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Open File Report 15

The Lithostratigraphy of Nassau County in Relation to the Superconducting Supercollider Site Investigation

by

Thomas M. Scott

Florida Geological Survey
Tallahassee, Florida
1987

THE LITHOSTRATIGRAPHY OF NASSAU COUNTY IN RELATION TO THE SUPERCONDUCTING SUPERCOLLIDER SITE INVESTIGATION

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INTRODUCTION

The State of Florida is currently conducting the initial site investigation in Nassau County for the proposed superconducting supercollider. Geologic parameters played a key role in the selection of several sites throughout the State. The final selection was made based on geological, environmental and socioeconomic factors with Nassau County being judged the most favorable location (Figure 1).

The Florida Geological Survey provided the initial site proposals based on the geological data available from Survey publications, personnel and files. The Nassau County site was included based upon the occurrence of a thick confining section above the Floridan aquifer system, the lack of potentially cavernous carbonates within the confining beds, and the existence of a surficial or shallow aquifer system that produces relatively limited quantities of water. The current Nassau County data base on file at the Florida Geological Survey is limited to lithologic samples from 30 wells (including 2 cores) and geophysical logs of 21 wells. These are listed in the appendicies.

STRUCTURE

Nassau County, the northeastern most county in Florida, lies on the northern and northwestern flank of the Jacksonville Basin of the Southeast Georgia Embayment (Figure 2). The Jacksonville Basin represents a localized thickening of the stratigraphic section within the Southeast Georgia Embayment. Figure 1 indicates the relationship of the Nassau County area to the other major structural features in Florida.

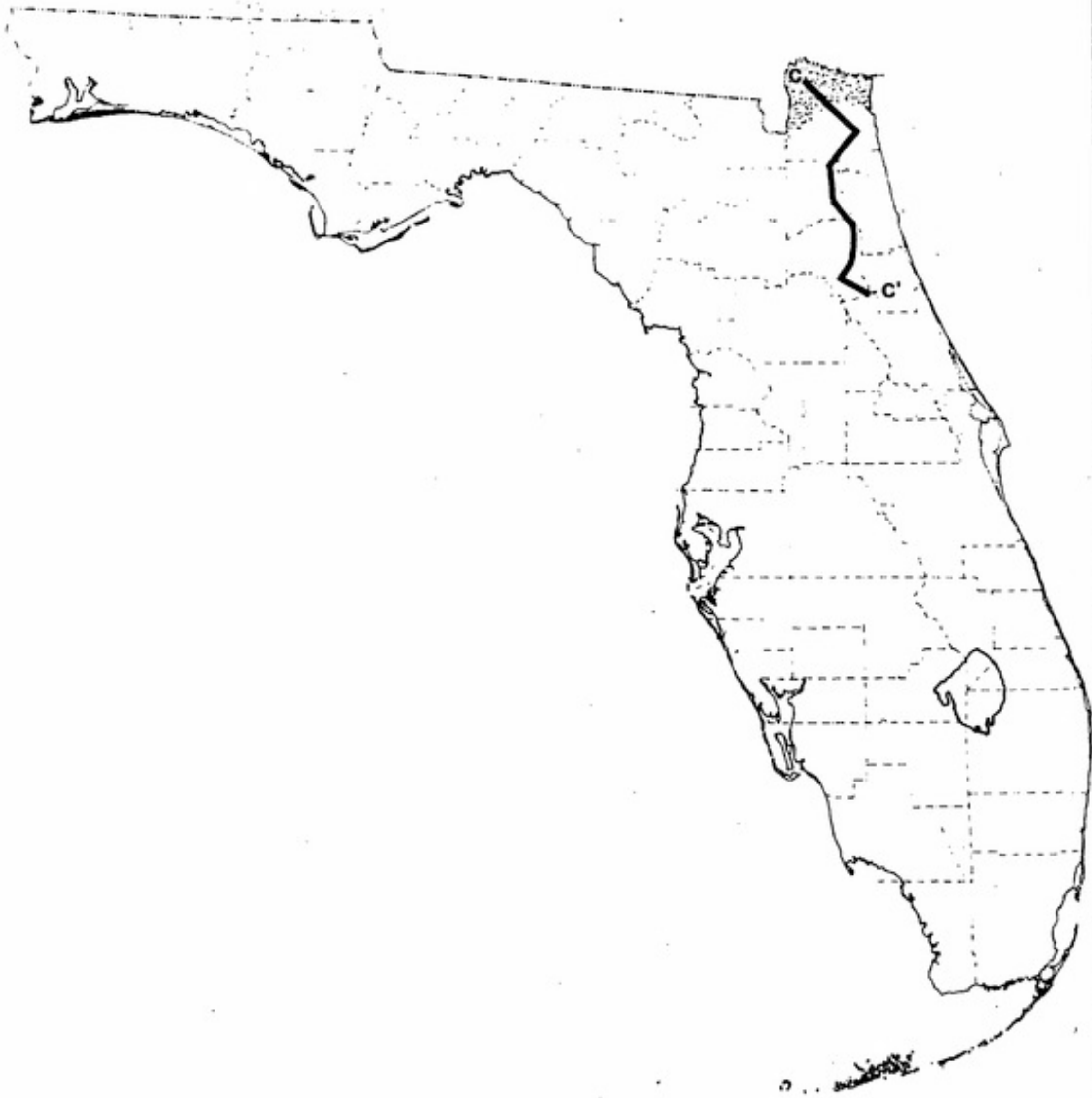


Figure 1 Study area and location of cross-section

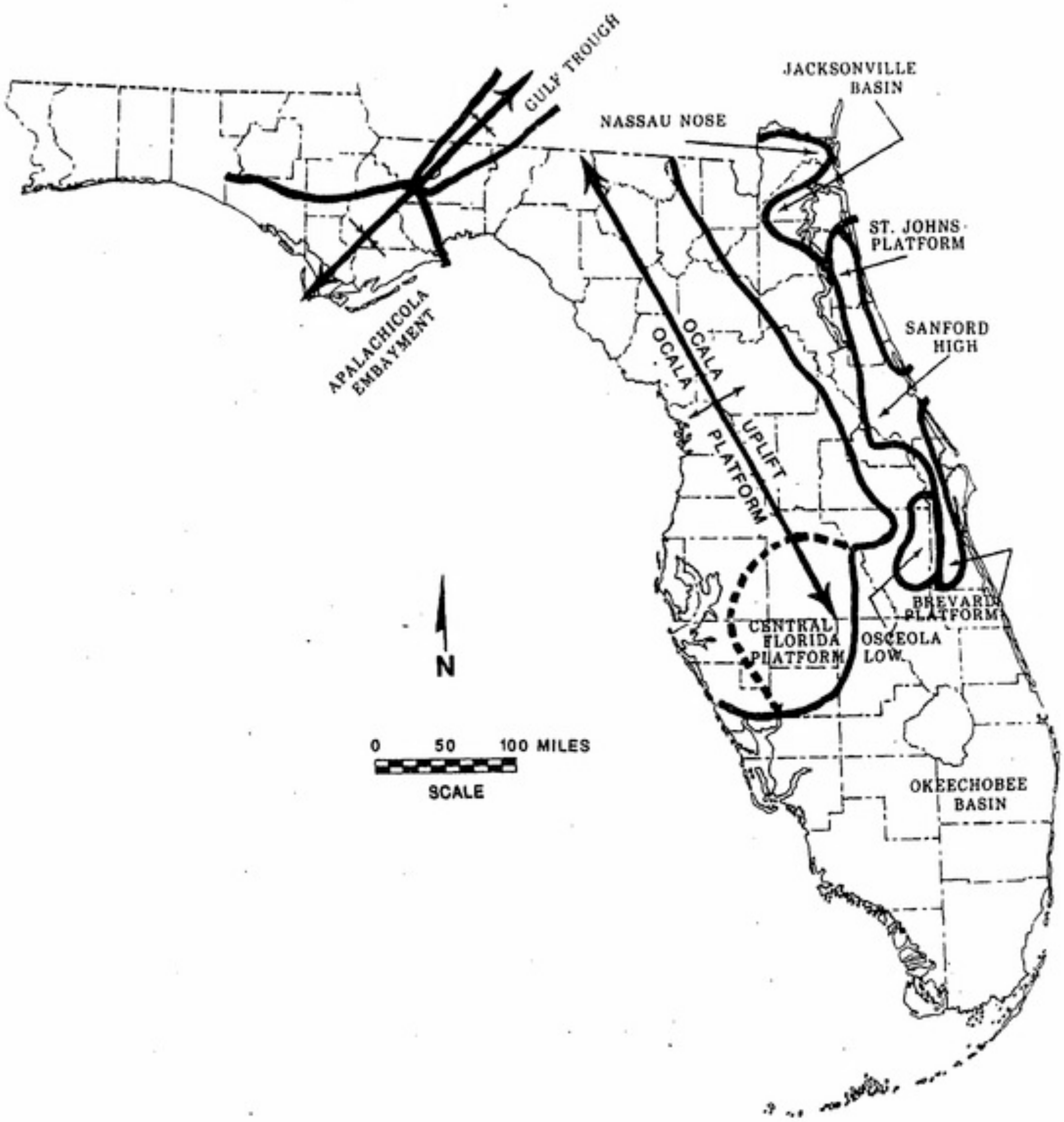


Figure 2 Structures affecting the Hawthorn Group

No faults have been recognized or postulated to occur in the county. Leve (1966) and Fairchild (1977) suggested the existence of faults in Duval County. If these faults exist, they do not appear to have cut through the Hawthorn Group sediments indicating that they have not been active since at least the late Middle Miocene.

Topography and Geomorphology

The topography of the Nassau County area characteristically consists of higher elevations with greater relief in the western one third of the county and lower elevations and little relief in the remaining area. The western area has elevations of as much as 107 feet above MSL near Boulogne; however, the average elevation in this area ranges from 70 to 80 feet above MSL. The lowlands surrounding the St. Marys River, generally the lowest points in the area, range in elevation from near 50 feet above MSL in the southwest to less than 5 feet above MSL along the northern boundary of the county. The eastern two-thirds of the county average less than 25 feet above MSL with the lowlands generally below 10 feet above MSL.

The topographic quadrangles covering Nassau County include, from west to east: Folkston, Boulogne, Kings Ferry, Kingsland, Toledo, Hillard, Hillard NE, Gross, St. Marys, Fernandina Beach, St. George, Hillard SW, Callahan, Italia, Hedges, Amelia City, McClenny NE, Bryceville, and Dinsmore.

Nassau County lies in the Northern or Proximal Zone of White (1970). The high areas of the western part of the county are part of the Duval Uplands. Most of the remainder of the county falls in the St. Marys Meander Plain. The east coast of Nassau County, the "Sea Islands", are part of the Atlantic Beach Ridges and Barrier Chain (Figure 3).

