Hydrogeologic Framework of the Floridan Aquifer System in Florida and in Parts of Georgia, Alabama, and South Carolina

By JAMES A. MILLER

REGIONAL AQUIFER-SYSTEM ANALYSIS

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Southeast Georgia or Savannah embayment, deposition of Lower Cretaceous clastic sediments was followed by deposition of carbonate rocks in the Late Cretaceous and early Cenozoic, which in turn was followed by deposition of Upper Cenozoic clastic rocks. The Southeast Georgia embayment represents a shallow east- to northeast-plunging syncline that subsided at a moderate rate. To the northwest of the Peninsular arch is the Apalachicola or Southwest Georgia embayment, a southwest-plunging syncline where a thick section of predominantly clastic rocks has been deposited, almost continuously, since Late Jurassic time. Rarely, in the Cenozoic, carbonate deposition spilled over westward into the Southwest Georgia embayment from the Florida carbonate platform located to the east. Farther westward, in extreme western panhandle Florida and in southern Alabama, time-stratigraphic units thicken abruptly and their tops slope steeply gulfward, reflections of the influence of the rapidly subsiding Gulf Coast geosyncline. The top and base of the Floridan aquifer system also reflect this steep gulfward slope. The limestone that comprises the Floridan, however, thins gulfward as it is replaced by fine-grained clastic rocks. This facies change continues until the limestone is absent altogether in a well about 60 mi offshore from Mobile Bay, Ala.

A negative feature in southeastern Georgia, just north of the Peninsular arch, has been called the Suwannee strait (Dall and Harris, 1892), channel (Chen, 1965), or saddle (Applin and Applin, 1967). This basin was first called a strait because it was thought to represent a channellike feature, perhaps similar to the modern Straits of Florida, that developed on the sea floor and received little sedimentation because it was swept clean by bottom currents. The feature was also thought to represent the boundary between carbonate sediments to the south and clastic sediments to the north. This carbonate-clastic boundary, however, migrates with time in a general northwest direction and is not always confined to the Suwannee strait area. Well data show a closed depression on the top of Paleocene rocks in southeastern Georgia that may be an arm of the Southeast Georgia embayment but is separated from the main body of the embayment by a sill-like ridge. The absence of such a depression in the top of rocks of lower Eocene age or younger shows that the Suwannee strait ceased to be an actively subsiding basin during the early Eocene. Accordingly, this feature had little effect on the Floridan aquifer system, although the Floridan is slightly thicker within it. Because the Suwannee strait area is a closed basin within which several stratigraphic units are anomalously thin, the exact origin of the basin is not clear. Perhaps "starved-basin" conditions during the time of deposition produced units that are thinner than what would be expected.

Several faults and fault systems are shown in figure 3. In western Alabama, north-trending arcuate faults bound the Mobile Graben, a negative feature that shows much vertical displacement (Murray, 1961). The faults to the north of the Mobile Graben are part of the Gilbertown-Pickens-Pollard fault zone, which is characterized by a series of both isolated and connected grabens. The northeast-trending series of small faults in central Georgia (fig. 3) are the boundary faults for a series of small grabens that, taken together, have been called the Gulf Trough, first described by Herrick and Vorhis (1963) and later by Gelbaum (1978) and Gelbaum and Howell (1982). Within the grabens bounded by the faults shown in figure 3, low-permeability clastic rocks have been downdropped opposite the limestone of the Floridan aquifer system and thus retard the flow of ground water within the system. Several faults shown along Florida's eastern coast (fig. 3) are of limited extent and generally show little vertical displacement. These small faults do not appear to have any effect on ground-water flow in the Floridan aquifer system.

STRATIGRAPHY

GENERAL

Because relief in the study area is generally low, outcrops of Coastal Plain strata are sparse. Accordingly, the stratigraphic units delineated herein, like the major permeability variations mapped, are based primarily on data from wells. Standard techniques of subsurface stratigraphic analysis were used to distinguish and map the separate stratigraphic units. Complex facies variations exist within all rock units throughout the study area; hence, chronostratigraphic units were mapped rather than rock-stratigraphic units. The upper and lower boundaries of the chronostratigraphic units have been made to coincide with rock-stratigraphic (lithologic) boundaries within each well used as a control point. The same rock type may not necessarily mark the boundary of the same chronostratigraphic unit from well to well, however, especially in places where facies change rapidly. Each chronostratigraphic unit may therefore encompass several different rock types. The formations or parts of formations included in the several chronostratigraphic units are shown on plate 2. The chronostratigraphic units are discussed below, from oldest to youngest. Only those units that are part of the Floridan aquifer system or its confining units are mapped and described. Thus, most of the units are not mapped past the updip limit of the aquifer system, even though some are known to continue for a considerable distance updip from the system.

