Prepared in cooperation with the
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

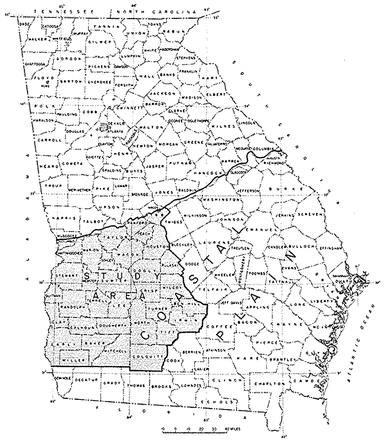

Figure 1.—Location of study area.

INTRODUCTION

Population growth and changes in farming practices in southwest Georgia since 1950 have resulted in a significant increase in agricultural, industrial, and municipal ground-water use. The total number of ground-water supplied irrigation systems in southwest Georgia increased from 57 in 1955 to about 3,000 in 1979. Total ground-water use from all aquifers increased about 240 percent in Albany from 1950 to 1980, and about 190 percent in Dawson from 1958 to 1980. Pumping in these and adjacent areas caused water levels in the Clayton aquifer to decline as much as 100 ft since 1954. By 1981, water levels had declined about 150 ft at Dawson and 175 ft at Albany since the predevelopment period.

The purpose of this study was to describe the hydrogeology of the Clayton aquifer and evaluate the effects of water use on the ground-water system. The study area lies within the southwestern part of the Coastal Plain physiographic province of Georgia and is outlined in figure 1. This atlas is part of a series intended to present results of the Upper Cretaceous-lower Tertiary aquifer study being conducted as part of the Georgia Accelerated Ground-Water Program.

The predevelopment, 1954, and March 1981 potentiometric surfaces of the Clayton aquifer were constructed from data listed by Stephenson and Veatch (1915), Wait (1963), and Ripy and others (1981); and from data files of the U.S. Geological Survey, the Georgia Geologic Survey, and the Georgia Environmental Protection Division. Hydrogeologic sections and structure-contour and thickness maps of the Clayton aquifer were constructed based on geophysical, lithologic, and paleontologic data from wells in the study area. The Arrowhead test well in Pulaski County, drilled in 1981 as part of this study, provided key information for evaluation of other wells.

Table 1.—Generalized correlation of stratigraphic, lithologic, and aquifer units of Mesozoic and Cenozoic age in southwest Georgia