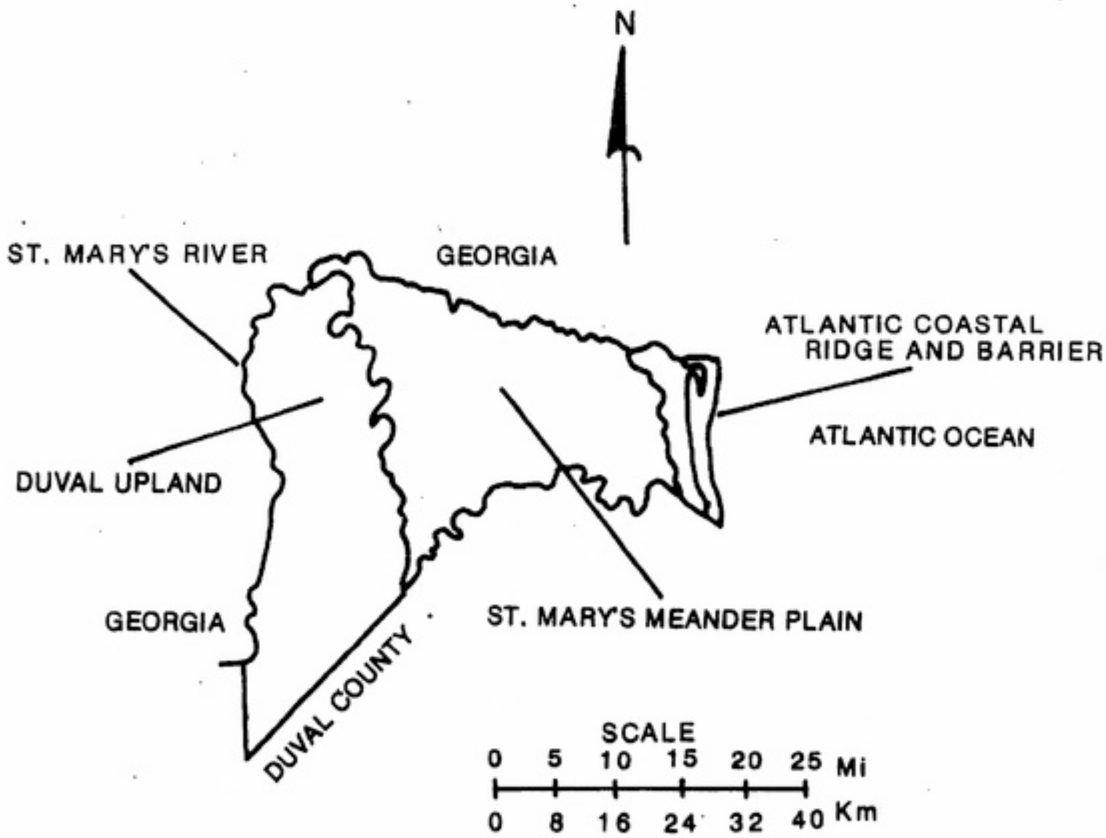


Figure 3 Geomorphology of Nassau County

LITHOSTRATIGRAPHY

Thin lithostratigraphic discussion of the supercollider site in Nassau County is limited to the carbonates of the upper part of the underlying Floridan aquifer system, the mixed carbonates and siliciclastics of the intermediate confining system and the sediments of the surficial or shallow aquifer system. This includes the Upper Eocene Ocala Group, the Miocene Hawthorn Group, the Pliocene Nashua Formation, and the undifferentiated Plio-Pleistocene and Holocene sediments (Figure 4). Total thickness of these sediments ranges from 400 to 500 feet within the county. Construction of the proposed supercollider will most likely occur in the upper 150 feet of this section within the Hawthorn Group.

Ocala Group

The Ocala Group consists of very pure limestones with limited occurrences of thin dolostone near the base of the group. The limestones are characteristically calcarenitic with varying amounts of carbonate mud in the matrix (grainstone to packstone). The grains are composed of fossil fragments, foraminifera, and biogenic debris. The limestones are generally tan or very light brown to white and range from soft, poorly consolidated to hard, well indurated and recrystallized. The dolostones are hard, generally well indurated, gray to moderate brown and crystalline.

The Ocala Group occurs throughout the county at elevations ranging from approximately 400 feet below mean sea level (MSL) in the western portion to greater than 500 feet below MSL along the east coast, dipping in a general west to east direction (Leve, 1966) (Figure 4). The thickness of the Ocala Group in this area ranges from approximately 350 feet to greater than 500 feet, thickening from west to east (Leve, 1966). Cooke (1945), Vernon (1951), Herrick and Vorhis (1963), Puri and Vernon (1964) and Stringfield (1966) provide more information on the Ocala Group. The rela-

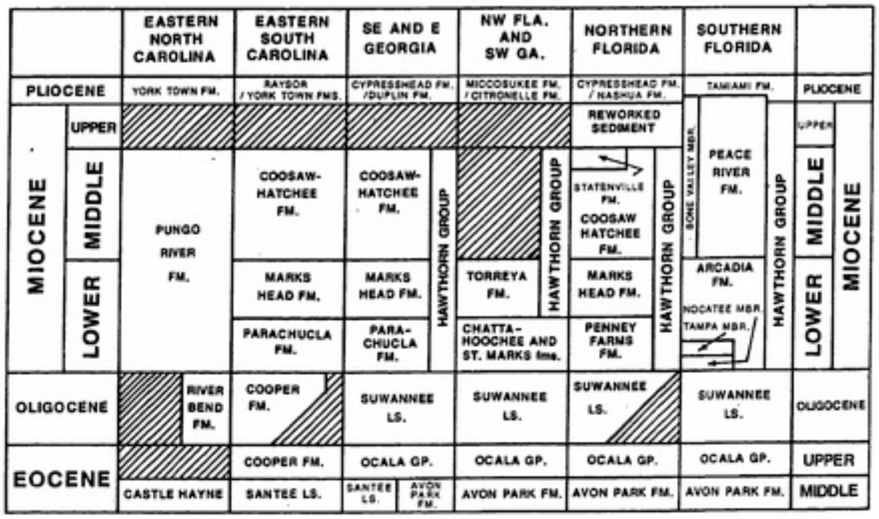


Figure 4 Lithostratigraphic units of the Hawthorn Group in north Florida

tionship of the Ocala Group to the overlying sediments can be seen in Figures 6 and 7.

The carbonates of the Ocala Group are part of the upper Floridan aquifer system and are capable of producing vast quantities of water. Leve (1966) indicates flow rates measured in zones of the Ocala Group often exceeded 3,000 gallons per minute. The sediments of the Floridan aquifer system will not be encountered during the construction of the supercollider. The construction activity will be separated from the Floridan aquifer system by as much as 300 feet of low permeability to relatively impermeable sediments of the Hawthorn Group.

Hawthorn Group

The Hawthorn Group sediments represent a dramatic depositional change from the carbonates of the Eocene (Oligocene is absent) to the siliciclastic dominated section in the Miocene. The Miocene sediments exhibit tremendous variability both laterally and vertically. In a general sense, the Hawthorn sediments contain more carbonate beds in the lower portion of the section. Carbonates decrease in abundance higher in the section. Research by Scott (1987) in Florida and Huddlestun (1987) in Georgia provides the lithologic framework and formational breakdown of the Hawthorn Group in this area. In ascending order the formations include: the Penney Farms/Parachucla Formations, the Marks Head Formation and the Coosawhatchie Formation including the Charlton Member (Figure 4). These units are recognized in cores (Figure 7). However, in well cuttings it is difficult to seperate the units due to the loss of fine grained sediments and the inclusion of material caving from above. If enough core control is available, cuttings can be utilized in a detailed study. The data pre-

