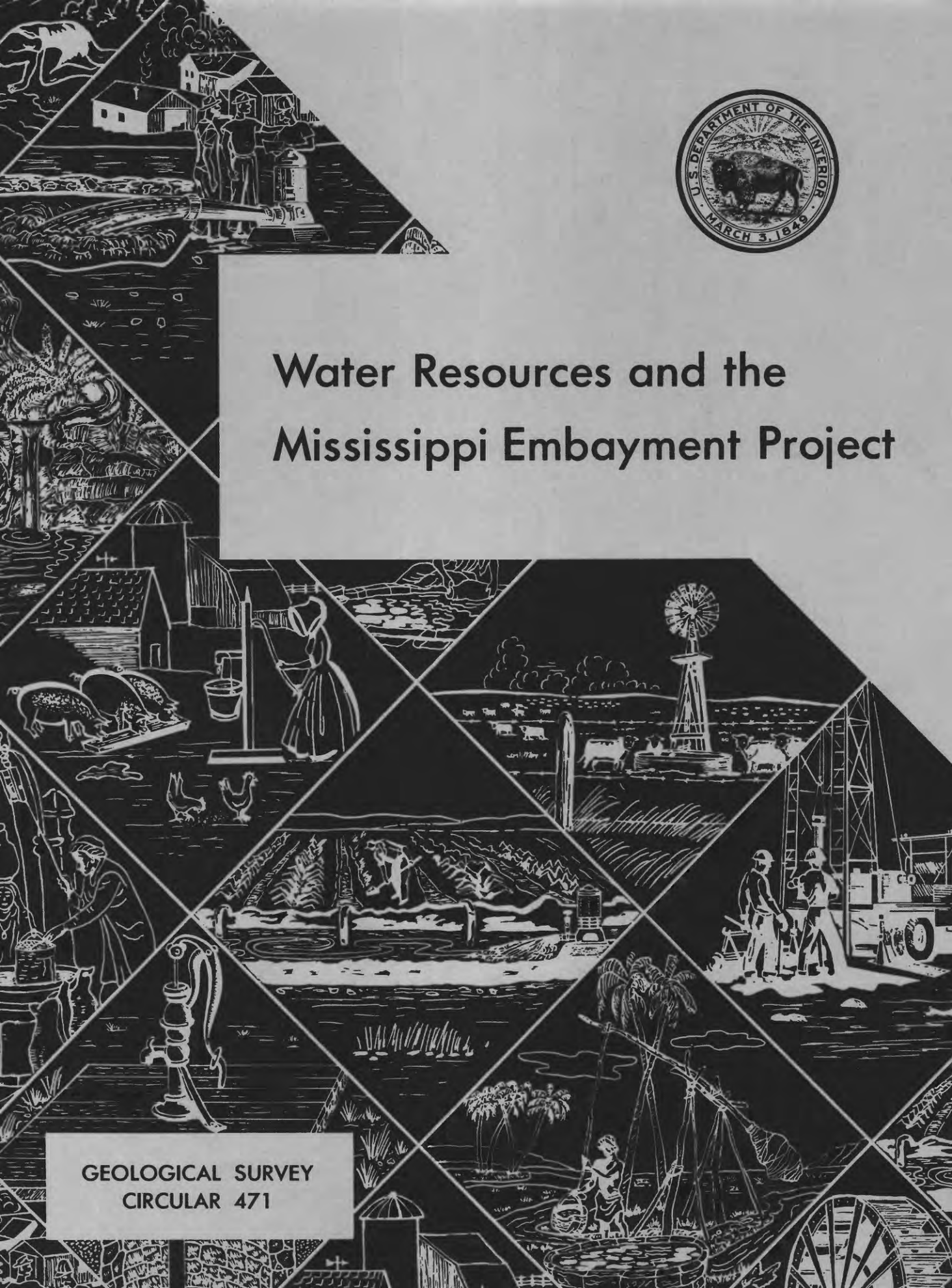

Water Resources and the Mississippi Embayment Project

GEOLOGICAL SURVEY
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Water Resources and the Mississippi Embayment Project

By E. M. Cushing

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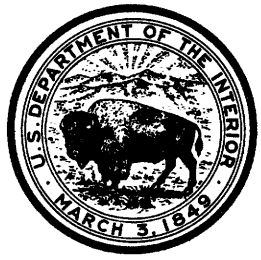

Geological Survey

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Free on application to the U.S. Geological Survey, Washington 25, D. C.

