A GEOLOGIC ATLAS OF THE WRENS-AUGUSTA AREA

by

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INTRODUCTION

The map area is within the Fall Line Hills and Vidalia Upland Physiographic Districts (Clark and Zisa, 1976), and includes the municipalities of Augusta, Thomson, and Wrens. See Plate 2 for the locations of the boundaries of the Physiographic Districts and the quadrangles which were mapped. The scale of the map is 1:100,000.

Most of the area is rural with the land primarily used for farming and timber production. An exception to this is the vicinity of Augusta which is a rapidly developing urban/industrial area. Other exceptions are the active kaolin mining areas between Wrens and Thomson, and near Hephzibah.

The area is environmentally sensitive because it contains a significant portion of the recharge area for the Cretaceous-Lower Tertiary aquifer system (Curtin, 1984; Pollard and Vorhis, 1980), which supplies water to a large area of south Georgia. Recent studies of the area have subdivided the local Cretaceous-Lower Tertiary aquifer system into the Dublin (Cretaceous and Tertiary) and Midville (Cretaceous) aquifer systems (Clarke, and others, 1985). Other aquifers which recharge in the area are the Gordon (Tertiary) aquifer system (Brooks, and others, 1985) and the Jacksonian (Upper Eocene) aquifer, which is a local source for shallow water wells (Vincent, 1982). In the area of Richmond and northern Burke Counties, there are concerns that the rapid growth in both population and industrial activity will stress the availability and quality of the ground water (Gorday, 1985).

Earlier geologic maps of the area include those of LeGrand and Furcon (1956) with a scale of 1:250,000, and the Georgia Geologic Survey's Geologic Map of Georgia (1976) with a scale of 1:500,000. Richmond County, Screven County, Glascock County, and Burke Counties, were mapped by Sandy (1966b, and 1966c), and Sandy and others (1966b, 1966c). The geologic map of the present atlas differs from these previous maps of the area in that 1) the crystalline rocks are not subdivided; 2) the kaolinitic sediments are subdivided into several formations; and 3) the Tertiary sediments are subdivided into several formations not shown on the earlier maps.

This atlas is one of a series which is being produced by the Georgia Geologic Survey to cover the zone of sediments immediately south of the Fall Line. The area covered by this atlas directly adjoins to the west with the area included in the geologic map of the Georgia Geologic Survey Geologic Atlas 6 (Hetrick and Friddell, 1990). Wherever possible identical colors were used on both maps. This was not entirely possible due to the fact that the Barnwell Group of Geologic Atlas 6 was shown as one map unit, whereas, in the current atlas the Barnwell is subdivided into two map units (Dry Branch Formation and Tobacco Road Formation). Also the undifferentiated sediments of the current atlas are more narrowly defined (Middle Eocene to Upper Eocene) than they were on Geologic Atlas 6 (Upper Cretaceous to Recent).

In one small area at the eastern edge of Geologic Atlas 6 the sediments undifferentiated were not separated from the Paleozoic undifferentiated; whereas, the separation was made in this atlas. The area of nonseparation in Geologic Atlas 6 is located east of Hamburg Millpond and north of the junction of Little Ogeechee River with the Ogeechee River.

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GENERAL LITHOGRAPHIC AND STRATIGRAPHIC DISTRIBUTIONS

The map area is divided into three physiographic districts (Clark and Zisa, 1976); the Washington Slope District, the Fall Line Hills District, and the Vidalia Upland District. Plate 2 contains a schematic showing the locations of the physiographic district boundaries within the area covered by the atlas. The rocks of the Washington Slope District are igneous and metamorphic and are not described in the atlas. However, a structure contour map (Plate 3) was produced for the unconformity between the Coastal Plain Sediments and the underlying "basement." "Basement" includes igneous and metamorphic rocks and Triassic sediments. The structure contour map was produced by combining the data collected for this atlas with data from Gorday (1985).

The Fall Line Hills District

All of the formations which crop out in the map area are found exposed within the Fall Line Hills District. This is due to the relatively hilly terrain in the district which affords numerous exposures and produces intricate outcrop patterns of stratigraphic units on the geologic map. Within the Fall Line Hills District of the study area, land surface elevations generally decrease eastward towards the Savannah River. This produces a general pattern on the geological map of progressively older sediments onlapping the Piedmont to the east. The net affect of this relationship is a change from marine (Upper Eocene) clays, sands, and cherts onlapping the Piedmont at the western edge of the map, to an onlap of marginal marine/fluvial (lower Tertiary) kaolinitic sands and clays near the center of the Fall Line Hills District, to an onlap of fluvial (Upper Cretaceous) kaolinitic sands and clays near the Savannah River.

