CHARACTERIZATION OF AQUIFERS DESIGNATED AS POTENTIAL DRINKING-WATER SOURCES IN MISSISSIPPI

U. S. GEOLOGICAL SURVEY
WATER RESOURCES INVESTIGATIONS
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Prepared in cooperation with the
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The Environmental Protection Agency has established that all ground water having a dissolved-solids concentration of less than 10,000 milligrams per liter be protected from injection of waste material. The Underground Injection Control program is intended to protect aquifers that are possible future sources of drinking water. Fourteen aquifers in Mississippi have been studied and their downdip limits for water containing 10,000 miligrams per liter dissolved solids have been delineated. The Environmental Protection Agency, in conjunction with the Mississippi Department of Natural Resources, Bureau of Pollution Control, will be responsible for enforcing regulations governing safe waste injection.

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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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by L. A. Gandl

Water-Resources Investigations
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Mississippi Department of Natural Resources,
Bureau of Pollution Control

Jackson, Mississippi
1982

UNITED STATES DEPARTMENT OF THE INTERIOR
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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) OF METRIC UNITS AND SOME ABBREVIATIONS

The following factors may be used to convert inch-pound units published herein to the International System of Units (SI):

Multiply inch-pound	By	To obtain SI units
	Length	
inch (in)	25.4	millimeters (mm)
foot (ft)	.3048	meter (m)
mile (mi)	1.609	kilometers (km)
	Area	
square mile (mi^2)	2.590	square kilometers (km^2)
	Flow	
cubic foot per second (ft^3/s)	28.32	liters per second (L/s)
	.02832	cubic meters per second (m^3/s)
gallons per minute (gal/min)	.06309	liters per second (L/s)
	6.309×10^{-5}	cubic meters per second (m^3/s)
million gallons per day (Mgal/d)	.04381	cubic meters per second (m^3/s)
	Gradient	
feet per mile (ft/mi)	18.9	centimeters per kilometer (cm/km)
	.189	meters per kilometer (m/km)
	Hydraulic conductivity	
cubic feet per day per square foot $(ft^3/d)/ft^2$ or ft/d	0.3048	cubic meters per day per square meter $(m^3/d)m^2$
	Transmissivity	
cubic feet per day per foot $(ft^3/d)/ft$ or ft^2/d	0.0929	cubic meters per day meter $(m^3/d)/m$
	Specific capacity	
gallons per minute per foot of drawdown (gal/min)/ft	0.21	liters per second per meter (L/s)/m

Abbreviations

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level". NGVD of 1929 is referred to as sea level in this report.

Milligrams per liter (mg/L)

CHARACTERIZATION OF AQUIFERS DESIGNATED AS POTENTIAL DRINKING WATER SOURCES IN MISSISSIPPI

by L. A. Gandl

ABSTRACT

The Environmental Protection Agency has established that all ground water having a dissolved-solids concentration of less than 10,000 milligrams per liter is to be protected from injection of waste material. The Underground Injection Control program is intended to protect aquifers that are possible future sources of drinking water. Fourteen aquifers in Mississippi have been studied and their downdip limits for water containing 10,000 milligrams per liter dissolved solids have been delineated. Maps have been prepared showing the top, bottom, thickness and potentiometric surface of the aquifers.

INTRODUCTION

Ground water is the principal source of drinking water in Mississippi. It is used for municipal, industrial, domestic, and agricultural purposes. Ground water is found in underground reservoirs and is available in large quantities almost everywhere in the state. It requires little or no treatment and is generally preferred to surface water, which requires treatment for most uses.

Besides providing large sources of freshwater, underground reservoirs are also utilized in Mississippi for injection of fluid waste, principally oil field brines. Because of this, the management and protection of Mississippi's underground water is necessary for current and future users. Minimum criteria established by Congress requires protection of all significant sources of ground water containing less than 10,000 milligrams per liter (mg/L) of dissolved solids. The Environmental Protection Agency (EPA) has chosen Mississippi as one of 22 states in which to implement the Underground Injection Control (UIC) program. The purpose of the program is to protect underground sources of drinking water from contamination by well injection.

Purpose and Scope

The U.S. Geological Survey, in cooperation with the Mississippi Department of Natural Resources, Bureau of Pollution Control (BPC), has identified, delineated, and described the fourteen regionally significant freshwater aquifers in Mississippi so that the aquifers can be protected from contamination by injection of waste materials. All water containing less than 10,000 mg/L will be protected as a potential source of drinking water, in accordance with Public Law 93-523. The information in this report will enable the EPA and the BPC to implement and manage the UIC program in Mississippi.

Information in this report is based on existing data from State and Federal files. Specifically, the report includes the following for each aquifer:

(1) Geologic description including: lithology, location of outcrop, and the top, bottom and thickness of the aquifer including impermeable layers.

(2) Hydrologic description including: location of potentiometric surface and changes in levels, sources of recharge, direction of water movement, identification of confining layers, and hydraulic characteristics of transmissivity, hydraulic conductivity, and specific capacity.

(3) Water quality description including general chemical type and extent of water quality zones from fresh to moderately saline water, based on dissolved-solids concentrations.

(4) Current and potential use description.

(5) Current and potential mineral, hydrocarbon, and geothermal use.

In addition, some of the above characteristics are summarized on a statewide basis. An appendix of terminology follows the report to assist those unfamiliar with hydrologic and geologic terminology.

Certain information of a nontechnical nature will be required for the state to administer the UIC program. This information, concerning such matters as water rights, mineral rights, and coordination between state agencies, is not included in this report.

The drafting of the illustrations in this report was done by the Mississippi Research and Development Center as part of the cooperative program with that agency. We gratefully acknowledge their assistance.

GEOLOGY AND MINERAL RESOURCES

Table 1 identifies all major geologic units and aquifers in the state, summarizes selected geologic and hydrologic data, and summarizes potential for extraction of minerals and hydrocarbons from the aquifers. Extraction of minerals and hydrocarbons from the earth has been one of the principal sources of manmade pollution to ground-water supplies.

Figure 1 shows the areas of major potential production of bentonite, iron ore, kaolinite, and lignite. Glauconite and gravel are also available in many locations throughout the state as shown in table 1 and in the sections on individual aquifers. The entire state has the potential for hydrocarbon production although development has been concentrated in the southern half of the state. Figure 2 shows the current oil and gas producing areas in the state and the locations of all salt domes. Figure 3 shows the locations of geothermal potential in

Table 1.--Geologic column of Mississippi indicating geologic and hydraulic characteristics

ERATHEM	SYSTEM	SERIES	GROUP	FORMATION	LITHOLOGY	THICKNESS ft	WATER BEARING CHARACTERISTICS	HYDRAULIC CHARACTERISTICS: TRANSMISSIVITY ft^2/d	SPECIFIC CAPACITY gal/min/ft	HYDRAULIC CONDUCTIVITY ft/d	MINERAL POTENTIAL: WHAT	LOCATION
CENOZOIC	QUATERNARY	HOLOCENE		Mississippi River Valley Alluvium	silty clay, sand and gravel	50-200	Mississippi River Valley alluvial aquifer	13,000-79,000	10-168	170-190	sand and gravel	throughout outcrop area
		PLEISTOCENE		Loess	silt	--	not an aquifer	--	--	--	--	--
				Terrace deposits (includes coastal deposits)	sand, gravel silt and clay	--	minor aquifers	--	--	--	--	--
	TERTIARY	PLIOCENE		Citronelle Formation	clay, sand and gravel	0-100	Citronelle aquifers	4,000-13,000	6.2-66	82-200	gravel	throughout outcrop area
				Graham Ferry Formation	clay and sand	0-100	local aquifer					
		MIOCENE		Pascagoula Formation	sand and clay	0-5000	Miocene aquifer system	13,000	up to 30	95	minor amounts of lignite	scattered throughout
				Hattiesburg Formation								
				Catahoula Sandstone								
		OLIGOCENE		Paynes Hammock Sand	sandy marl, clay, and silty limestone	20	not an aquifer	--	--	--	--	--
				Chickasawhay Limestone	impure limestone, marl and clay	30	not an aquifer	--	--	--	--	--
			VICKSBURG	Bucatunna Formation	clay	--	confining unit	--	--	--	--	--
				Byram Formation	clay, marl, limestone and sand	100-250	Oligocene aquifer system	120-3300	1.5-12	3-60	glauconite and bentonite	outcrop area
				Glendon Formation								
				Marinna Formation	silty limestone							
				Mint Spring Formation	sandy marl							
				Forest Hill Formation / Red Bluff Formation	clay and marl in extreme east sand and clay elsewhere							
		EOCENE	JACKSON	Yazoo Clay	clay	500+	confining unit	--	--	--	--	--
				Cocoa Sand Member	sand	0-40	local, minor aquifer	--	--	--	--	--
				Moodys Branch Formation	marls, sandy marls and sand	0-25	local, minor aquifer	--	--	--	--	--
			CLAIBORNE	Cockfield Formation		0-500	Cockfield aquifer	80-21,000	1.6-43	1-120	minor amounts of lignite	scattered throughout
				Cook Mountain Formation	limestone	200+	confining unit except in NW Mississippi	--	--	--	--	--
				Sparta Sand	several thick sand beds	0-1000	Sparta aquifer system	330-13,000	1-46	6-130	lignite	at contact with alluvium
											minor amounts of gas	downdip where dissolved solids exceed 35,000 mg/L
				Zilpha Clay	interbedded shale and siltstone		confining unit	--	--	--	--	--
				Winona Sand	fossiliferous sands and clays	0-600	Winona-Tallahatta aquifer	1200-6300	2.6-10.2	6.7	minor iron ore and glauconite	outcrop area
				Tallahatta Formation Neshoba Sand Member	micaceous quartz and gray clay							
				Basic City Shale	shale	--	confining unit except in NW Mississippi	--	--	--	--	--
				Meridian Sand Member	micaceous sand, massive, irregular beds of sand and sandy clay	50-400	Meridian-upper Wilcox aquifer	150-17,400	0.7-2.9	9-110	iron ore and lignite	outcrop area
			WILCOX	Hatchetigbee Formation							oil and gas	downdip where dissolved solids exceed 35,000 mg/L
				Bashi Marl Member	marl		Middle Wilcox aquifer	--	--	--	--	--
				Tuscahoma Formation	sands and clays							
		PALEOCENE		Nanafalia Formation Fearn Springs Member	thick sand beds in north and south; thin and irregular in central area	0-500	Lower Wilcox aquifer	670-51,000	0.9-74	25-470	iron ore and lignite	outcrop area
			MIDWAY	Naheola Formation							oil and gas	downdip where dissolved solids exceed 35,000 mg/L
											kaolinite	Wilcox-Midway contact
				Porters Creek Clay			confining unit	--	--	--	--	--
				Clayton Formation			not an aquifer	--	--	--	--	--
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS	SELMA	Owl Creek Formation / Prairie Bluff Chalk			confining unit	--	--	--	--	--
				Ripley Formation Chiwapa Sandstone Member McNairy Sand Member Coon Creek Tongue	sands and clays	0-200	Ripley aquifer	270-800	--	50-75	--	--
				Transitional clay	clay		confining unit	--	--	--	--	--
				Demopolis Chalk	chalk and lime	50-250	confining unit	--	--	--	--	--
				Coffee Sand / Mooreville Chalk	sands, clays and chalks		Coffee Sand aquifer	930-1200	1-15	9-20	--	--
				Arcola Limestone Member	lime and marl		not an aquifer	--	--	--	--	--
				Eutaw Formation Tombigbee Sand Member	glauconitic, calcareous, massive sand	0-400	Eutaw-McShan aquifer	200-4900	3.3	13.4	bentonite, glauconite and minor lignite	outcrop area
				Lower unnamed member	clay and sand						oil and gas	downdip where dissolved solids exceed 35,000 mg/L
				McShan Formation	thin beds of sand and clay							
			TUSCALOOSA	Gordo Formation	upper clay, lower sand and gravel unit	0-450	Tuscaloosa Aquifer System	535-21,400	--	42		
				Coker Formation Upper unnamed member	mixed clay, sand and gravel	0-800		762-80,200	--	--	gravel	outcrop area
											oil and gas	downdip where dissolved solids exceed 35,000 mg/L
				Eoline member	clay and massive sand			--	--	--		
		LOWER CRETACEOUS		Undifferentiated	clay, shale, sand and gravel	10,000+ (south Miss.)	not an aquifer	--	--	--	oil and gas	South Mississippi
	JURASSIC and TRIASSIC			Undifferentiated		10,000+ (South Miss.)	not an aquifer	--	--	--		
PALEOZOIC				Undifferentiated	weathered zone: limestone, chert, shale and sandstone	0-100	Palezoic aquifer	4000	--	71	oil and gas	Below and downdip of weathered zone throughout the state
					limestone, chert, shale, and sandstone		not an aquifer	--	--	--		

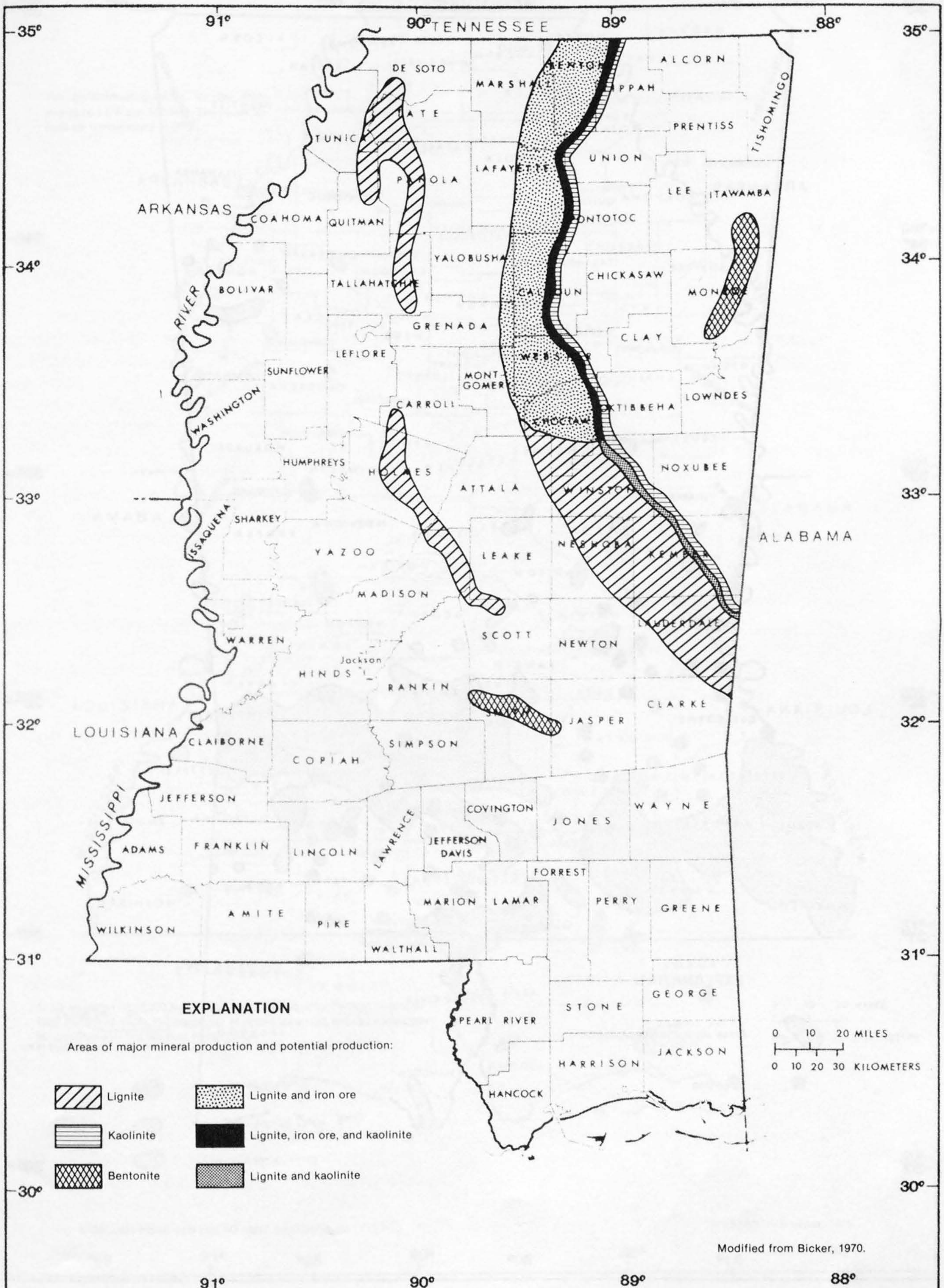

Figure 1. — Areas of major mineral production and potential production.

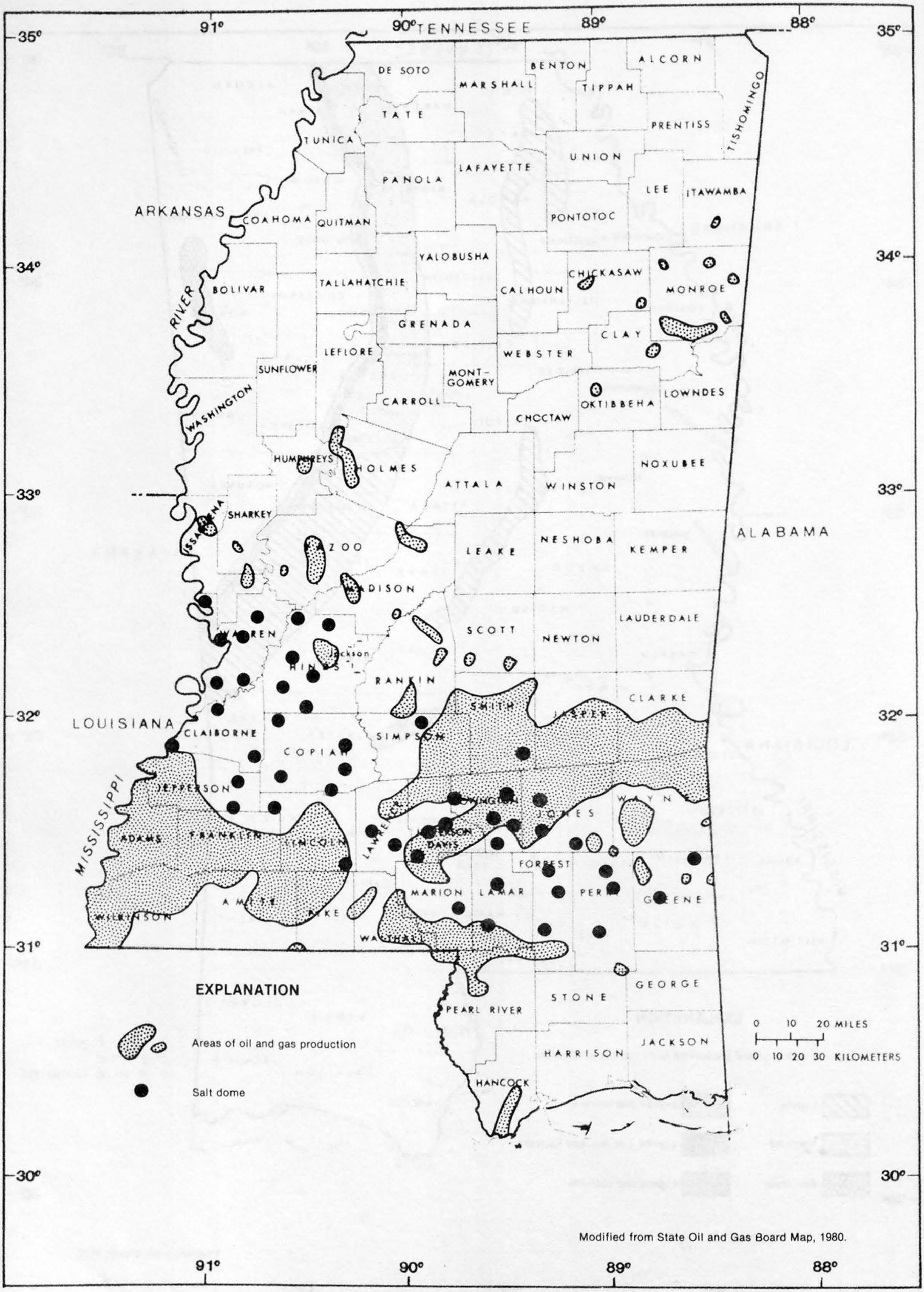

Figure 2. — Major hydrocarbon-producing areas of the state and salt dome locations.

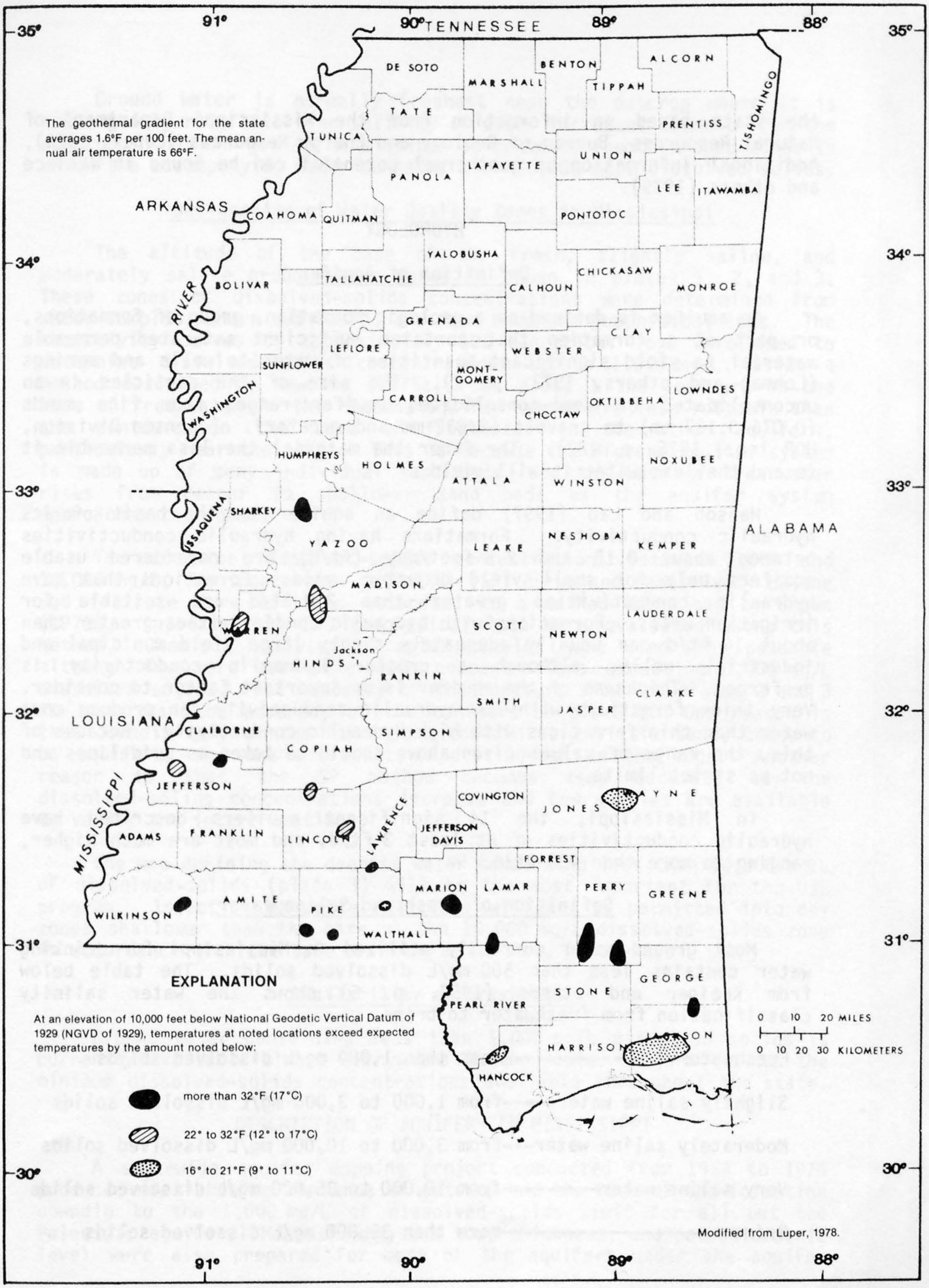

Figure 3. — Areas of geothermal potential in the state.

the state based on information from the Mississippi Department of Natural Resources, Bureau of Geology and Energy Resources (Luper, 1978). Additional information on geothermal potential can be found in Wallace and others (1979).

HYDROLOGY

Definition of Aquifer

An aquifer is defined as a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs (Lohman and others, 1972, p. 2). The size of the particles in an unconsolidated or semi-consolidated aquifer ranges from fine sands (0.076-0.127 mm) to gravels (2.032 mm and greater). (Johnson Division, UOP Inc., 1975, p. 182). The finer the material the less permeable it is and the less water it will yield.

Hanson and Lao (1957) define an aquifer on the basis of its hydraulic conductivity. Formations having hydraulic conductivities between about 0.13 and 2.8 feet/day (ft/d) are considered usable aquifers only for small yield domestic wells. Formations that have hydraulic conductivities greater than 2.8 ft/d are suitable for irrigation wells. Formations with hydraulic conductivities greater than about 10 ft/d can usually adequately supply large yield municipal and industrial wells, although a greater hydraulic conductivity is preferred. Thickness of the aquifer is an important factor to consider. Very thick formations with low hydraulic conductivity can produce more water than thin formations with high hydraulic conductivity. Because of this, the range of values given above should be taken as guidelines and not as strict limits.

In Mississippi, the 14 significant aquifers described have hydraulic conductivities of at least 3 ft/d, and most are much higher, ranging to more than 450 ft/d.

Definition of Fresh and Saline Water

Most ground water currently utilized in Mississippi for drinking water contains less than 500 mg/L dissolved solids. The table below from Kreiger and others (1957, p. 5) shows the water salinity classification from freshwater to brine.

Freshwater-----------------less than 1,000 mg/L dissolved solids

Slightly saline water-----from 1,000 to 3,000 mg/L dissolved solids

Moderately saline water---from 3,000 to 10,000 mg/L dissolved solids

Very saline water---------from 10,000 to 35,000 mg/L dissolved solids

Brine---------------------more than 35,000 mg/L dissolved solids

Ground water is normally freshest near the outcrop where it is recharged by rainfall. The salinity of water increases downdip from the outcrop. Oil and gas in Mississippi is commonly found in deep zones in which the accompanying water contains over 35,000 mg/L dissolved solids.

Delineation of Water Quality Zones in Mississippi

The altitude of the base of the fresh, slightly saline, and moderately saline ground-water zones is shown in plates 1, 2, and 3. These zones of dissolved-solids concentrations were determined from water samples, where available, and from borehole geophysical logs. The resistivity curves of approximately 500 electrical logs were used to determine dissolved-solids concentrations up to 1,000 mg/L, using a method described by Newcome (1975a). On plate 1 the contours on the base of freshwater in the Miocene aquifer system are less reliable than the contours on the base of freshwater in the other aquifers, particularly near the coast. This is because the Miocene aquifer system is made up of many individual sand beds, and the base of freshwater rises from deeper to shallower sand beds as the aquifer system approaches the coast.

To determine dissolved-solids concentrations between 1,000 and 10,000 mg/L, the spontaneous potential (SP) curve and resistivity of the mud filtrate were utilized according to a method described by Brown (1971). Approximately 150 geophysical logs were evaluated using this method. Chemical analyses of water samples were used when possible although few were available with concentrations exceeding 3,000 mg/L dissolved solids. The accuracy of the contours shown on plates 2 and 3 is less than the accuracy of the contours on plate 1. One reason is that downdip many of the formations contain very little sand, cease to be aquifers, and are difficult to distinguish on the logs. Another reason is that the SP method becomes less accurate as the dissolved-solids concentrations increase and few samples are available to verify the interpretations.

The map defining the deepest water containing less than 10,000 mg/L of dissolved-solids (plate 3) will be the most important for the UIC program. Injection of waste materials will not be permitted into any zones shallower than the base of the 10,000 mg/L dissolved-solids zone in accordance with the Safe Drinking Water Act, PL 93-923.

Availability of Freshwater

Ground water containing less than 1,000 mg/L dissolved solids is currently available almost everywhere in the state. Figure 4 shows the minimum dissolved-solids concentrations available throughout the state.

DESCRIPTION OF AQUIFERS IN MISSISSIPPI

A statewide aquifer mapping project conducted from 1974 to 1979 produced maps showing the area of outcrop and the base of the formation downdip to the 1,000 mg/L of dissolved-solids limit for all but the Paleozoic aquifer. Maps showing the top, thickness, and potentiometric level were also prepared for most of the aquifers under the aquifer

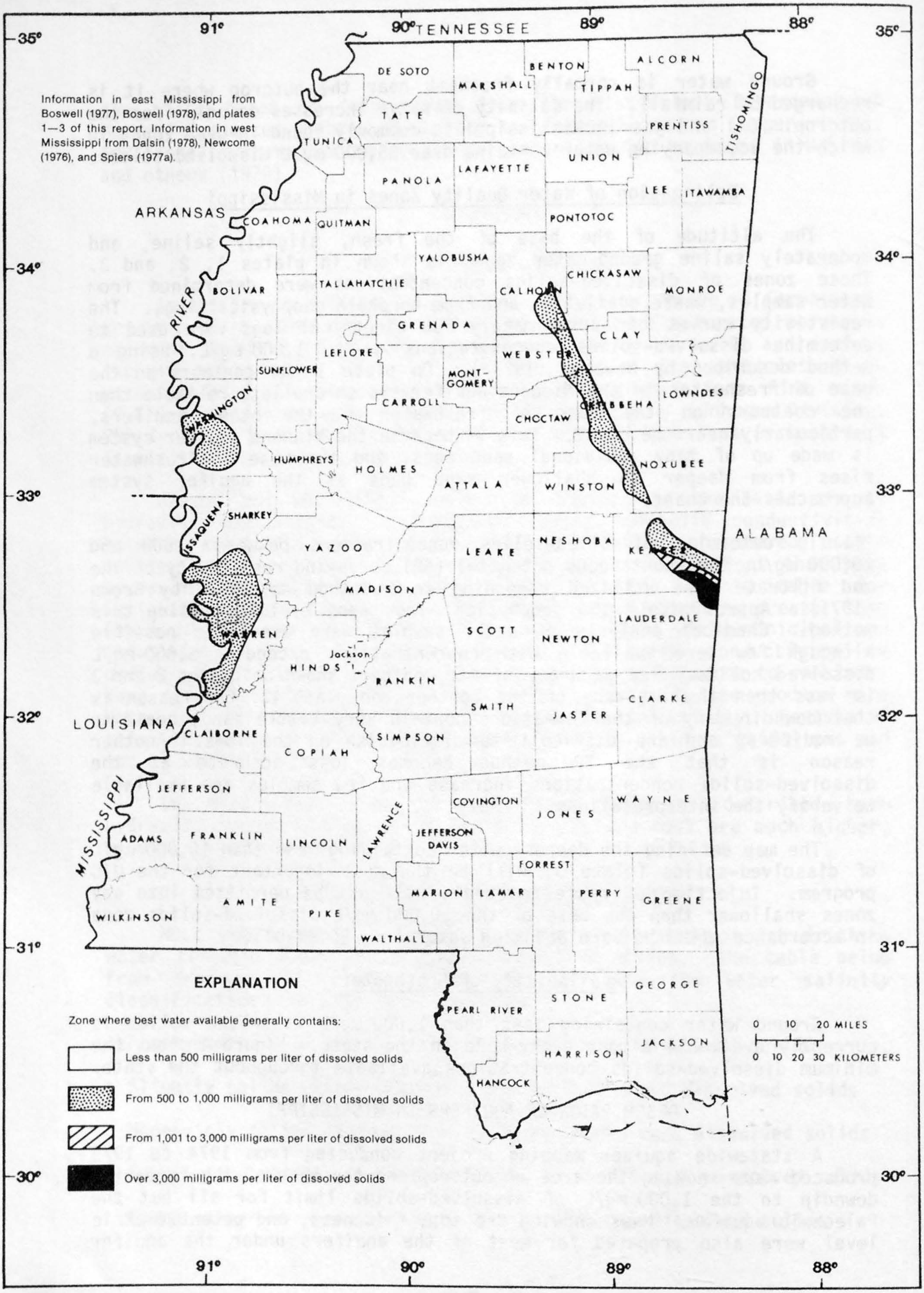

Figure 4. — Minimum dissolved solids concentrations of available ground water.

mapping program. More detailed potentiometric maps prepared recently for several aquifers have been utilized here. Additional maps in the following section were completed using information from the files of the U.S. Geological Survey.

The following section describes the geologic and hydrologic characteristics of major aquifers in the state and delineates the downdip limits of fresh, slightly saline, and moderately saline water. Areas of current and potential use as a source of drinking water are described. The area of potential use is defined as extending to the 10,000 mg/L dissolved-solids line.

Mississippi River Valley Alluvial Aquifer

The Mississippi River valley alluvial aquifer is located along the western boundary of the state. North of Warren County it extends farther to the east in an area known as the "Delta" (fig. 5). The formation dips gently to the south and is exposed at the surface over its entire area of occurrence. It was deposited by the Mississippi River and extends into Arkansas, Louisiana, Kentucky, Tennessee, and Missouri. The alluvial aquifer ranges from less than 50 to more than 200 feet thick, averaging 140 feet thick (fig. 6). It is thickest where it has filled in old stream channels. The aquifer generally consists of three layers: a lower gravel and sand layer, a middle sand layer, and a discontinuous silty clay layer at the surface.

The Mississippi River valley alluvial aquifer is primarily a water-table aquifer. Water levels average 20 feet below land surface, but seasonally fluctuate from about 30 feet below land surface during summer and fall to near the land surface during spring (fig. 7). Generally, recharge is from rainfall directly on the aquifer, and water moves to the south and towards streams in the area. Some water moves into the underlying Sparta and Cockfield aquifers which subcrop below the alluvium in the Delta. The Cook Mountain Formation, which acts as a confining unit in most of the State is sandy where it subcrops in the Delta, and some water also moves into it. South of Warren County, water movement is into the underlying Oligocene and Miocene aquifers. Seasonally, some streams may recharge the aquifer.

Results from fourteen aquifer tests in the alluvial aquifer indicate transmissivites of 13,000 to 79,000 ft^2/day, hydraulic conductivities of 170 to 190 ft/d, and specific capacities of 10 to 168 (gal/min)/ft of drawdown (Dalsin, 1978). Wells are from 60 to 260 ft deep with the deepest, screened in the basal gravel, producing 250 to 5,000 gal/min. Most large wells are irrigation wells although the aquifer also supplies municipalities and industries. Continued and increased use can be supported by the aquifer in future years.

Water from the alluvial aquifer is fresh in its entire area and contains less than 500 mg/L dissolved solids throughout most of its area. The water is a hard, generally alkaline, calcium-bicarbonate type that commonly has excessive iron.