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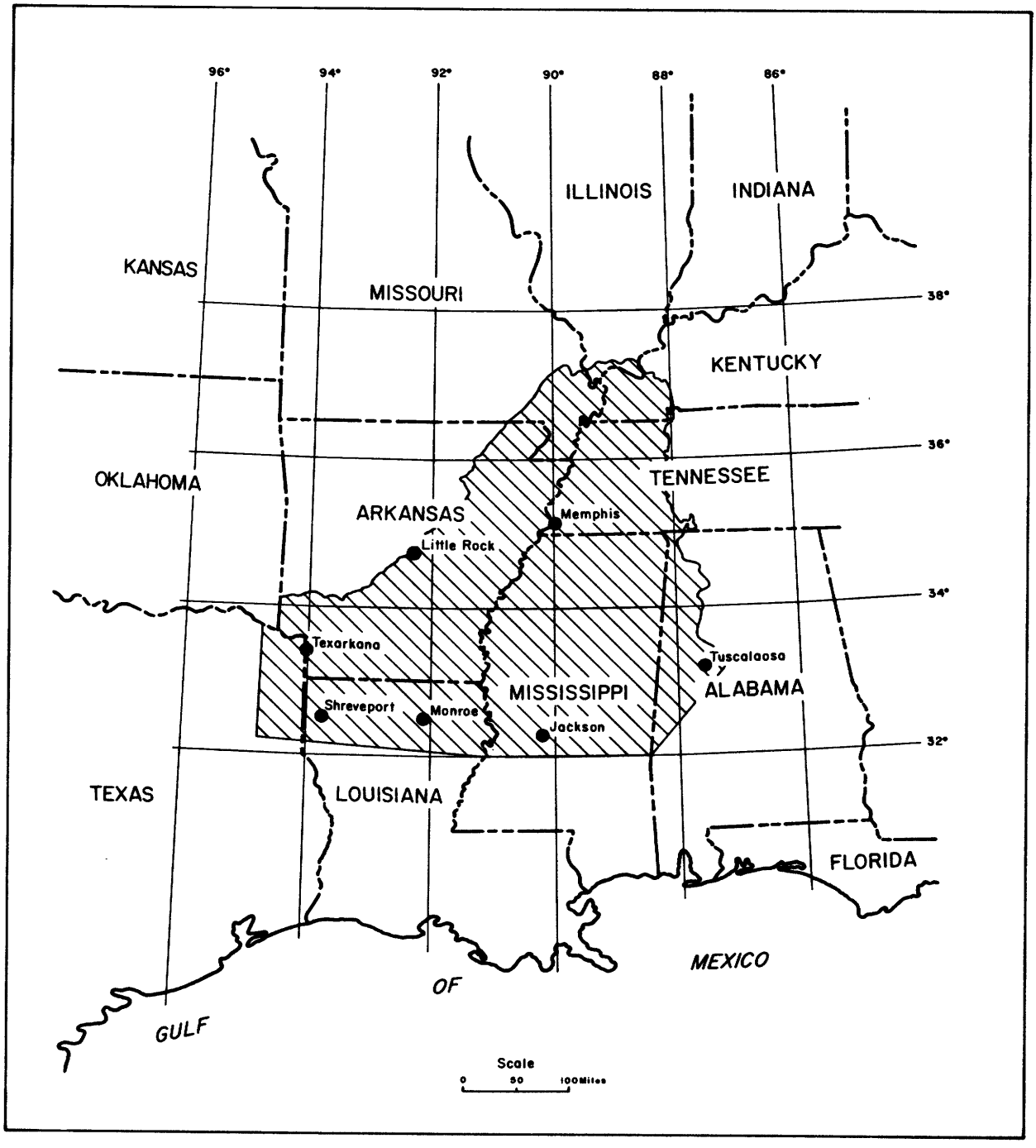

Figure 1.—Map showing area of study.

Water Resources and the Mississippi Embayment Project

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WHY APPRAISE OUR NATION'S WATER RESOURCES?

Every estimate indicates that this country's need for water in the next several decades will grow enormously. Increases in population and in the per capita use of water, in industrial expansion, and in water demands for agriculture are some of the factors that are causing the total use of water to approach or surpass the capacity of existing water-resources development. The total use is not approaching the supply available. New facilities, however, must be developed or existing ones expanded. If this development or expansion is not to be haphazard and wasteful, sound appraisals of our water resources must be available for planning purposes.

Sound appraisals consider all facets of the water resource and its potential for development. The hydrologic system must be defined, and how it operates must be determined before a wise management plan for the system can be devised.

THE MISSISSIPPI EMBAYMENT PROJECT

The Mississippi embayment (fig. 1) as defined for this project comprises about 100,000 square miles of a geologic province known as the Gulf Coastal Plain. From its apex in southern Illinois the region fans out southward to about the 32d parallel of north latitude and includes parts of nine States—Alabama, Arkansas, Illinois, Kentucky, Louisiana, Mississippi, Missouri, Tennessee, and Texas. The larger cities within the region include Tuscaloosa, Ala., Jackson, Miss., Monroe and Shreveport, La., Texarkana, Ark. and Tex., Little Rock and North Little Rock, Ark., and Memphis, Tenn.

The economy of the region is basically agricultural, but industry has become increasingly important since World War II. The diversification and mechanization of agriculture have resulted in a surplus of manpower, most of which is being absorbed by the expansion of industry. Further industrial expansion probably will occur because of available manpower, natural resources, and economical transportation. Increasing demands on available water supplies will be made, and the future economy of the embayment is largely dependent upon sound utilization and management of the region's water resources.

For several years the need for an appraisal of the water resources of the Mississippi embayment has been recognized by people associated with the development of the region. Most of the water-resources investigations in the embayment have been made in cooperation with State, county, and municipal agencies, and have been restricted to those parts of the aquifers (water-bearing units) that lie beneath the local area. Because these investigations have been local, the results have lacked the benefits that would have accrued from an understanding of the regional hydrologic system that extends over several States.

The present study, begun in August 1957, is a part of the Federal program of the U.S. Geological Survey and is aimed specifically toward appraising the water resources of the region, and determining the influence of the regional geologic structure and stratigraphy on the movement, availability, and quality of the water. Generally, more is known about the surface-water resource of the region than is known about the ground-water resource, and because of this, most of the present study

relates to the occurrence, availability, and quality of ground water.

WHAT IS THE MISSISSIPPI EMBAYMENT?

The Mississippi embayment is a syncline plunging gently to the south, the axis of which roughly follows the present course of the Mississippi River. During the geologic past the region was periodically occupied by an arm of the sea, and sediments, some more than 125 million years old, have been deposited on the Paleozoic rocks. Units ranging in age from Cretaceous to Quaternary (from 125 million years ago to the present time) crop out within the area of study (fig. 2). These units of gravel, sand, silt, clay, lignite, "marl," chalk, and limestone range in thickness from zero at the outcrop of Paleozoic rocks to several thousand feet at the axis of the syncline. In most of the region the dip of the beds generally is toward the axis of the syncline except where it is influenced locally by structural features. The dip of the beds southward, toward the Gulf, is slight in the northern part of the region, but becomes greater in the southern part.