The structural contours of the contact between the "basement" and the Coastal Plain sedimentary rocks, which show a general pattern of a northeast-southwest strike and a dip to the southeast, show a gradual increase in dip to the east. At the eastern edge of the map, near the Savannah River where the Cretaceous sediments onlap the Piedmont, the slope of the interface between the Cretaceous sediments and the buried surface of the "basement" is approximately 40 feet per mile. At the western end of the map, in the vicinity of Beal Springs, where Tertiary sediments onlap the Piedmont the slope of the Tertiary sediment/"basement" interface is approximately 20 feet per mile. Further west, near Warrenton, where Upper Eocene sediments onlap the Piedmont, the Coastal Plain/"basement" interface has a slope of 15 feet per mile.

Differences in the slope of the sediment/"basement" interface could be due to regional differences in (1) tectonic activity, (2) the amount of paleo-erosion, or (3) irregularities in paleo-shoreline. However, the direct association between the onlap of Tertiary sediments with a shallow dip on the underlying "basement" surface, and the onlap of Cretaceous sediments with a steeper dip on the "basement" surface, supports the idea that the lower slope of the Tertiary sediment/"basement" interface is related to events occurring since the Cretaceous sediments were deposited.

Based on the sediment/"basement" contact elevations in the Fort Gordon area, a reasonable interpretation of the sediment/"basement" interface agrees with the presence of the Belair fault (O'Connor and Prowell, 1976), and indicates that Cretaceous sediment was faulted. However, no evidence was found to indicate that Tertiary sediments were faulted.

Vidalia Uplands District

The Vidalia Uplands District has lower relief, fewer stratigraphic units cropping out, and less unweathered exposures than does the Fall Line Hills District. Exposures of Upper Eocene sands and cherts and Miocene clays and gravels cap the broad uplands, with only narrow bands of Middle to Upper Eocene sands and clays found along the edges of stream valleys. The beds which cap the uplands are composed of very cohesive, highly weathered, poorly sorted clayey sands, sandy clays, and cherts. It is probable that the cohesive consistency of these materials is at least partially responsible for the low relief and broad uplands of the Vidalia Uplands District.

Snipes and others (1990) reported the presence of the Pen Branch fault, a Late Cretaceous-Tertiary fault, in South Carolina. They found that "The western extent of the fault is not known, but probably continues westward into Georgia where it passes about 2 mi (3 km) north of Vogtle Electric Generating Plant." No evidence of this fault was found in the field study for this atlas.

GEOLOGIC UNITS THAT CROP OUT IN THE MAP AREA

The lithologic descriptions in this atlas are of the geologic units as they were observed within the map area. For more information on the regional distribution patterns, descriptions, paleontology, and correlations the reader is referred to the following: Austin (1972), Buie (1978), Buie and others (1979), Carver (1966), Crawford and others (1966), Herrick (1972), Herrick and Counts (1968), Hetrick (1990), Hetrick and Friddell (1983, 1990), Huddlestun (1981, 1988), Huddlestun and Hetrick (1978, 1979, 1986), Huddlestun and others (1974), LaMoreaux (1946), Pickering (1970), Schmidt and Wise (1982), Schroder (1982), Scrudato (1969), Scrudato and Bond (1972), Tschudy and Patterson (1975).

Alluvium (Quaternary)

The alluvium consists of sand, clayey sand, clayey silt and minor stringers and beds of gravel. The sediments are generally micaceous, poorly sorted and range in particle size from clay to gravel. Bedding is thin, crude to massive and locally cross bedded. The alluvium is as much as thirty feet thick in the study area. These sediments are distributed within the flood plains of present-day stream valleys and commonly underlie swampy or boggy areas, where they locally contain abundant organic matter.

Altamaha Formation (Miocene)

The Altamaha is a stratigraphic term which was reintroduced by Huddlestun (1988) as a formation within the Hawthorne Group. The Altamaha Formation, as defined by Huddlestun (1988) is essentially the same as the Altamaha Grit of Dall and Harris (1892). The Altamaha Formation of this atlas is the same as the Hawthorne Formation of LeGrand and Furcron (1956) in their map of the atlas area and the Neogene Undifferentiated of the 1976 Geologic Map of Georgia. For detailed descriptions and stratigraphic relationships of the Altamaha Formation, see Huddlestun (1988).

