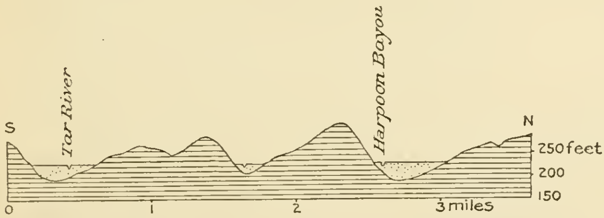


Scale of miles

1 ½ 0 1 2

FIG. 21.—Sketch topographic map near Many, Sabine Parish, La., showing the characteristic flat-bottomed, steep-sided small stream valleys of northern Louisiana and southern Arkansas, by A. C. Veatch, 1899.

In the area between the main streams the tributaries formed in time an interlocking drainage very little different from that of to-day, and at the close of this long period of erosion almost all of the old plain level had been destroyed (Pl. XXV) and the major topographic features of northern Louisiana and southern Arkansas produced. Indeed, the only great difference between the topography of that day and this was that the principal valleys were 100 to 150 feet deeper, and the Port Hudson terraces (Pl. XXVII) were entirely absent. The valleys of the small streams did not then show their present anomalous, steep sided, flat-bottomed, filled character (fig. 21), but the hill slopes passed in curves of gradually lessening gradient to the streams between them (fig. 22). The topographic features of to-day are but the features developed in that period, slightly modified by the partial filling of the valleys in the succeeding period of low level and the incomplete re-excavation of this filling which has taken place since that time.



From U. S. Geol. Surv.

FIG. 22.—Section near Many, La., showing typical flat-bottomed, filled character of small stream valleys in northern Louisiana and southern Arkansas; also showing typical steeper gradient of north-facing than of south-facing hill slopes.

PORT HUDSON DEPOSITION

CONDITIONS OF DEPOSITION

During the long preceding period, which in its results was essentially one of erosion, though there were doubtless many stages that have not yet been interpreted, the mantle of Lafayette sands and gravels was largely worn away and redeposited. The gravel was concentrated at many points by stream action and toward the close of the period, when perhaps the land stood slightly higher than before, and when the Mississippi may have been augmented by glacial flood waters, many of the valley bottoms were covered with sand and gravel.

With the slow subsidence which then began the carrying power of the streams was diminished and the gravels were covered with fine sands and, in time, with silts and clays. The bottom lands were converted into great low-lying swamps and mingled with the deposits formed at this time. In the valleys north of Baton Rouge are fresh-water shells[73] and many swamp-loving trees, as well as driftwood washed in from the higher lands.

These swamp deposits and their accompanying blue clays are succeeded by silty or sandy, somewhat calcareous clays, which reflect the general character of the sediments of the rivers along which they are found. Thus, on the Mississippi they are yellow or grayish yellow and contain numerous ferruginous and a few calcareous concretions, while on Red River they are bright red and contain many lime nodules not vastly different from those found in the loess and known as "loesskindchen."

These deposits are to-day best exposed in the riverward edges of the terraces. Along the Mississippi excellent exposures are found in the railroad cuts near Hamburg and in the Morehouse and Avoyelles hills (Pl. XXXI), while on Red River notable outcrops are found at St. Andres Bluff, near Colfax; at Campti; at Red Bluff, east of Frierson; on the Kansas City Southern Railway, north of Wallace, Cross, and Ferry lakes; in Caddo Parish; at Red Bluff, near Bodcau; at Hurricane Bluffs, in Bossier Parish;[74] and at Fulton and Mandeville, on the St. Louis, Iron Mountain and Southern Railway, in Arkansas (Pl. XXVII).

Occasionally some of the large animals which then lived in this portion of the country wandered into these marshes and became mired. Among the bones preserved in this way are species of the *Mastodon*, and *Elephas*, of the *Mylodon*, *Megalonyx*, *Megatherium*, and *Glyptodon*, large animals akin to the sloths, and armadillos, now found in South America, a camel, a large elk, and a prehistoric horse but little different from the domestic horse of today.

---

[73] Third Ann. Rept. Geol. Survey Louisiana for 1871, 1872, p. 177; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 190–191.

[74] See Geol. Survey Louisiana, Rept. for 1899 [1900] pp. 113–114, 189–192; Third Ann. Rept. Geol. Survey Louisiana, for 1871, 1872, pp. 185–190.

From U. S. Geol. Surv.

Escarpment on the Southern Edge of the Marksville Hills.

A Port Hudson terrace in Avoyelles Parish, La.

These deposits are all essentially fluviatile or estuarine in origin, and the present level tops of their remnants, which form terraces along the sides of the principal valleys (fig. 23), indicate that this depression was not over 100 feet below the present level. On Red River the height of the terraces is seldom over 60 feet above the present bottom lands, and in the Mississippi Valley, near the Arkansas-Louisiana State line, it ranges from 60 to 80 feet. To the north the terraces become lower, and in southeastern Missouri they have an elevation of but 20 to 30 feet,[75] a variation which is perhaps due to recent movements either along the line of the Angelina-Caldwell flexure, the Red River-Alabama Landing fault, or both (Pl. XXXVII).

These clay terrace

[75] Marbut, C. F., Univ. of Missouri Studies, vol. I, No. 3, 1902, p 16.

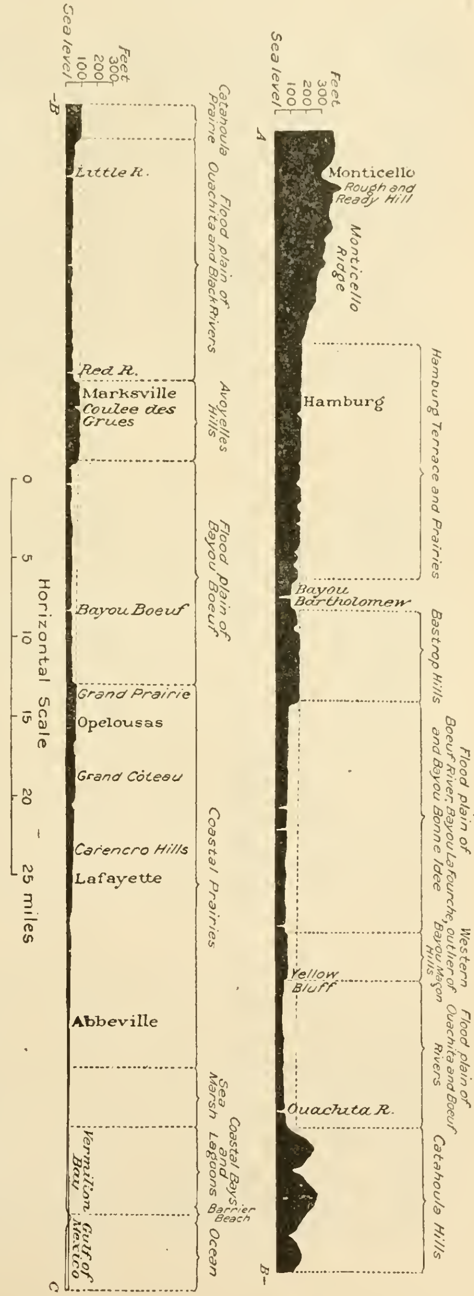


FIG. 23.—Section from Monticello, Ark., to the Gulf of Mexico, near Abbeville, La., showing the relation of the Hamburg terrace, Bastrop Hills, Catahoula Prairie, and Avoyelles Hills to the coastal prairies.
From U. S. Geol. Surv.

deposits are continued southward in the pine meadows of eastern Louisiana and the prairie and pine flats of southwestern Louisiana, which are doubtless of the same age. The hills which border the Bayou Teche, the Grand Coteau des Opelousas, and the Cote Gelee, represent the eastern scarp of this prairie region where it has been cut by the Mississippi. They are but the southern representatives of the isolated terrace remnant, the Avoyelles Hills, which is the connecting link between them and the Mississippi and Red River terraces (fig. 23). With the exception of the present sea marsh and the inconsiderable alluvial deposits of the present Mississippi flood plain, these coastal prairies are the most recent deposits of southern Louisiana above sea level.

DEPOSITION OF THE LOESS

Near the close of this low-level period great floods of water from the glaciers to the north brought down large quantities of very fine yellow rock meal. This is now found capping the highest hills east of the Mississippi as far south as the Mississippi-Louisiana State line and west of the Mississippi, in Arkansas and Louisiana, only on Crowleys Ridge, and at Sicily Island. It was early recognized at Vicksburg by Lyell and by him correlated with similar deposits in the Rhine Valley called "loess."[76] By some it is thought to represent the natural levees of an immensely swollen Mississippi, but the hypothesis best supported by the known facts is that it was deposited by glacial flood waters over the Mississippi plain and formed great mud flats, from which after drying, it was conveyed to its present position by the wind.[77]

EROSION OF THE PORT HUDSON DEPOSITS

With the elevation that followed the Port Hudson period of low-level the main streams began to cut out the deposits which partially filled their valleys. This erosion which was the last of the major stages in the formation of the present topography, has

[76] Lyell, Charles, Second visit to the United States, 1849, vol. 2, pp. 194–195.

[77] For an excellent summary of this question see Chamberlain, T. C., Jour. Geol. vol. 5, 1897, pp. 795–802.

resulted in the partial removal of the Port Hudson deposits, which in northern Louisiana and southern Arkansas are now found as terraces along the sides and underlying the present flood plains at no very great depth.[78] The nearness of the Port Hudson sediments to the surface and the relative thinness of the present alluvial deposits indicate that the flood plains of all the larger rivers of this area, except, perhaps, the Mississippi plain below Donaldsonville and New Orleans are to be regarded, on the whole, as destructional rather than constructional plains.

The amount of erosion accomplished in post-Port Hudson time is very small when compared with that accomplished in the long and complex late Tertiary and early Quaternary period of erosion, when the main topographic features of this region were produced.

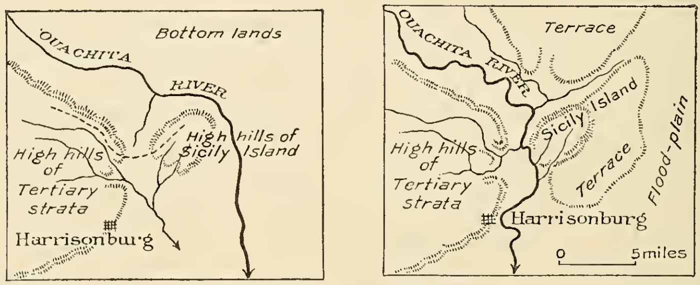
To the south the plain, which was continuous with the Opelousas Hills and low bluffs along the Mississippi near Baton Rouge and which formed an integral part of the prairies and pine flats of Louisiana, was broadly trenched leaving these bluffs on either side to indicate its former height and extent. In central Louisiana the Avoyelles Hills were separated, on the one hand, from the Opelousas Hills by a broad valley, formerly the flood plain of Red River, but now occupied by Bayou Boeuf (fig. 23), and, on the other hand, from the terraces to the northwest, whose edge is represented by Grimes and Innes bluffs, by the more recent Red River bottoms. In the Red River valley the "upland flats" were made into terrace benches at this time by the trenching of the Port Hudson deposits. To-day these "upland flats" form a notable minor feature of the topography and are particularly well developed in Lafayette County, Ark., and Bossier Parish, La., along what is perhaps the old course of Red River, which after the filling of the valleys, was abandoned for a more westerly course following the smaller valley of Sulphur Fork through eastern Caddo Parish (Pls. XXV, A; XXVII).

In parts of the Mississippi Valley where the erosion has been somewhat irregular these Port Hudson deposits have not been

[78] Hilgard, E. W., On the geological history of the Gulf of Mexico: Proc. Am. Assoc. Adv. Sci., 1871, pp. 230–236; Am. Jour. Sci., 3d ser., vol. 2, 1871, pp. 398–404; 48th Cong., 1st sess, House Ex. Doc. No. 37, vol. 19, 1884, pp. 480–481; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 118, 175–176; Geol. Survey Louisiana, Rept. of 1902, pp, 138–169.

completely worn down to the level of the surrounding gradational plains, and these remnants, though much below the height of the main terraces, are still noteworthy because of their peculiar soil, their relief above the bottoms, and the fact that the banks of the waterways traversing them are lower than the surrounding lands—like true upland creeks—while in the recent flood-plains the banks are typically higher and form more or less pronounced natural levees. To this class belong the Bayou Macon Hills (fig. 23, p, 51, Pl. XXVII,) and the hardly noticeable elevation just above high water extending from the high Bastrop Hills northward toward Dermot, Ark.

On the small tributary streams in the hill-land areas, especially toward the headwaters, the cutting has been less, and the present flood plains of these minor streams are often essentially the



From U. S. Geol. Surv.

A. Drainage in early Quaternary time. *B*. Present drainage.

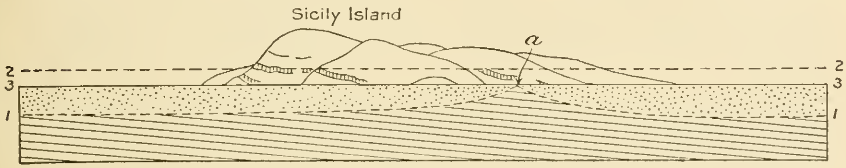
FIG. 24.—Change in Ouachita River drainage near Harrisonburg, La.

unaltered surface of the old Port Hudson deposits. Along Sabine River, though the Port Hudson deposits form occasional low bluffs and rise slightly above the restricted plain of the present river, they are much more a part of the bottoms, with which they are commonly classed, than are the terraces along the flood-plains of the present Red and Mississippi Rivers, which are commonly regarded as hill lands.

In the erosion of the relatively level Port Hudson constructional valley plains several peculiar topographic features have been produced. Among these are the gorge-like passage of Ouachita River; between Sicily Island Hills and the main uplands in Catahoula Parish, La.; the transverse cutting of the high terrace remnants by Bayou Bartholomew, Boeuf River and Deer Creek; and the level of the land immediately bordering the Ouachita lower than that bordering the Mississippi at the Arkansas-Louisiana State line (Pls. XXV, XXVII).

DIVERSION OF THE OUACHITA RIVER NEAR HARRISONBURG, LA.

Because of the hardness of the Catahoula formation, a notable contraction has been produced in the Mississippi Valley where these beds cross it (Pls. XXV, B, XXVII); in the period of high level preceding the Port Hudson deposition the group of hills forming the present Sicily Island hill mass was



From U. S. Geol. Surv.

FIG. 25.—Diagram illustrating the deflection of Ouachita River and the cause of the formation of the Catahoula Shoals near Harrisonburg, La.

a. Catahoula Shoals; old divide between north and south flowing drainage.
1–1. Beds of north and south flowing minor streams (First Stage).
2–2. Original level of valley filling (Second Stage).
3–3. Present Ouachita flood plain (Third Stage).

but a promontory on the main Catahoula hill mass and Ouachita River flowed to the east of it (fig. 24 A). When the main valley region was partially filled during the succeeding low-level period, the low divide between the two minor stream valleys, which partially separated this hill mass from the hills to the west, was buried with fluviatile sediments which extended 60 feet above the present bottoms (figs. 23, 25). The Sicily Island hill group was thus entirely separated from the main hill mass by a relatively flat fluviatile plain which was but a portion of the larger constructional plain occupying the whole Mississippi Valley (fig. 25). This plain was doubtless slightly higher in the main valley where the Mississippi brought down large quantities of sediments and the Ouachita naturally occupied the lower ground, and so passed to the west of the Sicily Island hill mass (fig. 24). In the succeeding period, when the streams cut out a portion of this filling and formed the terraces, the Ouachita cut down and became superimposed on the old rocky divide between the former north and south flowing creeks, and thus formed the present Catahoula Shoals (fig. 25).

TRANSVERSE CHANNELS OF BAYOU BARTHOLOMEW, BOEUF RIVER, AND DEER CREEK

When the slight uplift following the Port Hudson low-level caused the streams to commence trenching the Port Hudson Valley plains, Ouachita River, which then joined the main flood plain at about its present juncture with Saline River in southern Arkansas (Pl. XXV, B), early gained the ascendency over the other streams of the valley. This is evidenced by the courses of the tributary streams—the Bartholomew, the Boeuf, and Deer Creek—which pass through the intervening terrace remnants in more or less pronounced gorges to join it (Pl. XXVII). The cause of this ascendency is, primarily, that the greater amount of sediment carried by the Mississippi tended to produce a relatively greater depression along the present course of the Ouachita, both in building up and cutting out the Port Hudson plain. In the period of low-level the Port Hudson plain was built up more rapidly along the greater silt-carrying Mississippi, while in the succeeding periods of erosion the Ouachita, being less burdened with sediment, more nearly attained a perfect base-level. In the beginning of this period of erosion the streams of the valley, therefore, drained southwest into the Ouachita, and, as the latter has maintained its greater depth, they have continued to do so. In this process the streams have become intrenched in the Port Hudson deposits and, as a result of this and of the irregular removal of the beds by the complex system of drainage in the Mississippi bottoms, a stream sometimes leaves a broad flood plain and deliberately flows through a range of hills to join another flood plain beyond. Thus Bayou Bartholomew follows the eastern edge of a well-marked terrace escarpment 40 to 60 feet high through Lincoln, Drew, and Ashley counties, Ark., and, though separated from the present flood plain of the Mississippi in this part of its course by a low, almost imperceptible swell, may topographically be regarded as occupying the very western edge of the Mississippi bottoms (Pl. XXVII). In northern Louisiana it turns to the southwest, leaves this broad plain, and passes, in a steep-sided valley but a mile or two wide, through the escarpment which is continued southward in the eastern face of the Bastrop hills.

Similarly, though in by no means so striking a manner, Bayou Boeuf leaves the Mississippi flood plain and passes through a valley between the Bastrop and Bayou Macon Hills to the Ouachita flood plain beyond (Pl. XXVII).

Farther to the south Deer Creek cuts obliquely across the Bayou Macon Hills and separates them from the terraces flanking the Sicily Island hill mass.

DIFFERENCE IN LEVEL BETWEEN THE OUACHITA AND MISSISSIPPI FLOOD PLAINS AT THE LOUISIANA-ARKANSAS STATE LINE.

The difference in the height of the banks of the Mississippi and those of the Ouachita in the latitude of the Arkansas–Louisiana State line is very striking, the top of the former being 112 feet above sea level and that of the latter but 63 feet. The difference is, however, somewhat exaggerated by a small, very recent fault which cuts across the valley near Alabama Landing, La., and which if it continues across the Mississippi flood plain has been completely obliterated by the great amount of sediment carried by that river. The true ratio, with the recent displacement of this fault allowed for, is about 112 to 88—still a striking difference in the elevation of the main stream of the valley and one of its tributaries.

FORMATION OF NATURAL MOUNDS

GENERAL CHARACTER AND THEORIES OF ORIGIN

Some time after the formation of Port Hudson plains a vast number of low mounds, rudely circular, 20 to 100 feet in diameter and 3 to 5 feet high, were formed. These mounds have an extremely wide distribution. They are well developed on the prairies and pine flats of the Port Hudson deposits along the coast of Louisiana and Texas, where they form the now well-known "pimple prairies," and are popularly associated with the oil deposits, with which, however, they are in no way genetically connected. They occur irregularly throughout the Coastal Plain in northern Louisiana, northeastern Texas, Arkansas, and southeastern Missouri, except in the present flood plains. They are best developed on the Port Hudson terraces, but extend also over the hill lands. They are not restricted to any geologic formation or any range of elevation. The material of which they are composed is commonly a very fine loam, which is reported by the agriculturists to be coarser than, and quite distinct from the surrounding soil, which is commonly clay. Oil-well drillers in southern Louisiana and southeastern Texas report the material in these mounds to be entirely different from the surrounding soil and exactly the same as the fine sand found beneath the 50 to 100 feet of surface clay. The apparent difference in composition is, however, not so great as it seems at first sight and is in part due to the greater elevation and consequent better drainage of the mounds. Careful mechanical analyses will be necessary to determine the true character and degree of this difference.

Mr. J. A. Taff, of the U. S. Survey, reports that similar mounds are very abundant through Indian Territory, where they are best developed on the plains formed during the Tertiary by the erosion of the highly inclined Carboniferous shales and sandstones. They are there, as throughout the Coastal Plain, composed of somewhat coarser materials than that of the surrounding lands, which are commonly flat and water-soaked, while the mounds stand out as somewhat sandy islands. Mr. M. K. Shaler, field assistant, who during the season of 1904 worked with Mr. Taff in Indian Territory, reports that identical mounds occur in southeastern Kansas.

The question of the origin of these mounds is one of the most perplexing problems of this region and can not yet be said to be satisfactorily solved, though the range of possibility has been somewhat narrowed by recent work. The theories which have thus far been advanced may be grouped as follows:

1. Human[79]......
   - a. Garden beds.
   - b. Tepee or wigwam sites.
   - c. Burial mounds.
2. Animal[80] .....
   - a. Ant hills.
   - b. Mounds of burrowing animals.
3. Water erosion[81]
   - a. Great currents of floods.
   - b. Slow erosion at low level.
4. Eruptions[82]...
   - a. Springs or "aqueous" volcanoes due to artesian pressure.
   - b. Gas vents
   - c. Eruptions due to the unequal weight of an uneven clay layer on a water-logged sand bed.

2 Wind[83]........
   - a. Low dunes collected by scanty vegetation in a semiarid region of variable winds.
   - b. "roots wads." Masses of earth lifted by the uprooting of trees in storms, which have perhaps been enlarged or modified by burrowing animals.

Of these theories those deserving the most careful attention are (1) the spring and gas-vent theory, (2) the dune theory, and (3) the ant-hill theory.

SPRING AND GAS-VENT THEORY

The spring and gas-vent theory has, until the last year, seemed the most probable of the several hypotheses advanced. The

[79] Nadaillac, Marquis de, Prehistoric America, translated by N. d'Anvers, New York, 1895, p. 182. Lockett, S. H., First Ann. Rept. Topog. Survey, Louisiana, for 1869, 1870, pp. 66-67; Geol. Survey, Louisiana; Rept. for 1899, [1900], p. 194.

[80] Hilgard, E. W., Supplemental and final report of a Geological Reconnoissance of Louisiana, 1873, p. 11.

[81] Owen, D. D , Second Report of a Geological Reconnoissance of part of the state of Arkansas, Philadelphia, 1860, p. 144. Lerch, Otto, A preliminary report on the hills of Louisiana south of the Vicksburg, Shreveport and Pacific Railway; Bull. Louisiana State Exper. Sta., Geology and Agriculture, pt. 2, 1893, p. 106.

[82] Memorial and explorations of the Hon. J. B. Robertson in relation to the agriculture, mineral, and manufacturing resources of the state (Louisiana), with the report of the joint committee: Doc. 2d sess., 2d Legis., Rept. No. 23, 1867; also separate, New Orleans, 1867, pp. 14-15. Hopkins, F. V; First Ann. Rept. Geol. Survey Louisiana, 1869, 1870, pp. 80-82. Clendenin, W. W., A preliminary report upon the Florida parishes of east Louisiana and the bluff, prairie, and hill lands of southwest Louisiana; Bull. Louisiana State Exp. Sta , Geology and Agriculture, pt. 3, 1896, pp. 179-183; Geol. Survey Louisiana, Rept. for 1899 [1900], pp. 193-194.

[83] Featherman, A., Third Ann. Rept. Botanical Survey of Southwest and Northwest Louisiana, 1871, 1872, pp. 106-107. Clendenin, W. W., op. cit., p. 180.

argument in this case is that throughout the Coastal Plain strata there are large amounts of vegetable matter from which gas has been slowly generating. This gas, with the associated artesian water, on escaping has brought to the surface fine sands and built up low cones. In substantiation of this hypothesis two lines of evidence were adduced. First, there are at widely separated points—namely, near Sulphur City, La., and near Teneha, in northwestern Texas, in regions covered with mounds, a number of low cones a few inches in height and a few feet in diameter in the course of formation (Pl. XXXII). In both cases the very fine sand composing the cones was being brought up by the flow of gas and water in the center of the cone. Second, it is commonly reported by the oil-well drillers in southern Louisiana and southeastern Texas, though the statement could not be satisfactorily verified, that wells sunk on the mounds yield more gas than those in the intermound spaces. In these cases it has been assumed that the gas was of slightly more importance than the artesian water. It is, however, probable that the water was the principal cause and the gas but an accessory. Shepherd[84] has described low spring cones in southeastern Missouri, which are clearly of the same character as those just described. The region in which these occur is likewise covered with natural mounds. A number of cones and irregular "sand sloughs" were produced by water and gas eruptions or by water alone during the New Madrid earthquake of 1811-12, and these have naturally led to the classification of all the mounds in this section as of similar origin. From an examination of some of the mounds in southeastern Missouri along the line of the St. Louis, Iron Mountain and Southern Railway, the writer is inclined to doubt this generalization and to regard the greater number of them as identical with the same phenomena to the south and west, and not of the same origin as the low spring cones or the eruptions of the New Madrid earthquake. This locality is, however, the best argument for a water and gas origin. On Long Island, New York, there are a number of low mud cones which, while not entirely identical with the

[84] Shepherd, E. M., The New Madrid earthquake, Jour. Geol., vol. 13, 1905, pp. 45-62.

From U. S. Geo. Surv.

A

B

Small Sand Cones Forming Over Gas and Water Vent on Flat Creek, Three Miles South of Teneha, Shelby County, Tex.

From U. S. Geol. Surv.

Mud Cones Near Douglastown, Long Island, N. Y.
Formed by pressure of underlying artesian water.

mounds, are of interest as examples of cones produced by artesian pressure (Pl. XXXIII).

DUNE THEORY

A wind origin was suggested for these southern mounds by Featherman in 1872[85] and by Clendenin in 1896.[86] Recently Dr. C. W. Hayes, after having examined the mounds in southeastern Texas, observed very similar low mounds clearly due to wind action 15 or 20 miles southwest of Green River City, in southwestern Wyoming, and concluded that the Coastal Plain mounds were of the same origin. The objection to this theory, which is regarded as more probable than that just discussed, is the very great irregularity of wind-made features and the fact that these natural mounds of the south-central United States, over an area at least 300 miles wide and 500 miles long, are notably uniform in size and exactly resemble one another. It would seem that in so large an area a wind origin would involve a greater variation in size than has been observed and would necessitate the presence of occasional dunes or lines of dunes of noteworthy size whose origin could not in any way be doubted. This hypothesis, moreover, requires an arid or semiarid climate in this region at a very recent time, of which there is no other evidence and which, in the present state of the investigation, can hardly be considered as conclusively proved.

ANT-HILL THEORY

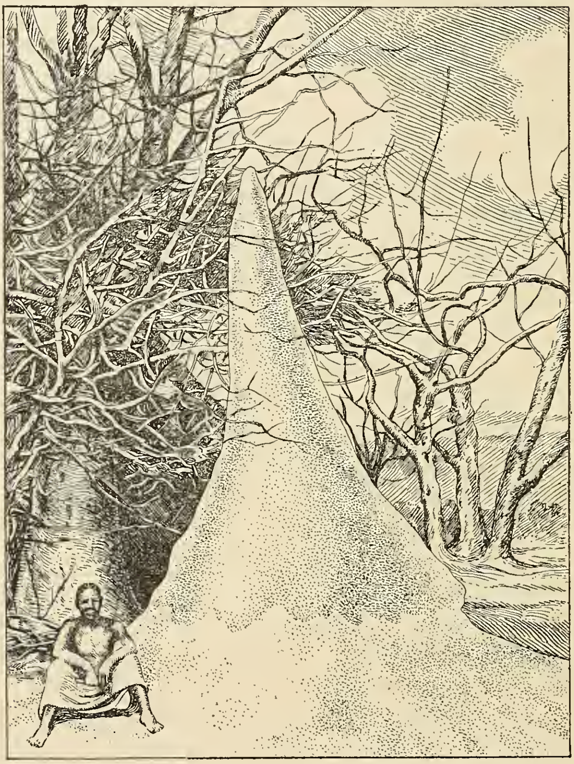
In considering the ant-hill hypothesis it must be conceded at the outset that in size and distribution these mounds exceed the work of any mound-building insects in this country. They are, however, approximated in size by some of the mounds of the leaf-cutting ants, the Atta. These are reported by Dr. W. M. Wheeler, formerly professor of zoölogy in the State University of Texas and an authority on ants, to reach a diameter in Texas of 40 to 50 feet and a height of 1 to 2 feet. He states that the hills are very stable and persist after the colony has migrated

[85] Third Ann. Rept. Botanical Survey of Southwest and Northwest Louisiana, 1871, 1872, pp. 106-107.

[86] Preliminary report upon the Florida parishes of east Louisiana and the bluff, prairie, and hill lands of southwest Louisiana; Bull. La. State Exp. Sta., Geology and Agriculture, pt. 3, 1896, p. 180.

or become extinct. Mr. E. A. Schwarz, of the National Museum, reports that in Cuba the Atta hills often reach a height of 10 to 12 feet, with a diameter several times as great, and in places completely overrun the cane fields. These occurrences greatly re-enforce the theory of an ant origin.

An alternative "ant theory" is that these mounds are the work



From U. S. Geol. Surv.

FIG 26.—An African termite hill. (Drawing from photograph by Sir H. H. Johnston.[88]) Note the broad, low mound, on which the central spire rests, produced by wash of the central hill.

of mound-building varieties of the so-called "white ants" (termites), which are notably developed in the tropical parts of South America and Africa and in Australia.[87] The immense hills

[87] For a discussion of termites see Encylcopædia Brittannica, 10th ed., vol. 33, 1902, pp. 255–256, and the references there given.

From U. S Geol. Surv. Photographed by G. K. Gilbert.

LOW CIRCULAR DUNES IN WHITE VALLEY, WESTERN UTAH.
Produced by sand or dust lodging about low desert vegetation.

of certain varieties of these termites, notably *Termes bellicosus*, which forms a very important minor topographic feature over wide areas in Africa, are the nearest approach of any insect work to these natural mounds, both in size and bulk of material represented. These structures have a conical, sugar-loaf, or bee-hive shape and range from 6 to 20 feet in height and 50 or more feet in diameter (fig. 26). They are composed of mud in which more or less vegetable matter is mixed, and so, like the mounds, are best developed in clay regions. Should these cones be deserted by the termites, they would weather down into broad, low mounds which because of their greater height and of the vegetable matter mixed with them, would have a looser character than the surrounding soil.

Regarded as the work of termites, these mounds suggest a warmer and moister climate, though modifications such as those which enabled large elephants, camels, and animals of the sloth and armadillo families to live in this region would also have enabled these now similarly restricted mound-building termites to do the same, and the causes which resulted in the extinction of the larger animals would in like manner, though at a later date, have destroyed the termites.

Opposed to the termite theory and pointing to a rodent origin is the fact that in exceptional cases in southern Arkansas these mounds are covered with gravel. This is more probably due to subsequent work of burrowing animals.

In conclusion it may be said that these mounds are clearly due to causes not now in operation in this region, and no theory of origin yet suggested is entirely satisfactory. The dune and ant-hill theories are, perhaps, the best supported. On either of these hypotheses the mounds are indications of important climatic changes in recent time, and so offer a line of investigation which may develop very important and far-reaching results.[89]

---

[88] British Central Africa, New York, 1897, p. 371.

[89] Since the above was written the following short articles, discussing the general subject of natural mounds, have appeared in Science: Branner, John C., Science, n. s., vol. 21, 1905, pp. 514–515; Hilgard, E. W., id., pp. 551–552; Spillman, W. J., id., p. 632; Purdue, A. H., id., pp. 823–824; and Piper, C. V., id., pp. 824–825. Branner and Purdue suggest that these mounds may represent immense concretionary formations. Spillman refers certain

RECENT

In Recent time, which may be defined more or less arbitrarily as that since the extinction of the mastodon and associated animals, and in this region more particularly as that since the completion of the main erosion of the Port Hudson deposits in the larger valleys, the topographic and geologic changes have been very slight. With the exception of irregular benches on the hill-sides produced by landslips which, as their formation began in early Quaternary time, are only in part Recent, the effects of these changes are noteworthy only in the bottoms. Aside from such local results as the destruction of river banks, the building of bars, and the formation of cut-offs, all produced by the wandering of the principal rivers in their flood plains and the building up of the front lands above the back lands by the deposition of sediment in overflows, the most important of these changes are (1) the formation and destruction of the lakes of Red River Valley, (2) the deflection of Red River through a narrow gap in the terrace deposits near Marksville, (3) the production of the "Rapides" near Alexandria, (4) the development of small rapids on Sabine and Angelina rivers and the production of a low swampy area in the latter above the rapids, and (5) a slight movement along the Red River fault line near Alabama Landing, La., with the resultant extreme swamping of the bottoms from that point to above the mouth of Bayou Moro, in Arkansas.

Of these, the formation and destruction of the lakes of Red River Valley is by far the most important, and, happening, as it has, in historic and semi-historic times, is of peculiar interest as an example of geology in the making.

mounds in southwest Missouri to unequal weathering of limestone containing large chert masses. Branner gives many references to the mounds of the Pacific coast, for which he states the following theories have been advanced: (1) surface erosion, (2) glacial origin, (3) æolian origin, (4) human origin, (5) burrowing animals, including ants and (6) fish nests exposed by elevation. Bushnell, D. I., jr., Science, n. s., vol. 22, 1905, pp. 712–714, has suggested the human origin theory, and this phase of the matter has been discussed by the writer in Science., n. s., vol. 23, 1906, pp. 34–36.

STRUCTURE

BROADER STRUCTURAL FEATURES RESULTING FROM CAUSES ASSOCIATED WITH CONDITIONS OF DEPOSITION

Earlier chapters in historical geology indicate that the Jurassic land surface was peneplained in this region, and very gradually warped in two principal directions. It was gently tilted southward in the direction of the present Gulf coast, and later, while the gulfward tilting was still continuing, a broad trough was developed southwest along the axis of the present Mississippi Valley, which, indeed, owes its origin to this fold. The general effect of this tilting was to give to all the beds deposited by the ocean on this old land surface a very gentle slope toward the Gulf, and, after a time, toward the Mississippi Valley. The relative intensity of these two slopes depended on the location; near the Mississippi Valley the slope toward the trough was more important, while to the east and west the gulfward slope increased in value until it became the principal element. The effect of this very slow progressive tilting and the usual wedge or lens shape of marine deposits, which are thin toward the land and thicker seaward, was to give to the lowest beds a greater slope than the succeeding ones.[90] (Pls. XXVII, XXXVIII, secs. B, D, E, F, G, H, I).

Thus the older Cretaceous beds—the Trinity, Goodland (Fredericksburg), and Washita formations—which attain great thickness in central Texas, grow thinner in passing eastward along the outcrop, and finally disappear in southwestern Arkansas. (See Pl. XXVII, compare secs. F, D, E, B, Pl. XXXVIII). The lowest formation of the upper Cretaceous in Arkansas, the Bingen, likewise thins out rapidly to the east, while to the west it grades into a very thick series, which ultimately becomes two or three distinct formations (compare secs. E, D, H, Pl. XXXVIII). In the latter part of the Cretaceous, with the development of the Mississippi embayment, the deep water shifted eastward, and the clays of this period, which are dark and cal-

[90] Still farther seaward the beds again grow thinner, but no such thinning has been observed in this area, and it is presumed that the point where these beds thin out is beyond the area under discussion.

careous in Texas, contain, in the Arkansas and Mississippi regions, large amounts of chalk and chalk marls.

In the Tertiary strata somewhat similiar causes have resulted in the entire absence of the Vicksburg beds west of Catahoula Parish, La. (Pl. XXVII.)

Besides these variations in thickness and lithological characters, due to conditions intimately connected with deposition, and the initial dips due to the gentle tilting of the surface of the old Triassic peneplain, notable variations in the structure have been produced in several other ways; (1) by the domes, (2) by the Angelina-Caldwell flexure, (3) by the Red River-Alabama Landing fault.

CHANGES BY SUBSEQUENT OROGRAPHIC MOVEMENTS

DOMES

The domes, twelve of which are now known in northern Louisiana and eastern Texas (Pl. XXXVIII), the presence of a thirteenth being suspected, are by far the most unique structural feature in this region. They are very symmetrical, four-sided folds or quaquaversals of Cretaceous strata, about a mile in diameter, that represent deformations of from 1,000 to 4,000 feet. They penetrate the Eocene beds without materially disturbing them, except, perhaps the Midway, and though their major development and partial truncation by erosion occurred during the late Cretaceous and early Tertiary, the Winnfield dome is known to have moved in post-Claiborne time, and the Belle Isle, one of a series of closely related domes in southern Louisiana, shows movements in Quaternary time.[91] In point of origin it is thought that these domes were perhaps produced by the upward pressure of intrusions of igneous rocks of limited area (see p. 18), and so may be termed bysmalithic[92] domes or bysmalithic quaquaversals.[93]

---

[91] Geol. Survey Louisiana, Rept. for 1899, 1900, pp. 228-229; Geol. Survey Louisiana, Rept. of 1902, pp, 99-100.

[92] Iddings, Jour. Geol., vol. 6, 1898 pp.705-706.

[93] Since the above was written I have found that Lee Hager (Eng. and Min. Jour., vol. 78, 1904, pp. 137-139, 180-183) has suggested a hypothesis which explains the origin of these and very similar domes in southern Louisiana and southeastern Texas by the upthrust of an igneous plug. His

From U. S. Geol. Surv.

GOOWIN RAPIDS ON SABINE RIVER, NEAR COLUMBUS, LA.

One of the group of low shoals produced by recent upward movement along the Angelina-Caldwell flexure.

ANGELINA CALDWELL FLEXURE

The low Angelina-Caldwell monoclinal flexure is known to extend from Angelina County, Tex., through Louisiana north of Natchitoches, Winnfield, and Columbia to Mississippi River north of Vicksburg (Pls. XXXVII; XXXVIII, secs. A, B, C, D, F). It began to develop in Tertiary time, perhaps as early as the Oligocene, and is still a line of weakness. Recent movement along its west end has resulted in the formation of a series of shoals on Sabine River and in the swamping of a part of the Angelina River Valley in Angelina and Nacogdoches counties, Tex. It has almost entirely destroyed the southern element of the dip of the beds between its northern edge and a point about 60 miles south of the Paleozoic border. Along the line of the flexure the dip of the Claiborne beds ranges from 46 feet at Vicksburg to 150 feet on Sabine River. Still farther south the dip becomes less, though this change of the dip has as yet been actually observed only on Sabine River, where, between Hattens Ferry and Burrs Ferry, it changes from 150 feet to about 30 feet per mile (Pl. XXVII).

It should be noted that the Nacogdoches oil field occurs near the upper bend of this monocline, and that the oil springs reported in Sabine Parish, La., occur in the same relation to this fold.

theory is in the most essential particulars parallel to the one here advanced. The fact that two workers in this field have independently arrived at the same hypothesis as the only one at all in accordance with the known facts greatly adds to its probable value. Mr. Hager's suggestion that the wonderful salt, sulphur, and gypsum deposits of this southern region are not of normal marine origin, but were concentrated and redeposited by the heated waters circulating around these igneous intrusions, and that these deposits are to be regarded as essentially the product of the change in conditions produced by these intrusions, appeals to me as the most probable theory that has yet been advanced. The stratigraphic and structural relations of the salt deposits of Grand Saline, Tex., are not well known, but the beds here do not indicate a dome, and the salt beds have therefore been referred to ordinary salt-pan action. The brines of the various northern Louisiana salines are in part clearly derived from water-bearing Cretaceous beds which have been brought up by this extreme folding, but the brines may be in part derived from salt beds formed about the center of the uplift and as yet unexposed.

RED RIVER-ALABAMA LANDING FAULT

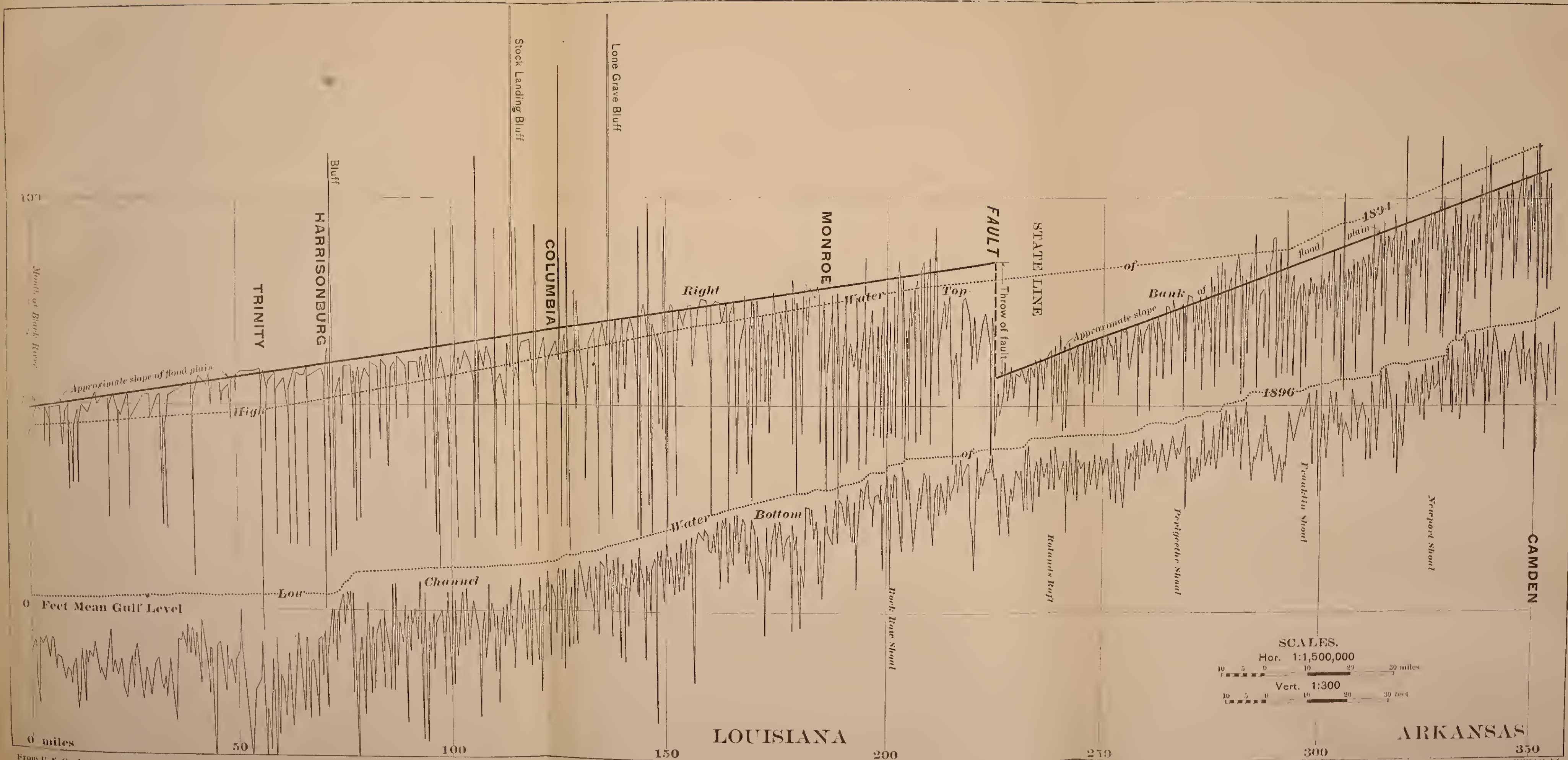
The Red River-Alabama Landing fault extends across northern Louisiana and southern Arkansas into northeastern Texas, approximately in the position shown on Pl. XXXVII, though in a much more irregular manner. Like the Angelina-Caldwell flexure, it is of late Tertiary age and has been the site of movement in the present time. The total displacement or "throw" of this fault along the Little Rock-Marksville section (Pl. XXXVIII, sec. B), where the data regarding it are most complete, is in the neighborhood of 600 feet, with the downthrow to the north.