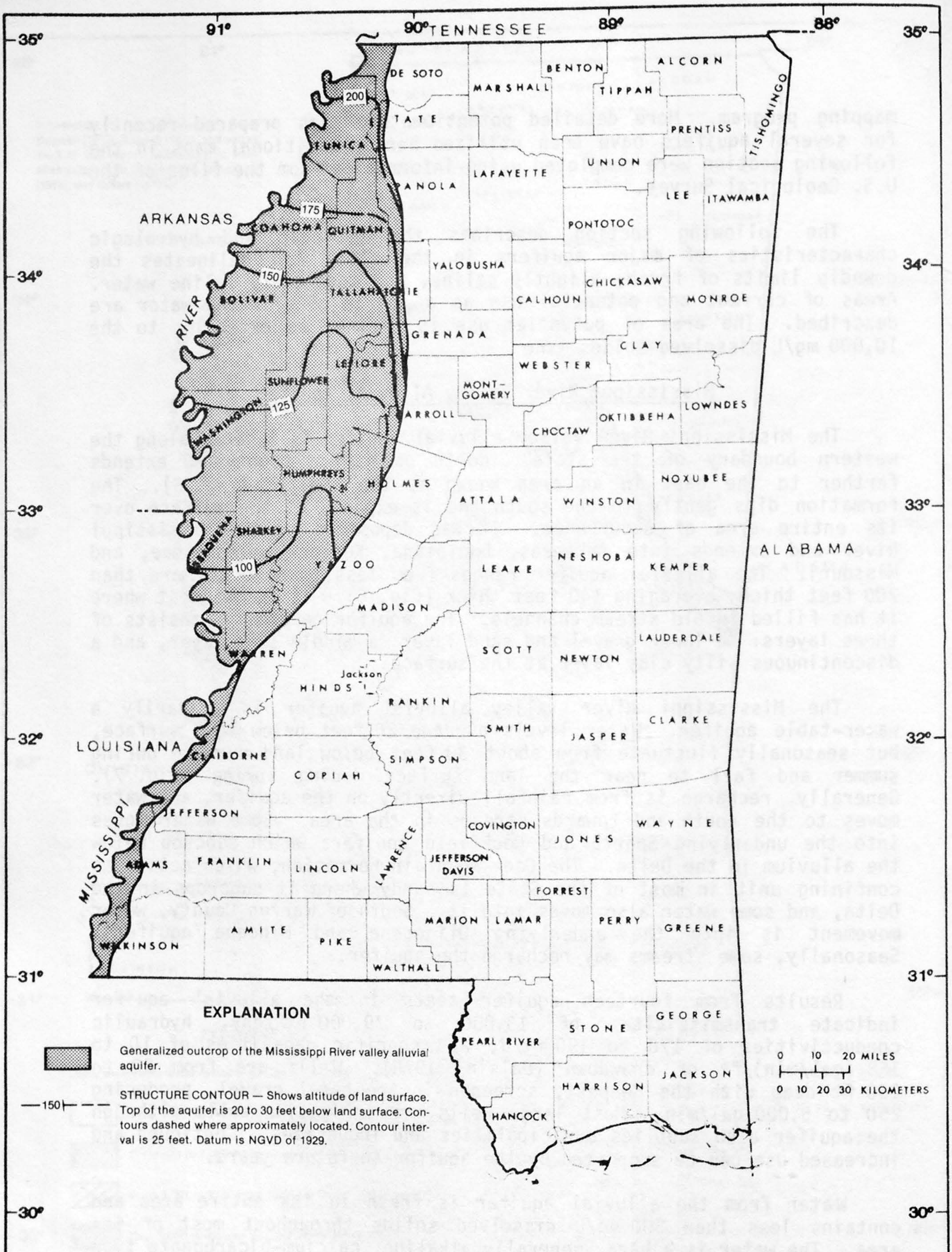

Figure 5. — Configuration of the top of the Mississippi River valley alluvial aquifer.

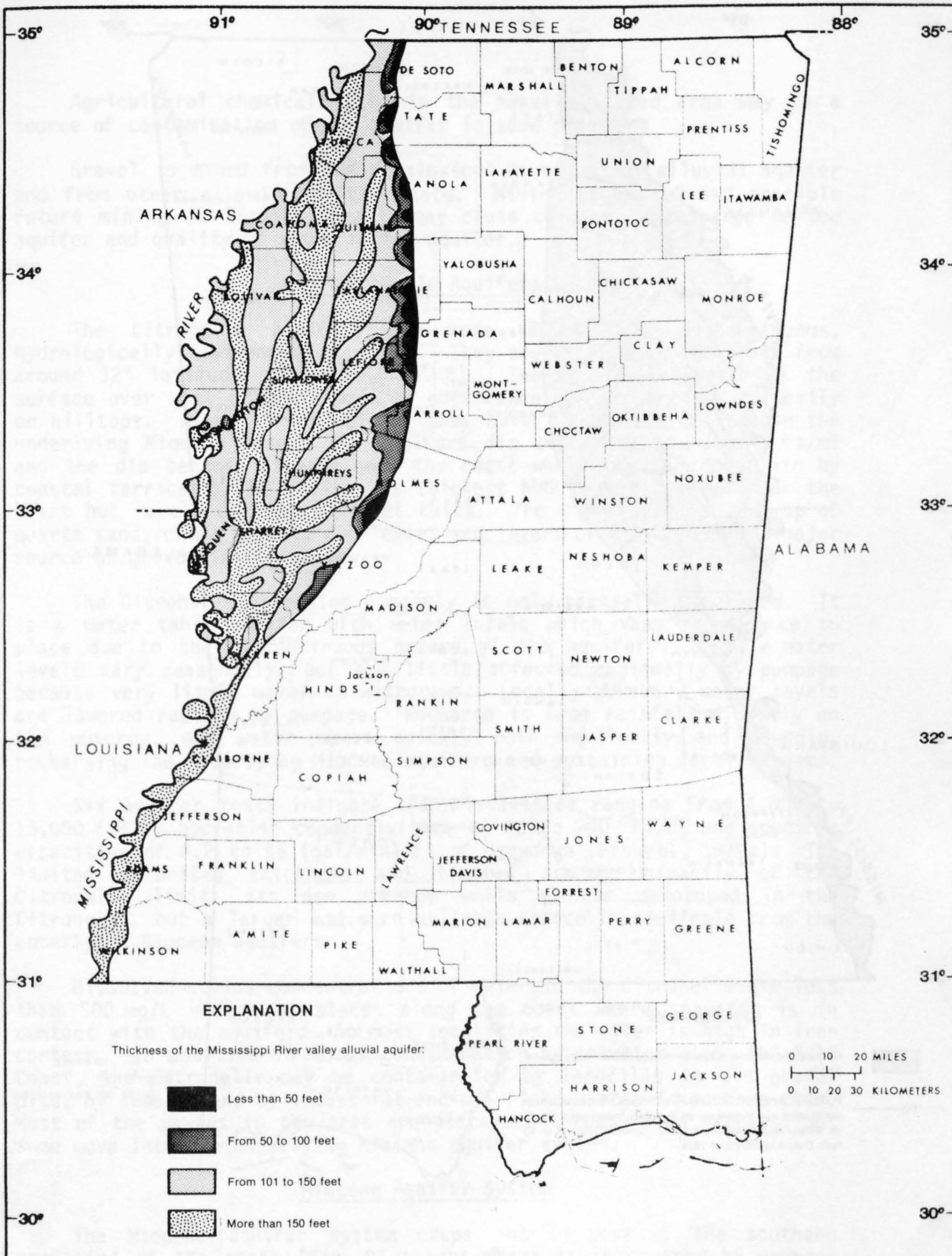

Figure 6. — Thickness of the Mississippi River valley alluvial aquifer.

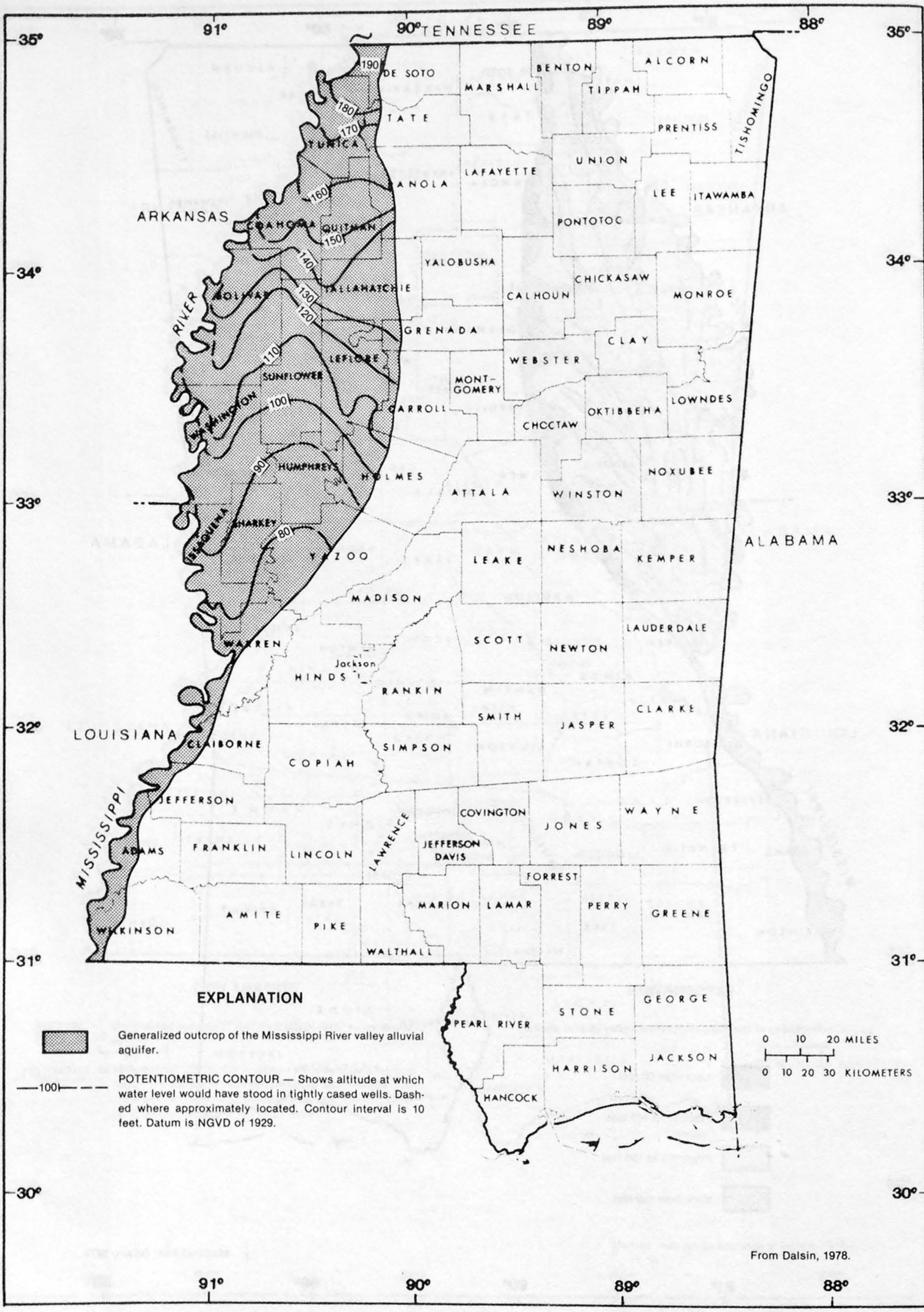

Figure 7. — Potentiometric surface of the Mississippi River valley alluvial aquifer.

Agricultural chemicals used in the heavily farmed area may be a source of contamination of the aquifer in some places.

Gravel is mined from the Mississippi River valley alluvial aquifer and from other alluvium in the state. Mining of gravel and possible future mining of lignite locally may cause changes in recharge to the aquifer and quality of water in the aquifer.

Citronelle Aquifers

The Citronelle aquifers are made up of many discontinuous, hydrologically independent aquifers. They are present in the state from around 32° latitude southward (fig. 8). The beds are exposed at the surface over most of their area of occurrence and are present primarily on hilltops. Along stream valleys they have been eroded to expose the underlying Miocene beds. The aquifers dip southward at about 6 ft/mi and the dip becomes steeper near the coast where they are overlain by coastal terraces. The aquifer is thickest and less dissected near the coast but rarely exceeds 100 feet thick. The Citronelle is made up of quartz sand, chert gravel, and lenses and layers of clay. It is a major source of gravel in the state.

The Citronelle Formation commonly is only partially saturated. It is a water table aquifer with water levels which vary from place to place due to the discontinuous nature of the aquifer. The low water levels vary seasonally, but are little affected regionally by pumpage because very little water is withdrawn. Locally however, water levels are lowered rapidly by pumpage. Recharge is from rainfall directly on the outcrop, and water moves quickly both vertically and downdip, recharging the underlying Miocene aquifers and sustaining local streams.

Six aquifer tests indicate transmissivities ranging from 4,000 to 13,000 ft^2/d, hydraulic conductivities of 82 to 200 ft/d, and specific capacities of 6.2 to 46 (gal/min)/ft of drawdown (Boswell, 1979a). The limited saturated thickness and limited storage capacity of the Citronelle limits its use. Large wells can be developed in the Citronelle, but a larger and more reliable source is available from the underlying Miocene aquifers.

Dissolved-solids concentrations of water in the Citronelle are less than 500 mg/L except at places along the coast where seawater is in contact with the aquifer. At most localities the water is high in iron content. In addition to local contamination by seawater along the Gulf Coast, the Citronelle may be contaminated by landfills in old gravel pits, by sewage, and by industrial and oil field wastes in surface pits. Most of the wastes in the area are dispersed through area streams, but some move into the underlying Miocene aquifer system.

Miocene Aquifer System

The Miocene aquifer system crops out in most of the southern one-third of the state (fig. 9) except where it is covered by younger coastal deposits and the Citronelle Formation. The aquifer system is composed of numerous interbedded layers of sand and clay that include

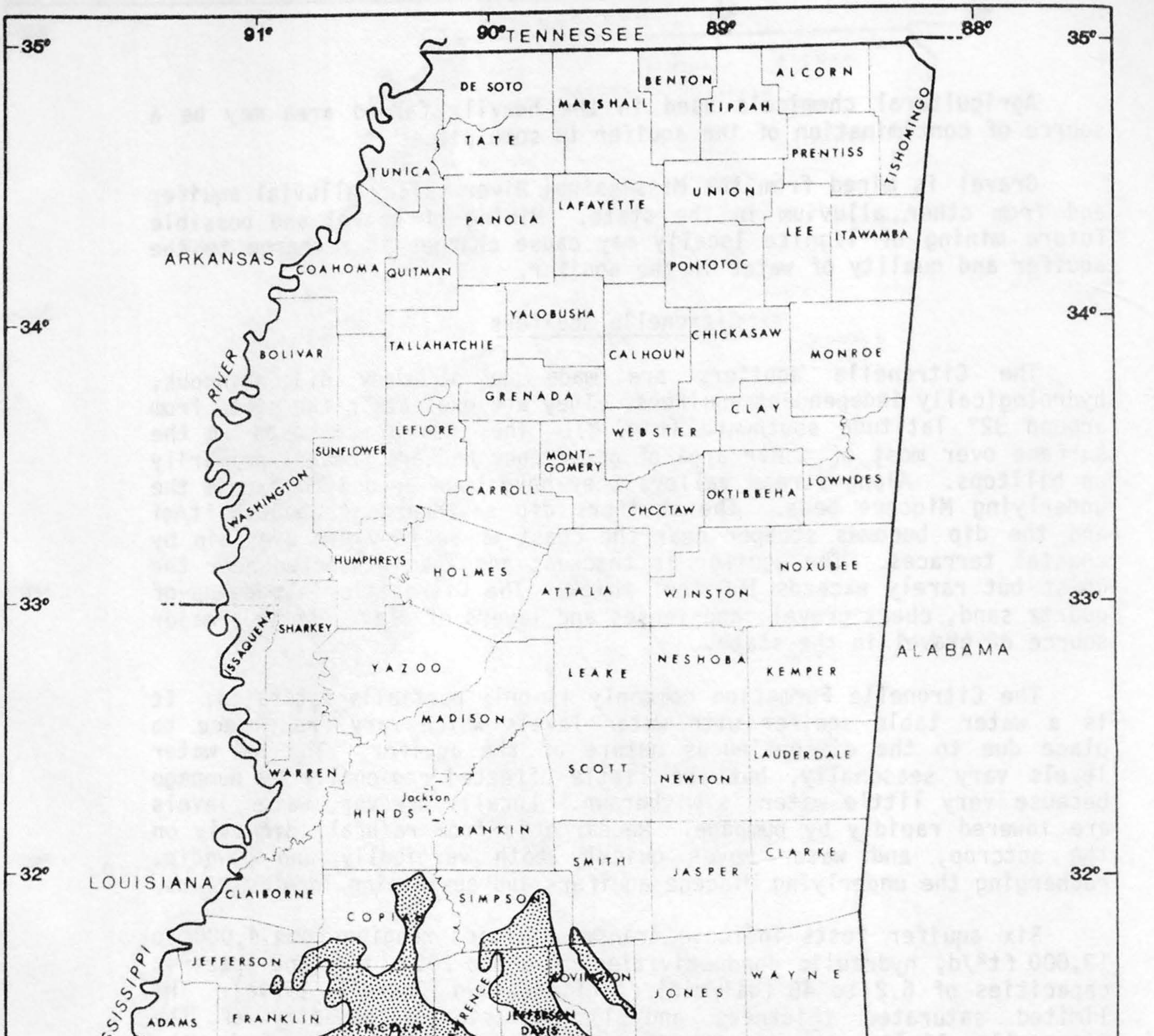

Figure 8. — Outcrop of the Citronelle aquifers and overlying coastal deposits.

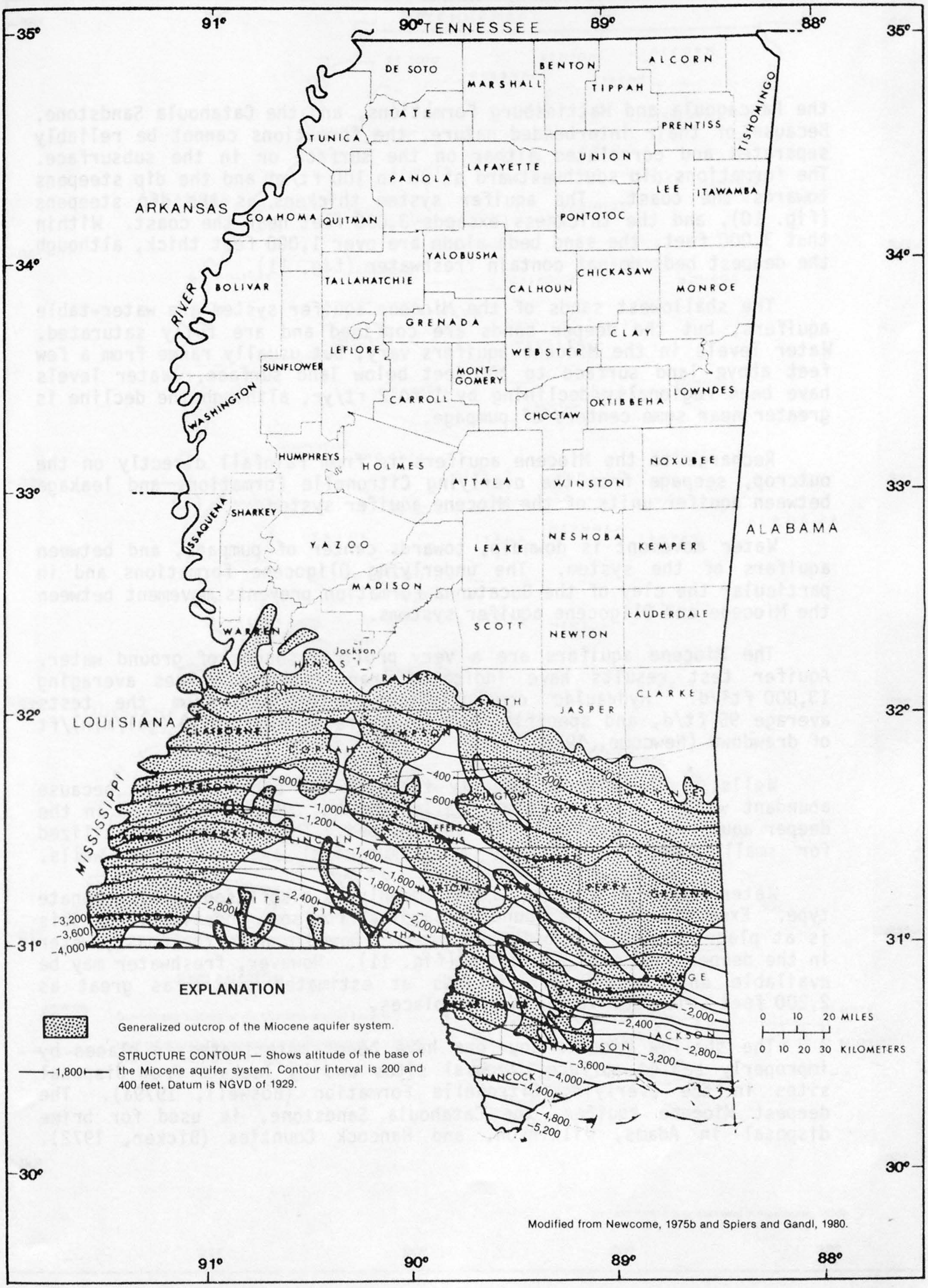

Figure 9. — Configuration of the base of the Miocene aquifer system.

the Pascagoula and Hattiesburg Formations, and the Catahoula Sandstone. Because of their interbedded nature, the formations cannot be reliably separated and correlated either on the surface or in the subsurface. The formations dip southwestward at 30 to 100 ft/mi and the dip steepens towards the coast. The aquifer system thickens as the dip steepens (fig. 10), and the thickness exceeds 3,000 feet near the coast. Within that 3,000 feet, the sand beds alone are over 1,000 feet thick, although the deepest beds do not contain freshwater (fig. 11).

The shallowest sands of the Miocene aquifer system are water-table aquifers, but the deeper sands are confined and are fully saturated. Water levels in the Miocene aquifers vary, but usually range from a few feet above land surface to 100 feet below land surface. Water levels have been regionally declining by 1 to 2 ft/yr, although the decline is greater near some centers of pumpage.

Recharge to the Miocene aquifers is from rainfall directly on the outcrop, seepage from the overlying Citronelle Formation, and leakage between aquifer units of the Miocene aquifer system.

Water movement is downdip, towards center of pumpage, and between aquifers of the system. The underlying Oligocene formations and in particular the clay of the Bucatunna Formation prevents movement between the Miocene and Oligocene aquifer systems.

The Miocene aquifers are a very prolific source of ground water. Aquifer test results have indicated transmissivity values averaging 13,000 ft^2/d. Hydraulic conductivities determined from the tests average 95 ft/d, and specific capacities are as high as 30 (gal/min)/ft of drawdown (Newcome, 1975b).

Wells in the Miocene usually tap only the upper aquifers because abundant water is available at shallow depths. Much freshwater in the deeper aquifers is available but undeveloped. The aquifers are utilized for small domestic wells and large municipal and industrial wells.

Water in the Miocene aquifers commonly is a soft sodium-bicarbonate type. Excessive iron is found in samples from some locations, but this is at places due to corrosion of pipes. Downdip near the coast, water in the deeper sand beds is saline (fig. 11). However, freshwater may be available on the offshore islands at estimated depths as great as 2,200 feet below sea level in some places.

The shallow Miocene aquifers have been contaminated in places by improperly sealed surface disposal sites and by leakage from disposal sites in the overlying Citronelle Formation (Boswell, 1979a). The deepest Miocene aquifer, the Catahoula Sandstone, is used for brine disposal in Adams, Wilkinson, and Hancock Counties (Bicker, 1972).

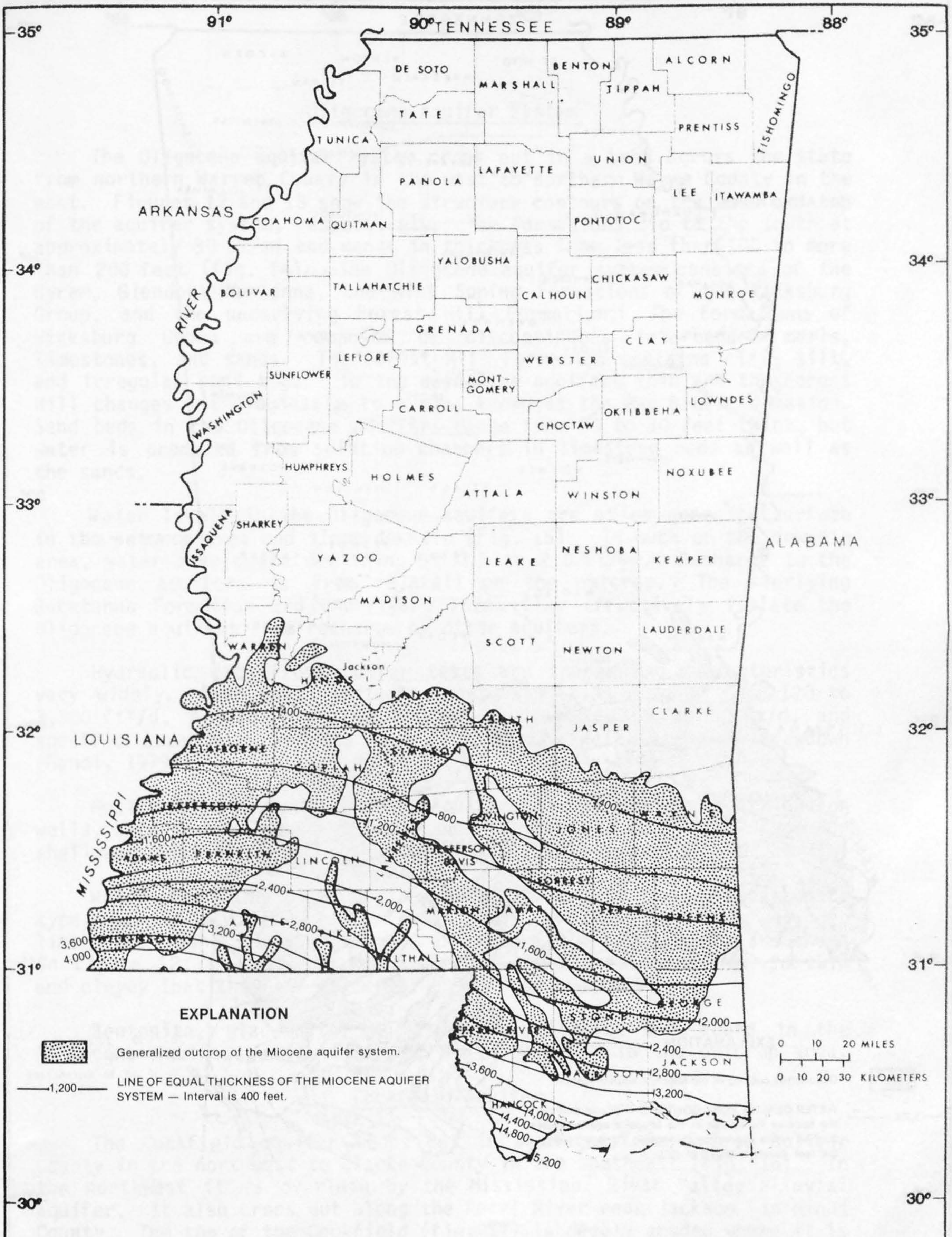

Figure 10. — Thickness of the Miocene aquifer system.

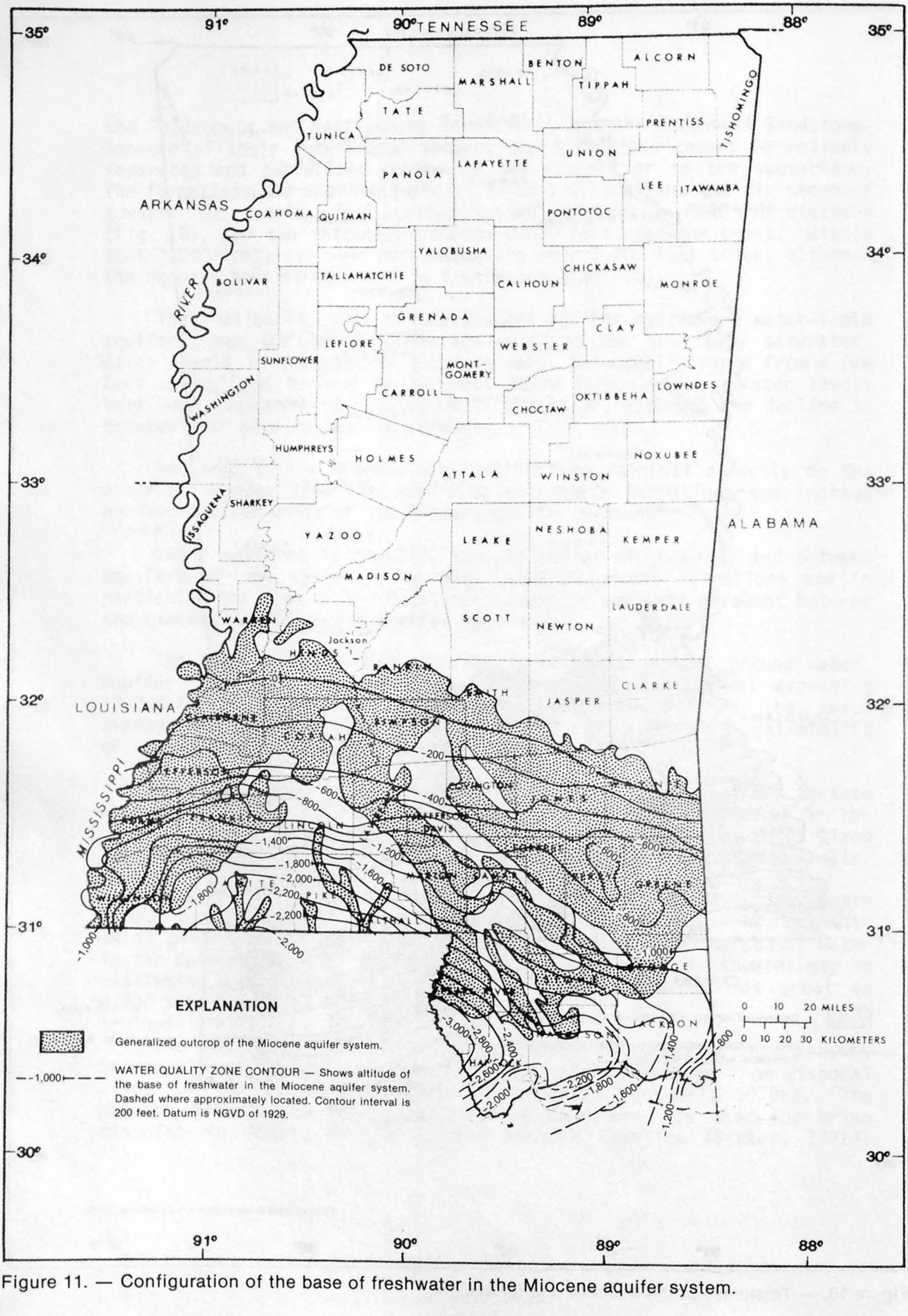

Figure 11. — Configuration of the base of freshwater in the Miocene aquifer system.

Oligocene Aquifer System

The Oligocene aquifer system crops out in a band across the state from northern Warren County in the west to northern Wayne County in the east. Figures 12 and 13 show the structure contours on the base and top of the aquifer system, respectively. The formations dip to the south at approximately 30 ft/mi and range in thickness from less than 100 to more than 200 feet (fig. 14). The Oligocene aquifer system consists of the Byram, Glendon, Marianna, and Mint Spring Formations of the Vicksburg Group, and the underlying Forest Hill Formation. The formations of Vicksburg Group are composed of discontinuous interbedded marls, limestones, and sands. The Forest Hill Formation contains clay, silt, and irregular sand beds. To the east, the aquifers thin and the Forest Hill changes lithologically to a clay known as the Red Bluff Formation. Sand beds in the Oligocene aquifers range from 20 to 80 feet thick, but water is produced from solution channels in limestone beds as well as the sands.

Water levels in the Oligocene aquifers are at or near the surface in the outcrop area and slope downdip (fig. 15). In much of the downdip area, water levels are declining at 0.5 to 2.0 ft/yr. Recharge to the Oligocene aquifers is from rainfall on the outcrop. The overlying Bucatunna Formation and underlying Yazoo Clay effectively isolate the Oligocene aquifers from recharge by other aquifers.

Hydraulic data from aquifer tests are sparse and characteristics vary widely. Four tests indicate transmissivities ranging from 120 to 3,300 ft^2/d, hydraulic conductivities ranging from 3 to 60 ft/d, and specific capacities ranging from 1.5 to 12 (gal/min)/ft of drawdown (Gandl, 1979).

Most wells in the Oligocene aquifers are domestic and irrigation wells, because more abundant water supplies are available from deeper or shallower aquifers. The highest yielding well produces 300 gal/min.

Water from the Oligocene aquifers is a soft sodium-bicarbonate type, but it may be high in iron, color, and fluoride. The downdip limits of fresh, slightly saline, and moderately saline water are shown in figure 12; however, in the southeast the formations become so thin and clayey that they are not considered to be aquifers.

Bentonite, glauconite, and scattered lignite are found in the Oligocene aquifers and, if mined, would be mined in the outcrop area.

Cockfield Aquifer

The Cockfield aquifer crops out in a diagonal band from Bolivar County in the northwest to Clarke County in the southeast (fig. 16). In the northwest it is overlain by the Mississippi River Valley alluvial aquifer. It also crops out along the Pearl River near Jackson in Hinds County. The top of the Cockfield (fig. 17) is deeply eroded where it is overlain by the alluvial aquifer. The Cockfield dips to the southwest at 20 to 30 ft/mi. It is thickest in the northwest and downdip to the west (fig. 18). To the southeast the formation thins; it becomes more

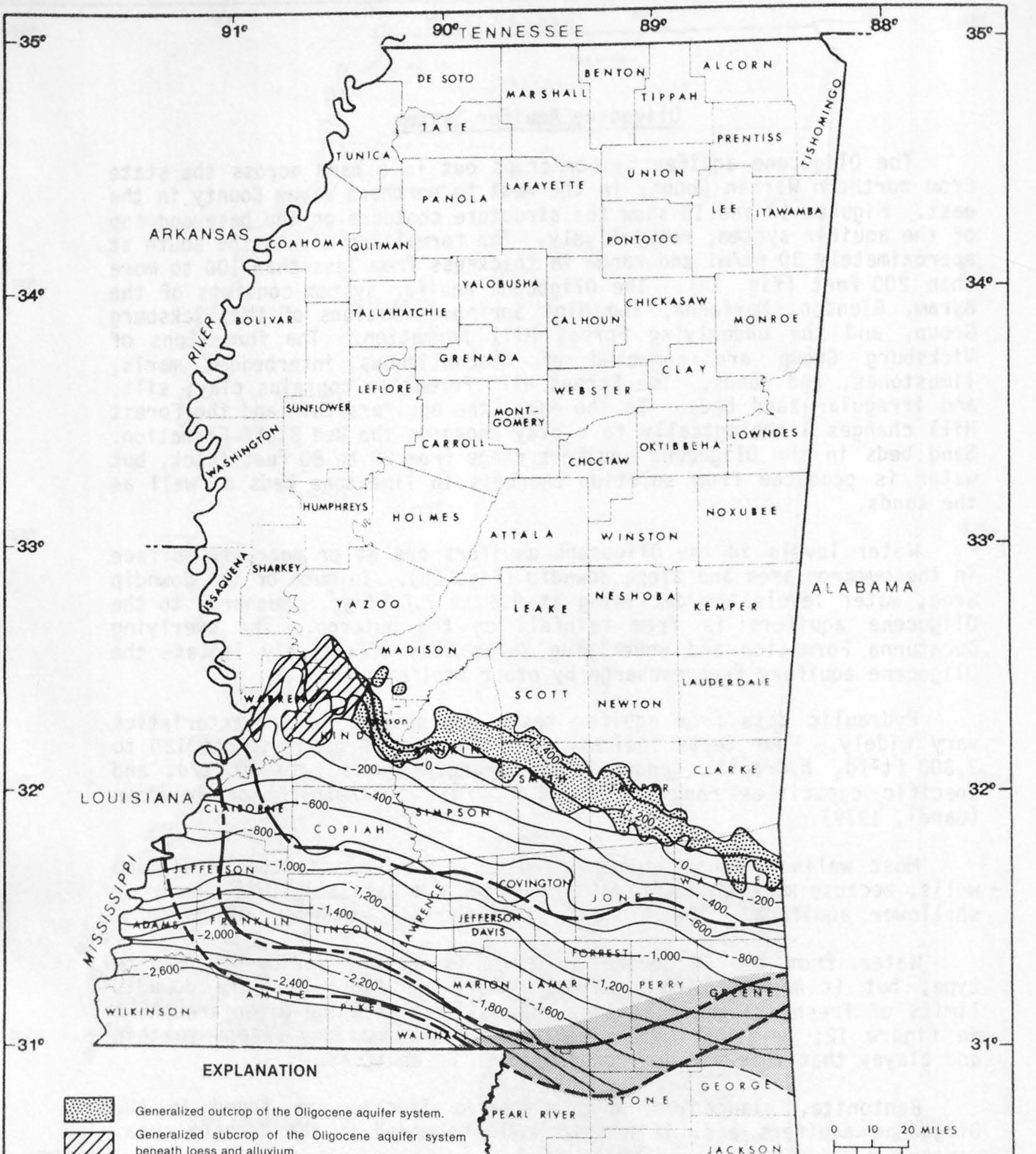

Figure 12. — Configuration of the base of the Oligocene aquifer system.

