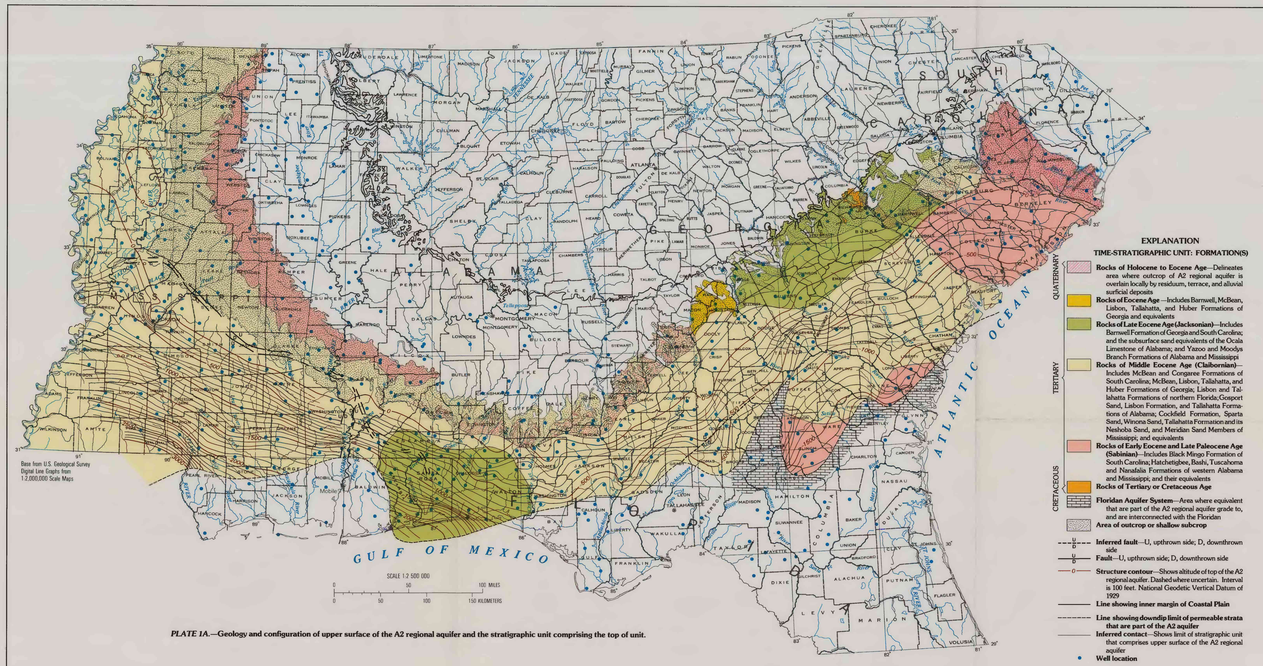

PLATE 1A.—Geology and configuration of upper surface of the A2 regional aquifer and the stratigraphic unit comprising the top of unit.