The Altamaha Formation is fluvial to upper estuary in origin (Huddlestun, 1988). The Altamaha is composed of poorly sorted, pebbly, argillaceous, micaceous sands, sandy clay, and minor amounts of gravel and angular pebbles. Unweathered exposures contain some feldspar. Typically the lowest bed of the Altamaha is a two to six-foot thick gray to green, silty, sandy clay lens which is overlain by sand beds containing gravel. The gravel is angular to rounded and contains some particles two inches or more in diameter. Much of the gravel is strongly cross-bedded. The overall color of the least weathered exposures of Altamaha is light gray. Typically the exposures are highly weathered and the color is tan to gray to dark reddish-brown color with the colors distributed in small irregular patches.

In the map area, a few isolated exposures with "Altamaha like" lithology were found at lower than expected elevations and surprisingly far updip. These exposures are most easily explained as being small isolated remnants of deposits associated with Tertiary-Quaternary stream terraces. Due to the very limited areal extent of these "Altamaha like" exposures they were not mapped separately.

One of the problems in identifying the Altamaha Formation is that the lower clay beds of the Altamaha resemble the clays found in the upper portion of the underlying Tobacco Road Formation. In some areas, such as in southern portion of the Keysville Quadrangle, this is not a problem because oyster fossils are found in the upper clays of the Tobacco Road Sand. A second problem in identifying the Altamaha Formation is that although the gravel clasts in the underlying Tobacco Road are usually flattened and rounded, identifying them as having a shore line origin, some of the Tobacco Road gravel clasts are not flattened and rounded and thus might be confused with the gravel of the Altamaha. In an attempt to resolve the above problems, the criteria of elevation and proximity to outcrops of known age were used.

In an area near the southeastern corner of the map (in the vicinity of Greens Cut, Shell Bluff, and Alexander), Altamaha Formation sediments occur at lower than expected elevations as compared to Altamaha exposures further to the west. The gravels found in the Altamaha in this area are scarce and are finer-grained than those typically found in the Altamaha, and the sands are finer-grained than typical for the Altamaha. The assignment of sediments near the Savannah to the Altamaha Formation took into consideration the opinions of earlier investigations of the stratigraphy of the area (LeGrand and Furcon, 1956; Herrick and Counts, 1968; Huddlestun, 1988).

Tobacco Road Sand Formation (Upper Eocene)

The Tobacco Road Sand is the same unit described by LaMoreaux (1946) as the Upper Sand Member of the Barnwell Formation. Recently the Barnwell Formation has been upgraded to the Barnwell Group (Huddlestun and Hetrick, 1986) with the Tobacco Road Sand as one of the formations included in the Group. For detailed descriptions and correlations of the Tobacco Road Sand see Huddlestun and Hetrick (1979, 1986).

The Tobacco Road Sand is highly variable in its particle size, and sorting, however, it is generally a medium-grained and very poorly sorted, slightly argillaceous sand. The bedding is typically cross-bedded and marked by discontinuous clay laminae. A zone of flattened and rounded fine gravel (¼″–¾″) is commonly found near the base, which indicates that at least the lowest several feet of the formation were deposited at the shoreline (Huddlestun and Hetrick, 1978). In most instances where the Tobacco Road Sand crops out, it is the formation which caps the ground surface; and usually it is weathered to a reddish brown color. Another feature which distinguishes the typical Tobacco Road exposure from other formations is the presence of numerous burrows, both *Ophiomorpha nodosa* and smaller (⅛ inch diameter) unidentified burrows.

The above description applies to many exposures of Tobacco Road Sand, especially in the vicinity of Augusta and Fort Gordon. There are a few exposures in all areas where the Tobacco Road crops out which contain the diagnostic characteristics of the type locality at Morgan Road, Augusta (Huddlestun and Hetrick, 1978). The Tobacco Road Sand, however, contains a number of other lithofacies and, the further away from the Fall Line area one proceeds, the less frequently the diagnostic sedimentary characteristics of the type locality are encountered. For example, although the beach pebble zone (rounded and flattened fine gravel) extends as far southeast as Peters Branch (just east of Alexander), in the vicinity of Girard and Shell Bluff (southeastern portion of map area) no beach pebbles were found in the coarse-grained sand portion of the Tobacco Road.

In the updip area of the Tobacco Road in the vicinity of Beal Springs and Bastonville (approximately 8 miles south of Warrenton) there are outcrops containing well-sorted, thin-bedded, fine-to very fine-grained sand distributed between outcrops containing only the more commonly occurring coarser-grained facies. A number of these beds of fine-grained sand are bioturbated to the point that all traces of bedding have been destroyed. This area of mixed facies (coarse-grain and fine-grain) is possibly the result of an irregular shoreline at the time of deposition, with local sedimentation in small bays that were protected from wave action. In such a wave-protected environment, burrows would have a better chance of being preserved and finer particles would settle out in the quieter environment. In the same general area, approximately four miles east of Gibson, there is a small lens of silicified limestone in the Tobacco Road.