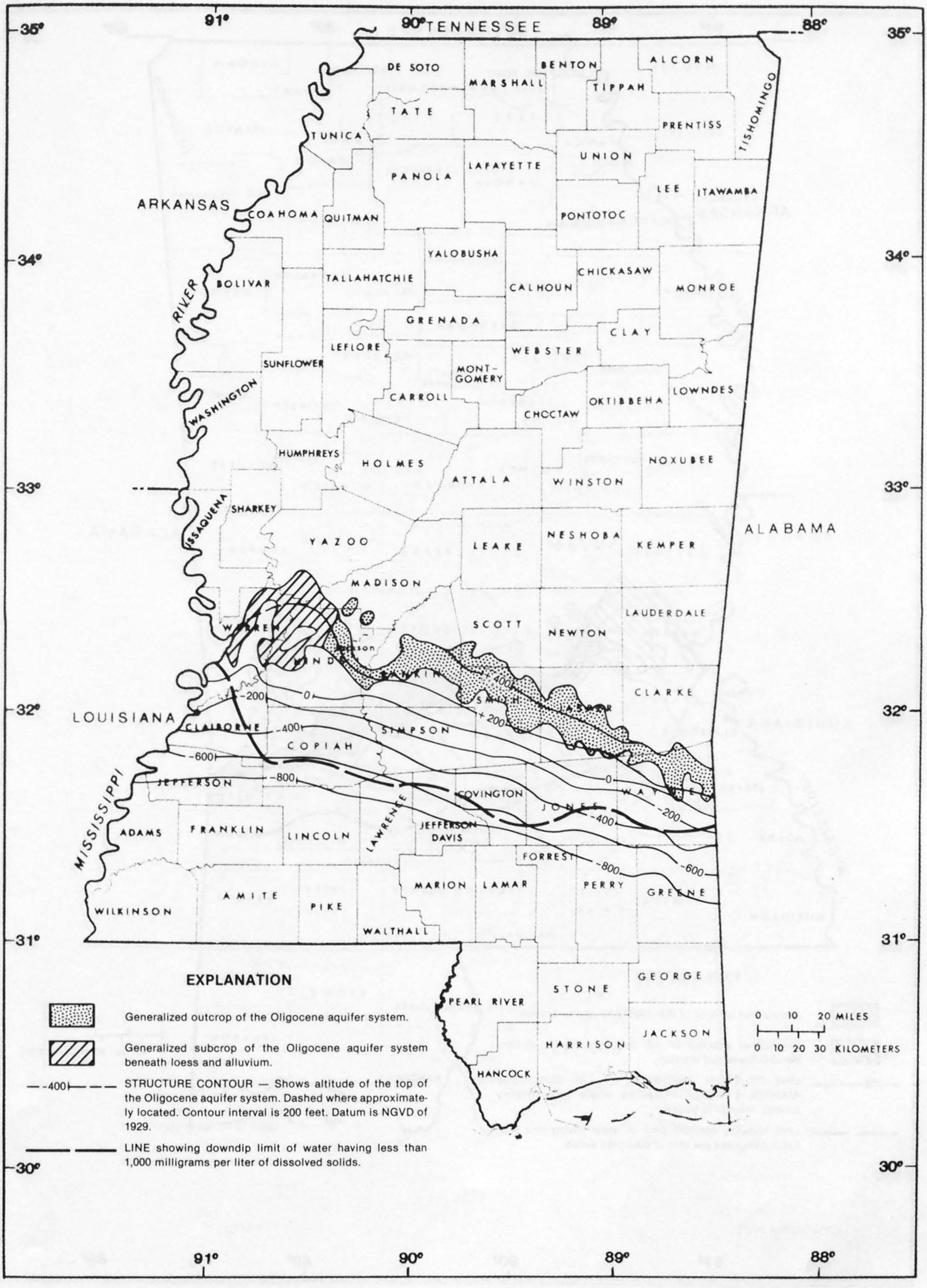

Figure 13. — Configuration of the top of the Oligocene aquifer system.

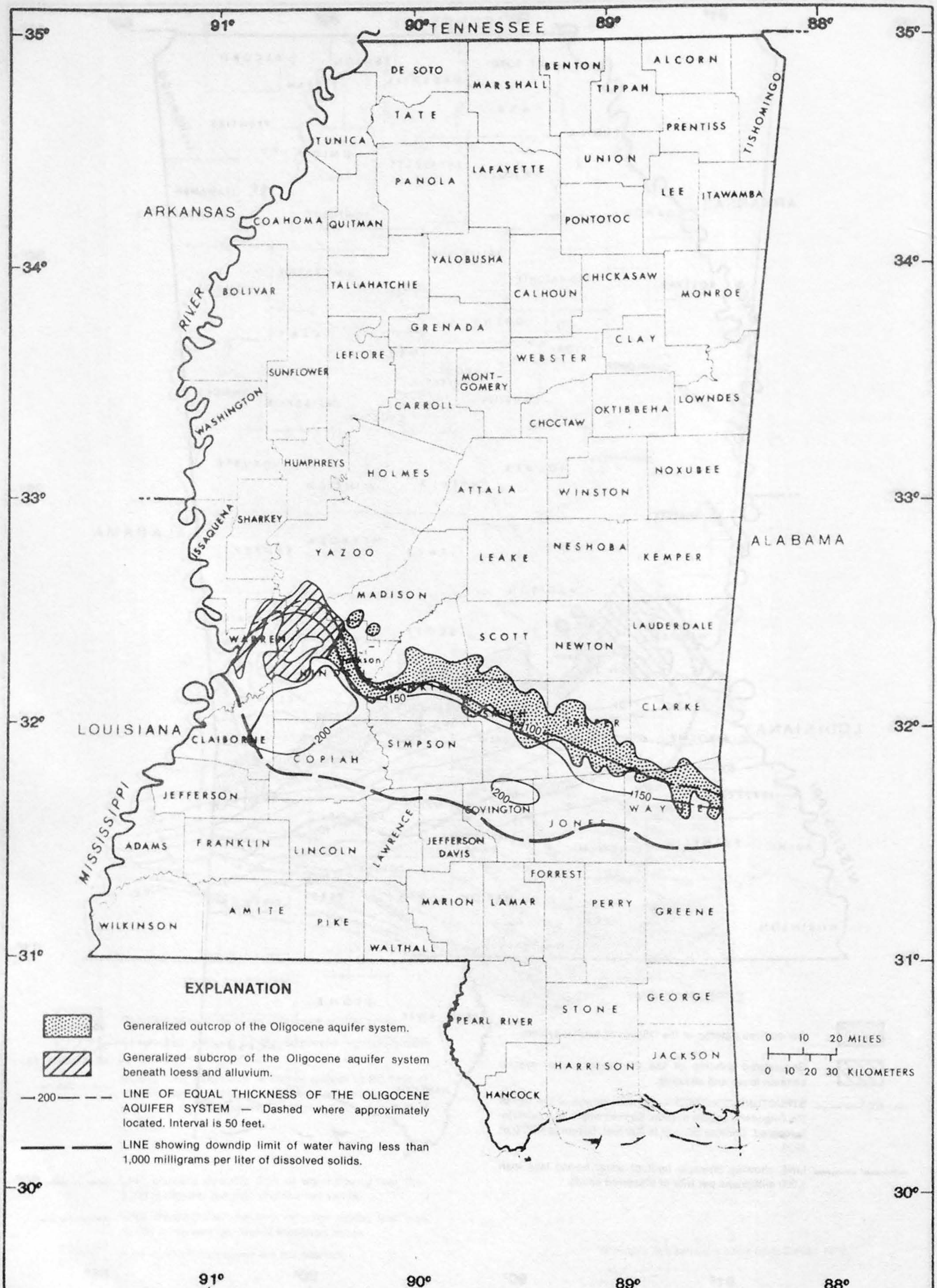

Figure 14. — Thickness of the Oligocene aquifer system.

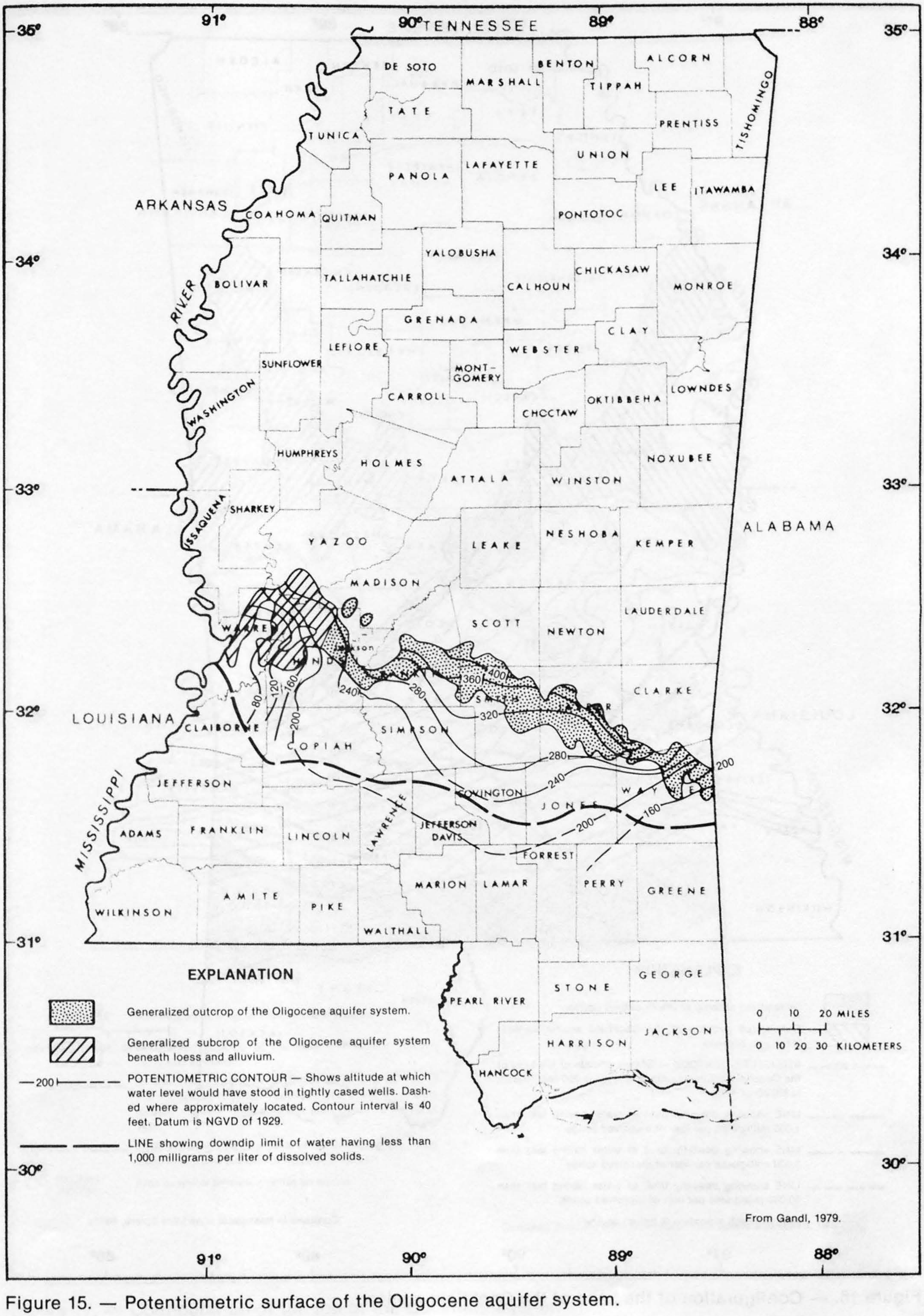

Figure 15. — Potentiometric surface of the Oligocene aquifer system.

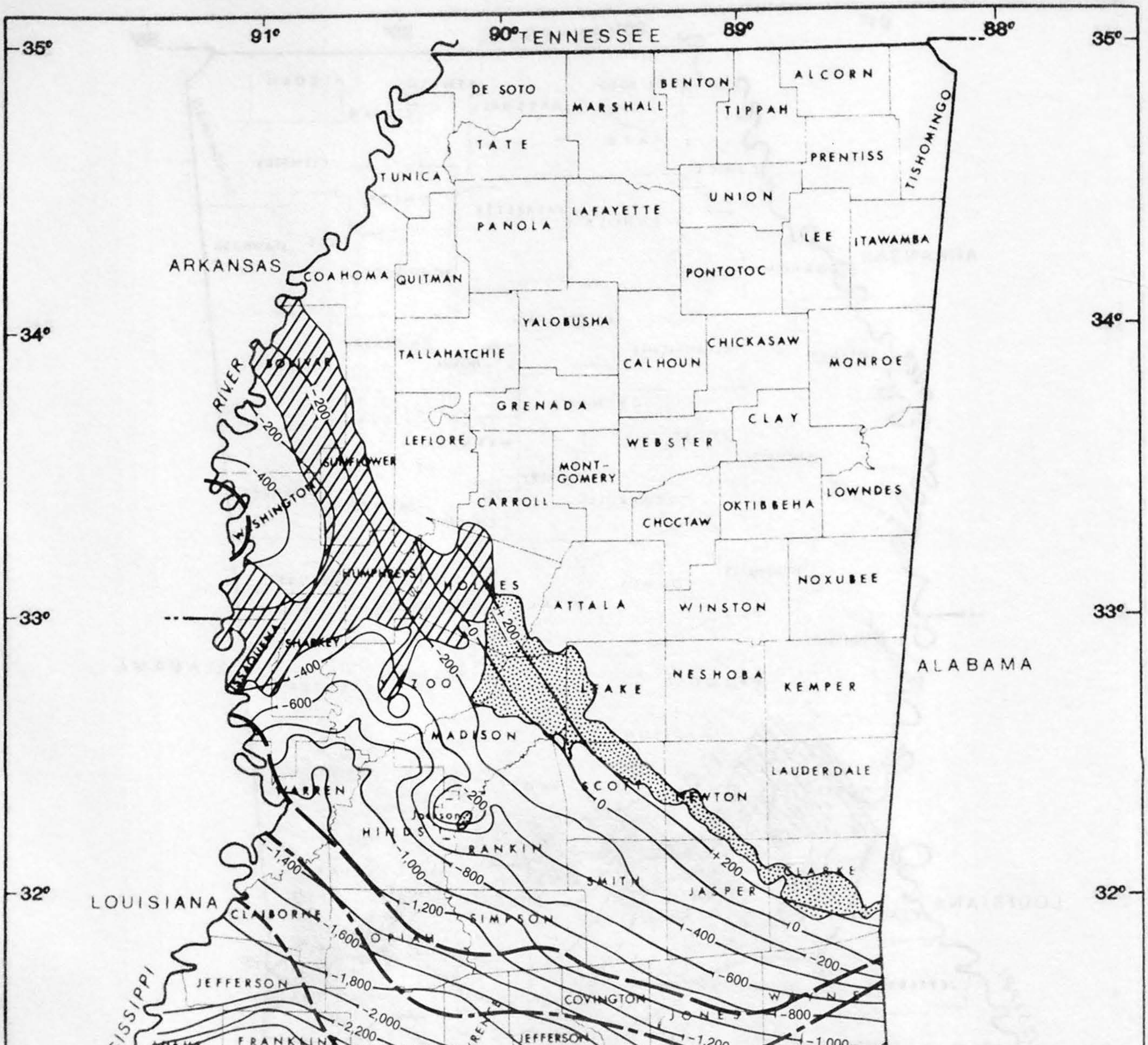

Figure 16. — Configuration of the base of the Cockfield aquifer.

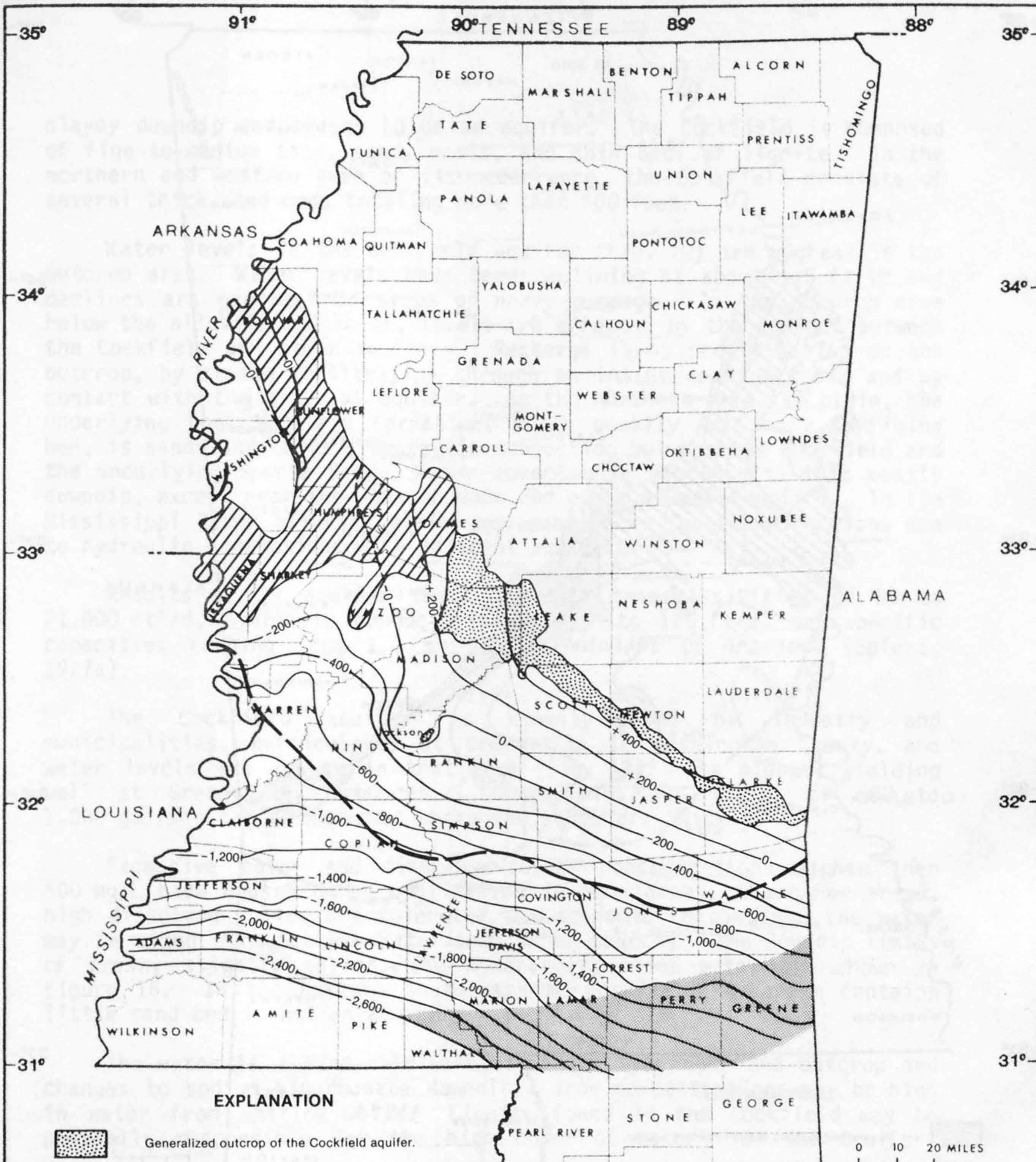

Figure 17. — Configuration of the top of the Cockfield aquifer.

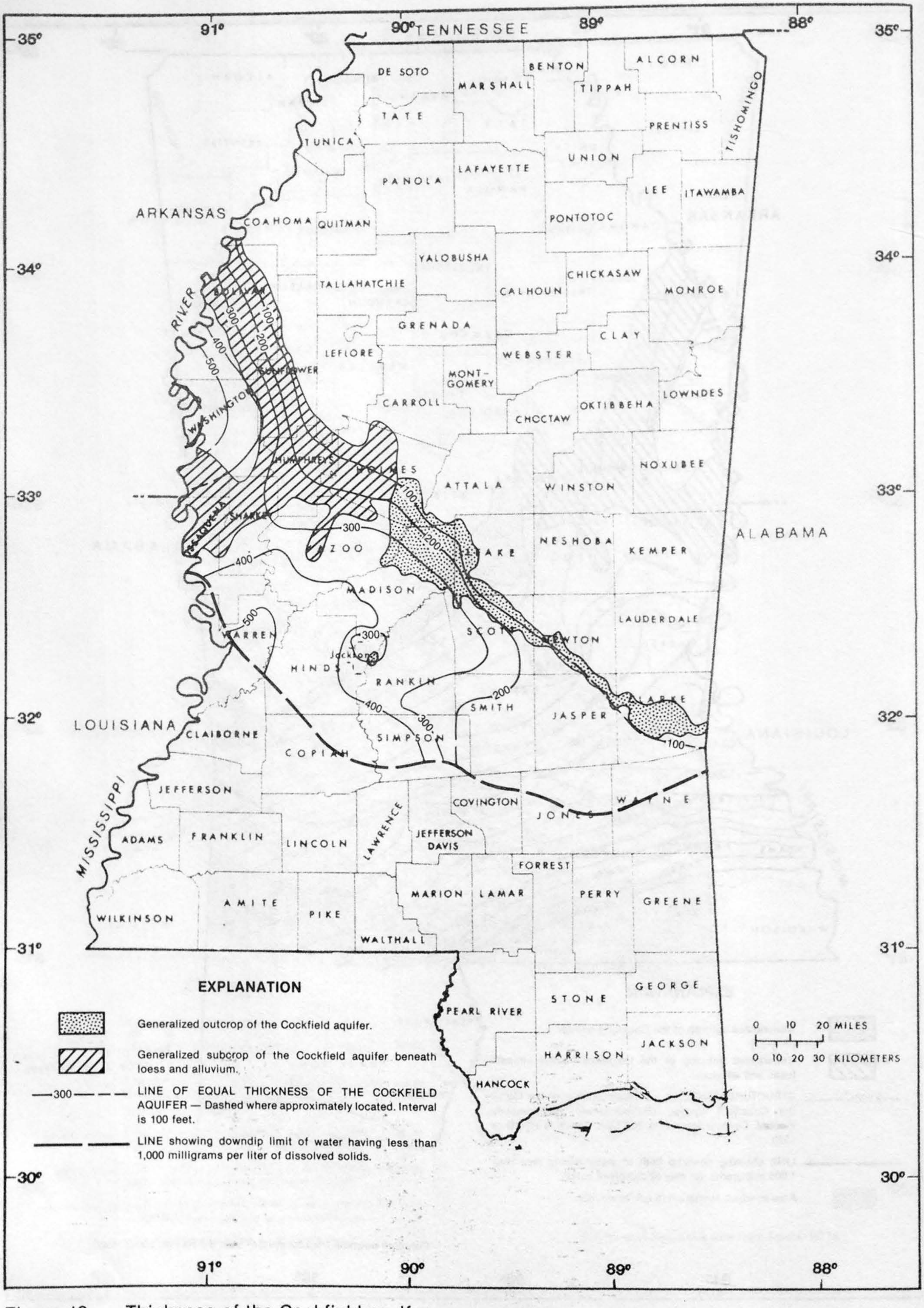

Figure 18. — Thickness of the Cockfield aquifer.

clayey downdip and ceases to be an aquifer. The Cockfield is composed of fine-to-medium sand, sandy marls, and thin beds of lignite. In the northern and western area of its occurrence, the Cockfield consists of several thick sand beds totaling more than 500 feet.

Water levels in the Cockfield aquifer (fig. 19) are highest in the outcrop area. Water levels have been declining at about 1.5 ft/yr and declines are greatest in areas of heavy pumpage. In the subcrop area below the alluvium and loess, levels are affected by the contact between the Cockfield and other aquifers. Recharge is by precipitation on the outcrop, by stream infiltration through an inlier near Jackson, and by contact with the alluvial aquifer. In the northern alluvial plain, the underlying Cook Mountain Formation, which usually acts as a confining bed, is sandy and forms a hydraulic connection between the Cockfield and the underlying Sparta Sand. Water movement in the Cockfield is mostly downdip, except near the Jackson dome and other areas of uplift. In the Mississippi River alluvial plain, movement is in several directions due to hydraulic connections with adjacent aquifers.

Results of 27 aquifer tests indicate transmissivities of 80 to 21,000 ft^2/d, hydraulic conductivities of 1 to 120 ft/d, and specific capacities ranging from 1.6 to 43 (gal/min)/ft of drawdown (Spiers, 1977a).

The Cockfield aquifer is heavily used by industry and municipalities, particularly at Greenville in Washington County, and water levels are lowest in that area (fig. 19). The highest yielding well at Greenville, produces 1,500 gal/min, and yields of 500 to 1,000 gal/min can be expected where the sands are thick.

Excessive color and dissolved-solids concentrations higher than 500 mg/L have caused under utilization in some areas. In other areas, high dissolved solids are tolerated for economic reasons and the water may be mixed with fresher water from other sources. The downdip limits of fresh, slightly saline, and moderately saline water are shown in figure 16. In the extreme southeast the Cockfield Formation contains little sand and is not an aquifer.

The water is a hard calcium-bicarbonate type near the outcrop and changes to sodium bicarbonate downdip. Iron concentrations may be high in water from shallow wells. Lignite found in the Cockfield may be partially responsible for the high color of water from the aquifer.

The Cockfield has been used for disposal of oil field wastes in the southwest, downdip from the 10,000 mg/L dissolved-solids zones (Bicker, 1972).

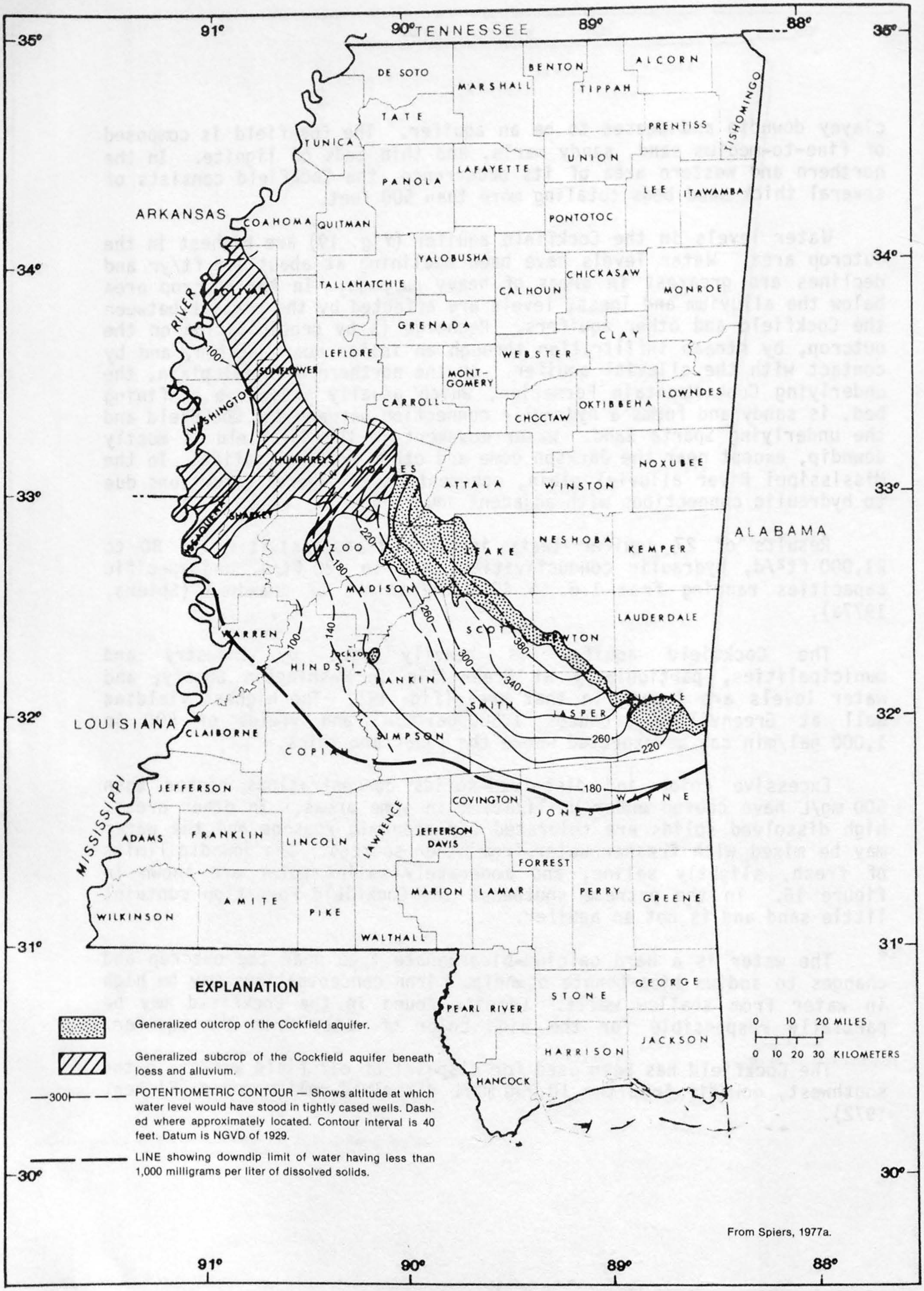

Figure 19. — Potentiometric surface of the Cockfield aquifer.

Sparta Aquifer System

The Sparta aquifer system crops out in a curving band from Marshall to Holmes to Clarke County (fig. 20). In the northwest it subcrops beneath the alluvial aquifer and loess deposits. Figures 20 and 21 show structure contours on the base and top of the aquifer system, respectively. The Sparta dips to the west at about 20 ft/mi in the northwest, and it dips to the southwest at about 35 ft/mi in the south. The Sparta has been uplifted by the Jackson and Tinsley domes. The Sparta thickens downdip and exceeds 800 feet in thickness in the southwest (fig. 22).

The Sparta Sand is composed of rounded, well-sorted quartz grains in two or three thick beds separated by beds of clay. It contains more sand relative to overall thickness than any other aquifer in the state. To the northwest near Memphis, Tennessee, it combines with underlying sand beds of the Claiborne Group and is known as the Memphis aquifer.

Water levels in the Sparta range from 450 to 100 feet above sea level decreasing downdip from the outcrop (fig. 23). In the confined part of the aquifer, the water levels have been declining 1 to 2 ft/yr except near Jackson where, due to heavy pumping, the declines are at least 3 ft/yr. Recharge to the aquifer is by rainfall on the outcrop and in the northwest by infiltration from the overlying alluvial aquifer. Water moves downdip, except near areas of heavy pumping. Except in the northwest the Sparta is isolated by the overlying Cook Mountain formation and the underlying Zilpha Clay.

Aquifer test results indicate transmissivities of 330 to 13,000 ft^2/d, hydraulic conductivities of 6 to 130 ft/d, and specific capacities ranging from 1 to 46 (gal/min)/ft of drawdown (Newcome, 1976).

The Sparta is utilized by industrial, municipal, and domestic users. The deepest wells are 1,400 feet deep and yields of 100 to 300 gal/min are readily available, although much greater yields are possible.

Water in the Sparta is a soft sodium-bicarbonate type, which is acidic in the outcrop area and the northern quarter of the area but alkaline elsewhere. It is commonly high in iron in the east and is high in fluoride and colored downdip near the freshwater limit. Figure 20 shows the limits of fresh, slightly saline, and moderately saline water in the Sparta. Downdip in the southeast, the formation contains little sand and is not considered an aquifer.

Natural gas has been found in small amounts in the Sparta, and lignite is available in the north in outcrop and subcrop areas. In the southwest the Sparta has been used for disposal of oil field wastes, sometimes in areas in which the water has less than 10,000 mg/L dissolved solids (Bicker, 1972).

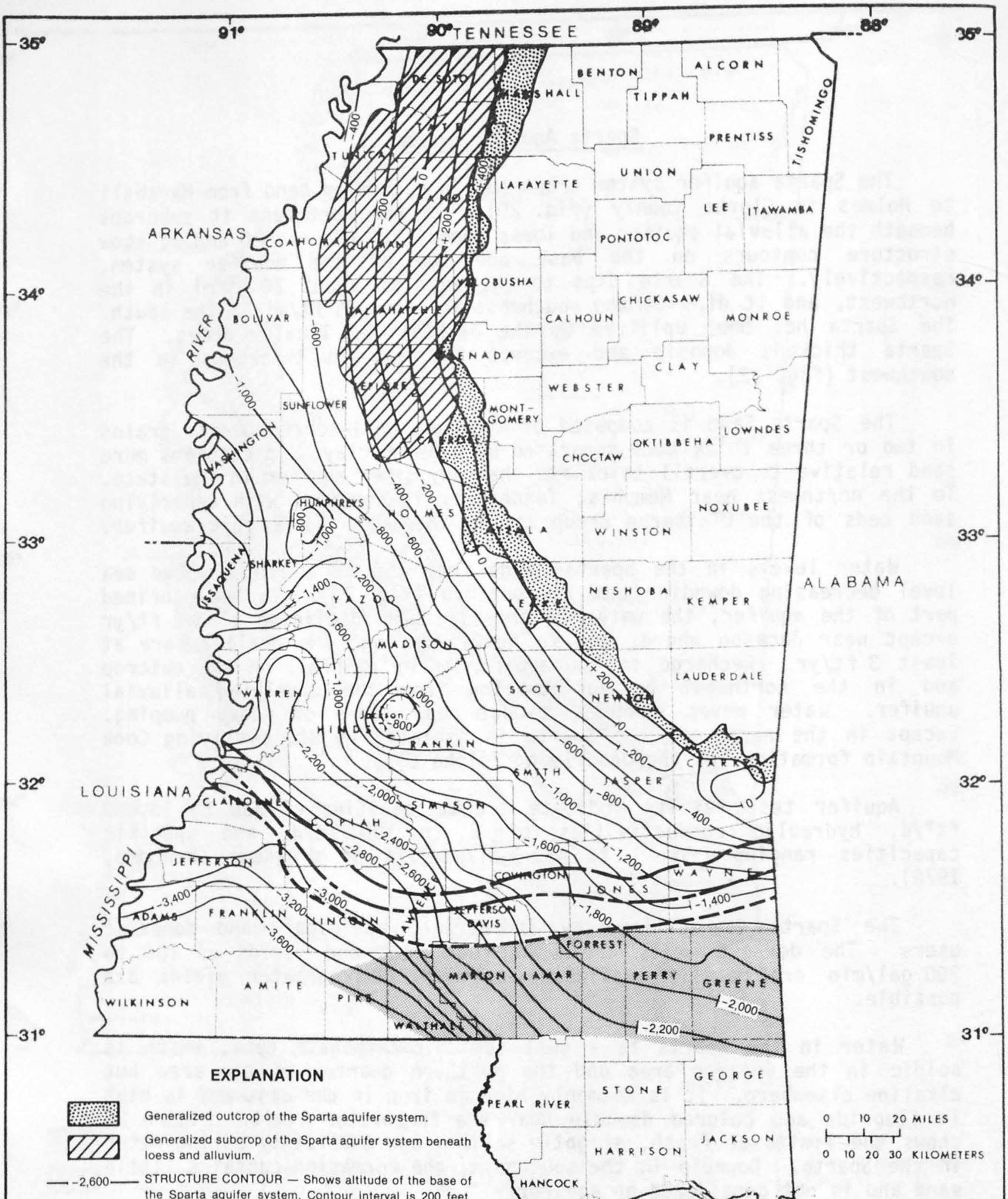

Figure 20. — Configuration of the base of the Sparta aquifer system.