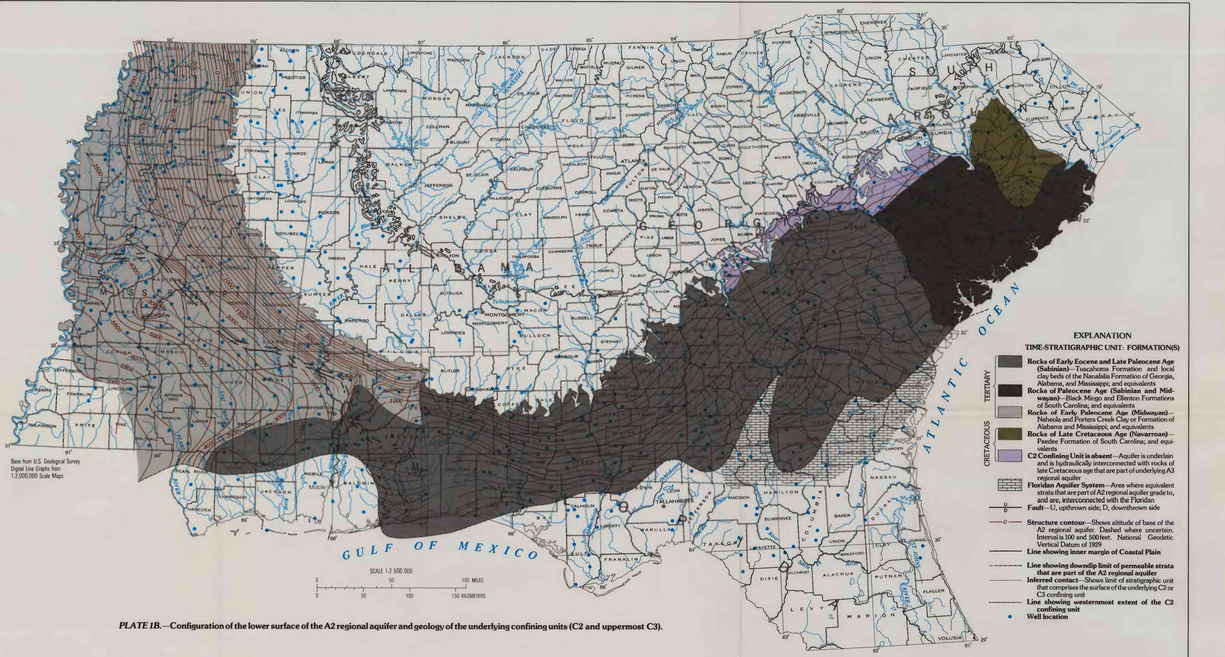

PLATE 1B.—Configuration of the lower surface of the A2 regional aquifer and geology of the underlying confining units (C2 and uppermost C3).

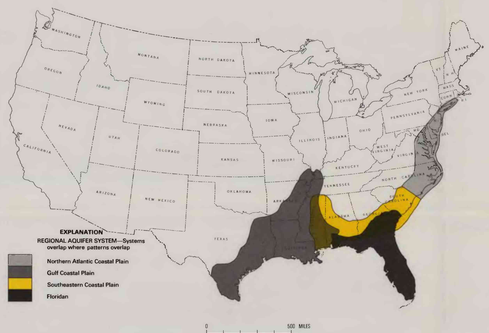

FIGURE 1.—Areal extent of regional aquifer systems of the United States Coastal Plain.

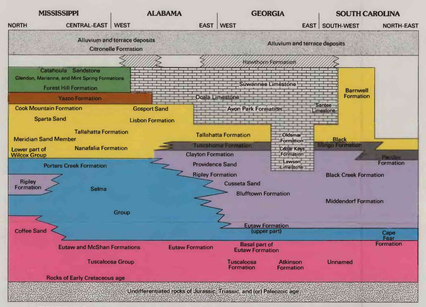

FIGURE 2.—Schematic diagram of regional hydrogeologic units and selected rock-stratigraphic units in the Southeastern U.S. Coastal Plain. Exact geologic correlations are not implied.

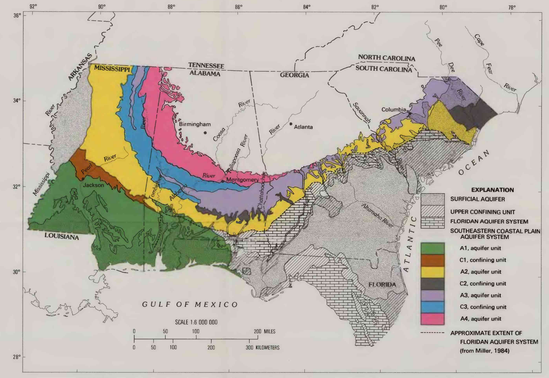

FIGURE 3.—Outcrop extent of regional aquifers and confining units of the Southeastern United States Coastal Plain.