Locally the Tobacco Road contains lenses of silty to sandy clay one to three feet thick. Most of these clay lenses are fissile, pale gray to pale greenish-gray and many are highly distorted, as if by compaction. Burrows are locally found in the sands associated with the clay lenses and overlying the lenses. In the Downs Quadrangle (southwest corner of map area) oyster fossils are found in massive bedded silty clays at the top of the Tobacco Road. There is a general trend within the Tobacco Road of increasing chert content in the downdip direction (towards the southeast). This trend is most apparent in the eastern portion of the map area, especially in the Storys Millpond and McBean Quadrangles, where the upper portion of the Tobacco Road contains numerous lenses of fossiliferous sandy chert (two to six feet thick). In the Alexander Quadrangle (adjacent to the south east corner of the McBean Quadrangle) most outcrops of Tobacco Road are composed of fine-grained sand and clayey silts which are thinly and intricately bedded. These fine sands and clayey silts are locally distributed between exposures of medium-grained sands with rounded and flattened pebbles. One of these exposures of medium-grained sand, at Hatcher's Mill (Huddlestun and Hetrick, 1978), contains a chert bed with the Upper Eocene index fossil *Periarchus quinquefarius*. At localities scattered throughout the map area, there are exposures of Tobacco Road which are composed of massive-bedded, moderately sorted, medium-grained sand up to 20 feet thick.

The origin and correlation of some thick beds of massive to nearly massively bedded sand in the Augusta area are an unresolved problem. In the present atlas, these beds are mapped as Tobacco Road Sand based on elevations. Exposures of the Dry Branch Formation, which underlies the Tobacco Road, occur beneath some of the massive sands in question; and exposures with the distinctive characteristics of the Tobacco Road occupy the localities with the highest elevations in the area. On first examination these massive sand beds appear to be eolian deposits; however, after further examination zones of bedded gravel were found within lower portions of the beds and at several localities these same beds are found directly overlying Lower Tertiary kaolins. The base of one of these "Tobacco Road" exposures contains disseminated kaolinite, kaolin clasts, flattened and rounded quartz pebbles, and burrows. The quartz pebbles and burrows appear identical to those found in the Tobacco Road, and the kaolinite and kaolin clasts are presumably reworked from the underlying Huber Formation.

The possibility that the sediments in the massively bedded sands are the result of recent stream terraces is small due to the lack of organic material, dark clay or metamorphic rock fragments, which are characteristics of local recent fluvial deposits. A possible origin of these sediments is the reworking of Tobacco Road sediment by storms and winds during or shortly after deposition. The relative "cleanness" of the deposits would be the expected end result of storm-reworked beach sand from a beach located some distance from the Piedmont highlands. The deposits in question are somewhat similar to beach ridge deposits described by Reineck and Singh (1975) as ". . . a continuous linear mound of rather coarser sediment near the high water line. The sediments have been heaped up by waves during high waters beyond the mean high-water line, and storm tides."

Dry Branch and Clinchfield Formations (Upper Eocene)

The Dry Branch and Clinchfield Formations, along with the overlying Tobacco Road Sand Formation make up the Barnwell Group. The Barnwell Group is a correlative of the Ocala Group of southwestern Georgia (Huddlestun, 1981). For detailed descriptions of the Barnwell Group and specifics of its correlation see Huddlestun and Hetrick (1986) and Herrick (1972).

Within the map area, the Dry Branch Formation occurs as the Twiggs Clay Member, the Irwinton Sand Member and the Griffins Landing Member. The occurrences of Twiggs Clay in the map area diminish to the east with only several small isolated exposures occurring near the Fall Line in the Fort Gordon-Augusta area. The Irwinton Sand Member extends across the entire map area; however, east of Brier Creek its occurrence is restricted to localities within several miles of the Fall Line. Many exposures of the Dry Branch contain both Irwinton Sand and Twiggs Clay Members interfingering in an unpredictable manner. The Griffins Landing Member occurs most frequently in areas adjacent to the Savannah River, and is not known to occur west of Wrens or within several miles of the Fall Line. Only several exposures which contain the Griffins Landing Member are also found to contain either the Twiggs or Irwinton Members.

The Clinchfield Formation underlies the Dry Branch Formation, however, in the map area the distribution of the Clinchfield is irregular and it is known to occur only in a few locations. The two members of the Clinchfield Formation exposed in the area are the Utley Limestone Member and the Albion Member. The Utley has been found at several small exposures in the vicinity of Georgia Power Company's Plant Vogtle in Burke County (Huddlestun and Hetrick, 1986). Exposures of the Albion have been found at the Albion kaolin mine near Hephzibah, on Winsor Springs Road, and at several localities in the southeastern quarter of the Harlem quadrangle (Sandy and others, 1966; Crawford and others, 1966).