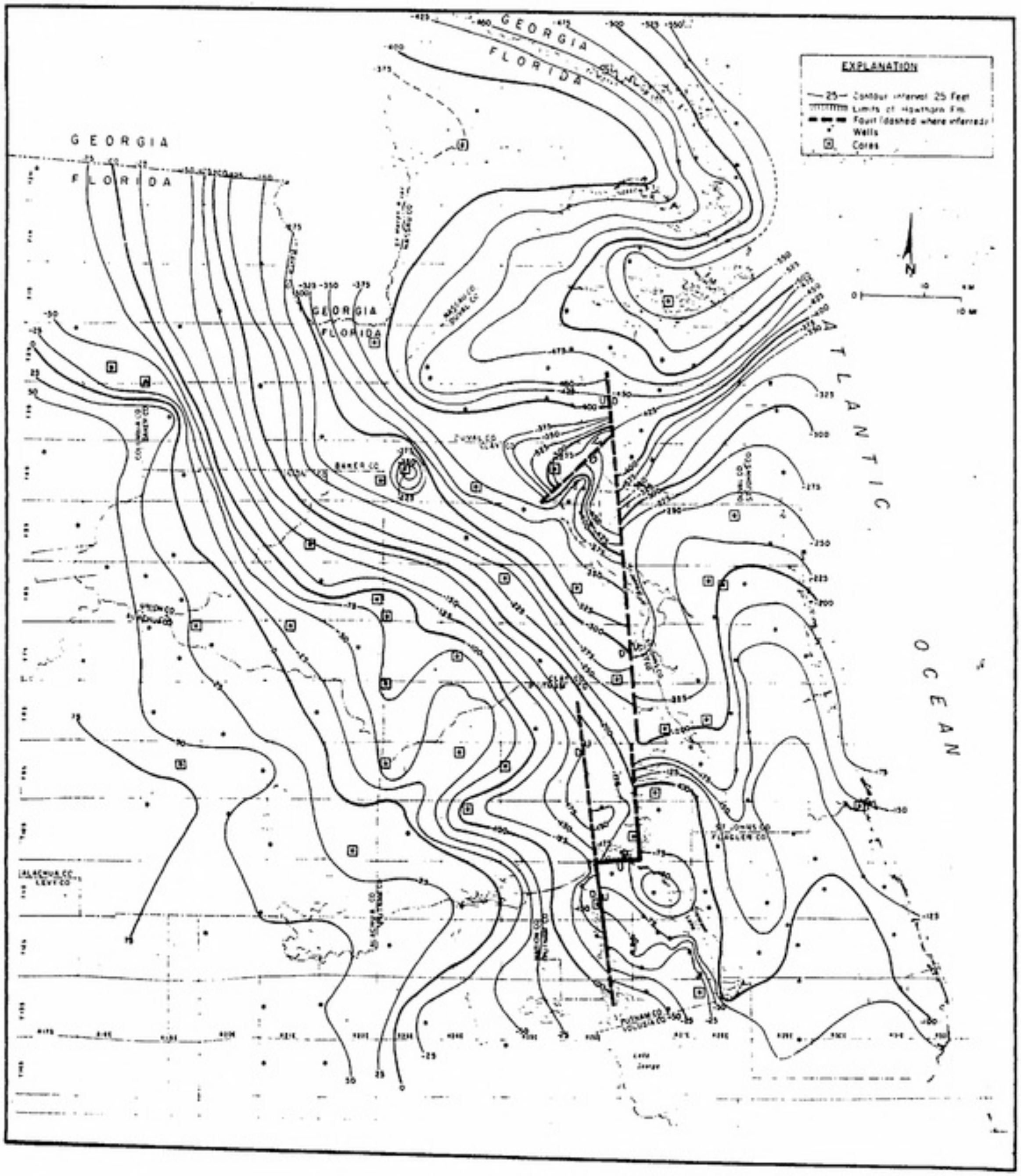


Figure 5 Top of Ocala Group in Northeast Florida

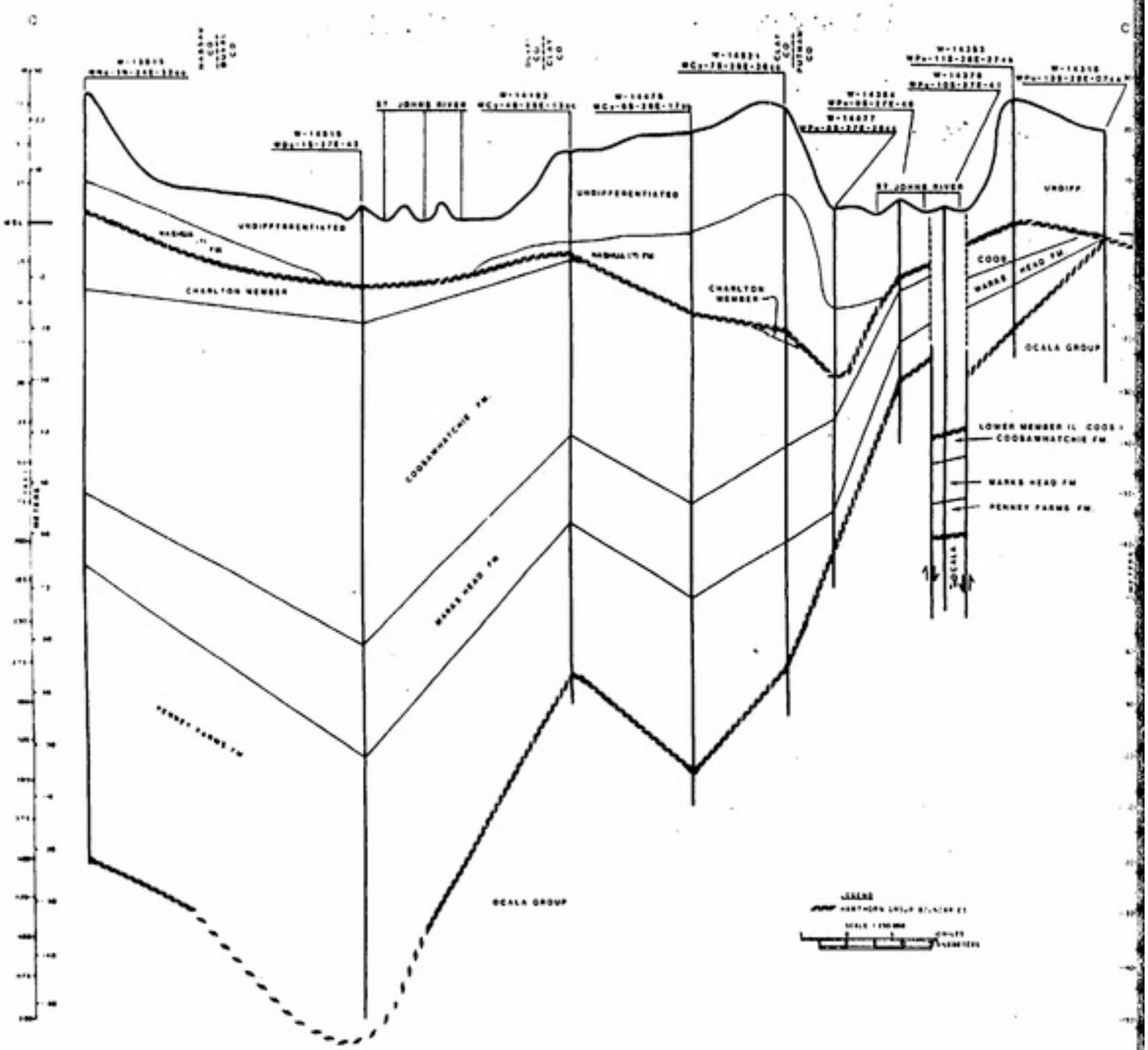


Figure 6 Cross section C-C' (see figure 1 for location)
(See Scott (1983) for discussion of faults)

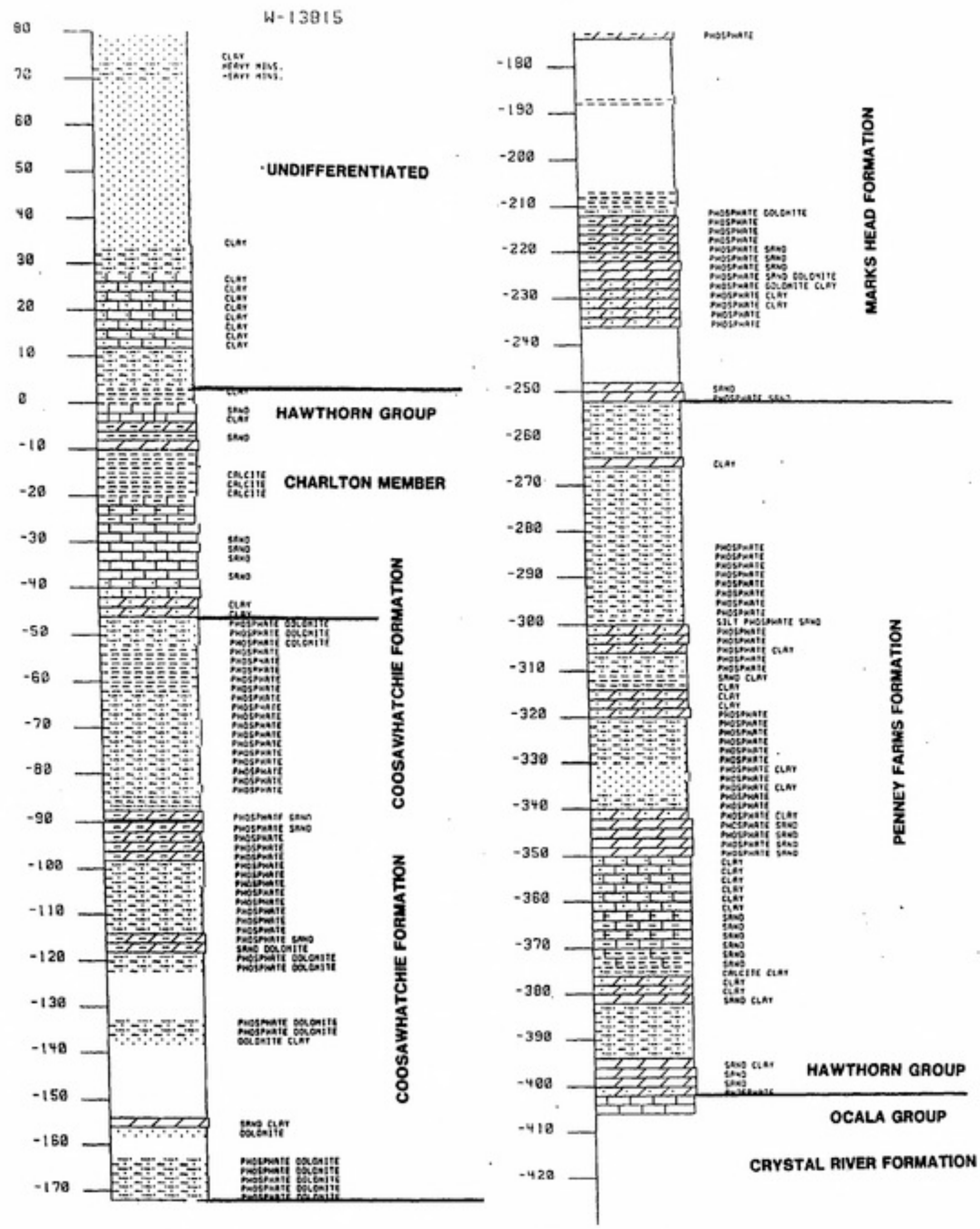


Figure 7 Reference core for the Charlton Member of the Coosawhatchie Formation, Cassidy #1, Nassau County (Lithologic legend Appendix B)

sented below on the formations of the Hawthorn Group is excerpted from Scott (1987) with only minor changes.

Penney Farms/Parachucla Formation

The Penney Farms Formation, introduced by Scott (1987), occurs throughout much of northern Florida as a subsurface unit (Figures 3 and 4). It is the lateral equivalent of the Parachucla Formation in southeastern Georgia as defined by Huddlestun (1987). The facies transition between the Penney Farms and the Parachucla occurs in northern Nassau County and into Charlton and Camden counties, Georgia. As a result, cores taken in Nassau County may contain either Penney Farms or Parachucla. The primary difference between the two units is the amount of carbonate present as discreet beds, with the Penney Farms containing more carbonate.

The carbonates are variably quartz sandy, phosphatic, clayey dolostones. Sand content is variable to the point that the sediment may become a dolomitic sand. Phosphate grains may comprise twenty-five (25) percent or more with an average of approximately five (5) to ten (10) percent. Clay percentages are generally minor [below five (5) percent] but often increase in the dolostones of the upper portion of the formation. The dolostones are medium gray to pale yellowish brown. They are generally moderately to well indurated and finely to coarsely crystalline in the lower part. The dolostones of the upper portion are generally less indurated. Thicker, more massive beds predominate in the lower zone while thinner beds are most common in the upper section. Mollusk molds are common in the dolostones, particularly in the more coarsely crystalline type.

Zones of intraclasts are common in the hard, finer grained dolostones of the lower part of the Penney Farms. The intraclasts are composed of dolostone that is essentially the same as the enclosing matrix. The intraclasts are recognizable due to a rim of phosphate replacement along the edges of the clasts. Edges of the clasts vary from angular to subrounded indicating very little to no transport of the fragments. They also may be bored, indicating at least a semi-lithified state prior to being redeposited.

Limestone, in the basal portion of the Penney Farms Formation, occurs sporadically. When it does occur, it is generally dolomitic, quartz sandy and phosphatic.

The quartz sands are fine to coarse grained, moderately to poorly sorted, variably phosphatic, dolomitic, silty and clayey. The phosphate grain content varies considerably, sometimes to the point of being classified as phosphorite sand [fifty (50) percent or greater phosphate grains]. In general, however, the phosphate grain content averages between five (5) and ten (10) percent. The sands are typically olive gray or grayish olive to medium light gray. Clay content varies considerably in the sands.

Clay beds in the Penney Farms Formation are typically quartz sandy, phosphatic, silty and dolomitic. The proportions of the accessory minerals vary from nearly zero to more than fifty (50) percent. Nearly pure clay beds are uncommon. Dolomite is very common in the clays, often being the most abundant accessory mineral. Olive gray and grayish olive green colors generally predominate, but colors may range into the lighter shades. Smectite typically dominates the clay mineralogy of this unit, with palygorskite, illite and sepiolite also present. X-ray analyses by Hetrick and Friddell (1984) indicate that palygorskite may become predominant over smectite in some samples. Reik (1982) indicated that palygorskite dominates in the lower part of the Penney Farms while smectite dominated in the upper portion in Clay County. Other minor mineralogic constituents include mica, K-feldspar and opal-ct. Clinoptilolite has been identified in a few samples.

When abundant silt-sized, unconsolidated dolomite occurs, difficulty arises in determining whether the actual rock type is a very dolomitic clay or a very clayey dolostone. Insoluble residue analysis is the only accurate method of determining the clay and dolostone contents. Rough analysis indicates that, in general, the lighter the color of the sediment, the higher the dolomite content. This method was employed for determining the sediment type in these situations.

The clastic beds of the Penney Farms Formation are lithologicaly very similar to those in the Parachucla Formation in southeastern Georgia (Huddlestun, 1987). As the Penney Farms Formation begins to lose its carbonate units northward and northwestward into Georgia, the characteristic lithologies are no longer apparent and the formation can no longer be identified as the Penney Farms. These sediments in Georgia are included in the Parachucla Formation (Huddlestun, 1987).

The Penney Farms Formation unconformably overlies limestones of the Upper Eocene Ocala Group in Nassau County. The unconformity is very apparent due to the drastically different lithologies of a pure limestone below to a sandy, phosphatic dolostone or dolomitic, clayey phosphatic sand above. The Marks Head Formation unconformably overlies the Penney Farms Formation throughout Nassau County.

The overlying Marks Head Formation consists of interbedded fuller's earth type clays, sands and dolostones which are generally lighter colored than the sediments of the Penney Farms. The top of the Penney Farms is placed at the break between the lighter colored sediments of the Marks Head and the darker colored sands and clays of the upper part of the Penney

Farms. Occasionally, a rubble zone marks the break between the Marks Head and the Penney Farms formations. When it occurs, the rubble consists of clasts of phosphatized carbonate. The relationship of the Penney Farms Formation to the underlying and overlying sediments can be seen in the cross section (Figures 5 and 6).