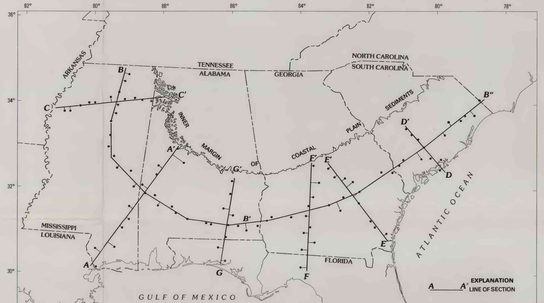

FIGURE 4.—Location of generalized hydrogeologic sections.

INTRODUCTION

Clastic sediments of Cretaceous and Tertiary age in the coastal plain of South Carolina, Georgia, Alabama, Mississippi, and adjacent areas of northern Florida and southeastern North Carolina comprise a major aquifer system that is formally called the Southeastern Coastal Plain aquifer system. This system is being studied as part of the U.S. Geological Survey's Regional Aquifer-System Analysis program, a series of investigations that present a regional overview and assessment of the hydrogeologic and geochemical conditions of extensive aquifer systems. The major objectives of the Southeastern Coastal Plain aquifer system study are to: (1) identify, delineate, and map the permeability distribution of clastic Coastal Plain aquifers; (2) describe the chemical evolution and quality of ground-water as it moves down the hydraulic gradient from the outcrop to areas of discharge; (3) examine the pattern of ground water flow within a network of regional aquifers whose physical boundaries extend beyond political subdivisions; and (4) simulate flow patterns by the use of a digital computer.

This report describes the configuration, extent, geologic age, and lithic character of the major aquifers and confining units that collectively comprise the Southeastern Coastal Plain aquifer system. The report represents part of a comprehensive outline adopted to study clastic aquifers in South Carolina, Georgia, Alabama, and Mississippi (Renken, 1984). Five detailed hydrogeologic maps presented herein are used in combination with eight hydrogeologic sections, two correlation charts and an outcrop map to graphically illustrate the relation between stratigraphy and region-wide changes in permeability. The illustrations in this report are based on detailed study of geophysical, lithologic, and paleontologic data from more than 750 oil and gas test wells and water wells. Geophysical logs from oil and gas wells were collected primarily from commercial geophysical log service companies. State government and U.S. Geological Survey well record files were the primary source of water well data. Published well data found in many reports also provided information. Drill cuttings were studied from selected water and oil test wells to obtain additional lithologic and paleontologic data.

The Southeastern Coastal Plain aquifer system consists of a thick and areally extensive body of strata that contains a number of aquifers and confining units. The aquifers are hydraulically connected in varying degrees and regionally may be treated as a single system. The hydrogeologic framework is described in this report by cross sections, and structure contour and isopach maps that illustrate the arrangement, distribution, and physical attributes of the individual aquifers and confining beds that comprise the regional system.

This report is concerned with the hydraulic character of coastal plain strata and is therefore unlike sedimentary basin studies that generally emphasize primary rock characteristics within a specific rock-stratigraphic or time-stratigraphic interval. The vertical limits of an aquifer may locally parallel those defined by lithology, or the time or mode of deposition. However, a body of hydraulically interconnected permeable strata does not always fall within such boundaries. The physical character of rocks that are stratigraphically equivalent generally changes from place to place; stratigraphically equivalent rocks may be an aquifer in one location and a confining unit in another area. Similarly, the correlation of outcropping rock-stratigraphic units is often difficult as their recognition is based on local outcrop descriptions that may not be representative elsewhere, especially in the subsurface. Rocks that comprise a regional aquifer unit or confining unit as mapped herein consist of a series of sand or clay beds that form discrete aquifers or confining units at the local level. However, when viewed on a regional scale, these rocks that are hydraulically imperfectly interconnected tend to behave as a single hydrologic unit. Strata that comprise regional aquifer units were combined according to: (1) their degree of hydraulic interconnection; (2) the uniformity and continuity of their potentiometric surface; (3) their areal distribution and extent; and (4) their ability to be regionally mapped.