The **Twiggs Clay Member** of the Dry Branch was probably deposited in mud flats within the intertidal zone. The Twiggs is a thin-bedded, silty, finely sandy, dense, micaceous, smectitic clay which contains minor amounts of cristobalite and kaolinite. The clay is fissile with subconchoidal to irregular fracture and ranges in color from very pale greenish-gray to very pale gray to dark gray. The Twiggs generally contains laminae of silt to very fine-grained sand. Thin layers of Irwinton type sand (the Irwinton is described below) are common within the Twiggs. The presence of small fragile pelecypods within the clay indicates that the Twiggs has a marine origin. In some of its northernmost occurrences in the area (near Harlem and in kaolin mines in the Bowdens Pond Quadrangle), the Twiggs contains abundant plant fossils. Typical exposures of Twiggs weather to a very pale-green color and readily undergo mass wasting and slumping, obscuring original bedding and texture. The exposures end up as a massive, viscous, and sticky, swelling clay which is a very poor base for roads or other construction. At Wrens, where the Twiggs is mined as fuller's earth, the clay readily weathers upon exposure to a hard brittle near-white clay. There are small lenses of this light colored brittle Twiggs at a few other localities very close to the Fall Line. X-ray diffraction of a piece of near-white brittle Twiggs clay from the Wrens mine revealed that the major mineral component is cristobalite. Another variant of the Twiggs lithology occurs in Richmond County where, in several cores, the basal few feet of Twiggs is composed of a clayey very coarse-grained very poorly sorted sand which contains angular quartz fragments up to ⅓ inch in diameter.

The **Irwinton Sand Member** of the Dry Branch Formation is probably a sand flat deposit within the intertidal zone. The Irwinton is a medium-grained moderately sorted sand. The bedding of the Irwinton is sharp and thin, and planar-truncated cross-bedding is common. The Irwinton contains low amounts of heavy minerals and its mica content is low to moderate. It has low resistance to erosion and thus, good exposures are found mainly on steep slopes, in ravines, and in mines. The Irwinton commonly contains "Twiggs type" clay in thin beds and rip-up clasts. Burrows are locally present in the Irwinton but they are not common.

The **Utley Limestone Member** of the Clinchfield Formation is, as described by Huddlestun and Hetrick (1986), ". . . typically a sandy, glauconitic, slightly argillaceous, fossiliferous limestone with varying degrees of induration. In places the sand content is great enough to render the deposit a very calcareous sand or sandstone."

The **Albion Member** of the Clinchfield Formation is described by Carver (1972) as consisting of ". . . discontinuous lenses of spiculite, spiculitic clay and mudstone and opal-cemented sandy spiculite and spiculitic sandstone (Buie and Oman, 1963; Carver, 1966, 1968)."

Sediments and Residuum Undifferentiated (Upper Eocene-Middle Eocene)

The undifferentiated sediments and residuum occur in highly weathered exposures located near the Fall Line, which by projection of formation contacts should be either Middle or Upper Eocene. The exposures are generally clayey, coarse-grained, poorly sorted sand or gravel. For many of the Fall Line exposures the distinction between highly weathered Eocene sediments and Piedmont saprolite is difficult to establish.

Lisbon Formation (Middle Eocene)

The Lisbon Formation is represented in the map area by the McBean and Blue Bluff Members (Huddlestun, 1981). The McBean member has a small outcrop area with exposures limited to the immediate vicinity of McBean Creek. The Blue Bluff Member is found exposed near the base of steep bluffs along the Savannah River, in the vicinity of Plant Vogtle. The descriptions and map outcrop patterns of the McBean and Blue Bluff Members are primarily based on cores.

The **McBean** is composed of soft, clayey, fine- to medium-grained, moderately sorted calcareous sand. Locally the McBean contains nodules of limestone and is fossiliferous (see Herrick and Counts (1968) for fossil list). The **Blue Bluff** is a tough, calcareous, pale bluish-gray, massive-bedded, clayey silt.

Huber Formation (Paleocene-middle Eocene)

The Huber Formation was named by Buie (1978) ". . . for all of the post-Cretaceous pre-Jacksonian strata in the kaolin mining districts of Georgia, northeast of the Ocmulgee River" (Buie, 1978, p. 1). Sediment shown on this atlas as Huber Formation was included in the Cretaceous Tuscaloosa Formation (LeGrand and Furcron, 1956) and in the Lower Tertiary-Cretaceous undifferentiated of the 1976 Geologic Map of Georgia. East of the study area, near Macon, the Huber has been divided into the Paleocene Marion Member and the Middle Eocene Jeffersonville Member (Huddlestun and Hetrick, 1991). Although in the study area there are some lithologic differences in the Huber at different depths, it has not yet been demonstrated that these differences correspond to the Marion and Jeffersonville Members.