The chronostratigraphic units delineated and mapped represent sequences of rocks judged to have been deposited over a given interval of geologic time. Because exact dating of the rocks is not available, the relative ages of the different units mapped are determined by the fauna (chiefly microfauna) that the rocks contain. The identity of the separate chronostratigraphic units, however, does not depend upon the presence of a certain fauna within them. Many of the "formations" in the subsurface in the area, particularly those in Florida, were originally defined as "a distinct microfaunal unit," or as the sequence of rocks extending between the highest stratographic occurrences of two concurrent species that were judged to be time diagnostic (see, for example, Applin and Applin, 1944). Under the rules of the present North American Stratigraphic Code, a unit defined on the basis of its faunal content is neither a time-stratigraphic unit nor a rock-stratigraphic unit; rather, it is a biostratigraphic unit (North American Commission on Stratigraphic Nomenclature, 1983). Many of the species described in the literature as being diagnostic of a particular "formation" are, in fact, good time markers in the study area and are recognized as such in this report (table 1). The fauna used in this study, however, serve only to support the assignment of strata to a particular chronostratigraphic unit and are nowhere the sole criterion by which any unit mapped herein is recognized. After a given unit's relative age is established, the top and bottom of the unit are adjusted at each well control point to match lithologic changes as shown in core or by a change in electric log pattern.

The external geometry of the different chronostratigraphic units is shown by a series of maps (pls. 3-14) that portray the configuration of the top of a particular unit or its thickness. Variations in the lithology of the units are shown on a series of cross sections (pls. 15-24) that were chosen to also demonstrate the permeability variations within the Floridan aquifer system and its confining units.

CRETACEOUS SYSTEM: GULFIAN SERIES

Rocks of the Gulfian Series of Late Cretaceous age underlie the entire study area and include, in ascending order, units equivalent to the Woodbinian, Eagle Fordian, Austinian, Tayloran, and Navarroan provincial stages of the gulf coast Upper Cretaceous. In the area covered by this study, the Gulfian Series is found only in the subsurface. North of the study area, rocks of the Gulfian Series comprise practically all of the band of outcropping Cretaceous strata found at or near the contact of Coastal Plain sediments and older crystalline rocks (fig. 2). Applin and Applin (1967) mapped and described the Gulfian Series over much of the study area. This report deals only with the rocks that are part of the Tayloran and Navarroan stages because they are the oldest geologic units that comprise either a part of the Floridan aquifer system or its lower confining unit.

ROCKS OF TAYLOR AGE

In the shallow subsurface and in outcrop, Tayloran rocks include parts of the Mooreville and Demopolis Chalks and the Cusseta Sand Member of the Ripley Formation in Alabama, parts of the Cusseta Sand Member of the Ripley Formation and the Blufftown Formation in Georgia; and the upper part of the Black Creek Formation and the lower part of the Peedee Formation of South Carolina (Hazel and others, 1977). Rocks of Taylor age, however, are unnamed in most of the subsurface of the eastern Gulf Coast, including the area covered by this study. Practically all Tayloran strata in the report area consist of low-permeability rocks that range from light-gray, massive, often calcareous clay in southern Alabama, panhandle Florida, and much of central Georgia to chalk or argillaceous chalk in most of peninsular Florida. Thin layers of dolomite are interbedded with the chalk over much of Florida. Beds of fine- to medium-grained glauconitic sand are present in northeastern Georgia and South Carolina, along with carbonaceous material and local shell beds. Clayey beds of Taylor age in northeastern Georgia and South Carolina are usually darker in color and contain less calcareous material than similar beds elsewhere in the study area. The Tayloran chalks of peninsular Florida are part of a thick Upper Cretaceous chalk sequence and can be differentiated only on the basis of their microfauna (Applin and Applin, 1967; Maher, 1971). All Tayloran strata in the study area were deposited in a marine environment. In Florida, southern Alabama, and southwestern Georgia, these rocks represent middle to outer shelf conditions; in northeastern Georgia and South Carolina, they were laid down in marginal marine and inner shelf environments.

Rocks of Taylor age attain a maximum thickness of about 1,300 ft in the study area (Applin and Applin, 1967) and are everywhere underlain by rocks of Austin age. Over much of the area, beds of Navarro age overlie Tayloran rocks. In panhandle Florida, southern Alabama, and southwestern Georgia, however, rocks of Navarro age are thin and discontinuous; here, rocks of Paleocene age may lie directly on rocks of Taylor age (Applin and Applin, 1967). A map showing the configuration of the top of the Cretaceous (fig. 4) is accordingly a composite map representing the tops of several Cretaceous units. Most of the major geologic structures that affect the stratigraphic and permeability units comprising the Floridan aquifer system are shown on this map (compare figs. 3 and 4). The low areas shown in figure 4 in southeastern Georgia and southwestern peninsular Florida represent the Southeast Georgia embayment and the South Florida basin, respectively. The high area in northern Florida is the Peninsular arch. Also shown in figure 4 is the steep, southwest-trending slope of the northern rim of the Gulf Coast geosyncline, and a series of faults in southwestern Alabama that represent the Mobile Graben and the Gilbertown-Pickens-Pollard fault zone.