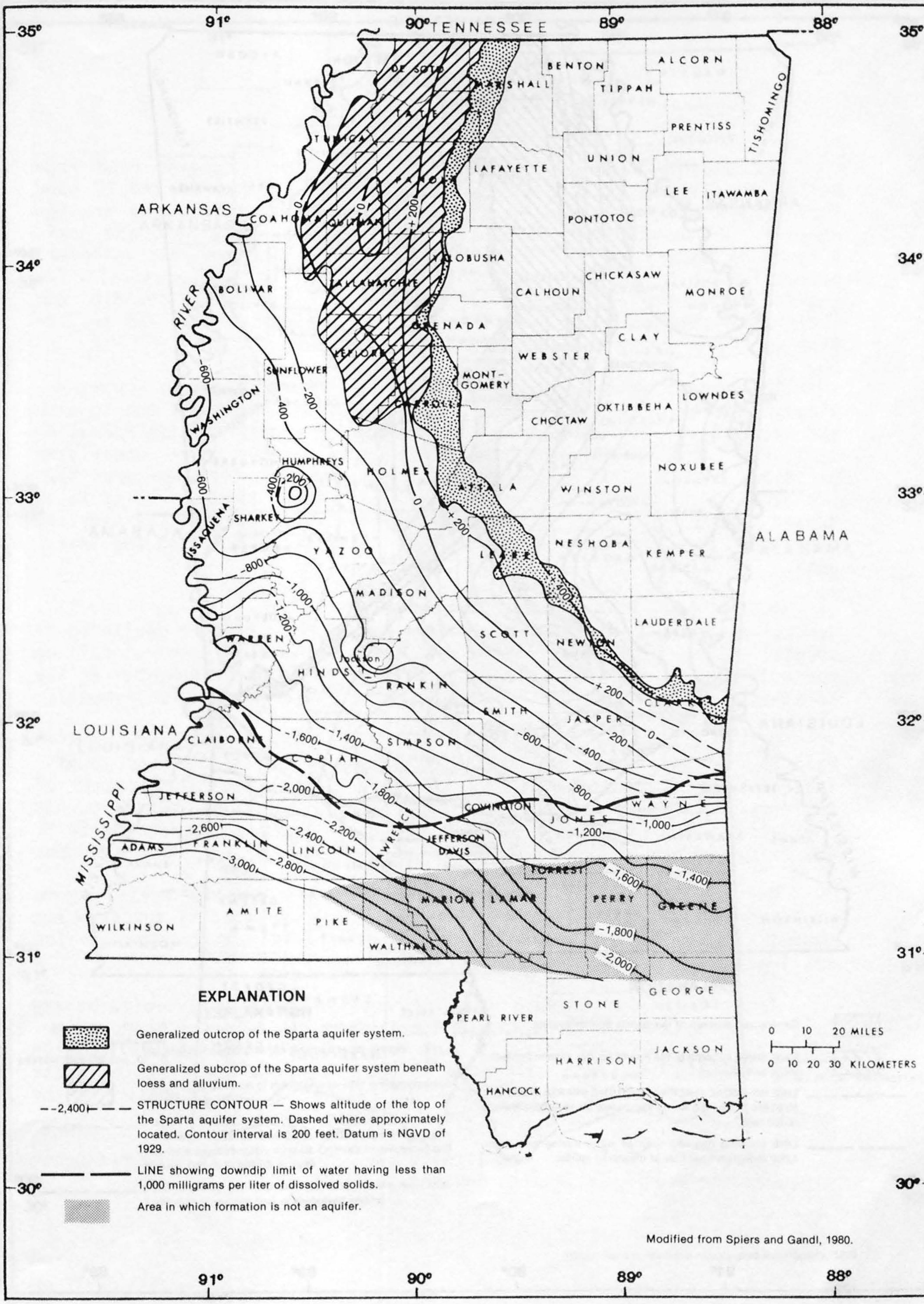

Figure 21. — Configuration of the top of the Sparta aquifer system.

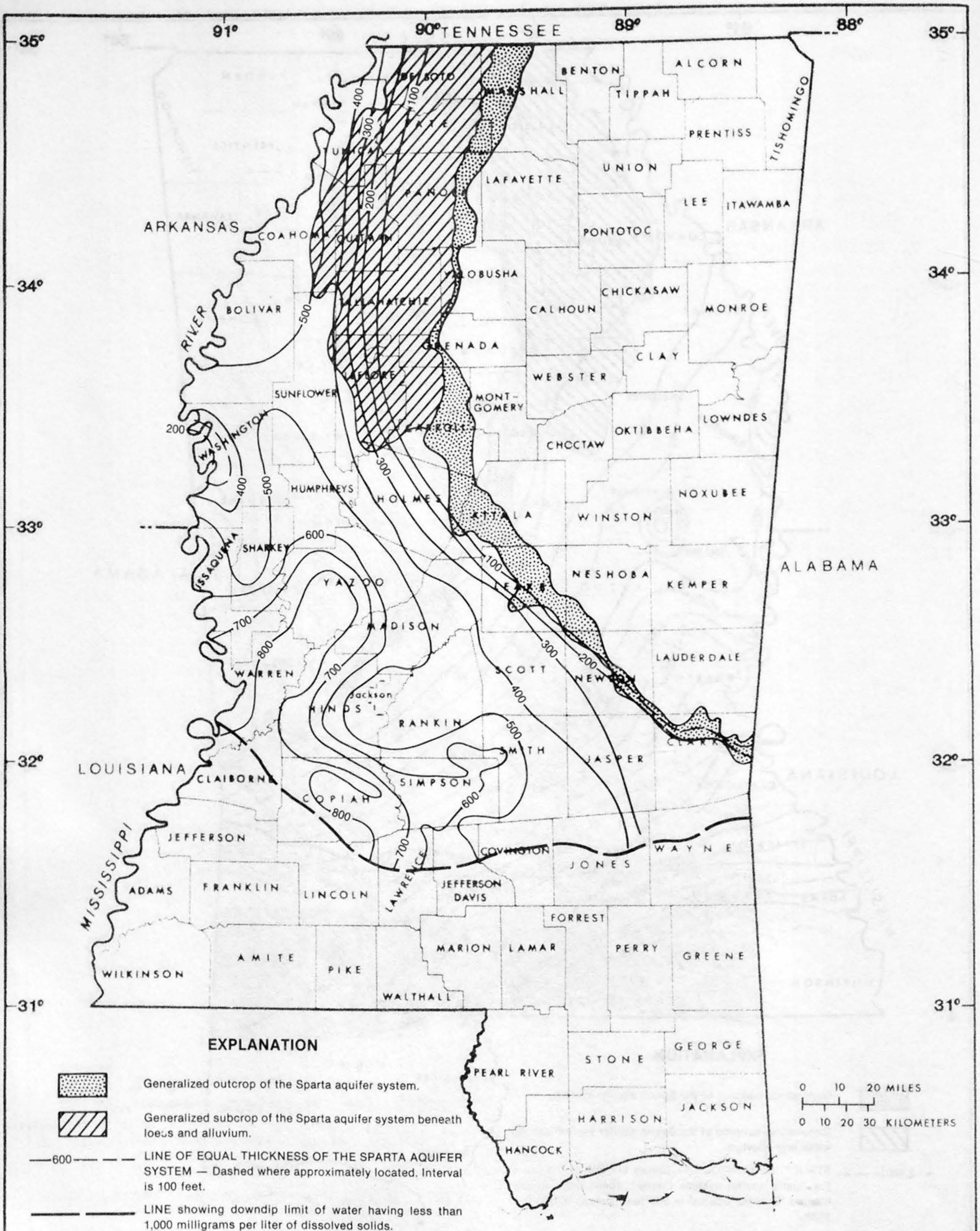

Figure 22. — Thickness of the Sparta aquifer system.

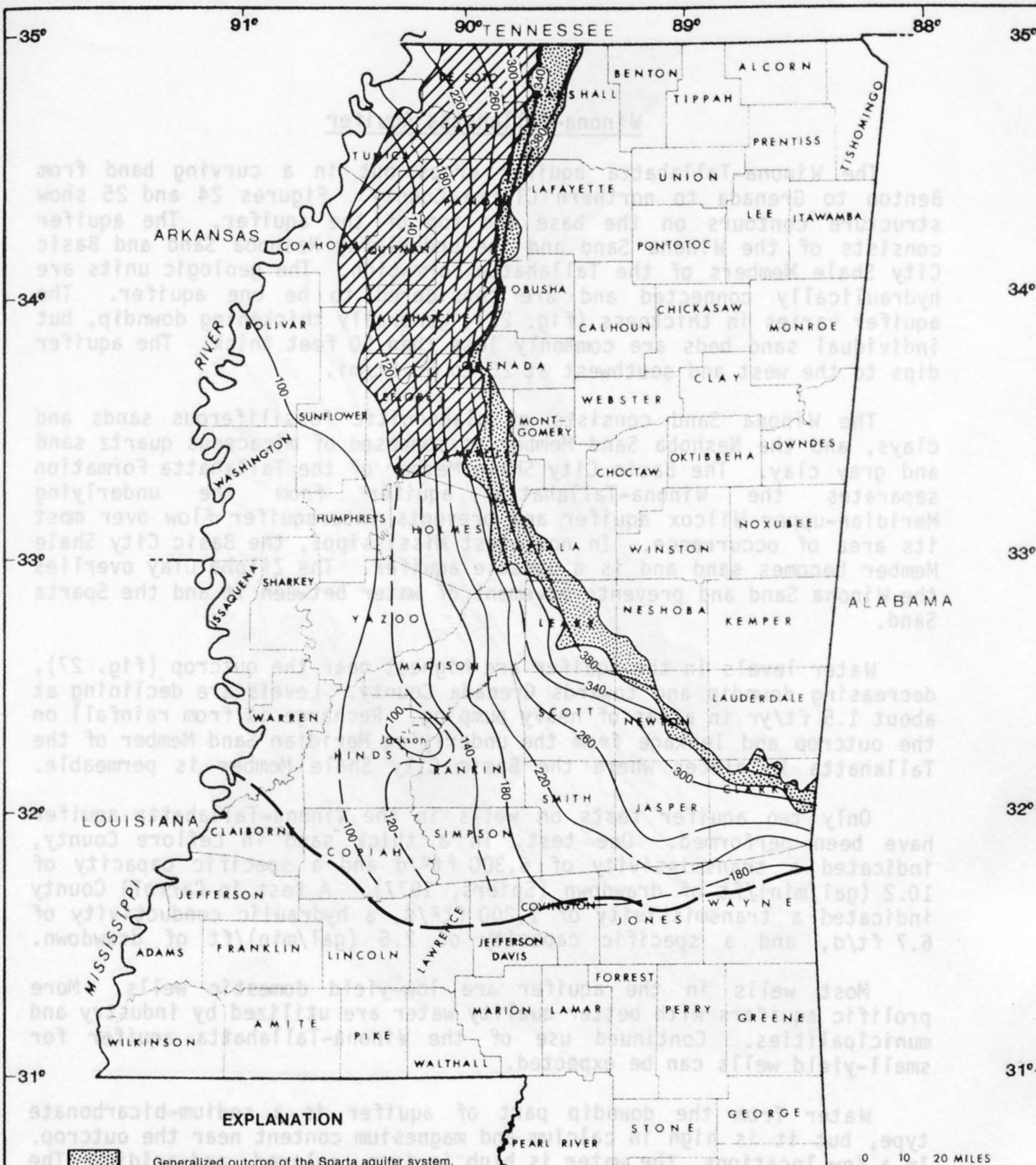

Figure 23. — Potentiometric surface of the Sparta aquifer system.

Winona-Tallahatta Aquifer

The Winona-Tallahatta aquifer crops out in a curving band from Benton to Grenada to northern Clarke County. Figures 24 and 25 show structure contours on the base and top of the aquifer. The aquifer consists of the Winona Sand and the underlying Neshoba Sand and Basic City Shale Members of the Tallahatta Formation. The geologic units are hydraulically connected and are considered to be one aquifer. The aquifer varies in thickness (fig. 26), generally thickening downdip, but individual sand beds are commonly less than 50 feet thick. The aquifer dips to the west and southwest at 25 to 50 ft/mi.

The Winona Sand consists of glauconitic fossiliferous sands and clays, and the Neshoba Sand Member is composed of micaceous quartz sand and gray clay. The Basic City Shale Member of the Tallahatta Formation separates the Winona-Tallahatta aquifer from the underlying Meridian-upper Wilcox aquifer and prevents interaquifer flow over most its area of occurrence. In northwest Mississippi, the Basic City Shale Member becomes sand and is a useable aquifer. The Zilpha Clay overlies the Winona Sand and prevents movement of water between it and the Sparta Sand.

Water levels in the aquifer are highest near the outcrop (fig. 27), decreasing downdip and towards Grenada County. Levels are declining at about 1.5 ft/yr in areas of heavy pumping. Recharge is from rainfall on the outcrop and leakage from the underlying Meridian Sand Member of the Tallahatta in places where the Basic City Shale Member is permeable.

Only two aquifer tests on wells in the Winona-Tallahatta aquifer have been performed. One test, in a thick sand in Leflore County, indicated a transmissivity of 6,300 ft^2/d and a specific capacity of 10.2 (gal/min)/ft of drawdown (Spiers, 1977). A test in Carroll County indicated a transmissivity of 1,200 ft^2/d, a hydraulic conductivity of 6.7 ft/d, and a specific capacity of 2.6 (gal/min)/ft of drawdown.

Most wells in the aquifer are low-yield domestic wells. More prolific aquifers with better quality water are utilized by industry and municipalities. Continued use of the Winona-Tallahatta aquifer for small-yield wells can be expected.

Water from the downdip part of aquifer is a sodium-bicarbonate type, but it is high in calcium and magnesium content near the outcrop. In a few locations, the water is high in iron, colored, and acidic. The downdip limits of fresh, slightly saline, and moderately saline water are shown on figure 24. The formation ceases to be an aquifer in the moderately saline zone and the line is somewhat arbitrary.

Glauconite, iron ore, and lignite are all present in the freshwater areas of the Winona-Tallahatta aquifer.

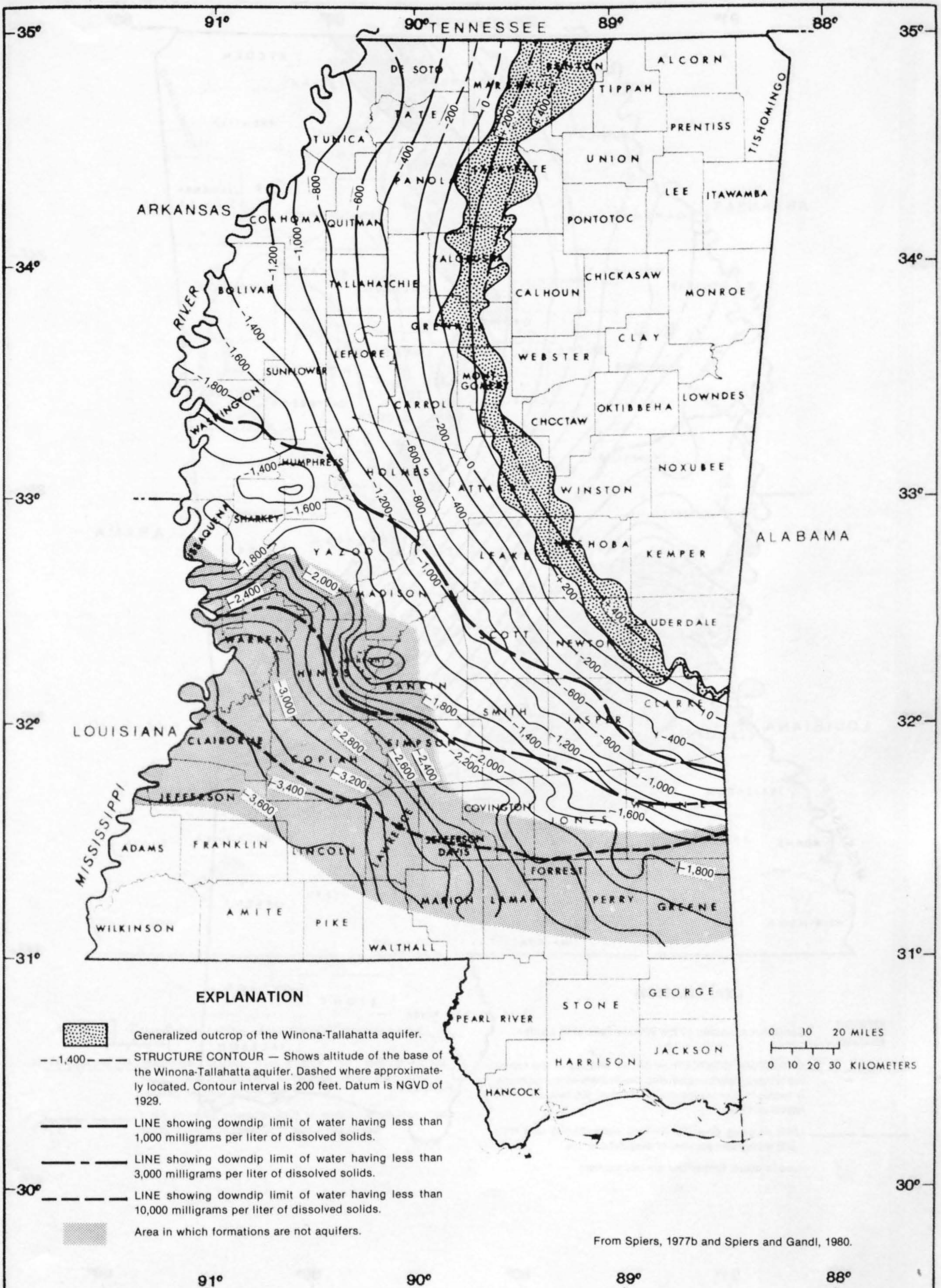

Figure 24. — Configuration of the base of the Winona-Tallahatta aquifer.

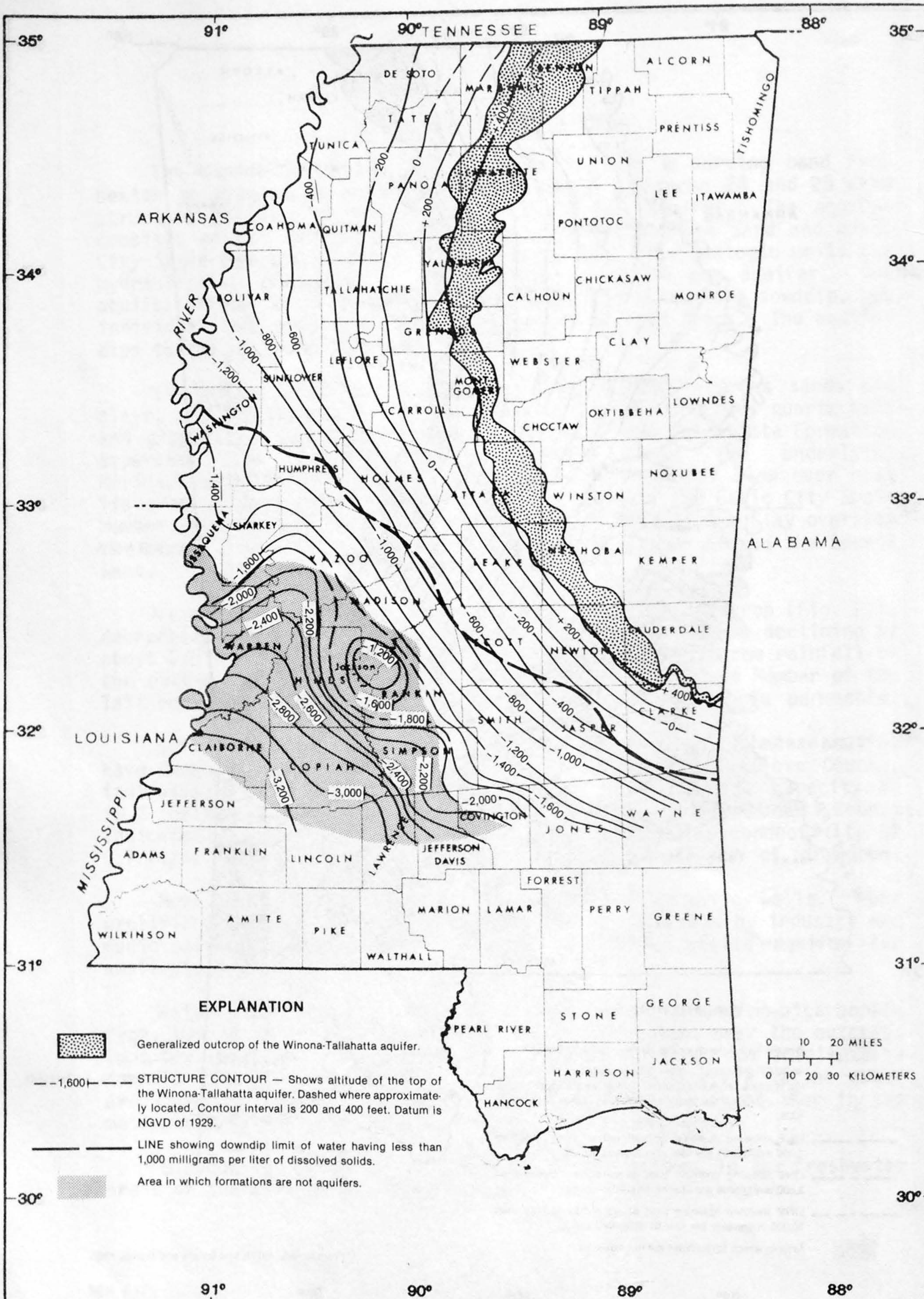

Figure 25. — Configuration of the top of the Winona-Tallahatta aquifer.

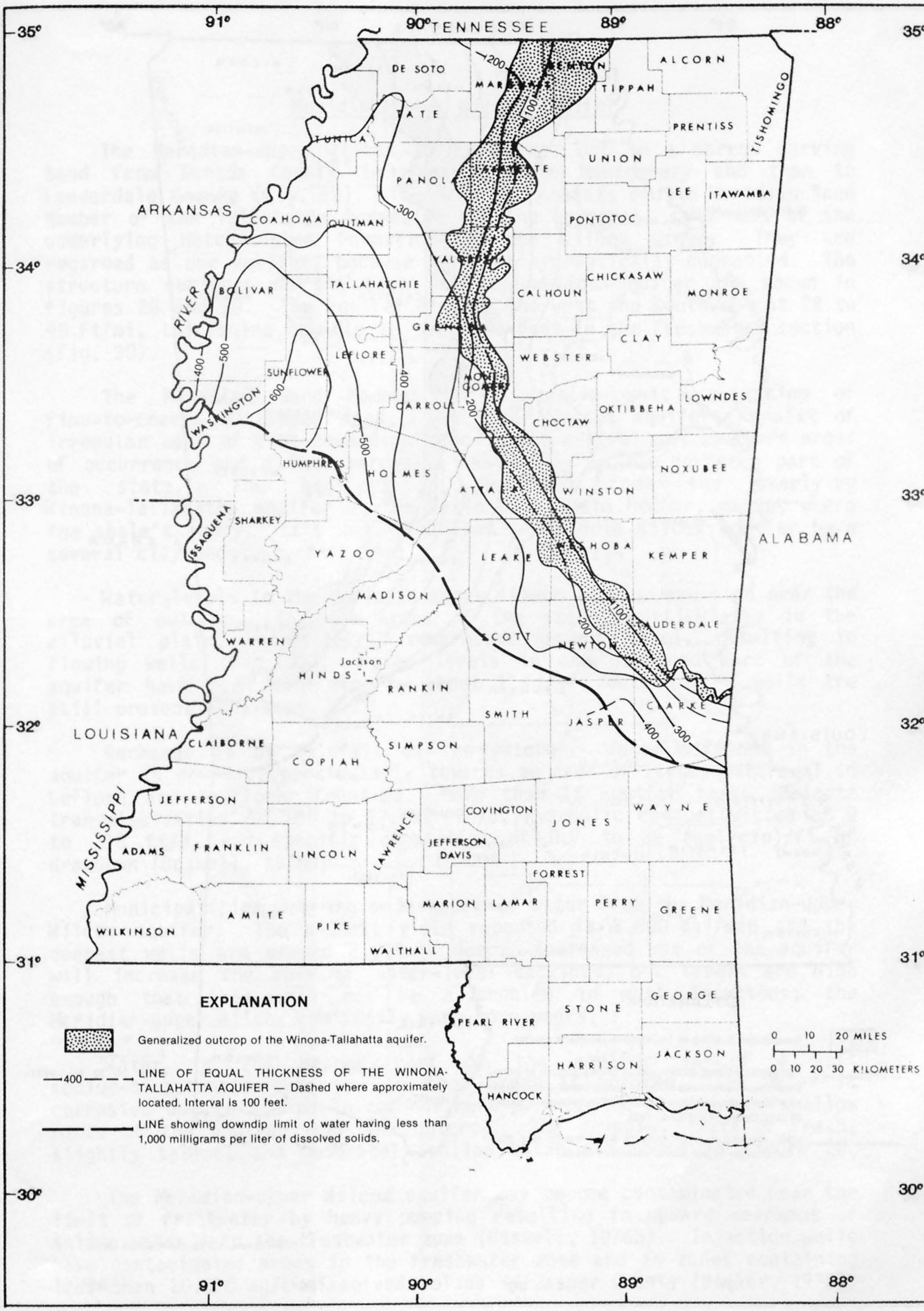

Figure 26. — Thickness of the Winona-Tallahatta aquifer.

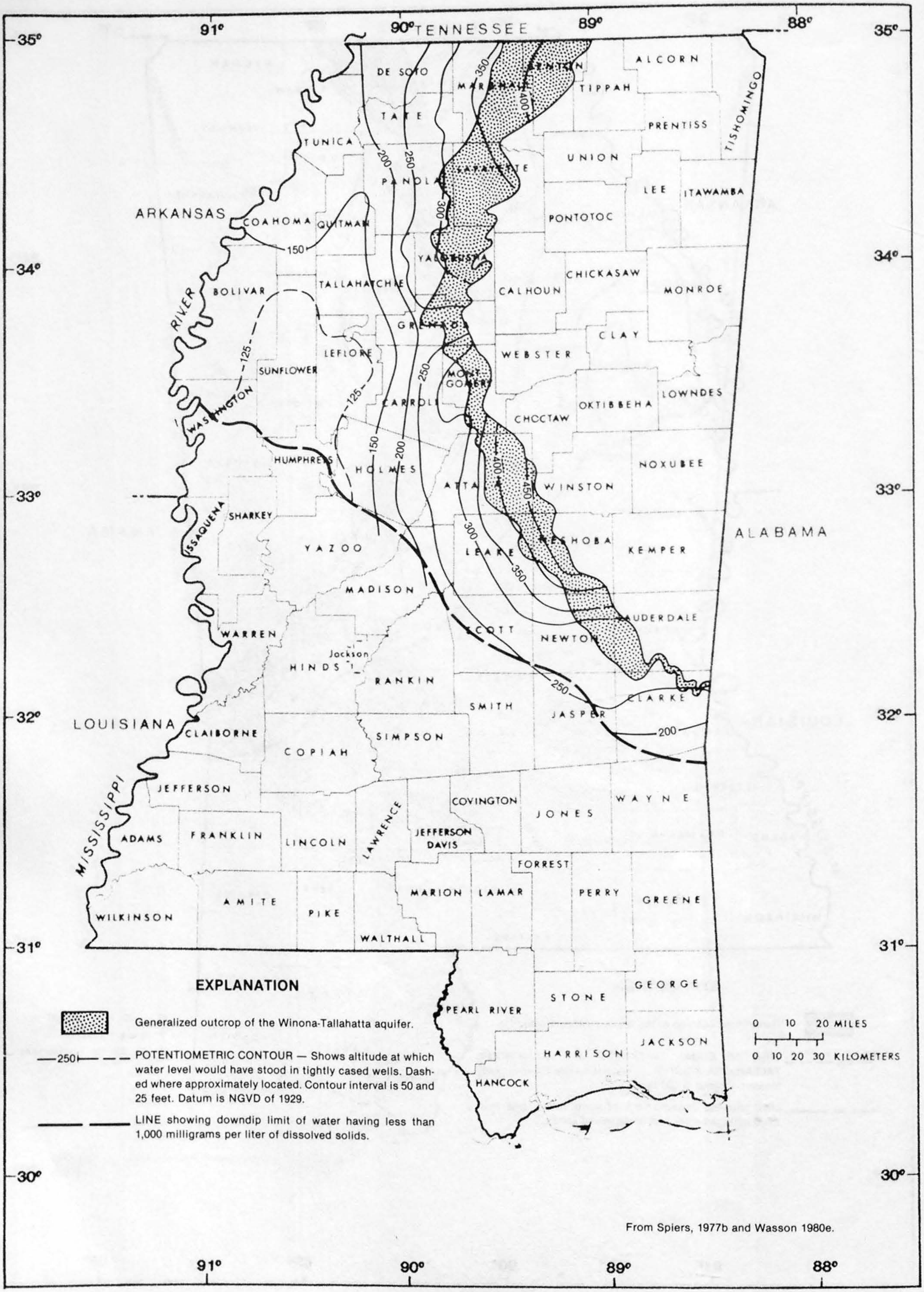

Figure 27. — Potentiometric surface of the Winona-Tallahatta aquifer.

Meridian-Upper Wilcox Aquifer

The Meridian-upper Wilcox aquifer crops out in a narrow curving band from Benton County in the north to Montgomery and then to Lauderdale County (fig. 28). The aquifer consists of the Meridian Sand Member of the Tallahatta Formation and the uppermost sand beds of the underlying Hatchetigbee Formation of the Wilcox Group. They are regarded as one aquifer, because they are hydraulically connected. The structure contours on the base and top of the aquifer are shown in figures 28 and 29. The aquifer dips to the west and southwest at 28 to 40 ft/mi, thickening downdip to over 300 feet in the freshwater section (fig. 30).

The Meridian Sand Member is a massive unit consisting of fine-to-coarse micaceous sand. The upper Wilcox aquifers consist of irregular beds of fine-to-medium sand in the central and southern areas of occurrence and a less permeable sandy clay in the northern part of the state. The aquifer is separated from the overlying Winona-Tallahatta aquifer by the Basic City Shale Member, except where the shale's sandy. It's separated from the middle Wilcox aquifer by a several clay beds.

Water levels in the Meridian-upper Wilcox aquifer are high near the area of outcrop. In some areas of the state, particularly in the alluvial plain, water levels are above ground level, resulting in flowing wells (fig. 31). Water levels in the confined part of the aquifer have been declining by about 1 ft/yr, but flowing wells are still present in places.

Recharge is by rainfall on the outcrop. Water movement in the aquifer is downdip, particularly towards an area of large withdrawal in Leflore and Sunflower Counties. More than 15 aquifer tests indicate transmissivities of 150 to 17,400 ft^2/d, hydraulic conductivities of 9 to 110 ft/d, and specific capacities of 0.7 to 29 (gal/min)/ft of drawdown (Boswell, 1976b).

Municipalities are the main users of water from the Meridian-upper Wilcox aquifer. The highest yield reported is 2,800 gal/min and the deepest wells are around 2,000 ft deep. Increased use of the aquifer will increase the rate of water-level declines, but levels are high enough that this will not be a problem in most locations; the Meridian-upper Wilcox can supply many more users.

Water in the deeper part of the aquifer is of a soft sodium-bicarbonate type and in some areas is colored. The water is corrosive due to low pH in the northern part of the area and in shallow parts of the aquifer near the outcrop. The downdip limits of fresh, slightly saline, and moderately saline water are shown in figure 28.

The Meridian-upper Wilcox aquifer may become contaminated near the limit of freshwater by heavy pumping resulting in upward movement of saline water into the freshwater zone (Boswell, 1976b). Injection wells have contaminated areas in the freshwater zone and in zones containing less than 10,000 mg/L dissolved solids in Jasper County (Bicker, 1972).

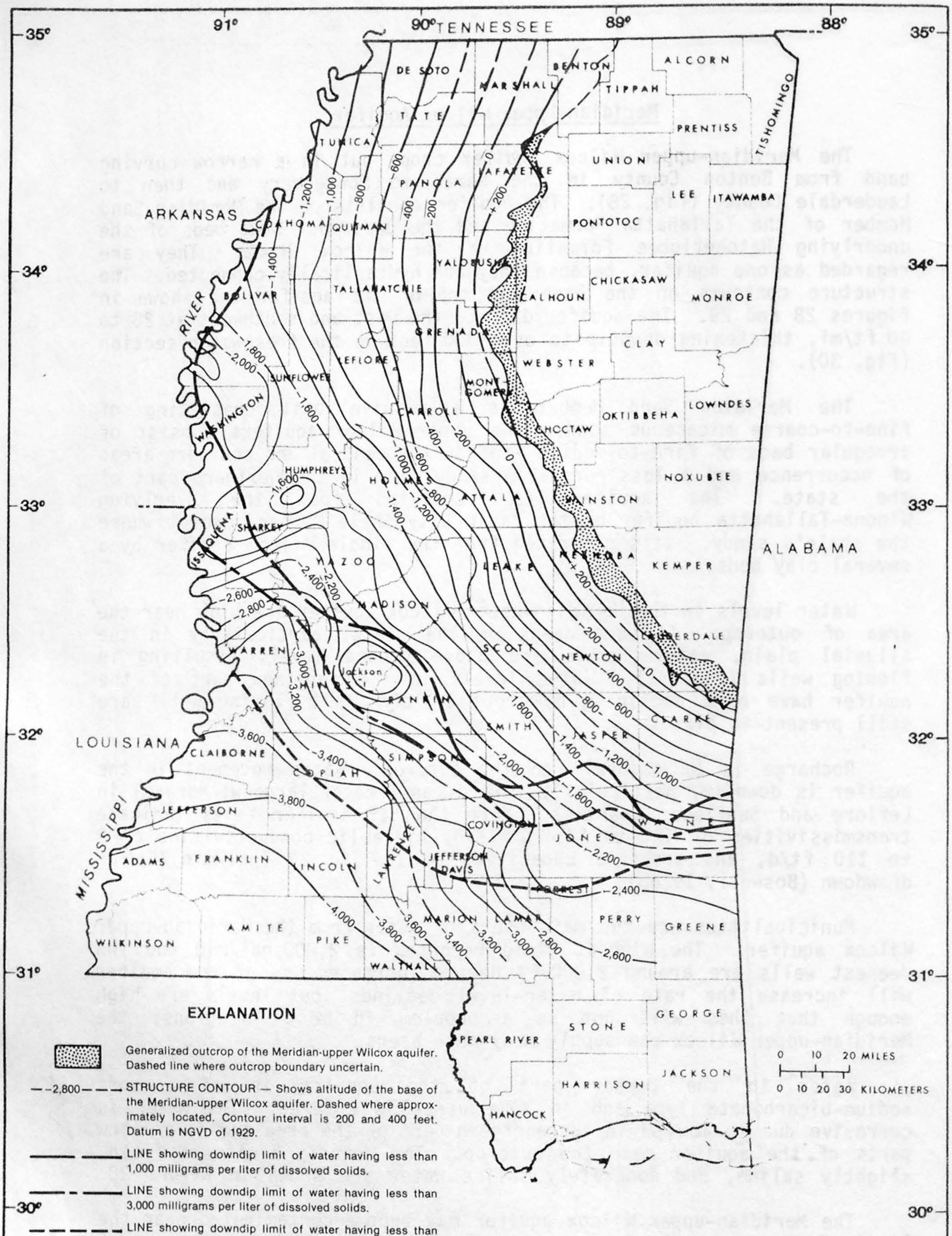

Figure 28. — Configuration of the base of the Meridian-upper Wilcox aquifer.