The relative position of the sediments of Cretaceous, Tertiary, and Quaternary age that overlie the Paleozoic rocks are shown by five generalized geologic sections. (See figs. 3, 4, and 5.) These sections also show the relative thicknesses of the sediments and the progressive thickening of the sediments southward toward the Gulf.

The influence of structural features on the dip of the beds can be seen on section D-D' (fig. 4). The high near the west end of the section is caused by the Sabine uplift and the

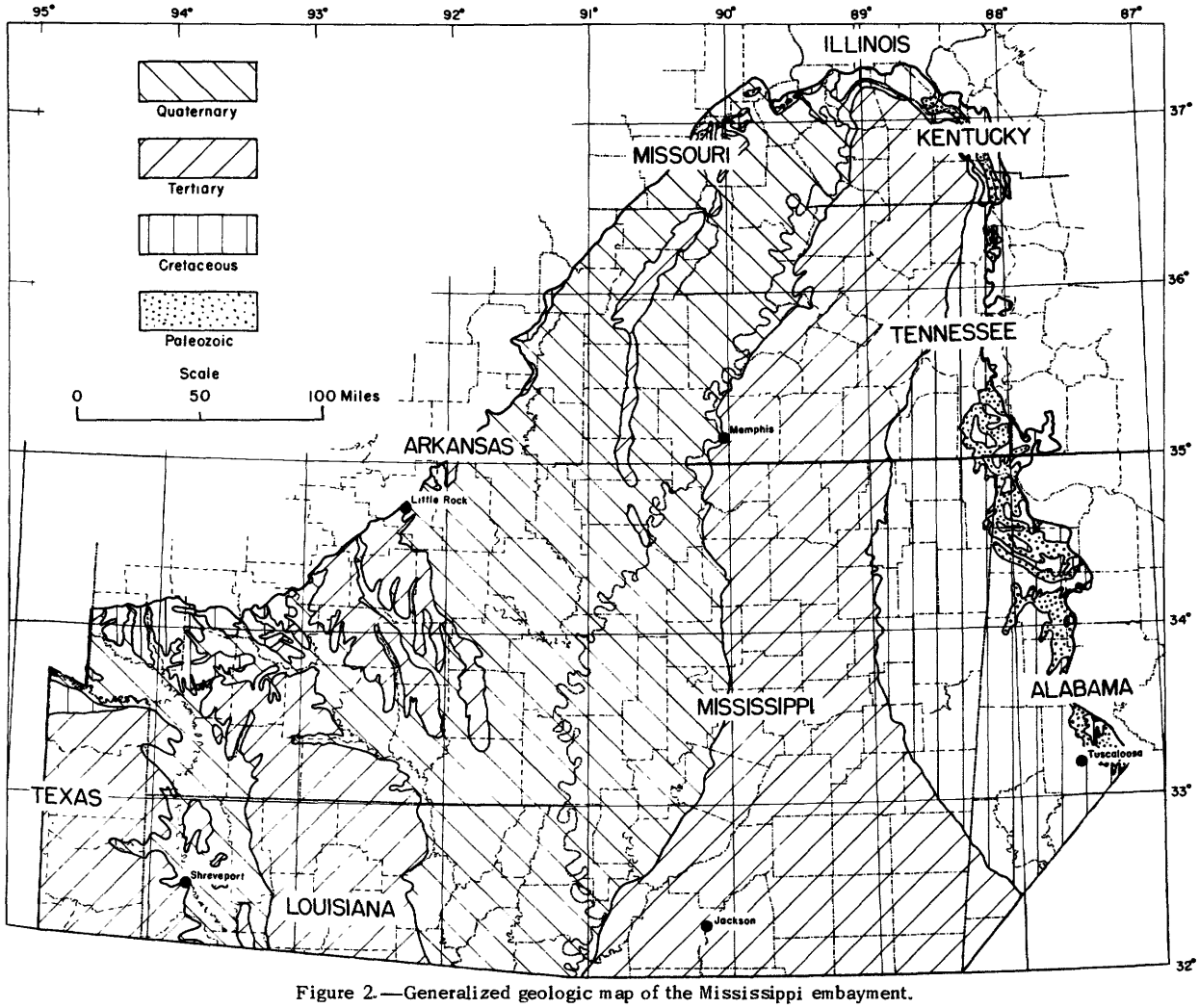

Figure 2.—Generalized geologic map of the Mississippi embayment.