HYDROGEOLOGIC FRAMEWORK

Coastal plain rocks in the Southeastern United States form a thick wedge of unconsolidated to poorly consolidated clastic and carbonate rocks that dip gently seaward from the Fall Line, except in Mississippi where they dip southwest and west toward the Mississippi River. These rocks are the product of the cyclical advance and retreat of ancient seas over the Paleozoic and Mesozoic basement complex and were deposited under marine, marginal marine, and nonmarine conditions during Jurassic to Holocene time. The fluctuating depositional conditions resulting from regional uplift, subsidence, and sea level changes caused the lithology, texture, bedding character, and therefore, the hydraulic conductivity (reservoir permeability) of these rocks to vary considerably, significantly affecting the occurrence and flow of ground water within the coastal plain. Coastal plain rocks are underlain in places by metamorphic, crystalline, and sedimentary rocks of Paleozoic and early Mesozoic age that are, in part, a southeastern extension of the Piedmont Province and in places by indurated sedimentary rocks of Paleozoic age which are a southwestern extension of the Appalachian Mountains. These rocks, taken together, are herein referred to as the Coastal Plain floor.

To simplify the hydrogeologic framework of the Coastal Plain into a sequence of regional aquifers and confining units that are suited to a digital ground-water flow model study, the complex stratigraphic and hydrologic nature of these rocks must be greatly idealized and generalized. Definitive geologic and hydrologic data are lacking for much of the Southeastern Coastal Plain, particularly where the different hydrogeologic units lie at great depths. The generalized lithic and hydraulic character of regional units expedites their extrapolation into areas having limited data.

The Coastal Plain can be separated into four major regional aquifer systems (fig. 1). The Southeastern Coastal Plain aquifer system is the central connecting link between three adjacent and overlapping aquifer systems: The Northern Atlantic Coastal Plain to the northeast; the Floridan to the south and southeast; and the Gulf Coastal Plain to the west. Several of the major clastic aquifers and confining units together comprise the Southeastern Coastal Plain aquifer system extend beyond Mississippi or South Carolina and are part of the adjoining Gulf Coastal Plain and Northern Atlantic Coastal Plain aquifer systems.

Clastic Tertiary and Cretaceous aquifers are the focus of the Southeastern Coastal Plain aquifer system investigation. These clastic strata grade southward into carbonate rocks of equivalent age present in Florida, southern and southeastern Georgia, southern Alabama, and southwestern South Carolina that comprise the highly productive Floridan aquifer system (Miller, 1986). In these States, the Southeastern Coastal Plain aquifer system is mostly overlain by, and is hydraulically interconnected with, the Floridan aquifer system. The limestone units that comprise the Floridan generally grade to, or interfinger with, the clastic rocks of the Southeastern Coastal Plain aquifer system. These carbonate rocks are therefore considered to be an integral part of the total hydrogeologic system of the Southeastern United States Coastal Plain. For purposes of this report, limestone of the outcropping Santee Formation and its shallow subsurface equivalents are included as part of the Floridan aquifer system in South Carolina, shifting the extent of the Floridan as mapped by Miller (1983b) northward to include limestone beds in Orangeburg, Clarendon, and Calhoun Counties. Low-permeability rocks of Oligocene to Pliocene age make up the upper confining unit of the Floridan aquifer system and, in turn, are overlain by unconsolidated sand and gravel of Pliocene to Holocene age (table 1). These uppermost deposits form the surficial aquifer that contains water under unconfined conditions.