The throw of the Red River fault, of which this seems to be the continuation, is given by Hill as about 626 feet at Preston and 617 feet north of Denison, Tex. The close agreement of these figures is very surprising when the distance between the places of measurement—about 275 miles—is considered, as such uniformity of fault structure is unusual.

Evidence of recent movement along this line is found on the Ouachita River just above Alabama Landing, where the displacement revealed by the careful levels of the United States engineers is 25 feet (Pl. XXXVI). This movement, which is so recent that the river has not yet perceptibly filled the depression, has resulted in the production of an extremely low, swampy area extending almost to the mouth of Smackover Creek in Arkansas.

LOCAL STRUCTURAL FEATURES

Besides these broader structural features, there are in every locality many minor examples of faults and folds on a minute scale that have no bearing on the general structure of the region, but are of importance to the teacher and student as examples of the larger and much more obscure occurrences. These little structural phenomena are generally the result of the readjustment of the strata resulting from erosion, and in some cases to slight readjustments produced by earthquakes.



From U. S. Geol. Surv.

Recent Fault crossing the Ouachita bottoms near Alabama Landing, La., inferred from "Profile of Bottom of channel and right bank of the Ouachita and Black rivers from Red River, La., to Camden, Ark., by the U. S. Engineers."

PRINCIPAL STRUCTURAL FEATURES OF THE COASTAL PLAIN IN NORTHERN LOUISIANA AND SOUTHERN ARKANSAS WITH SOME OF THE STRUCTURAL FEATURES OF ADJOINING AREAS.

Scale
40 0 40 80 120 miles

1905

LEGEND

Tertiary with Quarternary Covering in olaces.

Cretaceous.

Archean and Paleozoic.

From U. S. Geol. Surv.

DIP OF STRATA

The direction and character of the dip of the strata is shown on the structural (Pl. XXVII) and hydrologic sections (Pl. XXXVIII) and may be inferred from the figures given on the underground-water maps (Pls. XL–XLIII). However, the following values may be of interest:

The slope of the old Triassic land surface, or the "bed rock," is from 100 to 125 feet per mile all along the Cretaceous-Paleozoic contact in southern Arkansas from Arkadelphia westward. Northeast of Arkadelphia nothing is definitely known regarding its slope, and there is some indication that it may be faulted.

The dip of the upper part of the Bingen formation (the sub. Clarksville sand) is 70 feet per mile about Gurdon and 80 feet per mile at Texarkana.

The Nacatoch sands have a dip of 56 feet at Gurdon, 65 feet at Hope, 80 feet at Fulton, and 73 feet at Texarkana.

The southward element of the dip of the base of the Jackson north of the Red River-Alabama Landing fault along the line of the sections from Vicksburg to Marked Tree (Memphis) (Pl. XXXVIII, sec. A), and from Monroe to Little Rock (Pl. XXXVIII, sec. B) is about 1.7 feet per mile.

The southward element of the dip of the base of the Claiborne along the Angelina-Caldwell flexure is 46 feet per mile at Vicksburg, 48 feet at Columbia, 50 feet at Colfax, and 150 feet on Sabine River.

The dips toward the Mississippi trough range from 8 to 16 feet per mile.

CHAPTER II

GENERAL UNDERGROUND WATER CONDITIONS

INTRODUCTION

SOURCE OF UNDERGROUND WATER

Of the 40 to 50 inches of rain which commonly fall during each year in northern Louisiana and southern Arkansas (fig. 27) a considerable portion immediately flows off the surface in streams and ultimately reaches the sea. Another portion passes into the ground and, after a longer or shorter journey, returns to the surface in the form of springs either on the land or under bodies of water. In both of these cases a part is lost by evaporation, and a certain amount, though a comparatively small percentage, is consumed by living organisms and in chemical work.

The portion which passes into the earth furnishes the entire supply of well water both in surface and deep wells. Its availability for this purpose at any point and the permanency and quality of the supply, as well as the height to which the water will rise above the bed in which it is encountered, depend on the relative position, elevation, and permeability of the different strata in that region. Its potability, or mineral character, depends on the soluble minerals contained in the beds through which it passes.

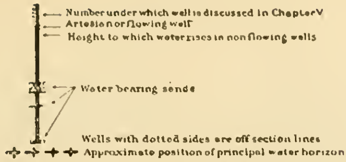
The percentage of the rainfall which sinks into the earth is determined by (1) the character of the rains, whether of a slow and steady or a torrential nature; (2) the topography of the country, whether flat or with many steep slopes; (3) the character of the vegetation covering the surface; and (4) the porosity of the soil and the physical character and state of saturation of the underlying beds.

NATURE OF MOVEMENT OF UNDERGROUND WATER

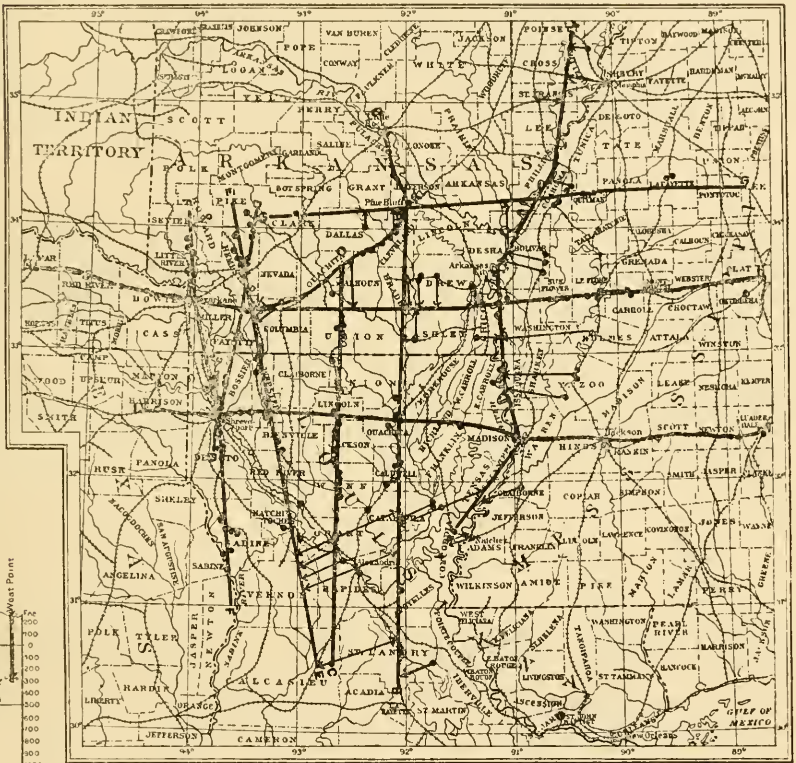
Except in thick limestone beds containing caverns, underground waters very rarely travel through channels or conduits of appreciable size, or in any way resemble surface streams; and

LA

EXPLANATION



Note These sections are greatly distorted because of the great difference between the horizontal and vertical scales, for more natural sections see Pl.III, for real character of dip see Pl.XXI.

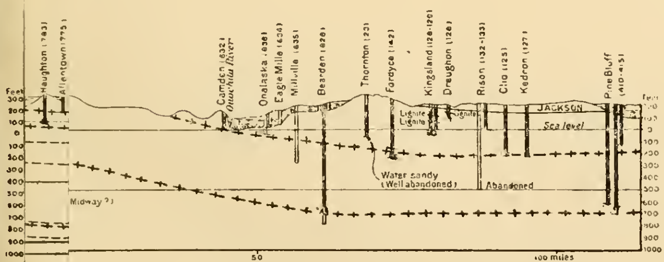


MAP SHOWING LOCATION OF SECTIONS A-A TO K-K

Scale

25 0 25 50 75 100 125 miles

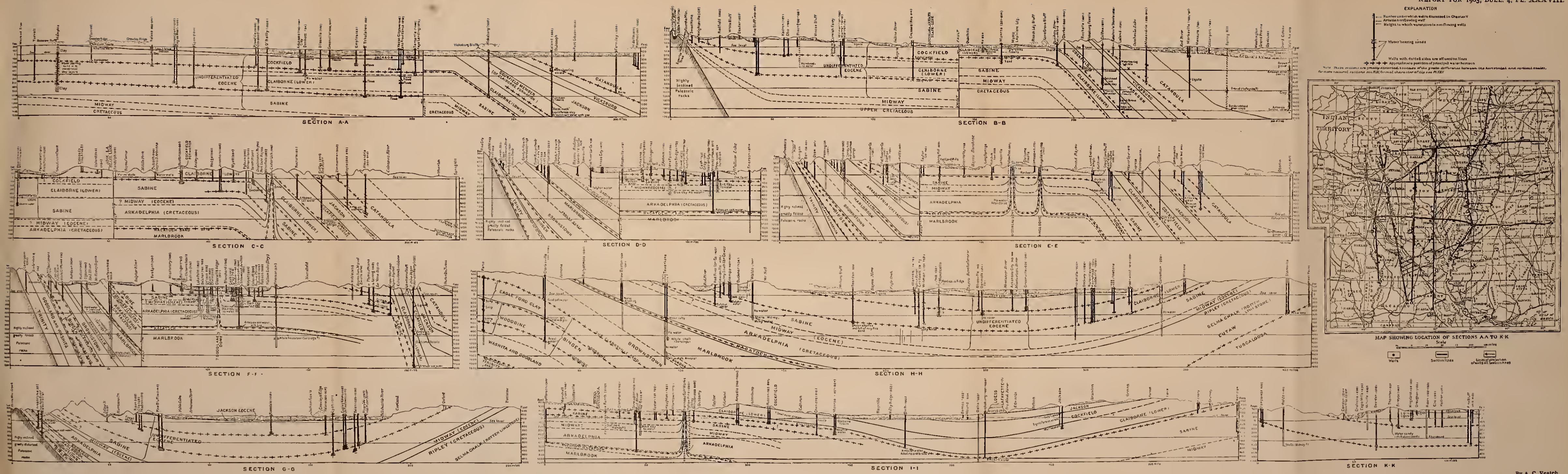
Wells Section lines Lines of projection of wells off section lines



SECTION K-K

By A. C. Veatch.

TER-



From U. S. Geol. Surv.

Sections Showing Principal Water-Bearing Horizons in Northern Louisiana, Southern Arkansas, and Adjacent Regions.

By A. C. Veatch.

m U. S. Geol. Surv.

. 27.—Annual rainfall in northern Louisiana and southern Arkansas compiled from reports of the United States Weather Bureau for the years 1902 and 1903. Lower figures represent period of years; upper figures, average rainfall for period given.

seldom can the underground water system of any area be said to even remotely "resemble the veins of the human body." The true cavern streams furnish an extremely small percentage of the world's water supply derived from wells, and well waters on the whole are to be regarded as coming from the saturated portions of porous beds, through which the water moves in the small spaces between the particles as the sand of a sand bed or sandstone, or the gravel of a gravel bed or conglomerate. This motion is to be described as a slow seeping, in which the water moves at the rate of a few feet per day, rather than a few miles, as in surface streams.

The manner and character of this flow may be artificially and somewhat arbitrarily shown by taking a sand pile of considerable size, placed on a relatively hard or impervious material, and spraying its center with water. When the lower portion of the pile has become saturated, little streams will begin to trickle from one or more points at the base, the number depending on the shape of the ground where the pile is situated. These little rivulets represent springs and it will be found that the water will flow for some time after the cessation of the spraying, the length of time depending on the size of the pile and the coarseness of the particles composing it. Imagine this sand pile increased to many feet in thickness and covering the top of a hill or group of hills which is underlain by clay beds, and you have an idea of the character and cause of many of the springs in northern Louisiana and southern Arkansas.[1]

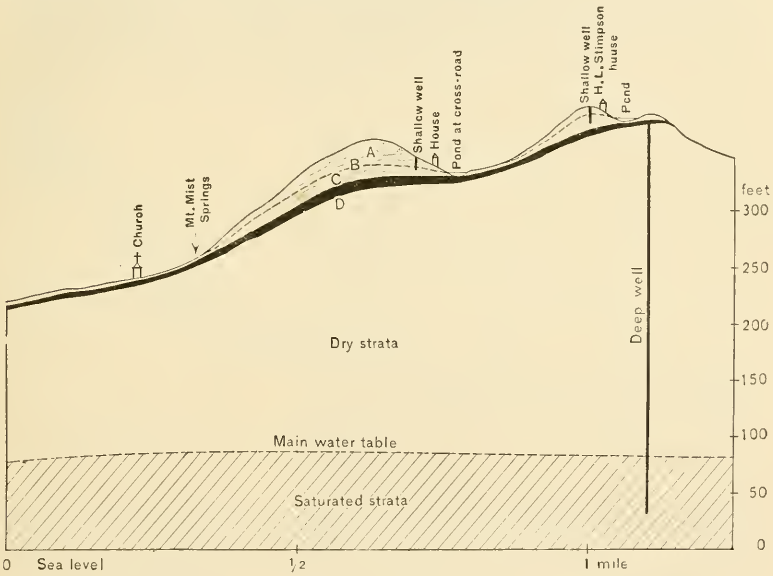
ZONES OF SATURATION

The effect of this constant influx of water into the earth is to completely saturate the rocks between an upper limit, whose position depends largely on the amount of rainfall and the relief of the country, and a lower limit, fixed by the point below which the enormous pressure of the upper layers of rocks prevents the existence of spaces of any character between the rock particles. The position of this zone of no pores has been estimated by Van Hise[2] to be about 6 miles from the surface.

[1] For another type of springs see U.S.Geol.Survey; Prof. Pap., No. 46, p. 76.
[2] Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1896, p. 593.

MAIN GROUND-WATER TABLE.

The upper limit of this zone of complete saturation is known as the main ground-water table. In regions of heavy rainfall it is relatively near the surface, while in areas of light precipitation it is deep in the ground. The possibility of obtaining water below this main ground-water table depends on the location of the coarse beds, such as sand and gravel, which will yield their contained water readily. Clay beds in this zone, though also completely saturated, release the water extremely slowly if at all, and have, therefore, no water-bearing value.



From U. S. Geol. Surv.

FIG. 28.—Cross section on Long Island, New York, showing the relation of a perched water table to the main water table and the production of springs dependent on a perched water table.

PERCHED GROUND-WATER TABLES

Above this zone of complete saturation and separated from it by nonsaturated strata, there are, in regions containing irregular clay or relatively impervious beds, more or less elevated, limited, and disconnected zones of saturation which may be termed "perched water tables." They supply local shallow wells, and when cut by valleys produce springs of greater or less importance (fig. 28). Wells dependent on perched water tables are in general much less satisfactory than those which pass below the main water table, as they derive their supply from more or less limited bodies of saturated strata which are quickly affected by periods of drought.

VARIATIONS OF PRESSURE OR HEAD

The water pressures in the main zone of saturation are very unequal. The differences in the coarseness of the strata, the leakage through springs, and the constant additions from rainfall prevent their ready equalization. They vary greatly in different layers in the same region, and in the same layer in different

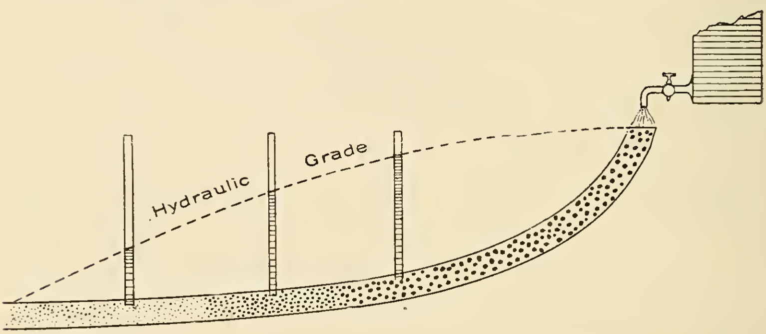
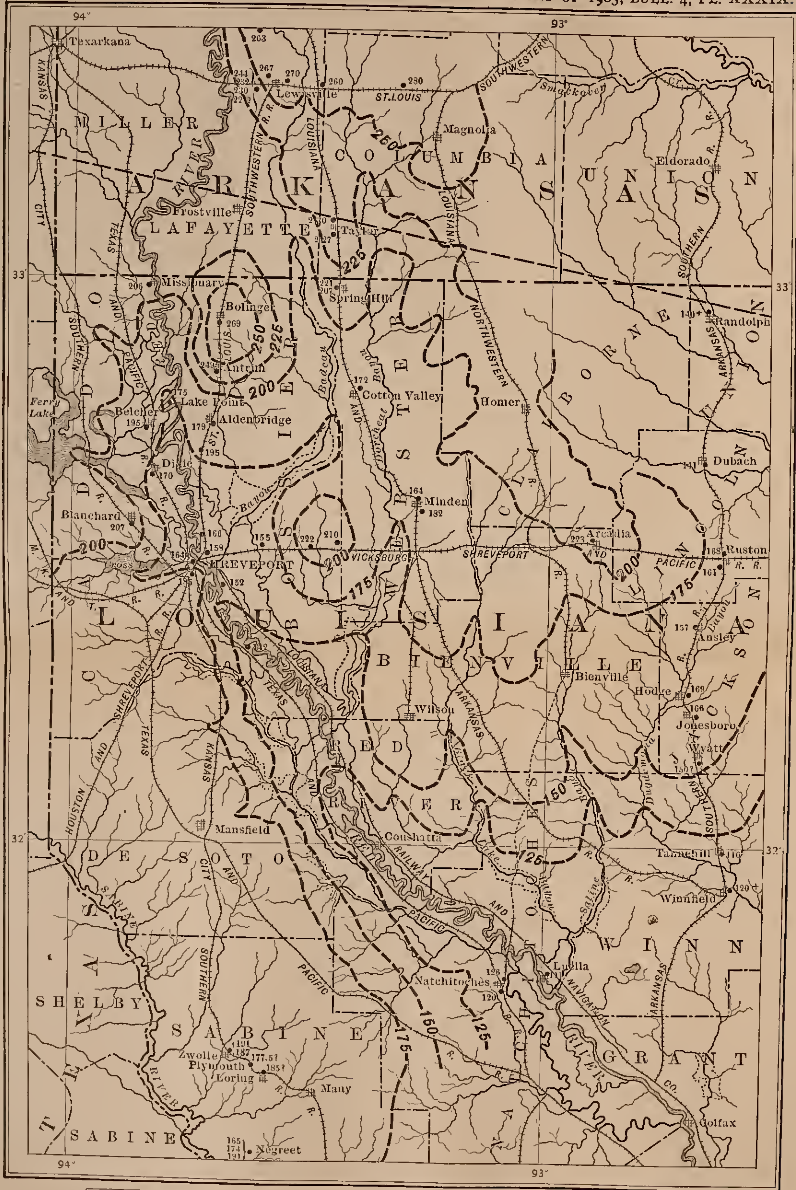


FIG. 29.—Experimental illustration of loss of head by resistance and leakage. (After David, 1893.)

regions. The extent and cause of this variation is indicated by the character of the factors in the following equation:

Pressure head at a given point in any stratum, expressed in feet above sea level = elevation of ground-water table at source— loss by resistance—loss by leakage.

All the members on the right-hand side of this equation are irregular variables. The first, the elevation of the ground-water table at the outcrop or source, depends on the elevation of the surface, which changes at different points. The second depends on the size of the spaces between the grains, which in even the most uniform beds is a constantly changing quantity and in beds such as those of the Lower Eocene is extremely variable. The third varies with any change in the



Elevation to which water will rise, in feet above sea level.

Scale 0 10 20 30 miles

Approximate lines of equal head.

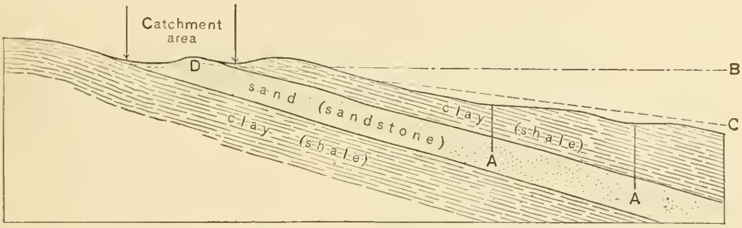
From U. S. Geol. Surv.

By A. C. Veatch, 1903.

Map showing variation in head of water in the Sabine Sands in Northwestern Louisiana and Southwestern Arkansas.

coarseness of the adjacent beds, which are never constant, and is affected by faults, joints, and other natural breaks.

This variation may be artificially shown in the manner indicated in fig. 29. In this experiment a tube is filled with sand, coarse shot, and marbles, representing beds of different coarseness, and the lower end of the tube is closed with a brick to prevent the materials from running out. When water is allowed to flow in from above, it rises to different heights in the small tubes, representing wells.



From U. S. Geol. Surv.

FIG. 30.—Diagram showing the common arrangement of factors producing artesian wells *A*, Artesian wells; *B*, head of water if there were no loss by resistance or leakage; *C*, actual head of hydraulic gradient; *D*, ground-water table at outcrop.

CAUSES PRODUCING ARTESIAN OR FLOWING WELLS

It is these variations in the pressure or head that make flowing or artesian wells possible under certain conditions. These may be briefly stated as follows:

1. There should be relatively porous beds suitably situated to collect and transmit the water.
2. There should be less porous or relatively impervious layers so placed that they may confine the water collected.
3. The level of the ground-water table at the source should be enough higher than the surface at the point where the well is drilled to compensate for the loss of head due to resistance and leakage.

In order that the well may be permanently artesian it is also necessary that there be sufficient rainfall and that the demand be not greater than the rate at which the water can flow through the porous stratum or strata.

The arrangement of the factors which produce a flow is by no means constant. They vary considerably from point to point and relatively new combinations are to be continually expected. Possibly the most usual combination is that shown in the accompanying diagram (fig. 30). Here the confining beds are clay and the porous bed is a sand which dips regularly in the direction in which the surface slopes. Water falling in the region marked "catchment area" sinks into the sand and supplies the artesian wells drilled on lower ground. Most of the artesian wells of this region have this arrangement of factors, which may be taken as typical of a large class of artesian wells, being perhaps, the one most commonly expounded and understood, but a radical rearrangement of factors will produce results depending on the same general principles.[3]

PRINCIPAL WATER-BEARING HORIZONS

The water-bearing value of the geologic formations of northern Louisiana and their relations to one another are briefly outlined in the table opposite and graphically shown on Pl. XXXVIII.

---

[3] For such exceptions, other than those described on pp. 81–82, see Prof. Paper U. S. Geol. Survey No. 44, 1906, pp. 68–72.

Water-bearing value of geologic formations of northern Louisiana.[4]

Geologic subdivisions.			Character of deposits.	Water-bearing value.
Quaternary.	Recent.	Alluvium.	Veneer of sand, silt, and clay on flood-plains.	Seldom of value except in connection with the underlying Port Hudson deposits.
	Pleistocene.	Port Hudson formation.	Clays and silts underlain by gravel beds, which occur beneath all the river valleys and as terraces along their sides.	The sand and gravel beds of this formation beneath the river valleys, and generally beneath the terraces, yield inexhaustible supplies of water, often hard and alkaline.
Tertiary.	Pliocene.	Lafayette formation.	Silt, sand, and gravel, forming a very irregular mantle over the older beds.	Of very little value, except in extreme southern portion of this region. Supplies occasional shallow wells, though these generally depend on the older formations.
	Oligocene.	Fleming clay.	Green calcareous clay.	None. Shallow wells in the area of the outcrop of this formation depend entirely on covering of surficial sand and gravel (Lafayette).
		Catahoula formation.	Green clays, with layer of white sand and sandstone.	Contains several important horizons in central Louisiana. (See Pl. XXXVIII.)
		Vicksburg formation.	Limestones and calcareous clays, somewhat lignitiferous.	None.
	Eocene.	Jackson formation.	Highly fossiliferous calcareous clays.	Serves in central Louisiana to retain water in underlying beds.
		Claiborne formation.	Cockfield member. Lignitiferous sands and clays.	One of the two important water-bearing formations of the Eocene. Water-bearing sands irregularly throughout, with the coarser and more prolific beds at the base.
			Calcareous clays, changing to the north into lignitiferous sands and clays.	Where typically developed, in central Louisiana, has small water-bearing value; to the north it contains several minor water-bearing horizons.[5]
		Sabine formation.	Lignitiferous sands and clays.	The most important water-bearing formation of the Eocene in this section; contains several horizons.
		Midway formation.	Limestones and marly clays.	None.

4 See table of geologic history, pp. 14 and 15.

5 The water-bearing sands reported in this formation in Alabama and eastern Mississippi seem to be represented in this region in the water-bearing beds of the basal portion of the Cockfield, which is a part of the Claiborne.

EOCENE HORIZONS

SABINE WATER SANDS

The main Sabine water horizons, as developed in northern Louisiana (Pl. XXXVIII, secs. B, C, D, E, F), occur from 100 to 200 feet below the lower Claiborne. To the south, where the formation thickens considerably, the water-bearing sands increase in number and are fairly uniformly distributed throughout the Sabine (Pl. XXXVIII, secs. E, F). In Arkansas a group of horizons is found in the Sabine at New Lewisville and Stamps, though only the upper ones, near the Claiborne, are generally developed. This horizon continues in the Mississippi Valley, where it has been successfully developed in many wells.

Pressure.—The pressure in the Sabine sands in the area in which this formation outcrops, and where it is covered by but a thin layer of the Claiborne formation, varies almost directly with the local topography or the local position of the main groundwater table. Here artesian wells are of local and more or less accidental occurrence. To the south and east, where these sands become embedded beneath the more impervious beds of the lower Claiborne, artesian conditions are developed which are uniform over considerable areas (Pl. XL). Along the Mississippi floodplain the head is greater on the east than on the west, as the hill land in northern Mississippi is uniformly higher than that in Arkansas and northern Louisiana, which is deeply trenched by Ouachita and Red Rivers.

Quality.—Water from the Sabine horizons is commonly soft and somewhat alkaline. Like some of the Cretaceous waters, it tends to collect soluble salts and is more highly mineral in deep than in shallow wells. In Sabine Parish (966, 969) the deep waters are somewhat mineral. At Natchitoches (909, 911) and Lueila (906) they are so highly charged with salt that they can not be used. This is due perhaps to brine which has leaked from the Cretaceous domes to the north. The area in which the water in the Sabine sands has been rendered impotable in this way has not been determined, but it probably includes southwest Bienville, eastern Red River, Natchitoches, with the possible exception of the west central portion, southern Winn, and central and western Grant parishes. At Monroe the water is so mineral that

MAP OF SABINE ARTESIAN RESERVOIR IN NORTH LOUISIANA

BY A. C. VEATCH

Area of flowing wells · = Flowing Wells ○ = Nonflowing Wells ⊘ = Failure

Scale 10 5 0 10 20 30 40 50 miles

CHARACTER OF WATER

A = Alkaline B = Brine S = Soft I = Iron X = Sulphurous

C* = Cretaceous Outcrops, usually accompanied with brine. LARGE FIGURES give depths of base of formation below sea level. SMALL FIGURES show total depth of wells or depth of water-bearing strata.

it is only occasionally used in the city water-works, though extensively employed for industrial purposes. At Delhi and Vicksburg the water, though artesian, is very alkaline, and this condition probably affects a large part of the Mississippi Valley in Louisiana east of Ouachita River. Brine has been obtained in this horizon at Crossett, Ark. (well 6, Pl. XXXVIII, sec. B), but all other developments in Arkansas and northwestern Mississippi, as at Wilmer and Pine Bluff, Ark. (410–415), and Indianola, Ittabena (1022), Greenwood (1018, 1020, 1021), O'Reilly (1005), Cleveland (1003–1004), Tchula (1012–1015) and Yazoo City, Miss. (1048), have yielded potable water.

Availability.—In the area which is underlain by the Sabine and the corresponding undifferentiated Eocene horizons (Pl. XL) these water-bearing sands may, in general, be said to be available at any point. Wells at Waldo (141) and near Bearden (628), while both developing water at the proper depths, are regarded as failures, the first because the supply did not seem sufficient and the second because the sand was so very fine that it easily passed through the strainers. The water was, moreover, very alkaline. It is felt, however, because of the great irregularity of the Eocene beds that these occurrences are essentially local and do not prove that a good well could not be developed at the same horizon 10 or 20 miles away. The only factor greatly restricting the development of these horizons is that imposed by the quality of the water in the areas near the domes.

WATER-BEARING VALUE OF CLAIBORNE (LOWER) FORMATION

In central Louisiana the fossiliferous Claiborne is a calcareous clay having no water-bearing value. To the north, however, it merges into lignitiferous sands and clays, and occasionally water-bearing strata are developed, as at Ruston and Arcadia, La. (Pl XXXVIII, sec. I). Along Mississippi River in Arkansas and Mississippi occasional horizons are developed in the undifferentiated Eocene in beds which are the stratigraphic equivalents of this part of the Claiborne (Pl. XXXVIII, secs. A, H), but the more important and persistent horizons are in the overlying Cockfield, which is of Claiborne age, though separated in central Louisiana because of lithologic differences.

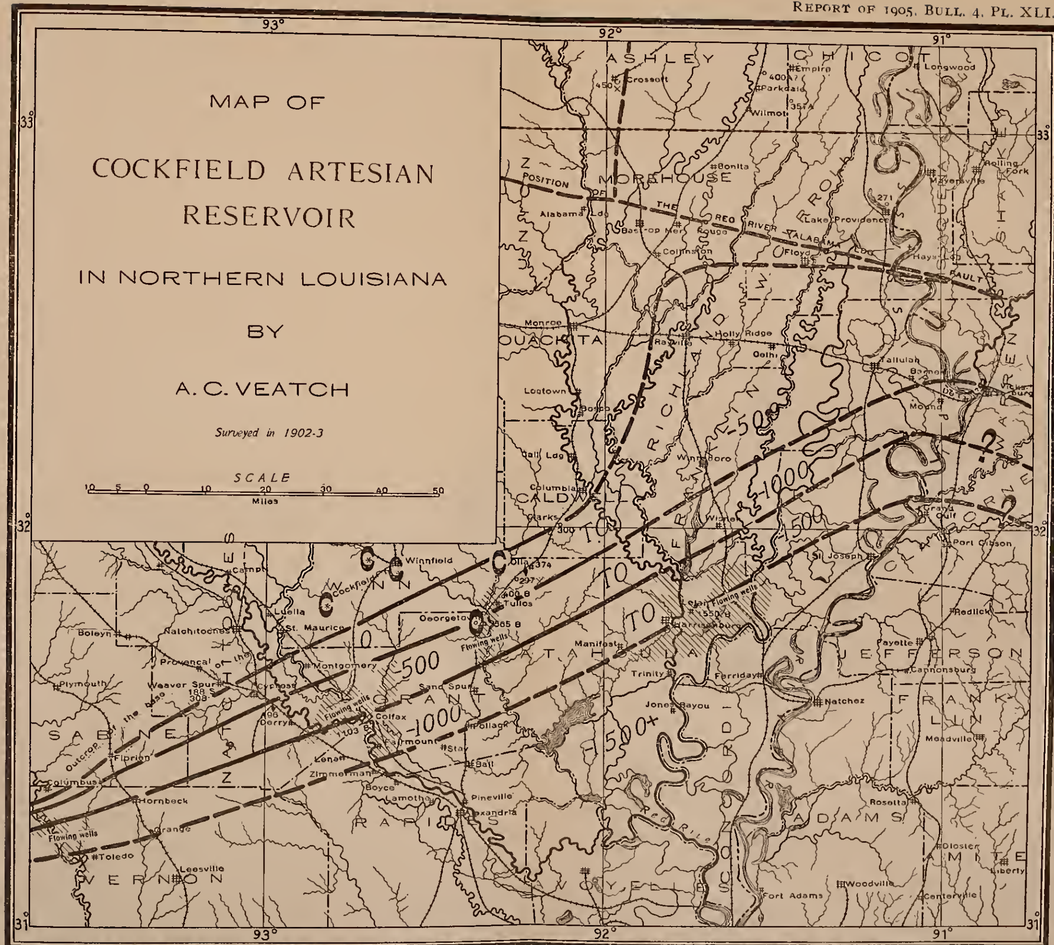
In the regions marked fossiliferous Claiborne on the geologic map (Pl. XXVII) it will generally be advisable to continue wells to the Sabine water sands.

COCKFIELD WATER SANDS

In central Louisiana the basal layers of the Cockfield member of the Claiborne are sandy, and where penetrated, except at Delhi, La., and Vicksburg, Miss., have yielded water (Pl. XLI). As a rule, the water in the deeper wells, as at Leland (855), Rochelle (881), Olla (856–857), Tullos (861), and Colfax (877), is impotable, though an exception is to be noted in the case of the deep well at Robinsons Ferry, on Sabine River (1120), in which a soft, pleasant-tasting water is reported at a depth of 1,010 to 1, 030 feet. Near the outcrop successful wells have been finished at Clarks (Pl. XXXVIII, sec. B) and at Weavers Spur (Pl. XXXVIII, sec. E), and a successful well could doubtless be finished at Montrose, Natchitoches Parish, by going about 100 feet deeper than the well abandoned (Pl. XXXVIII, sec. E).

In southern Arkansas and Mississippi, north of the Red River-Alabama Landing fault, a water horizon in the upper part of the undifferentiated Eocene, in about the same stratigraphic position as the basal Cockfield horizon, is very widely and extensively developed (Pls. XXXVIII, secs. A, B, G, H, K; XLI). Between it and the base of the Jackson a number of water sands have been developed in different wells, but they show little regularity, and the better wells have almost without exception been finished in the main horizon.

Pressure.—The outcrops of the Cockfield and corresponding undifferentiated Eocene water sands in Arkansas and Louisiana are all relatively low, and the water will generally not rise much over 100 feet above sea level, except in elevated regions where the head is dependent on the local height of the ground-water table. Flowing wells from this horizon will be obtained along the main stream channels in central Louisiana (Pl. XLI). In Arkansas and northwestern Mississippi the artesian area is near the eastern side of the flood plain, where a relatively higher head is possible because of the greater average height of the Mississippi hill lands. Water from these horizons will rise very near the



C = Cretaceous Outcrops •= Flowing Wells o= Non-Flowing Wells = Failure A = Alkaline B = Brine S = Soft X = Sulphurous

LARGE FIGURES give depths of base of formation below sea level. SMALL FIGURES show total depth of wells or depth of water-bearing strata.

surface over all the flood plain, but in Arkansas it is regarded as quite improbable that flowing wells will be obtained.

Quality.—In central Louisiana the water of this horizon is generally impotable except near the outcrop. West of Red River, as indicated by the Robinsons Ferry well (1120), water of good quality may be expected much deeper in the embed. Indeed, it is believed that in the section west of Red River the quality of the deep water will generally be better in this horizon than in the underlying Sabine.

In southern Arkansas and northwestern Mississippi no impotable water has been reported at this horizon in any wells except at Crossett, Ark. (6). As a rule the water from the basal layers is soft and more or less alkaline. At Empire (26) the water is so alkaline that it can not be used in boilers; but at Blissville (145), Greenville (1039), Arkansas City (143), Monticello (148–150), and Wilmer (153) good boiler water has been obtained. The water from the beds just below the Jackson, as at Warren (14–19), is generally hard, and better water can be obtained by deepening the wells.

Availability.—The water sands of the basal Cockfield are relatively very persistent. They may be confidently expected in eastern Arkansas and northwestern Mississippi at depths not greatly exceeding those indicated on Pl. XLI. Failures have been relatively few, those at Rison (133) and Thornton (23) being the most noteworthy; but these are entirely surrounded by successful wells and so represent only local variations. The area affected by the impotable sulphur water encountered in this horizon in the Crossett well (6, Pl. XXXVIII, sec. B,) is probably not large, as is indicated by successful wells at Warren (19), Monticello (148–150), Dermott (24), Blissville (145), and Greenville (1039).

In Louisiana the development of this horizon is probably limited to wells near the outcrop and west of Ouachita River (Pls. XXVII, XLI). On Sabine River the dip of the strata will make the depth prohibitive at any great distance from the outcrop. Between Red and Ouachita Rivers development is restricted by the mineral water in the embed, and east of Ouachita River the absence of this horizon in the Delhi and Vicksburg wells suggests that it is of minor importance in that section.

OLIGOCENE HORIZONS

CATAHOULA WATER SANDS

The sand and sandstone beds occurring through the Catahoula formation form a very important group of horizons which have been developed in central Louisiana at Ferriday, Harrisonburg, Pollock, Alexandria, Boyce, and Zimmerman (Pls. XXXVIII, secs. A, B, C, E; XLII).

Pressure.—The head in the Catahoula sand, except possibly in the unexplored region in Vernon Parish, is seldom over 100 feet above sea level. Flowing wells may be developed in the flood plain southeast of the high hills in Catahoula Parish and along Little, Red, and Sabine Rivers (Pl. XLII).

Quality.—In central Louisiana the water is commonly soft and slightly alkaline and is, perhaps, the best of the Tertiary waters. In the basal layers, however, the water is in two cases salty—at Boyce (943) and at Ferriday (867). Whether these occurrences are due to soluble salts in the strata themselves or to brine which has leaked from near-by Cretaceous domes is not known, but it is probably the latter.

Availability.—Successful wells may be expected in most of the regions south of the Catahoula outcrop (Pl. XLII), and wells should not be abandoned until they have reached the depth indicated. Thus the Pickering well (981) is believed to have been a failure because it did not go deep enough; the chances of developing a successful well at that point at a depth of 1,200 feet or less below sea level are regarded as extremely good.

WATERS IN THE SURFICIAL SANDS AND GRAVELS

LAFAYETTE AND PORT HUDSON

The irregular beds of late Tertiary and Quaternary sands and gravels which cover the older Tertiary and Cretaceous beds throughout this region are of varying value as water carriers. As a rule, however, the surficial deposits are in the hills of relatively limited and local importance, while under the large river valleys and portions of the accompanying terraces they contain very large supplies.

The deposits in the hill lands often produce perched water tables (p. 73), which supply domestic wells and sometimes springs.

LARGE FIGURES gives depths of formation below sea level. SMALL FIGURES show total depth of wells or depth of water-bearing strata.

This supply is generally small and readily exhausted, and the most successful wells and the larger springs depend on the sandy Tertiary and Cretaceous beds rather than on these surficial deposits.

Along the main river valleys, however, where these sands and gravels were concentrated in early Quaternary and Port Hudson time, large quantities of water can generally be obtained. In the flood plains limited supplies can be obtained from driven wells (p. 91) of no great depth, but where large supplies are needed wells should be pushed to the main gravel beds which overlie the older Tertiary and Cretaceous strata. These can be reached at depths of from 75 to 150 feet.

Pressure.—The water head of these beds varies directly with the topography and the height of the water in the adjoining waterways. Flowing wells are not to be expected, but the water in the bottom lands will in all cases rise relatively near the surface and, because of the large supply and the coarseness of the water-bearing beds, will not be lowered readily by pumping.

Quality.—Where large supplies can be obtained the water is mineral in character; in regions where the older deposits are very calcareous, as in the greater part of the Cretaceous and parts of the Claiborne and Jackson beds, the water is of very little value, but where the underlying beds contain less mineral matter the water is of better quality and affords the most available supply over wide areas. In general the mineral content is higher in the water from these gravels than in the neighboring surface streams, but the percentage of sediment is much less.

MINERAL SPRINGS AND MINERAL WATERS

The rain water in passing through the ground tends to dissolve a portion of the soluble salts contained in the strata through which it passes. Thus all spring and well waters contain a greater or less amount of mineral matter in solution. Sometimes the dissolved minerals have a medicinal value, or the water is of so great relative purity that its use is recommended and the springs or wells are developed commercially.

Throughout Louisiana and the Coastal Plain of southern Arkansas there are many "mineral" springs and wells. Some contain a very great amount of mineral matter in solution, and such waters should be used with great caution and only on the prescription of a competent physician. The water from all these springs is of local origin. It represents rain water which has fallen within a mile, or at most four or five miles, of the spring, and the greatest care must therefore be taken to see that the water is not polluted with harmful organic waste. Springs in large towns or other places so situated that they may receive either directly or indirectly the drainage of houses, barns, and outhouses should be carefully avoided, for if not polluted they are likely to be polluted at any time. In general, water from springs in any town or community of some size in this region is to be regarded with suspicion.

At several points in northern Louisiana and in the Coastal Plain of southern Arkansas attempts have been made to develop the spring waters. From many springs the waters are used locally and in a few cases, notably that of the Arkansas Lithia Spring near Hope, water has been shipped for some distance. The yield of the Coastal Plain springs is usually quite small, and this has been an important factor in restricting their development. Indeed, it is felt that if any large mineral water developments are to be made in the Coastal Plain portion of this section, they will have to depend on well rather than spring waters.

The following table shows some of the springs which have been partially developed, arranged alphabetically by counties:

Partial list of mineral springs in the Coastal Plain strata of northern Louisiana

No.[6]	County.	Location and name.	Character of water.	Remarks.
771	Bienville....	Kings Salt Works, Salt Springs	Brine	
772	....do.	Rayburn Salt Works, Salt Spring	....do	
814	Caddo.......	Shreveport, Currie Springs.....	Soft........	Sold locally for drinking purposes.
	....do.	Shreveport, Mineral Wells.....	....	Sold locally for medicinal purposes.
861	Catahoula. .	Tullos, Bayou Castor Salt Spring	Saline	
862	....do	White Sulphur Springs.........	....	Local resort, largely patronized before the war.
863	Claiborne...	Lisbon, 6 miles east of..........	....	Local resort.
871A	De Soto.....	Grand Cane Mineral Springs...	....	Local resort, with improvements..........
888	Lincoln.....	Ruston, Louisiana Chautauqua.	Iron.	
900	Natchitoches	Allen..............................	....do......	
912	Natchitoches	Natchitoches, Fourth of July Spring................................	....	Local resort.
913	... do.	Natchitoches, Iron Springs.....	Iron	
914	....do.	Natchitoches, Breazeale Springs	....	
915	....do.	Natchitoches, Sulphur Springs.	....	
916	....do.	Sans Souci........................	....	Do.
958	Red River ..	Coushatta, 10 miles east of.	Saline.	
972	Sabine......	Pleasant Hill, Ferrell's Mineral Spring....................	....	Local resort, with small improvements.
	....do.	Negreet Salt Springs...........	Brine......	
982	Webster	Bisteneau Salt Works...........	....do......	
984	....do.	Dubberly, Valentine Springs...	Sulphureted	Noted locality for medicinal purposes.
984A	....do	Minden, Long Springs..........	Iron	Local resort.
994	Winn.	Drakes Salt Works, Salt Springs	Brine	
995	....do.	Prices Salt Works, Salt Springs.	....do......	

[6] See chapter V.

HYGIENIC VALUE OF DEEP-WELL WATERS OF NORTHERN LOUISIANA AND SOUTHERN ARKANSAS

The relatively porous character of the Tertiary beds in northern Louisiana and southern Arkansas and the irregularity of these beds render surface wells particularly liable to pollution. Even in thinly-settled regions the domestic wells are always near the house and barns and the drainage from the barn lot and outhouses goes more or less directly into them. It is extremely essential in shallow wells that there be an impervious cover to divert this refuse, and from the very nature of most of the shallow wells in this region such a covering is seldom present. When the houses are in groups, as in towns and villages, the danger increases at a very rapid rate. As a rule deep-well waters, where the mineral content is not excessive, are much to be preferred to water from shallow surface wells. An exact quantitative statement of the relative value is particularly difficult because of the impossibility of obtaining complete information. However, in order to obtain some idea of the effect of the use of deep-well waters a circular letter was sent to persons at points where deep wells had been used for some time. This letter asked the following questions: "What was the relative amount of sickness before and after the use of deep-well water? In your town how does the general health of the people who use deep-well water compare with that of those who do not? How does the general health of your community compare with other places similarly situated, but where the people use shallow-well water?"