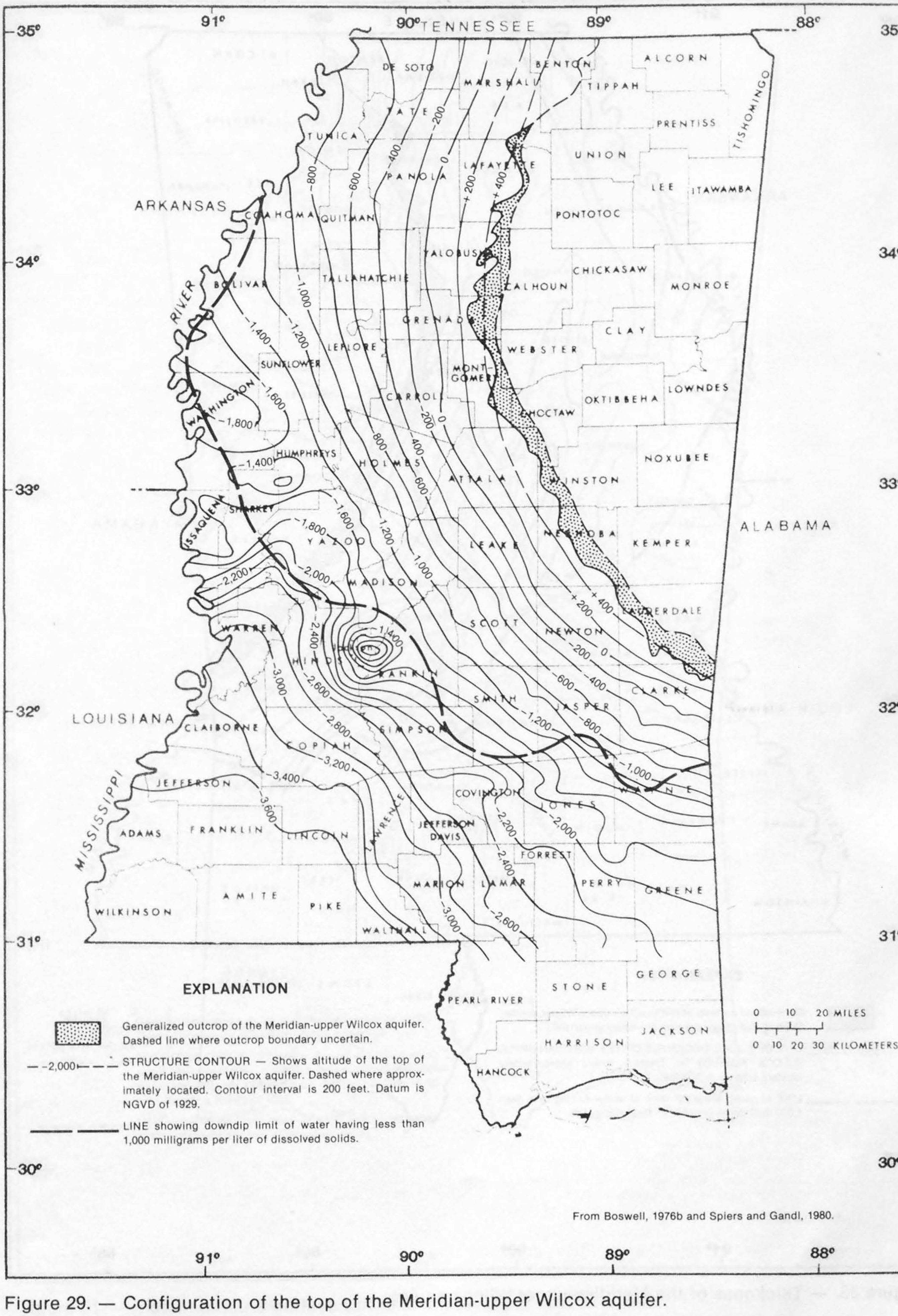

Figure 29. — Configuration of the top of the Meridian-upper Wilcox aquifer.

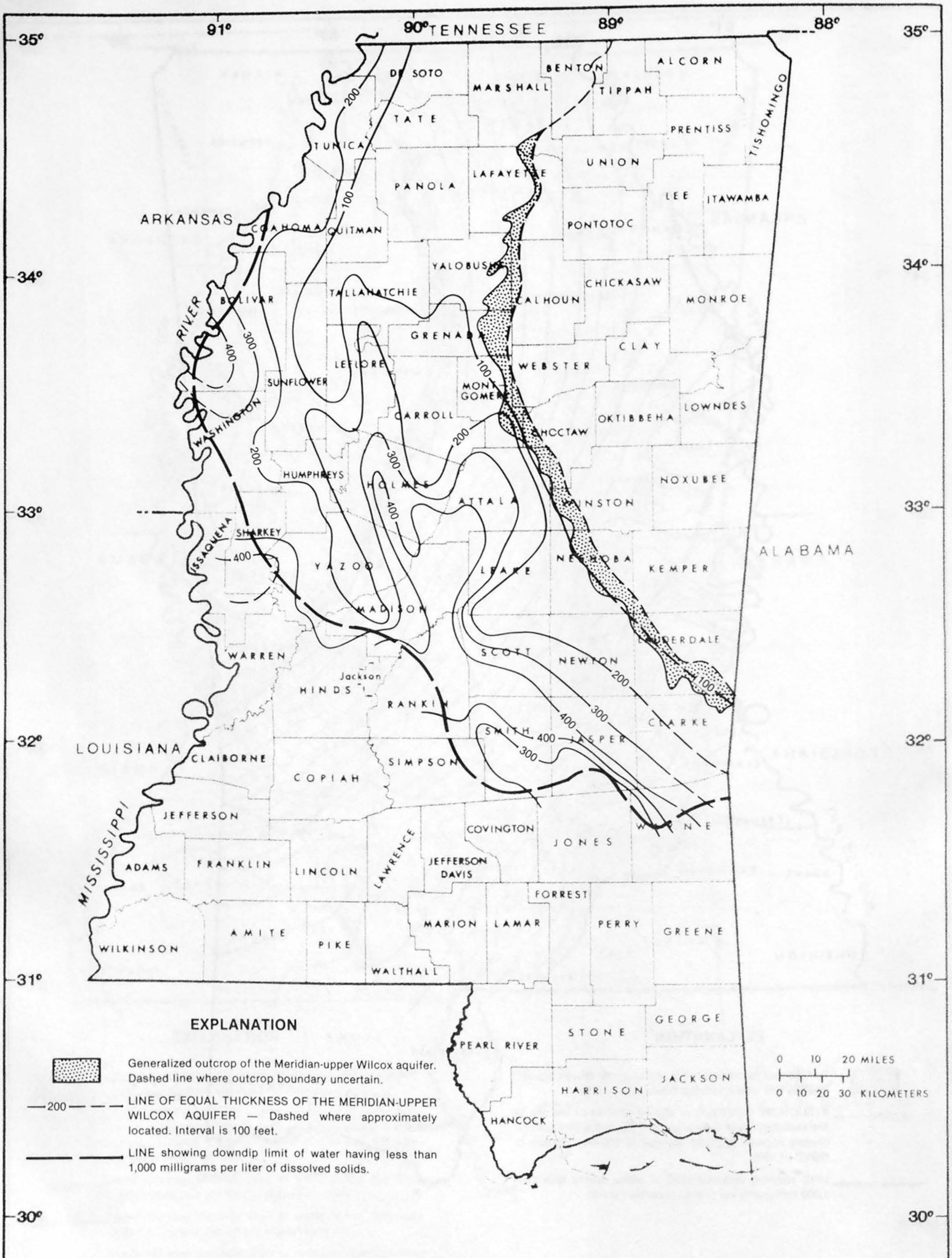

Figure 30. — Thickness of the Meridian-upper Wilcox aquifer.

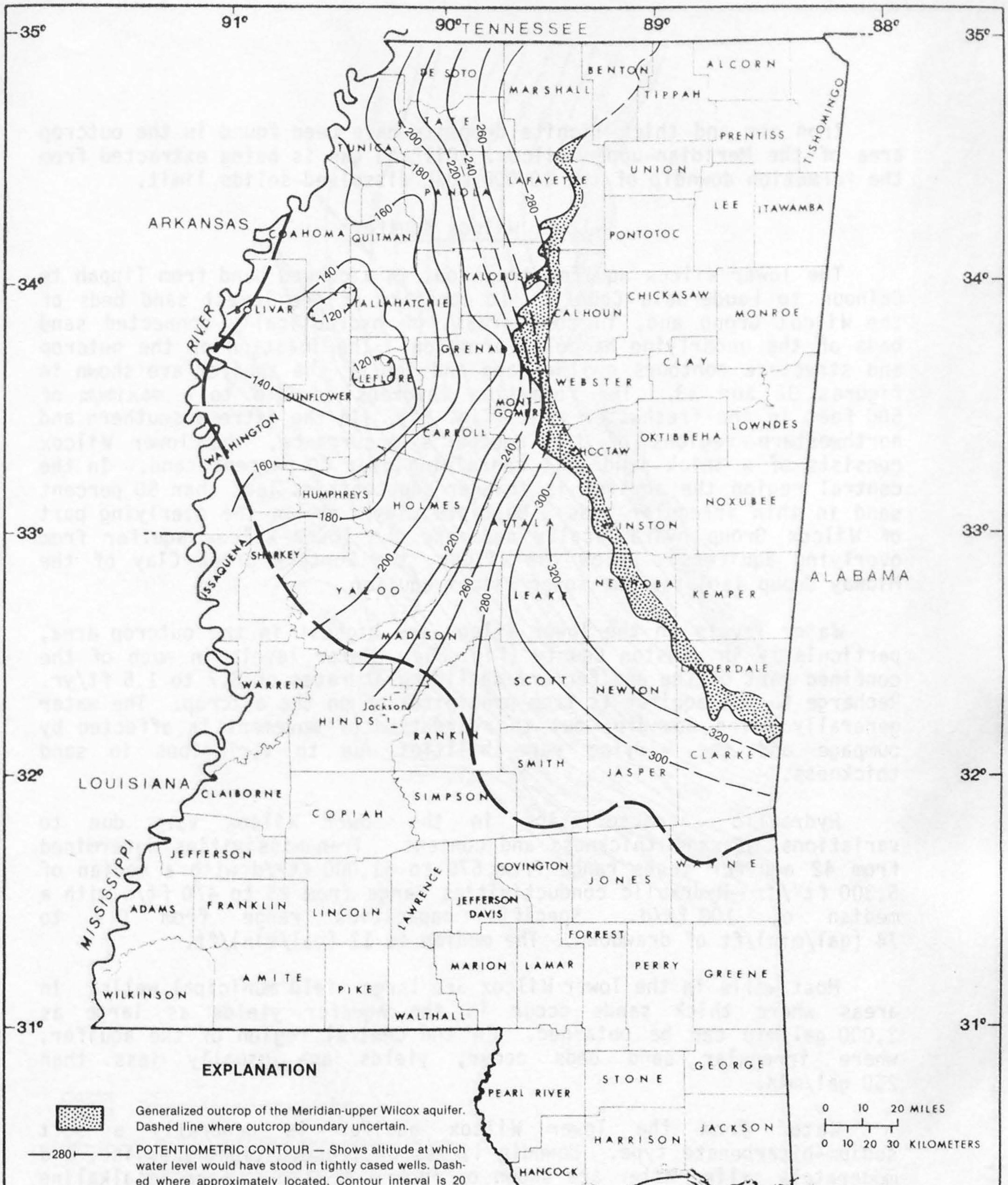

Figure 31. — Potentiometric surface of the Meridian-upper Wilcox aquifer.

Iron ore and thick lignite deposits have been found in the outcrop area of the Meridian-upper Wilcox. Oil and gas is being extracted from the formation downdip of the 10,000 mg/L dissolved-solids limit.

Lower Wilcox Aquifer

The lower Wilcox aquifer crops out in a curved band from Tippah to Calhoun to Lauderdale County. It consists of the lowest sand beds of the Wilcox Group and, in some areas, of hydraulically connected sand beds of the underlying Naheola Formation. The location of the outcrop and structure contours on the base and top of the aquifer are shown in figures 32 and 33. The formation thickens downdip to a maximum of 600 feet in the freshwater zone (fig. 34). In the extreme southern and northwestern regions of the aquifer's occurrence, the lower Wilcox consists of a thick sand unit containing over 60 percent sand. In the central region the aquifer is thinner and contains less than 50 percent sand in thin irregular beds. Multiple clay beds in the overlying part of Wilcox Group hydraulically separate the lower Wilcox aquifer from overlying aquifers. Below the Wilcox, the Porters Creek Clay of the Midway Group isolates the lower Wilcox aquifer.

Water levels in the lower Wilcox are highest in the outcrop area, particularly in Winston County (fig. 35). Water levels in much of the confined part of the aquifer are declining at rates of 0.7 to 1.5 ft/yr. Recharge to the aquifer is from precipitation on the outcrop. The water generally moves downdip, but the direction of movement is affected by pumpage and the varying permeabilities due to variations in sand thickness.

Hydraulic characteristics in the lower Wilcox vary due to variations in sand thickness and content. Transmissivities determined from 42 aquifer tests range from 670 to 51,000 ft^2/d with a median of 5,300 ft^2/d. Hydraulic conductivities range from 25 to 470 ft/d with a median of 100 ft/d. Specific capacities range from 0.9 to 74 (gal/min)/ft of drawdown. The median is 12 (gal/min)/ft.

Most wells in the lower Wilcox are large yield municipal wells. In areas where thick sands occur in the aquifer yields as large as 2,000 gal/min can be obtained. In the central region of the aquifer, where irregular sand beds occur, yields are usually less than 250 gal/min.

Water from the lower Wilcox aquifer is generally a soft sodium-bicarbonate type. Downdip limits of fresh, slightly saline, and moderately saline water are shown on figure 32. The water is alkaline except near and in the outcrop area, and is high in iron in the southern part of the area.

Lignite, iron ore, and kaolinite are all found in the outcrop of the lower Wilcox. Oil and gas is found at great depths, much below the 10,000 mg/L dissolved-solids limit.

Contamination of the aquifer has occurred due to improper disposal of oil field wastes into freshwater and slightly-to-moderately saline water (Bicker, 1972).

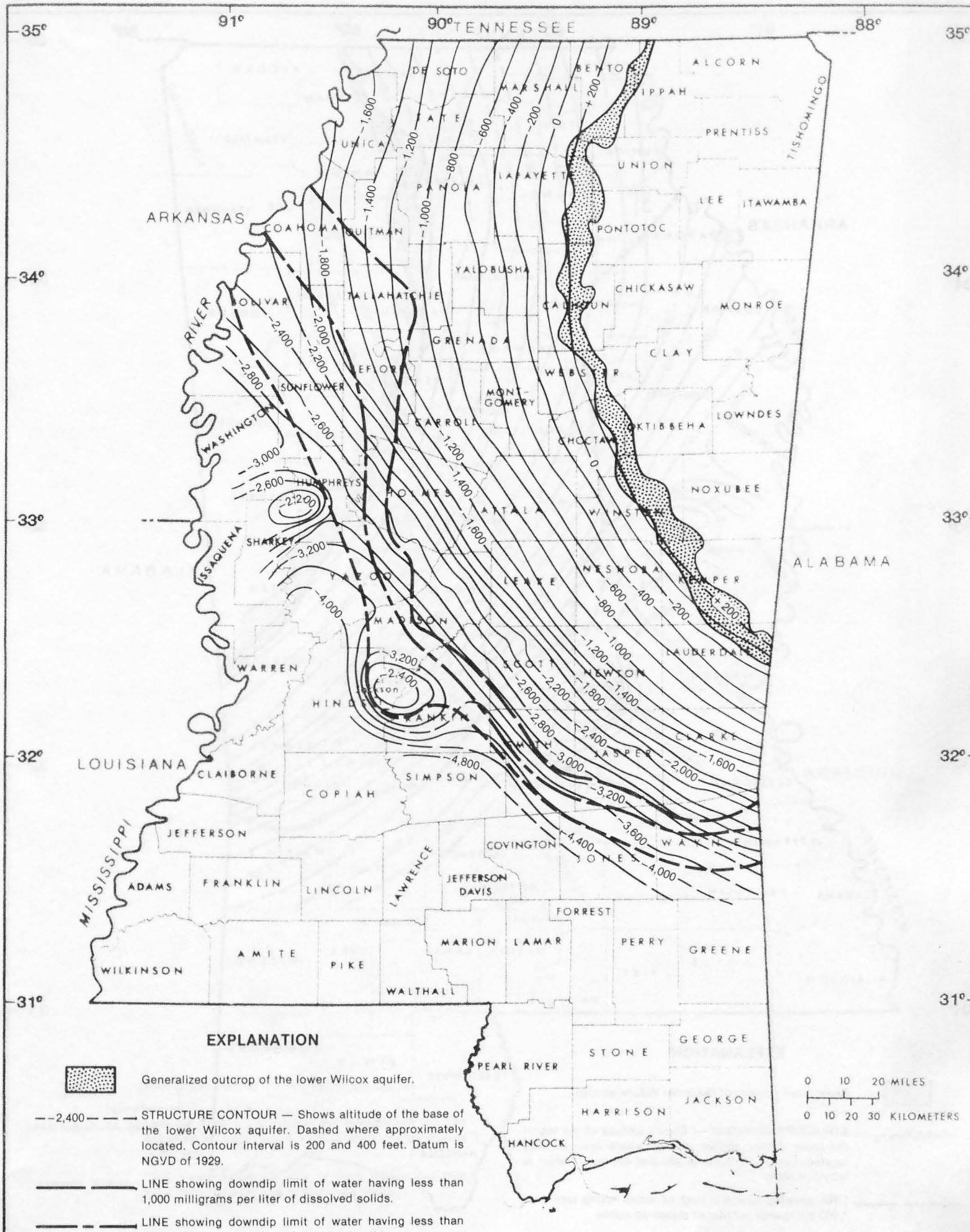

Figure 32. — Configuration of the base of the lower Wilcox aquifer.

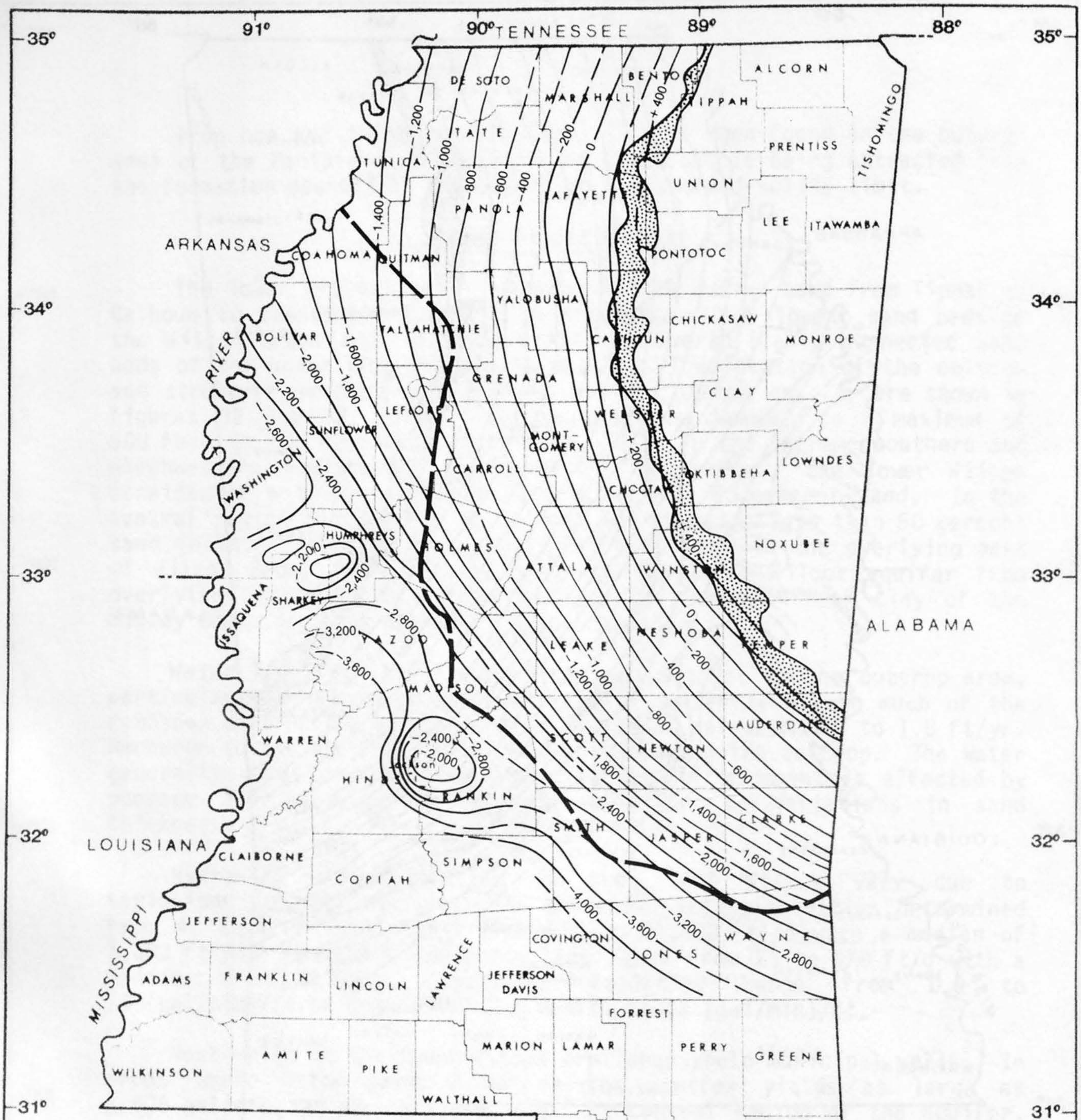

Figure 33. — Configuration of the top of the lower Wilcox aquifer.

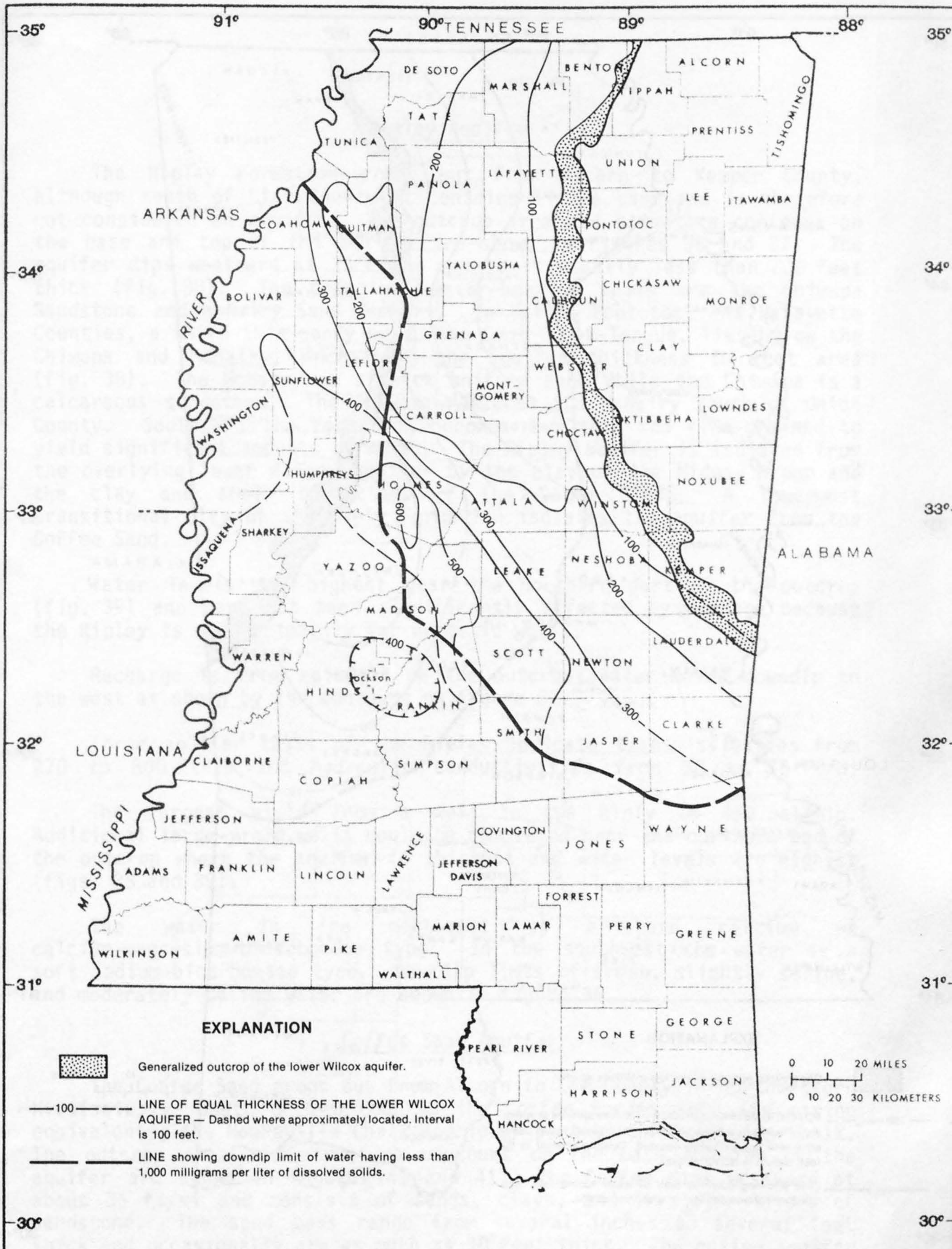

Figure 34. — Thickness of the lower Wilcox aquifer.

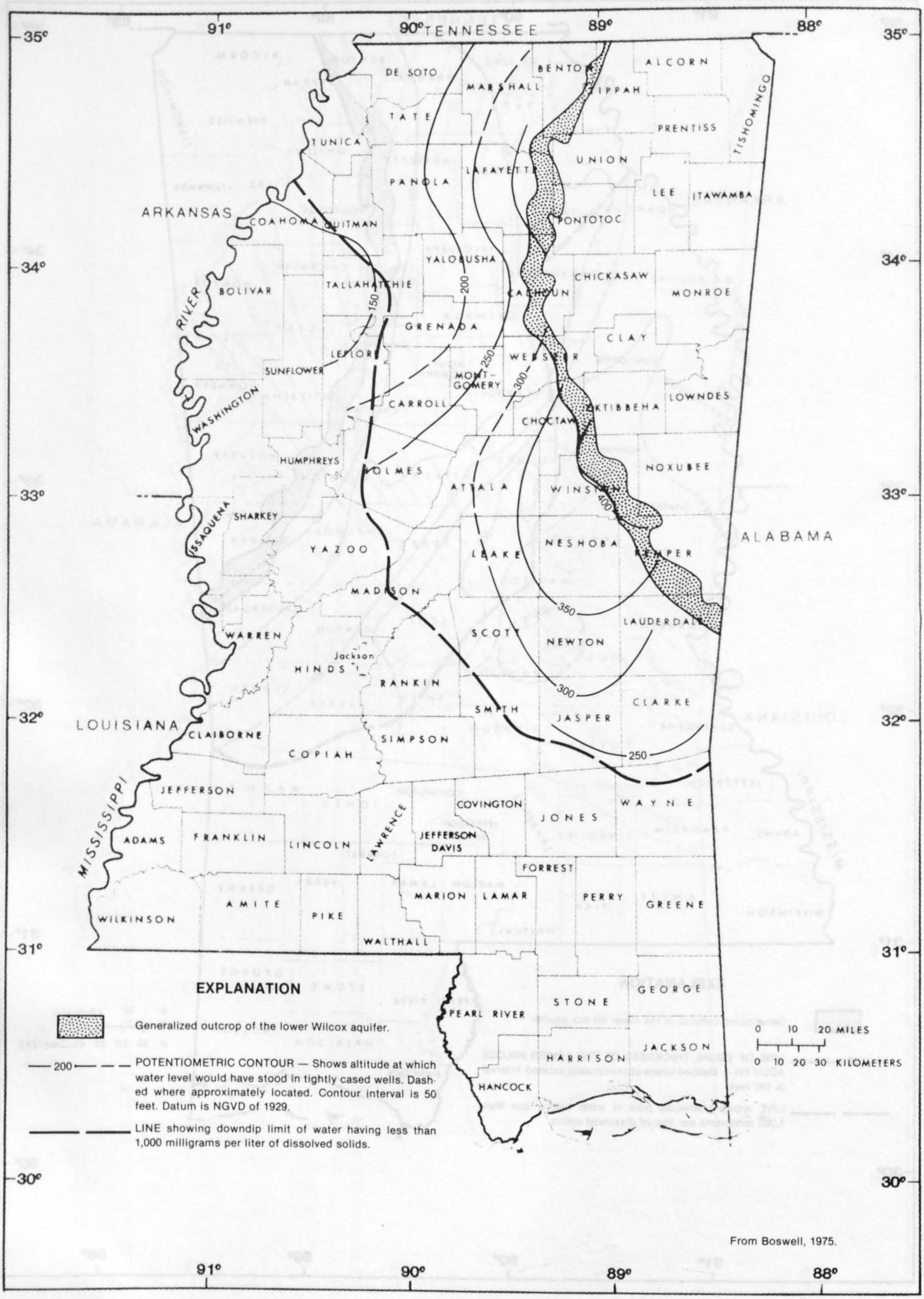

Figure 35. — Potentiometric surface of the lower Wilcox aquifer.

Ripley Aquifer

The Ripley Formation crops out from Alcorn to Kemper County, although south of Clay County it contains little sand and is therefore not considered an aquifer. The outcrop area and structure contours on the base and top of the aquifer are shown in figures 36 and 37. The aquifer dips westward at 35 ft/mi and it is usually less than 200 feet thick (fig. 38). The principal water-bearing units are the Chiwapa Sandstone and NcNairy Sand Members. In Union, Pontotoc, and Lafayette Counties, a third thin sandy unit, the Coon Creek Tongue, lies below the Chiwapa and McNairy, increasing the aquifer thickness in that area (fig. 38). The McNairy is a thick uniform sand while the Chiwapa is a calcareous sandstone. The Chiwapa replaces the McNairy south of Union County. Southward the formation becomes too thin and fine-grained to yield significant amounts of water. The Ripley aquifer is isolated from the overlying lower Wilcox aquifer by the clay of the Midway Group and the clay and chalk formations of the Selma Group. A lowermost transitional clay of the Riply Formation isolates the aquifer from the Coffee Sand.

Water levels are highest near the northern part of the outcrop (fig. 39) and have not been significantly affected by pumpage because the Ripley is used primarily for domestic wells.

Recharge is from rainfall on the outcrop; water moves downdip to the west as shown by the contours on figure 39.

Three aquifer tests of the Ripley indicate transmissivities from 270 to 800 ft^2/d and hydraulic conductivities from 50 to 75 ft/d.

The largest yield from a well in the Riply is 450 gal/min. Additional large-yield wells could be completed near the northern end of the outcrop where the aquifer is thickest and water levels are highest (figs. 38 and 39).

The water in the northeast is a hard calcium or calcium-magnesium-bicarbonate type. In the southwest the water is a soft sodium-bicarbonate type. Downdip limts of fresh, slightly saline, and moderately saline water are shown in figure 36.

Coffee Sand Aquifer

The Coffee Sand crops out from Alcorn to Lee County in northwestern Mississippi. South of Lee County, the Coffee merges into its marine equivalents, the Mooreville Chalk and lower part of the Demopolis Chalk. The outcrop area and structure contours on the base and top of the aquifer are shown in figures 40 and 41. The Coffee dips westward at about 35 ft/mi and consists of sands, clays, and irregular layers of sandstone. The sand beds range from several inches to several feet thick and occasionally are as much as 30 feet thick. The entire aquifer is about 200 feet thick (fig. 42). The lowermost transitional clay of the Ripley Formation hydraulically isolates the Coffee Sand from overlying aquifers. The underlying Mooreville Chalk separates the Coffee from the Eutaw-McShan aquifer in some locations.

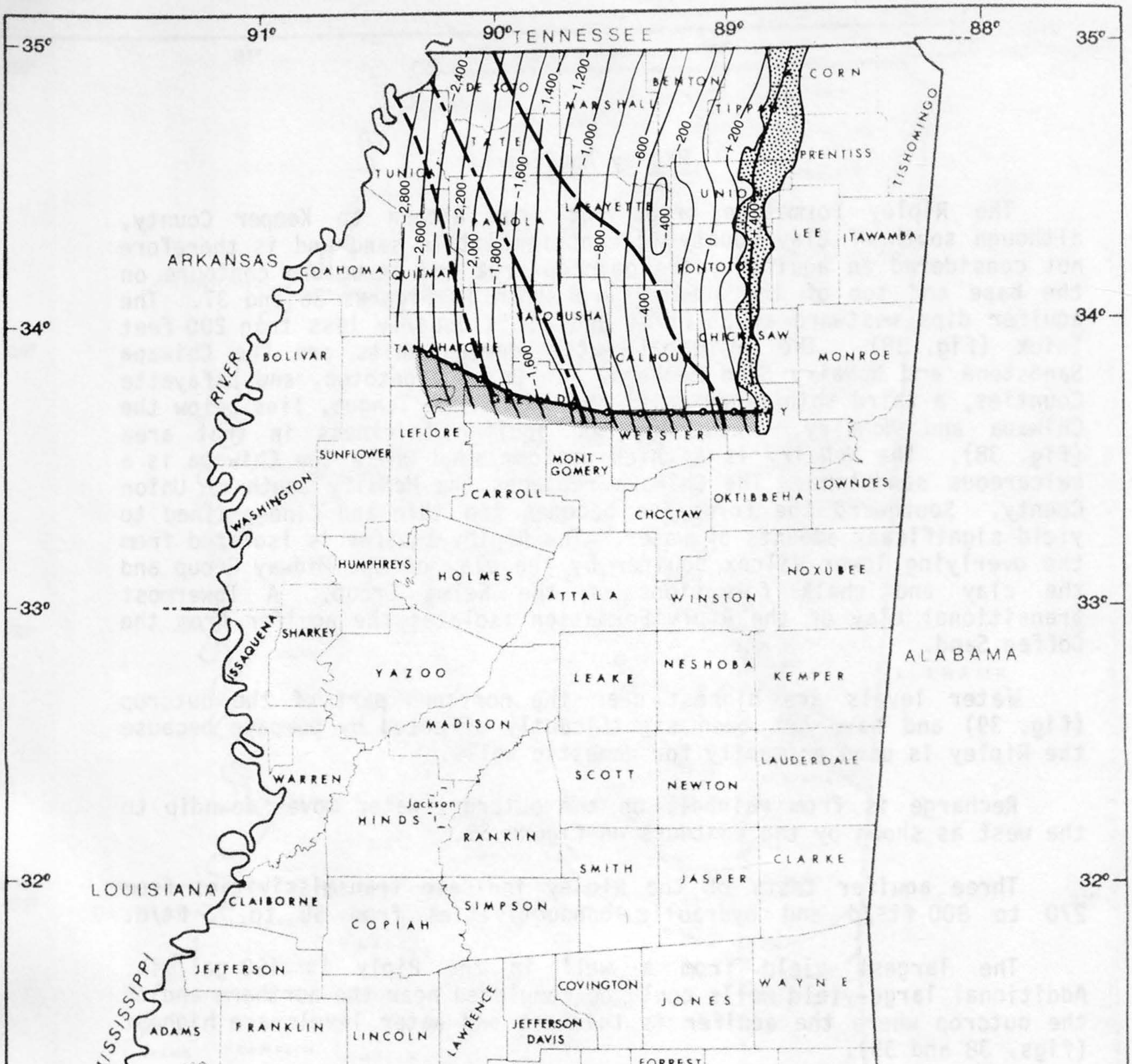

Figure 36. — Configuration of the base of the Ripley aquifer.