The Southeastern Coastal Plain aquifer system has been subdivided into seven regional hydrogeologic units: four regional aquifer units that are separated by three regional confining units (fig. 2). These hydrogeologic units cannot be described adequately by existing geologically-oriented nomenclatural schemes. This is partly due to the regional extent of the units and partly is a result of their poor correspondence with the physical boundaries of rock-and time-stratigraphic units. Therefore, regional aquifer layers have been informally designated by the letter A, and regional confining units by the letter C. A sequential number is assigned to each hydrogeologic unit to indicate its relative position in the hydrogeologic column. Aquifers consist mainly of quartzose, coarse to fine grained sand that is in places glauconitic, feldspathic, calcareous, or fossiliferous, and locally contain sandstone, gravel, and minor limestone beds. Confining units that bound and separate the regional aquifers are composed of clay, mudstone, siltstone, shale, and chalk. Except where they are covered by younger strata, the aquifers and confining units that make up the Southeastern Coastal Plain aquifer system crop out in adjacent bands that extend from Mississippi to South Carolina (fig. 3) and extend into the subsurface either in a seaward direction or westward toward the Mississippi River. Where the regional aquifers that comprise this system are covered by low-permeability rocks, they contain water under confined conditions everywhere. In outcrop areas, discrete water-bearing horizons within a given aquifer may be locally separated by beds of clay, shale, mudstone, and marl, and water may occur under confined conditions in these areas as well.

A1 REGIONAL AQUIFER AND C1 CONFINING UNIT

A thick, seaward-dipping sequence of clastic and minor limestone beds of Oligocene and Miocene age present in Mississippi and Alabama has been designated as the A1 regional aquifer. Cropping out as a 30- to 60-mile-wide band in southwestern Alabama and southern Mississippi, the A1 aquifer extends into Louisiana where it is considered part of the Gulf Coastal Plain regional aquifer system (Grubb, 1984). It is overlain in western Alabama and Mississippi by a thin veneer of sand and gravel of Pliocene, Pleistocene, and Holocene age that is part of the surficial aquifer. In southwestern Alabama, that A1 aquifer overlaps and, in places, is interconnected with the Floridan aquifer system; for the most part, however, the A1 aquifer is underlain in Mississippi and westernmost Alabama by calcareous, marine clays of late Eocene age and Oligocene age (Yazoo and Red Bluff Formations, table 1) that together comprise the C1 confining unit (figs. 4 and 5). The C1 confining unit extends from western Mississippi as a 30- to 60-mile wide outcrop band into westernmost Alabama where its width of outcrop decreases and it is overlapped by the A1 aquifer. The C1 confining unit extends westward into Louisiana and is part of the Gulf Plain Coastal aquifer system (Grubb, 1984).

A2 REGIONAL AQUIFER

A thick section of unconsolidated to poorly consolidated sand, sandstone, gravel, and minor limestone beds of Paleocene to late Eocene age forms the A2 regional aquifer (table 1). Local sand beds of Late Cretaceous age present in South Carolina (equivalent to the Peedee Formation) are also included as part of the A2 aquifer (fig. 6, plate 1). Sediments of the A2 aquifer were largely deposited under marine conditions except in Mississippi where they grade to a thick fluvial sequence. The A2 aquifer is comprised largely of quartzose sand (but contains glauconitic and feldspathic sand in places) that is fine to coarse grained and massive to thinly bedded. The aquifer is locally interbedded and interlaminated with clay, shale, marl, and mudstone. Extending from central South Carolina to northern Mississippi, it is part of a regional freshwater aquifer (Grubb, 1984) that can be mapped as far west as Texas.

The A2 aquifer crops out as a 20- to 30-mile-wide band in central South Carolina that decreases to 10 to 20 miles wide throughout Georgia and central Alabama; the width of outcrop expands to about 30 to 60 miles across western Alabama and in Mississippi. The A2 regional aquifer generally crops out far to the south or west of the inner Coastal Plain margin except in northcentral Georgia where it crops out adjacent to the Fall Line. The A2 aquifer dips seaward in South Carolina, Georgia, and eastern Alabama at a gradient of 10 to 30 feet per mile; in Mississippi the gradient increases to about 30 to 45 feet per mile and the sediments dip to the south, southwest, and west (fig. 7). Where the A2 aquifer is overlain by alluvial materials that are part of a surficial aquifer in northwestern Mississippi, the aquifer's top is nearly flat and represents a floodplain created by the ancestral Mississippi River.