Definite replies to this letter were received from Pine Bluff, Ark., and Ruston, Spring Hill, Zimmerman and Boyce, La.

Pine Bluff, Ark.—The data at this point refer to the effect of the water from wells 800 to 900 feet deep, supplied by the Sabine water sand (Pl. XXXVIII, sec. B), on the employees of the St. Louis Southwestern Railway in the Pine Bluff shops. Previous to the sinking of the wells in 1897 and 1899 (410,411) the water supply was from shallow wells. Mr. R. M. Galbraith, formerly general master mechanic of the Pine Bluff shops and now president of the Cotton Belt Trust and Savings Company at Pine Bluff, made the following statement in October, 1902:

Before the deep wells were completed 40 to 50 of the 437 men employed in the shop were on the sick list during the summer. After the deep-well water was used there was practically none on the sick list.

Ruston, La.—City water works were installed in this place in 1900-1901. The supply is from a well (890) 425 feet deep, which obtains its supply from the Sabine sands and from a thin bed in the lower Claiborne (Pl. XXXVIII, secs. C, I). Dr. R. F. Harrell reports under date of November 17, 1902:

There has been a very noticeable decrease in the number of cases of malarial sickness where the people confine themselves to the use of hydrant water. Of the 3,500 people in Ruston it is estimated that 945 are using deep-well water. We had 51 cases of typhoid fever here this year, and not one has occurred in families where the people have used deep-well water altogether.

Spring Hill, La.—The supply here is from the Sabine sands from a depth of 228 to 270 feet (989). The local manager of the Pine Woods Lumber Company writes:

The general health of our people has been immensely improved since we have used the deep-well water entirely for drinking purposes in the mills. If we could compel our employees to universally use it we could further decrease the sickness. The percentage of sickness here is much less than in the surrounding camps and farms.

Zimmerman, La.—Drinking water for the large mill at this point is supplied by a flowing well 175 feet deep, which is supplied by one of the Catahoula sands (956). The mill is situated on an old cut-off lake of Red River into which the sawdust and waste is dumped, and on the whole the conditions are not very inviting. Mr. J. A. Bentley, president of the J. A. Bentley Lumber Company, which operates this mill, reported November 10, 1902:

Before we had the artesian well the sickness among our people at Zimmerman was quite discouraging, but since we have put in the well chills and fevers have almost entirely disappeared. The comparative amount of sickness before the well was put down was ten sick to one now.

Dr. J. H. Reagan, resident physician for the Bentley Lumber Company, both before and after the well was sunk, reports:

Before the well was put down malaria was very prevalent. There was much more sickness in Zimmerman than in the high pine-covered hills to the south. After the well was put down we had at least 30 or 40 per cent less sickness than previously. I had no typhoid and very few cases of continual fever among the people at Zimmerman; and almost my entire practice was in the neighboring hill region, where the people depended on surface water. My conversation with neighboring physicians and people from adjoining towns elicited the fact that much fever existed when Zimmerman was comparatively immune.

Boyce, La.—The water for the town and shops of the Texas and Pacific Railway at this point is supplied from a number of artesian wells (942–946), generally about 300 feet deep, which obtain their supply from the Catahoula beds (Pl. XXXVIII, sec. C). Mr. H. A. Boyce reports regarding this locality:

To my certain knowledge the health of Boyce has been greatly benefited by the use of artesian water. Referring your letter to our two physicians, Doctor Sewell and Doctor Texada, both stated the same. They have been practicing here only since the wells were bored, but from information from former physicians have no hesitancy in saying that sickness has decreased at least 50 per cent. Formerly there was considerable typhoid fever; now there is rarely a case. Doctor Sewell, who has been here three years, says he has had four cases of typhoid fever in Boyce during that time. All four cases were in one family, who used only cistern water. Doctor Texada, who has been here about the same time, has had three cases—two at a house where cistern water was used; not certain about the other. They both agree that while there has been very little sickness in Boyce this year, and no typhoid fever, there has been considerable sickness, and many cases of typhoid fever in the surrounding country where cistern and surface waters are used. They attribute the health of the town to the use of artesian water for sanitary regulations are no better now than formerly. There has been no sickness among railroad employees this year.

HISTORY OF DEVELOPMENT

The pioneer development of the deep-well waters in northern Louisiana and southern Arkansas was in the Cretaceous region of southwestern Arkansas. Here in the fertile black lands there was no other available supply and the geologic conditions were such that deep wells could be easily and cheaply sunk. Many such wells were completed before the war, and since that time necessity and low cost have combined to make the development very active.

In the Tertiary region, on the other hand, where water could generally be obtained in shallow wells at any point, the necessity of developing the deep supply was not evident. Moreover, the difficulty of sinking such wells was greater than in the Cretaceous region and the cost therefore higher. In the Tertiary hill country the low value of the land and the absence of large industries prohibited very great expenditures for wells, and in the alluvial regions, where land values were higher, abundant water supplies could be obtained from the Port Hudson sands and gravels at depths ranging from a few to 150 feet (p. 82). Within the last fifteen years, however, many factors have combined to change this condition. The wealth of the country, which has been slowly accumulating since the civil war, has become sufficient to justify expenditures for deep wells at plantations and cotton gins in many widely separated places; ice factories have been established at many points; and compresses, cotton-oil mills, and cotton factories requiring large quantities of water have been erected. In the towns the rapid development has increased the fire risk and started the demand for waterworks, and the education of the people regarding the relation of water and drainage to health has aroused a demand for pure water. Of the waterworks thus far established, five in northern Louisiana and six in southern Arkansas depend entirely on underground water, and one in northern Louisiana and two in southern Arkansas depend in part on underground water, as shown in the table below. Finally, with the great extension of the railroads, the rapid exhaustion of white-pine lumber in the Northern States, and the greater demand for building materials from all sources, large mills have been erected at many points throughout this region. These mills, demanding an abundant and steady water supply, have been a most important factor in the development of the deep-well waters in the Tertiary beds of Louisiana and Arkansas.

Waterworks of northern Louisiana and southern Arkansas, 1904

Number of well.[7]	Name of town.	Ownership.	Source of supply.
934–935	Alexandria, La	Municipal	Deep wells.
948	Lecompte, La	do	Shallow wells.
988	Minden, La	do	Deep wells.
923	Monroe, La	do	Ouachita River; deep wells.
......	Natchitoches, La	do	Springs.
890	Ruston, La	do	Deep wells
....	Shreveport, La	Private	Cypress and Crow bayous.
....	West Monroe, La	Municipal	Ouachita River.
....	Arkadelphia, Ark	do	do.
....	Camden, Ark	do	do.
24	Dermott, Ark	do	Deep well.
321–322	Hope, Ark	do	do.
....	Hot Springs, Ark	do	Springs and surface water.
....	Little Rock, Ark	Private	Arkansas River.
148	Monticello, Ark	Municipal	Deep wells.
412	Pine Bluff, Ark	Private	do.
580	Prescott, Ark	Municipal	do.
478–479	Texarkana, Ark	Private	Shallow wells and surface water.

[7] These numbers correspond to those used in Chapter V, where additional data will be found.

CHAPTER III

METHODS AND COST OF WELL MAKING

METHODS

In wells of small diameter the three following processes are employed to break the material into pieces small enough to be readily removed from the hole: (1) Grinding or cutting with a rotary motion, (2) pounding or shattering by percussion, (3) washing or separating the particles by means of water currents. The first is illustrated in the well auger and diamond drill which cut or abrade by the rotary motion of a harder on a softer material. The second is illustrated in the cable rig, or common drop drill, which in its essential features is but a very heavy bar drill, with suitable appliances for lifting, which pounds and shatters the rock into pieces. In many applications of the grinding and pounding processes, which are used in varying combinations, water under pressure is an important accessory, and in the jetting and rotary process, used in unconsolidated sands and clays, it is of greater importance as an abrading agent than the other two.

After the material is loosened it is necessary to remove it before the drilling can proceed, and it is in the removal or disposition of this material that the different methods of well making show the sharpest distinctions. On this basis wells may be divided as follows:

A. Material from well hole not elevated to the surface.
    I. Removal automatic.
        a. Driven wells.
B. Material from well hole elevated to the surface.
    I. Removal involving a cessation of the drilling or boring.
        a. Dug wells.
        b. Wells made with a dirt or clay auger ("bored wells").
        c. Wells made with a well punch ("punched wells").
        d. Wells made with a simple percussion drill and sand pump (cable rig).
    II. Removal automatic, without a cessation of the drilling or boring.
        a. Well made with "self-cleaning" drills,[1] or automatic sand-pumping outfit.

[1] Sometimes improperly called "hydraulic process." It is no more a hydraulic process than is the cable rig, from which it differs essentially only in the automatic removal of the drillings.

b. Wells made by hydraulic process.
 1. Jet process.
 2. Rotary process.

III. Removal only in part automatic.[2]
 a. Wells made with core drills.
 1. Diamond drills.
 2. Chilled-shot drills.
 3. Hollow steel bit coring machines.

DRIVEN WELLS

In regions of unconsolidated strata, where the ground water is relatively near the surface (within the suction limit, or about 30 feet) and the water-bearing beds are relatively coarse, the cheapest and simplest method of obtaining a small water supply is by placing a strainer on a piece of pipe of the same size and driving it into the ground with a sledge or maul. Extra pieces of pipe are added after the first length is driven into the ground, and the well is thus made the desired depth. Unless the depth at which the best water supply can be obtained is already known, tests are made from time to time by screwing a small suction or "pitcher" pump on the top of the casing. When a desirable stratum has been located, the well should be pumped continuously for some time to free the strainer and remove the finer particles from the stratum in the immediate vicinity of the screen and so form a natural strainer of greater or less extent about the well (fig. 34). This is the commonest type of well in the river-bottom lands, but in the hill lands, though it is occasionally used, better results can usually be obtained by other methods.

BORED WELLS

The principle involved in the carpenter's auger was early extended to boring holes in unconsolidated sands and clays, and it still remains one of the simplest and cheapest methods of making wells of small diameter and of a few hundred feet depth. Various types of augers are employed, some of which are shown

---

[2] All drillings are automatically elevated by a water jet in all types of core drills, but the removal of the core proper involves a cessation of drilling.

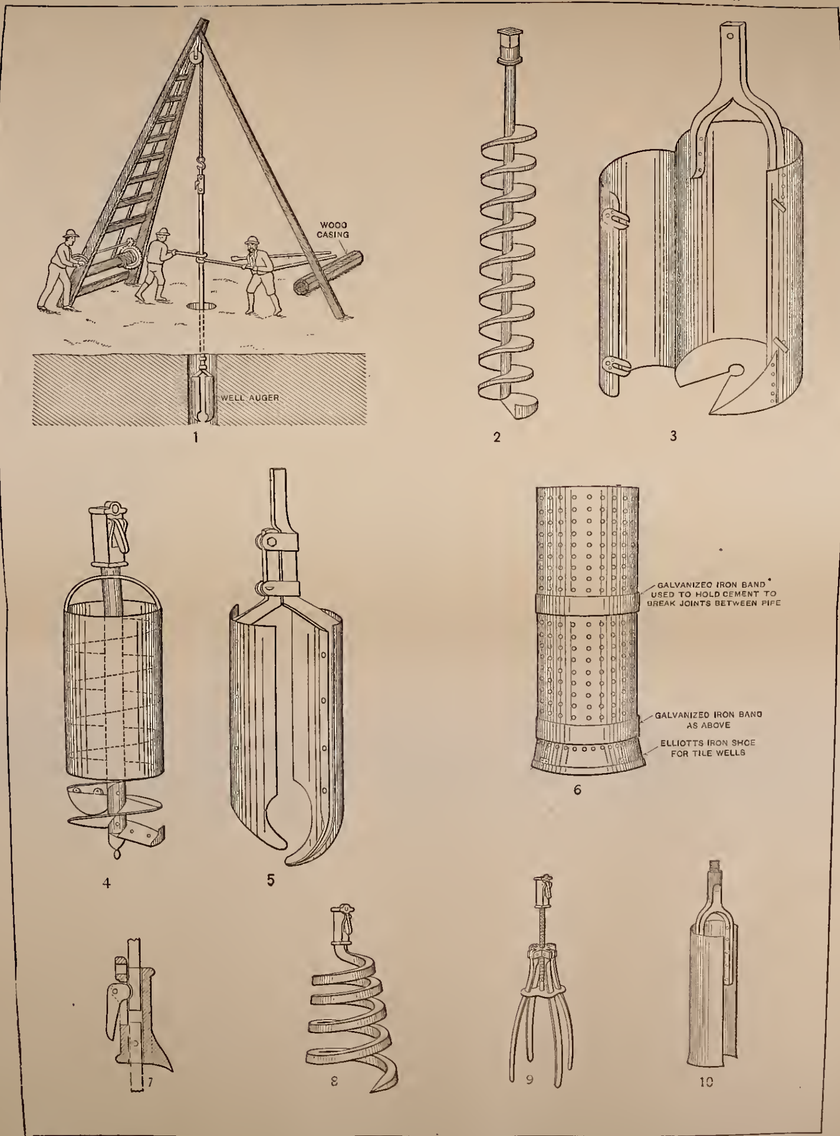
in Pl. XLIII, 2, 3, 4, 5. Forms Nos. 2 and 5 are adapted for use in clay and Nos. 3 and 4 for sand and sandy clay where it is desirable to have some sort of containing vessel to hold the cuttings. When small bowlders are encountered which can not be taken up by the auger, grabs of various kinds are used to remove them (see "ram's horn grab," Pl. XLIV, 1, 6); but if the bowlders or masses of rock are larger than the hole the well must be abandoned or some other form of tools employed. When the rock is thin it may be shattered by substituting a bar drill for the auger and raising and lowering, as in the cable rig.

The drill rods are of iron or wood, sometimes square (Pl. XLIII, 1), so that wrenches or other suitable turning devices can be attached, but more often round, when they are turned by a clamp or wrench (Pl. XLV). When the auger is filled with earth it is lifted to the surface with a windlass and emptied and the boring resumed. Bored wells are in some instances cased with hollow trees, but more commonly with boards, sheet-iron pipe, iron casing, or tile of some sort (Pl. XLIII, 7). Of the several forms of casing, tile properly put in is perhaps the most ideal.

Bored wells are found throughout this region. In the Tertiary strata they are generally very shallow, but wells 100 to 300 feet can be sunk by this method. On Long Island, New York, where there is a very gravelly, sandy soil, with irregular clay masses, somewhat similar to that in northern Louisiana and southern Arkansas, the well auger is still successfully used in making wells to depths of 250 feet, notwithstanding the nearness of New York City and the ease with which improved drilling tools may be obtained. In that region the cost of wells made with the well auger and finished with tile is less than half that of wells made with improved tools, and this will probably be the cheapest method of developing domestic wells in many parts of the Tertiary strata of northern Louisiana and southern Arkansas.

ARKANSAS CLAY AUGER

In the Cretaceous region, where there are thick beds of blue clay, which do not cave, experience has developed a clay auger radically different from those shown in Pl. XLIII, though somewhat resembling a "pod auger." With this holes are very easily



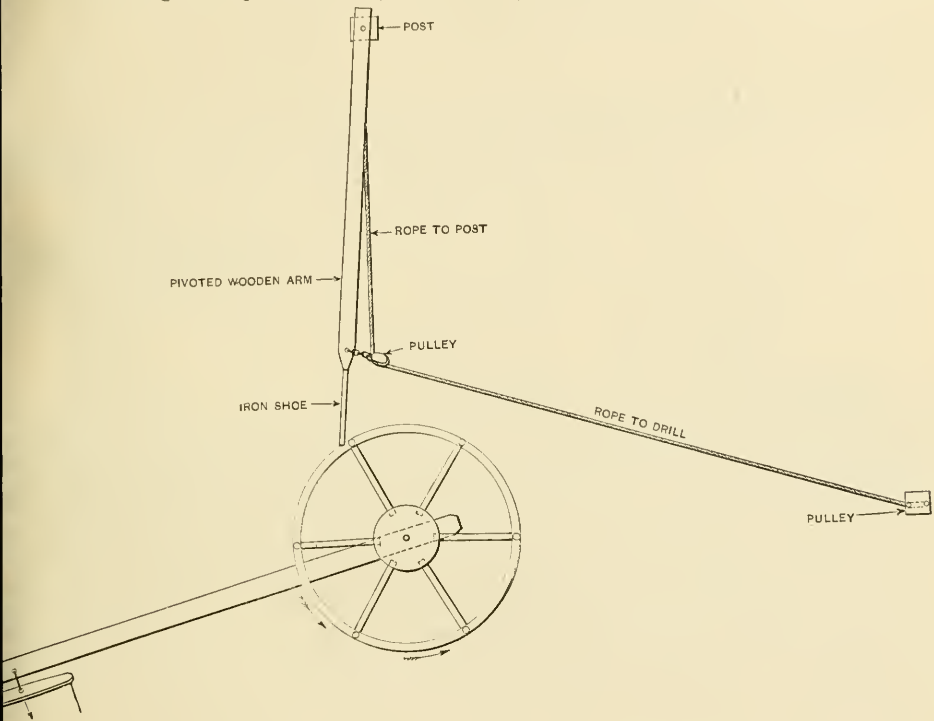
From U. S. Geol. Surv.

Well-Boring and Well-Punching Tools.

1, Ordinary well-boring outfit. 2, 3, 4, 5, Well-boring augers. 6, 18-inch perforated straight tile, used as strained in Elliott tile wells. 7, Self-fasteuing couplings used on Challenge well-auger poles. Note also Elliott patent iron shoe. 8, 9, Bowlder Catchers. 10, Well-punch.

bored to depths of 300 to 400 feet at a cost of 12½ to 40 cents a foot, and holes 700 feet deep have been drilled under favorable conditions.

The auger is 15 feet long[3] (Pl. XLIV, 14). It consists of an auger



From U. S. Geol. Surv.
FIG. 31.—Method of jumping rock drill in Arkansas well rig. Compare with Pls. XLIV and XLVI.

barrel 4 feet long, which is made of cast steel and resembles a 3-inch pipe sawed vertically in half. This is fastened by a flat piece of iron to a second auger barrel, 1½ to 2 feet long; above this is a second piece of flat iron, square at the top and cut with threads for fastening to the wooden poles (Pl. XLIV, 11, 17). At the bottom of the auger barrel, on the right-hand side, is riveted a steel cutting edge of the shape shown in Pl. XLIV, 15. This is

[3] In Plate XLIV, this is foreshortened because of the angle at which the auger is placed.

PLATE XLIV

[From United States Geological Survey]

TOOLS OF AN ARKANSAS WELL-BORING OUTFIT BELONGING TO MR. G. B. HIPP, OF GARLANDVILLE, ARK.

1. 9-inch "twister," or "ram's horn grab." Used for removing large stones and old wooden curbs.
2. 3½-inch bar drill, with solid iron bar attached ("drill stem"), used in drilling through the "water rock."
3. Wrench for tightening wooden poles.

4, 5. Stilson wrenches.

6. 3½-inch "twister," or "ram's horn grab." Used for removing stones, fishing for lost tools, and cleaning out old wells.
7. Pipe tongs.
8. Sand pump made of section of iron pipe. Used in removing sandy and clayey material which will not hold on the regular clay auger (No. 14).
9. 5-inch reamer or cutting bit for enlarging hole made with No. 14. It is used on same guide shown with No. 12.
10. Taper pin. Used in "fishing" for lost piping.
11. 10-foot wooden pole. Used just above the clay auger.
12. 9-inch reamer or cutting bit for enlarging hole.
13. 9-inch rock drill.
14. 3½-inch Arkansas clay auger.
15. Extra cutting edge or "cutting bit" for 3½-inch Arkansas auger.
16. Key for holding poles while unscrewing.
17. Regular 26-foot wooden pole, showing detail of lower connection.
18. Iron drill rod, sometimes used instead of wooden pole in drilling through the "water rock."

m U. S. Geol. Surv.

TOOLS OF AN ARKANSAS WELL-BORING OUTFIT.

commonly called the cutting bit and projects inward 1¼ inches. On the opposite side and slightly above is the "auger lip," which helps to hold the dirt in the auger barrel when the tools are lifted. In operation, the auger is fastened to a short 10 foot pole (Pl. XLIV, 11) known as the auger pole, and this to the regulation 26 foot pole. The tools are turned with a clamp, and when the bit begins to choke, the tools are lifted and dropped by means of a windlass (Pl. XLV). This operation jumps the dirt up in the bit, and so frees the lower end; it is termed "making a slip." If the clay is very dry a little water is added, and with the very sticky Cretaceous clay this process can be continued until the whole length of the auger is filled with a cylinder of mud. This 15 feet of mud represents about 10 feet in depth. Usually, however, the auger is filled for only about 10 feet, representing 7 feet of depth, before lifting the tools.

When rock is encountered a bar drill is used (Pl. XLIV, 2). This is sometimes attached directly to the wooden poles and sometimes to iron poles. The drill shown is fastened to a solid piece of iron weighing about 100 pounds, which in a rough way corresponds to the drill bar of the regular cable tools (Pl. XLVII).

In the outfit shown in Pl. XLVII, 2, the drill is jumped by means of an auxiliary wheel on the windlass (fig. 31). The drill rope passes through a pulley in a post near the driller and a second pulley on a pivoted arm, and is held in the supporting post by a wooden wedge. This wedge is removed and redriven when it becomes necessary to lengthen the drill rope.

When sandy layers are encountered, which will not hold in the auger, the sand pump is used or enough clay is dumped in the hole to make the sand stick together.

In cases where wells of larger diameter are desired, or where it is necessary to enlarge the upper part of the hole for wooden casing, the 3 or 3⅓-inch hole made with the Arkansas clay auger is enlarged with a reamer (Pl. XLIV, 10, 12).

PUNCHED WELLS

In regions where there are uniform clay beds without rocks or bowlders, wells are often made with a well punch. This consists of a cylinder of steel or iron one or two feet long split along one

PLATE XLV

[From United States Geological Survey]

WELL-BORING OUTFIT OF MR. G. B. HIPP, OF GARLANDVILLE, ARK.

Boring with clay auger (Pl. XLIV, 14) and wooden poles. The drill poles, with auger attached, are turned with clamp as shown, and when the auger begins to choke it is lifted and dropped by the boy turning back on the windlass and letting go. This jumps the dirt up in the bit and so frees the lower end. This process is repeated until the bit is full, when it is lifted to the surface and emptied. By this method from 7 to 10 feet can be bored without emptying.

PLATE XLVI

[From United States Geological Survey]

Drilling with iron poles and rock drill. Drill is jumped by means of pivoted arm, which is pushed outward and then freed from the cogs on the upper wheel of the windlass (fig. 31, p. 93).

WELL-BORING OUTFIT OF MR. G. B. HIPP, OF GARLANDVILLE, ARK.

Boring with clay auger (Pl. XLIV, 14) and wooden poles. The drill poles, with auger attached, are turned with clamps as shown, and when auger begins to choke it is lifted and dropped by the boy turning back on the windlass and letting go. This jumps the dirt up in the bit and frees the lower end. This is repeated until bit is full, when it is lifted to surface and emptied. From seven to ten feet can be bored without emptying.

From U. S Geol Surv.

DRILLING WITH IRON POLES AND ROCK DRILL.

Drill is jumped by means of pivoted arm, which is pushed outward and then freed from the cogs on the upper wheel of the windlass, which is turned.

side and slightly spread (Pl. XLIII, 8). The lower portion is very slightly expanded, sharpened, and tempered into a cutting edge. In use it is attached to a rope or wooden poles and lifted and dropped in the hole by means of a rope given a few turns around a windlass or drum. By this process the material is forced up into the bit, slightly springs it, and so is held. When the bit is filled it is raised to the surface and emptied. When working in very dry clay, water is sometimes added to aid the bit in "picking up" the material. Thin sand layers are passed by throwing clay into the well and mixing it with the sand until the bit will take it up.

This process is not very extensively used in this region, and is not so practicable as the Arkansas clay auger.

SIMPLE DROP DRILL OR CABLE RIG

It was early learned that the raising and dropping on stone of a metal bar with a horizontal cutting edge would, if the bar was turned slightly with each stroke, produce a circular hole. This primitive device in the form of a hand drill bar is used to-day in many stone quarries. As applied to well drilling the bar was at first attached to the end of a "spring pole" made by firmly fastening the small end of a sapling in the ground and fixing a support near the base so that it inclined upward at an angle of 30° or more. The hole was drilled by the "spring of the pole," the driller keeping it in motion by pulling down on the drill rope. As the hole deepened the rope was paid out and the limit of depth was determined by the elasticity of the pole and the ability of the men to raise the tools out of the well when it was necessary to remove the accumulated drillings with a sand bucket or sand pump (Pl. XLVII, 5, 6,). In time the lifting of the tools was done by horse power and then by steam; the spring pole was supplemented by a walking beam (Pl. XLVII, 3), whose motion depended not on its elasticity but on power transmitted from an engine by means of a crank shaft. This enabled much heavier tools to be jumped, and with improved lifting devices greatly increased the possible depth of wells.

A complete "string of tools" as used in the cable rig, is shown

PLATE XLVII

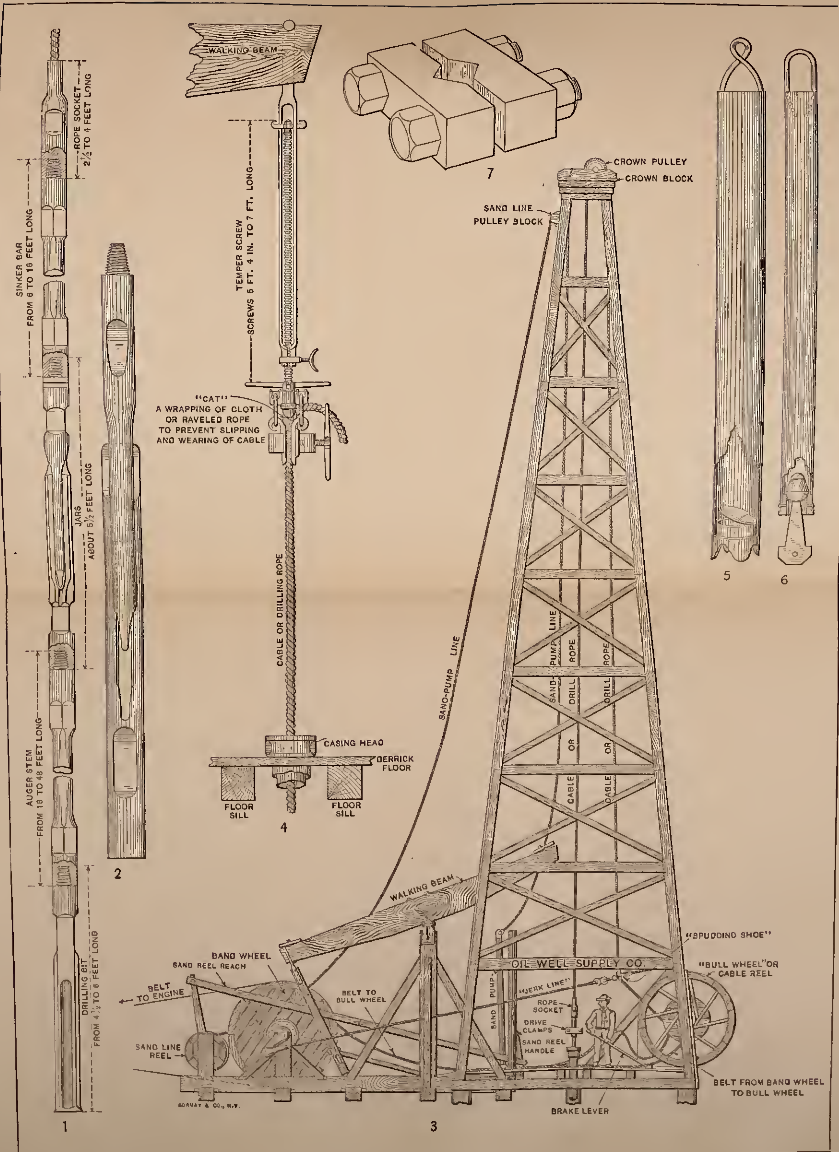
[From United States Geological Survey]

CABLE RIG OR DROP-DRILL OUTFIT

1. A complete "string of tools" for a cable rig. The auger stem or drill stem is used to add weight to the drill and increase its force of impact. The jars are composed of two linked pieces of extra-quality steel having a slack or endwise motion of 6 to 9 inches (No. 2); they enable a sharp, quick, upward blow to be delivered which "jars" the tools loose when they become fast. The sinker or sinker bar is used occasionally where the well is filled with water to help sink the cable rapidly; unless placed between the jars and the bit it adds little or no force or weight to the drill.
2. "Jars" open.
3. Standard rig arranged for starting the hole or "spudding." The "string of tools" is jumped by means of a "jerk line" attached to the crank of the band wheel. As the drilling progresses the tools are lowered by gradually unreeling the cable from the "bull wheel." The casing or pipe is "driven in" with driving clamps (No. 7), attached as shown.
4. Temper screw, with cable attached. After the hole has been sunk for some depth below the derrick floor the walking beam and temper screw are used. The string of tools is jumped by means of the walking beam, and the tools are lowered as the drilling progresses by means of the temper screw.

5, 6. Sand pumps or bailers; 5, Common form with steel-flap valve; 6, form with dart valve. When the accumulations of the drilling in the well impede the progress of the drill, the tools are lifted by reeling up the cable on the bull wheel and the drillings are removed with the sand-pump. The temper screw is then wound up or "elevated," the tools lowered, and the drilling resumed.

7. Driving blocks.



From U. S. Geol. Surv.

CABLE RIG OR DROP-DRILL OUTFIT.

in Pl. XLVII, 1, and the method of operation and construction of the derrick is illustrated in Pl. XLVII, 3-7.

For the successful operation of the cable rig, or drop-drill process, it is necessary that the material be relatively hard and brittle, and firm enough to stand up without casing. In regions where hard rock is at the surface or covered with but a relatively small amount of unconsolidated material, which must be penetrated with a casing before the drilling of the well proper begins, the cable or walking-beam rig is the cheapest and most commonly used method of sinking deep wells, but in regions of unconsolidated strata, such as the Tertiary and Quaternary beds of the Atlantic and Gulf States, drilling with cable tools is impracticable, and for large wells either the jet or rotary process should be used.

In some of the Cretaceous beds where the material is solid enough to stand up without casing the cable rig has been successfully used, as at Texarkana, Ark. (480), but even in this material better results can usually be obtained with the rotary process. Cable tools were tried at Gurdon, Ark., in the same strata geologically as at Texarkana; but here the material caved badly, and after two attempts the well was abandoned. It could have been finished to the desired depth with the proper rotary outfit.

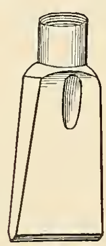
AUTOMATIC SAND-PUMPING OUTFIT

Drilling a well with a cable rig involves two principal operations—(1) a pounding up of the rock and (2) a removal of the drillings with a sand-pump. A combination of these two operations has resulted in a process which is of great value in regions of unconsolidated strata where the ordinary cable-rig process can not be used with advantage, and which is often more practicable than any other for wells of smaller diameter and comparatively shallow depths in rock regions.

The tools may be described, in the aggregate, as a sand-pump fitted with a drill having one or two perforations through which the drillings can enter the sand-pump barrel, which is composed of sections of pipe having a total length slightly greater than the depth of the well (Pl. XLVIII, 1). When this "string of tools" is "jumped" by a spring pole or walking beam, or other suitable device, such as shown in Pl. XLVIII, 4, 5, the drill loosens the material, which, as in the ordinary sand-pump, passes through the valve into the drill rods. In drilling in dry material enough water must be added to make a rather thin mud of the drillings in order to enable them to pass the drill valve. The continuous jumping of the tools, pumps the drillings through the drill rods without regard to the depth of the well, and finally throws them out at the surface.

The principle which makes the elevation of drillings in this manner possible may be briefly explained as follows:[4]

The drill is so shaped that when it falls it tends to compress the water and air in the lower part of the hole, and, in properly shaped tools, this force is suddenly brought to a culmination by a curved surface and thus pops the valve open and allows the



From U. S. Geol. Surv.

FIG. 32.—A well-shaped self-cleaning drill. Shoulder is circular and almost completely fills the drill hole; blade is flat and suddenly curves at the top, thus developing the maximum force in the space where it is most needed to pop open the drill valve.

FIG. 33.—A badly-shaped self-cleaning drill. Shoulder does not fill the hole, and drillings rush past the opening without lifting valve with maximum force. This is, however, a very good shape for a jetting outfit.

ingress of the water and drillings. In a way it is somewhat analogous to the sudden development of pressure in the hydraulic ram, by which water is elevated to considerable heights, only here the power is developed not by the fall of a column of water, but by the gravity drop of a string of tools.

The theory of action is so intimately connected with the efficiency of the drill that it may be well to call attention to some of the features of a well-made self-cleaning drill. It should be circular at the upper end and have a diameter very slightly less

[4] I am indebted to Dr. Arthur L. Day, physicist, of the United States Geological Survey, for suggestions in this matter.

than the width of the cutting edge. The blade should be flat and suddenly curve at the top in order to obtain the effect of a conical compression in a very short space (compare figs. 32, 33). If this curved area were slightly coned toward the opening (not so much that large fragments or pebbles would be likely to jam) a further increase in force would be gained, and the maximum amount of lifting power would be developed with the least expenditure of energy. In practice additional valves opening upward, called drill rods or blind valves (Pl. XLVIII, 2, 3), are added in the drill stock. They relieve the bottom or drill valve of some of the downward thrust of the drillings, and so increase the efficiency of the outfit.

The continuous sand-pumping and the method of drilling and driving the casing at the same time, by clamping the drive block to the drill rods, make it possible to pass through beds of relatively caving material which can not be handled with the ordinary cable rig.

The important feature of this rig from a water standpoint, and the one which makes it of peculiar utility for sinking water wells in the Coastal Plain region, is that it is impossible to pass a water-bearing stratum, no matter how small, without being aware of its presence. In the jet process it is very easy to pass a water-bearing stratum, and with the rotary process, in which very muddy water is used that commonly plasters up any small sand beds encountered, the determination of water horizons, unless they are very large, is comparatively impossible.

This type of rig has been used at a number of points, notably about Shreveport, and combined with a small jetting outfit it is now supplanting the boring outfits in the deep wells in the Cretaceous region. It is peculiarly adapted for work in the Eocene beds, and will doubtless become one of the commonest forms used in the development of this section.

JETTING PROCESS

In the jetting process the material is loosened and the drillings are elevated to the surface by means of water under pressure. Its use is entirely restricted to unconsolidated materials. The water is conducted into the well by means of pipes of relatively

PLATE XLVIII

[From United States Geological Survey]

AUTOMATIC SAND-PUMPING PROCESS

1. A "string of tools" for automatic sand-pumping outfit. The drill varies somewhat in size, length, and shape, but is characterized by the presence of a leather valve which allows the drillings to enter and prevents their egress, as in the sand pump (Pl. XLVII, 5, 6). The "drill stock" or drill rods are commonly 1 to 1½ inch pipe, though in wells 3 to 4 inches in diameter a short length of 2½-inch pipe is sometimes placed above the drill.

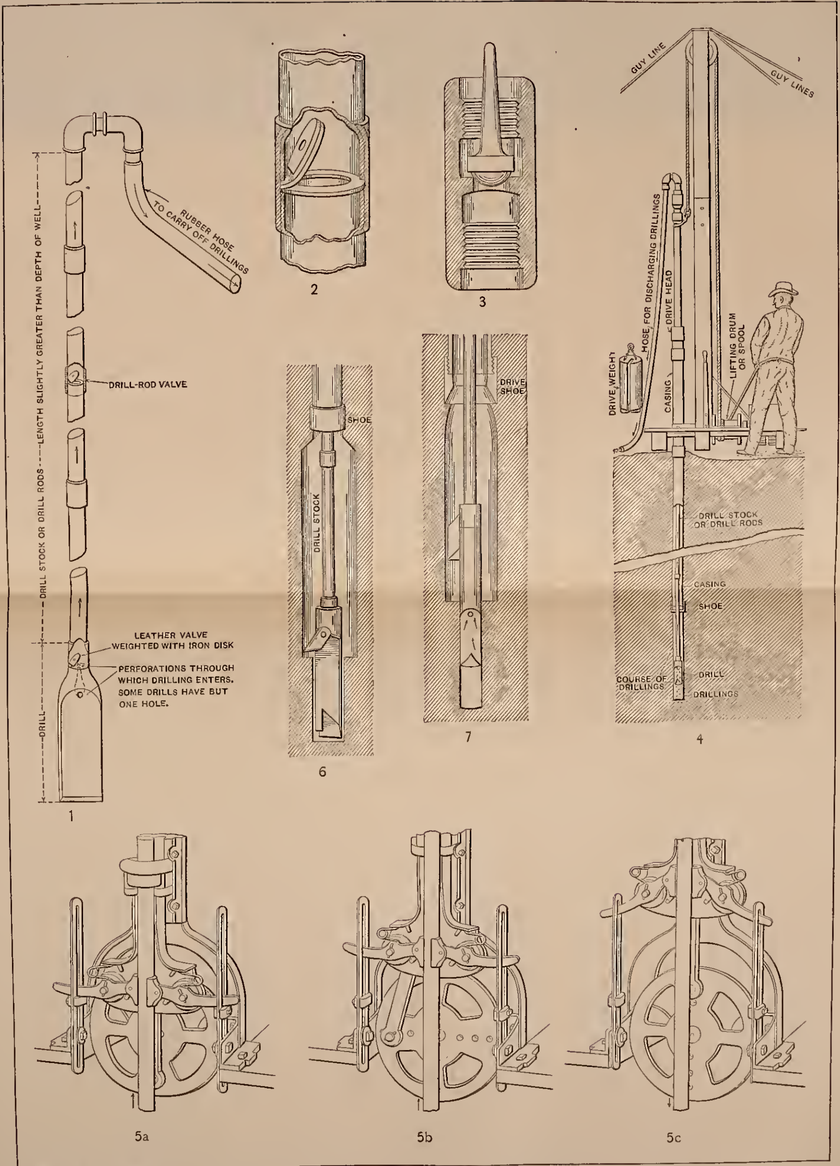
2, 3. Drill-rod or blind valves: 2, Leather drill-rod valve, with large opening; 3, metal drill-rod valve, with small opening. One or two drill-rod valves are inserted in the drill-rods, the number depending on the character of the material being drilled. They distribute the weight of the column of drillings along the drill-rods in the downward thrust, and allow pumping to continue if anything happens to the drill valve.

4. Common device for "jumping" or "churning" the tools. The rope is given a few turns around the lifting spool or drum, and the drill pipe alternately raised and lowered by tightening and loosening the rope. This "churning" drills the hole, as in the cable rig (Pl. XLVII), and by means of the valves (1) automatically elevates the drillings through the hollow drill-rods. The casing, armed with a driving shoe (Pl. XLIX, 5), is driven in the hole made by the drill with some form of drive weight. This is lifted and dropped in the same manner as the drill-rods. Sometimes the drive block is bolted to the drill-rods and the whole weight of the tools thus utilized in driving the pipe.

5 a, b, c. Improved device, used on the "Ohio tubular well-drilling machine," for rapidly and regularly lifting the drill-rods.

6. Automatic sand-pumping, enlarging "paddy" or expansion bit, for use in unconsolidated materials.

7. Automatic sand-pumping, enlarging shoulder bit, for use in rock.



From U. S. Geol. Surv.

Automatic Sand-Pumping Process.

small diameter, called wash pipes, jet pipes, or drill pipes, and is directed downward near the bottom of the well by means of a suitable bit (Pl. XLIX, 3, 4; fig. 33). The drill is turned from time to time by means of a clamp or wrench, and so keeps the hole true and aids the water in wearing away more resistant masses of clay or like substances. When local hardened strata are encountered the drill is lifted and dropped, as in the drop drill or cable rig and the automatic sand-pump outfit. If there are many "shells of rock" which require to be drilled in this manner it is often advisable to insert in the drill-rods a blind valve (Pl. XLVIII, 3), upside down, with a spring to keep the valve pressed up against the valve seat in order to prevent the drillings from entering the drill and choking it when the tools are dropped.

The casing is usually driven, but in some instances it is possible to use a paddy or expansion drill (Pl. XLIX, 2, 4), which makes the hole larger than the casing and enables it to settle of its own weight when moved with a pipe wrench from side to side (Pl. XLIX, 1).

This process is better suited for drilling wells of large diameter than the automatic sand-pumping process, and is admirably adapted for use in the unconsolidated materials of the Coastal Plain.

ROTARY PROCESS

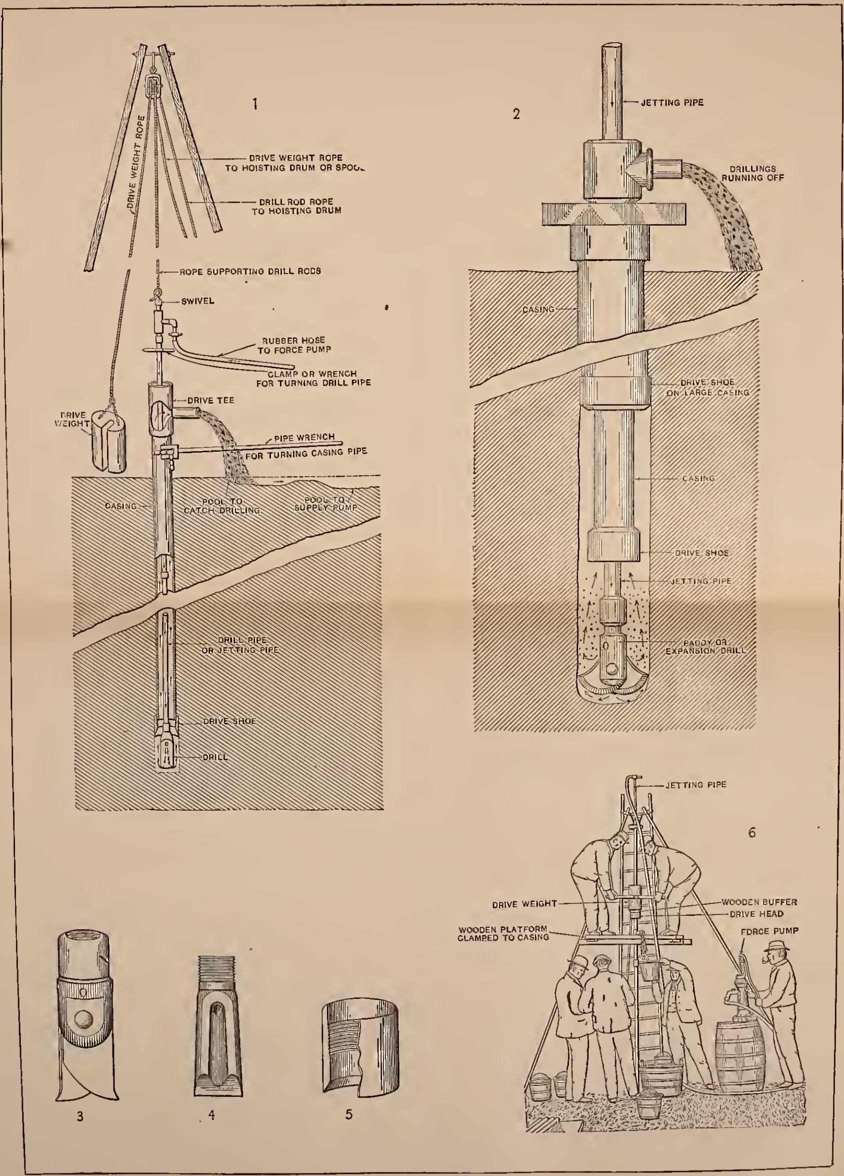
The rotary process is but a development of the jetting process, from which it differs mainly in that the more or less irregular turning of the drill-rods by hand in the jetting process is here replaced by regular and rapid turning by a revolving table or rotary moved by machinery. When the character of the material is such that the ordinary fishtail bit can be used (Pl. L, 3) the rotary process is very little different from the jetting process, except that the larger machinery, pumps, and derrick commonly used in rotary outfits permit larger holes to be drilled. The fishtail bit is used when the material does not cave readily and when the water pressure and the plastering of the sides with the mud in the wash water will make it stand up. Under favorable conditions holes may be drilled many hundred feet in this manner without casing, the bit then removed, and all the casing inserted at one time.