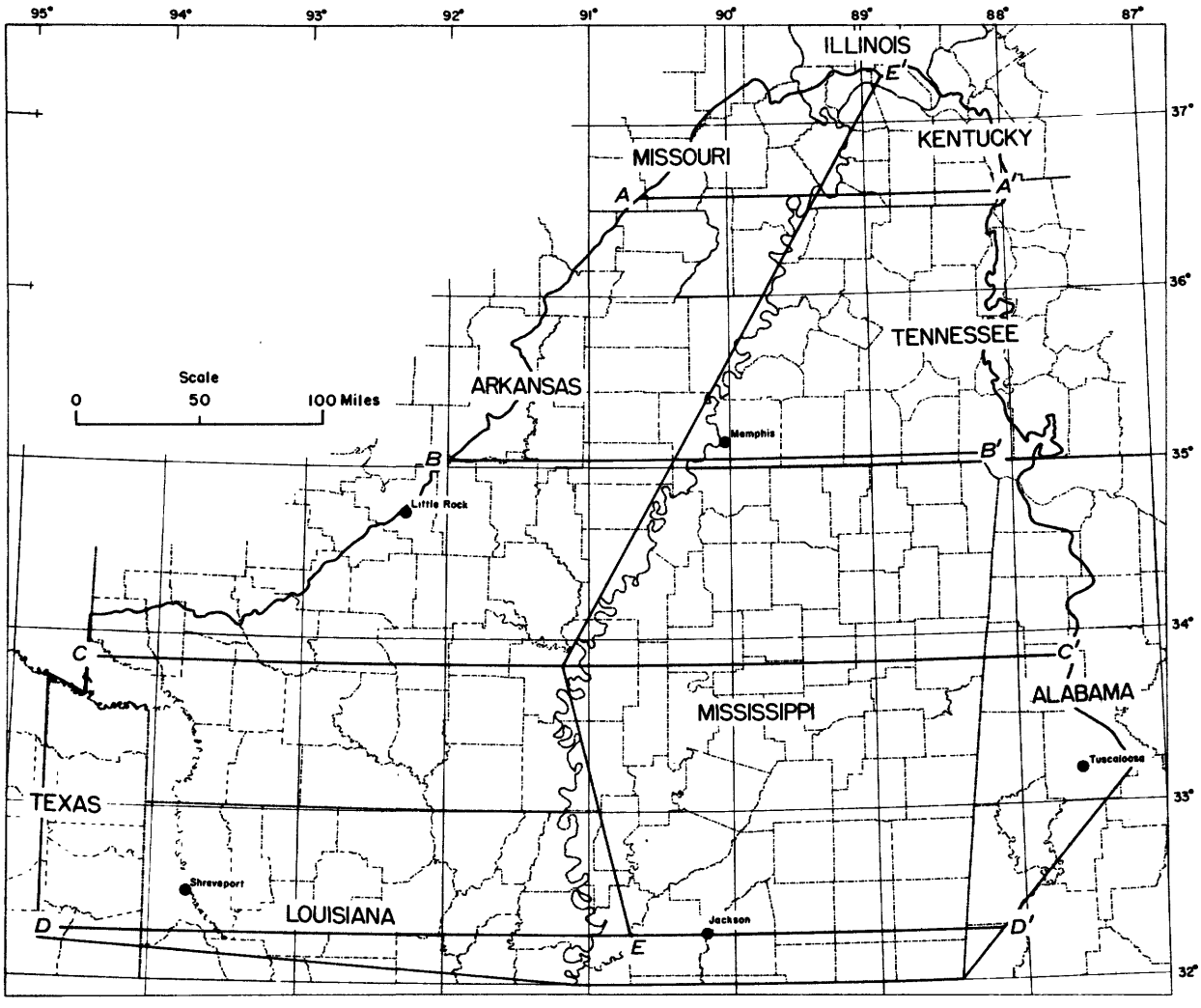

Figure 3.— Map showing location of geologic sections.

one immediately east of the axis of the syncline is caused by the Jackson dome. The high or the change in the direction of dip near the west end of section C-C' is caused primarily by the change in the direction of strike of the beds in that area.

STATUS OF THE GEOLOGIC STUDIES

One of the first phases of the embayment study, the definition of the generalized structure and stratigraphy of the region, has been completed. With the structure and stratigraphy defined, correlation of the water-bearing units can now be made, and the influence of the structure and stratigraphy on the movement, availability, and quality of the water in these units can be determined.

Correlations of the water-bearing units of Cretaceous age are well under way. Within the limits of available data, these studies will show (a) the areal extent of each aquifer, (b) thickness of the sand section and its permeability and storage coefficient, (c) piezometric surface of the water, (d) areas where flowing wells might be developed, (e) area of water use, (f) area of potential use, and (g) the change in quality and temperature of the water within the unit. Upon completing the study and report of the Cretaceous aquifers, similar studies of the Tertiary and Quaternary aquifers will be made.

WHAT ARE THE GROUND-WATER RESOURCES?

Deposition of sediments in the embayment during the geologic past was such that deposits of sand now form regional aquifers, many of which contain large quantities of fresh water available for development and use. Many of these aquifers extend across