ERA	SYSTEM	SERIES	GULF COAST STAGE	GROUP, FORMATION, AND MEMBER		LITHOLOGY			AQUIFER OR CONFINING ZONE, THIS REPORT	THICKNESS (FEET)
CENOZOIC	TERTIARY	Oligocene	Chickasawhayan							
			Vicksburgian							
		Eocene	Jacksonian	Ocala Limestone		White to light-pink, fossiliferous limestone.[1]			Principal artesian aquifer	0-200
			Claibornian	Claiborne Group	Lisbon Formation	Fine sand and marl, dense, earthy, fossiliferous; contains thin beds of sandstone and hard, sandy, fossiliferous, glauconitic limestone.			Lisbon confining zone	0-70
					Tallahatta Formation	Sand, fine to coarse; gravelly at the base; grades upward into poorly sorted fine to coarse sand interbedded with highly fossiliferous limestone layers.			Claiborne aquifer[3]	0-270
			Sabinian	Wilcox Group	Tallahatta Formation (?)[2]	Hatchetigbee Formation—In updip areas the formation consists of crossbedded fine to medium sand and interlaminated sequences of very fine sand, silt, and clay. In downdip areas, the formation consists of massively bedded, very fine to fine, well-sorted quartz sand that contains little or no glauconite.[2]				
					Bashi Formation / Hatchetigbee Formation	Bashi Formation—Very fine to fine sand, often clayey, silty, and calcareous; massively bedded; contains abundant glauconite and calcareous fossils. In downdip areas, the formation becomes clayey silt and very fine sand. The Bashi Formation is a downdip facies equivalent of the Hatchetigbee Formation.[2]			Wilcox confining zone—In some areas, sand and limestone layers in the Hatchetigbee Formation, Tuscahoma Formation, Nanafalia Formation, and upper Clayton formation provide ample supplies for domestic use.	0-260
		Paleocene			Tuscahoma Formation	Basal unit consists of glauconitic, medium to coarse sand containing quartz and phosphate pebbles, clay clasts, and shells. Upper unit consists of laminated silts and clays that are commonly carbonaceous and nonfossiliferous.[2]				
					Nanafalia Formation: Baker Hill Formation	Baker Hill Formation—Kaolinitic and bauxitic massively bedded clay, carbonaceous clay, and crossbedded micaceous quartz sand. The Baker Hill Formation is an updip facies equivalent of the Nanafalia Formation.[2]				
					Nanafalia Formation	Nanafalia Formation—Upper part consists of very-fine to coarse, glauconitic, micaceous, fossiliferous sand and clayey sand. Lower part consists of fine to coarse, micaceous quartz sand and carbonaceous clay.[4]				
			Midwayan	Midway Group	Porters Creek Clay	Dark-gray to black clay, waxy appearing, silty, fissle, fossiliferous, somewhat indurated, interbedded with fine sand. Unit absent over most of the western part of study area.[4]				
					Clayton Formation		Clastic area[5]	Carbonate area[5]	Transition area[5]	
							Medium to coarse, massive or crossbedded sand containing layers of clay, calcareous sand or sandy limestone, and local shell lenses.	Upper unit—very-fine to medium, calcareous, silty sand containing thin beds of limestone and clay. Middle unit—massive, recrystallized, highly fossiliferous limestone containing varying percentages of sand. Lower unit—calcareous, fine to coarse sand and sandy marl that is locally arkosic, glauconitic, and fossiliferous. Unit may be derived in part from erosion and redeposition of the underlying Providence Sand.	Well-sorted calcareous sand, silt, and clay containing thin layers of clayey fossiliferous limestone.	Clayton aquifer—Over most of the clastic area, forms a single aquifer unit with upper member of the Providence Sand and provides ample supplies of water for domestic use. In the carbonate area, the aquifer consists primarily of limestone and provides ample water for municipal, agricultural, and industrial supply. In the transition area, the aquifer consists of calcareous sand interbedded with thin limestone and clay layers and provides ample supplies of water for domestic use.	0-265
MESOZOIC	CRETACEOUS	Upper Cretaceous (Gulfian)	Navarroan	Providence Sand (upper unnamed sand member)		Fine to coarse silty sand, grades from a thickly bedded sand updip to a massive, marine sand containing calcareous intervals downdip.[4] In Albany, Dougherty County, upper part is a dense, clayey, fine sand; middle part is a slightly dolomitic coquina grading upward to a siltstone; lower part is sand containing varying amounts of silt.[4] Unit grades to a silty clay and very clayey sand at the Arrowhead test well in the northwestern part of the study area.			Clayton-Providence confining zone—over most of the clastic area, the confining zone is absent and the Clayton Formation and upper member of the Providence Sand form a single aquifer unit.	0-130
									Providence aquifer—Forms single aquifer unit with the Clayton Formation over most of the clastic area. Downdip and eastward, the Providence may form a single aquifer unit with the Ripley Formation and upper Cusseta Sand.	0-390
				Providence Sand (Perote member)		Silt or very-fine sand, dark gray, highly micaceous, carbonaceous. Unit merges with upper member east of Schley County where it grades into coarse sand.			Providence-Ripley confining zone—Where absent, the Providence Sand, Ripley Formation, and upper Cusseta Sand form a single aquifer unit.	0-300
				Ripley Formation		Sand, fine, clayey, micaceous, fossiliferous. Unit grades to clayey coarse sand in the eastern part of the study area.				
			Taylorian	Cusseta Sand		Sand, coarse, containing increasing amounts of thinly bedded carbonaceous clay toward the upper contact. Size and amount of sand decreases downdip where micaceous silt and clay dominate.[4]			Cusseta aquifer—Forms a single aquifer unit with the Providence Sand and Ripley Formation downdip and eastward.	0-150
				Blufftown Formation		Lower part consists of crossbedded, glauconitic, calcareous fine sand to micaceous clay and marl. Upper part consists of carbonaceous clay and silt, crossbedded sand, and highly fossiliferous clay to glauconitic fine sand.[4]			Blufftown aquifer.	0-700
			Austinian Eaglefordian Woodbinian	Eutaw and Tuscaloosa Formations (undivided)		Alternating layers of sand, sandy clay, and clay.				200-1200