PLATE XLIX

[From United States Geological Survey]

JETTING PROCESS

1. Jetting process. Water enters drill pipe or jetting pipe by hose from force pump and emerges from the two holes in the drill as jets directed downward or toward the bottom of the well. The drillings loosened by the jet and the drill, which is occasionally turned by a clamp or wrench, are carried to the surface with the upward current of water between the drill pipe and casing. If the hole is not large enough to allow the pipe to settle of its own weight when turned with a pipe wrench, it is driven with a drive block. Sometimes a solid drive head is used on top of the casing, sometimes a drive plate, and sometimes only an extra heavy tee or specially constructed drive head or tee.
2. Paddy or expansion drill in operation. This enables a hole larger than the casing pipe to be drilled, and in favorable material makes driving unnecessary.
3. Paddy or expansion drill, closed for lifting or lowering in the hole.
4. Common jetting drill. This shape, with the attachment of a valve, is often used in the automatic sand-pumping outfit, but for the best results the shape should be modified. (See p. 100.)
5. Drive shoe. Tempered steel or iron, with cutting edge, for use on end of casing pipe.
6. A simple jetting outfit. Designed and used by Roy S. Barker in drilling test holes on Long Island, New York. In this the drive weight is lifted by two men standing on a wooden platform clamped to the casing, and the weight of the men aids in sinking the casing.



From U. S. Geol. Surv.

JETTING PROCESS.

The constant rotation and the high water pressure used enables the rotary to be employed in a manner entirely different from any other outfit and makes the process peculiarly fitted for penetrating very caving, unconsolidated materials. In such instances the casing, armed with a toothed cutting shoe (Pl. L, 4), is itself used for the wash pipe and the water and drillings returned to the surface between it and the wall of the hole. In practice the wash water is mixed with fine clay, and this very muddy water tends to plaster up any sand beds encountered and so prevent any loss of water and consequent reduction of head. Constant motion and water pressure are required, and in order to facilitate the addition of drilling pipe two water swivels are employed. When the hole has been drilled to such a depth that the top of the pipe is near the revolving table a length of pipe is attached to the second water swivel and elevated by means of the lifting drum into position for coupling; the rotary is then reversed and the first water swivel unscrewed, the new length of pipe is coupled on, and the pumps are switched to the hose connected with it. This operation with skillful men requires but a few seconds, and drilling proceeds with scarcely an interruption. To prevent the drenching of the men when the water swivel is unscrewed "back-pressure valves" are sometimes inserted between the pipe couplings (Pl. L, 5). To guard against accident to the pumps and the consequent "sticking" of the pipe, all large outfits have two force pumps so connected that should one fail the other can be immediately used. Wells are usually started with large casing, which is pushed down as far as possible; smaller casing is then inserted, and so on to the bottom of the well. The well at Galveston, Tex., which is the deepest well ever sunk in unconsolidated materials, has 22-inch casing from 0 to 60 feet, 15-inch from 60 to 928 feet, 12-inch from 928 to 1,500 feet, 9-inch from 1,500 to 2,363 feet, and 5-inch from 2,363 to 3,067 feet.

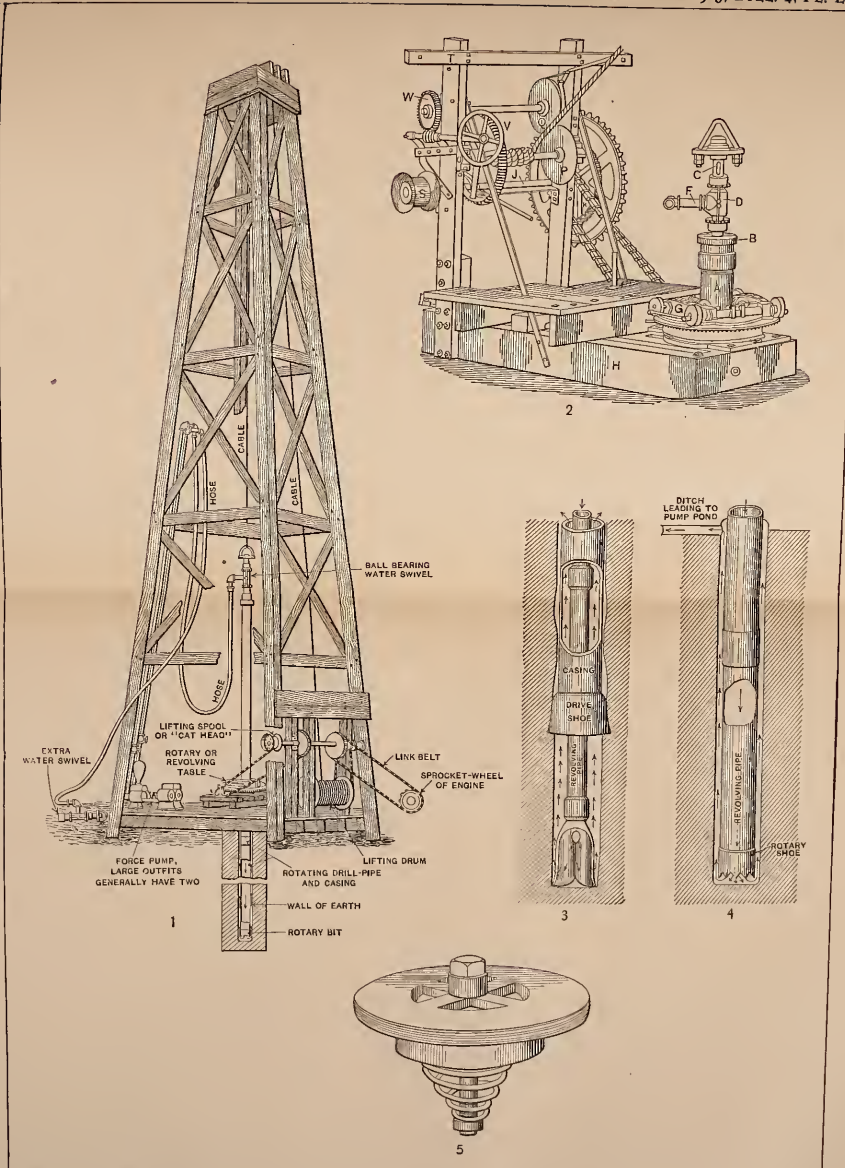
This process is by far the quickest method known for sinking wells of large diameter in unconsolidated material. Wells over 1,000 feet deep have in several cases been sunk in less than a day and a half. As a means of developing water wells it is not entirely satisfactory unless the exact point at which the water-bearing beds occur is already known.

PLATE L

[From United States Geological Survey]

ROTARY PROCESS

1. Rotary outfit. Water is forced from pump through water swivel and down casing or drill pipe and returns to surface as shown (Nos. 3, 4). The pipe, which is armed with a rotary shoe (No. 4) or a fishtail bit (No. 3), is constantly rotated by means of a rotary or revolving table (No. 2). The drillings loosened by the water and the drilling bit are brought to the surface by the return current outside the drilling pipe or casing.
2. Revolving table, hoisting machinery, and water swivel of Chapman's rotary.
3. Fishtail bit.
4. Toothed or rotary bit.
5. Back-pressure valve; occasionally used between couplings to keep drillings from entering wash pipe and to prevent a "back flow" when the water swivel is unscrewed to allow new lengths of pipe to be added.



From U. S. Geol. Surv.

Rotary Process Machinery.

CORE DRILLS

In the various types of core drills, all of which are intended for use in consolidated material or hard rock, there is a combination of a revolving and a hydraulic process. Hollow bits with some cutting or abrasive device are revolved by suitable machinery, and wear out a hole with a core standing in the center The drillings are removed by a jet of water, and from time to time lengths of the core are broken off and brought to the surface either by lifting the drill, which in some cases automatically breaks the core and clamps it, or by a separate "core lifter."

In the diamond drill a hollow bit is used in which eight diamonds (either carbons or borts) are inserted—four near the outer edge and projecting slightly outward, and four near the inner edge and projecting slightly inward.

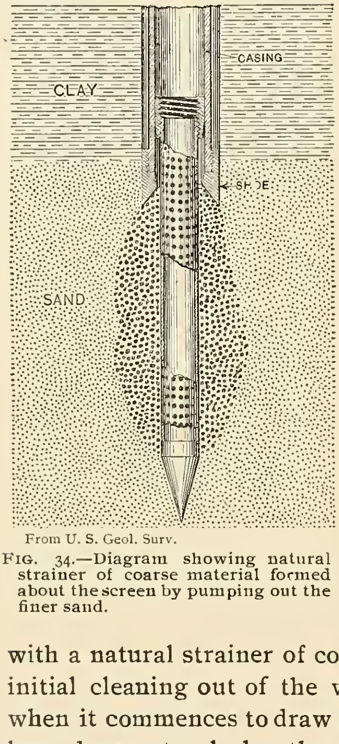
In the chilled-shot drill a hollow wrought-iron shoe is used in connection with chilled-steel shot or other loose abrasive. The constant rotation causes the shot to wear away the rock. This method can not be used in fissured or porous rocks where the shot can run out of the drilled hole, nor can it be used on bowlders or other irregular surfaces surrounded by clay, as the shot slide off and become embedded without accomplishing any work.

The toothed steel bit is similar to the ordinary rotary shoe or bit (Pl. L, 4). The rotary bit does not yield a good core because of the softness of the material worked and the rapid washing away of the core by the water current. Indeed, in most work the toothed rotary bit is fitted with a central cross-cutting edge which prevents the formation of any core whatever. This method of coring is well adapted for work in relatively soft, uniform rocks.

On account of the unconsolidated character of the material ordinary core drills can seldom be used in the Coastal Plain of Arkansas and Louisiana. Exceptional cases are found in the hard rocks encountered in some of the Cretaceous domes in northern Louisiana and in the salt and the sulphur deposits of southern Louisiana. In the latter, diamond drills have already been used.

FINISHING A WATER WELL

When the water sand is consolidated or hard enough to stand up in the hole, as in some of the Cretaceous beds, the finishing of a well offers no very great difficulty; but where not consolidated, as in the Tertiary and Quaternary beds, some sort of screen must be used. It is on the selection and setting of this screen that much of the success of the well depends. The screens commonly used are of two general types. One is made of pipe with round perforations covered with wire, wire gauze, or perforated metal gauze of some sort. The other is made of brass tubing with rows of horizontal slits increasing in size inward. The latter is perhaps the simpler, but is the more expensive type.



From U. S. Geol. Surv.

FIG. 34.—Diagram showing natural strainer of coarse material formed about the screen by pumping out the finer sand.

After the screen has been placed, which in most of the wells in this section is done after the drilling is completed, it is very desirable that the well be pumped heavily for several days or until the water clears. The point of this is to remove the finer particles immediately about the screen and thus to surround it with a natural strainer of coarser particles (fig. 34). During this initial cleaning out of the well the pump should not be stopped when it commences to draw sand. In many cases where this has been done not only has the well not been properly cleaned out or finished, but the pump valves and rods have been firmly fastened by the rapidly settling sediment and great difficulty has been experienced in their removal. In very fine sands, where there are no particles coarse enough to form a good natural screen, it is often practicable to introduce gravel from the surface and with it develop a strainer about the screen.

COST OF DEEP WELLS

The cost of wells naturally varies with the complexity of the tools needed, the skill of the driller, the character of the material drilled, the transportation facilities, and the amount of competition. If water is guaranteed it varies with the known water probabilities, and is always higher, except where the water conditions are thoroughly understood, than for a mere hole in the ground.

In the Cretaceous region of the southwestern Arkansas, where the conditions are such that deep-well water is the only supply over large areas and where very favorable geologic conditions exist, a very ingenious adaptation of the well-boring process has been developed. By this method the drillers, who are almost without exception local planters, can afford to make 3¼-inch wells for from 12½ to 40 cents a foot. When machine rigs of the jetting and automatic sand-pumping types were introduced in this region, as they have been within the last ten years, the "machine men" had to meet the competition of the "hand-tool men" and so prices have been kept down. It should be added in explanation of these prices that it is usually understood that the board for the drillers, and horse feed, will be furnished by the persons for whom the well is being drilled, who will also furnish the casing. As this is generally made of a few rough yellow-pine boards, which can be obtained at a near-by mill, it is not a very important item of cost.

In the Tertiary regions, where water can generally be obtained in shallow dug and driven wells, the demand for deep wells has not been so great. However, with the rapid development of this section in the last fifteen years, large and permanent water supplies have been demanded for manufacturing purposes and deep wells have been put down at many points. The first of these wells were put down by well drillers from other sections of the country. The cost was necessarily high, and the prices have been pretty well maintained to this time. The usual charges range from $1 to $4 a foot without casing, and while very large compared with the cost of wells in the Cretaceous region they are but slightly higher than those on Long Island, New York. The development is now largely restricted to wells for mills, ice factories, and waterworks, but conditions are very favorable for extensive developments for domestic and plantation purposes. Small jetting, automatic sand-pumping, and hand-boring outfits[5] are well adapted for such developments, and for ordinary wells 200 to 400 feet deep they should almost entirely supplant the larger rigs. The following example illustrates the difference in cost: Wells put down in Avoyelles Parish 100 to 150 feet deep into the Port Hudson gravels by professional well drillers cost $2 to $3 per foot. Judge Morrow, of Rapides, Rapides Parish, has put down three wells 102 feet deep in the same material with a jetting machine at an average cost of 39 cents per foot.

Statistics regarding the cost of wells in this region are given in the following tables, which are based on reports from various sources. In some instances it is probable that the total cost given does not include the cost of casing, and that the amount given under "Average per foot" should be transferred to the column "Average per foot without casing."

---

[5] The bits shown in Pl. XLIV are much better adapted for work in the Tertiary strata than the specialized clay bit used in the Cretaceous strata (Pl. XLI, 14).

Cost of deep wells in the Tertiary and Quaternary strata in northern Louisiana.

Location.						Cost.				
County.	Town.	Total Depth.	Diameter.	Size and length of casing.		Total.	Average per foot.	Average per foot, without casing.	Year drilled	Remarks.
		Feet.	*Inches.*	*Inches.*	*Feet.*					
Avoyelles . .	Bunkie . . .	125	4	. . . .	. . . .	$ 250.00	$2.00	. . . .	1901	
. . do	. . do . . .	158	4	. . . .	. . . .	522.00	3.30	. . . .	1897	
. . do . . .	. . do . . .	140	4	. . . .	. . . .	400.00	2.86	. . . .	1902	
. . do . . .	Masura . . .	110	6	. . . .	. . . .	500.00	4.54	. . .	1902	
. do . . .	Marksville .	[6]800	6-4	. . . .	. . . .	1,400.00	1.75	. . . .		
Bienville . . .	Arcadia . .	540	8¼-6	Not cased.		1,500.00	2.77	$2.77	1901	
do . . .	. . do . . .	535	5-3½	. . . .	480	. . . .	. . .	2.75	1893	
Bossier . . .	Antrim. .	286	4	4	286	. . . . . .	4.00	. . . .	1896	
do . . .	. . do . . .	233	6	6	233	. . .	4.00	. . . .	1902	
. . do . . .	Allentown .	110	5	5	110	250.00	2.27	. . . .	1899	Jetting machine.
. . do . . .	Antrim. . .	300	5	5	275	1,000.00	3.33	. . .	1898	
. . do . . .	Benton. . .	350	2½	2½	225	. . . . . .	.	2.00	. . .	Automatic sand-pumping rig.
. do . . .	. . do . .	196	3	3	196	600.00	3 06	. . . .	. .	do.
. do . . .	. . do . . .	170	2½	. . . .	. . .	. . . . . .	. . .	2.00	. . .	do.
. . do . . .	Bolinger . .	235	4	4	170	. . . . .	.	2.00	1897	
. . do . . .	Bossier City.	350	2½	2½	80	380.00	1.09	. . . .	1898	Automatic sand-pumping rig.
. . do . . .	do	195	6-2	6 2	70 98	[7]550.00	2.82	. . . .	. .	do.
. . do . . .	Curtis . . .	197	2½	2½	100	300.00	1.52	. . .	1897	do.
. do . . .	Foster . . .	210	3	3	150	300.00	1.43	. . . .	1898	do.
. . do . . .	Poole. . . .	300	4-2	. . . .	. . .	. . . . . .	1.65	. . . .	. . .	do.
Caddo . . .	Blanchard .	185	3	3	100	. . . . . .	. . .	1.25	1897	do.
. . do . . .	Missionary .	290	3-2	3 2	132 158	392.65	1 35	.	1900	do.
do . . .	Robson. . .	225	4	. . . .	. . . .	. . . . . .	.	(?)1.00	1898	
. . do . . .	Shreveport .	996	4	4	(?)996	8,000 00	8.03	. . . .	1891	Rotary Process.
. . do . . .	. . do . . .	280	4-2½	4 2½	83 69	500.00	1.79	. . . .	1901	Automatic sand-pumping rig.
. . do . . .	. . do . . .	338	6-4	6 4	96 60	[8]1,117.50	3.30	. . . .	1902	do.
. . do . . .	. . do . . .	225	2½-1½	2½ 1½	82 76	290.00	1.30	. . .	1901	do.
. . do . .	. . do . . .	338	6-4	. . . .	. . . .	. . . . . .	. . .	[9]1.50 2.00	1901	do.
. . do . . .	. . do . . .	201	2½	. . . .	. . . .	300.00	1.50	. . . .	1893	do.
. . do . . .	. . do . . .	324	4-2½	4 2½	80 69	700.00	2.16	. . .	1901	do.
. . do . . .	. . do . . .	150 180 290	6-4 6 4 6-4	. . . .	. . . .	650.00 650.00 650.00	4.20 3.61 2.24	. . . .	1902 1902 1902	do.
. . do . . .	. . do . . .	210	2½	2½	80	250.00	1.19	. . . .	1897	do.
Claiborne. .	Stateline . .	285	3-2	.	. . . .	365.00	1.25	. . . .	1900	do.
Grant. . . .	Colfax . . .	1,103	. . . .	2½	900	2,500.00	2.26	. . . .	1899	Rotary outfit. . .
. . do . . .	Pollock. . .	910	8-6-4	. . . .	. . . .	1,700.00	1.87	. . . .	1896	
do . . .	Rochelle . .	[10]555	. . . .	. . . .	. . . .	4,300.00	7.75	[11]1.00	. .	
Jackson . . .	Hodge . . .	330	6	6	330	1,300.00	3.94	. . .	1900	
. . do . . .	Jonesboro .	545	6	5	534	2,500.00	4.58	. . . .	1901	
do . .	Wyatt . . .	302	4	4	302	634.00	2.10	. . .	1902	
Lincoln . .	Ruston. . .	430	8-6	8 6	200 230	1,800.00	4.19	. . . .	1901	
do . . .	do . . .	450	4	4	450	1,200.00	2.68	. . . .	1901	
Natchitoches.	Natchitoches	726	6-4-2½	6	160	1,250.00	1.72	. . . .	1900	Rotary outfit.
do . . .	Weaver Spur	308	4-2	4	124	418.90	1.36	. . .	. . .	Automatic sand-pumping rig.

6 Depth paid for.
7 Amount paid drillers.
8 Contract price with certain stipulations as to yield.
9 First 100 feet, $1.50 per foot; below 100 feet, $2 per foot.
10 Statement of driller.
11 Contract price for drilling, owners to furnish everything but the drills.

Cost of deep wells in the Tertiary and Quaternary strata in northern Louisiana—Continued.

LOCATION.						COST.				
County.	Town.	Total depth.	Diameter.	Size and length of casing.		Total.	Average per foot.	Average per foot, without casing.	Year drilled	Remarks.
		Feet.	*Inches.*	*Inches.*	*Feet.*					
Ouachita . .	Monroe. . .	360	3½	3½	360	. . . .	. . .	$3.00	1892	Jetting process.
. . do . . .	. . do . . .	385	5	. .	. . . .	. . . .	. . .	3.50	1892	do.
. . do . .	. . do . .	375	5	5	375	$ 875.00	$2 33	. . . .	1901	do.
Rapides . .	Boyce . .	302	8	. . . .	. . . .	1,200.00	4.00	. . . .	1900	Rotary process.
. . do . .	. . do . . .	279	3½	3½	180	400.00	1.43	. . . .	1899	
. . do . . .	Rapides . .	102	2		102	40.00	0.39	. . . .	1900	Drilled by owner with jet machine.
. . do . . .	Zimmerman.	175	4	4	175	185.00	1.05	. . . .	1897	Drilled by owner.
Red River. .	Lake End .	287½	4–2½	4 2½	85 80	[12]530.00	1.84	. . . .	1900	Automatic sand-pumping rig.
Sabine . . .	Loring . . .	704	6	. . . .	. . . .	. . . .	. . .	3.25	1901	Rotary.
. . do . . .	Plymouth . .	521	4	. . .	. . . .	. . . .	. . .	2.25	1901	do.
Union. . . .	Randolph. .	206	3½	3½	206	500.00	2.43	. . . .	1901	
Webster. . .	Minden. . .	317	6	6	317	1,000.00	3.15	. . . .	1901	
. . do. . . .	Spring Hill.	368	3	3	(?)368	661.85	. . .	1.80	1899	
Winn. . . .	Tannehill . .	270	4	4	(?)270	500.00	1.85	. . . .	1902	

[12] Contract price ; well not accepted because of salty water.

CHAPTER IV

UNDERGROUND WATER PROSPECTS, BY COUNTIES

NORTHERN LOUISIANA

AVOYELLES PARISH

Avoyelles Parish is almost wholly dependent for its underground-water supply on the sands and gravels of the Port Hudson and redeposited Lafayette. These deposits underlie the whole parish (Pls. XXXVIII, sec. B), and while in the bottom lands shallow driven wells are nearly always successful, the best water can be obtained in the coarser gravels between 65 and 200 feet (756–767). This supply is practically inexhaustible; and while the water is hard, a chemical and bacteriological examination by Professor Metz, of New Orleans, of the water from this horizon at Lecompte (948), where city waterworks are contemplated, has resulted in a very favorable report.

The water-bearing sands developed in the Alexandria wells are, on account of the dip, very deep under most of this parish (Pl. XXXVIII, sec. B), and it will generally be inexpedient to try to develop them. The deep wells of the Natchez and Marksville Oil Company found no important horizon below the upper gravels which supply the municipal well at Marksville (767).

BIENVILLE PARISH

Throughout all of Bienville Parish, with the exception of limited areas immediately surrounding the Cretaceous domes at Kings and Rayburns Salt Works (Pls. XXVII; XXXVIII, secs. E, I), deep-well water can be obtained in the Sabine sands. The lower limit of profitable development ranges from 150 feet below sea level in the northeastern part of the parish to about 300 feet in the southeastern part (Pl. XL). Water sands will generally be found above this extreme depth, but in case they are locally absent at any point it will not be advisable to go deeper. The clays of the Midway and Arkadelphia formations, which underlie the Sabine, contain no water, and that of the next horizon, which is 600 or 700 feet below the Sabine, is very salty and is the source of the brine of the old salt works (Pl. XXXVIII, sec. E). This brine, in many cases, leaks into the Eocene sand beds and renders the water impotable. The prospects south of the domes are, therefore, not so good as those north.

The pressure head will vary somewhat with the local topography (Pl. XXXIX), and flowing wells are to be expected only locally and in deep valleys near high hill masses.

BOSSIER PARISH

The best water in Bossier Parish is obtained from the Sabine sands at depths not exceeding 100 to 150 feet below sea level (Pls. XXXVIII, secs. D, F, I; XL). The many wells in northern Bossier Parish have thoroughly demonstrated the possibilities there, and the well at Robson (805), in Caddo Parish, shows that good results can be expected at least that far down the river. Water-bearing sands will be found in the Sabine in the extreme south end of the parish at the depths indicated by the wells at Curtis, (789) Robson (805), and Frierson (871), but the quality can be determined only by drilling.

The water head in this region varies almost directly with the local topography (Pl. XXXIX). Flowing wells are therefore not to be expected, except locally, and if obtained will probably have a short life (778, 779, 784).

Under the Red River flood plain and the terraces accompanying it are considerable gravel deposits which yield abundant supplies of water of poor quality. This is the source of most of the water used in the bottom lands. In sinking deep wells the common practice in this region is to penetrate these gravels with a 3-inch casing, which is firmly seated in the underlying blue clay; a hole an inch or two in diameter is then drilled, which is cased but a few feet. In general it is felt that it would be better to case the wells the entire depth, using a still larger casing to penetrate the upper gravels, and to place screens opposite each of the water-bearing sands. The greatest care must be taken to cut out the water in the surficial gravels, or it will seriously impair the quality of the water obtained in the Sabine sands (797).

CADDO PARISH

The principal water-bearing horizons in Caddo Parish are (1) the Quaternary, or Port Hudson, gravels and sands, and (2) the sands in the Sabine formation (Pl. XXXVIII, secs. D, E, I).

The Quaternary, or Port Hudson, gravels and sands underlie the Red River flood plain at depths of 75 to 130 feet (782–785, 788, 796, 799, 800, 804, 805). They supply the shallow wells in this region, and will yield very large amounts when the wells are properly finished in the gravels near the base. The water is, however, hard, chalybeate, and alkaline, and a better quality can usually be obtained in the underlying sands.

The Sabine formation underlies all of Caddo Parish, except possibly a limited region near Sodo Lake, to a depth of 100 to 150 feet below sea level. In it there are several sand beds, some occurring in fairly well-defined horizons. These beds vary somewhat in thickness from place to place, but in general may be said to be available at any point in the parish. Failures are reported at Furrh (802), Uni (835, 836), and Dixie (801), but all of these represent essentially local variations. That the Furrh well represents only a local absence of the Sabine water sands is shown by the successful wells at Shreveport, Blanchard, and Marshall (Pl. XXXVIII, sec. I). At Uni a sand bed was encountered in the proper stratigraphic position (Pl, XXXVIII, sec. F), but yielded no water, though successful wells have been finished all about it. The well three miles south of Dixie, at the mouth of Cottonwood Bayou (801), has apparently struck one of the peculiar Cretaceous domes which occur irregularly throughout Louisiana, and which yield impotable salt water. To judge from other cases, the area affected by this disturbance is not great (p. 18). The conditions everywhere in Caddo Parish warrant sinking wells to depths of 100 to 150 feet below sea level, if water is not encountered above that point, but it is useless to continue them deeper. Below this point are the Midway and Arkadelphia clays, which contain no water, and below them is the Nacatoch sand, which contains artesian salt water (806, 871). Several deeper wells have been drilled throughout the parish, and it is popularly, though incorrectly, supposed that good water has been obtained at greater depths. At Shreveport there are several water-bearing horizons (fig. 35), the best one being about 50 feet below sea level. The water head varies almost directly with the local topography, and flowing wells are essentially of local occurrence. Nearly all the wells in this region are cased only part of the way to the bottom. It is believed to be desirable to case them the entire distance and to place proper screens opposite each horizon.

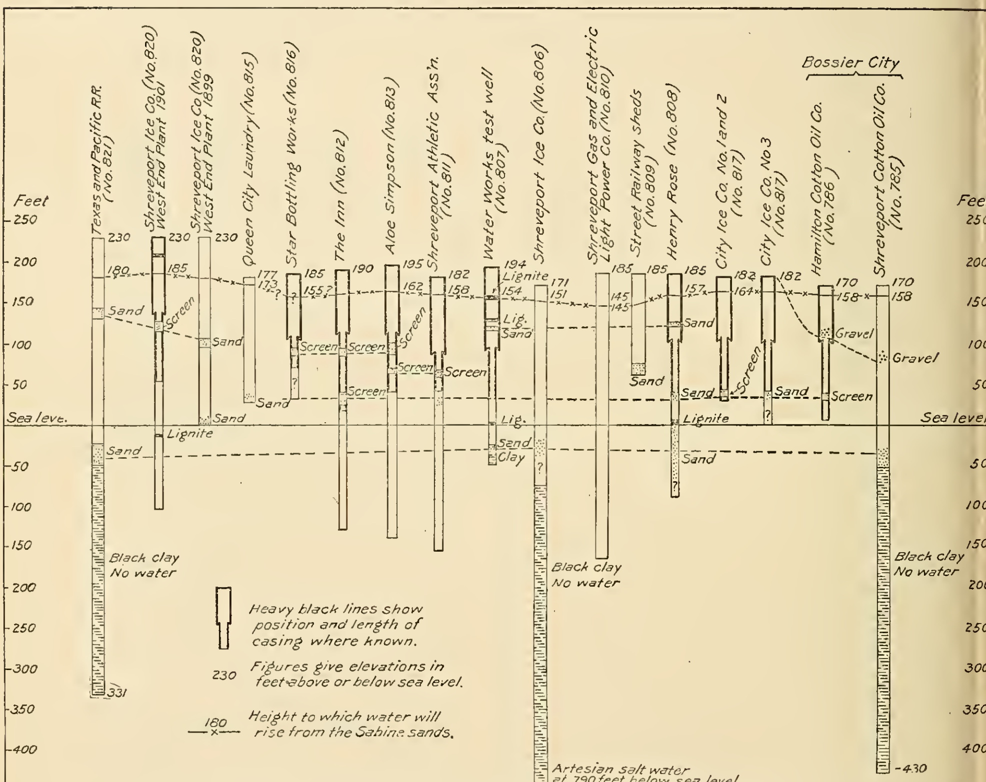


FIG. 35.—Wells in the vicinity of Shreveport, Caddo Parish, La.

CALDWELL PARISH

In Caldwell Parish large water supplies can commonly be obtained in the Quaternary sands and gravels which underlie the flood plain of Ouachita and Boeuf rivers at depths of from 25 to 100 feet (Pls. XXXVIII, sec. B.). In the hill lands shallow wells can be finished at almost any point, though in the southern and southeastern parts of the parish, in the region of the calcareous Jackson clays, the water is very hard and the yield not always good.

Of the deep waters the best results are to be obtained in the Sabine water sands. The top of this group will be encountered at depths ranging from 200 feet below sea level in the northwestern part to 900 feet in the southeastern part. This is the horizon developed in the Columbia well (841), at the depth of 358 to 438 feet below sea level, and in the many wells about Monroe (Pl. XXXVIII, sec. B). Over all the eastern part of the parish it will furnish flowing water. This is the most promising horizon along the Iron Mountain Railway south of Columbia; it will be encountered at depths ranging from 400 feet below sea level at Columbia to 800 feet at the Caldwell-Catahoula parish line. In no case would it be advisable to go much deeper than indicated on Pl. XL.

At a distance of 400 to 500 feet above the Sabine water sand is the basal Cockfield horizon (Pl. XXXVIII, sec. B). This may be reached by surface wells in the northern part of the parish, and by deep wells in the southeastern part. It has been found in wells at Clark Spur (838–840), Olla (856–857), Rochelle (881), and Leland (855). In all the deeper wells it furnishes impotable water, and it is not regarded as a horizon of much economic importance. Wells, except those north of the outcrop of the Jackson formation (Pl. XXVII), must be continued to the Sabine sands.

CATAHOULA PARISH

The chief underground-water supplies of Catahoula Parish are contained in (1) the Quaternary, or Port Hudson, deposits, (2) the Catahoula, (3) the Cockfield, and (4) the Sabine formations (Pl. XXXVIII, sec. B).

The Port Hudson deposits, are best developed in the lowlands along Little and Ouachita rivers and south of Catahoula Lake and Brushley Bayou (Pls. XXVII; XXXVIII, sec. B). These beds contain large supplies and are the ones most commonly developed. Shallow driven wells yield sufficient water for ordinary purposes, and when large supplies are needed they can be obtained in the main gravel beds at depths ranging from 50 to 150 feet.

The Catahoula beds form the high sandy hills northwest of Catahoula Lake and Brushley Bayou (Pl. XXVII). Here shallow wells generally yield good soft water. These sandy beds dip regularly southeastward, and are found under the parish south of the outcrop at depths less than those shown on Pl. XLII. This is the natural source for water at Harrisonburg, and in the region along and north of Little River and Catahoula Lakė, where in the lowlands flowing water will probably be obtained. There is some probability, as indicated by the Ferriday well, that in the extreme southern part of the parish salt water will be encountered. In the central portion, however, no trouble is anticipated. In the neighboring parishes the Catahoula beds supply the water at Pollock, Alexandria, Boyce, and Zimmerman. If a well does not obtain water in the Catahoula formation, it is believed to be inadvisable to sink deeper.

The next group of water sands occurs about 1,000 feet below the Catahoula (Pl. XXXVIII, sec. B) in the Cockfield formation. These have been encountered in wells at Leland, (855) Colfax, (871), Olla (856–857), and Rochelle (881), and in all these cases have yielded unsatisfactory water.

Below the basal Cockfield occur the Sabine sands, and in the northwestern part of the parish, beyond Bayou Funne Louis where the Catahoula sands are not available (Pls. XXVII; XLII) this is regarded as the most promising horizon. Successful wells have been finished in these beds at Columbia and along the Arkansas Southern Railroad from Winnfield northward (Pl. XXXVIII, secs. B, C). Its upper limit should be encountered at depths ranging from 800 feet at Olla to 1,000 feet at Georgetown or Rochelle. In no case will it be advisable to go deeper than 1,500 feet (Pl. XL). One unfavorable feature of the outlook here is the salt springs on Bayou Castor. If they represent brine leaking from one of the Cretaceous domes, it is possible that even the lowest horizon will be impregnated with salty water. In view of this, wells are more likely to succeed near the Catahoula-Caldwell Parish line than farther south.

CLAIBORNE PARISH

The conditions for deep water supplies in Claiborne Parish are very favorable. The Sabine water sands are everywhere available at depths not exceeding 200 feet below sea level (Pl. XL). Should the water sands in any case be locally absent, it is not advisable to continue wells deeper; the underlying Midway and Arkadelphia clays contain no water, and the Nacatoch sand, which lies 700 feet below the basal Sabine, furnishes salty water. (Pl. XXXVIII, sec. C, E, I). The head of the water from the Sabine sands will vary almost directly with the local topography (Pl. XXXIX), but flowing wells are likely to be developed in the bottom lands along Bayou D'Arbonne and Middle Fork.

CONCORDIA PARISH

Concordia Parish lies wholly within the flood plain of the Mississippi, and the usual supply is from the surficial gravel beds encountered at depths less than 150 feet. These yield very large supplies of somewhat chalybeate water suitable for boiler purposes.

The deep-well prospects are not very favorable; of the several early Tertiary formations, the Catahoula would be expected to yield the best water. In a number of wells at Natchez and Vidalia horizons have been developed in the upper part of this formation at depths of 300 to 500 feet. These horizons will be encountered to the south at depths which will increase about 50 feet per mile.

A deep test well put down by the Texas and Pacific Railway at Ferriday (866) obtained flowing salt water from the basal Catahoula beds at about the same horizon developed in the deepest wells at Alexandria (Pl. XXXVIII, secs. A, B). Below the Catahoula the water sands in the Cockfield and Sabine probably contain highly mineral water at this point, and it is hardly worth while to drill to them.

DE SOTO PARISH

Although but one deep well has been sunk in De Soto Parish (871), the wells in the surrounding parishes and the general geologic structure indicate very favorable conditions. Satisfactory water sands may be expected throughout the parish at depths ranging from less than 100 feet below sea level in the northwestern part to 200 feet in the southeastern part (Pls. (XXXVIII, sec. F; XL). The height to which the water will rise depends somewhat on the local topography, but throughout the parish will commonly be 175 feet above sea level (Pl. XXXIX). At Mansfield it is quite likely that the height will be over 200 feet. Flowing wells may be expected locally in deep valleys flanked by high hills; the most promising region for such wells is the east-central portion of the parish, along the western edge of the Red River flood plain and in the very deep valleys tributary to it. The water will usually be soft and alkaline and the yield abundant. The town of Mansfield should have no difficulty in developing a water supply from deep wells.

In case satisfactory water is not developed at any point at a depth less than those given above, it will not be advisable to continue the well deeper. Below the basal Sabine sands are the clays of the Midway and Arkadelphia formations, and below these the Nacatoch sand, which yields artesian salt water at Shreveport (806) and Ferriday (871).

EAST CARROLL PARISH

The Port Hudson silts, sands, and gravels underlie all of East Carroll Parish to depths of from 100 to 150 feet and will yield very large supplies of rather chalybeate water. Wells to yield the greatest amount should be finished in the gravel beds which lie near the base of these surficial deposits (Pl. XXXVIII, sec. A).

The Eocene water-bearing sands can be reached at any point by drilling to the requisite depth (Pls. XXXVIII, sec. A; XL, XLI). The quality of the water is, however, very uncertain. On the one hand, there is a highly mineral water developed in the wells at Crossett (6), Delhi (962), and Vicksburg (1,037), which comes from the Sabine sands (Pl. XXXVIII, secs. A, B, I). On the other hand, there is good water in the wells at Satartia (1,045), Yazoo City (1,046–1,049), Greenville (1,039), and Blissville (145). The deep well at Lake Providence developed the same horizon found in the Empire well (26). Better water might be obtained in the Cockfield horizon at an additional depth of 200 or 300 feet (Pl.

XXXVIII, sec. A). Flowing water would doubtless be obtained at this point from the Sabine sands at a depth of about 100 feet below sea level. The water from this horizon at Yazoo City is good, at Crossett bad, and the quality at Lake Providence can be determined only by boring.

FRANKLIN PARISH

The most important water-bearing formation in Franklin Parish is the Port Hudson. This underlies the whole parish, and the coarser beds, which can commonly be developed at depths ranging from 75 to 150 feet, will furnish very large supplies of fairly good boiler water.

Of the Eocene horizons, the only one of probable importance is the Sabine. The uppermost Sabine horizon, or that encountered in the Monroe (921–925), Columbia (841), and Delhi (962) wells will be found in this parish at depths ranging from 500 feet below sea level in the western part to 1,000 feet in the southeastern part. It will probably furnish mineral water of a character varying from potable water at Monroe and Columbia to the impotable water at Delhi. This horizon at Winnsboro will be found at 700 to 800 feet below sea level and will perhaps furnish feebly flowing water. In no case will it be advisable to go deeper than indicated on Pl. XL, unless a test well several thousand feet deep is contemplated.

GRANT PARISH

The principal water-bearing beds underlying Grant Parish are (1) the surfical gravels, (2) the Catahoula sands and sandstones, (3) the Cockfield sands, and (4) the Sabine sands.

The Port Hudson gravels are of importance only in the Red River flood plain, where they will furnish large supplies at depths of from 70 to 130 feet. Less important sands are encountered above these basal gravels, in which driven wells can often be finished, but for large yields the wells should be completed in the lower gravels. Over much of the hill land there are irregular deposits of gravel, which supply local wells with very pure water. A very important development of this sort is found near Sand Spur, where a number of wells have been completed for the St. Louis, Iron Mountain and Southern Railway (882).

The Catahoula beds form the high sandy hills in the southeastern part of the parish and wherever developed yield excellent water. Several different horizons occur in this group, as shown by the wells at Zimmerman, Boyce and Alexandria, and in no case will it be advisable to go deeper than shown on Pl. XLII. Flowing water will be encountered along Red River Valley in the southwestern part of the parish 10 miles south of Colfax, and along Little River.

The Cockfield member, which outcrops in southern Winn Parish (Pls. XXVII, XXXVIII, sec. D), contains several horizons which are of doubtful value in this parish. The most important occurs near the base, or about 1,000 feet below the Catahoula. This has been developed at Colfax (877) and at Rochelle (881), and in each case has furnished artesian salty water. At Rochelle better results may be obtained in the underlying Sabine sands, which will be encountered at depths over a thousand feet below sea level, but the presence of a Cretaceous dome at Cedar Lick and the suggested presence of one at Castor Salt Springs indicate that the probabilities are against such a development though potable water has been obtained in this Sabine horizon at Winnfield (998).

The Sabine sands yield very salty water at Luella (906) and Natchitoches (909,911), in Natchitoches Parish, and as these are believed to be due in large part to salt water from the Cretaceous domes no better results can be hoped for in western and southern Grant. On the whole, in Grant Parish surface wells are the only source of underground supply, except in the region of the Catahoula formation.

The chances of getting water at Colfax by going deeper are not very promising, except at very great depths. The first Cretaceous sand, the Nacatoch, if it is present in this region, occurs about 2,000 feet below the basal Cockfield, or, roughly, 3,000 feet from the surface. This yields artesian salt water at Shreveport (806) and Frierson (871) and will doubtless yield salt water here. In northeastern Texas, about 1,000 feet below this, is the sub-Clarksville sand, which will probably also yield salty water (Pl. XXXVIII, sec. H). One thousand feet deeper are the basal Woodbine horizons, which yield somewhat mineral water. The most promising horizons are the Paluxy and Trinity, which, at Corsicana, Tex., according to Hill,[1] are, roughly, 500 and 2,400 feet below the Woodbine. According to this estimate, which is necessarily a very rough one, the Paluxy sand is 5,500 feet below the surface at Colfax and the base of the Trinity 7,500 feet. The cost of so deep a well would be almost prohibitive, yet it is hardly worth while starting to drill at Colfax unless some such depth is planned for.

JACKSON PARISH

The deep-well propects throughout Jackson Parish are very promising. No circumstances are known which would introduce unfavorable conditions. Wherever wells have been drilled they have yielded satisfactory results, both in this parish, as at Ansley, Hodge, Jonesboro, and Wyatt (Pl. XXXVIII, sec. C), and in adjoining parishes, as at Ruston (890,891), Monroe (921,925), Columbia (841), Winnfield (998), Tannehill (997), and Pyburn (996). (See Pls. XXXVIII, secs. B, C, I; XL).

The depth of profitable development ranges from nearly 200 feet below sea level in the western part of the parish to 500 feet in the extreme southeastern part. At Vernon a good water-bearing stratum will probably be developed at a depth of 100 feet below sea level.

LINCOLN PARISH

Abundant supplies of water may be expected throughout Lincoln Parish at depths ranging from not over 200 feet below sea level in the western part of the parish to 400 feet in the eastern part (Pl. XL). Several water-bearing horizons will be encountered above this extreme depth. Where all the sands are locally absent, it will not be advisable to go much deeper than indicated. The principal horizon developed in the Dubach and Ruston wells, and in the adjoining parishes in the Ansley, Arcadia and Monroe wells (Pl. XXXVIII, secs. C, I), occurs at depths ranging from 100 feet below sea level in the western part of the parish to 200 feet in the eastern part. The Sabine sands will furnish flowing water along Bayou D'Arbonne and Middle Fork (Pl. XI).

[1]Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7, 1901, pls. 69–71.

MADISON PARISH

Madison is one of the alluvial parishes, in which the most available water supply is in the Port Hudson gravels. These extend to depths of over 100 feet (Pl. XXXVIII, sec. I; wells 892–894) and will everywhere furnish large supplies of water suitable for boiler use. The deep-well prospects are very unfavorable. Artesian water can be obtained throughout the parish from the upper Sabine sands at depths ranging from 800 to 1,000 feet below sea level, but this, as indicated by the wells at Delhi (962) and Vicksburg (1037), is too highly mineral to be of use. There is little chance that the deeper water horizons will yield better results. According to the best information obtainable the well at Delta (893) should have obtained artesian salt water at 1,000 feet below sea level. The depth reported for this well is believed to be rather excessive.