Fauna considered characteristic of rocks of Taylor age in the eastern Gulf Coast include the foraminifers *Bolivinoides decoratus* Jones, *Stensionina americana* Cushman and Dorsey, *Marsonnella oxycona* (Reuss), *Dorothia glabrella* Cushman, *Globotuncana ventricosa* White, *G. elevata* (Brotzen), and *G. calcarata* Cushman and the ostracod *Brachycythere sphenoides* (Reuss).

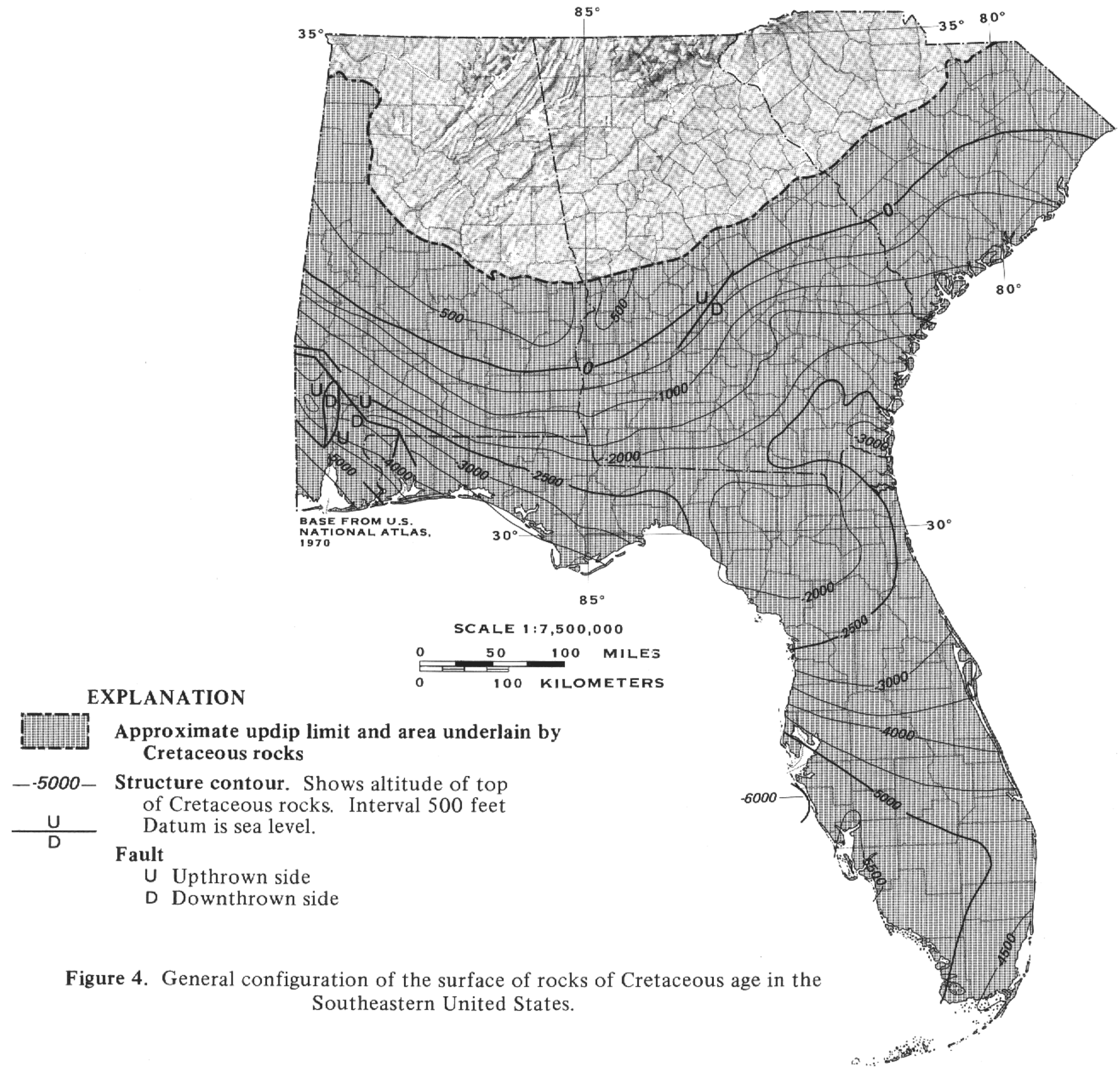

Figure 4. General configuration of the surface of rocks of Cretaceous age in the Southeastern United States.