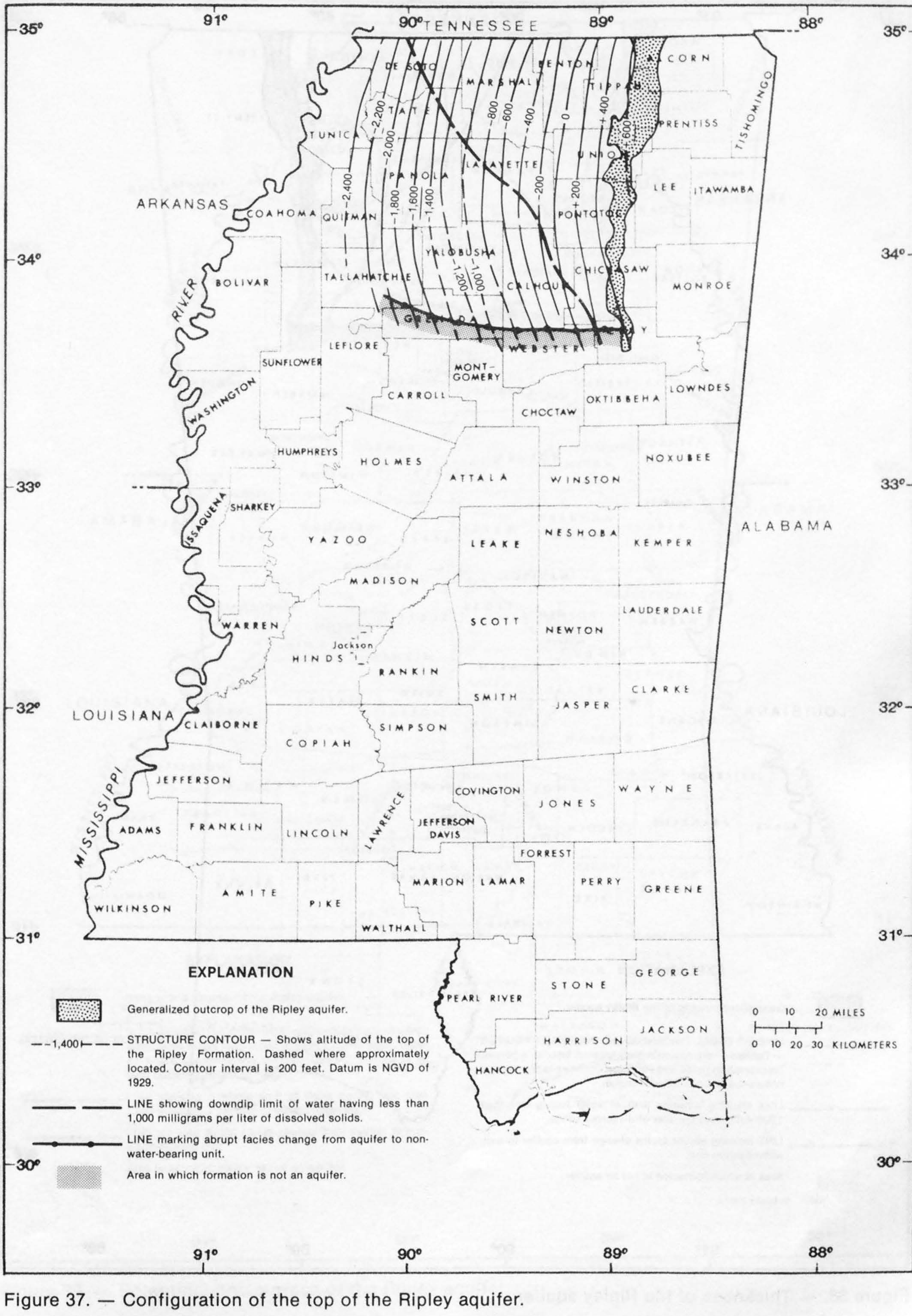

Figure 37. — Configuration of the top of the Ripley aquifer.

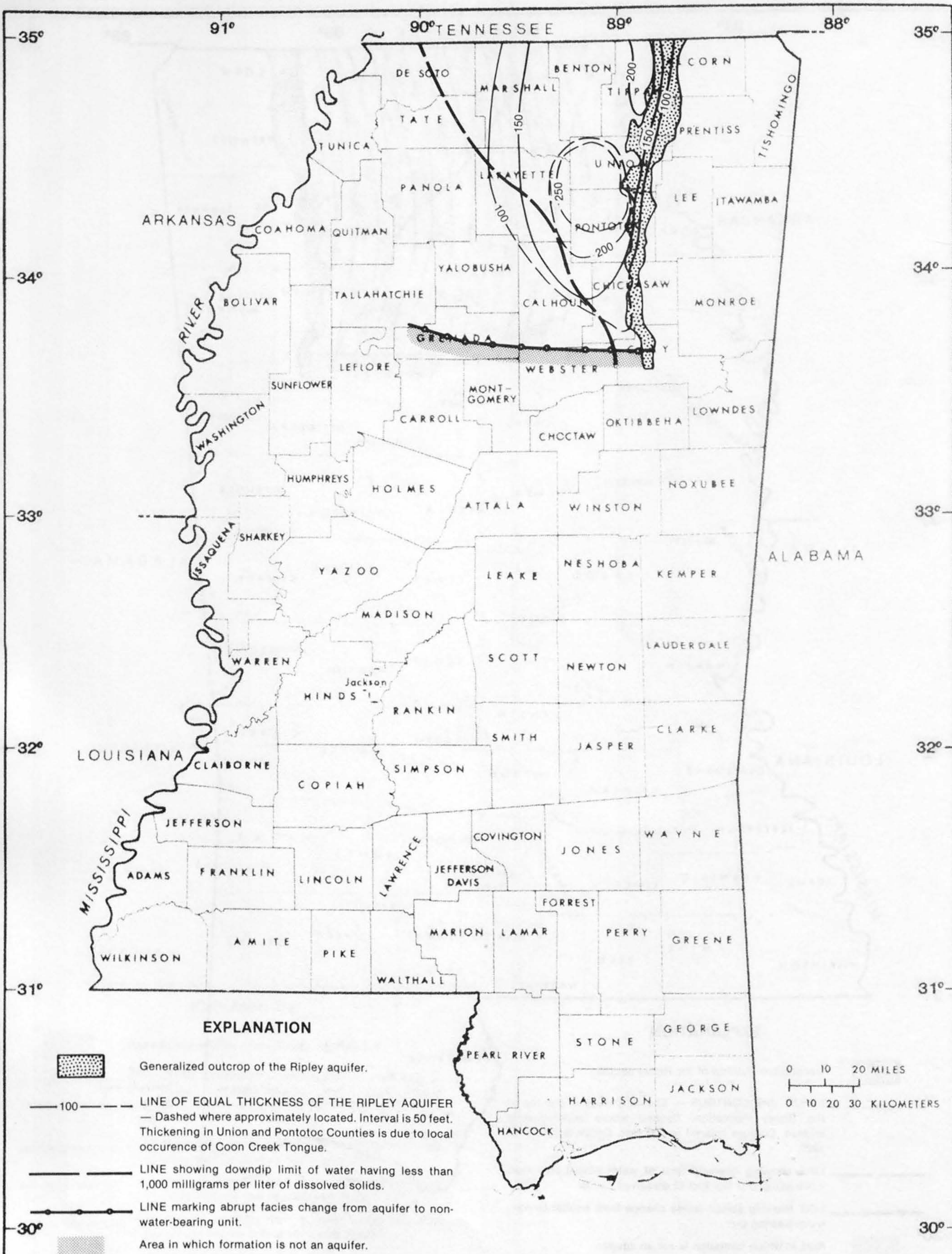

Figure 38. — Thickness of the Ripley aquifer.

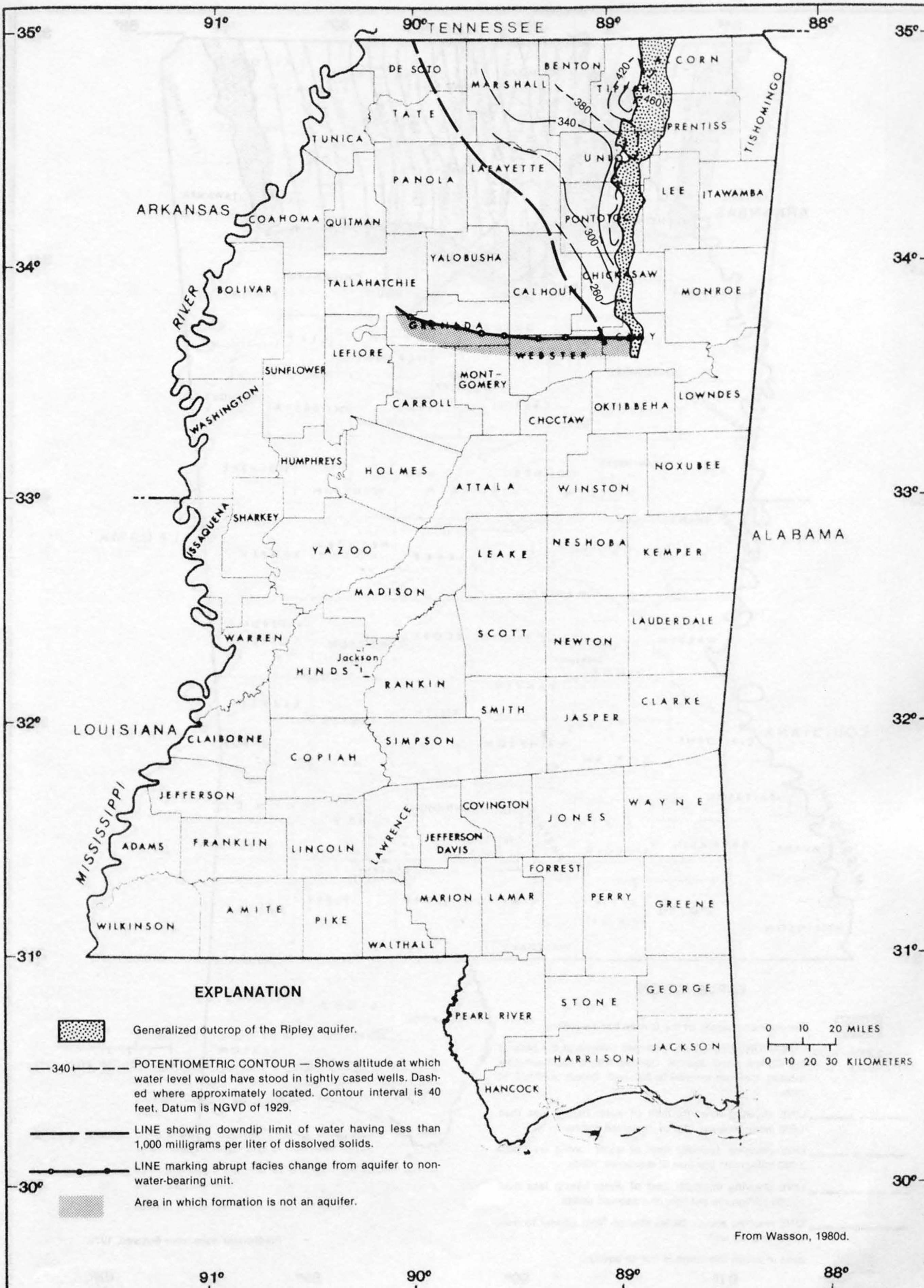

Figure 39. — Potentiometric surface of the Ripley aquifer.

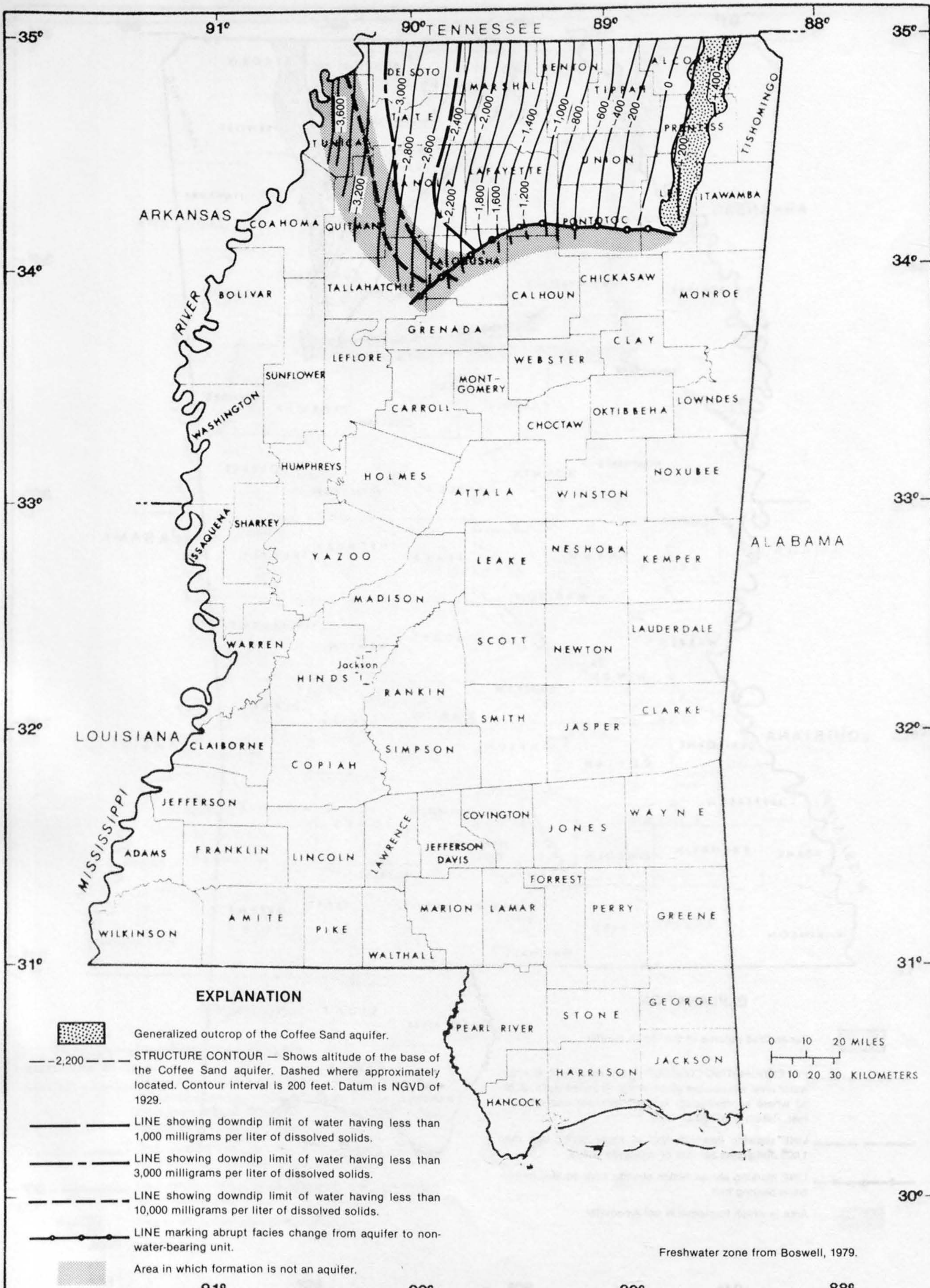

Figure 40. — Configuration of the base of the Coffee Sand aquifer.

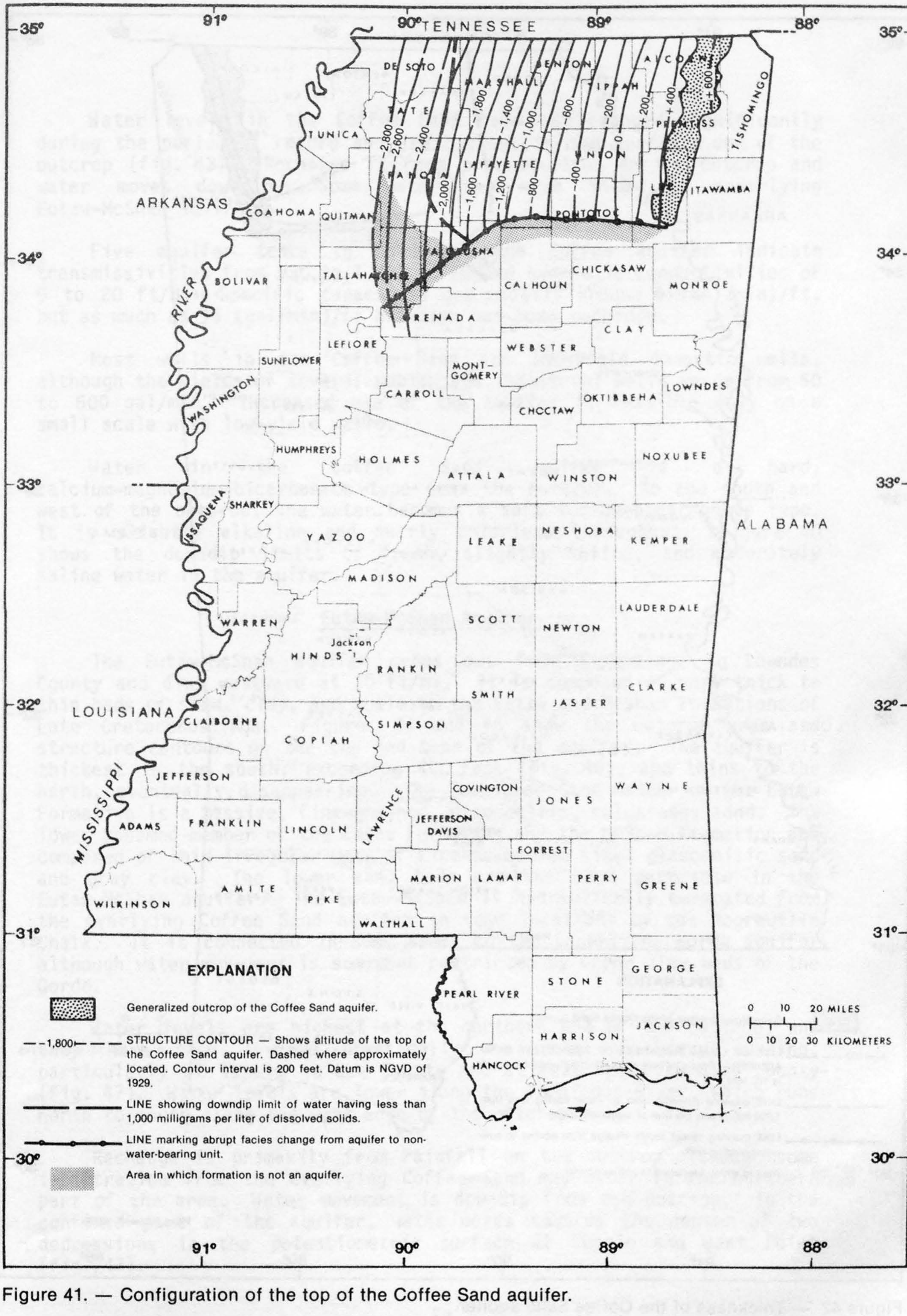

Figure 41. — Configuration of the top of the Coffee Sand aquifer.

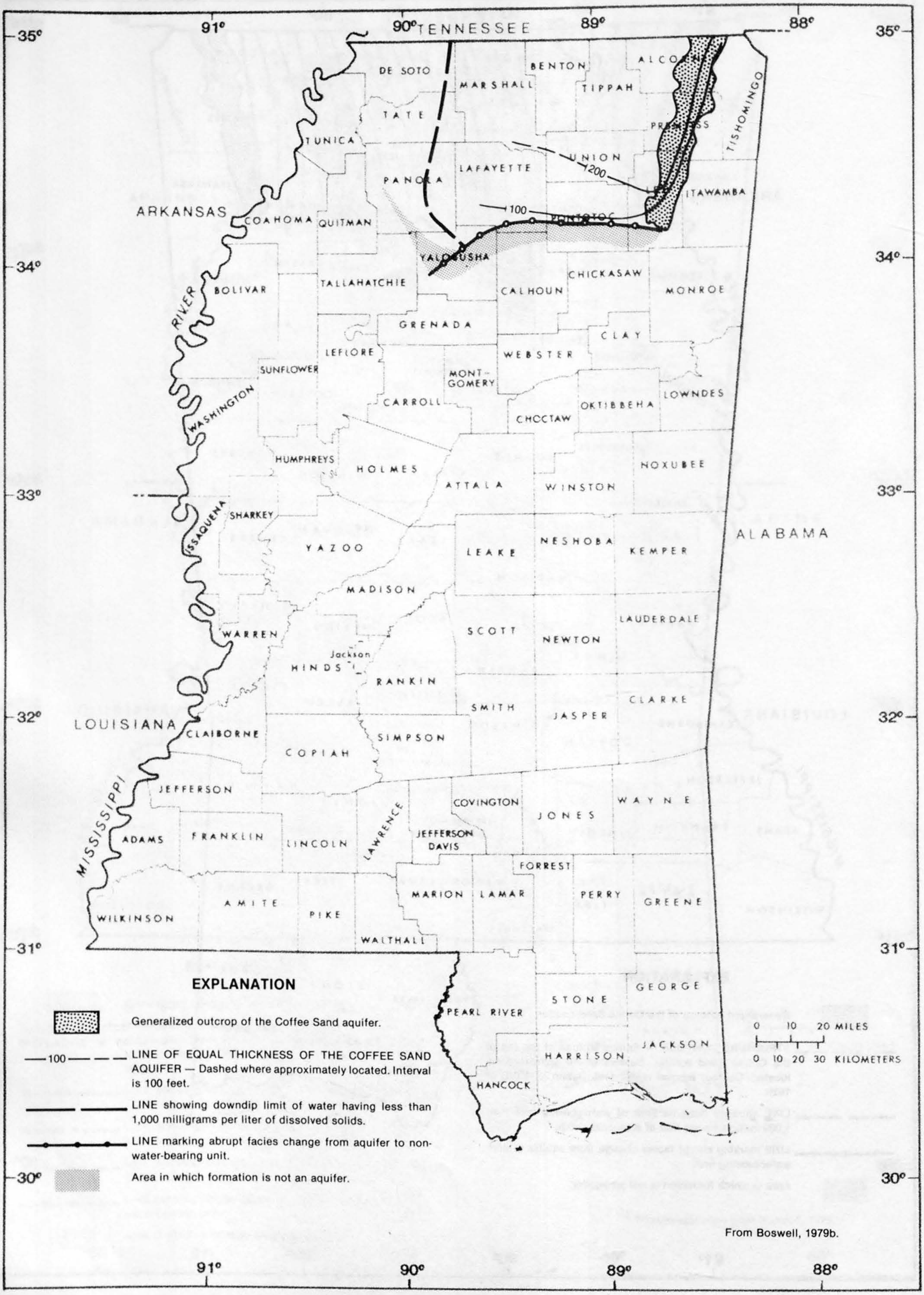

Figure 42. — Thickness of the Coffee Sand aquifer.

Water levels in the Coffee Sand have not changed significantly during the period of record and are highest in the northern end of the outcrop (fig. 43). Recharge is from precipitation on the outcrop and water moves downdip. Some water may move into the underlying Eutaw-McShan aquifer.

Five aquifer tests in sands of the Coffee aquifer indicate transmissivities from 930 to 1,200 ft^2/d and hydraulic conductivities of 9 to 20 ft/d. Specific capacities are usually around 1 (gal/min)/ft, but as much as 15 (gal/min)/ft drawdown has been recorded.

Most wells in the Coffee Sand are low-yield domestic wells, although the yields of several public and industrial wells range from 50 to 600 gal/min. Increased use of the aquifer is feasible only on a small scale with low-yield wells.

Water in the Coffee Sand aquifer is a hard, calcium-magnesium-bicarbonate type near the outcrop. To the south and west of the outcrop, the water becomes a soft sodium-bicarbonate type. It is slightly alkaline and nearly colorless throughout. Figure 40 shows the downdip limits of fresh, slightly saline, and moderately saline water in the aquifer.

Eutaw-McShan Aquifer

The Eutaw-McShan aquifer crops out from Tishomingo to Lowndes County and dips westward at 30 ft/mi. It is composed of many thick to thin beds of sand, clay, and shale in the Eutaw and McShan Formations of Late Cretaceous Age. Figures 44 and 45 show the outcrop area and structure contours on the top and base of the aquifer. The aquifer is thickest in the south, exceeding 400 feet (fig. 46), and thins to the north, eventually disappearing. The Tombigbee Sand member of the Eutaw Formation is a massive, fine-grained, glauconitic, calcareous sand. The lower unnamed member of the Eutaw Formation and the McShan Formation are composed of thin irregular beds of fine-to-medium sized glauconitic sand and gray clay. The lower sand beds are the most permeable in the Eutaw-McShan aquifer. The Eutaw-McShan is hydraulically separated from the overlying Coffee Sand aquifer in some locations by the Mooreville Chalk. It is connected in some areas to the underlying Gordo aquifer although water movement is somewhat restricted by upper clay beds of the Gordo.

Water levels are highest at the northern end of the outcrop, and they have been lowered drastically in areas of heavy pumping, particularly at Tupelo in Lee County and at West Point in Clay County (fig. 47). Water levels are lower along the Tombigbee River, which runs north to south along the west edge of the outcrop.

Recharge is primarily from rainfall on the outcrop although some infiltration from the overlying Coffee Sand may occur in the northern part of the area. Water movement is downdip from the outcrop. In the confined part of the aquifer, water moves towards the center of two depressions in the potentiometric surface at Tupelo and West Point (fig. 47).

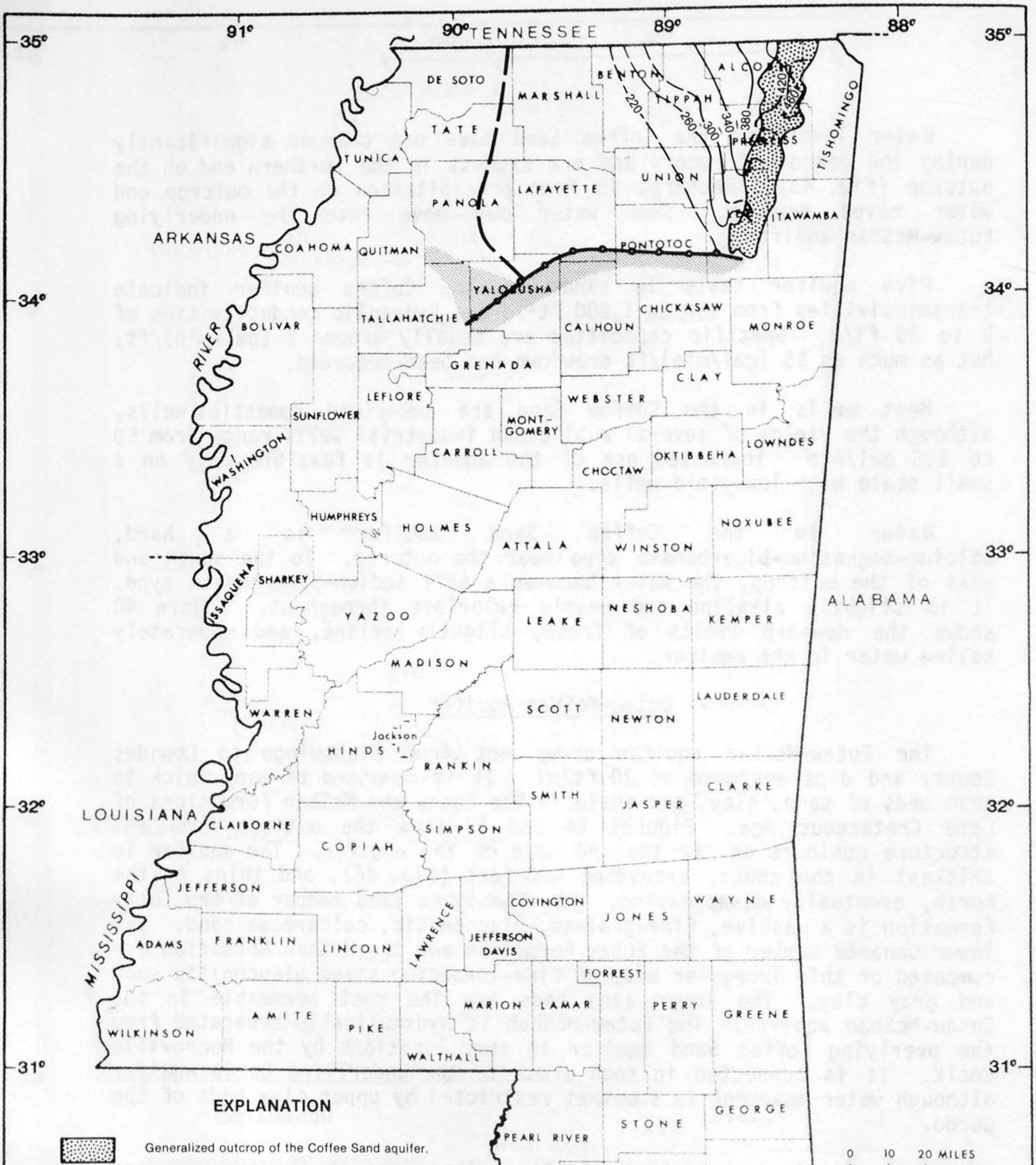

Figure 43. — Potentiometric surface of the Coffee Sand aquifer.

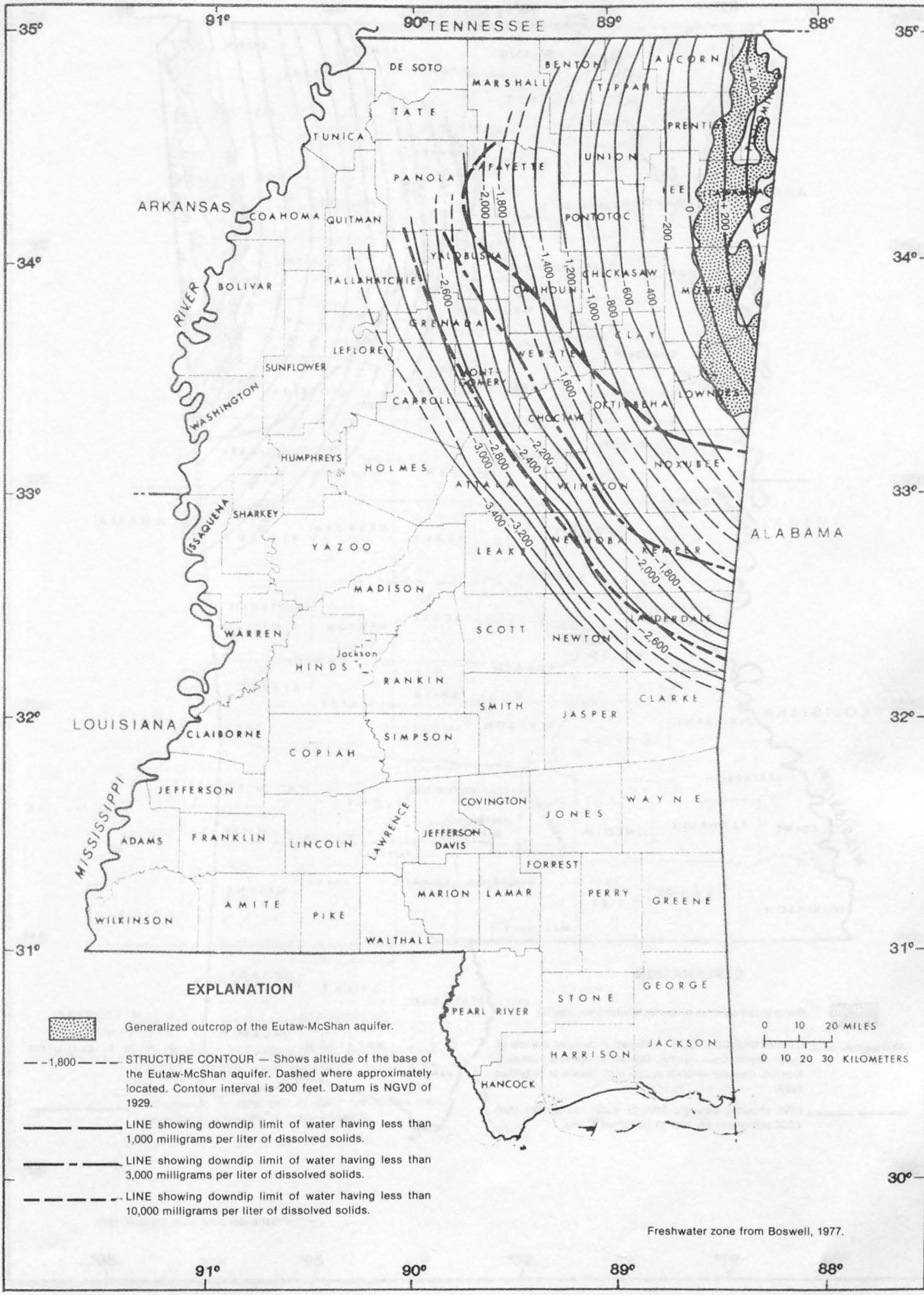

Figure 44. — Configuration of the base of the Eutaw-McShan aquifer.