MOREHOUSE PARISH

At no place in Morehouse Parish do the Eocene beds outcrop. The Port Hudson deposits, with a thin covering of alluvium in some places, form the whole surface of the parish and underlie it to depths of from 50 to 200 feet. These beds are coarser in their lower portions and will furnish very large supplies of slightly hard, chalybeate water, which is fairly good for boiler use (896–899).

No wells have yet been sunk in this parish below these surficial beds, but water may be developed in the underlying Eocene sands in all parts of the parish. South of the Alabama Landing fault line (p. 60) water can be developed in the same horizon that is found at Monroe and Delhi (Pl. XXXVIII, sec. B, I) at depths ranging from 200 to 400 feet below sea level in the western part of the parish to 700 to 900 feet in the southeastern part. The quality of the water will be between that at Monroe (921–924) and Delhi (962) and will flow over most of the bottom lands. North of the Alabama Landing fault line the basal Cockfield horizon will be encountered at depths between 300 to 400 feet below sea level. This horizon furnishes sulphur water at Crossett (6) and good water at Blissville (145), Dermott (24), and Greenville (1039). Its quality in northern Morehouse Parish could be determined only by drilling, but it will probably be mineral. A lower horizon can be reached in this portion of the parish at depths between 800 and 1,000 feet. This is the stratum which furnishes salty water at Crossett (Pl. XXXVIII, sec. B), and there is no reason to hope for better results here.

NATCHITOCHES PARISH

Natchitoches Parish presents in surface outcrops a very singular combination of five of the six most important water-bearing formations of northern Louisiana and southern Arkansas; nevertheless it is a region in which good water can be obtained only with difficulty.

The Port Hudson gravels are well developed under the Red River floodplain, where they extend to depths of about 150 feet. When the underlying beds are not calcareous, as in the portion of the valley about St. Maurice, the water is a fairly good chalybeate water, but to the south, where the underlying clays belong to the calcareous Claiborne and Jackson groups, the water is very hard and cisterns are commonly used.

The Catahoula formation outcrops in the southern part of the parish (Pls. III, XLIII) and near the Vernon Parish line will be available in deep wells. This group of sands has been developed in the adjoining parish of Rapides at Zimmerman, Boyce and Alexandria (Pl. XXXVIII, sec. E). As yet no deep wells have been sunk in this formation in Natchitoches Parish.

The Cockfield member outcrops in a narrow belt in T. 7 N. Rs. 8 and 9 W. (Pl. XXVII.) It furnishes good water where developed at Weaver Spur (917) near the outcrop, and it is the most promising horizon at Montrose, where it will be encountered at a depth of about 600 feet (Pl. XXXVIII, sec. E). This horizon dips southeastward and is encountered at a depth of 1,100 feet at Colfax, where it furnishes artesian salt water (Pl. XLI).

The underlying Sabine sands (Pl. XXXVIII sec. E) are of value only in the extreme west-central portion of the parish, beyond the area of contamination from the salt water that leaks from the Cretaceous domes at Drakes, Prices, Rayburns, and Kings (Pls. III, XXXVIII, sec E; XLI). Near Natchitoches there is a layer in the very uppermost part of the Sabine, just below the Claiborne, which is of local importance. It outcrops in the hills just south of Grande Ecore on Red River, and supplies the numerous springs north of Natchitoches, as Camp Salubrity Spring, Breazeale Spring, Iron Spring, and Fourth of July Spring. It is the horizon developed in the shallow wells at the waterworks (910), and encountered between 98 and 108 feet in the normal school well (911). The lower horizons, which are not interrupted by Red River (Pl. XXXVIII, sec. E), yield very salty water, which will flow in Red River Valley. These have been developed at Luella (906) and Natchitoches (909, 911), and in the adjoining Red River Parish at Lake End (960). Only in the extreme west-central portion of the parish about Marthaville and Robeline are the conditions in the Sabine sands regarded as favorable. Here, on account of the high land in northern Sabine and De Soto parishes, the direction of deep underflow is toward Red River Valley, and the head is so much higher that it prevents the inflow of the salt water from the north. Artesian water of good quality is reported at Boleyn (901) at a depth of 412 feet, and similar developments are to be expected in the same region.

At Drakes Salt Works, in the northern part of the parish, and at the salt works in the adjacent parishes of Winn and Bienville, the uppermost water horizon of the Cretaceous series, the Nacatoch sand is exposed and furnishes salt water (Pl. XXXVIII, sec. E). The brine escaping from these domes is, in part, responsible for the salinity of the water in the Sabine sands, and the prospects in northern Natchitoches for good wells in these sands are not very favorable; water-bearing beds will, however, be encountered at about the depth shown on Pl. XXXVIII sec. E.

The poor quality of the deep-well water in the greater part of this parish makes it desirable to ascertain what can be found in the underlying Cretaceous deposits. At Natchitoches, according to the best data at hand, the Nacatoch sand is 1,500 to 2,000 feet from the surface. This yields artesian salty water at Shreveport (806) and Frierson (871). In northeastern Texas about 1,000 feet below the Nacatoch is the sub-Clarksville sand, which will probably yield salty water. One thousand feet deeper are the basal Woodbine horizons (p.24), which will yield somewhat mineral water. The most promising horizons are the Paluxy and Trinity, which, at Corsicana, Tex., according to Hill,[2] are, roughly, 500 and 2,400 feet below the Woodbine. According to this estimate, which is necessarily a very rough one, the base of the Trinity at Natchitoches is about 6,000 feet from the surface, and the Paluxy 4,000 feet. The cost of so deep a well would be very great, yet it is hardly worth while starting to drill at Natchitoches unless some such depth is planned for. Such a deep test well might be undertaken by the cooperation of the State, the parish, the town, and the railroads of that section, for all would be benefited by the results obtained.

OUACHITA PARISH

Ouachita Parish is half hill land and half alluvial land. In the hills shallow wells yielding sufficient water for domestic and small plantation uses can be finished at almost any point. In the bottom lands inexhaustible supplies of slightly hard chalybeate water are to be obtained from the surficial Port Hudson gravels, which underlie this section of the parish, at depths, of 100 to 150 feet.

The Sabine sands underlie the whole parish and will be encountered at depths of from 200 to 400 feet below sea level (Pls. XXXVIII, sec. B, I; XL). In all the alluvial land and in some of the larger valleys of the hill land this water will flow. It has been extensively developed about Monroe (921, 924), where it furnishes a soft alkaline water which is extensively used by the industries at that place and by the large plantations. The water will probably be less mineral in the western portion of the parish than in the eastern.

RAPIDES PARISH

The principal sources of underground-water supply in Rapides Parish are (1) the Port Hudson gravels, (2) the very late Tertiary gravels, and (3) the Catahoula formation.

The Port Hudson gravels are well developed under the Red River flood plain and some of the terraces along it (Pl. XXXVIII, sec. B). The coarser beds are reached at depths of 100 to 150 feet (937, 940, 947, 948, 952), though shallower wells can often be

[2]Twenty-first Ann. Rept. U. S. Geol. Survey, pt. 7, 1901, pls. 69-71.

finished. This horizon yields good boiler water, and the tests at Lecompte (948) indicate that it is a very satisfactory quality for municipal purposes. Much of the hill land is covered with late Tertiary gravels, and in the southern part of the parish these are sometimes of sufficient thickness to be of considerable importance as sources of water.

The Catahoula formation is the source of the deep water developed at Zimmerman (956), Boyce (942–946) and Alexandria (933—939; Pl. XLII, secs. B, C). In all the northern part of the parish except in the immediate vicinity of Colfax, where they are absent, these beds will furnish the best water obtainable. The principal horizons are encountered from 400 to 500 feet above the base, and the ordinary depth of wells will be about 500 feet less than that given on Pl. XLII, which refers to the base of the formation. It will not be advisable in any case to go below the Catahoula. Flowing water is to be expected in Red River Valley and in the extreme northeastern portion of the parish about Catahoula Lake.

RED RIVER PARISH

In the hill lands of Red River Parish there has as yet been no demand for very large water supplies, and surface wells have furnished all the water needed. In the more thickly settled region, along Red River Valley, large supplies have been easily obtained from the Port Hudson sands and gravels, which underlie the whole flood plain and furnish, from the lower, coarser beds, at a depth of about 100 feet, unlimited supplies of hard water which is fairly good for boiler use.

The water-bearing sands of the Sabine, which underlie the whole of the parish, have been developed at only one point, Lake End (960), where they have yielded salty water. The quality of the water in these beds in other portions of the parish can be determined only by drilling. In the northeastern and eastern portions, in the direction of the Cretaceous domes (Pl. XL), they are likely to yield salty water; but in the northwestern and western portions the chances are somewhat better because, west of Red River, the greater head (Pl. XXXIX, p. 126), will prevent an inflow of salty water from the fractured Cretaceous beds brought up in the domes north of Red River. The Many dome is probably not a disturbing factor. Wells near the western side of the Valley, or in the steep creek valleys tributary to it, may furnish artesian water.

In developing these beds it is not advisable to go deeper than 100 to 200 feet below sea level (Pl. XL), unless it is planned to sink a very deep test well. The prospects along this line have been discussed under Natchitoches Parish (p. 125). At Coushatta the lower beds will be reached at a depth of about 700 feet less than at Natchitoches.

RICHLAND PARISH

In Richland Parish, as in the other parishes east of Ouachita River, large supplies can be obtained in the surficial and Port Hudson deposits, which underlie the whole region. Wells can commonly be finished at depths of from 25 to 50 feet, but where large supplies are desired it is generally advisable to go to the coarse gravels which overlie the older Tertiary beds. These beds are commonly encountered at a depth of 100 to 150 feet.

Artesian water from the Sabine sands may be obtained in any part of the parish by going to the requisite depth, which will usually be from 400 to 500 feet below sea level in the western and southwestern portions of the parish and 700 feet in the extreme eastern portion. This horizon is developed at Monroe (921—924), Columbia (841), and Delhi (962; Pl. XXXVIII, secs. B,I). The quality of the water at any point may be roughly predicted by its position relative to these three localities. Along Bayou Lafourche and Boeuf River, in the west central and south-western portions of the parish, the chances are sufficiently good to warrant sinking deep wells. In no case will it be advisable to go below the depths given on Pl. XL, unless a test well 4,000 to 6,000 feet deep is planned.

SABINE PARISH

In Sabine Parish, in the region north of the Cockfield member (Pls. XL, XLI), the best water horizons are in the Sabine sands. These have been developed at Noble, Zwolle, Plymouth, Loring, and Negreet (Pl. XXXVIII, sec. F). With the possible exception of the Negreet well, the water obtained in each of the above cases is to be recommended rather then the surface water, which is commonly used about the mill towns. It is certainly less likely to be contaminated, and the mineral matter does not appear to be greater than in other wells where good results have been obtained. These sand beds vary considerably from point to point, but may be said, in general, to be available at any locality.

Flowing water has been obtained from this group of horizons at Boleyn (901), on Bayou Negreet (969), and at Robinsons Ferry (1120), and is likely to be developed in deep wells in the northeastern part of the parish and along Sabine River. Deep in the embed and south of the Bayou Negreet Salt Springs the water is highly mineral, but in the whole southern part of the parish where this occurs water can be obtained from the Cockfield member or in the upper part of the Claiborne. These beds cross the parish in a narrow belt just south of Many (Pl. XXVII) and dip southward. At Robinsons Ferry a soft artesian water has been obtained at a depth of 1,010 to 1,030 feet (Pl. XXXVIII,) sec. F). This is regarded as a horizon of probable importance in southern Sabine Parish (Pl. XLI).

TENSAS PARISH

This is an alluvial parish in which the best water is obtained in the Port Hudson gravels. These are commonly encountered at depths varying from 100 to 150 feet, and yield large supplies of chalybeate water. No deep wells have been sunk, though the conditions are favorable in the area shown on Pl. XLII, in which the base of the Catahoula is from 0 to 500 feet below sea level, and in wells not over 400 feet deep along Mississippi River below this belt. In the first case it is hoped to develop the lower Catahoula sands found in the Catahoula Shoals and Leland wells (Pl. XXXVIII, sec. B); and in the second to develop the upper Catahoula sand found in the Port Gibson and Natchez wells (Pl. XXXVIII, sec. A) which are supplied by a lateral westward flow from the Mississippi region. Deep wells in the southern part of the parish as indicated by the Ferriday well (866), will probably obtain salt water.

UNION PARISH

The deep-well prospects are very favorable throughout Union Parish. Two successful wells have been developed at Randolph (979), and the wells in the adjoining parishes at Dubach (889), Ruston (890–891), and about Monroe (921-927) clearly indicate the conditions to be expected (Pl. XXXVIII, secs. B, C, I). South of the Red River-Alabama Landing fault line, water will be encountered at depths ranging from 100 to 300 feet below sea level and in no case will it be advisable to go deeper than shown on Pl. XL, or 200 feet below sea level in the western part of the parish and 500 feet below in the eastern part. Flowing water is to be expected along Bayous D' Arbonne, Cornie, and L'Outre and their principal tributaries. At Farmerville the horizon developed at Randolph, Dubach, Ruston, and Monroe will be encountered at about 200 feet below sea level. North of the fault, water can be obtained in the upper Eocene or Cockfield sands at 0.300 feet below sea level, but it will not be advisable to try to develop the lower sands, as the wells at Crosset (6) and Bearden (628) obtained very unsatisfactory water from this horizon (Pl. XXXVIII, secs. B, C).

VERNON PARISH

With the exception of that obtained in the surficial gravels, the underground water supply of Vernon Parish is to be obtained from the Catahoula beds (p. 128). This formation yields good results at Zimmerman, Boyce, and Alexandria, in Rapides Parish, and near Rockland, Tex.

In Vernon Parish but two deep wells have been sunk; that at Hawthorn (980) is reported as successful and that at Pickering (981) as unsuccessful. It will be seen from the dip shown on Pl. L that the Pickering well lacked about 100 feet of reaching the horizon developed at Hawthorn. Between the Hawthorn horizon and the extreme depth shown on Pl. XLIII several water-bearing sands are to be expected which will yield good soft water. In the hill lands along the Kansas City Southern Railway water will not flow, but on Sabine River below Bayou Toro flowing wells are to be expected. It is believed to be inadvisable to go deeper than shown on Pl. XLIII, as the water in the underlying Cockfield and Sabine sands will probably be salty.

WEBSTER PARISH

In Webster Parish, except in the limited area around and south of the Cretaceous dome at the Bisteneau Salt Works (Pls. XXXVIII, secs. C, I; XL), very good water can be obtained from the Sabine sands at depths less than 200 feet below sea level. The main water horizon, as developed in the wells at Taylor (139–140), Spring Hill (989), Cotton Valley (938), Minden (985–987), and near Shreveport, is about 100 feet below sea level throughout the parish. Above this sand a minor horizon has been developed at Allentown (775) and in the ice factory and cotton-oil mill well at Minden (988). The failure at yellow pine is due to the disturbance of the Bisteneau dome, which directly affects only a small area. Good water can probably be obtained at Lanesville and Dubberly at the depths indicated by the Minden well.

WEST CARROLL PARISH

Throughout West Carroll Parish the Port Hudson deposits are very near the surface. They form the Bayou Macon hills and in the bottom lands are overlain by but a thin covering of alluvium. These beds are from 100 to 150 feet thick, and the coarser beds near the base will yield very large supplies of somewhat hard chalybeate water.

No wells have as yet been sunk below these gravels, but in every part of the parish water can be obtained in the underlying Eocene beds. South of the Alabama Landing fault line water can be had in the horizon developed at Monroe (921–927), Delhi (962), and Vicksburg (1037), at depths between 300 and 500 feet below sea level (Pl. XXXVIII, secs. A', B, I). This water will probably flow, but, as indicated by the Delhi and Vicksburg wells, will be highly mineral. Other horizons may be developed for several hundred feet below this one, and will probably also yield mineral water.

North of the fault line the basal Cockfield, or upper Eocene water sands, will be encountered at depths between 400 and 500 feet below sea level. This horizon furnishes sulphur water at Crossett (6; Pl. XXXVII, sec. B), and good water at Blissville (145), Dermott (24), and Greenville (1039; Pl. XXXVIII, sec. A). Its quality in northern West Carroll Parish can be determined only by drilling. Two hundred feet below this horizon is that developed in the Empire and Lake Providence wells (Pl. XXXVIII, sec. A). A lower horizon can be reached in this portion of the parish at depths between 800 and 1,000 feet. This is the stratum which furnishes salty water at Crossett (Pl. XXXVII, sec. B), and there is little reason to hope for better results here.

WINN PARISH

The three important water-bearing formations available in Winn Parish are (1) the Nacatoch, (2) the Sabine, and (3) the Cockfield. The Nacatoch is commonly from 1,000 to 2,000 feet below sea level in this region, but is folded up in the Cretaceous domes (Pl. XXXVIII, secs. C, I). It yields salty water, which, leaking from the fractured and truncated domes, fills the Sabine sands to the southwest.

The Sabine formation, which occurs about 700 feet above the Nacatoch, and is from 500 to 900 feet thick, likewise underlies the whole parish (Pl. XXXVIII, sec. C; XLI). In the region north and east of the domes the sands in this formation yield good fresh water, which at Winnfield (998) is artesian. South and southwest of the Cretaceous domes these sands are present, but, as shown at Luella (906) and Natchitoches (909—911 ; Pl. XXXVIII, sec. E), they will probably yield salty water, though the exact limit of the brine impregnated areas can de determined only by drilling.

The Cockfield member outcrops in a belt extending across the parish south of St. Maurice and Winnfield (Pls. XXVII, XLI). Along the outcrop these beds will probably yield potable water at depths varying from a few feet at the northern edge to 500 feet near the Cockfield-Jackson contact (Pl. XXXVIII, sec. C). In the embed, as shown at Rochelle 881 and Colfax 871, this horizon will yield salty water.

Wells and springs in LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	AVOYELLES PARISH.						
[1]756	Bunkie	1 S . .	3 E .	. . . .	General [2]	. . . .	Postmaster . . . .
757	. . . do.	1 S . .	3 E .	. . . .	Bunkie Compress and Warehouse Co.	. . . .	Bunkie Compress and Warehouse Co.
*758	. . . do.	1 S . .	3 E .	. . . .	Union Oil Co. . .	. . . .	Union Oil Co. . . .
*759	. . . do.	1 S .	3 E .	. . . .	Bunkie Ice and Bottling Co.	. . . .	C. J. Pope, president.
760	. . do.	1 S . .	3 E .	. . . .	Texas and Pacific Rwy.	. . . .	G. W. Reiber, pumpman.
761	Bunkie, 1 mile west of.	1 S . .	3 E .	. . . .	——Sentell	L. B. Hart Well Co.	L. B. Hart Well Co.
762	Cottonport. . . .	1 S . .	4 E .	. . . .	Lemoine Brothers.	. . . do	. . . do . . . .
*762A	Eggbend	. . . .	. . . .	. . . .	T. L. Grimes. . .	. . . .	T. L. Grimes . . . .
763	Mansura.	1 N .	4 E .	. . . .	Emil Regard . . .	. . . .	Emil Regard . . . .
764	. . . do.	1 N .	4 E .	. . . .	Regard cotton gin	L. B. Hart Well Co.	L. B. Hart Well Co.
*765	Marksville.	2 N .	4 E .	. . . .	Natchez and Marksville Oil Co.	W. B. Sturm . . .	A. W. Myers, foreman.
*766	. . . do.	2 N .	4 E .	. . . .	General	. . . .	C. P. Couvillion . .
*767	. . . do.	2 N .	4 E .	. . . .	Corporation . . .	Andrews Well Co.	. . . do . . . .
	BRINVILLE PARISH.						
*768	Arcadia	18 N .	5 W .	. . . .	Vicksburg, Shreveport and Pacific Rwy	Andrews Well Co.	H. P. Touzet, foreman for Andrews Well Co.
768A	. . . do	18 N .	5 W .	. . . .	Levy Compress Co.	Will A. Strong . .	Will A. Strong . . .
*769	. . . do	18 N .	5 W .	19. . .	Dr. J C Christian	. . . .	Dr. O Lerch [3] . . .
*770	Jamestown	15 N .	8 W .	. . . .	John Gigleux. . .	John Gigleux. . .	John Gigleux. . . .
*771	Kings Salt Works .	15 N .	8 W .	34-35 .	H. P. Wardlaw. .	. . . .	A. C. Veatch [4] . . .
*772	Rayburns Salt Works.	15 N .	5 W .	34. . .	A G. Whitlow . .	. . . .	A. C. Veatch [5] . . .
	BOSSIER PARISH.						
773	Alden Bridge . . .	20 N .	13 W .	34[6] . .	Whited & Wheless	L. B. Clifford Well Co.	L. B. Clifford . . .
*774	. . . do.	20 N .	13 W .	34[6] . .	. . . do	. . . do	. . . do . . . .
775	Allentown	18 N .	11 W .	11[6] . .	Allen Brothers & Wadley.	. . . .	Allen Brothers & Wadley.
*776	Antrim	22 N .	13 W .	27[6] . .	Antrim Lumber Co.	L B. Clifford Well Co.	Thos. A. Antrim, president.
777	Arkana	. . . .	. . . .	. . . .	Trigg Lumber Co.	. . . do	L. B. Clifford . . .
*778	Benton	20 N .	13 W .	30[6] . . .	W. H. Smith & Son.	J. P. Clifford. . .	W. H. Smith. . . .
779	Benton, 1 mile north of.	. . .	. . . .	. . . .	Lone Star Mill . .	. . . do	J. P. Clifford. . . .

* For additional data see "Descriptive notes," following this table.

1 Numbers up to 156 refer to Arkansas localities and hence are not given in this report. The location of many may be seen on Pl. XXXVII.

2 See note.

3 Geology and Agriculture of Louisiana, pt. 1, 1892, pp. 46-47.

northern Louisiana.

(NORTHERN)

Diameter of well	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*				
....	12–40	....	....	......	....	....	......	.....	....	756
4	180	65	— 10	......	....	66	Quaternary ..	.....	....	757
4	158	....	— 8	......	....	50	...do ..	Hard, alkaline.	....	758
4	140	....	— 16	115-140	....	100	...do ..	Hard.	Strainer, 16 feet ..	759
4 4	142 90	...	— 13	......	....	....	...do ..	.....	....	760
....	135	....	— 10	......	....	....	...do ..	Hard.	2 wells	761
....	135	....	....	......	....	....	...do ..	..do ..	....	762
....	35–60	....	....	......	....	....	.do ..	.do ..	....	762A
6	110	....	— 32	......	....	140	...do ..	Alkaline; magnesia.	....	763
....	135	....	....	......	....	....	...do ..	.....	....	764
16	1,282	85	....	42–132 243–259 452–523	....	40	Quaternary	Hard.	....	765
....	40–150	....	....	40 45 65	....	Small. Large.	Quaternary ..	Hard. .	....	766
6–4	[2]290	82	— 42	......	....	100	......	Brackish	Public well; used for stock.	767
8–6	540	363	—130	40 150 165 415–465 535-540?	...	53	Sabine ..	Hard. .	Supplies water tank: pumped with air lift.	768
5-3½	535	370	—136	435	....	....	...do ..	Soft ...	Casing and strainer, 480 feet.	768A
....	....	....	....	......	....	....	......	..	Mineral well	769
2	145	235	....	142	....	....	Sabine ..	Hard. .	....	770
3? 36	136 10–20	160 160	— 2	......	....	....	Nacatoch	Brine. .	Salt manufactured from 1840 to 1865.	771
....	10–20	....	....	......	....	....	...do ..	.....	Salt manufactured from 1840 to 1877.	772
4	286	209	— 30	140-160 260–286	....	 42	Sabine .. ...do ..	Strongly alkaline. Good[7] ..	In red sand..... In gray sand	773
6	233	211	....	120–140 230-233	....	 125	...do . ...do ..	.. Good[7] .	.... In gray sand	774
5	110	....	— 9	......	....	....	...do ..	Soft . .	Used for boilers in saw mill	775
5	300	255	— 6	160–263	....	....	...do ..	. . do . .	Fine for boilers and drinking ..	776
3	110	....	....	......	....	....	......	..	Completed in 1896 .	777
2½	350	215	[8]—20	......	....	Large.	Sabine ..	Soft . .	Completed in 1899	778
3	196	215	([8])	......	....	....	...do ..	.....	Water above a bed of lignite.	779

[4] Geological Survey Louisiana, Rept. of 1902, pp. 76-80.
[5] Op. cit., pp. 71-75.
[6] In town.
[7] Also reported "a little hard."
[8] Flowed for a short time.

Wells and springs in
LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	BOSSIER PARISH—continued						
780	Benton	. . . .	. . . .	. . . .	. . . do	. . . do	. . . do . . . .
781	Benton, 4 miles east of.	. . . .	. . . .	. . . .	Hanks Sawmill. .	. . . do	. . . do . . . .
*782	Bolinger	23 N .	13 W .	34. . .	S. H. Bolinger & Co	L. B. Clifford Well Co.	. . . .
*783	Bossier City, 3 miles north of.	. . . .	. . . .	. . . .	Cash Plantation .	A. L. Pullin . . .	A. L. Pullin . . . .
*784	Bossier City, 2½ miles north of.	. . . .	. . . .	. . . .	Benj. Gray	A. L. Pullin . . .	A. L. Pullin . . . .
*785	Bossier City	. . . .	. . . .	. . . .	Shreveport Cotton Oil Co.	. . . .	. . . .
*786	. . . do.	. . . .	. . . .	. . . .	Hamilton Oil Mill Co	Stoer & Backus .	Stoer & Backus. . .
787	Bossier City, 5 miles southeast of.	. . . .	. . . .	. . . .	J. H. Fullilove. .	. . . do.	J. H. Fullilove. . .
*788	Collinsburg, 8 miles south of.	21N .	14W .	. . . .	Will Sentell . . .	. . . .	. . . .
789	Curtis	17N .	13W .	. . . .	A. Curtis	. . . .	A. Curtis. . . . . .
790	Curtis Station . . .	17N .	13W .	. . . .	. . . do	. . . .	. . . .
791	Foster Station . . .	18N .	13W .	. . . .	J. F. Foster . . .	. . . .	J. F. Foster . . .
792	Foster Station, 1 mile north of.	18N .	13W .	. . . .	J. M. Foster Planting Co	. . . .	J. M. Foster Planting Co.
793	Haughton	18N .	11W .	. . . .	R. L. McAnn . .	Stoer & Backus. .	Stoer & Backus. . .
794	Pool	15N .	11W .	. . . .	Connell, Moss & Co	. . . do	. . . do . . . .
	Red River Valley .	. . . .	. . . .	. . . .	General	A. L. Pullin . . .	A. L. Pullin . . . .
	CADDO PARISH.						
*795	Belcher	20N .	14W .	5. . .	Glassell Brothers.	A. L. Pullin . . .	A. L. Pullin . . . .
*796	. . . do.	20N .	14W .	5. . .	John Glassell. . .	. . . do	. . . do . . . .
*797	Belcher, 3 miles northeast of.	21N .	14W .	34. . .	Colonel Swan . .	. . . do	. . . do . . . .
798	Blanchard	18N	15W .	3. . .	R. T. Coal & Son.	. . . do.	R. T. Coal . . . . .
*799	Dixie	20N .	14W .	29. . .	M. A. & J. D. Dickson	. . . .	. . . .
*800	Dixie, 2½ miles east of.	20N .	14W .	26. . .	John Sentell . . .	A. L. Pullin . . .	A. L. Pullin . . . .
*801	Dixie, 3 miles southwest of.	19N .	15W .	2. . .	Glassell & Adger.	. . . do.	E. M. Adger . . .
*802	Furrh :	. . . .	. . . .	. . . .	Furrh & Co . . .	. . . do.	A. L. Pullin . . . .
*803	Missionary	23N .	14W .	4. . .	W. B. Means. . .	Stoer & Backus. .	Stoer & Backus. . .
*804	Red River Valley .	. . . .	. . . .	. . . .	General	A. L. Pullin . . .	A. L. Pullin[6] . . .

*For additional data see "Descriptive notes," following this table.
[1] Flowed for a short time.
[2] Water lowered on pumping to 30 feet below the surface.

northern Louisiana—Continued.

(NORTHERN)—Continued.

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*				
3	140	215	— 8	. . . . . .	. . . .	. . . .	. . .do . .	. . . . .	. . . .	780
2½	170	215	. . . .	. . . . . .	. . . .	. . . .	. . .do . .	Soft . .	. . . .	781
3 4 4	235 235 315	309	— 40	162-235	. . . .	Large.	. . .do . .	. . do . .	Used for mill and drinking; temperature, 64° F.	782
3	330	177	— 35	50-130 155-160 180-185 315-330	. . . .	Large. 20	Quaternary Sabine . .	Hard. . do . . Bad . . Good .	Completed in 1898; casing, 120 feet.	783
2½	330	175	[1]— 28	300-330	. . . .	10	Sabine . .	Slightly hard.	Completed in 1898; casing, 80 feet.	784
4	600	170	[2]— 30	225-235	. . . .	. . . .	. . .do . .	. . . .	No water below 235 feet.	785
6-4	195	170	[2]— 12	147-159	. . . .	. . . .	. . .do . .	Hard .	Screen placed from 147 to 159 feet; end of casing at 169 feet.	786
2½-1	210	164	[3]— 12	172-210	. . . .	10	. . .do . .	Iron, alkaline.	Temperature, 66° F.	787
2½	600	195	— 15	30-120- 232-240-	. . . .	. . . .	Quaternary Sabine . .	Hard. . Soft. . .	Well at Lake Point on Red River.	788
2½	197	174	— 15	197	. . . .	. . . .	. . .do . .	Soft, alkaline.	Temperature, 66° F.; casing, 100 feet.	789
. . . .	200±	170±	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	Poor . .	. . . . .	790
3	210	167	[4]— 14	200-210	. . . .	20	Sabine . .	Hard. .	Casing, 150 feet. . .	791
3	215	167	— 10	. . . . . .	. . . .	20	. . .do . .	Soft. . .	Casing, 140 feet. .	792
2½-1¼	250	230	. . . .	200-250	. . . .	. . . .	. . .do . .	. . do . .	1¼ inch screen from 200 to 25[illegible] feet; completed in 1890.	793
. . . .	300	. . . .	. . . .	105-111	. . . .	. . . .	. . . . . .	. . . . .	Screen placed 105-111 feet.	794
. . . .	. . . .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	See No. 804.	
3-2	260	186.5	— 12	245-260	. . . .	Large.	Sabine . .	Soft. . .	Casing, 3 inches, 0-160 feet; 2 inches 160-220.	795
2½	225	187.5	— 8	213-225	. . . .	. . . .	. . .do . .	do . .	Temperature, 66° F; casing, 100 feet.	796
2½	240	193	— 4	30-125 230-240	. . . .	Large. . .do	Pleistocene Sabine . .	Hard. . Soft .	Gravel at 125 feet; Crescent place.	797
3	185	227	— 16	. .	. . . .	. . . .	. . .do . .	Soft, fine	Casing, 100 feet.	798
2½-1½	371	182	— 12	21[illegible] 225	. . . .	. . . .	. . .do . .	Soft . .	No water below 225 feet.	799
3 3	391 182	183	— 16	170-182	. . . .	16	. . .do . .	Soft, brackish	. . . .	800
. . . .	425	175	. . . .	425	. . . .	Large.	. . . . . .	Hard, salty.	Abandoned.	801
3	750	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Dry hole, abandoned	802
3-2	290	205	[5]+0.4	152-158 2[illegible]2 270	1	50	Sabine . .	Soft . .	Completed in 1900 .	803
. . . .	. . . .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	804

[3] Lowers on pumping to — 24 feet.
[4] Depth to water in 1898 was 6 feet.
[5] Sept. 20, 1902. In 1900 water would rise 2 feet.
[6] Geol. Survey Louisiana, Rept. for 1899, 1900, pp. 179-181.

Wells and springs in
LOUISIANA

No.	Location.	Town-ship.	Range.	Sec-tion.	Owner.	Driller.	Authority.
	CADDO PARISH—continued.						
*805	Robson	16 N .	12W .	18. . .	Captain Robson .	A. L. Pullin . . .	A. L. Pullin . . . .
*806	Shreveport (Market street and Cross Bayou).	. . .	. . . .	. . . .	Shreveport Ice Co.	American Well Works Co.	. . . . F. Collins, chief engineer.
*807	Shreveport (Louisiana avenue and Cross Bayou).	. . . .	. . . .	. . . .	Shreveport water works.	A. L. Pullin . . .	H. F. Juengst, C. E.
*808	Shreveport (Spring between Texas and Milam streets).	. . . .	. . . .	. . . .	Henry Rose . . .	Stoer & Backus. .	Stoer & Backus. . .
809	Shreveport (Market and Cypress streets).	. . . .	. . . .	. . . .	Shreveport Street Railway.	. . . .	L. M. Levison . . .
810	Shreveport (Edwards and Cypress streets).	. . . .	. . . .	. . . .	Shreveport Gas, Electric Light and Power Co.	. . . .	Engineer . . . . .
811	Shreveport (Marshall and Crockett streets).	. . .	. . . .	. . . .	Shreveport Athletic Association.	Stoer & Bac' us. .	Chas. Stoer. . . . .
*812	Shreveport (Milam and Louisiana streets).	. . .	. . . .	. . . .	The Inn	. . . do	. . . do . . . .
813	. . . do	. . . .	. . . .	. . . .	Aloe Simpson . .	. . . do	. . . do . . . .
814	Shreveport (Louisiana and Donovan streets).	. . .	. . . .	. . . .	Andrew Currie . .	. . . .	. . . .
815	Shreveport (Louisiana and Howell streets).	. . . .	. . . .	. . . .	Queen City Laundry	Stoer & Backus. .	John Sewell, proprietor.
816	Shreveport (Louisiana and Lake streets).	. . .	. . . .	. . . .	Star bottling works	. . . do	Chas. Stoer. . . . . .
*817	Shreveport (Commerce and Battle streets).	. . .	. . . .	. . . .	City Ice Co. . . .	. . . do	—Alexander, manager.
818	Shreveport (Texas and Tryon streets).	. . . .	. . . .	. . . .	Chas. Stoer. . . .	. . . do	Chas. Stoer. . . . .
819	Shreveport (Texas street).	. . . .	. . . .	. . . .	C. C. McCloud . .	. . . do	. . . do . . . .
820	Shreveport (M. K. & T. and T. & P. crossing).	. . .	. . . .	. . . .	Shreveport Ice Co.	A. L. Pullin . . . Stoer & Backus. .	A. L. Pullin . . . . Chas. Stoer. . . . .
821	Shreveport Junction.	. . . .	. . . .	. . . .	Texas and Pacific Rwy.	American Weil Works Co.	. . . .

*For additional data see "Descriptive notes," following this table.
[1]Depth also given, 165–175.
[2]Each well.
[3]Test November, 1899.

northern Louisiana—Continued

(NORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
4	225	155	—16	79–106	. . . .	Large.	Pleistocene	Hard, alkaline iron.	Completed in 1898.	805
				225	. . . .	. . do .	Sabine . .	Soft, magnesia.		
4	996	171	—20	200±	. . . .	. . . .	. . . do . .	Soft . .	With gas; temperature, 84° F.	806
			+15	961-996	. . . .	. . . .	Nacatoch.	Brine .		
5 4½ 4½	1250	171	—30	200±	. . . .	225	Sabine . .	Soft . .	Water used in making ice; temperature, 70° ± F.	
6-4½	244	194	—43	218-228	. . . .	370	. . . do . .	. . do . .	City supply from filtered surface water.	807
4-2½	280	185	—18	. . . . . .	. . . .	20	. . . do . .	. . do . .	Temperature, 66° F.	808
4	120	185	. . . .	120	. . . .	. . . .	. . . do .	. . do . .	Good for boiler purposes.	809
4	350±	185	—40	. . . . . .	. . . .	. . . .	. . . do . .	Slightly hard .	. . . .	810
6-4	338	182	—24	106 150 ?	. . .	30±	. . . do . .	Alk'line soft.	Casing, 6-inch, 0 to 96 feet; 4-inch, 96 to 150 feet; screen, 20 feet	811
4-2½	324	190	. . . .	99-109 148-163 ?	. . .	30	. . . do . .	Soft . .	Pumps sand if pumped hard.	812
4-2½	335	195	—32	93-105 148-163 ?	. . .	. . .	. . . do . .	. . . . .	Casing, 4 inch, 0 to 83 ft.; 2½ inch, 83 to 157 ft.; used for laundry.	813
	Springs	. . . .	. . . .	. . . . . .	50 ±	. . . .	. . . . . .	Soft . .	Used largely for drinking water in Shreveport.	814
3	150±	177	— 45	. . . . . .	. . . .	Large.	Sabine . .	. . do . .	Used for laundry in 1898.	815
3-1½	137+	185	—30	117 ?	. . .	. . do .	. . . do . .	. . do . .	Casing and screen, 137 feet; temperature, 68° F.	816
6-4	150	182	. . . .	140- 150	. . . .	47	. . do . .	. . do . .	Water scales badly.	817
6-4	180	182	—18	. . . . . .	. . . .	9				
6 4	290	182	. . . .	. . . . . .	. . . .	7				
2½	350±	215	—20	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	818
2½	220	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	819
6-4½	237	230	. . . .	140-146 213-225	. . .	+30	Sabine . .	Soft . .	Completed June, 1899; temperature, 68° F.	820
6-4½	338	230	—45	140-150 ?	. .	5+30	. . . do . .	Iron, soft[6].	Completed June, 1901; lignite at 240 feet.	
7	561	230	—50	80-100 250 280	. . .	60	. . . do . .	Soft	No water below 280 ft.	821

[4] With air lift; driller reports 24 gallons each with deep-well pump.
[5] Estimated by engineer 75 gallons.
[6] Slight smell of hydrogen sulphide.

Wells and springs in
LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	CADDO PARISH continued.						
822	. . . do.	. . . .	. . .	. . . .	Stave factory . . .	. . . .	Chas. Stoer. . . . .
823	Shreveport (High House addition)	. . .	. . . .	. . . .	R. E. Bell	Stoer & Backus. .	. . . do . . . .
824	Shreveport .	. . . .	. . . .	. . . .	T. C. Backus . . .	. . . do	. . . do . . . .
825	Shreveport (Olive street).	. . .	. . . .	. . . .	Claiborne Foster .	Chas. Stoer. . . . A. L. Pullin . . .	. . do . . . . . A. L. Pullin . . . .
826	. . . do	. . . .	. . . .	. . . .	J. M. Foster . . .	. . do . . . . Chas. Stoer. . .	. . . do . . . . Chas. Stoer . . . . .
827	Shreveport (9-Mile House).	. . . .	. . . .	. . . .	S. B. Nichols. . .	Richter & Pullin .	. . . do . . . .
828	Shreveport, 2½ miles southeast of, on Grigsbys Island.	17N .	13W .	. . . .	Ardis & Co. . . .	. . . .	U. H. Brown, agent.
*829	Shreveport, 3 miles southeast of, on Shreves Island.	17N .	13W .	. . . .	Aug. Mayer . . .	. . . .	Aug. Mayer . . . .
830	Shreveport, 4 miles southeast of, on Harts Island.	17N .	13W .	. . . .	Andrew Querbes .	. . . .	Chas. Stoer. . . . .
831	Shreveport, 8 miles southeast of, on Dogwood Place.	17N .	13W .	. . . .	R. K. Colquitt . .	Stoer & Backus. .	. . . do . . . .
*832	Shreveport, 10 miles southeast of, on Bayou Pierre.	. . . .	. . . .	. . . .	A. H. Leonard . .	. . . do	Stoer & Backus. . .
*834	Surrey.	20N .	16W .	1 . . .	. . . .	. . . .	A. C. Veatch[2] . . .
*835	Uni	20N .	14W .	. . . .	Uni Plantation . .	A. L. Pullin . . .	A. L. Pullin . . . .
836	Uni, 1 mile west of	21N	14W .	8 . . .	W. S. Taylor. . .	. . . do	. . . do . . . .
	CALDWELL PARISH						
*837	Blankston	14N	3E .	. . . .	U. S. Eng. test boring.	. . . .	M. H. Marshall[3]. .
*838	Clarks.	12N	3E .	. . . .	Clark Spur Lumber Co	Oscar Shanks. . .	Oscar Shanks. . . .
839	. . . do	12N	3E	. . . .	. . . do	. . . do	. . . do . . . .
*840	. . . do	12N .	3E .	. . . .	. . do	. . . do	. . . do . . . .
*841	Columbia	13N	3E .	17. . .	Town of Columbia	Oscar Shanks. . .	County clerk . . . .
*842	Columbia, 2 miles below . . .	13N .	3E .	. . . .	U. S. Eng test boring	. . . .	M. H. Marshall[3]. .
*843	Columbia	. . . .	. . . .	. . . .	. . . do	. . . .	. . . do . . . .
*844	Col'bia, 1 mile above	. . . .	. . . .	. . . .	. . . do	. . . .	. . do . . . .
*845	Columbia, 2 miles above.	. . .	. . . .	. . . .	. . . do	. . . .	. . . do . . . .
*846	Columbia, 3 miles above.	. . . .	. . . .	. . . .	. . do.	. . . .	. . . .
*847	Ouachita River (Call Landing).	. . . .	. . . .	. . . .	. . . do	. . . .	. . . .

*For additional data see "Descriptive notes," following this table.
[1]Owner reports 15 feet.

northern Louisiana—Continued

(NORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
4 2½	180	230	—60	......	....	....	...do..	.....	....	822
2½-1½	225	....	....	1 0-123 140-144 ?	...	....	...do..	Soft..	Casing, 158 ft.: completed September, 1901.	823
2½-1½	103+	....	....	103	....	....	...do..	..do..	....	824
2½	160	....	....	......	....	....	...do..	..do..	Casing, 100 feet.	825
2½	245	240±	....	......	....	....	...do..	..do..	Completed in 1890.	
2¼	225	230±	....	......	....	....	...do..	..do..	...do......	826
2½	180	....	....	......	....	....	...do..	..do..	Casing, 80 feet...	
2½	197	....	....	......	....	....	......	..do..	Completed in 1897.	827
2½	210	176	—18	......	....	+5	Sabine..	..do..	Does not scale boilers; temperature, 67.5° F.	828
2½	201	172	—15	100 200	....	 10	Quaternary. Sabine..	Alk'line hard. Soft..	Completed in 1893.	829
2½-1½	197	170	—20	......	....	....	...do..	..do..	....	830
2½ 1½	288	167	1—8	......	....	Large.	...do..	..do...	Casing, 110 feet...	831
2½-1½	205	....	—18	......	....	..do.	...do..	..do..	At gin.......	832
....	55	....	....	......	...	....	Quaternary.	Hard, sulphur	....	834
....	650	185	....	......	....	None.	......	.....	No water in sand between 190 and 198 ft.	835
....	370	....	....	......	....	..do.	......	.....	Same sections as Uni well.	836
....	51 50 50	27 15 27	...	......	....	....	......	.....	....	837
....	208	150±	—70	135-145	....	68	Cockfield.	Soft..	Completed January, 1, 1903.	838
....	300	150±	—80	252-300	....	50	Cockfield?	Iron..	Completed August, 1901.	839
....	180	150±	—80	110-150	....	30	...do..	..do.	Bad for boilers and drinking. Completed in 1902.	840
4-2	503	65	+35	423-503	20	....	Sabine..	Soft, magnesia.	Completed August, 1903.	841
....	43	15	....	......	....	....	......	.....	....	842
....	52	18.5	....	......	....	....	......	.....	....	843
....	220	20	....	......	....	....	......	.....	....	844
....	48	28	....	......	....	....	......	.....	....	845
....	52	24	....	......	....	....	......	.....	....	846
....	50 50	14 16	...	......	....	....	......	.....	....	847

[2]Geol. Survey Louisiana, Rept. for 1899, [1900], p. 190.
[3]Rept. Chief of Eng. for 1902, pt. 2, 1902, pp. 1560-1563.