The Penney Farms Formation of the Hawthorn Group occurs as a subsurface unit in Nassau County. The top of the Penney Farms Formation ranges in cores from -333 feet MSL in Carter #1, W-14619, Duval County to +80 feet MSL in Devils Millhopper #1, W-14641, Alachua County. In Nassau County, the top of the Penney Farms Formation occurs at approximately -250 feet MSL in the northwestern area to an estimated -350 feet MSL in the southeastern to eastern area (Figure 8). The Penney Farms Formation dips in a general easterly to southeasterly direction in Nassau County toward the Jacksonville Basin with an average dip of 4 feet per mile. Locally, both the direction and angle of dip may vary.

The Penney Farms Formation varies in thickness from zero on the crests of the Ocala Platform and Sanford High (Figure 2) to more than 155 feet in Carter #1, W-14619, Duval County in the Jacksonville Basin (Figure 2). The total thickness of this unit was not determined in this core as the core terminated in the Penney Farms Formation after penetrating 155 feet. This author estimates that the base of the Penney Farms should occur near -575 feet MSL based on nearby water wells. This suggests that approximately 230 feet of the unit should be present in the deepest portion of the Jacksonville Basin. The observed thickness of the Penney Farms in Cassidy #1, W-13815, Nassau County is 150 feet (Figure 9).

The Hawthorn Group sediments of northern Florida yield very few datable fossils or fossil assemblages. Diagenetic overprinting on the

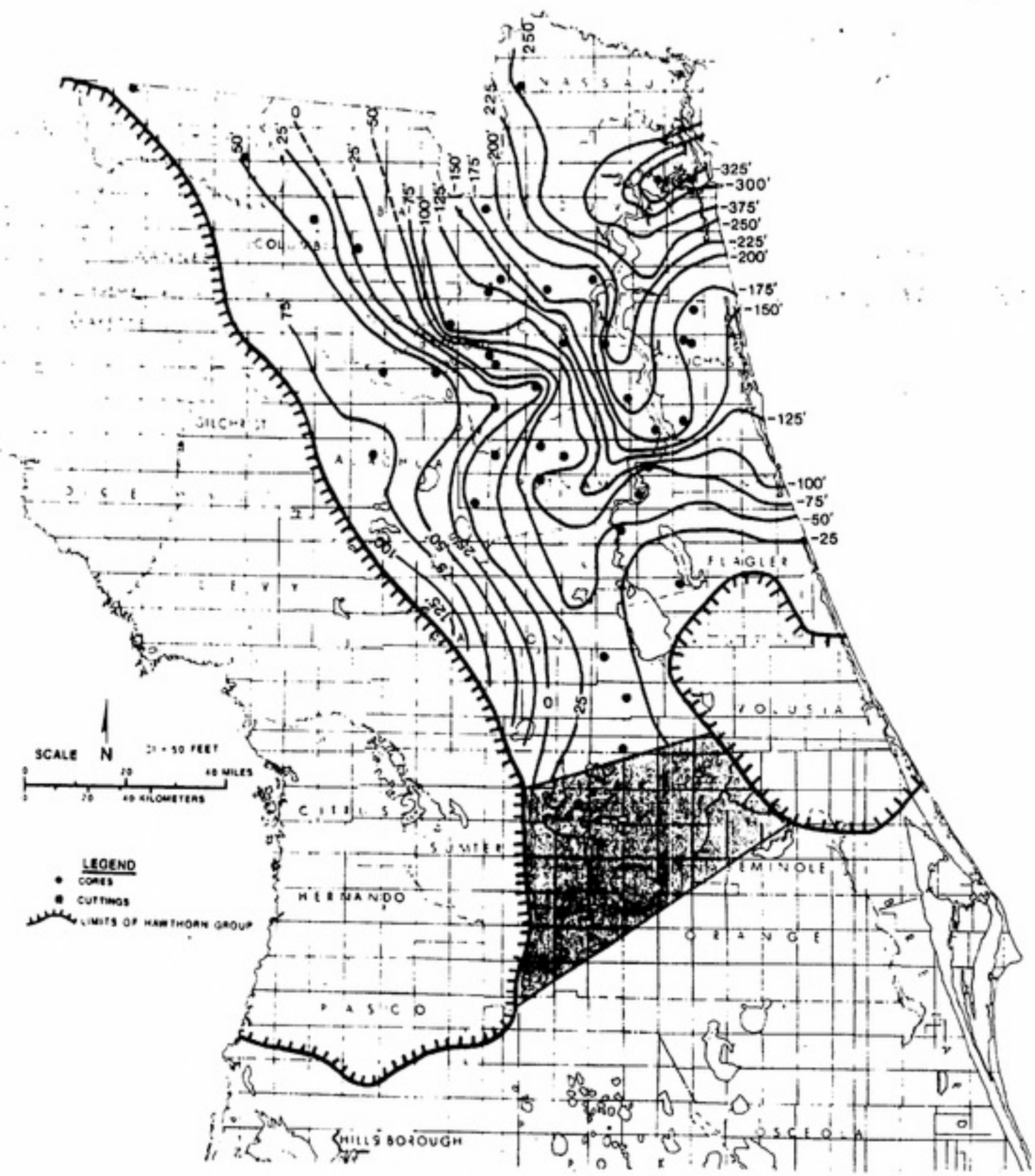


Figure 8   Top of Penney Farms Formation (shaded area indicates undifferentiated Hawthorn Group)

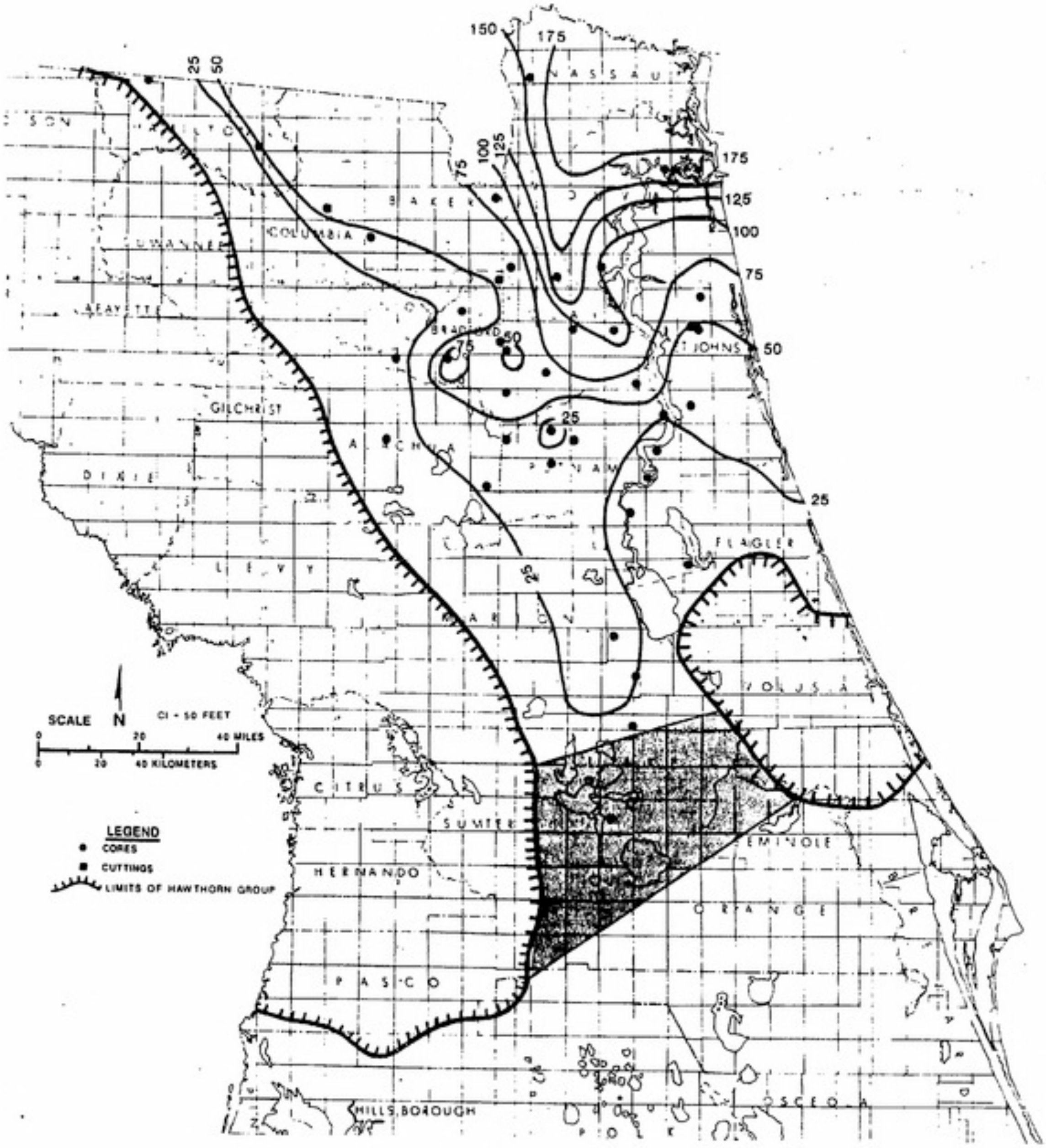


Figure 9 Isopach of Penney Farms Formation (shaded area indicates undifferentiated Hawthorn Group)

sediments has obliterated the vast majority of fossils leaving mainly molds and casts. Diatom and mollusk molds are the most frequently encountered fossil remains. At the present time, a date has been obtained from the Cassidy #1 core, W-13815, Nassau County in the interval from -370 to -375 MSL. The sediment, a calcareous, quartz sandy clay, contained benthic and planktonic foraminifera, ostracods, spicules (sponge?), echinoid fragments and bryozoans. The planktonic foraminifera indicate an Aquitanian, upper Zone N.4 or lower N.5 of Blow (1969)) for this interval (Huddlestun, personal communication, 1983).

The Penney Farms Formation of the Hawthorn Group is older than the commonly accepted age for the Hawthorn Formation as described by Puri and Vernon (1964). Puri and Vernon used a Middle Miocene age only for their Hawthorn Formation. This has been the accepted age for the Hawthorn Formation by the Florida Geological Survey for sometime. Armstrong and Wise (1985) suggested a latest Oligocene age for the base of the Hawthorn in southeastern Florida. The data presented here indicate this should further be revised.

The carbonate section of the Penney Farms Formation has often been referred to as the basal Hawthorn dolostone in northern Florida. The gamma-ray signature is quite distinctive, consisting of a number of very high counts per second (cps) peaks (see section on gamma ray logs).

Marks Head Formation

Huddlestun (1987) reintroduced the Marks Head Formation in Georgia and included it as part of the Hawthorn Group. The Marks Head Formation is extended into northern Florida as the middle unit of the Hawthorn Group. The lithologic similarities between the Marks Head Formation in southeast Georgia and in north Florida warrants the use of the same nomenclature.

The Marks Head Formation in Florida consists of interbedded sands, clays and dolostones throughout its extent. Carbonate beds are more common in the Marks Head Formation in Florida than in Georgia; the proportion of carbonate, both as a rock type and an accessory (matrix) mineral, gradually increases into Florida. This unit is the most lithologically variable formation of the Hawthorn Group in north Florida. Miller (1978) defined his Unit D (equivalent to the Marks Head Formation) in the Osceola National Forest in Columbia and Baker counties, Florida as being "complexly interbedded shell limestone, clay, clayey sand and fine grained sandstone."