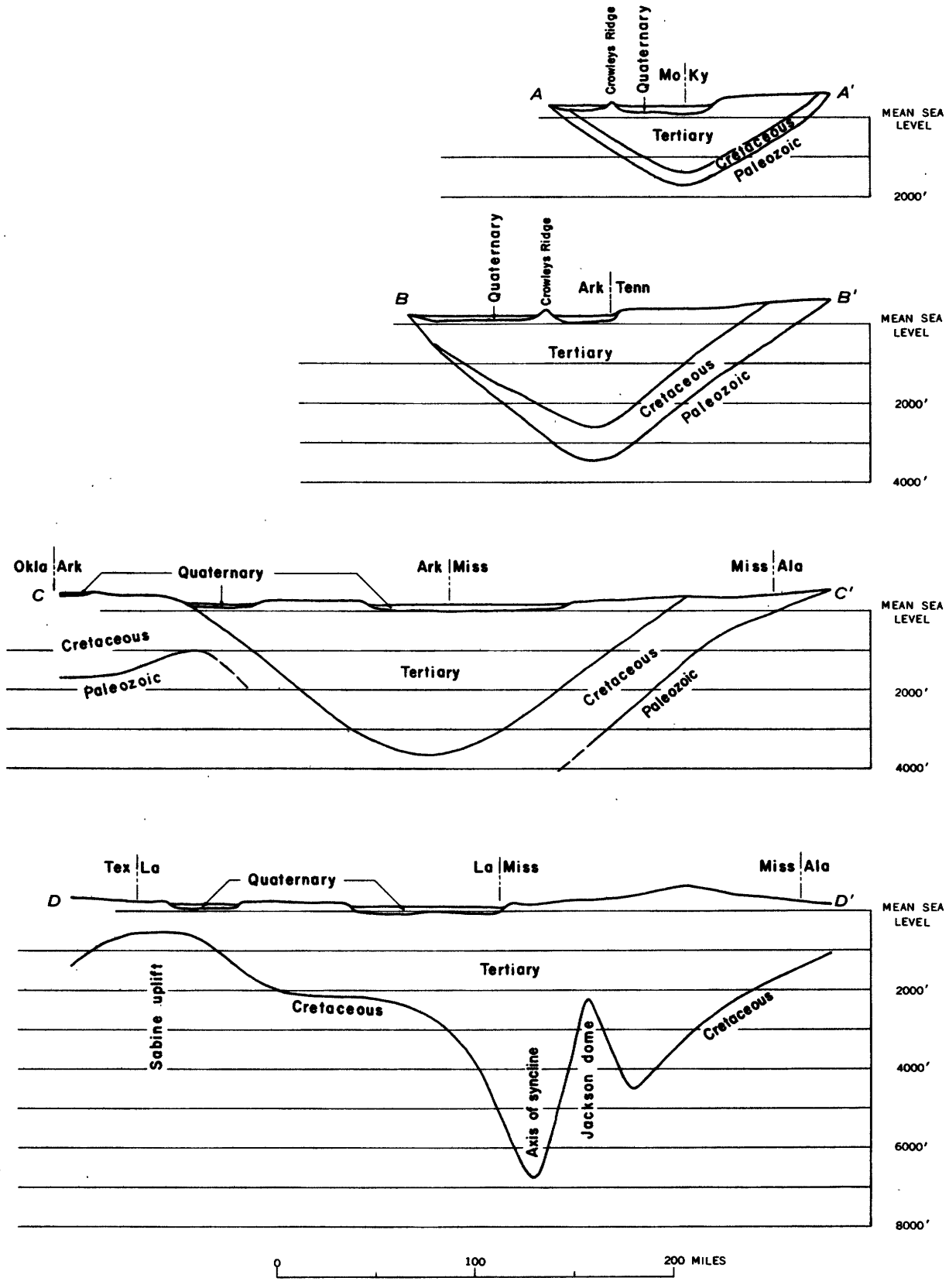

Figure 4.—Generalized east-west geologic sections.

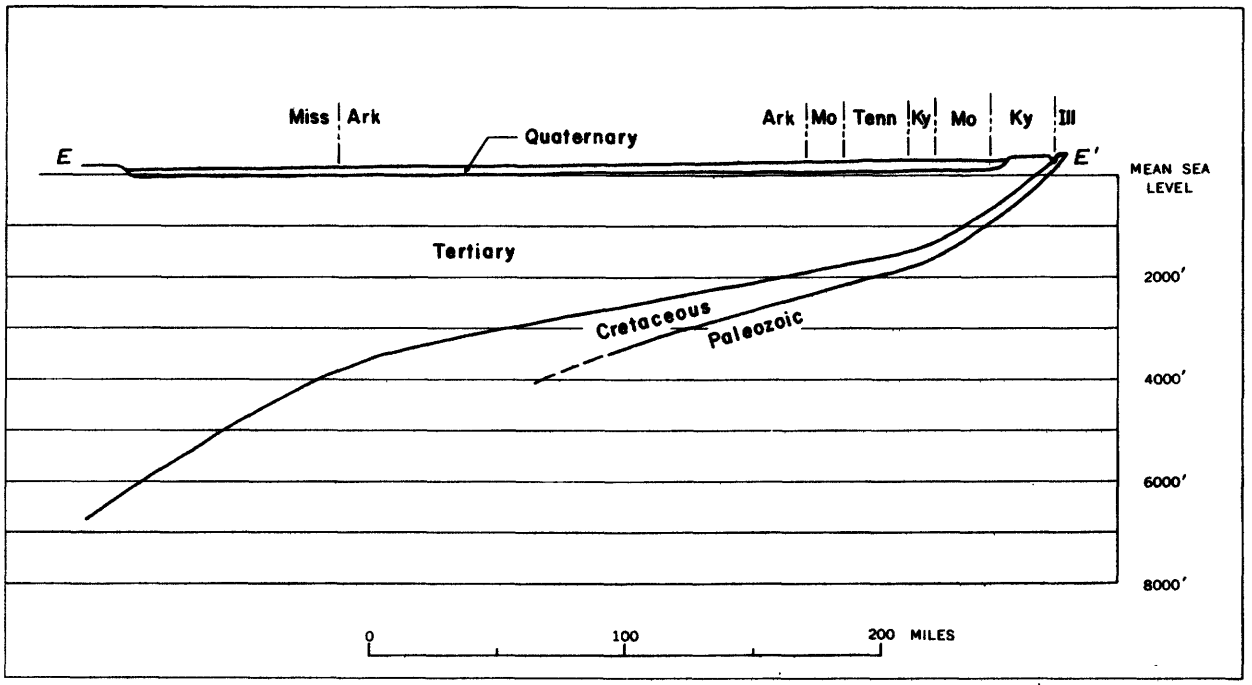

Figure 5.—Generalized north-south geologic section.

State and topographic boundaries and underlie watersheds that at the land surface are independent units. The study of the groundwater resources is concerned primarily with the Cretaceous, Tertiary, and Quaternary units, which contain the principal water-bearing beds in the region.