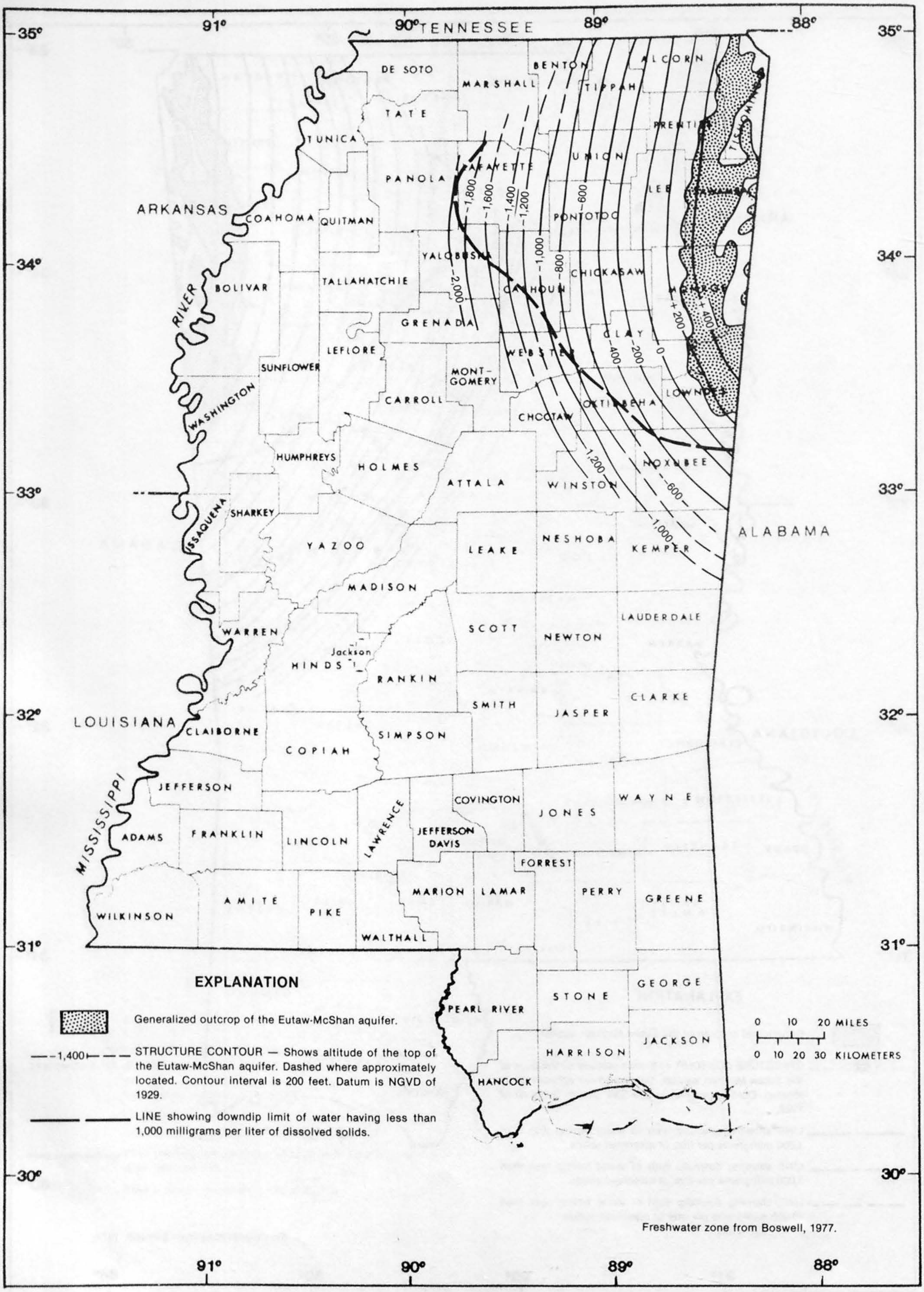

Figure 45. — Configuration of the top of the Eutaw-McShan aquifer.

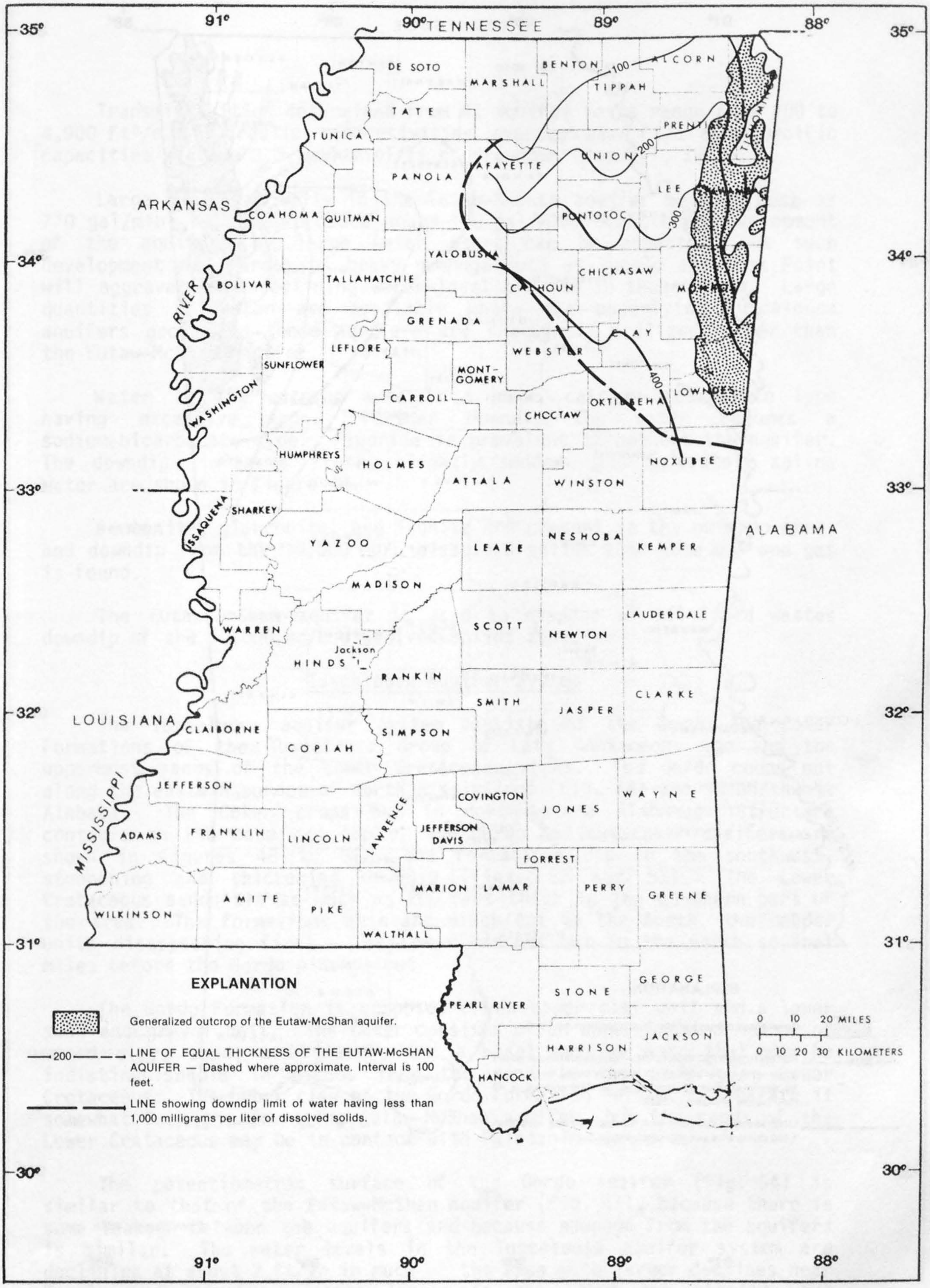

Figure 46. — Thickness of the Eutaw-McShan aquifer.

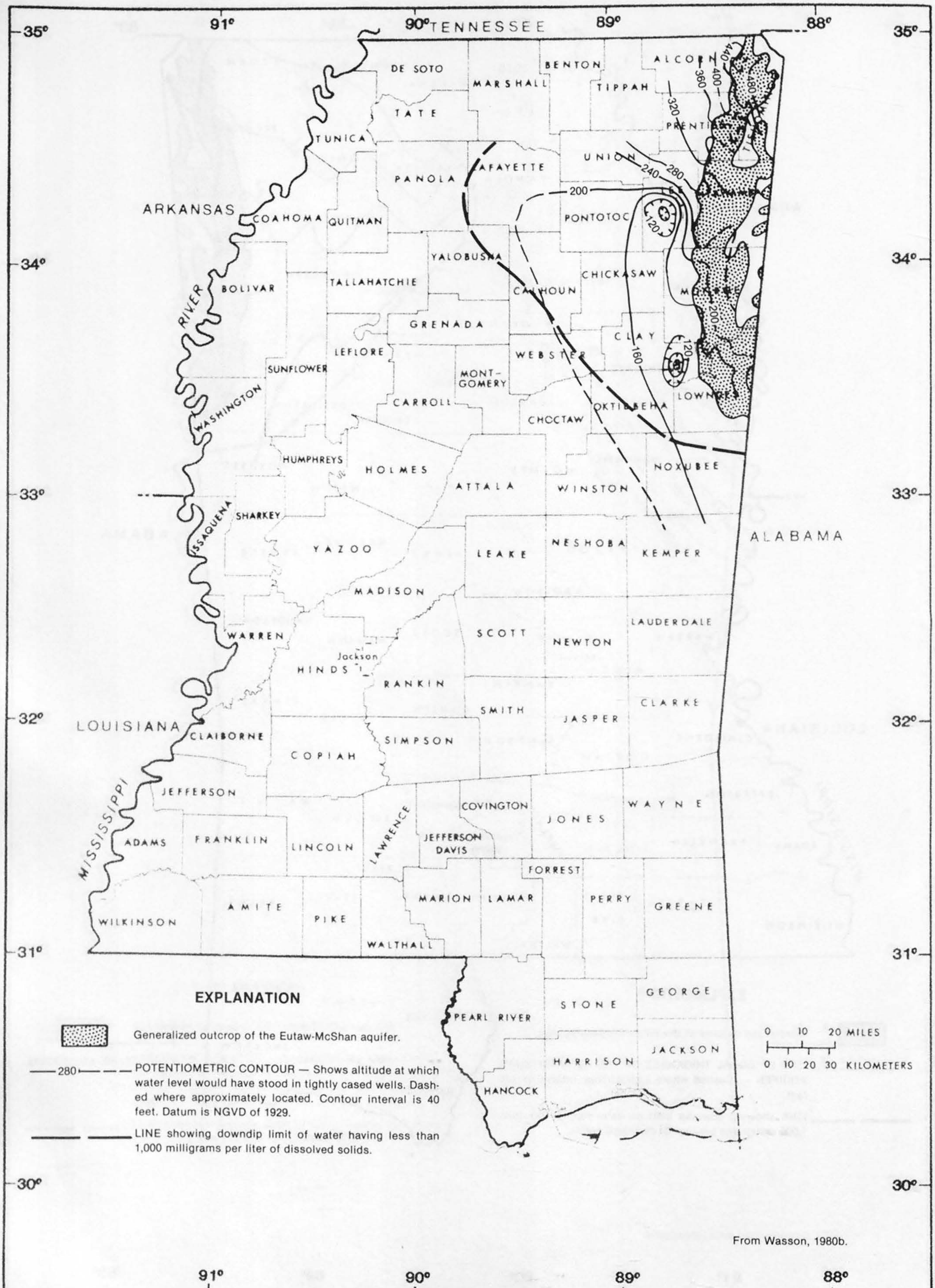

Figure 47. — Potentiometric surface of the Eutaw-McShan aquifer.

Transmissivities determined from 41 aquifer tests range from 200 to 4,900 ft^2/d. Hydraulic conductivities average 13.4 ft/d and specific capacities average 3.3 (gal/min)/ft of drawdown (Boswell, 1977).

Large municipal wells in the Eutaw-McShan aquifer pump as much as 770 gal/min, but some produce under 100 gal/min. Continued development of the aquifers by large water users can be expected, but such development near areas of heavy pumpage such as Tupelo and West Point will aggravate the declining water-level problem in those areas. Large quantities of water are available where the underlying Tuscaloosa aquifers occur and these aquifers are frequently utilized rather than the Eutaw-McShan aquifer.

Water in the outcrop area is a hard, calcium-bicarbonate type having excessive iron. Further downdip the water becomes a sodium-bicarbonate type. Fluoride is prevalent throughout the aquifer. The downdip limits of fresh, slightly saline, and moderately saline water are shown in figure 44.

Bentonite, glauconite, and lignite are present in the outcrop area, and downdip from the 10,000 mg/L dissolved-solids zone some oil and gas is found.

The Eutaw-McShan aquifer is used to dispose of oil-field wastes downdip of the 10,000 mg/L dissolved-solids zone.

Tuscaloosa Aquifer System

The Tuscaloosa aquifer system consists of the Gordo and Coker Formations of the Tuscaloosa Group of Late Cretaceous age and the uppermost sands of the Lower Cretaceous rocks. The Gordo crops out along the eastern border of north Mississippi (fig. 48) and in northwest Alabama. The Coker crops out in northwestern Alabama. Structure contours on the base and top of the Gordo and the Coker aquifers are shown in figures 48 to 51. The formations dip to the southwest, steepening and thickening downdip (figs. 52 and 53). The Lower Cretaceous sands are as much as 200 feet thick in the southern part of the area. The formations thin and pinch out to the north, the deeper units disappearing first. The Coker pinches out to the north several miles before the Gordo pinches out.

The Gordo Formation is composed of an upper clay unit and a lower sand and gravel unit. The Coker consists of an upper unnamed member of mixed clay, sand, and gravel, and a basal massive sand that may be indistinguishable in places from the sand in the underlying Lower Cretaceous. The upper clay of the Gordo Formation serves to separate it somewhat from the overlying Eutaw-McShan aquifer, but the sands of the Lower Cretaceous may be in contact with Paleozoic aquifers.

The potentiometric surface of the Gordo aquifer (fig. 54) is similar to that of the Eutaw-McShan aquifer (fig. 47), because there is some leakage between the aquifers and because pumpage from the aquifers is similar. The water levels in the Tuscaloosa aquifer system are declining at about 2 ft/yr in much of the area with larger declines near Tupelo and Columbus. Water levels in the Coker are similar, but drawdowns have not been as large because the Coker is not heavily used.

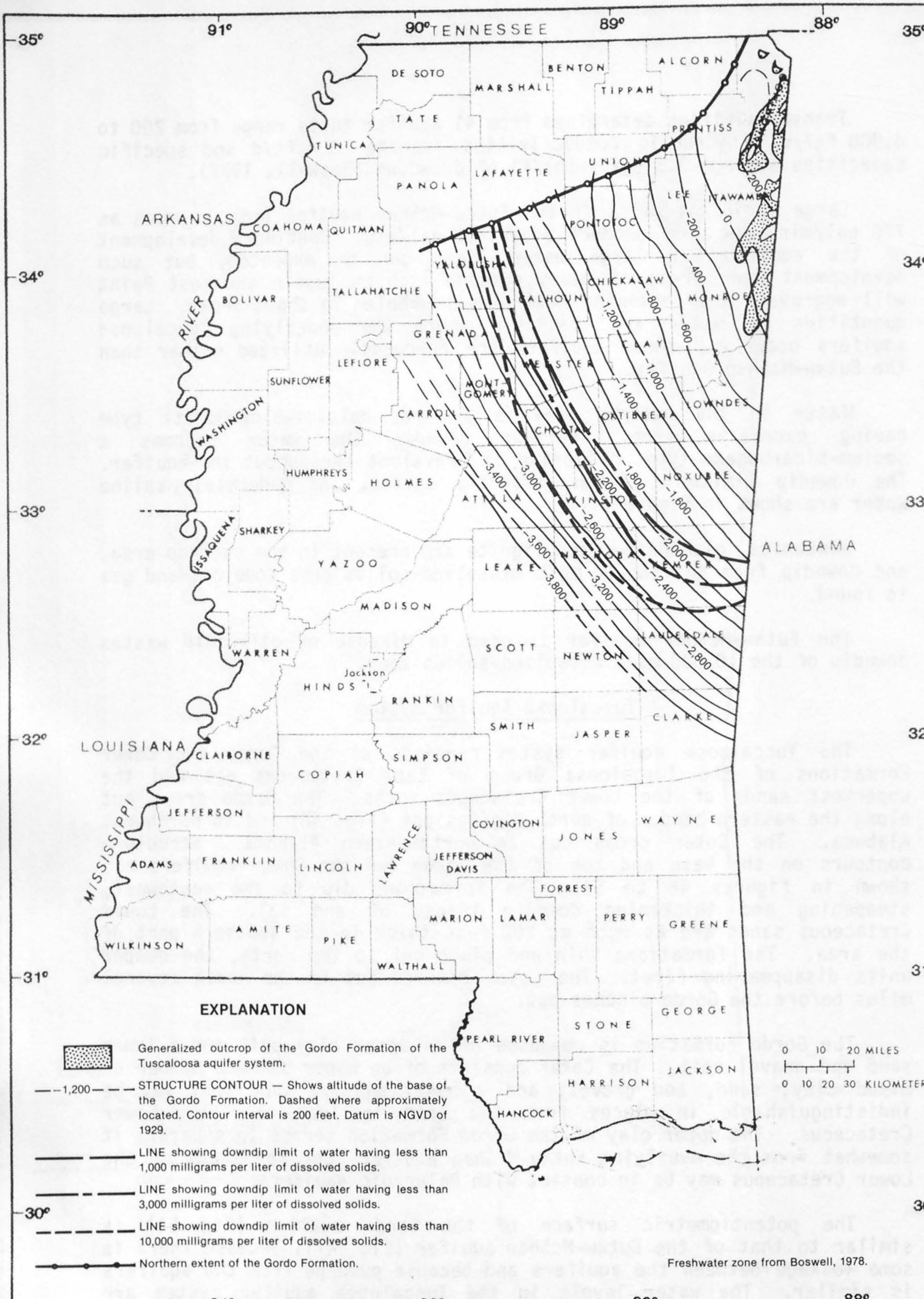

Figure 48. — Configuration of the base of the Gordo Formation of the Tuscaloosa aquifer system.

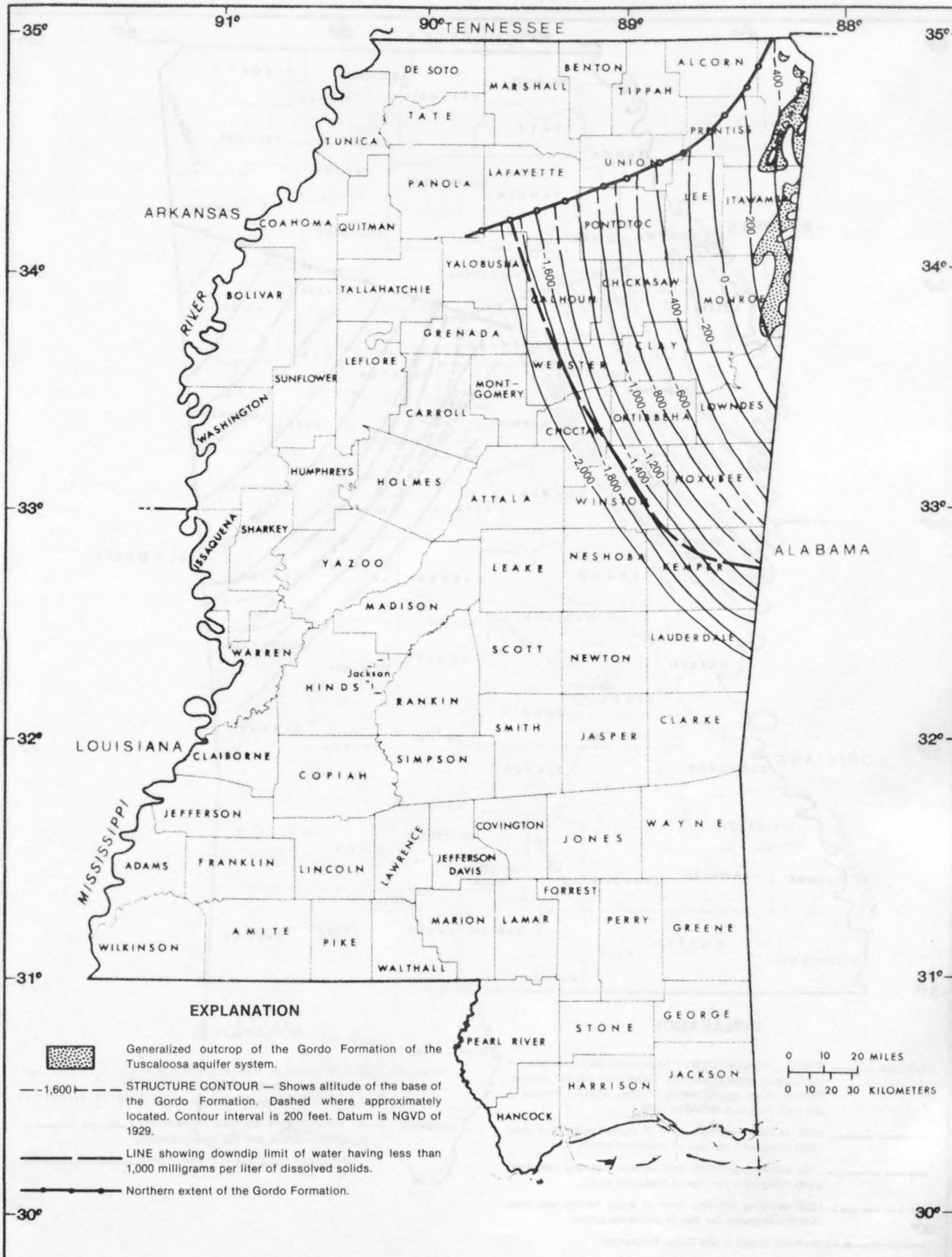

Figure 49. — Configuration of the top of the Gordo Formation of the Tuscaloosa aquifer system.

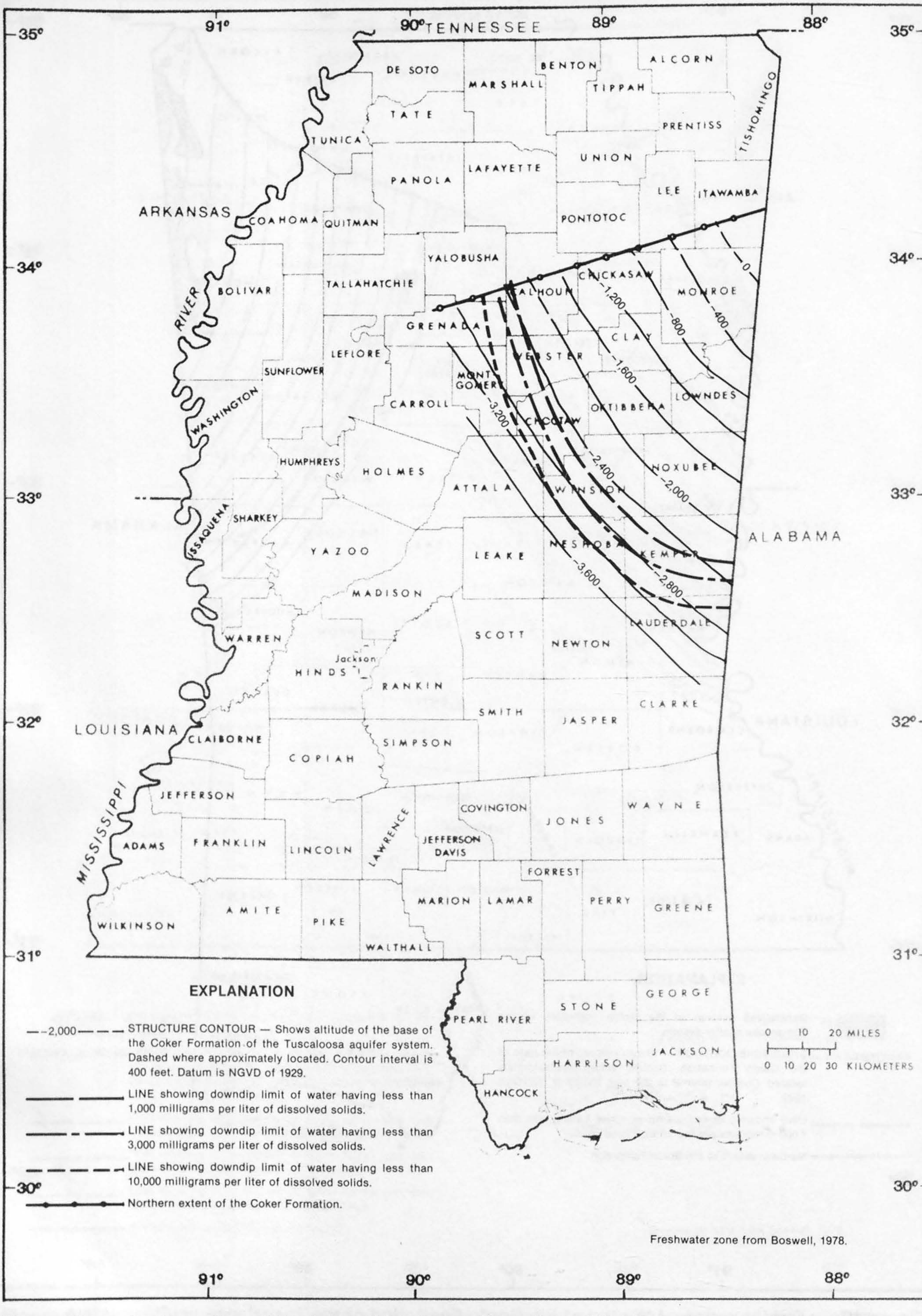

Figure 50. — Configuration of the base of the Coker Formation of the Tuscaloosa aquifer system.

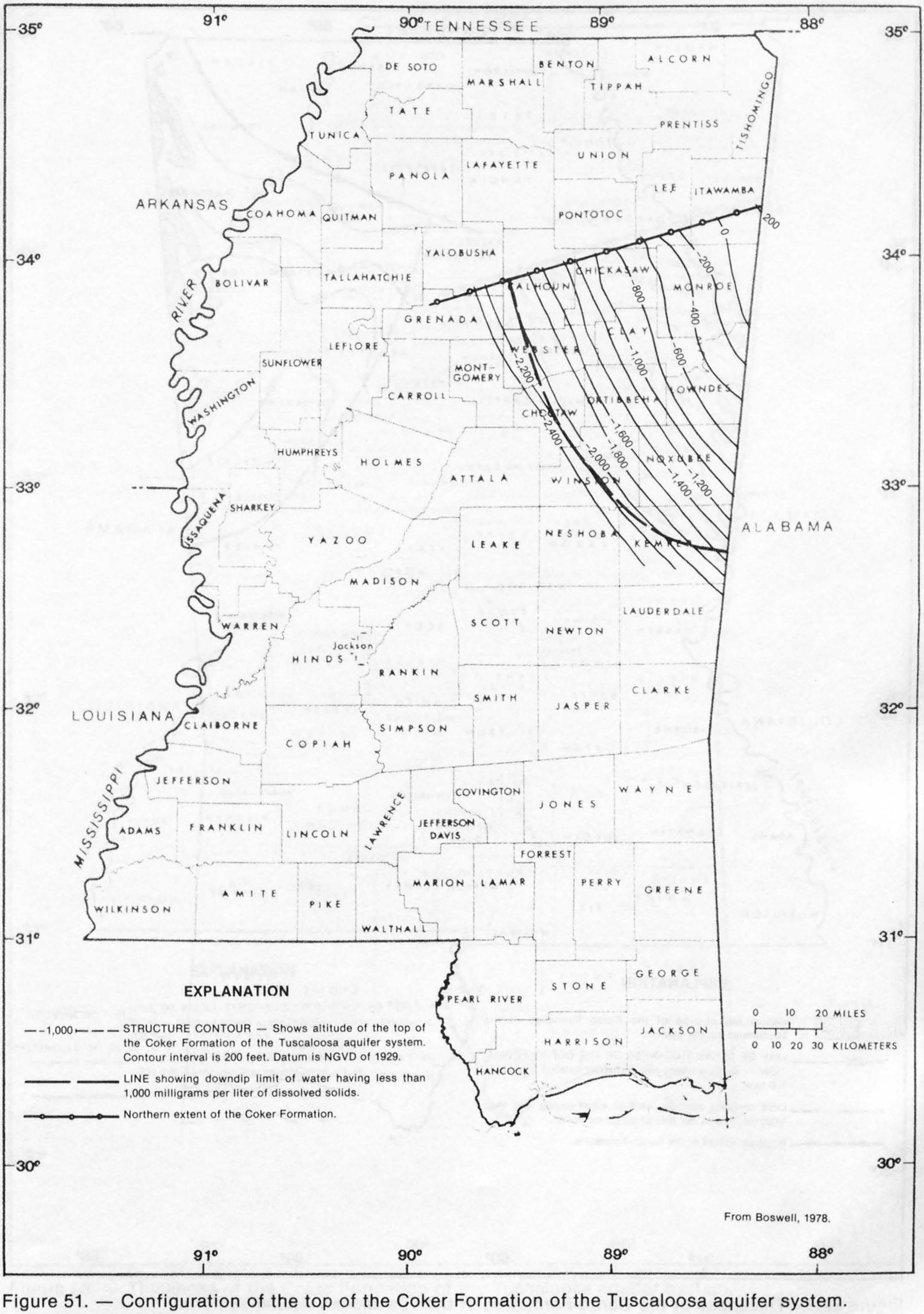

Figure 51. — Configuration of the top of the Coker Formation of the Tuscaloosa aquifer system.

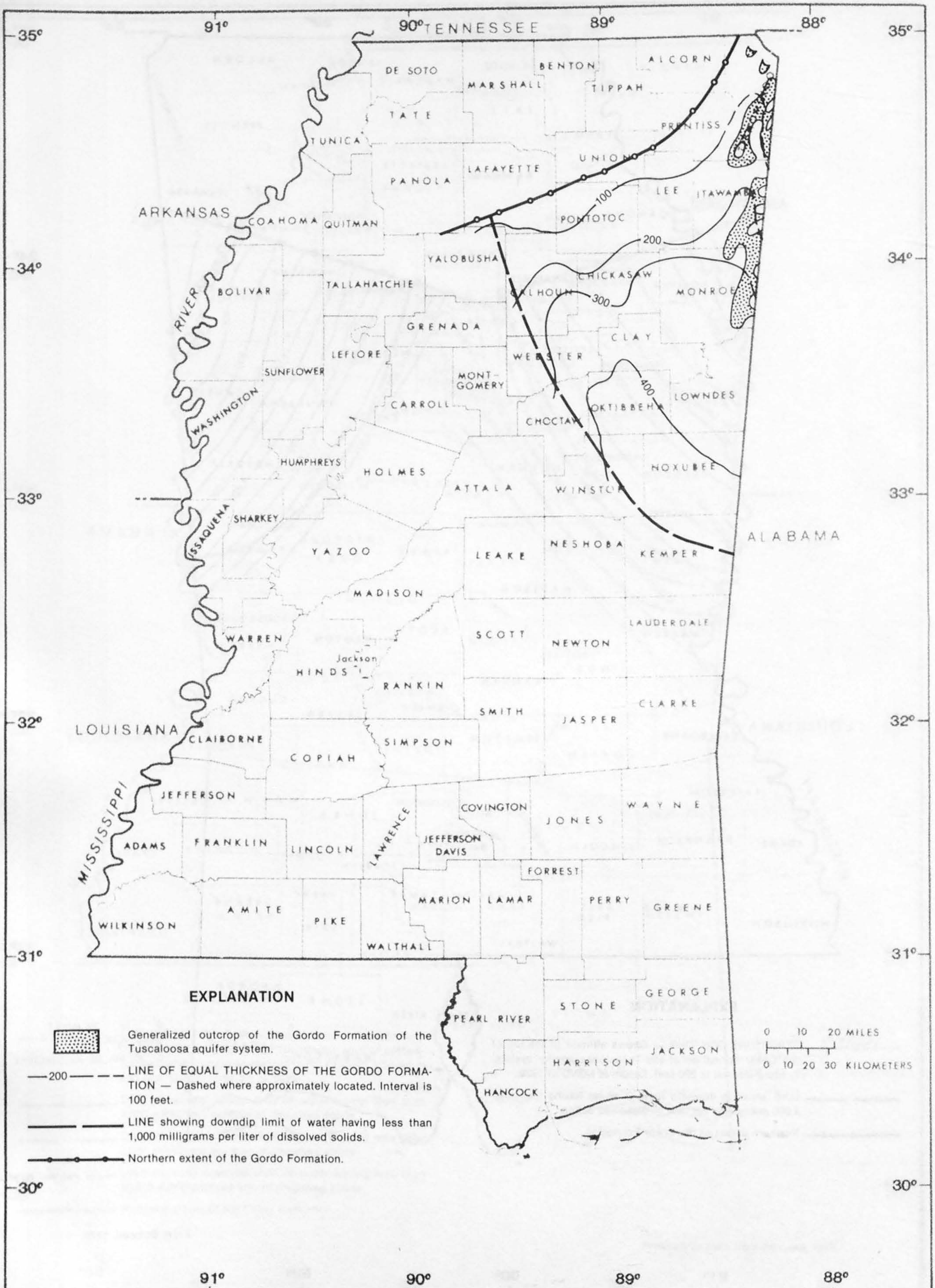

Figure 52. — Thickness of the Gordo Formation of the Tuscaloosa aquifer system.

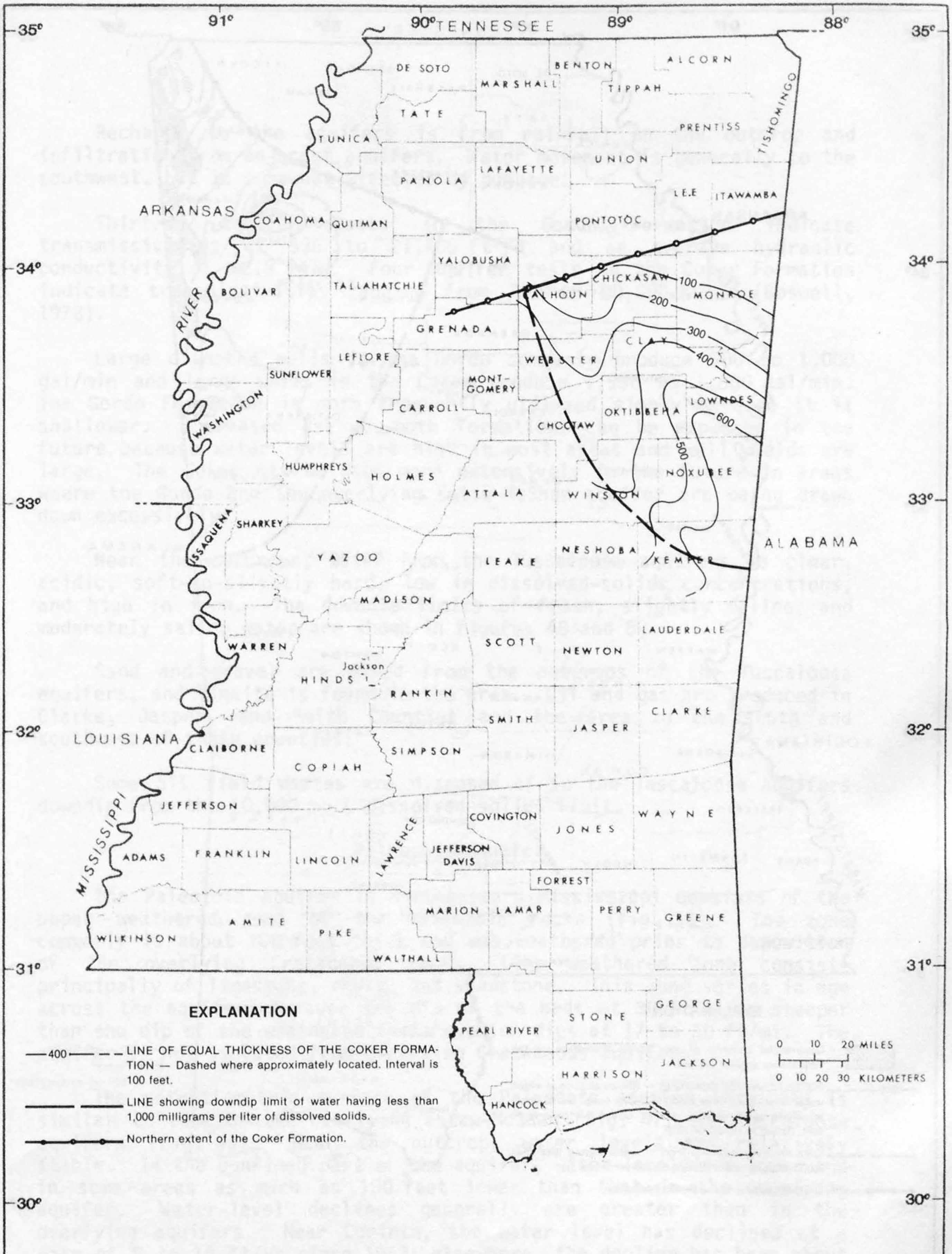

Figure 53. — Thickness of the Coker Formation of the Tuscaloosa aquifer system.