The Huber is composed of kaolinitic sand, sand, sandy kaolin, and kaolin. The sands of the upper portion of the Huber are generally kaolinitic, micaceous, coarse-grained and poorly sorted. Most beds are cross-bedded, and contain numerous kaolin clasts of assorted sizes. Commonly near or at the top of the Huber there is a bed 7 to 20 feet thick which is composed of a very sandy kaolin or kaolinitic sand in which the sand is very coarse-grained and very poorly sorted, with angular particles in the coarser sizes. Some beds of this sandy kaolin are pyritic and lignitic. Locally these pyritic beds are weathered to a mottled dark reddish brown to pale-green color. Near Hephzibah and in the Augusta area, the upper sandy koalins are cemented by silica, which appears to have migrated down from the overlying Albion Member of the Upper Eocene Clinchfield Formation. Mica and heavy minerals are present in the upper portions of the Huber, but typically are not as abundant as in the lower portions of the Huber or the underlying Cretaceous sediments.

Between Wrens and Thomson, especially in the Bowdens Pond Quadrangle, there are numerous active kaolin mines. All of the kaolin present is within the Huber and is probably correlative with the Jeffersonville Member (new name formalized by Huddlestun and Hetrick, 1991). On the north edge of this mining area, where the middle Eocene sediments impinge upon the Piedmont crystalline rocks, the presence of a basal zone containing well-rounded coarse quartz gravel is a characteristic of the contact of Middle Eocene sediments with the Piedmont.

The sands of the lower portion of the Huber are generally better size-sorted and have a smaller particle size than do the sands of upper portions of Huber sediments. However, the lower Huber sands do contain some beds which contain very coarse-grained (up to gravel-size) clastics and are very poorly sorted. Clayey sands and clays are common within the Huber, as are lignitic clays. Mica content is moderate to very high and opaque heavy minerals are locally abundant. In cores near Blyth (GGS core 3762) and Bath (GGS core 3184), beds of medium-to fine-grained, moderately sorted, highly micaceous sand were found in thicknesses of up to thirty feet.

Gaillard and Pio Nono Formations Undifferentiated (Upper Cretaceous)

Cretaceous sediments near Macon have recently been divided into the Gaillard and Pio Nono Formations (Huddlestun and Hetrick, 1991). On previous maps Cretaceous age sediments in the atlas area were included in the Tuscaloosa Formation (LeGrand and Furcron, 1956) and Lower Tertiary-Cretaceous undifferentiated (Geologic Map of Georgia, 1976). Although the Pio Nono is reported to have been found in the Miller's pond core (GGS core 3758) near McBean Creek (Huddlestun, personal communication, 1991), it is uncertain that the Pio Nono crops out in the map area. In fact, it is only with difficulty that the Cretaceous sediments are differentiated from the Huber Formation sediments within the map area. Most of the criteria which have been used for separating the Huber Formation from the Cretaceous sediments are based on differences in the physical properties of the kaolin clay beds (Buie, 1978; Buie and others, 1979; Hetrick and Friddell, 1983). Between Macon and Sandersville deposits of kaolin at the top of the Cretaceous are so continuous that the kaolin has been formally named the Buffalo Creek Member of the Gaillard Formation (Huddlestun and Hetrick, 1991).

In the map area, with the possible exception of commercial kaolin in the Albion mine near Hephzibah, the thick Cretaceous kaolin deposit (Buffalo Creek Member) is not found. In the absence of the Buffalo Creek Member, the criterion most relied upon for determining the top of the Cretaceous deposits is the presence of zones of deeply weathered sediment. Commonly, the upper three to twenty feet of the sand (or kaolin) is very strongly stained maroon to purple and contains considerable iron oxide. The sands of the Cretaceous are pebbly to very coarse-grained, kaolinitic, and contain very coarse-grained mica flakes. Gravel is locally present in the upper-most sand. Some thin sandy "soft" kaolin beds are present, but generally the kaolin is disseminated within the sand. Kaolin balls are locally present, but not common. At several exposures kaolin is abundantly present in the form of clasts the size of coarse-grained sand. In cores lignite and pyrite also are present.