Cretaceous sediments underlie most of the embayment and contain at least five water-bearing units of regional importance. Although water in these units over a large part of the region is salty or highly mineralized, in many large areas (fig. 6) the water in the Cretaceous deposits may be fresh (less than 1,000 parts per million of dissolved solids). Analysis of electric logs indicates that in some places relatively fresh water occurs in Cretaceous sands to a depth of more than 3,000 feet below sea level. Locally, within the fresh-water areas, sand containing highly mineralized water overlies sand containing fresh or less mineralized water.

Tertiary sediments crop out or underlie about 75 percent of the region (fig. 7), and they too contain at least five aquifers of regional extent. Almost anywhere within this area, except near its periphery, at least one aquifer of Tertiary age contains fresh water. As in the Cretaceous sediments, Tertiary sand deposits that contain water of poor quality may overlie sand beds containing water of a better quality.

The most productive water-bearing unit in the embayment is the Mississippi River alluvium of Quaternary age. It is from this alluvium that most of the water for irrigation is pumped. The distribution of Quaternary deposits is shown on figure 8.

WHAT ARE THE SURFACE-WATER RESOURCES?

Coincident with the study of the groundwater resources, streamflow records are being analyzed to determine the expected low flow of streams in the embayment on a frequency basis. The magnitude, duration, and frequency of these low flows determine how much storage is needed to operate a planned water facility. The largest expected discharge of a stream is of interest in regard to flood protection, but it is the magnitude of the low flow that determines a stream's suitability for a water-use project.

Low-flow frequency studies have been made for the river basins in the Mississippi

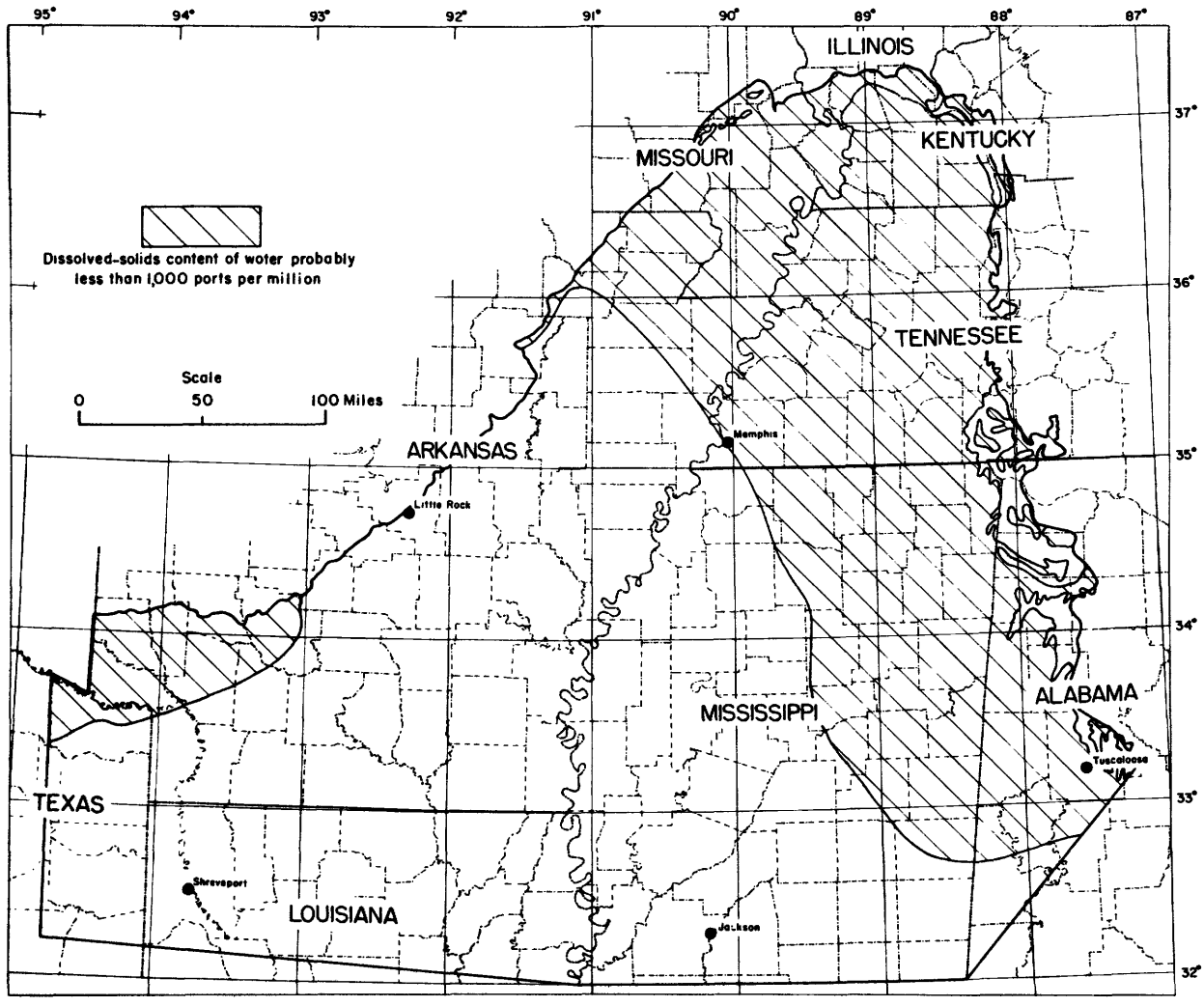

Figure 6.—Map showing areas where water in Cretaceous deposits probably contains less than 1,000 parts per million of dissolved solids.

embayment part of Mississippi and Alabama. Included in these studies were streams in the basins of the Tombigbee-Black Warrior River, the Pascagoula River, the Pearl River, the Tennessee River, the Hatchie River, the Wolf River, the Yazoo River, the Big Black River, and Bayou Pierre. Analyses will be made also of low flows of streams in the remaining States of the embayment.