Wells and springs in
LOUISIANA

No.	Location.	Town-ship.	Range.	Sec-tion.	Owner.	Driller.	Authority.
	CALDWELL PARISH—continued						
*848	Ouachita River (Lower Breston place.)				. . . do		. . . do
*849	Ouachita River (Upper Breston place)				. . . do		. . . do
*850	Ouachita River (Smithland.)				. . . do		. . . do
	CATAHOULA PARISH						
*851	Black River (New Hope place.)	6N.	7E		Test boring		M. H. Marshall[1]
*852	Black River (Star View place.)	6N.	7E		. . . do		. . . do
*853	Black River (Jones Bayou).	7N.	6E		. . . do		. . . do
*854	Catahoula Lake						
*855	Leland				Catahoula Oil and Development Co.		S. McDowell, president.
*856	Olla	11N.	2E		St. Louis, Iron Mountain and Southern Rwy.		E. Fisher, chief engineer of bridges and buildings.
857	Olla, 1 mile south of	11N.	2E		Smith & Adams Lumber Co.		Smith & Adams Lumber Co.
*859	Ouachita River (Catahoula Shoals).				Test boring		M. H. Marshall[1]
860	Tullos	10N.	1E		St. Louis, Iron Mountain and Southern Rwy.		Postmaster
861	Tullos, northeast of.						A. R. Kilpatrick[3]
*862	White Sulphur Springs.	7N.	2E				S. H. Lockett[4]
	CLAIBORNE PARISH						
862A	Haynesville				Hampton Stave Co.	Chas. Halloway	Hampton Stave Co.
*863	Lisbon, 6 miles east of.	21N.	4W	15			Dr. O. Lerch[5]
864	State line	23N.	8W		J. F. Deloach & Bro.	Stoer & Backus.	Chas. Stoer.
	CONCORDIA PARISH						
. . . .	Black River						
865	Black River station.	7N.	6E		Natchez, Red River and Texas R. R.		A. A. Gardner, vice-president.
866	Ferriday				Texas and Pacific Rwy.		B. S. Wathen, chief engineer.
*867	Fish Pond				. . do		C. H. Chamberlin, division engineer.
868	Helena				New Orleans and N'eastern R. R.		S. McDowell.
869	Vidalia	7N.	10E		Natchez, Red River and Texas R. R.		A. A. Gardner, vice-president.
870	. . . do	7N.	10E		Concordia Oil Co.		S. McDowell.

*For additional data see "Descriptive notes," following this table.
[1]Rept. Chief of Eng. for 1902, pt. 2, 1902, pp. 1560-1563.
[2]See "Descriptive notes."
[3]DeBow's Review, vol. 12, 1852, pp. 268-269.

northern Louisiana—Continued

(NORTHERN)–Continued.

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above ( ) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE.		Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
					Flow.	Pump.				
Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*				
....	47	13	....	......	....	....	......	.....	....	848
....	{ 52 { 52	17 18	{ ...	......	....	....	......	.....	....	849
....	47	19	....	......	....	....	......	.....	....	850
....	{ 39 { 41	5 2	} ...	......	....	....	......	.....	....	851
....	50	8	....	......	....	....	......	.....	....	852
....	50	6	....	......	....	....	......	.....	....	853
....	Springs	....	....	......	....	....	......	Salty. .	Numerous salt sp'gs.	854
	1,550	....	Flows.	(5)	10	....	Cockfield.	.....	Salt water with gas; temperature 86.5° F.	855
....	374	....	....	......	....	Small	......	.....	Abandoned.	856
....	297	150±	—130	......	....	Large	Cockfield.	Sulphur, iron.	Not used.	857
....	197	11	Flows.	158–197	60	....	Catahoula	.....	....	859
....	400±	106	....	......	....	....	Cockfield.	Salty. .	....	860
....	Springs	....	....	......	....	....	......	Brine .	Bayou Castor salt springs.	861
....	. do . .	....	....	......	....	....	Catahoula	Sulphur.	....	862
4–3	600	350+	—20	......	....	Large .	Sabine . .	Soft . .	Completed in 1904 .	862 A
....	Spring.	....	....	......	....	....	......	.....	....	863
3–1½	285	....	—65	205–285	....	....	Sabine . .	Good, soft	Completed in 1900; casing 200 feet.	864
....	....	....	....	......	....	....	......	.....	See under Catahoula Parish.	....
5	70	....	....	......	....	....	Quaternary	.....	....	865
....	950	60	Flows.	950	Small.	Large .	Catahoula	Brine .	Alluvial d'p's, 0–80; yellow clay, 80–950.	866
4	145	....	—10	105–145	....	140	Quaternary	.....	Used for locomotives	867
....	340?	60	Flows.	......	....	....	......	Brine .	Probably refers to Ferriday well.	868
5	70	63	—40	......	....	15	Quaternary	.....	....	869
....	300±	63	...	......	....	....	Catahoula	Fresh .	....	870

[4]Ann. Rept. Louisiana State Univ. for 1869, 1870, p. 57.
[5]Preliminary report on the wells of Louisiana south of the Vicksburg, Shreveport and Pacific Railway; Geol. and Agr. of Louisiana, pt. 2, 1893, p. 118.

Wells and springs in
LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	DE SOTO PARISH						
*871	Frierson	15N. .	13W .	. . . .	R. G. Hedrick . .	. . . .	Foreman . . . . . .
871 A	Grand Cane, 3½ mi., from.	. . . .	. . . .	. . . .	. . . .	. . . .	A. C. Peale[1] . . . .
	EAST CARROLL PARISH						
*872	Hays Landing . . .	20N. .	13E .	. . . .	Test boring. . . .	. . . .	E. W. Hilgard[2]. . .
*873	Lake Providence. .	21N. .	13E .	. . . .	. . do	. . . .	do . . . .
874	. . . do.	21N. .	13E .	. . . .	Town of Providence	L. B. Hart Well Co.	F. J. Powell, mayor
*875	. . . do.	21N. .	13E .	. . . .	. . . .	. . . .	G. D. Harris[3]. . . .
	FRANKLIN PARISH						
876	Wisner	12N. .	8E .	. . . .	St. Louis, Iron Mountain and Southern Rwy.	C. H. Winters . .	C. H Winters . . .
	GRANT PARISH						
*877	Colfax.	6N. .	3W .	7	Town of Colfax .	L. B. Hart Well Co.	L. B. Hart . . . . .
878	Fairmount	5N. .	3W .	. . . .	General	. . . .	Postmaster . . . . .
879	Georgetown	9N. .	1E .	. . . .	. . . do	. . . .	. . . do . . . .
*880	Pollock	6N. .	1E .	. . . .	Big Creek Lumber Co.	. . . .	. . . .
*881	Rochelle	9N. .	1E .	. . . .	Louisiana Lumber Co. (Ltd.)	Oscar Shanks. . .	Oscar Shanks. . . .
*882	Sandspur (Antonia station.)	7N. .	1E .	. . . .	St. Louis, Iron Mountain and Southern Rwy	. . . do	. . . do . . . .
*883	Stay.	6N. .	1W .	. . .	S. Hopper Mill Co.	. . . do	. . . do . . . .
	JACKSON PARISH						
*884	Ansley	16N. .	3W .	5	Davis Bros	L. B. Clifford Well Co.	L. B. Clifford . . .
*885	Hodge	16N. .	3W .	19	Huie-Hodge Lumber Co	. . . do	. . . do . . . .
*886	Jonesboro	15N. .	3W .	31	Southern Arkansas Lumber Co.	L. B. Clifford Well Co.	G. S. Smith[5]. . . .
*887	Wyatt	. . . .	. . . .	. . . .	Wyatt Lumber Co.	. . . do	L. B. Clifford . . .
	LINCOLN PARISH						
*888	Chautauqua Station.	. . . .	. . . .	. . . .	La. Chautauqua.	. . . .	Dr. O. Lerch[6] . . .
889	Dubach	20N. .	3W .	26	Fred B. Dubach Lumber Co.	L. B. Clifford Well Co.	L. B. Clifford . . .
*890	Ruston	18N. .	3W .	. . . .	Ruston Waterworks	. . do	. . . do . . . .

*For additional data see "Descriptive notes," following this table.
[1]Bull. U. S. Geol. Survey No. 32, 1886, p. 124.
[2]Ann. Rept. Miss. River Com. for 1883: 48th Cong., 1st sess., House Ex. Doc. No. 37, 1884, pp. 494-496.
[3]Geol. Survey Louisiana, Rept. of 1902, pp. 231-232.

northern Louisiana—Continued.

(NORTHERN)—Continued.

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*				
8–4	1,500	198	Flows.	241–281; 998–1,275	. . . .; 10	. . . .	Sabine . .; Nacatoch?	. . . .; Salty. .	Not tested . . . . .; Salt water with gas; temperature 70F.	871
. . . .	. . . .	. . . .	. . . .	. . . . . .	+60	. . . .	Sabine . .	. . . . .	De Soto Mineral Springs, local resort	871 A
. . . .	181	100±	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Test boring of Mississippi River Commission.	872
. . . .	248	105	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	873
6	271	105	—22	. . . . . .	. . . .	80	Eocene. .	Good .	. . . .	874
. . . .	112	105	. . . .	. . . . . .	. . . .	. . . .	Quaternary	. . . . .	Water excessively ferruginous.	875
. . . .	100	75	—30	. . . . . .	. . . .	+50	Quaternary	. . . . .	. . . .	876
2½	1,128	96	—15; +65	70–130; 1,103	. . . .; 440	Large .;	Quaternary; Cockfield.	. . . .; Salty. .	Gas at 660 and 1,100 ft; 2 ounces of salt per gallon.	877
. . . .	25	94	. . . .	. . . . . .	. . . .	. . . .	Quaternary	Hard .	. . . .	878
. . . .	35	76	. . . .	. . . . . .	. . . .	. . . .	. . . . .	Soft .	Below 35 feet water is salty.	879
8–4	910	88	5+16	255	2	. . . .	Catahoula	. . do . .	Used for drinking purposes.	880
. . . .	565	80	+5	555–565	1	75	Cockfield.	Salty. .	Abandoned. . . .	881
6	75	189	—45	60–75	. . . .	124	Lafayette?	Soft . .	Group of three wells	882
6	78	. . .	—45	60–78	. . . .	100	. . . . .	. . do . .	Water in gravel. . .	883
5	245	190	—33	190–245	. . . .	100	Sabine . .	Soft . .	Pumping 100 gallons per minute water lowers to 80 feet.	884
4	300	205	—36	292–300	. . . .	50	. . .do . .	. . do . .	Casing 300 feet; completed in 1901.	885
5	545	200	—34	500–545	. . . .	40	. . .do . .	. . do . .	Well at planer, completed in 1901.	886
4	538	200	—34	490–538	. . . .	34	. . .do . .	. . do . .	Well at sawmill, completed in 1902.	886
4	302	200±	. . .; —52	242–252; 272–302	. .	55	. . .do . .	. . do . .	. . . .	887
. . . .	Spring.	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	Iron . .	. . . .	888
5	179	135+	+6	173–179	. . . .	Large .	Sabine . .	Soft . .	Many fossil shells above water horizon	889
8–6	425	288	7—120	120–126; 373–425	. . . .;	. . . .; 68	Claiborne (lower).; Sabine . .	. . . . .; Soft . .	Will lower 40 ft. when pumping 100,000 gallons per day.	890

[4]In 1900; in 1902 flow reported 20 gallons.
[5]In 1896; in 1902 would rise only 5 feet.
[6]Geology and Agriculture of Louisiana, pt. 1, 1893, pp. 46–47.
[7]Chief engineer gives depth in 1902 as 137 feet.

Wells and springs in
LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	LINCOLN PARISH—continued						
891	Ruston	18N. .	3W	. . . .	Ruston Compress Co.	L. B. Clifford Well Co.	L. B. Clifford . . .
	MADISON PARISH						
892	Barnes	16N. .	13E .	. . . .	Vicksburg, Shreveport and Pacific Rwy.	. . . .	R. B. Coxe, superintendent water division
*893	Delta	16N. .	15E .	. . . .	. . . do	. . . .	. . . do . . . .
*894	Mound	16N.	14E .	. . . .	. . . do	. . . .	F. L. Maxwell . . .
	MOREHOUSE PARISH						
*895	. . . .	. . . .	. . . .	. . . .	General	. . . .	A. E. Washburn, parish surveyor.
*896	Bastrop	21N.	5E .	. . . .	Court-house . . .	. . . .	W. A. Harrington .
*897	Collinston	20N. .	6E .	. . . .	St. Louis, Iron Mountain and Southern Rwy.	C. H. Winters . .	C. H. Winters . . .
*898	Mer Rouge . . .	21N. .	7E .	. . . .	. . . do	Oscar Shanks. . .	Oscar Shanks. . . .
899	Oak Ridge	19N. .	7E .	. . . .	. . . do	C. H. Winters . .	C. H. Winters . . .
	NATCHITOCHES PARISH						
900	Allen	. . . .	. . . .	. . .	General	. . . .	D. A. Blackshear. .
*901	Boleyn	9N. .	10W .	19	Petty & Brown Lumber Co.	. . . .	D. G. Petty . . . .
902	Campti, 2 miles northeast of.	. . . .	. . . .	. . . .	Louisiana Railway and Navigation Co.	. . . .	Louisiana Railway and Navigation Co.
903	Derry	. . . .	. . . .	. . . .	General	. . . .	Postmaster . . . . .
*904	Goldonna[3]	12N. .	5W .	21	Louisiana and Arkansas Rwy.	H. H. Jones . . .	H. H. Jones . . . .
905	Grappes Bluff . . .	11N. .	8W .	. . . .	Sawmill	A. L. Pullin . .	A. L. Pullin . . . .
*906	Luella.	9N. .	6W .	. . . .	J. W. Cockerham, Jr.	. . . .	J. W. Cockerham, Jr.
907	. . . do.	9N. .	6W .	. . . .	. . . do	. . . .	. . do . . . . . .
*908	Montrose	7N. .	6W .	. . . .	Montrose Lumber Co.	. . . .	J. C. Rives, secretary
909	Natchitoches. . . .	9N. .	7W .	. . . .	City waterworks .	Clifford Well Co .	Judge C. H. Levy, superintendent.
*910	. . . do.	9N. .	7W .	. . . .	. . do	. . . .	. . do . . . . . .
*911	. . . do.	9N. .	7W .	. . . .	Natchitoches Normal School.	Andrews Well Co.	President Caldwell
912	Natchitoches, 1 mi west of.	9N. .	7W .	. . . .	Fourth of July Spring	. . . .	G. D. Harris[5]. . . .
*913	Natchitoches, 1½ miles northwest of.	9N. .	7W .	. . . .	Iron Springs . . .	. . . .	. . . do . . . .

*For additional data, see "Descriptive notes," following this table.
[1]Varies with height of river.
[2]Harris. G. D., Geol. Survey Louisiana, Rept. of 1902, pp. 231.

northern Louisiana—Continued

(NORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet*	*Feet*	*Feet*	*Feet*	*Galls.*	*Galls.*				
4	449	301	—140	. . . . . .	. . .	68	Sabine . .	Soft . .	Supplies compress and ice factory.	891
. . . .	72	81	(1)	28–72	. . . .	. . . .	Quaternary	. . . . .	Used for locomotives	892
. . . .	1,200±	87	[1]—38	12–50 100–135	. . . .	. . . .	. . . . . .	. . . . .	No water below 135 feet.	893
6	135	83	[1]—30	. . . . .	. . . .	. . . .	Quaternary	. . . . .	Used for locomotives	894
. . . .	25–60	. . . .	. . . .	. . . . . .	. . . .	. . . .	Quaternary	Slightly hard.	. . . .	895
36±	153	[2]113.4	[2]—67.1	67–153	. . . .	. . . .	. . .do . .	. . . . .	. . . .	896
6	81	79	— 8	64–81	. . . .	140+	. . .do . .	. . . .	Good soft water; exlent for locomotives	897
6	79	93	— 7	79–89	. . . .	70	. . .do . .	Iron . .	Completed in 1898 .	898
. . . .	40	(1)	. . . .	24–40	. . . .	. . . .	. . .do . .	. . . . .	. . . .	899
. . . .	Springs	. . . .	. . . .	. . . . . .	. . . .	. . . .	Sabine . .	. . . . .	Many chalybeate springs	900
1	412	250±	+20	412	. . . .	. . . .	. . .do . .	Good .	. . . .	901
. . . .	Spring.	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . do . .	Supplies railroad tank by pipe line.	902
. . . .	. . . .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	No wells. Cisterns used exclusively.	903
. . . .	475+	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Test well.	904
4	155	145	—25	. . . . . .	. . . .	. . . .	Quaternary	. . . . .	Water in coarse sand and gravel, 30-foot screen.	905
4	707	111	—20 Flows . do .	36–300? 640 700–707	. . . .	. . . .	. . .do? . Sabine . . . . .do . .	Iron . . Salty . . . do . .	. . . .	906
4 4 4	36 86 106	110	—20	. . . . . .	. . . .	10+	Quaternary	Iron . .	. . . .	907
6	496	100	. . . .	80–180	. . . .	Large.	. . .do . .	Poor . .	No water below 180 ft.	908
4	457	130	— 4	200–220 457	. . . .	. . . .	Sabine . . . . .do . .	Salty . Brine .	Salt water with gas .	909
360 1½	19–64	. . . .	— 3	. . . . . .	. . . .	200	. . . . . .	Good, soft .	. . . .	910
4–2½	726	130	—12 . . . [4]—0.5	35–38 96–108 710–726	. . . .	 25	Claiborne? Sabine . . . . .do . .	Brine . Fresh Brine .	Small amount of gas at 710 feet.	911
. . . .	Springs	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . .do . .	. . . . .	Local resort	912
. . . .	. .do .	. . . .	. . . .	. . . . . .	. . . .	. . .	. . .do . .	Iron . .	. . . .	913

[3]See No. 994, Drakes Salt Works, Winn Parish.
[4]Flowed for a short time after completion.
[5]Geol. Survey Louisiana, Rept. of 1902, pp. 147–148.

Wells and springs in
LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	NATCHITOCHES PARISH—continued						
*914	Natchitoches, 2 mil's northwest of.	9N. .	7W .	. . . .	Breazeale Springs	. . . .	G. D. Harris . . .
915	Natchitoches, 2 mil's north of.	9N .	7W .	. . . .	Sulphur Spring. .	. . . .	. . . .
916	Sans Souci.	11N. .	6W .	22	. . . .	. . . .	. . . .
917	Weaver Spur . . .	. . . .	. . . .	. . . .	Weaver Bros . . .	Stoer & Backus. .	Chas. Stoer . . . .
	OUACHITA PARISH						
*918	Bosco	. . . .	. . .	. . . .	U.S. Eng. test boring.	. . . .	M. H. Marshall[1] . .
*919	Cheniere, 3 miles southeast of.	17N .	3E .	. . . .	Louisiana Oil Co .	. . . .	. . . .
*920	Logtown	. . . .	. . . .	. . . .	U. S. Eng. test boring.	. . . .	M. H. Marshall[1] .
*921	Monroe	. . . .	. . . .	. . . .	Consolidated Ice Co.	Will A. Strong . .	Will A. Strong . . .
*922	. . . do.	. . . .	. . . .	. . . .	. . . do	. . . .	Consolidated Ice Co.
*923	. . . do.	. . . .	. . . .	. . . .	Monroe Waterw'ks and Light Co.	Will A. Strong . .	Will A. Strong . . .
*924	. . do.	. . . .	. . . .	. . . .	Planters' Oil Co .	. . . .	. . . .
925	Monroe, ¾ mile south of.	. . . .	. . . .	. . . .	Ouachita cotton mills.	. . . .	Guy P. Stubbs . . .
926	Monroe, ½ to 1½ miles north of.	. . . .	. . . .	. . . .	. . . .	. . . .	G. D. Harris[2] . . .
927	Monroe, 6 miles north of.	. . . .	. . . .	. . . .	Stubbs's place . .	. . . .	M. M. Munson[3] . .
*928	Monroe	. . . .	. . . .	. . . .	U.S. Eng. test borings.	. . . .	M. H. Marshall[1] . .
*929	Rock Row Shoals (Ouachita River.)	19N. .	3E .	. . . .	. . . .	. . . .	. . . .
	POINTE COUPEE PARISH						
930	. . . .	. . . .	. . . .	. . . .	General	. . . .	E. G. Benker, sheriff
931	Batchelor	. . . .	. . . .	. . . .	Texas and Pacific Rwy.	. . . .	B. S. Wathen, chief engineer.
932	New Roads	. . . .	. . . .	. . . .	. . . do	. . . .	. . . do . . . .
	RAPIDES PARISH						
*933	Alexandria (city hall)	4N. .	1W .	. . . .	Corporation of Alexandria.	Andrews Well Co.	(4)
*934	Alexandria (waterworks).	4N. .	1W .	. . . .	. . . do	. . do	(4)

*For additional data see "Descriptive notes," following this table.
[1]Ann. Rept. Chief of Eng. for 1902, pp. 1564–1566.
[2]Geol. Survey Louisiana, Rept of 1902, p. 211.
[3]Pump repairer, St. Louis, Iron Mountain and Southern Rwy.

northern Louisiana—Continued

(NORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
. . . .	Springs	. . . .	. . . .	. . . . . .	. . . .	. . .	Sabine . .	. . . . .	. . . .	914
. . . .	. . do .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . do . .	Sulphureted.	. . . .	915
. . . .	. . do .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . do . .	Iron . .	Local resort	916
4-2½	308	. . . .	—17	188	. . . .	. . . .	Cockfield.	Good .	Casing, 188 feet. . .	917
. . . .	44 32	25 16	. . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . .	. . . .	918
. . . .	515	85	Flows.	265–275 465 515	Small.	. . .	Sabine . .	. . . . .	. . . .	919
. . . .	50 50	15 17	. . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	920
5-3½	485	75	+40	20 65 280-485	 50	 50	Quaternary . . . do . . Sabine . .	Alkaline . . do . . Soft . .	Drilled in 1891 . . .	921
5-3½	360	75	+40	280-360	50	50	. . . do . .	. . do . .	Drilled in 1892; casing 80 feet.	
7-3½	400	75	Flows.	250–400	20	50	. . . do . .	Very soft	Drilled in 1901 . .	922
5-3½	385	80	. do . .	320-385	. . . .	. . . .	. . . do . .	Soft . .	Temperature 71° F.; completed in 1892.	923
4	400 ±	82	. do . .	. . . . . .	30	. . . .	. . . do . .	. . do . .	. . . .	924
5-3½	375	85	. do . .	. . . . . .	3	. . . .	. . . do . .	do . .	Used for factory and drinking.	925
. . . .	400 ±	. . . .	. do . .	. . . . . .	. . . .	. . . .	. . . do . .	. . . . .	Three wells.	926
4	260	. . . .	. do . .	. . . . . .	. . . .	. . . .	. . . do . .	. . . . .	Completed February, 1903; second well on this farm.	927
. . . .	51 50 44	38 44 28	. . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	928
. . . .	157 63	42 39	. . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	929
2-8	145-165	. . . .	. . . .	. . . . . .	. . . .	Large.	Quaternary	. . . . .	Palatable for drinking in some cases; used for machinery on sugar and cotton plantation.	930
. . . .	170	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . do . .	Good .	All alluvial; water in sand and gravel.	931
. . . .	190	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . do . .	. . do . .	Water in sand and gravel.	932
1½	473	78	[5]+10 [6]—60	. . . . .	10 ±	. . . .	Catahoula	Soft . .	. . . .	933
4-2½	560	77	[5]+12 [6]—138	540-560	50 ±	118	. . . do . .	. . do . .	Well No. 1. . . .	934

[4]See "Descriptive notes."
[5]In 1898.
[6]August 6, 1902.

Wells and springs in
LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	RAPIDES PARISH continued.						
*935	Alexandria (Waterworks).	4N. .	1W .	. . . .	Corporation of Alexandria.	Andrews Well Co.	([1])
*936	Alexandria (corner Fourth and St. James streets).	4N. .	1W .	. . . .	. . . do	. . . do	([1])
*937	Alexandria (round house).	4N. .	1W .	. . . .	St. Louis. Iron Mountain and Southern Rwy.	Hart Well Co . .	L. B. Hart . . . . .
*938	Alexandria (Sixth and Monroe sts).	4N. .	1W .	. . . .	Alexandria Ice and Storage Co.	Andrews Well Co.	Jas. Drouant[4] . . .
*939	. . . do.	4N. .	1W .	. . . .	. . do	Hart Well Co . .	G. D. Harris[5] . . .
*940	Alexandria	4N. .	1W .	. . . .	Sonia Cotton Oil Co.	. . . .	Ira W. Sylvester . .
*941	Ball	5N. .	1E .	. . . .	Ball Sawmill Co.	Shanks & Smith .	Oscar Shanks. . . .
942	Boyce	5N. .	3W .	. . . .	Texas and Pacific Rwy.	Hart Well Co . .	L. B. Hart . . . . .
*943	. . . do.	5N. .	3W .	. . . .	. . . do	. . do	. . . do . . . .
*944	. . . do.	5N. .	3W .	. . . .	Boyce Ice Manufacturing Co.	. . . .	D. J. Heidrich . . .
945	. . . do.	5N. .	3W .	. . . .	M. Grillette . .	. . . .	. . . do . . . .
946	. . . do.	5N.	3W .	. . . .	Boyce Cotton Oil and Manufacturing Co.	. . . .	H. P. Haynes, president.
*947	Lamothe	. . . .	. . . .	. . . .	L. C. Sanford . .	. . . .	L. C. Sanford . . .
948	Lecompte.	1N. .	1E .	. . . .	Corporation of Lecompte.	. . . .	Ira W. Sylvester, consulting engineer.
949	Loyd	1N. .	1E .	. . . .	Postmaster . . .	. . . .	General . . . . . .
*950	Pineville	4N. .	1W .	. . . .	Pineville Development Co.	. . . .	F. S. Hoyt, president
*951	do.	4N. .	1W .	. . . .	State Insane Asylum.	Oscar Shanks. . .	Oscar Shanks. . .
*952	Rapides	5N. .	3W .	. . . .	C. A. Morrow . .	. . . .	C. A. Morrow . .
*953	. . do.	4N. .	2W .	. . . .	. . . do	. . . .	. . . do . . . .
954	Richland	. . . .	. . . .	. . . .	General	. . . .	Postmaster . . . . .
955	Springhill	4N. .	4W .	1, 2	J. A. Bentley Lumber Co.	. . . .	J. A. Bentley. . . .
*956	Zimmerman	5N. .	3W .	. . . .	. . . do	. . . .	. . . do . . . .

*For additional data see "Descriptive notes," following this table.
[1]See "Descriptive notes."
[2]In 1898.
[3]August 6, 1902.
[4]Foreman for Andrews Well Co.

northern Louisiana—Continued

(NORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
10-4	760	77	[2] +12 [3] —110	540 620 760	70±	121	Catahoula	Soft . .	Well No. 2.	935
2	606	76	[2] Flow [3] —49	. . . .	. . . .	. . . .	. . .do . .	. . do . .	. . . .	936
6-4	858	75	. . . .	850	. . . .	. . . .	. . . . .	. . . . .	Abandoned.	937
8 8	580 621+	77 77	—60	480 580	. . . .	60	Catahoula	. . . .	Abandoned.	938
. . . .	927	77	Flows.	853-927	125	. . . .	Catahoula	Soft .	. . . .	939
. . . .	110	. . . .	. . . .	. . . . . .	. . . .	Large.	Quaternary.	Hard. .	. . . .	940
. . . .	365[5]	145	—60	310-365	. . . .	. . . .	. . .	. . . . .	Drilled in 1899 . . .	941
7	300	88	+15	300	. . . .	100	Catahoula	Soft . .	Temperature, 60° F.; drilled in 1898.	942
6-4	810	88	+18	300 802	. . . .	. . . .	. . .do . . Catahoula?	. . do . Brackish.	Drilled in 1898 . . .	943
8	302	85	[6] +34	292-302	. . . .	30+	Catahoula	Soft . .	Drilled in 1900; used for ice manufacture, casing 200 feet.	944
2	280	88	Flows.	. . . . . .	. . . .	. . . .	. . .do . .	. . do . .	. . . .	945
3½	279	. . . .	+7	. . . . . .	[7] 30 [8] 4	. . .	. . .do . .	. . do . .	Used for drinking only; completed in 1899.	946
2	105	90	—8 —18	95-105	. . . .	Large.	Quaternary	Hard. .	. . . .	947
6	125	75	. . . .	. . . . . .	. . . .	100+	. . . do . .	. . do . .	Completed in 1902; pronounced an excellent water.	948
. . . .	. .	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Many large springs.	949
. . . .	720 100 230+	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Test wells for oil . .	950
. . . .	1,020	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	951
2	96-106	85	—20	94-104	. . . .	Large.	Quaternary	Slightly hard.	Four wells completed in 1900.	952
2	323	85	—20 —5 Flows (?)	96 108 280 320?	. . . .	. .do	.do . . Catahoula . . .do	. . do . . Soft . . . . do	. . . .	953
. . . .	20-30	. . . .	. . . .	. . . . . .	. . . .	. . . .	Quaternary	Hard, alkaline.	. . . .	954
. . . .	Spring.	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	Soft . .	Supplies watering tank of Zimmerman, Leesville and Southern R. R.	955
4	175	94	[9] +25	175	[9] 20 [10] 2	. . . .	Catahoula	. . do . .	Temperature, August, 1902, 58° F.; used for drinking only.	956

[5] Water-Sup. and Irr. Paper No. 101, U. S. Geol. Survey, 1904, p. 20.

[6] Pressure stated to be 15 pounds when first drilled: lowers on pumping to —40 feet; casing 200 feet long.

[7] In 1899.

[8] August 12, 1902.

[9] In 1897.

[10] August, 1902.

Wells and springs in
LOUISIANA

No.	Location	Township.	Range.	Section.	Owner.	Driller.	Authority.
	RED RIVER PARISH						
957	Coushatta	. . . .	. . . .	. . . .	General	. . . .	Postmaster . . . . .
958	Coushatta, 10 miles east of.	12N. .	8W .	22	. . . .	. . . .	J. W. Martin. . . .
959	Coushatta	. . . .	. . . .	. . . .	——Armstead . . .	Chas. Stoer. . . .	Chas. Stoer. . . . .
*960	Lake End	11N. .	9W .	. . . .	Atkins Bros . . .	Stoer & Backus. .	Chas. Stoer. . . . .
961	Wilson	14N. .	9W .	10	. . . .	. . . .	J. W. Martin. . . .
	RICHLAND PARISH						
962	Delhi	17N. .	9E .	. . . .	Cotton gin	. . . .	Mrs. A. K. Hawley.
963	Holly Ridge. . . .	17N. .	8E .	. . . .	Vicksburg, Shreveport and Pacific Rwy.	. . . .	R. B Coxe, superintendent water division.
	SABINE PARISH						
964	East Pendleton . .	6N. .	14W .	2	Salt works	. . . .	A C. Veatch[2] . . .
965	. . . do.	6N. .	13W .	33	do	. . . .	. . . do . . . . . .
*966	Loring	7N. .	12W .	9	Bowman-Hicks Lumber Co.	L.B. Clifford Well Co.	W. A. Shields, superintendent.
967	Many	7N. .	11W .	27	J. T. Sirmon . . .	. . . .	Dan Vandegaer, parish surveyor.
968	Myricks Ferry . . .	9N. .	14W .	. . . .	. . . .	. . . .	E. W. Hilgard[4]. . .
*969	Negreet	5N. .	12W .	5	D. M. Foster . .	D. M. Foster. . .	D. M. Foster. . . .
970	Negreet Salt Works	5N. .	13W .	24	. . . .	. . . .	A. C. Veatch[2] . . .
*971	Noble	8N. .	13W .	. . . .	Trigg Lumber Co.	L. B. Clifford Well Co .	L. B. Clifford . . .
*972	Pleasant Hill . . .	9N. .	12 W .	2	John Ferrell . . .	. . . .	Dr. O. Lerch[5] . . .
973	Plymouth	7N. .	12W .	8	Bowman-Hicks Lumber Co.	L. B. Clifford Well Co.	G. S. Smith[6] . . . .
*974	Zwolle.	8N. .	13W .	36	H. J. Allen Lumber Co.	. . . .	— Coxe, superintendent.
	ST. LANDRY PARISH						
*975	Melville, 12 miles south of.	6S . .	7E .	. . . .	Latannier Oil Co.	Oscar Shanks. . .	Oscar Shanks. . . .
	TENSAS PARISH						
976	Buck Ridge	. . . .	. . . .	. . . .	——Kelley	. . . .	F. L. Maxwell . . .
977	St. Joseph	. . . .	. . . .	. . . .	General	. . . .	A. Blanche. . . . .
	UNION PARISH						
*978	Ouachita River (Loch Lomond).	20N .	3E .	. . . .	U. S. Eng. test boring.	. . . .	M. H. Marshall[7] . .
979	Randolph	23N. .	3W .	. . . .	Summit Lumber Co.	L. B. Clifford Well Co.	L. B. Ciifford . .
	VERNON PARISH						
980	Hawthorne	3N. .	9W .	29	Lumber company.	. . . .	. . . .
981	Pickering	. . . .	. . . .	. . . .	do	. . . .	—Pickering . . . .

*For additional data see "Descriptive notes," following this table.
[1]Also reported 300 feet.
[2]Geol. Survey Louisiana, Rept. of 1992, p. 30.
[3]See "Descriptive notes."
[4]Supplementary and Final Report of a Geological Reconnoissance of Louisiana, New Orleans, 1873, p. 22.

northern Louisiana--Continued

(NORTHERN)—Continued

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	Yield per minute. Flow.	Yield per minute. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Galls.*	*Galls.*				
. . . .	25-50	. . . .	. . . .	. . . . . .	. . . .	. . . .	Quaternary.	Hard. .	. . . .	957
. . . .	Spring.	. . . .	. . . .	. . . . .	. . . .	. . .	. . .	Brine. .	Salt spring, with gas.	958
4	1140	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	959
4-2½	287.5	127	—24	. . . . . .	. . . .	. . . .	Sabine . .	Brackish	Abandoned	960
. . . .	Shallow	. . . .	Flows.	. . . . . .	. . . .	. . . .	. . .do . .	. . . . .	Ever-flowing well. .	961
. . . .	825±	95	Flows.	. . . . . .	. . . .	. . . .	Sabine . .	Brackish	. . . .	962
. . . .	64	88	—24	24–62	. . . .	100	Quaternary.	Hard. .	. . . .	963
. . . .	Shallow	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	Brine .	Abandoned salt works	964
. . . .	. .do .	. . . .	. . . .	. . . . . .	. . . .	. .	. . . . . .	. . do . .	do	965
6	704	285	—100	(3)	. . . .	30	Sabine . .	Soft . .	Water from 11 different sand beds.	966
. . . .	110	. . . .	—60	. . . . . .	. . . .	. . . .	. . . . .	Good .	Used in boiler . . .	967
. . . .	Shallow	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	Brine .	Salt and soda works during the war.	968
8	630	173	−8 +1 +1 +18	167 212 350 630	 30	. .	Sabine . .	. . . . .	Temperature, 70° F.	969
. . . .	Shallow	. . . .	. . .	. . . . . .	. . . .	. . .	. . . . . .	Brine .	Abandoned salt works	970
. . . .	400	275	. . . .	160	. . . .	Fair.	Sabine . .	. . . . .	. . . .	971
. . . .	22	. . . .	. . . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	Ferrell's mineral well	972
4	521	277.5	—100	360–380 418–430 492–520	. . .	25	Sabine . .	Salty; alk'line	. . . .	973
4 6	120 195	203 203	—12 —16	100–120 100–120 190	. . . .	55 55	. . .do . . . . .do . .	. . . .	. . . .	974
. . .	2,103	. . . .	Flows.	537–555 1450–2000	Large. . .do .	. . . .	. . . .	Pure, soft Sulphur	. . . .	975
. . . .	135	. . . .	. . . .	. . . . . .	. . . .	Large.	Quaternary	Good .	. . . .	976
. . . .	100-135	. . . .	. . . .	. . . . . .	. . . .	. .do .	. . .do . .	Iron . .	. . . .	977
. . . .	50	48.8 47.5	. . .	. . . . . .	. . . .	. . . .	. . . . . .	. . . . .	. . . .	978
4 5	206	140	Flow[8] 9—16	200-206	. . . .	. . . .	Cockfield.	Slightly alk'line	Two wells.	979
. . . .	280	. . . .	. . . .	. . . . . .	. . . .	. . . .	Catahoula	. . . . .	. . . .	980
8-6	740	223	. . . .	. . . . . .	. . . .	None.	. . . . . .	. . . .	. . . .	981

[5]Geology and Agriculture of Louisiana, pt. 2, 1894, pp. 118, 119.
[6]Foreman for L. B. Clifford Well Co.
[7]Rept. Chief of Eng. for 1902, p. 1566.
[8]In 1901.
[9]In 1902.

Wells and springs in
LOUISIANA

No.	Location.	Township.	Range.	Section.	Owner.	Driller.	Authority.
	WEBSTER PARISH						
*982	Bistineau Salt Works.	18N. .	10W .	. . . .	. . . .	. . . .	A. C. Veatch[1] . . .
*983	Cotton Valley . . .	21N. .	10W .	. . . .	Valley Lumber Co.	L. B. Clifford Well Co.	L. B. Clifford . . .
984	Dubberly	. . . .	. . . .	. . . .	Valentine Spring .	. . . .	. . . .
984A	Long Springs . . .	19N. .	9W .	6	. . . .	. . . .	. . . .
*985	Minden.	19N. .	9W .	21	Minden Lumber Co.	L. B. Clifford Well Co.	L. B. Clifford . . .
*986	. . . do.	19N. .	9W .	21	. . . do	. . . do	. . . do . . . .
987	do.	19N. .	9W	. . . .	Minden steam laundry.	. . . do	. . . do . . . .
*988	. . . do.	19N. .	9W .	. . . .	Minden Cotton Oil and Ice Co.	. . . .	S. G. Webb, president.
*989	Spring Hill	23N. .	11W .	. . . .	Pine Woods Lumber Co.	L. B. Clifford Well Co.	L. B. Clifford . . .
*990	Yellow Pine. . . .	17N. .	9W .	7	Globe Lumber Co.	A. L. Pullin . . .	A. L. Pullin . . . .
	WEST BATON ROUGE PARISH						
*991	Baton Rouge Junction.	8S . .	12E .	. . . .	Texas and Pacific Rwy.	. . . .	Chas. Anderson, pump man.
992	Lobdell.	7S . .	12E .	. . . .	. . . do	. . . .	B. S. Wathen, chief engineer.
	WEST CARROLL PARISH						
993	Floyd	. . . .	. . . .	. . . .	General	. . . .	Postmaster . . . . .
	WINN PARISH						
*994	Drakes Salt Works[2]	12N. .	5W .	20–21 28–29	. . . .	. . . .	A. C. Veatch[3] . . .
*995	Prices Salt Works .	13N. .	5W . 4W .	25 30	. . . .	. . . .	A. C. Veatch[5] . . .
996	Pyburn	13N. .	3W .	34	North Louisiana Lumber Co.	. . . .	North Louisiana Lumber Co.
997	Tannehill	12N. .	3W .	22	Hall & Legin. . .	J. M. Phillips . .	J. M. Phillips . . .
998	Winnfield	. . . .	. . . .	. . . .	Winnfield ice factory.	L. B. Clifford Well Co.	L. B. Clifford . . .
999	Winnfield, 2 miles south of (Cedar Lick).	. . . .	. . . .	. . . .	. . . .	. . . do	. . . do . . . .
1000	Winona	. . . .	. . . .	. . . .	Pine Tree Lumber Co.	. . . .	Pine Tree Lumber Co.

*For additional data see "Descriptive notes," following this table.
[1]Geol. Survey Louisiana, Rept. of 1902, pp. 81-99.
[2]See also No. 904, Goldonna, Natchitoches Parish.

northern Louisiana—Continued

(NORTHERN)—Continued.

Diameter of well.	Depth of well.	Approximate elevation of surface.	Height of water above (+) or below (—) the ground.	Depths of principal water-bearing strata.	YIELD PER MINUTE. Flow.	YIELD PER MINUTE. Pump.	Geologic horizon of water-bearing strata.	Quality.	Remarks.	No.
Inches	*Feet*	*Feet*	*Feet*	*Feet*	*Gall.*	*Gall.*				
....	10–15	140	....	......	....	....	Nacatoch.	Brine .	Salt made from 1850 to 1892.	982
4	271	220	—48	245–271	....	55	Sabine . .	Soft . .	....	983
....	Spring.	....	....	......	....	....	......	Sulphureted.	....	984
....	..do .	....	....	......	....	....	......	Iron . .	Local resort	984A
6	317	192	—28	247–317	....	115	Sabine . .	Soft . .	Used for sawmill and drinking.	985
4	247	192	—28	247	....	110	. . .do . .	. . do . .	....	986
4	251	....	—48	......	....	..	. . .do . .	.....	....	987
8	115	190	— 8	100–115	...	50	. . .do . .	Soft; iron	Temperature, 65.3°F..	988
3	368	235	—14 —28	228–270 338–368	...	....	.do . .	Soft . .	Temperature, 66° F.; lower horizon not developed.	989
4–3	1,015 ±	190	....	......	....	None .	......	.....	Abandoned.....	990
....	110	....	....	110	....	Large.	Quaternary	.....	Well fluctuates with the river.	991
....	165	....	...	......	....	..do .	. . .do . .	Good .	Water in sand and gravel.	992
....	40	....	....	......	....	Small.	. . .do . .	Poor; hard	....	993
...	10–20	....	....	......	....	Large.	Quaternary[4]	Brine .	Saltworks 1800–1865.	994
...	100–200	....	Flow.	......	....	....	....	. . do . .	....	994
10	1,011	....	+35	......	18	....	Cretaceous	. . do . .	Temperature, 75° F..	994
....	6–15	....	....	......	....	....	Quaternary[4]	. . do . .	Salt works 1840-1869.	995
6 4	600 ±	210	—18	....	....	....	Sabine . .	.....	Two wells	996
4	270	120	—10	140–270	....	60	. . .do . .	Soft . .	Water lowers 7 feet when pumping 60 gallons per minute	997
....	700	120	Flows.	......	....	....	. . .do . .	. . do . .	Shells common from 20 to 490 feet.	998
....	268+	....	....	......	....	...	......	.....	Large amount of gas.	999
4	454	210	—90	60 200	...	....	Sabine . .	.....	Too much quicksand; well abandoned.	1000

3Geol. Survey Louisiana, Rept. of 1902, pp. 51–64.
4Leaks from the Cretaceous beds into the bottom-land silts.
5Geol. Survey Louisiana, Rept. of 1902, pp. 64–70.

DESCRIPTIVE NOTES

758. It is reported that this well interferes with the railroad well about one-fourth mile distant. Used in boiler, the water forms a large amount of scale, but the addition of a little kerosene is found to furnish almost complete relief.

Analysis of water from well of Union Oil Company at Bunkie, Avoyelles Parish, La.

[By E. W. Brundage.]

	Parts per million.
Sodium chloride (Na Cl)	39.5
Sodium sulphate (Na_2SO_4)	7.1
Sodium carbonate (Na_2CO_3)	15.5
Potassium carbonate (k_2CO_3)	1.2
Magnesium carbonate ($MgCO_3$)	183.8
Calcium carbonate ($CaCO_3$)	291.4
Silicon dioxide (silica) (SiO_2)	30.0
Oxides of iron and aluminum (Fe_2O_3 Al_2O_3)	23.0
Organic matter	148.0
Total	739.5

"Characteristics: Odor suggestive of hydrogen sulphide; clear, turbid on standing; considerable sediment. Test with litmus: alkaline."