The carbonate portion of the Marks Head Formation is typically dolostone; limestone is uncommon but does occur sporadically as is the case throughout the Hawthorn Group. The Marks Head dolostones are generally quartz sandy, phosphatic and clayey. The dolostones vary in induration from poorly consolidated to well indurated. The induration varies in inverse relationship to the amount of clay present within the sediment. Phosphate grains normally comprise up to five (5) percent; however occasional beds may contain significantly higher percentages. Quartz sand content varies from less than 5 percent to greater than 50 percent where it grades into a dolomite cemented quartz sand. The dolostones range from yellowish gray to olive gray in color. Crystallinity varies from micro-to very finely crystalline with occasional more coarsely crystalline zones. Molds of mollusk shells are often present.

The occurrence of limestone within the Marks Head Formation in Florida is quite rare. The majority of the "limestone" reported from this part of the section by other workers is actually dolostone. The limestone that does occur is characteristically dolomitic, quartz sandy, phosphatic, clayey, and fine grained.

The quartz sands from the Marks Head Formation are generally fine to medium grained (occasionally coarse grained), dolomitic, silty, clayey and phosphatic. The dolomite, silt and clay contents are highly variable and gradational with the other lithologies. Phosphate grains are usually present in amounts ranging from one (1) to five (5) percent; however, phosphate percentages may range considerably higher in thin and localized beds. The quartz sands are typically light gray to olive gray in color. Induration varies from poor to moderate.

Clay beds are quite common in the Marks Head Formation, occasionally comprising a large portion of the section. The clays are quartz sandy, silty, dolomitic and phosphatic. As is the case in the underlying Penney Farms Formation, the Marks Head clays contain highly variable percentages of accessory minerals; relatively pure clays do occur but are not common. The clays range from greenish gray to olive gray in color and are typically lighter colored than the clays of the underlying unit.

Phosphate grains are present virtually throughout the Marks Head Formation. They characteristically occur as brown to black, sand-sized grains scattered throughout the sediments. The phosphate grains are rounded and often in the same size range as the associated quartz sands. Phosphate pebbles occur rarely.

Mineralogically, the Marks Head Formation clays contain palygorskite, sepiolite, smectite and illite; kaolinite is present only in the weathered section (Hettrick and Friddell, 1984). Hettrick and Friddell (1984) indicated that palygorskite is often the dominant clay mineral in this unit; smectite is the second most abundant clay mineral. Smectite becomes the most abundant clay mineral when palygorskite content decreases. Other minor mineralogic constituents include mica, opal-ct and feldspar. Huddlestun (in press) reports the occurrence of zeolite in the Marks Head

Formation.

The Marks Head Formation is underlain disconformably throughout Nassau County by the Penney Farms Formation. The upper part of the Penney Farms Formation consists predominantly of darker, olive gray colored sands and clays with occasional dolostone beds. The base of the Marks Head Formation is placed at the contact between the darker colored sands and clays of the upper Penney Farms and the generally lighter colored, more complexly interbedded sands, clays and dolostone of the Marks Head. Occasionally, the contact is marked by a rubble zone containing phosphatized carbonate clasts but the unconformity is often difficult to recognize. The Coosawhatchie Formation disconformably overlies the Marks Head Forma-tion throughout Nassau County. The Coosawhatchie-Marks Head contact is generally placed at the top of the first hard carbonate bed or light colored clay unit below the darker colored clayey, dolomitic, quartz sands and dolostones of the basal Coosawhatchie Formation. Occasionally, the contact appears gradational in a sequence of dolostone and interbedded sands. In this case the top of the Marks Head is placed at the uppermost hard dolostone bed in the interbedded sequence. A rubble bed sometimes marks the unconformity. The relationship of the Marks Head Formation to the underlying and overlying units is graphically illustrated in Figures 6 and 7.

The Marks Head Formation of the Hawthorn Group occurs as a subsurface unit in Nassau County. The top of the Marks Head Formation in the subsurface varies from -260 feet MSL in Carter #1, W-14619, Duval County to +114 feet MSL in Devil's Millhopper #1 W-14641 in Alachua County. The top of the Marks Head in Nassau County varies from -100 feet MSL in the southwestern most corner to -250 feet MSL on the east coast (Figure 10).

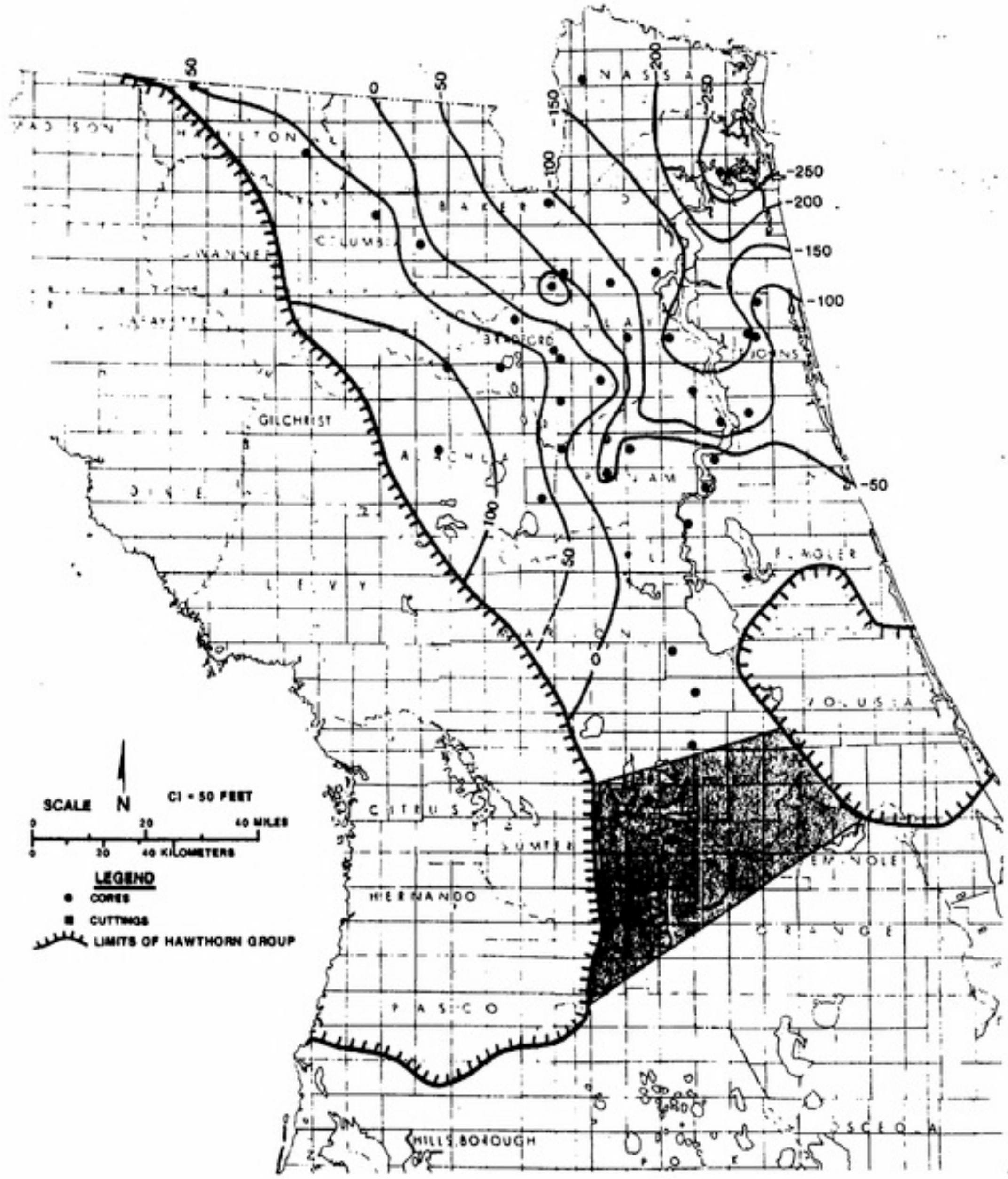


Figure 10 Top of the Marks Head Formation (shaded area indicates undifferentiated Hawthorn Group)

The Marks Head Formation in Nassau County dips to the northeast and east with an average dip of 4 feet per mile. The direction and angle of dip may vary locally.

The thickness of the Marks Head Formation varies from zero on the crest of the Ocala and Sanford highs to 130 feet in the core N.L. #1, W-12360, Bradford County. In northwestern Nassau County, it is 80 feet thick (Figure 11).

Datable fossil assemblages within the Marks Head Formation have not been found in north Florida. The only fossils noted were scattered molds of mollusk shells and occasional diatom molds. Lithologic correlation between these sediments and those in Georgia, where fossiliferous sediments are found, indicates that the Marks Head Formation is late Early Miocene (Burdigalian) age (Huddlestun, personal communication, 1983). Planktonic foraminifera in Georgia indicate Zone N.6 or early N.7 of Blow (1969).

As is the case for the Penney Farms Formation, the Marks Head Formation is older than the previously accepted age for the "Hawthorn Formation" in Florida as interpreted by Cooke (1945) and Puri and Vernon (1964). Cooke (1945) and Puri and Vernon (1964) suggested a strictly Middle Miocene age for their "Hawthorn Formation".

Coosawhatchie Formation

The Coosawhatchie Formation of the Hawthorn Group is used the upper unit of the group in much of north Florida. Huddlestun (1987) proposed the Coosawhatchie as a formal lithostratigraphic unit in Georgia. It extends into north Florida with only minor lithologic changes (Scott, 1987).

The Coosawhatchie Formation in Florida consists of quartz sands, dolostones and clays. Characteristically, clayey, sandy to very sandy dolo-

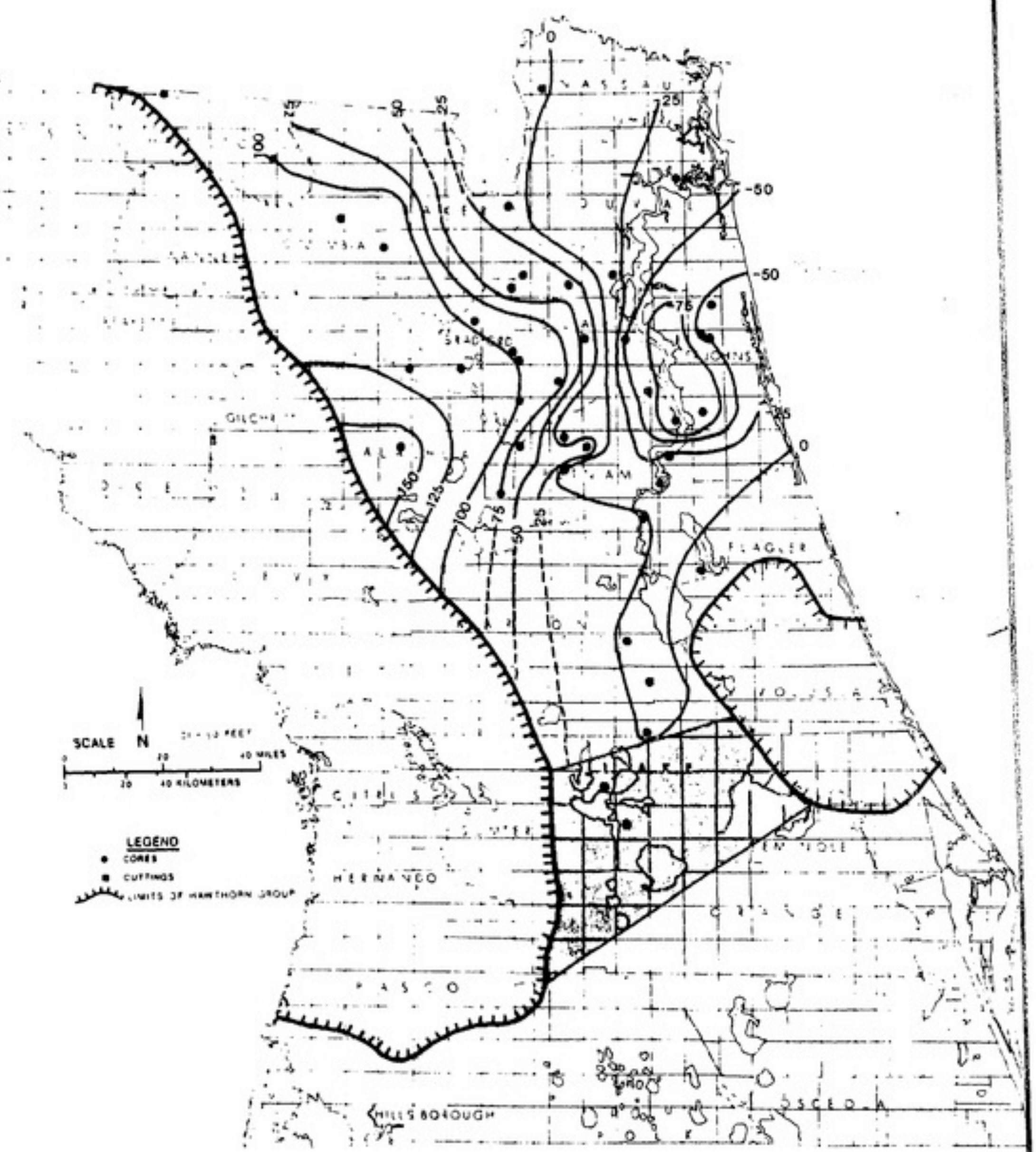


Figure 12 Top of Coosawhatchie Formation (shaded area indicates undifferentiated Hawthorn Group)