In most places, the A2 regional aquifer grades seaward from porous sand, sandstone, gravel, and minor limestone beds into low-permeability clay, shale, mudstone, chalky, and chalk limestone that mark the downdip limit of the aquifer. In southwestern South Carolina and southern Georgia, however, the A2 aquifer grades into stratigraphically equivalent permeable limestone and dolomitic strata that are part of the Floridan aquifer system (figs. 8, 9, 10).

Rocks of late Paleocene to early Eocene age (Sabinian Stage) outline the top of the A2 aquifer in southwestern South Carolina, southeastern Georgia, westcentral Alabama and northeastern Mississippi. Where these rocks crop out and extend into the South Carolina subsurface, the A2 aquifer is made up of littoral to estuarine, fine to coarse grained, fossiliferous, argillaceous, glauconitic quartz sand that is part of the Black Mingo Formation. Rocks of equivalent age and similar lithology are found in southeastern Georgia, but are more indurated and are typically interbedded with fossiliferous marl and sandy limestone. Where these permeable water-bearing strata crop out in western Alabama and northern Mississippi, they consist of a fluvial-deltaic sequence containing massive to thinly bedded, fine to coarse grained, quartzose sand and lignitic clay that are part of the Wilcox Group.

Water-bearing strata of middle Eocene age that mark the top of the A2 aquifer extend westward in outcrop and in the subsurface as a continuous band from southwestern South Carolina into northern Mississippi. These Claibornian strata were deposited under marine conditions in South Carolina, Georgia, and Alabama. As is true of the Sabinian rocks that lie beneath them, Claibornian rocks grade westward to a thick, fluvial-deltaic, massively bedded quartz sand sequence in Mississippi. Elsewhere, water-bearing strata of Claibornian age that are part of the A2 aquifer consist of massive to thinly bedded, fine to coarse grained, fossiliferous to sparsely fossiliferous, glauconitic quartz sand that is, in places, interbedded with silty, carbonaceous, micaceous, fossiliferous marl, minor limestone beds, mudstone, and clay. Where these strata crop out in western Georgia and southern Alabama, they are overlain by a thin residuum of varicolored, very fine to coarse grained sand and fossiliferous chert.

Rocks of late Eocene age form the top of the A2 aquifer in middip and downdip areas of southwestern Alabama, and where they crop out and lie in the shallow subsurface of the northeastern Georgia-northwestern South Carolina Coastal Plain. In the latter areas, upper Eocene rocks consist of deep red, fine to coarse grained, arkosic quartz sand; in southwestern Alabama, they consist of calcareous, glauconitic sand and interbedded clay.

C2 and C3 REGIONAL CONFINING UNITS

The depth, age, extent and configuration of the low-permeability rocks that collectively separate the A2 aquifer from deeper permeable strata are shown on Plate 1B. The A2 aquifer is not underlain by one regionally-extensive confining unit, but rather, is underlain by strata of Paleocene and Cretaceous age that are part of two different regional confining units, C2 and C3. The strata that form these confining units dip gently southward at a gradient of 15 to 30 feet per mile except in Mississippi where they dip westward or southwestward at 30 to 55 feet per mile. In updip areas of northeastern Georgia and northwestern South Carolina, no confining unit underlies the A2 aquifer, and it is directly hydraulically connected with underlying massive nonmarine quartz sand beds of Cretaceous age that are part of the A3 regional aquifer.

In central South Carolina, the C2 confining unit is comprised of calcareous sandy mudstone, muddy, very fine grained sand, and marl of Late Cretaceous age (Navarroan Stage). Phosphate and glauconite are minor constituents of this confining unit. Here, the C2 confining unit is equivalent to the outcropping Peedee Formation and was deposited in an open marine, shallow-shelf environment. In south-central and southwestern South Carolina, the C2 confining unit is of Paleocene age and is comprised of either (1) gray to greenish gray, locally fossiliferous, marine arenaceous shale, siliceous mudstone, and sandy clay that are in part equivalent to the outcropping Black Mingo Formation or (2) lignitic micaceous clay of the Ellenton Formation.