1 Hicks and others, 1981.
2 Gibson, 1982.
3 Ripy and others, 1981.
4 Reinhardt and Gibson, 1980.
5 Location of areas shown in figure 2.

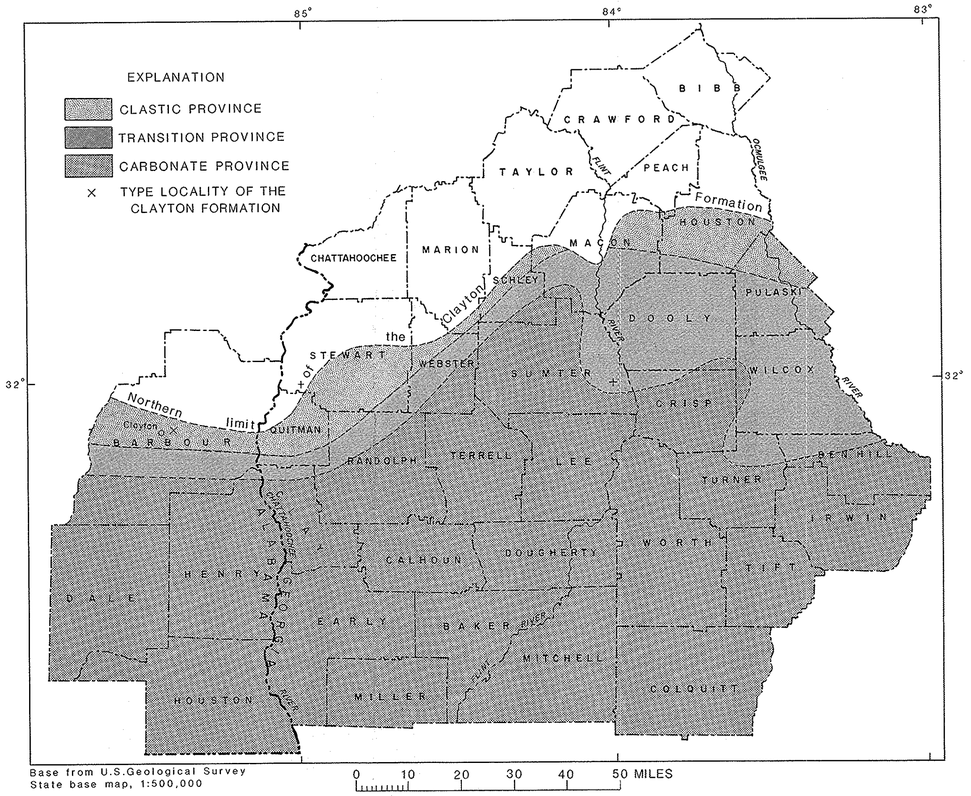

Figure 2.—Type locality and lithologic provinces of the Clayton Formation.

PREVIOUS STUDIES

Previous investigations in the study area include comprehensive studies of the geology and ground-water resources of Dougherty County (Wait, 1963); Lee and Sumter Counties (Owen, 1963); the Macon area, including Houston, Macon, and Schley Counties (LeGrand, 1962); and the Albany area (Hicks and others, 1981). Stewart (1973) discussed the effects of dewatering the Clayton Formation during construction of the Walter F. George Lock and Dam. The hydrogeology of the Providence aquifer in southwest Georgia was described by Clarke and others (1983).