ROCKS OF NAVARRO AGE

In outcrop and in the shallow subsurface, Navarroan rocks include the Prairie Bluff Chalk, the Ripley Formation (except for the Cussetta Sand Member), and the upper part of the Demopolis Chalk in Alabama; the Ripley Formation (again, excluding the Cusseta Sand Member) and the Providence Sand in Georgia; and the upper part of the Peedee Formation in South Carolina (Hazel and others, 1977). Downdip, rocks of Navarro age are unnamed except for the Lawson Limestone of northern Florida and southeastern Georgia (Applin and Applin, 1944, 1967). As mentioned previously, beds of Navarro age are thin and discontinuous over much of the area, particularly where these strata are clastic. Navarroan rocks in the study area can be grouped into four general facies: (1) calcareous gray shale interbedded with thin, fine-grained sand in southern Alabama and panhandle Florida; (2) light- to dark-gray, glauconitic, locally shelly and calcareous sand, clayey sand, and clay in northeastern Georgia and South Carolina; (3) dominantly tan to white, pelletal, soft, friable, locally gypsiferous dolomitic limestone (Lawson Limestone) that contains the remains of algae and rudistid pelecypods in north-central Florida and southeastern Georgia (the Lawson is locally very porous owing to a decrease in its micrite matrix, and, where it is porous it is included as part of the Floridan aquifer system); (4) white chalk interbedded with light-gray argillaceous micritic limestone in southern peninsular Florida. The transition from clastic to carbonate rocks is abrupt and takes place along a northeast-trending line in southern Georgia, where both clastic and carbonate materials thin drastically. Navarroan rocks thicken to the northwest and southeast of this line, which is located approximately in the area labeled "Suwannee strait" on figure 3, and along its extension to the southwest. Applin and Applin (1967) thought that this area of thin Navarroan sediments represented a flexure that was positive during much of Late Cretaceous time but subsequently became a negative feature.

Although the Lawson Limestone is quite extensive, it is only in and near the Brunswick, Ga., area that the Lawson is sufficiently permeable to be considered part of the Floridan aquifer system. Elsewhere, rocks of Navarro age are of low permeability. The Lawson can be readily recognized because of its distinctive lithology and the rudistid pelecypod fauna that it commonly contains. Micritic limestone and clayey strata of Navarro age, by contrast, can often be distinguished from older rocks only on the basis of the microfauna that they contain. Rocks of Navarro age reach a maximum thickness of about 600 ft in southern peninsular Florida. For the most part, however, they are less than 200 ft thick.

Fauna characteristic of Navarroan rocks include the rudistid pelecypods mentioned earlier and the foraminifers *Vaughanina cubensis* Palmer, *Lepidorbitoides nortoni* (Vaughan), and *Sulcoperculina cosdeni* Applin and Jordan.

Fine-textured Navarroan strata in the study area were deposited in middle to outer shelf environments. The clastic rocks of Navarro age that lie updip from the chalks and micritic limestones were laid down in inner shelf to shoreline environments.

TERTIARY SYSTEM

PALEOCENE SERIES

GENERAL

Rocks of Paleocene age underlie the entire study area and can be grouped into two general facies categories: (1) a carbonate-evaporite facies that consists mostly of interbedded dolomite and anhydrite and (2) a clastic facies that consists primarily of shallow-marine clay and minor amounts of fine sand and impure limestone. The carbonate-evaporite facies underlies all of peninsular Florida and a small part of southeastern Georgia, and the predominantly clastic facies lies to the north and west of the carbonate platform. The demarcation between these two facies is sharp, and they are assumed to interfinger with each other over a narrow transition zone, although no well drilled to date (1983) has shown such interfingering.

The distribution of the clastic and carbonate facies in rocks of Paleocene age is shown on plate 3, which also shows the configuration of the top of the Paleocene and the area where rocks of Paleocene age crop out. In Alabama and extreme western Georgia, the top of the Paleocene is contoured into the outcrop area. From central Georgia northeastward to South Carolina, the updip extent of the Paleocene is based on well control because Paleocene rocks are mostly overlapped there by younger strata. In South Carolina, the Paleocene is known to extend for a considerable distance to the north of the contours shown on plate 3. Paleocene rocks were contoured only to the limit of the well control used to delineate the Floridan aquifer system.

Plate 3 shows that several large-scale structural features affect the shape of the top of Paleocene rocks. In the western third of the study area, the Paleocene top slopes steadily at a rate of about 30 ft/mi toward the axis of the Gulf Coast geosyncline. Farther eastward, a low area of moderate size extending from Franklin County to Leon County, Fla., represents the