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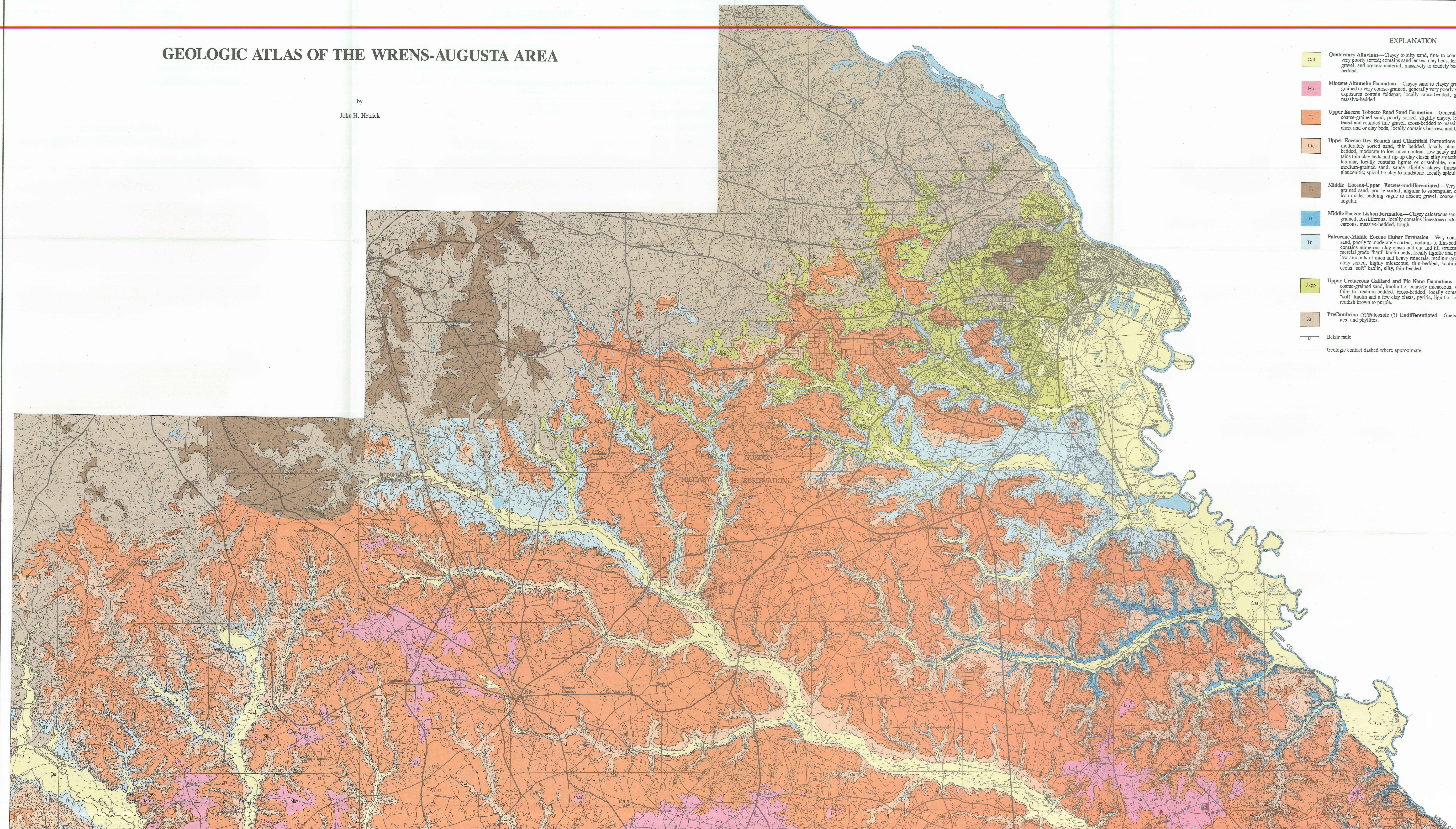
GEOLOGIC ATLAS OF THE WRENS-AUGUSTA AREA

by

John H. Hetrick



EXPLANATION

Qal — **Quaternary Alluvium**—Clayey to silty sand, fine- to coarse-grained, well- to very poorly sorted; contains sand lenses, clay beds, lenses and stringers of gravel, and organic material, massively to crudely bedded, locally cross-bedded.

Ma — **Miocene Altamaha Formation**—Clayey sand to clayey gravel; sands are fine-grained to very coarse-grained, generally very poorly sorted; unweathered exposures contain feldspar; locally cross-bedded, generally thick and massive-bedded.

Tt — **Upper Eocene Tobacco Road Sand Formation**—Generally medium- to very coarse-grained sand, poorly sorted, slightly clayey, locally contains flattened and rounded fine gravel, cross-bedded to massive, locally contains chert and or clay beds, locally contains burrows and bioturbation.