The hydrogeology of the Clayton and Claiborne aquifers in a 15-county area in southwestern Georgia was described in an interim report by Ripy and others (1981) and in a final report by McFadden and Perriello (1983). The present report describes the hydrogeology of the Clayton aquifer over an expanded 34-county area and relates sediments of the Clayton Formation in southwestern Georgia to sediments of equivalent age in eastern Alabama and east-central Georgia. The report also describes hydrologic relations between the Clayton aquifer and the underlying Providence aquifer.

Geologic studies in the area include descriptions of Upper Cretaceous and lower Tertiary units of the Chattahoochee River valley by Toulmin and LaMoreaux (1963), Marsalis and Friddell (1975), and Reinhardt and Gibson (1980). Herrick (1961) presented 354 lithologic logs of wells throughout the Coastal Plain of Georgia. Other hydrologic and geologic reports on the study area are listed in Selected References.

WELL-NUMBERING SYSTEM

Wells in this report are numbered according to a system based on the Georgia index map of U.S. Geological Survey 7.5-minute topographic quadrangle maps. Each quadrangle in the State has been given a number and letter designation according to its location based on a generally Cartesian pattern with its origin at the southwest corner of the State. Numbers increase eastward and letters increase alphabetically northward. Quadrangles in the northern part of the State are designated by double letters. Wells inventoried in each quadrangle are numbered consecutively beginning with one. Thus the third well scheduled in the Doverel quadrangle in Randolph County is designated 9P3. Additional information regarding wells used in this report may be obtained by referring to the well identification in any correspondence to the U.S. Geological Survey, 6481-B Peachtree Industrial Boulevard, Doraville, GA 30360.

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GEOLOGY

GENERAL SETTING

The study area is characterized by alternating units of sand, limestone, clay, and shale of Late Cretaceous to Holocene age, having a maximum thickness of at least 5,000 ft. The general stratigraphy and lithology of the sedimentary units are described in table 1.

The boundary between the Coastal Plain and the Piedmont physiographic provinces and the approximate inner margin of Coastal Plain sediments is marked by the Fall Line (fig. 1). The sedimentary units are exposed in northeast-trending belts that parallel the Fall Line and dip to the southeast, progressively thickening in that direction. The sedimentary sequence unconformably overlies metamorphic, igneous, and sedimentary rocks of probable Precambrian to Paleozoic age, and red beds and diabase of early Mesozoic age (Chowns and Williams, 1983).

GEOLOGIC UNITS

LATE CRETACEOUS

Providence Sand

The Providence Sand is the youngest formation of Late Cretaceous age in the study area. At the type locality at Providence Canyon, Stewart County, the Providence is about 85 ft thick and is divided into two members: the lower Perote Member and an upper unnamed sand member.

The Perote Member consists of dark-gray, highly micaceous, carbonaceous silt or very-fine sand. The upper unnamed sand member consists primarily of medium to coarse silty sand that is thick and well bedded in the outcrop area. South of the outcrop area, the upper member is a massively bedded marine sand that contains local calcareous material. East of Schley County, the Perote Member grades into coarse sand and is indistinguishable from the upper sand member. At the Arrowhead test well (well 18T1, figs. 3, 7), in the northeastern part of the study area, the members grade into silty clay and very clayey sand.

PALEOCENE-EARLY EOCENE

Midway Group

Clayton formation and Clayton formation equivalents.—The Clayton formation as used in this report includes all beds that unconformably overlie the Providence Sand of Late Cretaceous age and that are unconformably overlain by formations of the Wilcox Group of Paleocene-early Eocene age (table 1). For the purpose of simplicity, the Clayton formation has been expanded to include strata of equivalent age and stratigraphic position that are not present at the type locality.

Areal changes in the composition of the Clayton formation were mapped from descriptions of drill cuttings and cores and by examining geophysical logs. Three separate areas (fig. 2) were identified on the basis of lithology: (1) a clastic province in the northern part of the study area in which the principal sediments are sand and clay; (2) a carbonate province in the southern two thirds of the study area where the principal sediments are limestone and calcareous sand; and (3) a transition province that occurs between the clastic and carbonate provinces and contains sedimentary elements common to both areas and a high percentage of fine-grained sediment. The lithologic provinces probably represent areas where the depositional environment altered the lithologic character of the sediments.