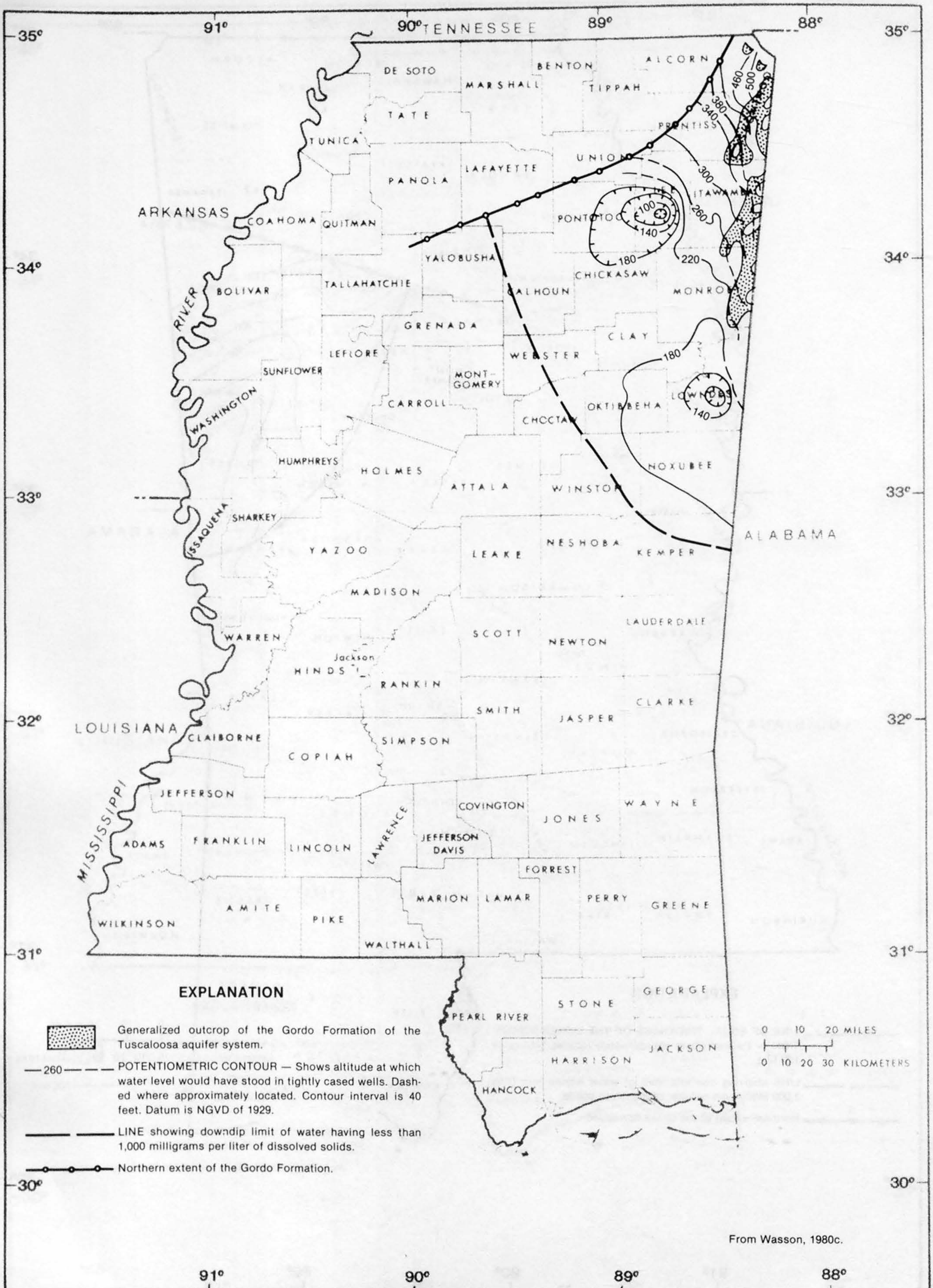

Figure 54. — Potentiometric surface of the Gordo Formation of the Tuscaloosa aquifer system.

Recharge to the aquifers is from rainfall on the outcrop and infiltration from adjacent aquifers. Water movement is generally to the southwest, but is somewhat affected by pumpage.

Thirteen aquifer tests in the Gordo Formation indicate transmissivities of 535 to 21,400 ft^2/d and an average hydraulic conductivity of 42.8 ft/d. Four aquifer tests in the Coker Formation indicate transmissivities ranging from 762 to 80,200 ft^2/d (Boswell, 1978).

Large diameter wells in the Gordo commonly produce 500 to 1,000 gal/min and large wells in the Coker produce 1,500 to 1,800 gal/min. The Gordo Formation is more frequently utilized simply because it is shallower. Increased use of both formations can be expected in the future because water levels are high in most areas and well yields are large. The Coker may be used more extensively in the future in areas where the Gordo and the overlying Eutaw-McShan aquifer are being drawn down excessively.

Near the outcrops, water from the Tuscaloosa aquifers is clear, acidic, soft-to-slightly hard, low in dissolved-solids concentrations, and high in iron. The downdip limits of fresh, slightly saline, and moderately saline water are shown in figures 48 and 50.

Sand and gravel are mined from the outcrops of the Tuscaloosa aquifers, and lignite is found in the area. Oil and gas are produced in Clarke, Jasper, and Smith Counties and the area to the south and southwest of these counties.

Some oil field wastes are disposed of in the Tuscaloosa aquifers downdip from the 10,000 mg/L dissolved-solids limit.

Paleozoic Aquifer

The Paleozoic aquifer in northeastern Mississippi consists of the upper weathered zone of the Paleozoic rocks (fig. 55). The zone commonly is about 100 feet thick and was weathered prior to deposition of the overlying Cretaceous rocks. The weathered zone consists principally of limestone, chert, and sandstone. This zone varies in age across the aquifer, because the dip of the beds at 30 ft/mi is steeper than the dip of the weathered surface which dips at 17 to 30 ft/mi. The aquifer is not isolated from overlying Cretaceous aquifers.

The potentiometric surface of the Paleozoic aquifer (fig. 56) is similar to that of the overlying Eutaw-McShan (fig. 47) and Tuscaloosa aquifers (fig. 54). Near the outcrop, water levels are relatively stable. In the confined part of the aquifer, water-levels are lower and in some areas as much as 100 feet lower than that in the overlying aquifer. Water-level declines generally are greater than in the overlying aquifers. Near Corinth, the water level has declined at a rate of 9 to 15 ft/yr since 1962; elsewhere, the decline has been about 1 ft/yr. At current rates of withdrawal, it has been predicted by Wasson and Tharpe (1975) that water levels in the Corinth area will be drawn down to the top of the aquifer by 1987.

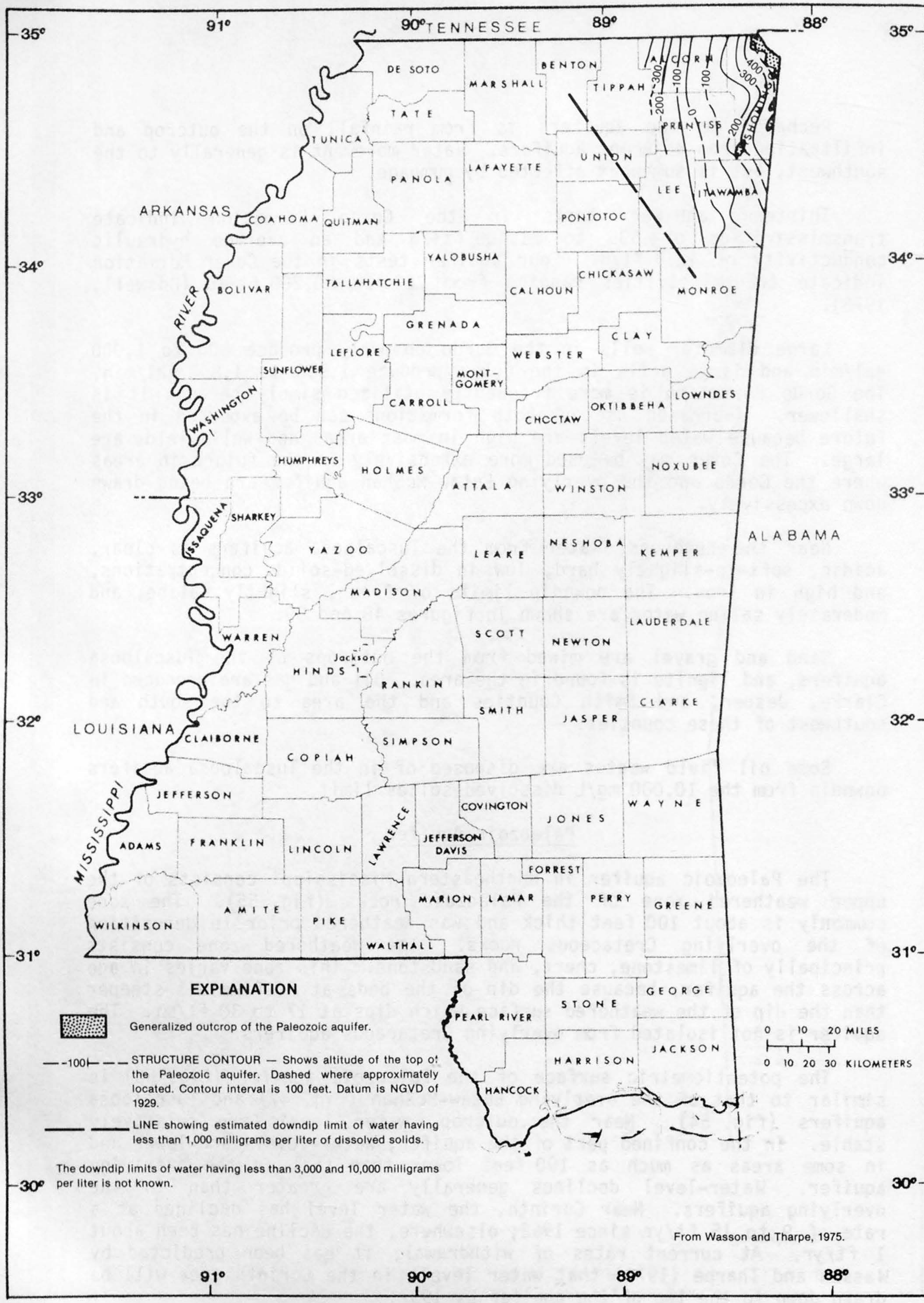

Figure 55. — Configuration of the top of the Paleozoic aquifer.

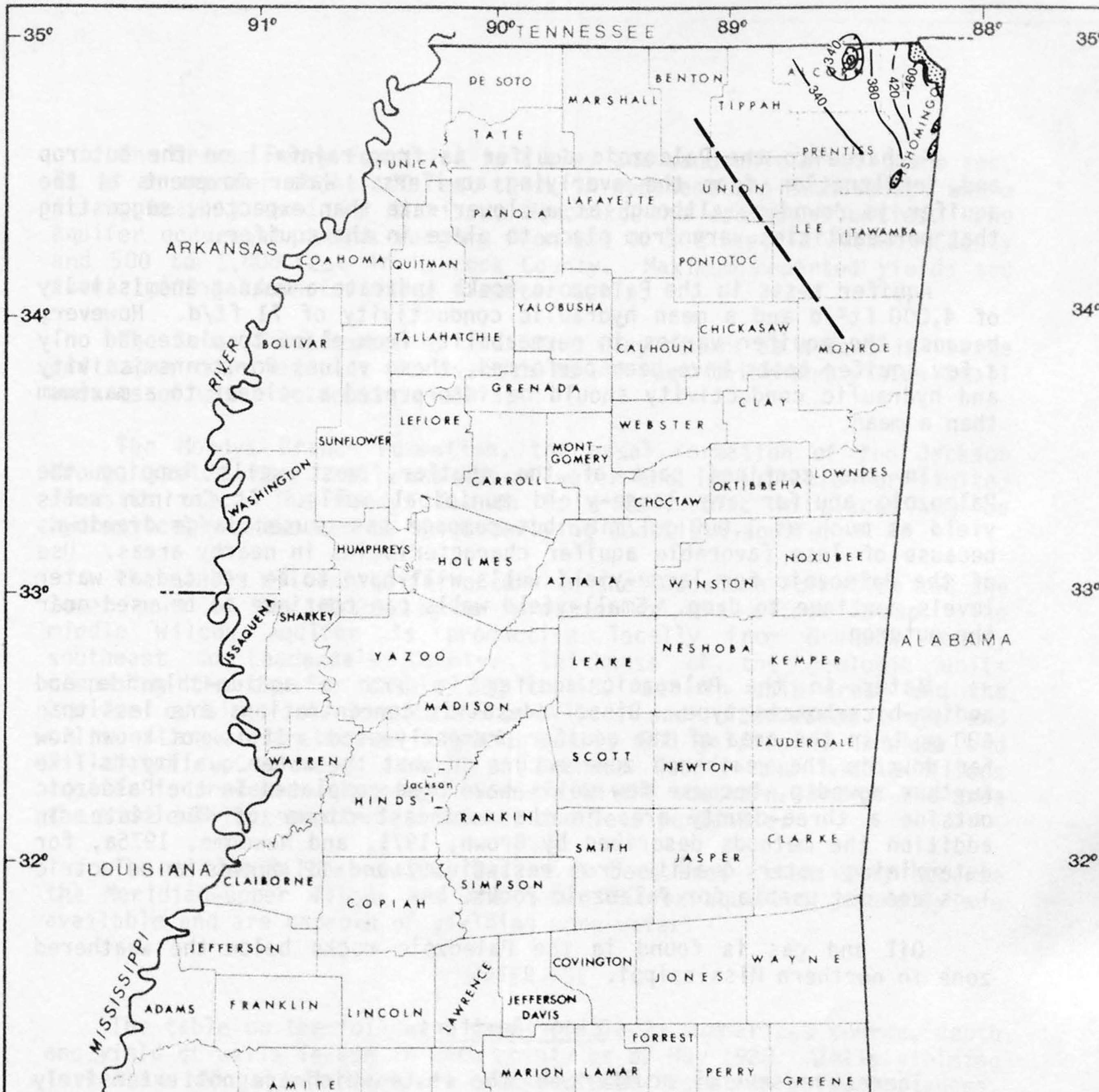

Figure 56. — Potentiometric surface of the Paleozoic aquifer.

Recharge to the Paleozoic aquifer is from rainfall on the outcrop and infiltration from the overlying aquifers. Water movement in the aquifer is downdip, although at a slower rate than expected, suggesting that permeablities vary from place to place in the aquifer.

Aquifer tests in the Paleozoic rocks indicate a mean transmissivity of 4,000 ft^2/d and a mean hydraulic conductivity of 71 ft/d. However, because the aquifer varies in permeability from place to place and only a few aquifer tests have been performed, these values for transmissivity and hydraulic conductivity should be interpreted as closer to a maximum than a mean.

In the confined part of the aquifer, most wells tapping the Paleozoic aquifer are large-yield municipal wells. At Corinth wells yield as much as 1,000 gal/min, but pumpage has caused large drawdowns because of less favorable aquifer characteristics in nearby areas. Use of the Paleozoic for large-yield wells will have to be reduced as water levels continue to drop. Small-yield wells can continue to be used near the outcrop.

Water in the Paleozoic aquifer is both a sodium-chloride and sodium-bicarbonate type. Dissolved-solids concentrations are less than 400 mg/L in the area of the aquifer presently used. It is not known how far downdip the weathered zone occurs or what the water quality is like further downdip, because few wells have been completed in the Paleozoic outside a three-county area in the northeast corner of the state. In addition the methods described by Brown, 1971, and Newcome, 1975a, for determining water quality from resistivity and SP curves on electric logs are not usable for Paleozoic rocks.

Oil and gas is found in the Paleozoic rocks below the weathered zone in northern Mississippi.

Minor Aquifers

There are several aquifers in the state which are not extensively used nor widespread in occurrence. They are important to their users however and should be protected from injection. Because they are shallower than the deepest freshwater, they will be protected by the fact that the deeper aquifers underlying them are protected in accordance with the minimum depths for protection that will be established by EPA.

Alluvial deposits along the major rivers in Mississippi are used in places for small-yield wells. The deposits consist of layers of clay, sand, and gravel. Water quality is often poor in these aquifers where chemically and biologically polluted streams recharge the aquifer and the water has not traveled far enough to have had the impurities filtered or adsorbed.

Coastal terrace deposits and river terraces, consisting of clay, sand, and gravel, yield small amounts of water. Along the coast the shallow aquifers may be contaminated by seawater and thus may not be suitable for drinking water.

The Graham Ferry Formation is a clay and sand unit of Pliocene age. It is an aquifer about 100 feet thick in southeastern Mississippi where it is heavily used in Harrison, Hancock, and Jackson Counties. The aquifer occurs at depths ranging from 100 to 500 feet in Jackson County and 500 to 1,000 feet in Hancock County. Maximum reported yields are about 1,000 gal/min for large diameter wells.

The Cocoa Sand Member of the Yazoo Clay occurs as a lens in Clarke and Wayne Counties. It is as much as 40 feet thick and yields small amounts of water to domestic wells.

The Moodys Branch Formation, the basal formation of the Jackson Group, yields very small amounts of water and is suitable for limited domestic use. The Moodys Branch is a marl that in places may be hydraulically connected to the underlying Cockfield aquifer.

The middle Wilcox aquifer occurs in the Tuscahoma Formation and the lower part of the Hatchetigbee Formation of the Wilcox Group. The middle Wilcox aquifer is productive locally from Grenada County southeast to Lauderdale County. Thickness of the geologic units composing the aquifer totals 300 to 400 feet in this area, and the aquifer consists of lenticular sand beds and interbedded clays and silts. Large diameter wells yield nearly 600 gal/min in Grenada and Tallahatchie Counties. North of Grenada County the middle Wilcox aquifer is predominately clay. Downdip in the southern part of the area the middle Wilcox aquifer is thinner and less permeable.

The middle Wilcox aquifer has never been used extensively because the Meridian-upper Wilcox and the lower Wilcox aquifers generally are available and are capable of yielding more water.

WATER USE

The table on the following pages (table 2) summarizes source, depth and yield of wells in use in each county as of May 1980. Wells yielding less than 100 gal/min have not been included except in a few instances. More detailed information concerning specific wells is available from files of the U.S. Geological Survey, and in Wasson, 1980e, but was not included here because of the space that would be necessary to describe the large number of wells involved.

Table 2.--Summary by county of large water wells in use in Mississippi, 1980.

Aquifer	Number of wells	Range in depth (feet)	Range in yield (gallons per minute)
ADAMS COUNTY			
Mississippi River valley	18	184-242	2000
Miocene	20	155-888	295-2500
ALCORN COUNTY			
Coffee	4	546-870	250-267
Eutaw-McShan	2	370-420	150
Paleozoic	17	445-656	105-1000
AMITE COUNTY			
Miocene	7	163-620	100-835
ATTALA COUNTY			
Winona-Tallahatta	2	204-210	120
Meridian-upper Wilcox	11	309-622	150-1000
Middle Wilcox	4	520-1258	150-300
Lower Wilcox	2	760-951	150
BENTON COUNTY			
Meridian-upper Wilcox	2	114-119	100-140
Ripley	4	560-920	150-300
BOLIVAR COUNTY			
Cockfield	10	230-490	150-500
Sparta	21	282-847	222-1900
Winona-Tallahatta	6	1214-1294	100-500
Meridian-upper Wilcox	8	1493-1635	150-750
CALHOUN COUNTY			
Lower Wilcox	2	270-286	50
Eutaw-McShan	3	1721-1775	105-700
Gordo	13	1522-2200	100-500
Coker	3	1911-2384	160-200
Paleozoic	1	1850	350
CARROLL COUNTY			
Meridian-upper Wilcox	7	420-1030	100-500
Middle Wilcox	4	529-849	157-503
CHICKASAW COUNTY			
Ripley	2	300-320	75-125
Eutaw-McShan	12	507-1510	100-600
CHOCTAW COUNTY			
Meridian-upper Wilcox	5	100-150	146-400
Lower Wilcox	9	386-762	150-260
CLAIBORNE COUNTY			
Mississippi River valley	3	110	100+
Miocene	17	152-692	100-600
CLARKE COUNTY			
Cockfield	9	120-378	55-80
Sparta	15	169-597	106-608
Winona-Tallahatta	1	918	100
Meridian-Upper Wilcox	4	250-424	155-292
Lower Wilcox	9	1242-2368	250-1655

Table 2.--Summary by county of large water wells in use in Mississippi, 1980.--Continued

Aquifer	Number of wells	Range in depth (feet)	Range in yield (gallons per minute)
CLAY COUNTY			
Eutaw-McShan	18	341-1053	100-472
Gordo	6	760-1692	100-1400
COAHOMOA COUNTY			
Mississippi River valley	14	88-180	200-3334
Sparta	20	283-815	200-3298
Winona-Tallahatta	1	1236	150
Meridian-Upper Wilcox	21	1063-1440	100-503
Lower Wilcox	1	1853	260
COPIAH COUNTY			
Citronelle	22	60-160	100-628
Miocene	37	111-919	100-602
Oligocene	1	761	100
COVINGTON COUNTY			
Miocene	28	164-964	100-1000
DE SOTO COUNTY			
Mississippi River valley	1	105	120
Sparta	50	220-478	150-1600
Winona-Tallahatta	4	340-476	348-1700
Meridian-upper Wilcox	1	410	1250
Lower Wilcox	4	1397-1580	111-1250
FORREST COUNTY			
Miocene	66	100-900	100-1387
FRANKLIN COUNTY			
Miocene	11	202-345	100-500
GEORGE COUNTY			
Miocene	8	130-1044	195-500
GREENE COUNTY			
Miocene	14	125-994	100-350
GRENADA COUNTY			
Meridian-upper Wilcox	17	167-509	100-2800
Middle Wilcox	13	435-765	100-578
Lower Wilcox	5	500-655	150-400
HANCOCK COUNTY			
Graham Ferry	8	520-1000	150-750
Miocene	13	465-2003	100-1787
HARRISON COUNTY			
Graham Ferry	53	250-1002	100-1016
Miocene	84	528-1760	100-2009

Table 2.--Summary by county of large water wells in use in Mississippi, 1980.--Continued

Aquifer	Number of wells	Range in depth (feet)	Range in yield (gallons per minute)
HINDS COUNTY			
Miocene	3	298-480	175-180
Oligocene	8	421-550	150-500
Cockfield	28	525-1280	100-578
Sparta	59	616-1411	100-1000
HOLMES COUNTY			
Mississippi River valley	1	108	3000
Winona-Tallahatta	2	826-1310	75-145
Meridian-upper Wilcox	24	658-1805	100-1000
Lower Wilcox	1	1339	100
HUMPHREYS COUNTY			
Mississippi River valley	17	98-133	125-3000
Cockfield	1	360	100
Sparta	9	765-1100	250-1100
ISSAQUENA COUNTY			
Sparta	1	902	200
ITAWAMBA COUNTY			
Eutaw-McShan	3	262-350	137-222
Gordo	12	155-355	116-400
JACKSON COUNTY			
Citronelle	1	759	100
Graham Ferry	35	130-578	100-674
Miocene	68	156-1205	100-1750
JASPER COUNTY			
Cockfield	8	304-913	200-369
Sparta	12	437-1034	167-1005
Meridian-upper Wilcox	1	1202	200
Middle Wilcox	2	878-886	200
Lower Wilcox	1	1890	400
JEFFERSON COUNTY			
Miocene	5	263-540	125-425
JEFFERSON DAVIS COUNTY			
Miocene	14	217-450	150-500
JONES COUNTY			
Miocene	87	84-813	100-1600
Oligocene	3	130-498	110-150
Cockfield	6	600-1236	100-495
Sparta	1	640	175
Meridian-upper Wilcox	1	3001	300
KEMPER COUNTY			
Lower Wilcox	4	178-601	148-290
Eutaw-McShan	2	1218-1348	115-185
Coker	3	2210-2369	150-287
LAFAYETTE COUNTY			
Meridian-upper Wilcox	25	91-366	100-1000
Lower Wilcox	8	230-596	100-1000
Gordo	2	330-430	130-178

Table 2.--Summary by county of large water wells in use in Mississippi, 1980.--Continued

Aquifer	Number of wells	Range in depth (feet)	Range in yield (gallons per minute)
LAMAR COUNTY			
Citronelle	1	200	171
Miocene	32	165-975	150-2000
LAUDERDALE COUNTY			
Middle Wilcox	5	258-408	100-300
Lower Wilcox	32	168-1195	110-1007
LAWRENCE COUNTY			
Citronelle	2	207-214	326-350
Miocene	13	208-917	100-500
LEAKE COUNTY			
Sparta	4	246-510	100-310
Meridian-upper Wilcox	5	611-776	136-750
Middle Wilcox	1	849	157
Lower Wilcox	3	1272-1659	300-847
LEE COUNTY			
Coffee	1	580	250
Eutaw-McShan	41	282-655	100-585
Gordo	15	535-729	200-726
LEFLORE COUNTY			
Mississippi River valley	18	90-187	1300-2675
Sparta	1	252	600
Winona-Tallahatta	1	811	300
Meridian-upper Wilcox	21	640-1200	100-1900
LINCOLN COUNTY			
Citronelle	5	160-185	120-440
Miocene	9	168-1200	224-500
LOWNDES COUNTY			
Gordo	25	323-1255	110-700
Coker	8	895-1300	1455-1865
MADISON COUNTY			
Cockfield	10	564-720	150-650
Sparta	20	594-1404	100-1100
Meridian-upper Wilcox	1	1500	102
MARION COUNTY			
Miocene	29	103-960	100-1000
MARSHALL COUNTY			
Meridian-upper Wilcox	6	338-371	108-900
Ripley	3	729-1640	200-450
MONROE COUNTY			
Eutaw-McShan	24	124-511	110-800
Gordo	21	198-444	125-1600
MONTGOMERY COUNTY			
Meridian-upper Wilcox	5	288-480	162-500
Middle Wilcox	4	486-617	105-200
Lower Wilcox	1	580	125

Table 2.--Summary by county of large water wells in use in Mississippi, 1980.--Continued

Aquifer	Number of wells	Range in depth (feet)	Range in yield (gallons per minute)
NESHOBA COUNTY			
Meridian-upper Wilcox	2	160-381	100-228
Middle Wilcox	1	727	185
Lower Wilcox	18	560-1200	120-750
NEWTON COUNTY			
Sparta	4	311-496	168-510
Meridian-upper Wilcox	8	242-639	115-520
Lower Wilcox	2	965	150-174
NOXUBEE COUNTY			
Eutaw-McShan	2	942-1884	200-204
Gordo	2	1533-1540	247
Coker	4	1815-1857	150-1200
OKTIBBEHA COUNTY			
Gordo	34	862-4306	100-1064
PANOLA COUNTY			
Mississippi River valley	3	105-110	100-2000
Sparta	8	154-240	150-1000
Winona-Tallahatta	3	240-340	130-230
Meridian-upper Wilcox	4	420-522	165-650
Middle Wilcox	3	823-966	160-200
Lower Wilcox	9	1034-1500	150-750
PEARL RIVER COUNTY			
Miocene	18	250-1350	125-1175
PERRY COUNTY			
Miocene	17	77-1192	100-500
PIKE COUNTY			
Citronelle	9	100-215	100-296
Miocene	26	170-1363	153-1800
PONTOTOC COUNTY			
Ripley	2	208-440	150-267
Eutaw-McShan	11	775-1383	162-500
Gordo	8	1160-1575	100-533
PRENTISS COUNTY			
Eutaw McShan	9	207-514	100-362
Gordo	8	279-620	197-1000
QUITMAN COUNTY			
Winona-Tallahatta	1	655	150
Meridian-upper Wilcox	3	869-887	430-500
Lower Wilcox	8	1405-1524	150-500
RANKIN COUNTY			
Miocene	6	218-341	100-150
Oligocene	1	492	112
Cockfield	52	116-1097	100-950
Sparta	47	638-1806	100-800

Table 2.--Summary by county of large water wells in use in Mississippi, 1980.--Continued

Aquifer	Number of wells	Range in depth (feet)	Range in yield (gallons per minute)
SCOTT COUNTY			
Cockfield	4	280-534	182-400
Sparta	9	596-1322	100-700
Meridian-upper Wilcox	18	552-1681	120-750
SHARKEY COUNTY			
Mississippi River valley	1	103	300
Sparta	4	311-1197	100-500
SIMPSON COUNTY			
Citronelle	7	96-204	110-500
Miocene	15	256-629	120-400
Cockfield	2	1111-1139	150-250
Sparta	1	1620	300
SMITH COUNTY			
Miocene	9	240-408	120-517
Oligocene	1	424	175
Cockfield	5	430-1100	100-240
Sparta	9	870-1520	200-250
STONE COUNTY			
Miocene	9	325-1320	195-1000
SUNFLOWER COUNTY			
Sparta	3	673-735	176-300
Winona-Tallahatta	1	1600	360
Meridian-upper Wilcox	21	1097-1772	100-790

Aquifer	Number of wells	Range in depth (feet)	Range in yield (gallons per minute)
TALLAHATCHIE COUNTY			
Mississippi River valley	5	93-105	2000
Winona-Tallahatta	4	802-875	200-325
Meridian-upper Wilcox	8	490-1004	100-403
Middle Wilcox	2	1005-1026	300-500
Lower Wilcox	3	1070-1312	110-500
TATE COUNTY			
Sparta	5	158-316	150-350
Meridian-upper Wilcox	1	900	200
Lower Wilcox	7	1070-1695	120-1000
TIPPAH COUNTY			
Ripley	3	147-265	120-300
Coffee	16	765-1306	100-560
Eutaw-McShan	2	244-720	90-150
TISHOMINGO COUNTY			
Gordo	5	120-185	100-102
Paleozoic	6	133-400	150-750
TUNICA COUNTY			
Meridian-upper Wilcox	1	1004	400
Lower Wilcox	7	1646-1800	100-700

Table 2.--Summary by county of large water wells in use in Mississippi, 1980.--Continued

Aquifer	Number of wells	Range in depth (feet)	Range in yield (gallons per minute)
UNION COUNTY			
Ripley	3	340-431	100-150
Coffee	8	512-855	100-290
Eutaw-McShan	8	720-1147	150-545
WALTHALL COUNTY			
Miocene	13	228-566	100-700
WARREN COUNTY			
Mississippi River valley	18	82-181	130-2000
Oligocene	8	127-460	150-500
Cockfield	1	857	250
WASHINGTON COUNTY			
Mississippi River valley	3	98-110	250-800
Cockfield	50	396-666	100-1560
Sparta	4	963-1164	130-400
Meridian-upper Wilcox	3	1690-1790	500-800
WAYNE COUNTY			
Miocene	7	122-631	204-350
Oligocene	5	118-138	250-385
Cockfield	2	220-574	150-200

Aquifer	Number of wells	Range in depth (feet)	Range in yield (gallons per minute)
WEBSTER COUNTY			
Lower Wilcox	6	171-359	100-400
Gordo	5	1870-2410	125-200
Coker	2	1698-2233	100-317
WILKINSON COUNTY			
Citronelle	2	130-208	165-554
Miocene	9	146-1600	100-600
WINSTON COUNTY			
Middle Wilcox	7	200-610	111-300
Lower Wilcox	21	151-530	110-893
YALOBUSHA COUNTY			
Meridian-upper Wilcox	9	68-470	100-1250
Middle Wilcox	2	? - 380	100-325
Lower Wilcox	10	250-940	100-366
YAZOO COUNTY			
Mississippi River valley	22	106-202	1000-3000
Cockfield	4	303-767	100-626
Sparta	21	901-1582	100-2000
Meridian-upper Wilcox	2	1816-1940	200-250

APPENDIX

Definitions

Aquifer: A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Aquifer system: A water-bearing unit made up of several aquifers separated by confining beds. The aquifers are interconnected in places and separated in others.

Aquifer test: A test involving the withdrawal of measured quantities of water from, or addition of water to, a well and the measurement of resulting changes in water level in the aquifer both during and after the period of discharge or addition. From the results of a test, the hydraulic characteristics of the aquifer can be calculated or estimated.

Artesian aquifer: A confined aquifer.

Brine: Water containing over 35,000 mg/L dissolved solids. The zone in which oil and gas is usually found.

Confined aquifer: An aquifer under pressure significantly greater than atmospheric, confined by overlying and underlying impermeable units. The water is under pressure and the potentiometric level is above the top of the aquifer.

Confining bed: A body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers.

Dissolved-solids concentrations: The quantity of dissolved material in a sample of water, the sum of all determined constituents.

Electric log: A geophysical log consisting of a continuous record of various electrical properties of geologic formations encountered at various depths in a well borehole. Resistivity and spontaneous potential are most frequently measured. The log is used to determine changes in composition, for correlation, and for indicating the nature and amount of fluid in the pores of the rocks.

Freshwater: Water containing less than 1,000 mg/L dissolved solids.

Geophysical logs: Logs obtained by lowering an instrument into a borehole or well and recording continuously at the surface some physical property of the rock material being logged.

Hydraulic conductivity: In a homogeneous aquifer, the volume of water that will move through a specific area in a specific period of time under a specific gradient. Homogeneity must be assumed when discussing aquifer properties. It is measured in feet per day and represents $ft^3/d/ft^2$.

Inlier: An area of outcropping rocks surrounded by outcrops of younger age.

Moderately saline water: Water containing between 3,000 and 10,000 mg/L of dissolved solids.

NGVD of 1929 (National Geodetic Vertical Datum of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level."

Permeability: The capacity of a porous rock to transmit fluid. An impermeable rock is not capable of transmitting fluid although it may contain water.

Porosity: A measure of void volume versus total volume of a rock. A rock may be porous but not permeable if the voids are not connected.

Potentiometric level or surface: The level at which water will stand in a tightly cased well.

Resistivity: Electrical resistivity is the resistance of the earth to transmission of electrical impulses. It is affected by porosity, grain size, fluid content, and water quality. For instance, a freshwater sand will have a high resistivity and a highly compacted clay will have a low resistivity.

Slightly saline water: Water containing between 1,000 and 3,000 mg/L of dissolved solids.

Specific capacity: The ratio of rate of well discharge to drawdown of the water level in the well; it is roughly proportional to transmissivity. Specific capacity is affected by the construction characteristics of the well.

Spontaneous potential (SP): A curve on an electric log representing the potential voltage caused by infiltration of drill fluid into the rock. Used to determine porosity and permeability as well as water quality.

Transmissivity: The rate at which water is transmitted through a certain width of an aquifer at a certain gradient. It is expressed in ft^2/d and represents $ft^3/d/ft$.

Unconfined aquifer: An aquifer which is exposed to the atmosphere and, thus, the water is under atmospheric pressure and the water level stands at or below the top of the aquifer.

Very saline water: Water containing between 10,000 to 35,000 mg/L of dissolved solids.

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