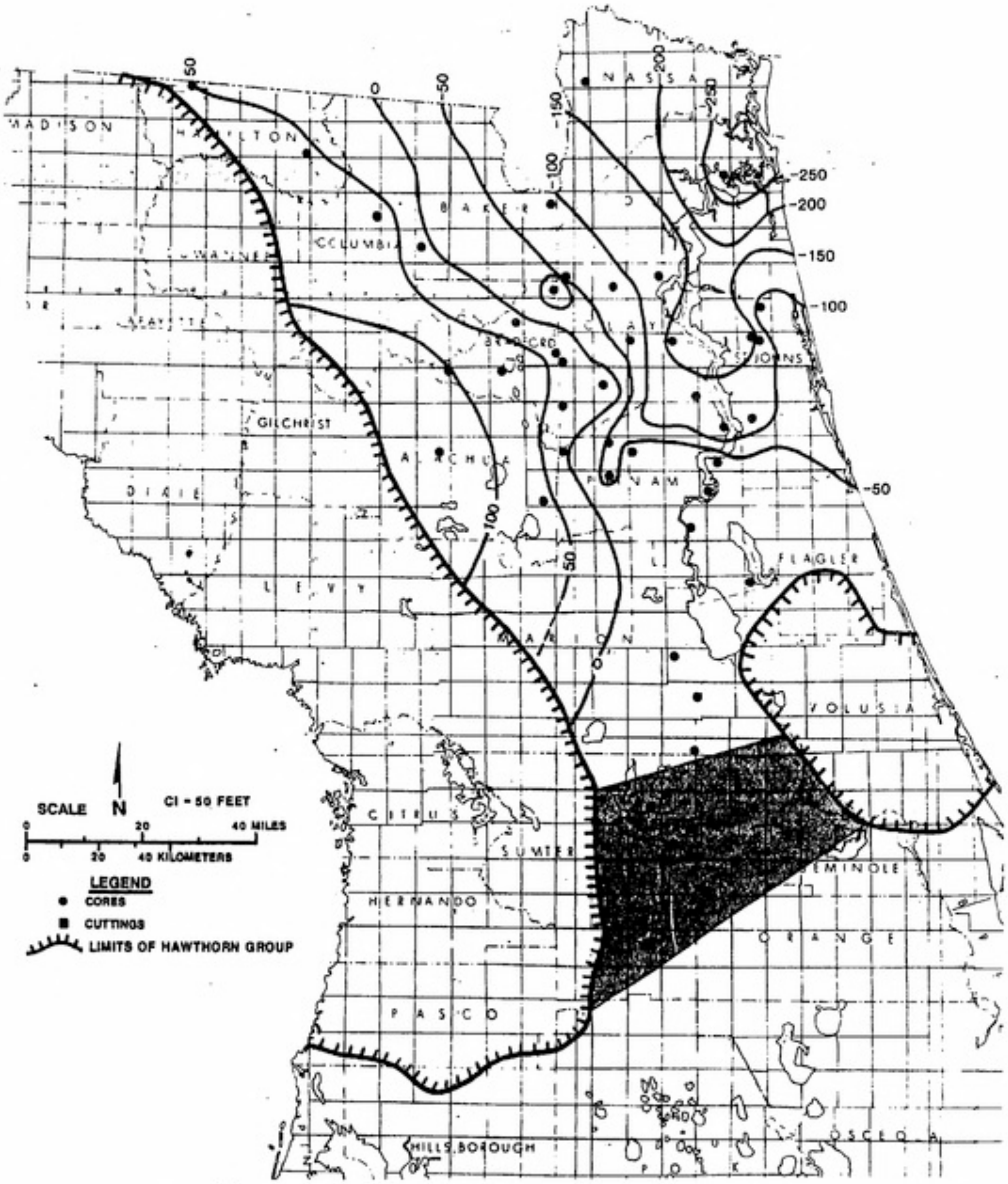


Figure 12 Top of Coosawhatchie Formation (shaded area indicates undifferentiated Hawthorn Group)

stone and dolomitic, clayey sands are the most common lithologies in the upper part. In the lower part, the quartz sands and clays predominate with interbedded dolostones.

The quartz sands are dolomitic, clayey and phosphatic. The sand grains are fine to medium grained, poorly to moderately sorted, and subangular to subrounded. The proportions of accessory materials vary greatly. The sands grade into the dolostones and clays in many instances. Phosphate content is quite variable ranging from a trace to more than 20 percent. Clay content varies from less than 5 percent to greater than 30 percent. The sands are often lighter colored in the upper part where there is more carbonate in the matrix and darker in the lower part. Colors range from greenish gray and light gray to olive gray. Induration is generally poor.

The dolostones of the Coosawhatchie Formation are quartz sandy, clayey and phosphatic. The percentages of quartz sand and clay vary widely and may be as much as 50 percent in transitional zones. Phosphate is quite variable also, but is generally less than 10 percent. The dolostones are micro-to finely crystalline, poorly to moderately indurated and occasionally contain molds of fossils. They range in color from light gray and greenish gray to light olive gray. The dolostones of the upper part appear to become more calcareous in the Jacksonville Basin.

The clays in the Coosawhatchie Formation are typically quartz sandy, silty, dolomitic and phosphatic. The clays are light olive gray to olive gray. Clay beds are most common in the lower member (Scott, 1983). The clay mineralogy is dominated by smectite (Hettrick and Friddell, 1984). The clay beds often contain diatoms (Hoenstine, 1984).

The phosphate grains present in the Coosawhatchie Formation are normally amber colored to brown or black; lighter colors occur near the land surface. The phosphate grains are usually well rounded and in the same size range as the associated quartz sands. Coarser phosphate sands and phosphate pebbles or rubble are not common but are present.

The Coosawhatchie Formation disconformably overlies the Marks Head Formation but the disconformity is often not readily apparent. It is, however, recognized biostratigraphically in Georgia (Huddlestun, personal communication, 1983). The contact often occurs in a thin gradational sequence of interbedded sands and dolostones. Occasionally, the contact is marked by a rubble bed.

The Coosawhatchie is overlain by undifferentiated Plio-Pleistocene deposits in most of northern Florida. In much of Nassau County, the Coosawhatchie is overlain disconformably by the Pliocene Nashua Formation. The relationship of the Coosawhatchie to the underlying and overlying units is indicated in Figures 6 and 7.

The Coosawhatchie Formation occurs throughout much of north Florida. The top of the Coosawhatchie ranges from -93 feet MSL in Bostwick #1, W-14477, Putnam County to +168 feet MSL in Devils Millhopper #1, W-14641, Alachua County. In Nassau County, the top of the Coosawhatchie ranges from near sea level in the southwestern corner edge to greater than -50 feet MSL along the east coast (Figure 12). It attains a maximum thickness in Florida (including the Charlton Member) of 222 feet in Carter #1, W-14619, Duval County (Figure 13). Huddlestun (1987) indicates that the Coosawhatchie attains a maximum thickness of 284 feet in the southeast Georgia Embayment in Georgia. The Coosawhatchie Formation dips in a northeasterly to easterly direction in Nassau County. The average dip is approximately 4 feet per mile. The angle and direction of dip is variable throughout the region.

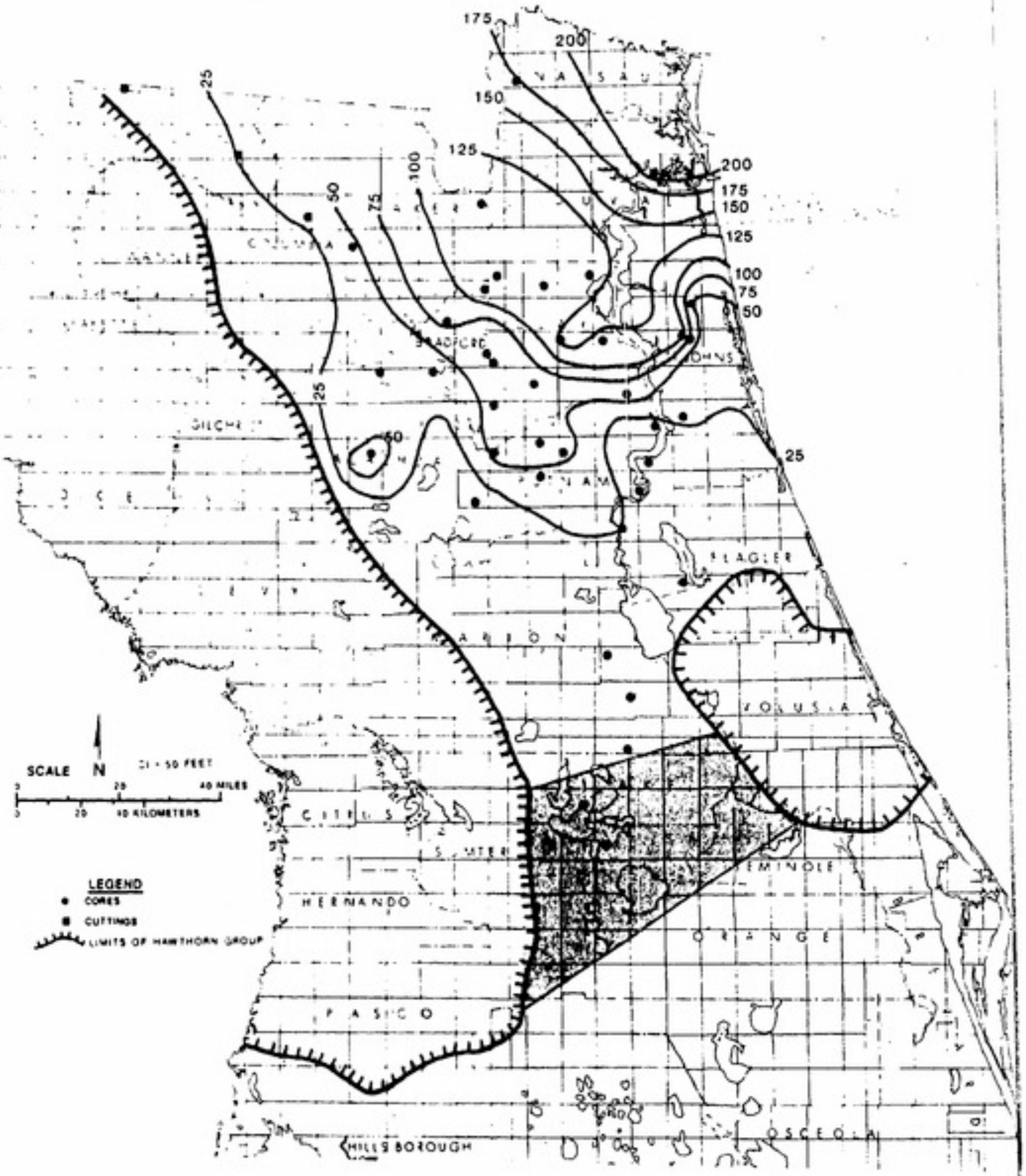


Figure 13 Isopach of Coosawhatchie Formation (shaded area indicates undifferentiated Hawthorn Group)

The Coosawhatchie Formation is not known to occur over the Ocala and Sanford highs or in the immediately surrounding areas. This is thought to be due primarily to erosion; nondeposition may also have played a role. The Coosawhatchie extends from Georgia southward into central Florida.