759. *Section of well of Bunkie Ice and Bottling Company, Bunkie, Avoyelles Parish, La.*

	Feet.
Quaternary (Port Hudson):	
1. Red clay	0- 70
2. Quicksand	70- 115
3. Gravel	115- 140

762A. Mr. T. L. Grimes reports: "I had the water from my well analyzed by Professor Calwell, of Tulane University, who reported that it contained a little soda, a little magnesia, some lime, and a trace of iron and sulphuric acid. He did not make a quantitative analysis. A well was bored a few miles from me last year that behaved quite strangely. The curbing was gotten down 64 feet by pumping out sand and letting it sink of its own weight, and then it refused to sink any deeper. When they quit work at night there was 4 feet of water in the well, but next morning the water could be dipped from the top with a cup held in the hand. There were constant noises like the escape of gas, and the height of the water changed often, though it was not affected by the stage of water in the river. The well finally caved in. This well was bored in the center of one of the numerous mounds that are all over this section of the State on the Bluff (Port Hudson) formation."

765. *Record of well of Natchez and Marksville Oil Company, Marksville, Avoyelles Parish, La.*

[By A. W. Myers, driller.]

	Feet.
1. Red clay, with ferruginous concretions	0 – 18
2. Fine red sand	18 – 42
3. Reddish sand and gravel containing good, fresh water	42 – 132
4. Soft sand rock	132 – 136
5. Coarse sand and pebbles	136 – 158
6. Rock	158 – 158.5
7. Medium red sand	158.5– 174
8. Loose rock and bowlders	174 – 177
9. Sand and gravel about the size of a pea	177 – 193
10. Red clay	193 – 199
11. Fine red sand	199 – 206
12. Coarse sand	206 – 214
13. Red clay	214 – 222
14. Rock	222 – 222 5
15. Red sand and clay	222.5– 232
16. Blue sand and gravel	232 – 243
17. Fine sand and gravel	243 – 259
18. Sticky blue clay and bowlders	259 – 318
19. Blue clay, with black particles	318 – 333
20. Red gumbo (stiff clay)	333 – 337
21. Black gumbo	337 – 360
22. Blue clay	360 – 380
23. Medium white sand	380 – 390
24. Blue gumbo	390 – 405
25. Blue clay, with mica	405 – 417
26 Medium white sand	417 – 425
27. Blue shale	425 – 452
28. Very coarse sand (red, white, and blue)	452 – 523
29. Blue and red gumbo	523 – 623
30. Blue shale	623 – 631
31. Blue gumbo	631 – 645
32. Blue shale	645 – 663
33. Sticky blue clay	663 – 697
34 Rock	697 – 698
35. Blue sticky clay and shale	698 – 736

36. Brown clay and sand	736 – 796
37. Blue and red gumbo	796 – 806
38. Blue clay and sand	806 – 822
39. Blue clay, rather hard	822 – 827
40. Coal (lignite)	827 – 827.5
41. Blue gumbo	827.5– 847
42. White rock	847 – 849
43. Blue and red gumbo	849 – 855
44. Gumbo and bowlders, almost black	855 – 926
45. Sand and gravel	926 – 976
46. Sand and bowlders	976 –1,016
47. Sand, with pieces of wood	1,016 –1,034
48. Alternate layers of sand and rock	1,034 –1,062
49. Sand, gravel, and bowlders	1,062 –1,146
50. Impure limestone	1,146 –1,147
51. Blue sand	1,147 –1,205
52. Lime rock	1,205 –1,207
53. Very dark clay	1,207 –1,280
54. Clay with iron pyrites	1,280 –1,282

Total depth December 12, 1902, 1,282 feet; casing 320 feet. In water well screen is placed from 70 to a 100 feet below the surface. There is an abundant supply of water, but it is not very soft.

766. Around Marksville water is generally reached between 40 and 45 feet but the supply is not permanent. Below a thin bed of blue clay at about 65 feet a very good supply is reached, which yields slightly hard water in large quantities.

767. No complete information is available concerning this well. According to the drillers it was 800 feet deep, but it was sounded by Mr. C. B. Couvillion, parish surveyor, about two years after its completion in 1896 and found to be 290 feet deep. As neither the quality nor the supply of water from the well had changed, and the bottom encountered at 290 feet was entirely solid, he concluded that this represented the total depth of the well.

Mr. H. P. Touzet, foreman in charge of the work, writes: "I left the well after driving the 6-inch casing down 200 feet to blue clay. There is an abundance of water to be found about Marksville at depths of 80 to 200 feet. I have no written record referring to the well, but as far as I can remember my successors abandoned the work at a depth of 500 feet, after having bored to that depth with a 4-inch pipe without locating water below the 6-inch casing."

G. D. Harris[1] reports: "At a depth of 230 feet a 5-foot stratum of lignite was penetrated. Mouth of well, 0.3 foot above railroad station, hence approximately 82 feet above tide.

"The gravel bed found between 100 and 160 feet is very much like the

[1]Water-Sup. and Irr. Paper No. 101, United States Geological Survey, 1904, p. 54.

gravel found in the wells in the southwestern Louisiana rice fields. A seam of black clay and lignite was found at 160 feet. The gravel below the lignite was heavily charged with pyrites." It is doubtless from this layer that the water is obtained.

768. *Section of well of Vicksburg, Shreveport and Pacific Railway., Arcadia, Bienville Parish, La.*

[By H. P. Touzet.]

	Feet.
1. Yellow and red clay	0– 30
2. Coarse white sand	30– 40
3. Blue clay	40–100
4. Fine blue sand	100–110
5. Blue clay	110–150
6. Water-bearing gray sand	150–165
7. Calcareous rock	165–175
8. Blue clay	175–275
9. Calcareous rock	275–290
10. Blue clay, mixed with broken rock	290–415
11. Fine white sand	415–465
12. Hard blue clay	465–525
13. Calcareous rock	525–530
14. Very stiff white clay	530–535
15. Blue sand	535–540
16. Blue clay	540–

769. *Analysis of water from mineral well of Dr. J. C. Christian, Arcadia, Bienville Parish, La.*[2]

[By Maurice Bird.]

	Parts per million.
Soluble silica	1,114.9
Iron and alumina	226.7
Lime	573.9
Magnesia	540.2
Potash	11.6
Soda	520
Chlorine	1,647.7
Sulphuric acid	1,538.5

"Mainly sulphates and chlorides of alumina, lime, magnesia, and soda."

770. *Section of well of John Gigleux, Jamestown, Bienville Parish, La.*

	Feet.
1. Surface	0– 18
2. Shell marl, with many *Ostrea sellaeformis* (Claiborne)	18– 30
3 Black clay	30– 90
4. Dark-colored clay, weathering white	90–100
5. Dark sand and clay	100–142
6. Sand, water bearing	142–145

771. *Analysis of brine from Kings Salt Works, Bienville Parish, La.*[3]

[By Maurice Bird.]

	Per cent.
Sodium chloride	6.94
Calcium sulphate	.01
Calcium chloride	.152
Magnesium chloride	.135
Alumina	.148
Other solids	.065

772. *Analysis of brine from Rayburns Salt Works, Bienville Parish, La.*[4]

[By Maurice Bird.]

	Per cent.
Sodium chloride	4.60
Sodium sulphate	.022
Calcium sulphate	.322
Magnesium sulphate	.029
Alumina	.061
Other solid matter, partly in suspension	.03

774. Air lift brings from well fine dark-gray sand, with occasional white quartz grains as large as grains of wheat, and numerous particles of white clay.

Dump heap is, for the most part, fine gray sand, similar to the Shreveport water sand. It shows the following succession of strata:

1. Red clay.
2. Dark-colored clay.
3. Chocolate-colored clay.
4. Gray or greenish-gray sand.

776. *Section of well of Antrim Lumber Company, Antrim, Bossier Parish, La.*

[By L. B. Clifford.]

Sabine:	Feet.
1. Yellow clay, passing below into blue clay	0– 44
2. Lignite of good quality	44– 48
3. Blue clay	48–160
4. Water-bearing sand	160–263
5. Sand and clay, no water	263–300

[2]Geology and Agriculture of Louisiana, pt. 2, 1892. p. 47. (See page 160)
[3]Geological Survey Louisiana Report of 1902, p. 80.
[4]Geological Survey Louisiana Report of 1902, p. 75.

778. *Section of well of W. H. Smith & Son, Benton, Bossier Parish, La.*

[By J. P. Clifford.]

Sabine.	Feet.
1. Slate-colored clay	0–122
2. Gray rock	122–124
3. Stiff, hard clay	124–140
4. Mahogany-colored clay	140–
5. Water-bearing sand.	
6. "Coal" (lignite)	–350

It is reported that this well flowed for a short time.

782. *Partial section of well of S. H. Bolinger & Co., Bolinger, Bossier Parish, La.*

[By L. B. Clifford.]

Claiborne and Sabine:	Feet.
1. Yellow clay	0– 14
2. Sand rock	14– 16
3. Yellow clay	16–
4. Blue clay	–162
5. Water-bearing sand	162–235
6. Dark-colored sand and clay, no water	235–315

783. *Section of well at Cash plantation, 3 miles north of Bossier City, Bossier Parish, La.*

[By A. L. Pullin.]

Quaternary (Port Hudson):	Feet.
1. Clay, passing below into fine gravel, containing hard water	0–130
Sabine:	
2. Blue clay	130–155
3. Sand, containing hard water	155–160
4. Blue clay	160–180
5. Sand, with bad water	180–185
6. Blue clay	185–225
7. Lignite	225–
8. Blue clay	–300
9. Brown clay	300–315
10. Water sand; water rises to within 35 feet of surface	315–330

784. *Section of well of Benj. Gray, 2½ miles north of Bossier City, Bossier Parish, La.*

[By A. L. Pullin.]

Quaternary (Port Hudson):	Feet.
1. Soil	0.0– 10.0
2. Soft red sand; becomes coarser and passes into large gravel	10.0– 76.0

Sabine:	
3. Rock (probably a limestone concretion)	76.0– 79.5
4. Blue clay, with layer of lignite at 160 feet.....	79.5–300.0
5. Water-bearing sand (water flowed over top of pipe when well was first sunk)	300.0–330.0

785. *Section of well of Shreveport Cotton-Oil Company, Bossier City, Bossier Parish, La.*

	Feet.
Quaternary (Port Hudson):	
1. Surface clay, sand and gravel..................	0– 80
Sabine:	
2. Blue clay, with occasional thin layers of sand...	80–225
3. Water-bearing sand..........................	225–235
4. Blue clay, containing no water.................	235–600

786. Six-inch pipe, 0–70.5 feet; four-inch pipe. 70.5–168 feet. The six-inch pipe passes through the Quaternary into the Sabine clays.

788. *Section of well of Will Sentell, Lake Point, just above Cedar Bluff, Bossier Parish, La.*

	Feet.
Quaternary (Port Hudson):	
1. Surface clay, passing below into sand and coarse gravel	0–120
Sabine:	
2. Blue clay....................................	120–232
3. Fine sand, containing good soft water..........	232–240
4. Dark-colored clay, containing no water........	240–600

Completed in 1902. Water lowers readily on pumping.

795. The gravel bed which usually lies at the base of the Quaternary deposits is in this well represented by a coarse sand. No lignite was encountered.

796. *Section of well of John Glassell, at Belcher, Caddo Parish, La.*

[By A. L. Pullin.]

	Feet.
Quaternary (Port Hudson):	
1. Surface clays, passing below into fine gravel....	0– 96
Sabine:	
2. Clay	96–213
3. Water sand, not passed through	213–225

797. It is reported that the water is at one time soft and at another time hard; this is probably due to a leak in the pipe, which permits the water from the surface gravel to mingle with that in the Sabine sands.

799. *Section of well of M. A. & J. D. Dickson, Dixie, Caddo Parish, La.*

	Feet.
Quaternary (Port Hudson):	
1. Red sand	c– 6
2. Red buckshot clay	6– 12
3. Red sandy soil, becoming coarser below and passing into coarse sand	12– 60
Sabine:	
4. Blue clay	60–219
5. White sand, water bearing	219–225
Sabine and Midway?:	
6. Blue clay, with occasional rock	225–371

Well completed November, 1902.

800. *Section of well of John Sentell, Cairo plantation, 2½ miles east of Dixie, Caddo Parish, La.*

[By A. L. Pullin.]

	Feet.
Quaternary (Port Hudson):	
1. Red sand	0– 6
2. Buckshot clay	6– 12
3. Red sandy soil, becoming coarser below and passing into coarse sand containing water	12– 85
Sabine:	
4. Soft white clay	85–160
5. White clay, changing gradually to dark brown and passing into lignite	160–170
6. White sand, water bearing	170–182

A test well put down at this place reached a depth of 391 feet without developing water. A second well, a few feet distant, however, obtained water between 170 and 182 feet.

Well completed April, 1902.

801. *Partial section of well of Glassell & Adger, Sodo Lake, 3 miles southwest of Dixie, Caddo Parish, La.*

[By A. L. Pullin.]

	Feet.
1. Overflow sand from Cottonwood Bayou	0 – 3
2. Clay	3 – 11
3. Soft red sand	11 – 41
4. White milky clay, mixed with white sand and gravel, with little or no water	41 –121
5. Hard brown clay	121 –131
6. Hard blue clay	131 –255
7. Hard blue rock	255 –278.5
8. Hard black clay	278 5–283.3

9. Hard brown clay	283.3–294.3
10. Dark-gray clay	294.3–310.3
11. Light-gray hard rock	310.3–311
12. Dark clay	311 –364

802. Furrh & Co. report that a very small amount of hard water was obtained. The driller reports shell marl at about 500 feet. Well drilled in 1894.

803. Three-inch casing, 0–132 feet; 2-inch casing, 132-290 feet; 2-inch screens placed at 152–158 and 262–270 feet. Very sandy material from 152 to 290 feet. Well first flowed at 270 feet.

804. *General section of wells in Red River Valley below Shreveport, Caddo Parish, La.*[5]

[By A. L. Pullin.]

Quaternary (Port Hudson):	Thickness in feet.
1. Red soil; sandy loam	4– 10
2. Red clay and sand, water bearing. This stratum is clayey above and becomes more sandy below. The lower 5 to 10 feet are quick-sand. This layer is the source of the highly mineral water which is obtained in the driven wells	45– 60
3. Gravel and sand. Firmly bedded, so much so that it is impossible to drive a pipe into it. The gravel sometimes reaches the size of a goose egg. White chert and quartz pebbles are common. The gravel is largest at the top and gradually grows finer until at the base of the stratum it grades into a fine white sand	20– 40
Sabine:	
4. Soft gray sandy clay, containing vegetable remains and occasional shells	8– 16
5. Fine white sand	0– 40
6. Hard tenacious blue clay, called "rubber clay," containing scattered iron concretions about the size of a pea	40–132
7. Indurated sand, water bearing. Furnishes an abundant supply of soft water. Water from this stratum generally rises to within 10 or 20 feet of the surface.	

5Geological Survey Louisiana, Report for 1899 [1900], pp. 179–180

805. *Section of well of Captain Robson, Robson, Caddo Parish, La.*[6]

[By A. L. Pullin.]

	Feet.
Quaternary (Alluvium and Port Hudson):	
1. Red sandy loam	0– 4
2. Fine red clay, with sand	4– 79
3. Red sand, water bearing	79– 82
4. Gravel and sand, same as 3 in well No. 804	82–106
Sabine	
5. Lignitiferous clay with shells	106–118
6. Brown lignite	118–121
7. Good black lignite	121–123
8. "Soapstone," soft white friable clay	123–130
9. Very hard blue limestone	130–131
10. Hard black lignite	131–135
11. Blue clay	135–225
12. Water sand, not passed through	225–

806. According to the best information obtained from several sources and from the sections in adjacent wells, the strata penetrated in this well are as follows:

Section of deep test well of Shreveport Ice Company, Market Street and Cross Bayou, Shreveport, Caddo Parish, La.

	Feet.
Sabine:	
1. Dark-colored clays, with lignite	0–200
2. Gray sand, water bearing	200–250
Midway and Arkadelphia:	
3. Blue clay, with occasional hard streaks of rock; no water	250–961
Nacatoch:	
4. Very hard quartzitic rock	961–
5. Soft sandstone, with occasional hard rock; furnishes artesian salt water with gas	–996

The gas from stratum 5 is used to light the ice factory. Temperature of water, August 22, 1902, 84° F. The water used by the ice company is obtained from three wells developing stratum 3.

807. *Section of test well of Shreveport Waterworks Company, Shreveport, Caddo Parish, La.*

[By H. F. Juengst.]

	Feet.
1. Yellow clay	0 – 38
2. Lignite	38 – 43
3. Yellow clay	43 – 55
4. Sand	55 – 57

[6] Ibid., pp. 180–181

5. Blue clay	57 – 62
6. Black clay	62 – 65
7. Lignite	65 – 70
8. Blue clay	70 –105
9. Clay and sand	105 –115
10. Blue clay	115 –135
11. Yellow clay	135 –160
12. Blue sand and clay	160 –165.5
13. Blue clay	165.5–190.5
14. Lignite	190.5–193.5
15. Yellow clay	193.5–218.5
16. Sand	218.5–228.5
17. Blue clay	228.5–244

Casing, 6-inch, 0–80 feet; 4½-inch, 80–136 feet. An attempt was made to retest the well in 1902, but yielded no results. As the depth to water was at that time only 14 feet, the well had probably caved in and the water-bearing strata had been entirely cut off.

Analysis of water from test well of Shreveport Waterworks Company, Shreveport, Caddo Parish, La.

[By Francis C. Phillips.]

	Parts per million.
Total solids	600
Hardness, expressed in parts per 1,000,000, of carbonate of lime	168
Hardness after boiling one-half hour	154
Chlorine	94
Nitrogen as nitrates	None
Nitrogen as nitrites	None
Free ammonia	.38
Albuminoid ammonia	.04
Oxygen required	1.38

808. The drillers report 83 feet of 4-inch casing, 44 feet of 2½-inch casing, and 15 feet of screen, indicating that a portion of the supply is from above 142 feet. The drilling of this well was carefully watched by Mr. S. Y. Snyder, who has furnished the following report:

Section of well of Henry Rose, Shreveport, Caddo Parish, La.

[By S. Y. Snyder.]

	Feet.
1. Clay and sand	0– 40
2. Dark-blue clay	40– 50
3. Yellow clay	50– 65
4. Quicksand, water bearing	65– 71

5. Hard blue clay	71–150
6. Sand, water bearing	150–165
7. No record	165–175
8. Lignite	175–177
9. Sand	177–272
10. Rock	272

812. The drillers report 4-inch casing, 0-80 feet; 2½ inch casing, 80-169 feet; 10-foot screen, 99-109 feet; 15-foot screen, 148-163 feet; total depth, 324 feet. Completed July, 1901. Cost, $700.

817. Wells Nos. 1 and 2 have 80 feet of 9-inch casing, 60 feet of 4 inch casing and 12 feet of 4-inch screen at the bottom. Well No. 3 has 80 feet of 6-inch casing and 60 feet of 4-inch casing; no screen.

829. Mr. Mayer reports: "In all the wells in this region water rises to within about 15 feet of the surface, is very soft, and free of alkali. It remains pure as crystal at all times, pleasantly cool, and of the same temperature the year round, and extremely wholesome. If allowed to stand exposed to the atmosphere and under ordinary atmospheric temperature it emits an odor of sulphurated hydrogen; no physical change is apparent. The water rises from a stratum of beach sand."

832. *Section of well of A. H. Leonard on Bayou Pierre, 10 miles southeast of Shreveport, Caddo Parish, La.*

[By T. C. Backus]

	Feet.
Quaternary (Port Hudson):	
1. Sandy clay	0– 40
2. Sand and gravel	40– 70
Sabine:	
3. Dark-blue clay	70–130
4. No record	130
5. Water sand	205

Casing, 2½-inch, 0–80 feet; 1½-inch, 80–120 feet.

834. *Section of well in sec. 1, T. 20 N., R. 16 W., Caddo Parish, La.*[7]

	Feet.
Port Hudson:	
1. Fine loamy sand	0– 4
2. Yellow and gray mottled clay, post-oak clay	4–11
3. Red clay, with calcareous concretions in lower part	11–29
4. Blue mud, with vegetable matter and mussel shells	29–46
5. Fine blue sand, not passed through	46–55

7 Geological Survey Louisiana, Report for 1899 [1900], p. 190.

835. *Section of gin well, Uni, Caddo Parish, La.*

[By A L. Pullin.]

	Feet.
Quaternary	
1. Stiff red clay	0– 8
2. Fine red sand	8– 15
3. Buckshot soil	15– 20
4. Very fine yellow sand	20– 35
5. White sand, gradually becoming coarser	35– 60
6. Fine gravel, size of grain of corn, water bearing	60– 70
Sabine:	
7. Blue clay	70–190
8. Dry white sand	190–198
Sabine and Midway?:	
9. Brown clay	198–348
Midway?:	
10. Shell marl	348–400
Arkadelphia.	
11. Dark-gray clay	400–650

A second well was drilled to the same depth without obtaining water.

837. *Section of test boring in Ouachita River near Blankston, Caldwell Parish, La. (143.5 miles above mouth of Black River.)*[8]

	Depth in feet.
1. Stiff red clay	0.0
2. Sandy clay	19.7
3. Coarse gray sand, with small percentage of clay	22.4
4. Gray sand	26.3
5. Black sand and clay	51.2

Sections of test borings in Ouachita River near Blankston, Caldwell Parish, La. (144.5 miles above mouth of Black River).[9]

BORING No. 16

1. Brown sand, with small percentage of clay	0.0
2. Gray sand, with some clay	27 89
3. Stiff clay, with some sand	50.

BORING No. 17.

1. Dark-gray sand and clay	0.0
2. Sand and clay	16.41
3. Gray sand and clay	19 69
4. Stiff, sticky blue clay, with small percentage of sand	43.38
5. Stiff and very sticky blue clay	50.

8 Annual Report Chief of Engineers for 1902, pt. 2, 1902 p. 1563.
9 Ibid., p. 1563.

BORING No. 17a.

1. Sand and clay	0.0
2. Brown sand	1.65
3. Gray sand	13.13
4. Gray sand, with small percentage of clay	34.29
5. Gray sand, with larger percentage of clay	42.66
6. Gray sand, with still larger percentage of clay	50.

838. *Section of well of Clark Spur Lumber Company near Clarks, Caldwell Parish, La.*

(By Oscar Shanks.)

	Feet.
1. Clay	1–130
2. Pepper-and-salt water sand	130–145
3. Clay, white and sticky	145–208

840. *Section of well of Clark Spur Lumber Company near Clarks, Caldwell Parish, La.*

(By Oscar Shanks.)

	Feet.
1. Clay	1–110
2. Water sand, red in color	110–150

841. *Section of well at Columbia, Caldwell Parish, La.*

(By Oscar Shanks.)

	Feet.
1. Black sandy loam	0– 7
2. Brown clay	7– 17
3. Blue quicksand, lignite, and mica mixed	17– 57
4. Gray-colored joint clay, with streaks of yellow sand	57– 72
5. Soft blue sandstone	72– 73
6. Coarse white water sand and gravel (iron water)	73– 85
7. Blue clay mixed with shells	85–102
8. Blue flint rock, with gray-colored streaks	102–162
9. Black sticky clay	162–377
10. Chocolate-colored rock	377–388
11. Black sticky clay	388–422
12. Clay, with iron pyrite	422–423
13. Fine sand, with lignite and mica, containing artesian water	423–503

842. *Section of test boring in Ouachita River at Standfield Place, 2 miles below Columbia, Caldwell Parish, La. (123.3 miles above mouth of Black River).*[10]

	Depth in feet.
1. Yellowish sand and clay	0.0
2. Yellowish sand	1.62
3. Mud, with gray sand	19.69
4. Gray sand	22.31
5. Mud, with dark sand	25.10
6. Sand	41.01
7. Mud, with sand	43.47

843. *Section of test boring in Ouachita River at Columbia, Caldwell Parish, La. (125 6 miles above mouth of Black River).*[10]

	Depth in feet.
1. Reddish-yellow sand and clay	0.0
2. Reddish-yellow sand	8.20
3. Gray sand	9.84
4. Mud, with sand	15.75
5. Dark-gray sand	17.39
6. Mud, with small percentage of sand	24.28
7. Gray sand	24.61
8. Mud, with gray sand	29 03
9. Gray sand	32.31
10. Sand, with small percentage of mud	36 58
11. Gray sand	40.68
12. Mud and sand	50.59
13. Mud and sand	52 49

844. *Section of test boring in Ouachita River 1 mile above Columbia, Caldwell Parish, La. (126.9 miles above mouth of Black River).*[11]

	Depth in feet.
1. Brown sand and clay	0.0
2. Gray sand	16.41
3. Gray-brown sand	32.81
4. Blue-gray sand, with small percentage of clay and pieces of coal	48.23
5. Blue-gray sand, with some clay and gravel	73.43
6. Clay, with small percentage of sand and pieces of rock	100.03
7. Very coarse sand and clay	113.19
8. Gray sand	120.47
9. Gray sand, with small percentage of clay	177.07
10. Gray sand, with small percentage of clay	220.14

[10] Ann. Rept. Chief of Engineers for 1902, pt. 2, p. 1561.

[11] Ibid., p. 1561.

845. *Section of test boring in Ouachita River 2 miles above Columbia, Caldwell Parish, La. (127.5 miles above mouth of Black River).*[12]

	Depth in Feet.
1. Soft, boggy sand and mud, full of trash.... ...	0 0
2. Gray sand, with bark and wood	24.60
3. Gray sand....	45.57

846. *Section of test boring in Ouachita River, 3 miles above Columbia, Calwell Parish, La. (128.1 miles above mouth of Black River.)*[12]

	Depth in Feet.
1. Brown sand and clay...........	0.0
2. Gray-brown sand, with some clay..............	17.02
3. Gray-brown sand, with some clay..............	52.49

847. *Section of test borings in Ouachita River at Calls Landing, Caldwell Parish, La. (134.5 miles above mouth of Black River).*[13]

BORING No. 14.

	Depth in Feet.
1. Brown sand, with some clay..................	0.0
2. Gray sand..................................	9.84
3. Stiff gray-blue sand and clay.....	31.08
4. Stiff gray-blue sand and clay..................	50.86

BORING No. 14a.

1. Brown sandy clay............................	0.0
2. Gray sand	6.56
3. Stiff gray-blue sand and clay..................	39.76
4. Stiff gray-blue sand and clay..................	50 00

848. *Section of test boring in Ouachita River at Lower Breston place, Caldwell Parish, La. (132.2 miles above mouth of Black River).*[14]

	Depth in Feet.
1. Very soft sand and mud......................	0.0
2. Brown sand, with small percentage of clay.....	9.84
3. Lot of trash, principally wood.................	13.12
4. Fine, clean gray sand..........................	16.40
5. Coarse, clean gray sand..........	19 68
6. Coarse, clean gray sand.........................	45.57

[12] Ann. Rept. Chief of Engineers for 1902, pt. 2, p. 1561.
[13] Ibid., p. 1563.
[14] Ibid., p. 1562.

849. *Section of test boring in Ouachita River at Upper Breston place, Caldwell Parish, La. (133.3 miles above mouth of Black River).*[14]

BORING No. 13.

	Depth in Feet.
1. Brown sand and mud	0.0
2. Fine gray sand, full of trash	16.40
3. Coarse gray sand	34.78
4. Stiff blue mud, with some sand and pieces of rock	44.06
5. Stiff blue mud, with some sand and pieces of rock	52.59

BORING No. 13a.

1. Soft brown sand	0.0
2. Fine gray sand, with some trash	16.40
3. Coarse gray sand	32.81
4. Stiff blue mud, with some sand and pieces of rock	47.64
5. Stiff blue mud, with some sand and pieces of rock	52.49

850. *Section of test boring in Ouachita River at Smithland, Caldwell Parish, La. (131.2 miles above mouth of Black River).*[15]

	Depth in Feet.
1. Brown sand, with some clay	0.0
2. Log	9.84
3. Gray sand, with small percentage of clay	10.50
4. Clean gray sand	16.41
5. Gray-brown sand	21.33
6. Gray sand, with clay in lumps or layers	32.81
7. Gray sand, with larger percentage of clay	34.16
8. Coal (lignite)	46.03
9. Gray sand and some clay	46.69

851. *Section of test boring in Black River (37.9 miles above mouth) at New Hope place, Catahoula Parish, La.*[16]

BORING No. 1.

	Depth in Feet.
1. Sandy clay	0.0
2. Sand and lumps of mud	6.57
3. Dark sand	9.85
4. Dark sand	41.02

[14] Ibid., p. 1562.
[15] Ann. Rept. Chief of Engineers, 1902, pt. 2, p. 1562.
[16] Ibid., p. 1560.

BORING No. 1a.

1.	Sandy clay	0.0
2.	Dark-gray sand	3.93
3.	Dark sand and mud	12.47
4.	Blue mud	14.11
5.	Mud and sand	18.21
6.	Dark sand	29.53
7.	Dark sand	39.37

852. *Section of test boring in Black River (42.2 miles above mouth) at Star View place, Catahoula Parish, La.*[16]

		Depth in Feet.
1.	Brown sand and mud	0.0
2.	Gray sand	6.58
3.	Gray sand	50.00

853. *Section of test boring in Black River (51.4 miles above mouth) at Jones Bayou, Catahoula Parish, La.*[16]

		Depth per Feet.
1.	Gray-brown sand	0.0
2.	Clean gray sand	9.85
3.	Clean gray sand	50.00

854. Salt springs are described in this region by a number of the early explorers.[17] They were visited by Hopkins in 1871 and pronounced to be of little economic value.

855. Mr. Thomas W. Robertson, field assistant, visited this well August 18, 1902, and obtained from Mr. A. A. Arnold, head driller, and Dr. J. C. Harden, fossils found at a depth of 1,000 to 1,250 feet. These have been pronounced Jackson (Eocene) by Prof. G. D. Harris. The depth at which they were found confirms the dip observations made on Ouachita River between Stock Landing and Carter Landing.[18]

Dr. Harden, with whom the drillers stayed, was greatly interested in the well and kindly allowed Mr. Robertson to copy the following from his personal memorandum. It should be noted that it differs materially from the record furnished by the president of the company, and given below, which on the whole more nearly agrees with the known structure.

Section of well of Catahoula Oil and Development Company, Leland, Catahoula Parish, La.

[By Dr. J. C. Harden.]

		Feet.
1.	No record	0 – 40
2.	Coarse gray sandstone, containing pure freestone water	40 – 60

[16] Ibid., p. 1560.

[17] Geol. Survey Louisiana, Rept. of 1902, pp. 91–92.

[18] Ibid., p. 164.

3. Black clay, with pebbles	60 – 70
4. Soft sandstone, with water	70 – 246
5. Dark-green clay	246 – 546
6. Sandstone	546 – 559
7. Coarse red and white sand	559 – 601
8. Black and yellow clays	601 – 666
9. Soft sandstone	666 – 670.5
10. Sand, with soft, warm water	670.5– 700.5
11. Black clay	700.5– 760.5
12. Yellow clay	760.5– 775.5
13. Fine gray sand, with water	775.5– 800.5
14. Black clay	800.5– 875.5
15. No record	875.5–1,000
16. Clay, with shells (Jackson)	1,000 –1,250
17. No record	1,250 –1,300
18. Very black formation, old seaweed, mud, and lignite (Cockfield)	1,300 –1,500
19. Sand, with artesian salt water	1,500 –1,645
20. Rock, "gypsum"	1,645 –1,651
21. Very fine gray gypsum?; sand; water not artesian	1,651 –1,701
22. Black and yellow clay	1,701 –1,751
23. Rock	1,751 –1,764
24. No record	1,764 –1,864

"Pipe was withdrawn from 1,864 to 900 feet, when an explosion occurred which could be heard over three-fourths mile; then a gusher of very foul-smelling gas, mud, lignite, and salty water shot up over 100 feet. This contained some oil. Flow continued for twenty-two hours, when it stopped by choking. Before flow stopped salty water became quite clear."

The president, Mr. S. McDowell, furnished the following record in February, 1903:

Section of well of Catahoula Oil and Development Company, Leland, Catahoula Parish, La.

[By S. McDowell, president.]

	Feet.
1. Gray-mottled clay	0– 60
2. Quicksand, with water	60– 80
3. Sandstone	80– 130
4. Blue or green clays	130– 370
5. Water-bearing sand	370–
6. Blue or green clays	–1,550
7. Artesian salt water	1,550–

No water was encountered between the 370-foot sand stratum and 1,550 feet.

Section of test well of St. Louis, Iron Mountain and Southern Railway, Olla. Catahoula Parish, La.

[From records in the office of E. Fisher, chief engineer of bridges and buildings.]

	Feet
1. Clay	0–242
2. Water and sand	242–254
3. Streaks of sand and clay	254–257
4. Fine sand, with layers of sand rock and some water	257–314
5. Clay and sand in layers	314–328
6. Soapstone	328–341
7. Gray, hard clay, and black, tough clay or soapstone	341–358
8. Fine sand, water trace	358–364
9. Clay and fine sand, not much water	364–369
10. Fine sand, not much water	369–374

859. *Section of test boring in Ouachita River at Catahoula Shoals, Catahoula Parish, La., (77 miles above mouth of Black River).*[19]

	Depth in feet.
1. Sandy mud	0.0
2. Sand, clay and gravel	.99
3. Gravel	3.28
4. Gray sand	15.75
5. Blue-brown sandy clay	30.35
6. Blue-gray rock	52.50
7. Very hard blue gray clay or soft rock	54.33
8. Soft blue-gray rock	76.18
9. Blue sandy clay	86.32
10. Gray rock	139.67
11. Blue sandy clay	140
12. Fine gray sand; water flowed at the rate of 3,600 gallons per hour	158 07
13. Fine gray sand; water flowed at the rate of 3,600 gallons per hour	197.51

862. Lockett[20] gives the following regarding this locality: "In the vicinity of La Croix Ferry, and near the mouth of Trout Creek, is a small area of about 1 mile square, peculiarly characterized by numerous sulphur springs. The best known of these are on the eastern bank of Trout Creek, known as the Catahoula White Sulphur, and now owned by Mrs. Ward. Her husband first opened these springs to the public in 1846, and for many years they were a fashionable resort for the planters of Rapides and other parishes. Their waters were thought to be beneficial to those afflicted with liver complaint, dyspepsia and all kinds of cutaneous diseases.

"One mile from Wards Springs, on the opposite side of Trout Creek, are the sulphur springs of Captain Welch, which are better, more numerous, and stronger than the former, but are not so well known, from never having been opened to the public."

[19] Ann. Rept. Chief of Engineers, 1902, pt. 2, p. 1560.

[20] Ann. Rept. Louisiana State Univ. for 1869, 1870, pp. 56, 57.

863. *Analysis of spring water from sec., 15, T. 21 N., R. 4 W., Claiborne Parish, La.*[21]

	Parts per million.
Silica	52.4
Peroxide of iron and alumina	13.2
Lime	23.9
Magnesia	7.01
Potash	4.78
Soda	22.9
Sulphuric anhydride	22 9
Chlorine	16 59
Carbonic acid	35.9
Oxygen absorbed from potassium permanganate in three hours	.30

No ammonia and mere traces of nitrates, nitrites, and phosphoric acid.

867. *Section of Texas and Pacific Railway well at Fish Pond, Concordia, Parish, La.*

[By C. H. Camberlain.]

Alluvium and Port Hudson:	Feet.
1. Top soil and clay	0– 40
2. Blue clay, with streaks of sand	40– 70
3. Quicksand	70– 95
4. Clay and cottonwood drift	95–100
5. Loose stones and gravel	100–105
6. Sharp water sand and gravel	105–145

871. *Section of R. G. Hedrick's test well, 2 1-2 miles northeast of Frierson, De Soto Parish, La.*

Sabine:	Feet.
1. Gray sands and clays, with lignite	0– 241
2. Coarse white sand; lost water in large quantities	241– 281
Midway and Arkadelphia:	
3. Dark clay	281– 301
4. Rock	301– 302
5. Dark-colored laminated lignitiferous clay, with large concretions and occasional layers of iron pyrite	302– 901
6. Harder clay; did not cave as badly as that above	9 1– 998

[21] Preliminary report on the hill lands south of the Vicksburg, Shreveport and Pacific Railway to Alexandria: Geol. and Agric. of La., pt. 2, 1893, p. 118.

Nacatoch:

7. Indurated sand, containing Foraminifera and Ostracoda. Furnishes artesian salt water ...	998–

Marlbrook:

8. Blue clay........................	–1,275
9. White limestone; gas at 1,300 feet, (Saratoga?)..	1,275–1,300
10. Light clayey shale, with some sand......... ...	1,300–1,500

Diameter, 8 inches, 0–380 feet; 6 inches, 380–913 feet; 4 inches, 913–1,500 feet. Temperature of artesian water August 25, 1902, 70° F. Elevation of gound, 198.3 feet; top of 4-inch pipe, 203.5 feet above mean Gulf level.

872. *Section of Mississippi River Commission test boring, Hays Landing, East Carroll Parish, La.*[22]

[By E. W. Hilgard.]

	Feet.
Alluvium:	
1. Noncalcareous clayey silt, with abundant vegetable matter not lignitized..................	0– 56
Port Hudson:	
2. Coarse sand, with gravel and grains of lignite A clay streak occurs at 82.5 to 82.6..........	56–109
"Upper Claiborne" (Jackson):	
3. Whitish greensand marl. On washing and settling the greensand falls to the bottom, the red sand occupies the middle, and the calcareous débris lies on top......................	127–132
4. Greensand marl like the last, with calcareous concretions containing shell fragments........	132–135
5. Concretions from marl bed, with shell fragments	145–150
6. Bluish clay, with lignite grains	158–160
7. Fine sand of a clay color with greensand.......	166–176
8. Bluish clayey silt, with lignite grains...........	176–181

"This boring at Hayes Landing, about 5½ miles southwest from the boring at Lake Providence (873), shows in its upper portion the same unusual variety of materials as No. 873. For that very reason it is extremely probable that if it were of the older formation the corresponding fossils would be easily found. The depth of the alluvium here may therefore probably be placed at 56.8 feet; from this depth to that of 109 feet there can be no doubt of the true character of the older or 'bottom gravel.'"

[22] Ann. Rept. Miss, River Com. for 1883: 48th Cong., 1st sess., House Ex. Doc. No. 37, 1884, pp. 494, 496.

Harris[23] has identified the following forms from this well: *Leda multilineata* (radial marking on anterior only), *Leda*, depth 135 feet; *Venericardia planicosta* and *V. rotunda*, depth 137 feet.

These forms, together with those obtained from the other borings along the river, indicate that this formation is Jackson rather than Claiborne.

873. *Section of Mississippi River Commission test boring at Lake Providence, East Carroll Parish, La.*[24]

[By E. W. Hilgard.]

	Feet.
Alluvium:	
1. Yellowish noncalcareous silt, with macerated vegetable matter, varying in the proportions of sand and clay every few feet	0– 9.6
2. Blue clay	9.6– 15.6
3. Yellowish sand, slightly coherent	15.6– 29
4. Blackish-blue clay	29 – 30
5. Grayish-yellow sand, slightly coherent	30 – 42.9
Port Hudson:	
6. Loose sand, with grains of lignite	54.8–
7. Fine brownish silt, darker below, with lignite in grains	56 – 82
8. Bluish-gray clay	82 – 84
9. Clayey silt of a terra-cotta color; abundant lignite grains	100.5–101
10. Grayish-yellow sand; vegetable matter abundant	101 –103.2
11. Brownish clay	103.2–104
12. Coarse sand, with chert pebbles	109 –127.6
13. Black lignite	127 –131.5
14. Whitish-blue sandy clay	131.5–170
15. Fine yellowish clayey sand	170 –191
16. Gray sand, with clayey streaks	191 –247
17. Blackish-brown clay	247 –248

"Boring No. 2, the deep boring at Lake Providence town, is one of the most interesting, not only on account of the great depth reached (248 feet) and the great variety of materials encountered, but mainly from the fact that at this great depth the Tertiary strata (contrary to the impression of the engineer in charge) have not been reached." For the general run of wells in this section the writer is inclined to regard stratum No. 12 as the base of the Quaternary or Port Hudson deposits.

[23] Geol. Survey Lousiana, Rept. of 1902, p. 23.

[24] Ann. Rept. Miss. River Com. for 1883: 48th Cong., 1st sess., House Ex. Doc. No. 37, 1884 pp. 494, 496.

875 *Section of well at Lake Providence, East Carroll Parish, La.*[25]

[By John L. Kennedy.]

	Feet.
1. Black, blue, and red loam	0–10
2. Fine sand	10–19
3. Coarse water-bearing sand	19–34
4. "Concrete"	34–38
5. Water-bearing sand	38–77
6. "Concrete"	77–79
7. Sand	79–85
8. "Concrete"	85–86
9. Water sand	86–93

"Abandoned at 112 feet, the water being found too ferruginous for general purposes."

877. *Section of town well at Colfax, Grant Parish, La.*

[By L. B. Hart.]

	Feet.
Port Hudson:	
1. Surface	0– 70
2. Water-bearing sand and gravel	70– 130
Jackson:	
3. Very hard clay	130– 300
4. Blue joint clay	300– 550
Cockfield:	
5. Fine quicksand	550– 650
6. Hard brown clay	650– 800
7. Sand rock	800– 835
8. Alternate layers of quicksand and black clay	835–1,000
9. Sand rock	1,000–1,060
10. Loose sand	1,060–1,100
11. Hard sandstone	1,100–1,128
12. Hard white clay, not passed through	1,128–

"Pipe pulled back and set at 1,103 feet. This water proved to be very salty or full of soda. It seemed to be propelled by gases, the water rising in a pipe 65 feet above the surface. The natural flow is 60,000 gallons for twenty-four hours."

Mr. R. S. Cameron reports that below 150 feet gypsum and shells (principally small spirals) were quite common. No shells were found above 150 feet.[26]

[25]Geol. Survey Louisiana, Rept. of 1902, p. 232.

[26]Shells are incorrectly reported above 150 feet in Geol. Survey Louisiana, Rept. of 1902, p. 211.

880. The artesian water obtained in the sandstone at 255 feet is used entirely for drinking. The well was continued to 910 feet without obtaining water except at 500 feet, where an impotable water was found in a blue mud.

881. *Section of well of Louisiana Lumber Company Limited, Rochelle, Grant Parish, La.*

[By Oscar Shanks.]

	Feet.
1. White dirt soil	1– 45
2. Fine sand, with sticks, logs and acorns	45– 56
3. Alternate layers of blue clay and flint rock, with streaks of salt water in fine sand	56–555
4. Alternate layers of fine white sand and porous chocolate-colored rock, in layers 6 to 12 inches thick; furnishes artesian salt water	555–565

Mr. F. T. Boles, manager of the Lord & Bushnell Lumber Company, Chicago, reports: "Well at Rochelle was 1,100 feet deep; at that depth brackish water with gas was obtained. One of our men who worked on the job reports that a slight flow of fairly good water was obtained at 700 feet." This refers to the same well reported by Mr. Shanks.

882. *Section of well of St. Louis, Iron Mountain and Southern Railway at Sandspur, Grant Parish, La.*

[By Oscar Shanks.]

	Feet.
1. Red clay	0–50
2. Cemented gravel	50–60
3. Coarse Gravel and sand	60–75

Well finished with a Cook strainer 14 feet long.