In the clastic province, the Clayton formation consists of about 10 to 120 ft of medium to coarse, massive, crossbedded, locally calcareous sand containing layers of clay, sandy limestone, and discontinuous shell-rich lenses. This lithology was described at the type locality of the Clayton Formation at Clayton, Ala., and represents nearshore subtidal deposition (Reinhardt and Gibson, 1980, p. 403). A similar lithology is shown in Section B-B' at the Hatcher test well (5N2, fig. 4) in southern Quitman County. At the Arrowhead test well in Pulaski County (well 18T1, fig. 3) in the northeastern part of the study area, fine to medium, noncalcareous, clayey sand that is the same age as the Clayton and deposited largely in a deltaic environment (David C. Prowell, U.S. Geological Survey, written commun., 1983) is herein included in the Clayton formation in the clastic province.

In the carbonate province, the Clayton formation includes:

(1) A lower unit consisting of about 10 to 30 ft of calcareous, fine to coarse sand and sandy marl that is locally arkosic, glauconitic, and fossiliferous, and may be derived, in part, from erosion and redeposition of the underlying Providence Sand.
(2) A middle unit consisting of about 10 to 265 ft of massive, recrystallized, highly fossiliferous limestone containing varying percentages of sand.
(3) An upper unit consisting of about 10 to 90 ft of very-fine to medium, calcareous, silty sand containing thin layers of limestone and clay.

The carbonate province is the most widespread in the study area and was recognized in wells 5L7, 6M1, 9M7, 10N18, 11N2, 12P4, 6K9, 10Q4, 21L21, 13H8, and 15N1 (table 2, figs. 3-7). In this province, the Clayton formation is mainly limestone, indicative of deposition in an offshore marine environment. However, at wells 7J1 and 7G3 (fig. 4) in the southern part of the carbonate province, more than 50 percent of the Clayton formation consists of fine to coarse sand and interbedded clay that locally is silty and fossiliferous. At well 13L10 (fig. 5) in Dougherty County, the Clayton formation consists of fossiliferous, calcareous siltstone and clayey limestone, which are lithologies similar to those of the transition province. The high percentage of sand at wells 7J1 and 7G3, and the transition-type lithologies at well 13L10 suggest a local clastic influx, possibly due to offshore turbidity currents.

In the transition province, the Clayton formation consists of about 10 to 60 ft of calcareous well-sorted fine sand, silt, and clay containing layers of clayey, fossiliferous limestone as much as 20 ft thick. These strata represent the change between predominantly clastic deposition in northern areas to predominantly carbonate deposition in southern areas (fig. 2). The mixture of fine clastic sediment and carbonate suggests that these sediments were deposited in a shallow-shelf marine environment. Lithologies characteristic of the transition province were recognized in wells 14Q7 and 15R7 (fig. 3) in the northeastern part of the study area.

Porters Creek Clay.—The Porters Creek Clay consists of dark-gray to black, waxy, silty, fissle, fossiliferous, somewhat indurated clay interbedded with fine sand. This unit is absent over most of the western part of the study area and reaches a maximum thickness of 60 ft at the Arrowhead test well (well 18T1, fig. 3) in the northeastern part of the study area.

Wilcox Group

The Wilcox Group in southwestern Georgia consists of the Nanafalia Formation, Baker Hill Formation, Tuscahoma Formation, Bashi Formation, Hatchetigbee Formation, and lower part of the Tallahatta Formation (table 1). The Wilcox Group ranges in thickness from about 10 to 200 ft and is characterized by alternating layers of clay and very-fine to coarse sand that locally is glauconitic, silty, micaceous, clayey, calcareous, and fossiliferous. Strata of the lower part of the Wilcox Group are characterized by a relatively high clay content, good sorting, and a fine-grained character.

HYDROGEOLOGY OF THE CLAYTON AQUIFER OF SOUTHWEST GEORGIA.

By
John S. Clarke, Robert E. Faye, and Rebekah Brooks

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Cartography by Willis G. Hester