Huddlestun (1987) suggests a Middle Miocene (Early Serravallian age) for the Coosawhatchie Formation based on planktonic foraminifera. Huddlestun placed it in Zone N.11 of Blow (1969). Hoenstine (1984) studied diatoms from a few selected cores through the Hawthorn. He recognized a Middle Miocene assemblage in Florida sediments assigned in this paper to the Coosawhatchie Formation in northeastern Florida.

The Coosawhatchie Formation is widespread in northern Florida and throughout most of this area the Coosawhatchie is the uppermost Hawthorn sediment encountered. In limited areas, it is shallow enough to be exposed in some foundation excavations. The Coosawhatchie Formation in the Jacksonville Basin contains a lower clay bed of variable thickness. This clay bed correlates with the Berryville Clay Member of the Coosawhatchie Formation in southeastern Georgia.

Charlton Member Of The Coosawhatchie Formation

Huddlestun (1987) redefined the "Charlton Formation" of Veatch and Stephenson (1911) as a formal member of the Coosawhatchie Formation in Georgia. He found that the Charlton Member is a lithofacies of the upper part of the Coosawhatchie in south Georgia and north Florida. Huddlestun (1987) discussed the reference localities in some detail. A reference section for the Charlton Member of the Coosawhatchie Formation in Florida is the Cassidy #1 core, W-13815, Nassau County (NW1/4, NW1/4, Sec. 32, T3N, R24E). The surface elevation is 80 feet MSL. The Charlton Member occurs from +3 feet MSL to -43 feet MSL.

The Charlton Member characteristically consists of interbedded carbonates and clays. It is less sandy than the upper part of the Coosawhatchie, into which it grades. It is typically low in sand and phosphate (Huddlestun, 1987). Huddlestun (1987) states that the clay component is often very conspicuous in the cores. This has been found to be true in Florida also.

The carbonates of the Charlton Member are often dolostones but range into limestone. They are slightly sandy, slightly phosphatic to non-phosphatic and clayey. They often contain abundant molds of fossil mollusks. The dolostones are finely crystalline, light olive gray and poorly to moderately indurated. The limestones are characteristically very fine grained, slightly sandy, clayey, poorly to moderately indurated, and yellowish gray.

The clays are dolomitic to calcareous, with poor to moderate induration, silty, and light gray to greenish gray. The clay minerals present include smectite, palygorskite, illite and kaolinite (Hettrick and Friddell, 1984).

The Charlton Member both overlies and interfingers laterally with the upper portion of the undifferentiated Coosawhatchie Formation. The Charlton is simply a distinct facies of the upper Coosawhatchie. It is overlain by the sediments discussed as overlying the Coosawhatchie Formation. The upper contact is unconformable.

Sediments assigned to the Charlton occur at Brooks Sink (SW1/4, SW1/4, Sec. 12, T7S, R20E, Bradford County) at an elevation of +145 feet MSL. The highest elevation for the top of the Charlton in a core was in Wainwright #1, W-14283, Bradford County where it occurred at +109 feet MSL. The deepest that the top of the Charlton Member was found is in Carter #1, W-14619, Duval County where it is -38 feet MSL. The top is very near MSL to Nassau County (Figure 14).

The Charlton Member of the Coosawhatchie Formation reaches its maximum recognized thickness in Florida in Cassidy #1, W-13815, Nassau County, where it is 70 feet thick (Figure 7 and 15). It is very spotty in its occurrence.

The Charlton Member, as originally defined by Veatch and Stephenson (1911), was considered Pliocene. Huddlestun (1987) postulates that, based on his observations of the molluscan fauna and the lithostratigraphy of the unit, it is Middle Miocene (Seravallian) in age.

Nashua Formation

The Nashua Marl of Matson and Clapp (1909) was reintroduced by Huddlestun (1987) as the Nashua Formation. The name Nashua Marl had been abandoned by Cooke and Mossom (1929) who replaced it with the Caloosahatchee Marl, a presumed south Florida equivalent. The Florida Geological Survey, in following the recommendation of Huddlestun (1987), utilizes the Nashua Formation in northern Florida for the shelly sands, clays and some coquina. In Florida, the Nashua is primarily shelly sands and clay. Data on the extent of the Nashua and it's thickness in northern Florida is limited. Huddlestun (1987) indicates that the Nashua underlies most of Nassau County. The Florida Geological Survey core hole Cassidy #1, W-13815 in west-central Nassau County, encountered the Nashua at 27.5 feet above MSL with a thickness of approximately 50 feet.

Lithologically, the Nashua contains fine to medium quartz sands with varying percentages of calcilutite, clay and shell. The occurrence of shell, both whole and fragmented, occasionally becomes the dominant lithologic component. Colors range from light gray to light olive gray.

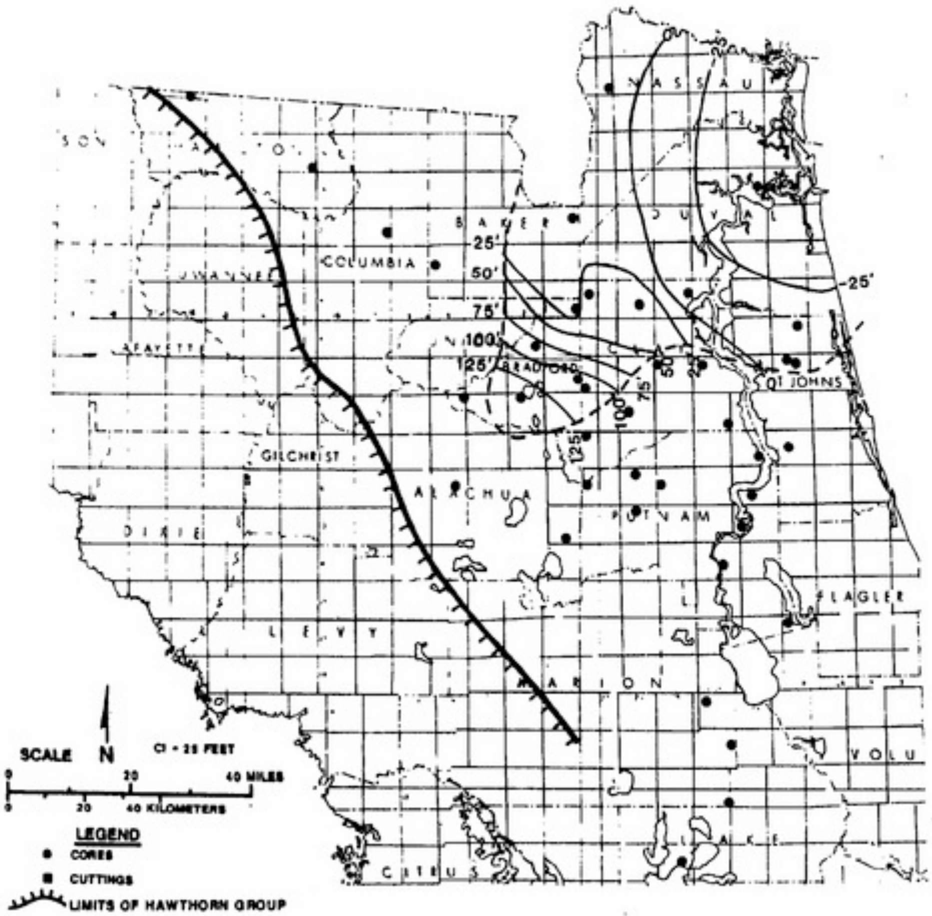


Figure 14 Top of the Charlton Member (dashed line indicates extent of Charlton)

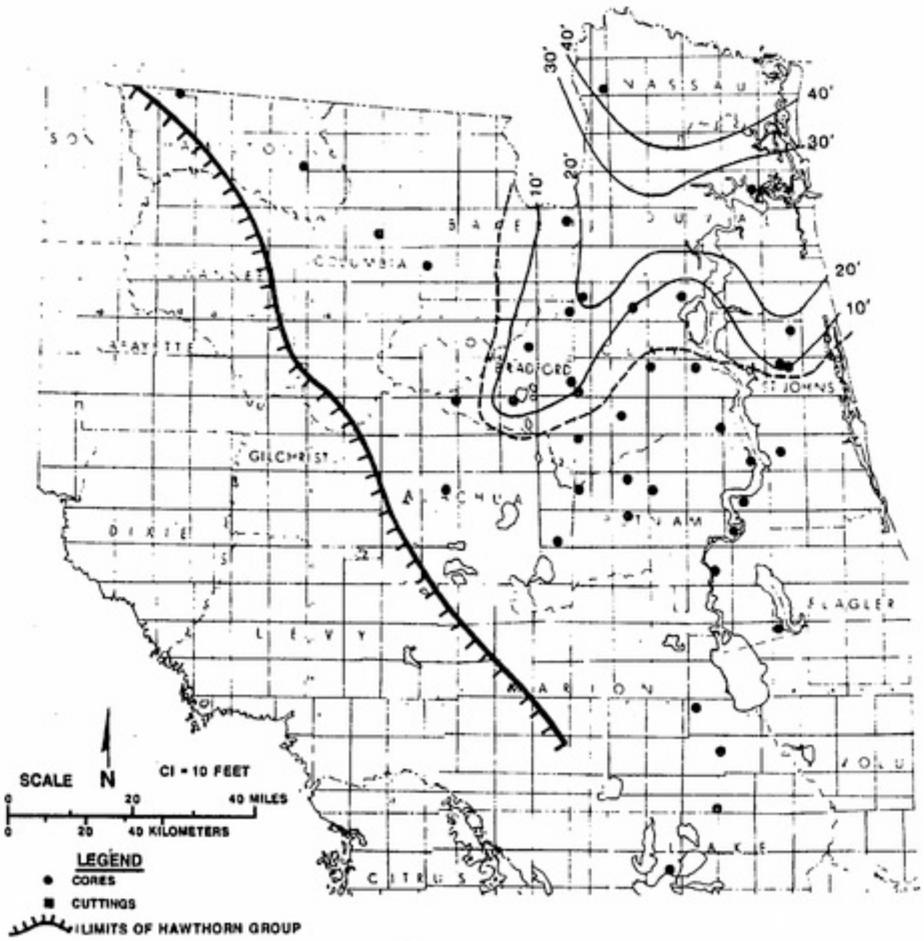


Figure 15 Isopach of the Charlton Member (dashed line indicates extent of Charlton)

Plio-Pleistocene Undifferentiated and Holocene Sediments

The Plio-Pleistocene undifferentiated sediments mantle the Nassau County area with a blanket of fine to medium quartz sands. These sediments contain variable amounts of heavy minerals, silt, clay, iron staining and organic matter. Data on the thickness of these sediments is very limited, however, a thickness of 52.5 feet is recognized in W-13815. Holocene sediments occur along the modern coastline and in association with the present day rivers and streams.