883. *Section of well of S. Hopper Mill Company, Stay, Grant Parish, La.*

[By Oscar Shanks.]

	Feet.
1. White and yellow clay	1–20
2. Quicksand	20–30
3. Blue clay	30–60
4. Coarse gravel and white sand	60–78

884. *Section of well of Davis Brothers, Ansley, Jackson Parish, La.*

[By L. B. Clifford.]

Claiborne and Sabine:	Feet.
1. Red clay	0– 22
2. Blue clay and rock	22–190
3. Gray sand, water bearing	190–245

885. *Section of well of Huie-Hodge Lumber Company, Hodge, Jackson Parish, La.*

[By L. B. Clifford.]

Claiborne and Sabine:	Feet.
1. Marl and blue clay	0–292
2. Gray sand, water-bearing	292–300

886. Mr. L. B. Clifford writes: "In the Jonesboro well there were about 70 feet of lignite in different layers; balance was blue marl, with occasional rocks. The water-bearing sand was gray and about 30 feet thick."

887. *Section of well of Wyatt Lumber Company, Wyatt, Jackson Parish, La.*

[By L. B. Clifford.]

Claiborne:	Feet.
1. Blue shell marl	0– 70
Claiborne and Sabine:	
2. Blue clay and layers of rock	70–208
3. Hard packed sand, layers of blue rock at bottom	208–242
4. Fine white sand, water bearing	242–252
5. Hard-packed gray sand and rock	252–272
6. Gray sand, water bearing	272–302

888. *Analyses of spring water from Chautauqua grounds; near Ruston, Lincoln Parish, La.*[28]

[By Maurice Bird.]

Constituents (in parts per million.)	Griffen Springs, No. 1.	Griffen Springs, No. 2.
Soluble silica	47.9	45 5
Iron and alumina	26.3	41.0
Lime	26.3	20 3
Magnesia	11.6	15.0
Potash	Trace.	Trace.
Soda	19.0	20.3
Chlorine	7.2	5 5
Sulphuric acid	11.5	12.8
Phosphoric acid	Trace.	Trace.
Nitrogen as nitrates	Trace.	Trace.
Nitrogen as nitrites	None.	None.
Nitrogen as ammonia	None	None.
Carbonic acid	Not determined	Not determined.

Both springs are slightly chalybeate.

890. *Section of well of Ruston Waterworks, Ruston, Lincoln Parish, La.*

[By L. B. Clifford.]

	Feet.
1. Sand	0– 18
2. Light-blue clay	18– 59
3. Water-bearing sand	59– 60
4. Rock	60– 61
5. Blue clay, with limestone concretion	61– 67
6. Water-bearing sand	67– 68
7. Clay	68– 69
8. Rock	69– 74
9. Water-bearing sand	74– 76
10. Rock	76– 81
11. Water-bearing sand	81– 84
12. Rock	84– 85
13. Water-bearing sand	85– 86
14. Clay, with occasional rocks	86–120
15. Water-bearing sand	120-126
16. Clay, with occasional rocks	126–152
17. Water-bearing sand	152–154
18. Clay, with occasional rocks	154–373
19. Water-bearing sand	373–425

Pipe was perforated between 120 and 126 feet and between 373 and 425 feet.

[28]Geology and Agriculture of Louisiana, pt. 1, 1892, p. 47.

893. *Section of Vicksburg, Shreveport and Pacific Railway test well at Delta, Madison Parish, La.*

[By R. B. Coxe.]

Alluvium and Port Hudson:	Feet.
1. Clay	0– 12
2. Quick sand	12– 50
3. Light clay, passing below into sand and gravel	50– 118
4. Coarse gray water-bearing sand	118– 135
5. Clay; no water	135–1,200±

894. Pronounced by State experiment station a good drinking water.

895. "Wells in the valleys and on the bayous are generally from 25 to 50 feet deep; on the hills from 60 to 150 feet. The water is in most cases slightly hard. There is a flowing well in T. 19 N., R. 16 E., and one that flows at times in the channel of Bonne Idee Bayou in T. 21 N., R. 7 E. Sulphur springs abound along upper Bartholomew and Boeuf rivers."

896. *Section of well at court-house, Bastrop, Morehouse Parish, La.*

[By W. A. Harrington.]

Port Hudson:	Feet.
1. Clay and soil	0– 25
2. Dry sand	25– 65
3. Medium coarse sand, filled with good, almost pure, water	65–153
4. Hardpan	153–

897. *Section of well of St. Louis, Iron Mountain and Southern Railway, Collinston, Morehouse Parish, La.*

[By C. H. Winters.]

Alluvium and Port Hudson:	Feet.
1. Sandy clay and soil	0–10
2. Hard gumbo and yellow clay	10–64
3. Fine sand	64–68
4. Coarse sand and gravel	68–71
5. Fine sand	71–78
6. Gravel and sand	78–81

Well is furnished with a No. 4 Cook well strainer. When pumping 140 gallons per minute the water level remains unchanged.

898. *Section of well of St. Louis, Iron Mountain and Southern Railway, Mer Rouge, Morehouse Parish, La.*

[By Oscar Shanks.]

	Feet.
Port Hudson:	
1. Black soil	0– 6
2. Stiff clay	6–79
3. Water-bearing sand	79–89

901. Mr. D. G. Petty reports: "A well 1 inch in diameter was sunk here in the early part of 1902, and at 412 feet flowed from the pipe 20 feet above ground for half a day. The pipe was on a rock, and as that was the time of the oil excitement the workmen concluded to go through the rock and strike oil. The rock was penetrated and the water ceased to flow. Nothing more has been done to the well except to remove the pipe. The pipe was never fast and one man could easily turn it at any time. The water was very good for drinking. Did not test for hard or soft.

904. *Partial section of test well at Drakes Salt Works, sec. 21, T. 12 N., R. 5 W., Natchitoches Parish, La.*

[By H. H. Jones.]

	Feet.
1. Yellow sand clay	0– 5
2. White sand, with water which steams all right in a boiler, but turns deep red and coats everything with a salty crust	5– 42
3. Cypress log, very much decayed, charred on one side	42– 43
4. Soft sand, gravel, and streaks of clay of various colors so mixed in drilling that we could not classify or give stratification	43–318
5. Very porous crystalline limestone; crevices filled with white and yellow calcite crystals	318–475

"At 150 feet a foam found on the water which tasted very much of alum, puckering the mouth very much."

Samples from stratum 5 are in every way identical with the limestone found at the Winnfield "Marble Quarry."

906. *Partial section of well of J. W. Cockerham, Jr., Luella, Natchitoches Parish, La.*

	Feet.
Alluvium and Port Hudson:	
1. Surface loam	0 – 36
Transition:	
2. Sand and gravel, with large lignitized cottonwood (?) log at 270 feet	36 –300
Sabine:	
3. Rock	300 –304
4. Blue clay, with occasional rock several feet thick	304 –640
5. Sand, with artesian salt water	640 –
6. Fossiliferous sand, with artesian salt water	700.5–707

Mr. Cockerham has three wells on his place which obtain water from the sand and gravel stratum No. 2, and which are, respectively, 36, 86, and 106 feet deep. The water in these stands from 18 to 21 feet below the surface, and from the 36-foot well a supply of 10 gallons per minute has been pumped without affecting the water level.

908. *Section of well of Montrose Lumber Company, Montrose, Natchitoches Parish, La.*

	Feet.
Alluvium and Port Hudson:	
1. Surface clay and loam	0– 80
2. Quicksand, abundant supply of water, but it can not be used in boilers	80–180
Jackson and Cockfield:	
3. Blue clay, with fossil shells; no water	180–496

Well sunk in January, 1899. Judging from the depth of the water-bearing sand in the Weaver spur well, water should be obtained at this place at a depth of about 600 feet. (P. 138; Pl. XXXVIII, sec. E)

910. *Section of well at waterworks, Natchitoches, Natchitoches Parish, La.*

[By Judge C. H. Levy.]

	Feet.
Claiborne:	
1. Red clay	0– 5
2. Blue clay	5–12
3. Red clay	12–13
4. Blue and red sandy clay	13–16

Sabine:

5. Fine gray quicksand, very variable in thickness.	16–39
6. Black sandy clay	39–40
7. Coarse gray sand, not passed through	40–64

The well at the waterworks consists of a dug well, 30 feet in diameter and 19 feet deep, in which five 1½-inch pipes and one 3-inch pipe have been driven to a depth of 40 to 45 feet below the bottom of the well. The water flows rapidly from the top of these pipes into the well.

911. The following record has been prepared from the statements of President Caldwell, and from data collected on the ground while the well was being drilled:

Section of well of Normal School, Natchitoches, Natchitoches Parish, La.

1. Red and chocolate clays	0 – 34
2. Soft sandstone, iron stained	34 – 35.5
3. Gray sand, with a moderate supply of very salty water, rising to within 14 inches of the surface	35.5– 38
4. Alternate beds of blue-gray and red-gray sandstone and blue clay, with occasional bits of pyrite and lignite	38 – 96
5. Very fine, nearly pure white sand, with a large supply of water, not distinctly salt	96 –108
6. Chocolate clay, blue clay, and thin beds of sand	108 –134
7. Iron pyrite	134 –144
8. Coarse, white rounded sand	144 –156
9. Pyrite	156 –160
10. Alternate layers of clay and sand, with one or two thin beds of impure lignite	160 –462
11. Shells and gravel	462 –496
12. Blue clay	495 –558
13. Lignite	558 –558.5
14. Blue clay	558.5–560
15. Lignite	560 –571
16. Blue clay, with occasional seams of lignite	571 –637
17. Gray clay, with limestone concretions	637 –680
18. Lignite	680 –700
19. Sandstone	700 –704
20. Soft blue clay	704 –710
21. Light-gray sand, with artesian salt water and gas	710 –726

Harris[28] adds the following information, obtained from the foreman of the Andrews Well Company:

[28] Geol. Survey Louisiana, Rept. of 1902, p. 210.

Partial section of well of Normal School, Natchitoches, Natchitoches Parish, La.

		Feet.
1.	Greenish brittle clay, with shells	0–547
2.	Lignite	547–558
3.	Clay, with shells	558–678
4.	Bowlder	678–681
5.	Clay (no shells), rock, fine sand	681–728

913. *Analysis of water from Iron Springs, near Natchitoches, Natchitoches Parish, La.*[29]

[By Maurice Bird.]

	Parts per million.
Silica	64.0
Iron and aluminum oxides	8.0
Lime (CaO)	12.0
Magnesia	9.3
Sulphuric acid (SO_3)	20.6
Potash	4.0
Soda	22.0
Chlorine	17.4

"Water is colorless, but contains a little brown suspended matter; it is neutral to litmus paper and practically tasteless."

914. *Analysis of water from Breazeale Spring, 2 miles northwest of Natchitoches, Natchitoches Parish, La.*[30]

[By Maurice Bird.]

	Parts per million.
Silica	55 0
Iron and aluminum oxides	4.0
Lime (CaO)	9.0
Magnesia	5.7
Sulphuric acid (SO_3)	20.6
Potash	4.0
Soda	22.0
Chlorine	17.4

"Water is clear and colorless, neutral to litmus paper, and practically tasteless."

[29] Geol. Survey Louisiana, Rept. for 1899 [1900], p. 148.
[30] Ibid., p. 148.

918. *Sections of test borings in Ouachita River near Bosco, Ouachita Parish, La. (155 miles above mouth of Black River).*[31]

BORING No. 18.

	Depth in feet.
1. Yellow sand	0.0
2. Gray sand, with small percentage of clay	13.12
3. Mud	36.09
4. Mud, with small percentage of sand	43.96

BORING No. 18a.

1. Fine, clean sand	0.0
2. Fine gray sand and mud	4.43
3. Coarse gray sand and blue mud, with gravel	17.06
4. Clean gray sand	17.56
5. Gray sand and mud	23.46
6. Mud, with small percentage of sand	24.78
7. Mud	25.10
8. Mud	32.14

919. The following section of the well of the Louisiana Oil Company was prepared from samples at the well :

Description of samples from well of Louisiana Oil Company, 3 miles southeast of Cheniere, Ouachita Parish, La.

[By A. C. Veatch.]

	Depth in feet.
1. Dark clay	10
2. Light, sandy clay	35
3. Mottled clay	45
4. Pebbly clay	55
5. Dark, stiff clay	65, 75
6. Dark, sandy clay	85, 95, 105
7. Dark sand	115
8. Dark sand, with small shells	125, 135, 145, 155
9. Dark, sandy clay	165, 175, 185, 195
10. Light c'ay	205
11. Light clay and sand	215
12. Hard clay	225, 235, 245, 255
13. White sand	265–275
14. Sand and clay	285, 295
15. Clay, with shells	305, 315

31Ann. Rept. Chief of Engineers for 1902, p. 1564.

16. Lignitic clay	325
17. Lignite and sand	335, 345
18. Sand	355, 430
19. Hard clay	445
20. Clay and sand	455
21. Gray sand, reported to contain artesian water	465–515

920. *Sections of test borings in Ouachita River near Logtown, Ouachita Parish, La. (160 1 miles above mouth of Black River).*[32]

BORING No. 19.

	Depth in feet.
1. Brown sand and trash	0.0
2. Brown sand	1.64
3. Sand and coarse gravel	13.12
4 Very stiff, sticky blue-black clay	23.78
5. Very stiff, blue-black clay, with pockets and streaks of greensand and shells, also many small pieces of rock, some as large as a hen's egg	37.73–50

BORING No. 19a.

1. Brown sandy clay	0 0
2. Brown sand	1.97
3. White sand	13.13
4. Sand and coarse gravel	19.69
5. Sand and coarse gravel, with small percentage of clay	28.12
6. Stiff, sticky blue-black clay	34.78
7. Very stiff clay, with pockets and streaks of green sand	42.65
8. Very stiff clay, with pockets and streaks of greensand marl; also several pieces of rock about the size of a hen's egg	49.22–50

32Ann. Rept. Chief of Engineers for 1902, p. 1564.

921. *Analyses of waters from wells of the Consolidated Ice Company, Monroe, Ouachita Parish, La.*[33]

[By Maurice Bird.]

Constituents (in parts per million).	Jackson well.	Boone well.
Soluble silica	14.022	50.958
Iron and alumina	27.018	30.438
Lime	14.022	17.955
Magnesia	2.394	3.420
Potash	3.762	3.762
Soda	224.694	259 407
Chlorine	24.795	27.018
Sulphuric acid	7.524	9.405
Phosphoric acid	12.825	17 784
Nitrogen as nitrates	None.	None.
Nitrogen as nitrites	None.	None.
Nitrogen as ammonia	None.	None.
Carbonic acid	177.840	87.039

922. *Section of well of Consolidated Ice Company, Monroe, Ouachita Parish, La.*

	Feet.
Port Hudson:	
1. Clay and earth	0– 40
2. Sand, water bearing	40– 60
3. Clay	60– 65
4. Water-bearing sand	65– 75
5. Hard clay	75– 90
6. Coarse sand and gravel	90– 95
Claiborne and Sabine ?:	
7. Blue clay mixed with sand and a few layers of rock	95–250
Sabine:	
8. Sand, with some black substance like lignite; water begins to flow at 250 feet and flow increases with depth	250–400

923. There are three wells at the waterworks, but because of the large amount of mineral matter the water is used only in case of fire. The main supply is derived from Ouachita River. In 1898 Mr. Strong gave the following record of this well:

33Report on the hills of Louisiana north of the Vicksburg, Shreveport and Pacific Rwy.; Geol. and Agric. of La., pt. 1, 1893, pp. 45-47.

Section of waterworks well No. 1, Monroe, Ouachita, Parish, La.

[By Will A. Strong.]

	Feet.
Port Hudson:	
1. Clay and quicksand	c– 80
Claiborne and Sabine:	
2. Soft bluish clay	80–180
3. Blue marl, with shells	180–190
4. Rock	190–191
5. Soft blue pipe clay	191–289
Sabine:	
6. Water-bearing sand	289–385

The water first began to flow at 289 feet and the flow increased with the depth.

924. *Analysis of water from deep well of Planters' Oil Company, Monroe, Ouachita, Parish, La.*[34]

[By Maurice Bird.]

	Parts per million
Soluble silica	71.820
Iron and alumina	52.668
Lime	7.182
Magnesia	14.364
Potash	7.524
Soda	252.909
Chlorine	53.865
Sulphuric acid	9.234
Phosphoric acid	None.
Nitrogen as nirates	None.
Nitrogen as nitrites	None.
Nitrogen as ammonia	None.
Carbonic acid	102.942

928. *Sections of test borings in Ouachita River at Monroe, Ouachita Parish, La. (183.4 miles above mouth of Black River).*[35]

BORING No. 20.

	Depth in feet.
1. Brown sand	0 00
2. Gray sand	17.39
3. Blue-black clay and sand	40.22
4. Blue-black clay and sand	51.38

34 Report on the hills of Louisiana north of the Vicksburg, Shreveport and Pacific R'y. Geol. and Agric. of La., pt. 1 1893; pp. 45-47.

35 Ann. Rept. Chief of Engineers for 1902 pp. 1564-1565.

BORING No. 20a.

	Depth in feet.
1. Brown sand and clay	0.00
2. Brown sand	3 28
3. Grayish sand	22.96
4. Blue-black clay, with some mud	36.28
5. Blue-black clay, with some mud	50.20

BORING No. 20b.

1. Yellow sand and mud	0.0
2. Gray sand	6.56
3. Coarse sand mixed with gravel and mud	22.31
4. Coarse bits of broken gravel and sand	23.95
5. Sand	25.59
6. Fine sand and mud	27.23
7. Mud	28.55
8. Blue mud	31.50
9. Mud and sand	33.79
10. Mud	36.42
11. Mud and sand	41.01
12. Mud and sand	43.97

BORING No. 20c.

1. Clean white sand	0.00
2. Yellow sand	5.26
3. Wet brown sand	5.58
4. Wet black sand	5.91
5. Gray sand	12.47
6. Fine sand and mud	35.86
7. Blue clay	39.77

929. *Sections of test borings in Ouachita River at Rock Row Shoals Ouachita Parish, La. (200.9 miles above mouth of Black River).*[36]

BORING No. 21.

	Depth in feet.
1. Brown-gray sand, with small percentage of clay	0.00
2. Brown sand	1.64

[36] Ann. Rept. Chief Engineers for 1902, pt. 2, pp. 1565–1566.

Claiborne:

	Depth in feet.
3. Very stiff clay and greensand marl	24.27
4. Very stiff clay and greensand marl, with a few shells	49.70
5. Rock	62.73
6. Very stiff clay and greensand marl, with a few shells	62.99
7. Same clay, with more greensand and pieces of rounded rock, size 1 inch	69.62
8. Rock	70.99
9. Greensand, with small precentage of clay	71.68
10. Greensand and clay	74.45
11. Stiff clay, with some greensand and a few small shells	78.74
12. Very stiff blue-black clay, with a few small shells	82.02
13. Rock	102.39
14. Very stiff blue-black clay, with a few small shells	102.72
15. Very stiff dark-brown clay and sand, with some shells	117.97
16. Gray rock, very hard and full of shells	126.31
17. Dark-gray sand and clay, with shells	126.46
18. Rock	131.36
19. Blue-black clay, with shells and sand	131.69
20. Gray and green rock full of shells	146.78
21. Very stiff clay, with shells and pockets of sand	149.14
22. Gray-green rock full of shells	153.70
23. Very stiff clay, with shells and sand	155.02
24. Gray-green rock full of shells	156 39
25. Gray-green rock full of shells	157.05

BORING No. 21a.

	Depth in feet.
1. Brown-gray sand and mud	0.00
2. Greensand marl, with large precentage of clay	16.40
3. Stratum of rock about 1 inch thick	40.35
4. Very stiff greensand and clay	48.49
5. Very stiff mud or soft rock	62.79

933–936. In 1894 and 1895 four wells were put down by the city of Alexandria—two near the corner of Monroe and Fourth streets, where the waterworks now stand; one behind the city hall, and the fourth on the corner of St. James and Fourth streets. All these were flowing wells, the water rising from 4 to 10 feet above the surface, and were used at first to supply public watering troughs. After the installation of the waterworks in 1895, the yield of the wells at the city hall and St. James and Fourth streets gradually decreased. For several years they would cease flowing when pumping began at the waterworks, and recommence about three hours after the pumps, had stopped. Since 1899 they have not flowed at all and the water level is gradually lowering. On August 6, 1902, it was found to be from 58 to 60 feet below the surface in the city-hall well, and 49 feet in the well at St. James and Fourth streets.

No record was kept of these wells, and the various reports received concerning them are very contradictory and confusing. The following represents the best data obtainable:

Well behind city hall.—Diameter, 1.5 inches; completed in 1894; flowed intermittently until 1899, the water supplying a public watering trough. On August 6, 1902 the well was sounded and found to be 473 feet deep; about 20 feet of sand had accumulated in the bottom, but the plumb bob finally reached hard clay.

Waterworks well No. 1.—Diameter, 4 inches; strainer, 2.5 inches; completed 1898. Mr. H. C. Kenneker, foreman in charge of the drilling, states that the well is 560 feet deep, the water-bearing sand extending from 540 to 560 feet. This, with well No. 2, was pumped with a direct-suction pump from 1895 to 1901, when an air lift was installed. The air-lift pipe is 198 feet long, and the air pressure on August 4, 1902, indicated that the water was at that time approximately 138 feet from the surface. Mr. Ira W. Sylvester, city engineer, states that it takes over a day for the water in No. 1 to rise to within 3 feet of the surface. Yield of well April 16, 1902, 53 gallons in 27 seconds.

Waterworks well No. 2.—Diameter, 10 inches, 0–210 feet; 8 inches, 210–612 feet; 4 inches, 612–760 feet. Mr. H. C. Kenneker, the driller, reports that water-bearing sand was encountered at 540, 620 and 760 feet, and that strainers were placed at each of the sands. Mr. Ira W. Sylvester, city engineer, is of the opinion that there are no strainers in the well at 540 and 620 feet, because pumping well No. 2 does not affect the water level in well No. 1. Yield of well April 16, 1902, 53 gallons in 26 seconds. On August 6 the depth of water was about 110 feet.

Well corner St. James and Fourth streets.—Diameter, 2 inches; flowed originally 10 feet above the surface; flowed intermittently from 1894 until 1899. On August 6, 1902, well was sounded and found to be 606 feet deep;

bottom of the casing was filled with about 50 feet of sand; plumb bob finally struck hard bottom.

In order to obtain some idea of the effect of pumping the waterworks wells a number of observations were made on the wells at the city hall and St. James and Fourth streets, on August 6 and 7, 1902. Both of the waterworks wells had been pumped steadily up to this time, and well No. 1 was cut out from 10.15 a. m. to 6 p. m., August 6. The water in the city hall well rose steadily after the pumping of No. 1 ceased, indicating that these two wells depend on a common horizon. The well at the corner of St. James and Fourth streets, however, did not show any fluctuation which could clearly be attributed to the increased demand on well No. 2.

937. In 1900 a well was started for the St. Louis, Iron Mountain and Southern Railway, near the round-house, by the Hart Well Company. Mr. Hart has furnished the following statement regarding it: "The well was drilled to a depth of 858 feet. Water was struck at 850 feet, but, through a disagreement with the railroad company, was not developed. A considerable thickness of sandstone was penetrated before reaching 850 feet; below, this was loose sand "

The following has been taken from a blueprint, dated February, 1890, on file in the Iron Mountain Railway office at Bearing Cross, Ark.:

Partial record of well of St. Louis, Iron Mountain and Southern Railway, Alexandria, Rapides Parish, La.

	Feet.
Port Hudson:	
1. Soil	0– 60
2. White sand	60– 75
3. Yellow sand	75– 80
4. Bowlders	80– 90
Catahoula:	
5. Solid rock	90–110
6 "Slate" (blue clay), and sand rock	110–390
7. Sand rock	390–402
8. "Shale" (blue clay), sand rock, and blue soapstone (blue clay)	402–520
9. Sand rock	520–528
10. "Shale" (blue clay), sand rock, and blue soapstone	528–540

Casing, 6-inch, 0–300 feet; 4-inch, 300–482 feet.

938. In 1902 two test wells were put down on the property of the Alexandria Ice and Storage Company, near the corner of Monroe and Sixth streets, by the Andrews Well Company. Mr. James Drouant, foreman, has furnished the following data: "In well No. 1 water was struck at 480 and 580 feet; stratum at 480 feet yield 60 gallons per minute; water from 580 feet stood within 60 feet of the surface."

Section of second test well of the Alexandria Ice and Storage Company, Alexandria, Rapides Parish, La.

[By James Drouant.]

	Feet.
1. Clay	0–150
2. White sand	150–155
3. Clay	155–176
4. Rock	176–180
5. Clay	180–330
6. Sandstone	330–375
7. Clay	375–410
8. Shale	41c–450
9. Sand	450–510
10. White rock	510–520
11. Clay	520–545
12. Sand	545–580
13. Green clay, typical Catahoula (Grand Gulf) material	58c–621

These horizons are clearly the same as those developed in the waterworks wells. The depth to the water is about what would be expected because of the depression of the water table produced by the pumping at the waterworks.

As neither of these wells furnished the amount of water required by the ice factory, they were abandoned.

939. After the abandonment of the two Andrews test wells, a new well was drilled by the Hart Well Company on the Fifth street line of the property. Harris gives the following section:

Section of well of Alexandria Ice and Storage Company, Alexandria, Rapides Parish, La.[37]

[By G. D. Harris.]

	Feet.
1. Surface clay	0 – 21
2. Sand	21 – 23
3. Clay	23 – 38

[37] Water-Sup. and Irr. Paper No. 101, U. S. Geol. Survey, 1904, p. 20.

4. Rock	38 – 65
5. Blue clay	65 –153
6. Hard rock	153 –155
7. Blue clay	155 –175
8. Rock	175 –183
9. Blue joint clay	183 –328
10. Limestone	328 –331
11. Clay	331 –374
12. Hardpan	374 –464
13. Hard limestone	464 –466.5
14. Green clay	466.5–478.5
15. Hard rock	478.5–480
16. Blue clay	480 –490
17. Sandstone	490 –504
18. Clay	504 –534
19. Sand	534 –537
20. Rock	537 –539
21. Clay	539 –549
22. Sand	549 –550
23. Clay	550 –558
24. Sand	558 –560
25. Blue clay	560 –649
26. Sand	649 –665
27. Clay	665 –693
28. Sand	693 –703
29. Blue clay	703 –727
30. Soft sandstone	727 –780
31. Clay	780 –804
32. Sand	804 –809
33. Soft sandstone	809 –851
34. Clay	851 –853
35 Sandstone	853 –897
36. Sand	897 –927

"This well is provided with a 70-foot strainer, and before it was cleaned had a flow of 125 gallons a minute, according to the report of a local paper."

The fact that this is a flowing well indicates a stratum entirely distinct from those developed in the waterworks wells.

940. *Section of well of Sonia Cotton Oil Company, Alexandria, Rapides Parish, La.*

[By Ira W. Sylvester.]

	Feet.
Port Hudson:	
1. Sandy soil	0– 5
2. Clay	5– 60
3. Shelly rock	60– 65
4. Sharp sand, water bearing	65– 95
5. Clay and gravel	95–110
Sabine:	
4. Rock	64–
5. Clay	– 77
6. Lignite	77– 85
7. Fine sand, with turbid water	85–
8. Rock	115–116
9. Fine sand, water bearing	116–
10. No record	–287.5

Casing, 4-inch, 0–85 feet; 2.5-inch, 85–168 feet. Water was brackish and well is not used.

941. *Section of well of Ball Sawmill Company, Ball, Rapides Parish, La.*

[By Oscar Shanks.]

Catahoula:	
1. Yellow clay	0– 17
2. Soft blue sandstone	17– 22
3. Fine sand and clay	22– 48
4. Medium sandstone	48– 60
5. Blue clay	60–310
6. Fine water sand mixed with lignite and mica	310–365

This stratum was cased off and an attempt made to get flowing water, but the well was abandoned.

943. *Section of well of Texas and Pacific Railroad Company, Boyce, Rapides Parish, La.*

[By Charles Anderson]

	Feet.
1. Clay	0 – 42
2. White sand	42 – 62
3. Hard clay	62 – 82

	Feet.
4. Clay and sand	82 –145
5. Sandstone	145 –156
6. Clay	156 –180.5
7. Sandstone	180.5–204.2
8. Sand	204.2–215.2
9. Blue clay	215.2–217.2
10. Flint Rock	217.2–221.2
11. Hard clay	221.2–263.2
12. Quicksand	263.2–279.2
13. Clay	279.2–281.2
14. Sand and clay	281.2–300.2
15. Clay	300.2–318.4
16. Sandstone	318.4–325.4
17. Clay	325.4–329.4
18. Sandstone	329.4–335.4
19. Clay	335.4–344.4
20. Sandstone	344.4–368.4
21. Clay	368.4–376.4
22. Sandstone	376.4–398.4
23. Clay	398.4–411.4
24. Flint rock (quartzite)	411.4–418.8
25. Clay	418 8–438.8
26. Sandstone	438.8–441.2
27. Clay	441.2–529.2
28. Sandstone	529.2–531.2
29. Hardpan	531.2–541.2
30. Gravel and clay	541.2–616
31. Sandstone	616 –696
32. Sand, with artesian water	696 –708
33. Flint rock (quartzite)	708 –711
34. No record	711 –774
35. Soft sandstone	774 –802
36. Soft sandstone, with brackish artesian water	802 –808.6

"Depth September 14, 1898, 808.6 feet. Pipe was pulled back to 696 feet and well used until 1901, when it caved."

944. When this well is pumped the water lowers to 40 feet from the surface. It requires about eight days to entirely recover—that is, to flow. The original pressure at the top of the pipe was 15 pounds to the square inch.

947. *Section of well of L. C. Sanford, Lamothe, Rapides Parish, La.*

[By L. C. Sanford.]

Port Hudson:	Feet.
1. Soil, sand and clay	0– 35
2. Quicksand; does not yield the water readily	35– 80
3. Tough red clay	80– 95
4. Sand and gravel, with abundant supply of hard water	95–105

950. *Sections of wells of Pineville Development Company, Pineville, Rapides Parish, La.*

[By F. S. Hoyt.]

WELL No. 1.	Feet.
1. Gravel, water bearing	200 –
2. Light-greenish clay (Catahoula)	235.5–
3. Gravel, water bearing; water flowed out of pipe 55 feet above the ground for four hours	430 –440
4. Sand; lost water at	460 –
5. Soft limestone	580 –600
Total depth	–720

WELL No. 2.	
1. Clay, with a little sand	0 –100

WELL No. 3.	
1. Soil	0 – 12
2. Packed sand	12 –112
3. Rock	112 –124
4. Gravel from size of pea to that of a hen's egg, with a little water	124 –230
Total depth (August 8, 1902)	–230

951. Mr. Oscar Shanks has furnished the following samples from this well:

Samples from asylum well, Pineville, Rapides Parish, La.

	Feet.
1. Medium to coarse reddish-yellow quartz sand	20– 24
2. Fine white indurated sand	24– 35
3. Very fine light-gray sandy silt	52– 92

	Feet.
4. Clay conglomerate, composed of small rounded clay pebbles containing considerable lime....	228– 324
5. Fine-grained white sand......................	324– 328
6. Light-gray clay with rounded calcareous clay pebbles................................	328– 428
7. Hard gray fine-grained quartzitic sandstone....	455– 461
8. Green clay.............	461– 540
9. Green clay and fine gray sand	540– 610
10. Green clay and fine gray sand, with numerous thin calcareous plates that resemble shell fragments, but which cannot be definitely proved to be of organic origin......................	610– 650
11. Greenish-gray clayey sand	720– 800
12. Medium white sand, with a little clay	800– 806
13. Very fine gray clayey sand....................	806– 925
14. Rounded white calcareous concretions, lignite and gray laminated lignitic sand	927–
15. Greenish clay, lignite and sand; a few thin white calcareous plates similar to those in sample 10................................	925– 985
16. Fine greenish-gray sand	985–1,020

952. *Section of well at Judge Morrow's residence, near Rapides, Rapides Parish, La.*

[By C. A. Morrow.]

Port Hudson:	Feet.
1. Soil	0– 8
2. Red clay........	8– 77
3. Sand	77–102
4. Gravel	102–106

953. *Partial section of deep test well near Rapides, Rapides Parish, La.*

[By C. A. Morrow.]

Port Hudson:	Feet.
1. Soil	0– 8
2. Red clay	8– 77
3. Sand	77–102
4. Gravel	102–108
Catahoula:	
5. Clay........	108–180
6. White sand, water bearing; water soft and pure and did nct overflow........................	180–

7. Artesian water	288–
8. Quicksand, which forced its way up in the pipe 80 feet and caused the well to be abandoned ..	323–

956. *Section of well of J. A. Bentley Lumber Company, Zimmerman, Rapides Parish, La.*

[By J. A. Bentley.]

	Feet.
Port Hudson:	
1. Alluvial deposits	0 – 60
Catahoula:	
2. Soft rock and clay, alternating	60 –175.5
3. Rather coarse white sand, containing artesian water....	175.5–

960. *Partial section of well at Lake End, Red River Parish, La.*

[By Charles Stoer]

	Feet.
Port Hudson:	
1. Clay soil........................	0–
2. Quicksand.	
3. Gravel........................	– 64

966. Mr. W. A. Shields, superintendent, reports water bearing sand at the following depths: 188–190, 220–230, 251–264, 436–444, 460–462, 505–507, 524–528, 536–540, 545–549, 560–566, 670–704 feet. Screens have been placed opposite each of these layers. At 454 and 557 feet a little oil is reported. Mr. L. B. Clifford, the driller, states that seven beds of lignite were encountered in this well.

Mr. Robert Moechel reports the following: "Reaction, faintly alkaline to litmus. Appearance, turbid, with brown sediment. Microscopically, the sediment showed the presence of refuse matter. The water after twenty-four hours' sedimentation contained the following:

Analysis of water from deep well at Loring, Sabine Parish, La.

[By Robert Moechel.]

	Parts per million.
K_2O	15.91
Na_2O	25.66
Cl	27.00
SO_3	15.45
NO_3	1.77
SiO_2	50.20
Al_2O_3 (in clay)	1.20

$Fe_2O_3+Al_2O_3$	7.10
CaO	2.68
MgO	1.44
SO	1.47

HYPOTHETICAL COMBINATION.

Sodium chloride	43.67
Potassium sulphate	27.79
Sodium sulphate	94.94
Sodium nitrate	2.43
Sodium carbonate	4.30
Silica+clay	51.40
Iron+alumina	7.10
Calcium sulphate	2.49
Calcium carbonate	2.94
Magnesium carbonate	3.02

"Suspended and settled matter contains 531.2 parts of solid matter per million, composed of 42.9 parts mineral matter, quite a per cent of which is phosphates.

"This is not a mineral nor sanitary water analysis. Determinations have been made so as to be able to render an intelligent opinion as to the suitability of this water for economically generating steam, etc. This water contains sewage."

From a knowledge of the location and surroundings of this well, the writer is inclined to believe that the water is not contaminated. Water derived from these lignitiferous beds containing considerable organic matter and chlorine must necessarily show characteristics which are in other regions interpreted as indicating sewage. This well is situated on a knoll with no polluting source near it; is cased and the water sands amply protected by clayey layers. So far as the possibilities of pollution are concerned the deep-well water is greatly to be preferred to the water from the shallow wells which are now exclusively used at this place for the supply of drinking water.

969. *Section of Foster well, 2.5 miles southwest of Negreet, Sabine Parish, La.*[38]

[By William Kennedy.]

	Feet.
1. Soil and clay	0– 18
2. Quicksand	18– 23
3. Blue clay, changing to blue shale	23– 50
4. Blue limestone	50– 52

[38]Bull. U. S. Geol. Survey No. 212, 1903, p. 55

5. Blue clay, with bowlders; first sign of oil at 75 feet	52– 75
6. Blue shale, oil signs, and plenty of gas	75–200
7. Lignite	200–205
8. Blue shale and gas	205–340
9. Brown gummy shale, oil on water	340–350
10. Blue shale with oil and gas	350–430
11. Slate colored talcky rock	430–494
12. Bluish-gray lime rock, very hard; gas blew out drillings	494–502
13. Tan-colored shale, with yellow sand	502–542
14. Milky-white talcose rock	542–580
15. Blue shale, with small white pebbles	580–600
16. Blue, hard, and flinty limestone; gas under this rock	600–604
17. Shells and pebbles, with strong indications of oil and much gas	604–630

971. The water-bearing layer at 160 feet is very thin, and was developed by pumping sand out until a sufficient cavity was made to yield a fair supply of water. There is no strainer in the well.

972. *Analysis of water from Ferrell's mineral well, near Pleasant Hill, Sabine Parish, La.*

[By Maurice Bird.]

	Parts per million.
Silica	61.56
Peroxide of iron and alumina	10.26
Calcium	875.52
Magnesia	1,134.02
Potash	3.42
Sodium	884.07
Sulphuric anhydride	3,062.61
Chlorine	2,110.14
Carbonic acid	206.91
Oxygen absorbed from potassium permanganate in three hours	1.642

HYPOTHETICAL COMBINATION.

Sodium chloride (common salt)	2,241.1
Calcium chloride	1,162.8
Calcium sulphate	1,368.0
Magnesium sulphate	3,231.9
Magnesium bicarbonate	171.0

"On ignition, the residue obtained from evaporation fuses and darkens, quickly becoming white, however. The water is perfectly clear and colorless and does not contain sufficient organic matter to make it unwholesome. The mineral ingredients of this water are so high that it may properly be called a medicine, and for this reason it should be used only in cases of sickness, and then only upon the prescription of a physician who is acquainted with its composition. The reaction of the water with litmus is slightly acid."

974. Mr. Coxe, superintendent, reports that a small vein of lignite was encountered at about 75 feet; and that three water-bearing sands were encountered between 100 and 195 feet, the one between 100 and 120 being the thickest of the three.

975. *Section of well of Latannier Oil Company, 12 miles south of Melville, St. Landry Parish, La.*

[By Oscar Shanks.]

	Feet.
1. River deposits	0– 20
2. Blue clay	20– 150
3. Gravel and bowlders	150– 232
4. Hard blue flinty rock	232– 336
5. Caving brown gravel	336– 532
6. Hard blue flinty rock	532– 537
7. Coarse blue sand, with a large flow of pure soft water	537– 555
8. Gumbo shale	555–1,452
9. Pepper-and-salt sand, with a strong flow of water having a slight sulphur taste	1,452–1,458
10. Strata of gumbo and rock containing strong artesian sulphur water	1,458–2,003

Occasional layers of sand and shells are reported in stratum 10.

978. *Sections of test borings in Ouachita River at Loch Lomond, Union Parish, La.*[39]

BORING No. 22.

	Depth in Feet.
1. Brown sand, with small percentage of gravel	0.00
2. Greensand marl, with medium percentage of clay	20.47
3. Greensand marl, with small percentage of clay	34.48
4. Very stiff greensand and mud	42.16
5. Very stiff greensand and mud	50 00

39Ann. Rept. Chief of Engineers for 1902, pt. 2, 1902, p. 1566.

BORING No. 22a.

	Depth in Feet.
1. Brown sand and mud	0.00
2. Brown sand, with small percentage of gravel	0.99
3. Greensand marl, with large percentage of clay	13.88
4. Greensand marl, with small percentage of clay	32.68
5. Very stiff greensand and mud	39.37
6. Very stiff greensand and mud	50.00

982. *Analyses of brines from Bisteneau Salt Works, Webster Parish, La.*[40]

[By Maurice Bird.]

Constituents (in parts per hundred).	Bryan's well.	Potters Pond	Head of Salt Island.
Sodium chloride	8.450	7.810	3.800
Calcium chloride	.234	.301	.081
Magnesium chloride	.102	.156	.083
Alumina	.056	.052	.056
Other solid matter	.088	.061	.058

983. *Section of well of Valley Lumber Company, Cotton Valley, Webster Parish, La.*

[By L. B. Cifford.]

	Feet.
1. Red clay	0– 40
2. Red sand	40– 45
3. Blue clay and rock	200–245
4. White sand	245–271

985. *Section of well of Minden Lumber Company, Minden, Webster Parish, La.*

[By C. L. Whitmarsh.]

Sabine:

	Feet.
1. White clay	0– 20
2. Fine sand	20– 70
3. Clay	70– 71
4. Lignite (1 foot thick)	71– 72
5. Sand and clay	72–110
6. Coarse white water-bearing sand	110–120

[40]Geol. Survey Louisiana, Rept. of 1902, p. 89.

	Feet
7. Clay	120–244
8. Lignite	244–247
9. Water-bearing sand, increasing in coarseness with depth	247–317

986. Mr. L. B. Clifford states that the sand encountered in this well at 110 feet, which furnishes water at the ice factory, yields practically no water at this point.

988. *Section of well of Minden Cotton Oil and Ice Company, Minden, Webster Parish, La.*

[By S. G. Webb, president.]

	Feet.
Sabine?:	
1. Surface sands and clay	0– 60
2. Sand	60– 75
Sabine:	
3. Dark-colored clay	75–100
4. Water sand	100–115

989. The water from the lower layer in this well is shut out and the well draws entirely from the stratum between 228 and 270 feet. Both horizons furnish good soft water.

990. Mr. A. L. Pullin states that he worked on this well until it reached a depth of 750 feet and that the well was afterwards drilled to a depth of 1,015 feet. He gives the following partial record:

Partial record of well at Yellow Pine, Webster Parish, La.

[By A. L. Pullin.]

	Feet.
1. Log at	280–
2. Layers of rock.	
3. Marl that looks like slack lime	600–640
4. Rock	640–680
5. Blue clay, with a very offensive smell	680–750

"No water was encountered to a depth of 750 feet. Casing, 4-inch, 0–500; 3-inch, 500–750."

Mr. H. C. Walter, woods foreman for the Globe Lumber Company, who was at Yellow Pine when the well was drilled, gives the total depth as 800 feet. He says: "The matter passed through was a black sticky clay, with a very bad odor, and was full of shells of all kinds. In some places the clay changed to very hard rock. At a depth of 500 feet a log was struck which was supposed to be a cypress. They finally struck a very hard substance, which effectully stopped work with a rotary rig."

991. *Section of well of Texas and Pacific Railway, Baton Rouge Junction, West Baton Rouge Parish, La.*

[By Charles Anderson.]

	Feet.
1. Black clay	0– 10
2. Heavy clay	10–100
3. Quicksand	100–110
4. Coarse sand, not passed through	110–

994. *Analyses of brines from Drakes Salt Works, Winn Parish, La.*[41]

[By Maurice Bird.]

Constituents (in parts per hundred).	I.	II.	III.	IV.
Sodium chloride	4.90	3.55	5.58	5.44
Calcium chloride	.184	.127	.303	.356
Magnesium chloride	.142	.133	.135	.159
Alumina	.061	.066	.072	.055
Other solid matter	.083	.044	.070	.030

I. Little lick, west side, old Drake well.
II. Smith's lick.
III. Lower lick, old Drake well.
IV. Upper lick, south side, in slough.

995. *Analysis of brine from Price's Salt Works, Winn Parish, La.*[42]

[By Maurice Bird.]

	Per cent.
Sodium chloride	3.14
Calcium chloride	.079
Magnesium chloride	.138
Alumina	.050
Other solid matter	.030

999. This well was largely through porous crystalline limestone similar to that seen in a number of Cretaceous exposures in northern Louisiana. Between 250 and 260 feet a large amount of gas was encountered, which was used for fuel in the engines of the drilling machines. The well was finally abandoned because of the heavy gas pressure, and the company planned to start a new hole in January, 1904. Two small oil-bearing layers are reported.

[41] Geol. Survey Louisiana, Rept. of 1902, pp. 63–64.
[42] Geol. Survey Louisiana, Rept. of 1902, p. 69