HOW MUCH WATER IS IN THE EMBAYMENT?

Based on available streamflow records, the quantity of water which originates within the region and which leaves it as streamflow during an average year is about 90 million acre-feet. This amount is approximately the perennial yield of the region under the existing climatic and hydrologic conditions. If the average annual rainfall is assumed to be about 50 inches, or about 4.2 feet, then about 1.4 feet of the rainfall leaves the region as streamflow, and about 2.8 feet is returned to the atmosphere within the region primarily by evaporation and transpiration.

In addition to the 90 million acre-feet, about four times this amount enters the embayment from adjacent areas and flows through it as streamflow during an average year. Thus about 450 million acre-feet of water leaves the embayment as streamflow during an average year, a quantity sufficient to cover the entire region to a depth of about 7 feet.

The amount of water in the ground-water reservoirs in the embayment is sufficient to cover the entire region to a depth of about 80 feet. This estimate was made as follows:

The electric logs at about 100 locations within the embayment were examined, and an estimate was made of the total thickness of

the saturated sand containing fresh water at each location. Using these representative thicknesses, the total volume of fresh-water sand within the embayment was calculated. This volume was divided by the surface area, and the average thickness of fresh-water sand was computed as about 400 feet. If the average specific yield of the sand is assumed to be 0.2; that is, if 0.2 foot of water can be obtained from each vertical foot of sand, or 0.2 cubic foot of water from each cubic foot of sand, then an amount of water sufficient to cover the entire embayment to a depth of 80 feet is available in the subsurface units.

The quantity of water pumped in the Memphis area for municipal and industrial use is about 150 mgd (million gallons per day). If the 450 million acre-feet of water that leaves the region as streamflow could be stored and utilized by Memphis, then 1 year's streamflow would be sufficient to supply the Memphis area at the 150-mgd rate for more than 2,600 years. The amount in the ground-water reservoirs of the embayment would be sufficient to supply Memphis at the 150-mgd rate for at least 30,000 years.

These estimates of the amount of water within the embayment do not indicate the proportion of water that can be recovered economically, or how large a supply from surface water or ground water can be developed at a particular site within the region. Without storage facilities, the size of a surface-water supply probably would be governed by the low flow of the stream, and the low flow may be only a few percent of the average discharge of the stream. Also, the low flow of a stream is derived primarily from ground water so that ground-water

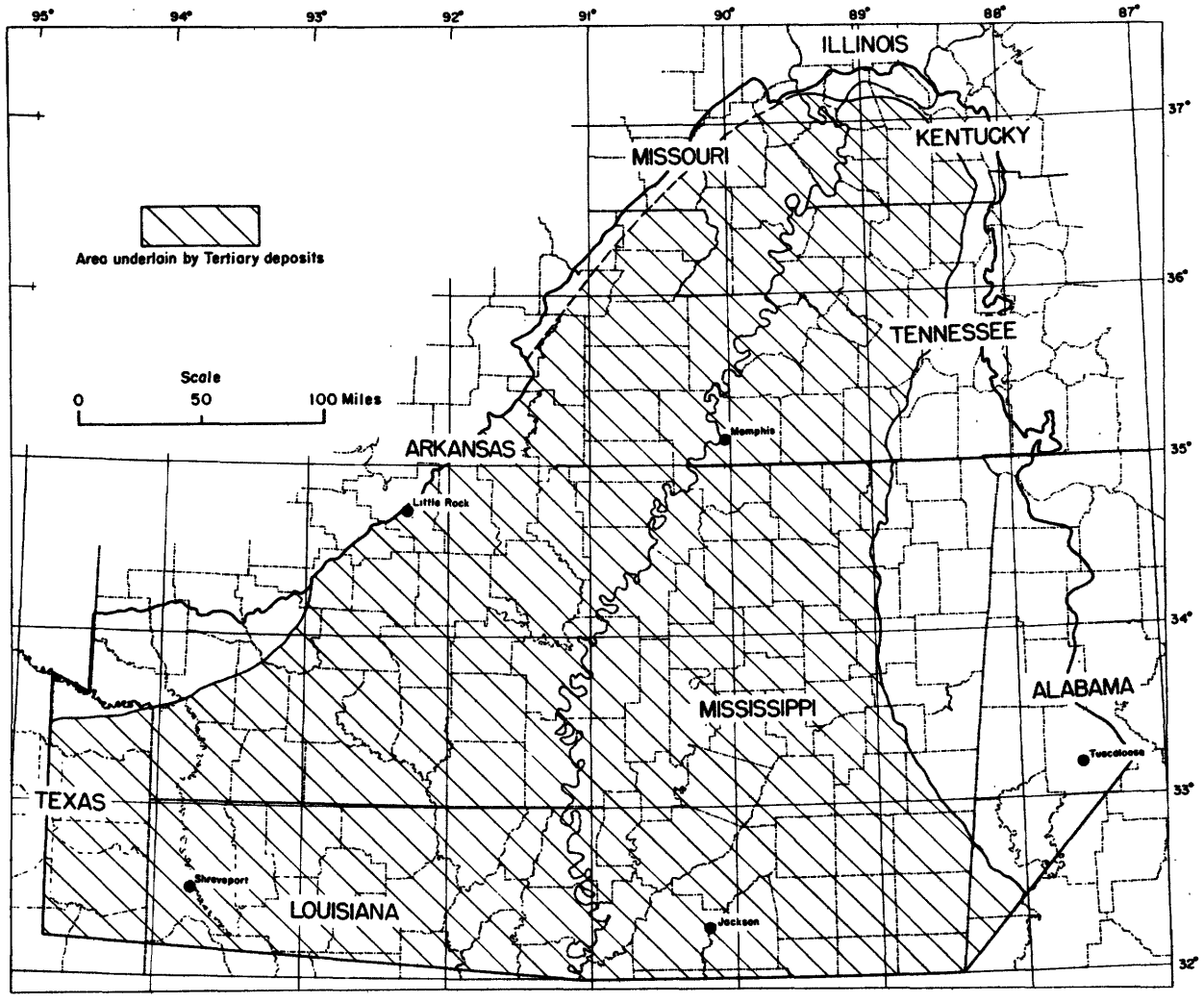

Figure 7.—Map showing area underlain by deposits of Tertiary age.