HAWTHORN GROUP GAMMA-RAY LOG INTERPRETATION

Gamma-ray logs are of particular importance to the investigator studying the complex section of the Hawthorn Group. The gamma-ray activity in the Hawthorn Group sediments is generally significantly higher than subjacent or suprajacent formations, thus allowing the delineation of this unit. Also, since these sediments are often partially or entirely cased off during well construction, the ability of gamma-ray probe to obtain information through casing is most important. In the course of this study gamma-ray logs were the only geophysical logs used. For a discussion of resistivity logs of the Hawthorn Group sediments see Johnson (1984).

The Hawthorn Group of northern Florida consists of a complex sequence of clastics and carbonates containing varying percentages of uranium-bearing phosphate minerals. The resultant gamma-ray log shows widely varying peak intensities (Figure 16). The patterns of peaks are similar throughout much of the area from Duval County west to western Hamilton County and from Nassau County south to southern Putnam County. The Hawthorn thins and the gamma-ray signature changes somewhat south of Putnam County in Marion, Lake and northwestern Orange counties. This is due to

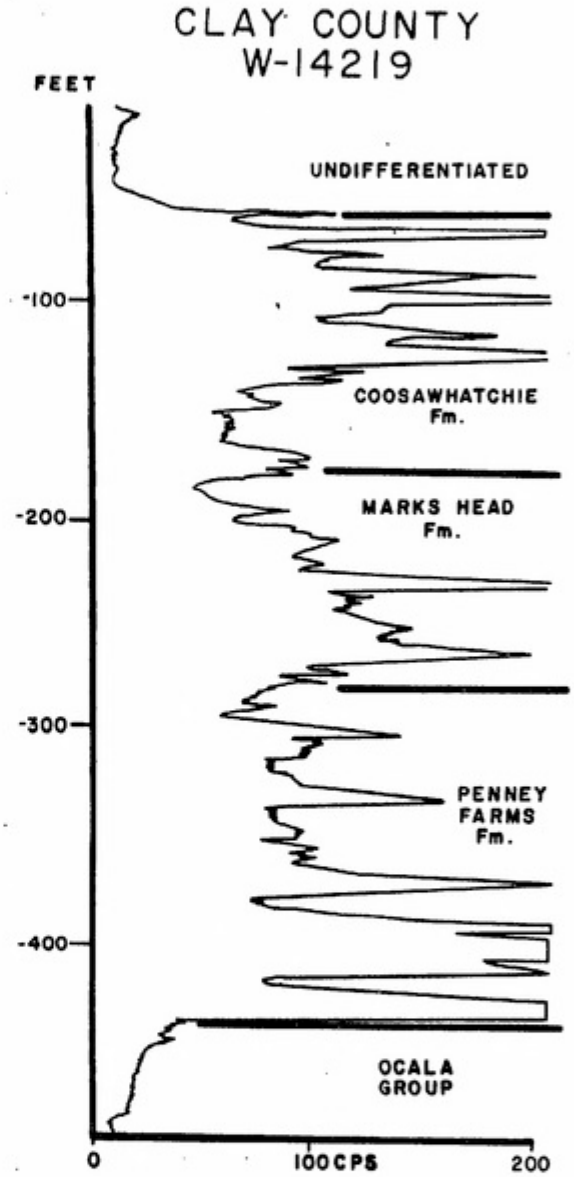


Figure 16 Gamma ray log, Jennings #1, W-14219, Clay County

both erosional removal of the upper sediments and less deposition in the area between the Ocala Uplift and the Sanford High.

A typical gamma-ray log from the north Florida area (Figure 16) consists of five generalized zones. This gamma-ray signature is generally present in north Florida. However, the pattern may show significant variation in the intensities of peaks and thicknesses of peak groups. Formational correlation with the gamma-ray signiture is relatively consistent. The upper, high intensity zone and part of the subjacent lower intensity zone correlate with the Coosawhatchie Formation. The Marks Head Formation correlates with part of the low intensity zone, the underlying higher intensity zone, and the upper portion of the second low intensity zone. The Penney Farms Formation incorporates the remainder of this low intensity zone and the basal, high to very high intensity zone. The underlying Ocala Group has significantly lower generalized signatures than the sediments of the Hawthorn Group. The formational correlations with the gamma-ray signature are shown in Figure 15. The upper and lower boundaries of the Hawthorn Group are generally easily picked on the gamma-ray logs. However, caution must be exercised in making formational identifications based solely on the signatures.

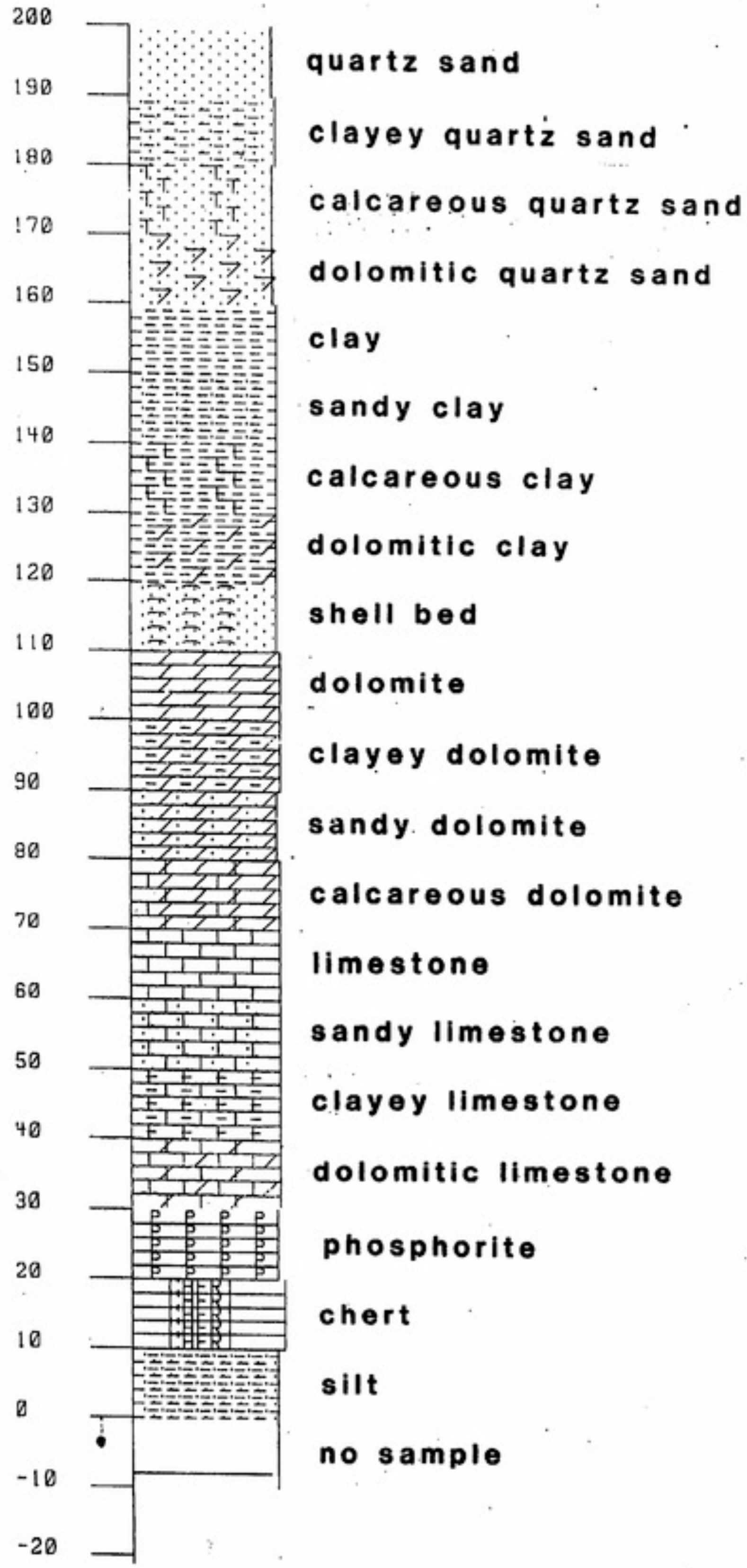
TABLE 1. GEOLOGISTS LOGS/CUTTINGS - NASSAU COUNTY

Well #	Location (T,R,Sec)	Elevation	Depth	Geol. Log
336	4N, 24E, 19, SE4	99'	4,824'	Yes
371	3N, 28E, 14	15'	900'	Drillers
391	Ft. Clinch/Amelia Is.	5'	800'	Yes
343	3N, 28E, 24	15'	750'	Partial
670	3N, 28E, 24	11'	1,060'	Yes
890	3N, 28E, 30, NE4	20'	2,130'	Yes
2918	3N, 28E, 24, NE4	25'	1,205'	Drillers
1030	5N, 24E, 27	10'	60'	Yes
1026	30-43-10/81-37-50	5'	45'	Drillers
2964	2N, 27E, 42, SW4	37'	905'	Drillers
3586	Hilliard	--	821'	Yes
4310	Fernandina Beach	--	1201'	Drillers
4875	Hilliard	55'	700'	Drillers
6265	2N, 28E (Fer. Bch)	--	1200'	Drillers
6532	3N, 24E, 9, SW4	70'	803'	Yes
10482	4N, 23E, 26	95'	98'	Core
10715	3N, 27E, 50	40'	990'	Yes
11100	2N, 28E, 22	--	1016'	Drillers
12315	2N, 28E, 39	10'	95'	Yes
12317	2N, 28E, 39	10'	700'	Yes
13074	3N, 27E, 50	--	580'(?)	-----
13563	2N, 27E, 44	--	624'	Drillers
13815	3N, 24E, 22, NW4	80'	490'	Core
15662	4N, 23E, 27, NE4	60'	905'	-----

TABLE 2. GEOPHYSICAL LOGS - NASSAU COUNTY

Geol. Log #	Location (T,R,Sec)	Elevation	Ft. Below LSD Charl.	Coosa.	H. Head	P. Farms	Ocala
1	3N, 28E, 30	20.1		112	295	404	560
2	- elect. only -						
3	" "						
4	" "						
5	Ft. Clinch 543	10	65	90	228?	360	529
6	3N, 28E, 24	40	--	47?	223?	384	536
7	Caliper only	12					
8	3N, 28E, 35		--	107	308?	366	545
9	3N, 24E, 32 (core)	80	77	123	252	332	482
*10	Same as #9						
*11	SE Callahan	26	94	119	170?	258	421
12	Fernan. Bch. CCA9	32	?	?	?	387	535
13	Same as #5						
14	Fernan. Bch (Test Well)	3	77	119	302?	380	546
15	CCA #6	4	--	74	?	380	532
16	CCA #10	17	?	?	?	394	558
17	2N, 28E, 5	11	--	98	298?	357	533
*18	4N, 23E, 27	60	75?	129	304?	359	307
19	2N, 28E, Gulf Coarse	?	--	118	310?	366	540
20	3N, 28E, 24	11	82?	111	308?	373	547
21	3N, 28E, 23	9	?	113?	?	390	545
*22	2N, 25E, 29	20	--	50	?	237	388

*These are located west of Amelia Island; remainder are located in or near Fernandina Beach.


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
quartz sand
clayey quartz sand
calcareous quartz sand
dolomitic quartz sand
clay
sandy clay
calcareous clay
dolomitic clay
shell bed
dolomite
clayey dolomite
sandy dolomite
calcareous dolomite
limestone
sandy limestone
clayey limestone
dolomitic limestone
phosphorite
chert
silt
no sample

Appendix B

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