In western Georgia and eastern Alabama, the C2 confining unit is equivalent to the Tuscahoma Formation of Paleocene age (Sabinian Stage), whereas in central and eastern Georgia, the unit also includes rocks equivalent to the lower part of the Eocene Huber Formation. In the shallow subsurface of Alabama and Georgia, the C2 confining unit consists largely of blocky, silty, carbonaceous to kaolinitic clay or marl; minor constituents include lignite, glauconite, mica, and pyrite. The C2 confining unit grades downdip into gray to greenish gray, calcareous, glauconitic, arenaceous shale, and nonfossiliferous limestone.

In central Alabama, the C2 confining unit grades into a fine-grained, glauconitic sand and interbedded silty clay sequence that are part of the A2 aquifer (fig. 11). Consequently, a deeper, more extensive confining unit (C3) is considered to be the major confining unit that separates the A2 aquifer from underlying aquifers in these places (fig. 12). Where the C3 confining unit underlies the A2 aquifer, it is largely equivalent to the outcropping massive clay of the Porters Creek Formation of Paleocene age.

CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)

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.

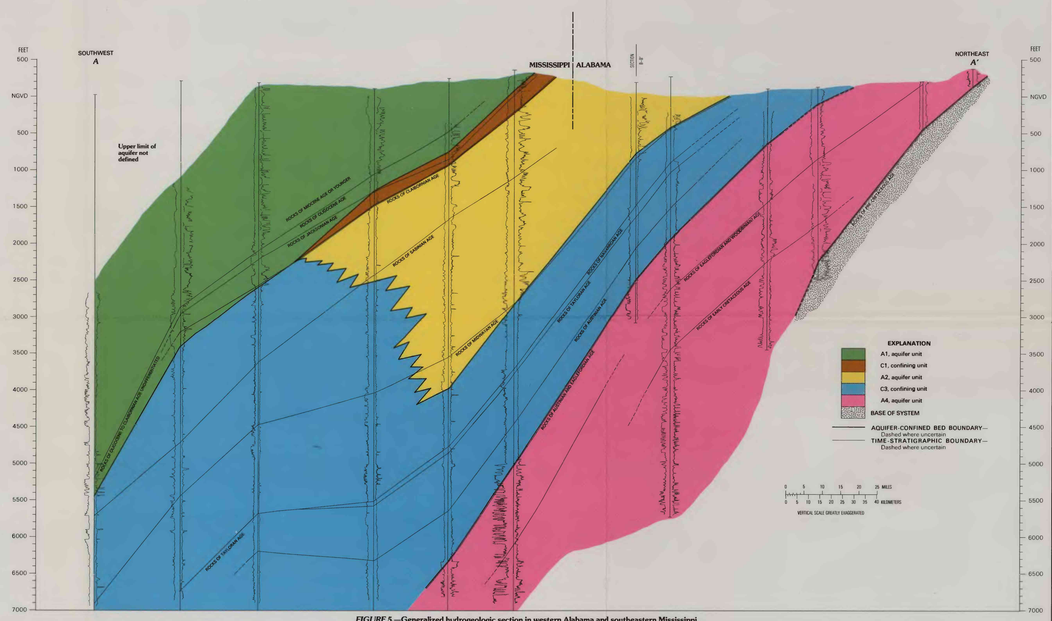

FIGURE 5.—Generalized hydrogeologic section in western Alabama and southeastern Mississippi.

HYDROGEOLOGY OF CLASTIC TERTIARY AND CRETACEOUS REGIONAL AQUIFERS AND CONFINING UNITS IN THE SOUTHEASTERN COASTAL PLAIN AQUIFER SYSTEM OF THE UNITED STATES

By
Robert A. Renken, Gary L. Mahon, and Marvin E. Davis

1989

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