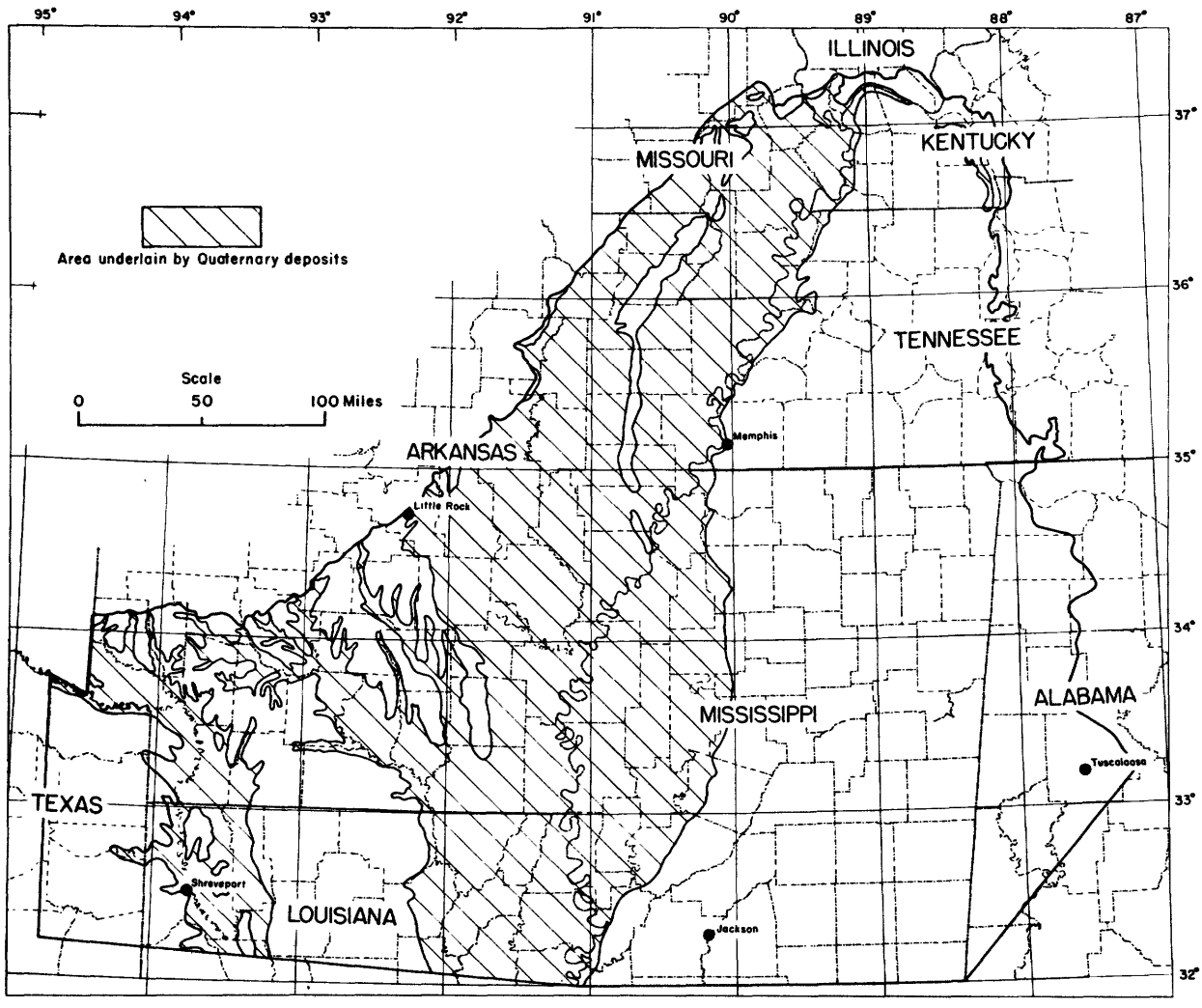

Figure 8.—Map showing area underlain by deposits of Quaternary age

development in the area might reduce or eliminate the low flow.

The size of a ground-water supply at a particular site would be governed largely by the thickness of the saturated sand units. Near the outcrop of the Paleozoic rocks the sand units generally are thin; the thickest sections are usually at or near the axis of the syncline (fig. 4). Other considerations that would govern the size of a ground-water supply would be (a) its proximity to streams, (b) the amount of recharge that may occur, (c) the effect of vertical leakage that may occur as the water levels are lowered, (d) the effect of up-dip movement of mineralized water or the vertical leakage of mineralized water from overlying or underlying sand units, and (e) the effect of subsidence caused by lowering water levels.

CONCLUSIONS

Proper development, use, and conservation of the water resources of the embayment can be achieved only with an understanding of the hydrologic system and the response of the system to climate and to change caused by water-supply development and use. The Mississippi embayment project is designed to define this regional geologic environment. Information and data developed as a result of the investigation should prove invaluable in predicting regional effects of the increasing use, reuse, import and export of water. In addition, with the hydrologic system being known, management analysis should be possible by the development of analog models that will provide solutions to specific regional and local water problems.

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