Tdc — **Upper Eocene Dry Branch and Clinchfield Formations**—Medium-grained moderately sorted sand, thin bedded, locally planar truncated cross-bedded, moderate to low mica content, low heavy mineral content, contains thin clay beds and rip-up clay clasts; silty smectitic clay, micaceous, laminar, locally contains lignite or cristobalite, contains thin beds of medium-grained sand; sandy slightly clayey limestone, fossiliferous, glauconitic; spiculitic clay to mudstone, locally spiculitic sandstone.

Tu — **Middle Eocene-Upper Eocene-undifferentiated**—Very coarse- to fine-grained sand, poorly sorted, angular to subangular, clayey, stained with iron oxide, bedding vague to absent; gravel, coarse to fine, rounded to angular.

Tl — **Middle Eocene Lisbon Formation**—Clayey calcareous sand, fine- to medium-grained, fossiliferous, locally contains limestone nodules; clayey silt, calcareous, massive-bedded, tough.

Th — **Paleocene-Middle Eocene Huber Formation**—Very coarse- to fine-grained sand, poorly to moderately sorted, medium- to thin-bedded, cross-bedded, contains numerous clay clasts and cut and fill structures, contains commercial grade "hard" kaolin beds, locally lignitic and pyritic, moderate to low amounts of mica and heavy minerals; medium-grained sand, moderately sorted, highly micaceous, thin-bedded, kaolinitic, lignitic; micaceous "soft" kaolin, silty, thin-bedded.

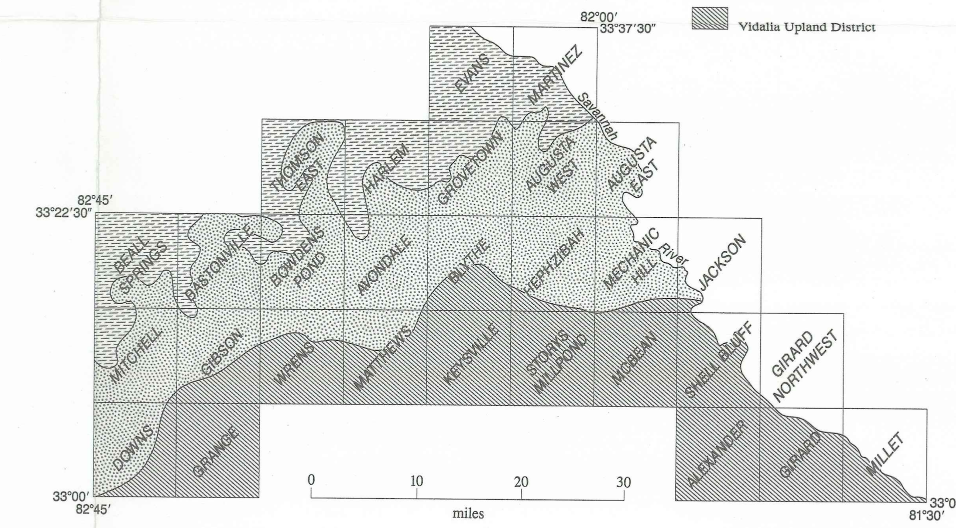
UKgp — **Upper Cretaceous Gaillard and Pio Nono Formations**—Medium- to very coarse-grained sand, kaolinitic, coarsely micaceous, very poorly sorted, thin- to medium-bedded, cross-bedded, locally contains beds of sandy "soft" kaolin and a few clay clasts, pyritic, lignitic, locally stained dark-reddish brown to purple.

Xtl — **PreCambrian (?)/Paleozoic (?) Undifferentiated**—Gneisses, schists, granites, and phyllites.

U — Belair fault

Geologic contact dashed where approximate.

Map Area With Outlines of Physiographic Districts* and Quadrangles Superimposed



*after Clarke and Zisa (1976)

N

SCALE 1:100 000
1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND
CONTOUR INTERVAL 10 METERS

KILOMETERS 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

MILES 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13

STRUCTURE CONTOUR OF SEDIMENT/BASEMENT* INTERFACE
WRENS-AUGUSTA AREA

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John H. Hetrick

*Basement is defined as igneous and metamorphic rocks and triassic sediments.

EXPLANATION

—50-- **STRUCTURE CONTOUR**—Shows altitude (feet above mean sea level) of the sediment/basement interface. Dashed where approximately located. Structure contour interval is 25 feet.

—U— **Belair Fault,** U is upthrown side

N

SCALE 1:100 000

1 CENTIMETER ON THE MAP REPRESENTS 1 KILOMETER ON THE GROUND

CONTOUR INTERVAL 10 METERS

KILOMETERS 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

MILES 1 0 1 2 3 4 5 6 7 8 9 10 11 12 13