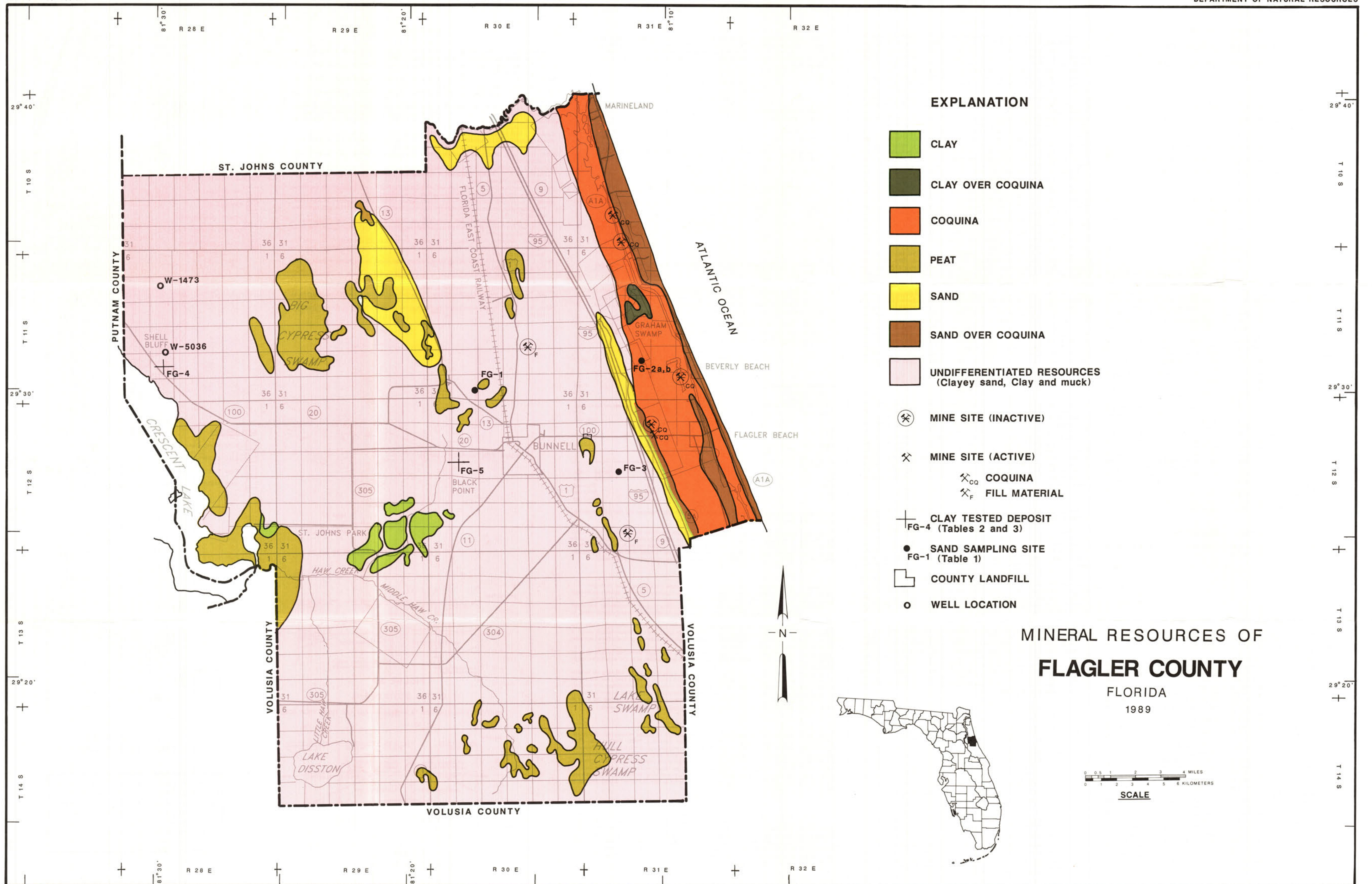




MAP SERIES NO. 127

MINERAL RESOURCES OF FLAGLER COUNTY, FLORIDA

BY

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FLAGLER COUNTY

INTRODUCTION

In recent years, considerable attention has been focused on Florida's rapid development, the accompanying population increase, and their effect on the state's important mineral resources. Frequently, this development occurred in areas underlain by known mineral deposits, precluding extraction of the minerals. The economics associated with these mineral resources represent substantial employment and income to the private sector as well as taxes to county and state governments. One response to the growing conflict between rapid growth and development of the state's mineral resources was in the form of legislation enacted by the Florida Legislature in 1985 requiring each county to establish a comprehensive land use plan. Additional guidelines and due dates were established by the 1986 Florida Legislature.

In response to this act and at the request of the Northeast Florida Planning Council, the Florida Geological Survey initiated a study of Flagler County's mineral resources. The objective of this report is to interpret and summarize geologic data (i.e., core and well cutting descriptions, geophysical logs, and data derived from field reconnaissance) in a format appropriate for use by city and county planners.

A knowledge of Flagler County's mineral resources is basic and integral to the process of initiating, developing, and implementing an effective comprehensive land use plan. This information is essential to planners and officials in their analyses of urban and rural development in areas such as zoning, road construction and the establishment of waste disposal sites.

Factors used in evaluating the economic value of the county's known and potential mineral resources are varied and changing. In many instances, interrelated conditions greatly complicate an accurate assessment. This evaluation process is inherently dependent on an extensive exploration program, which is a necessary precursor to mining in order to determine reserves, content and extent of specific mineral resources. In addition, such factors as operating expenses, transportation, beneficiation, reclamation and capital costs of mining must be included in the overall calculations.

Resource evaluation for this report is based on a number of sources, including Florida Geological Survey reports and unpublished data, field reconnaissance, state and federal statistical data, company reports, questionnaires, and discussions with mining company personnel and state and federal officials. Additional information sources for the geology and mineral resource sections of this report are from Bernes et al. (1963) and Scott (1979). Although detailed information on company statistics are confidential, information of a more general nature is readily available or can be reasonably extrapolated from existing data. The diversity of sources as well as their close association to the various aspects of resource evaluation lend substantial confidence to the general assessments and inferences of this report.

METRIC CONVERSION FACTORS

In order to prevent the awkward duplication of English and metric units in this report the following conversion factors are provided.

MULTIPLY	BY	TO OBTAIN
feet	0.3048	meters
miles	1.609	kilometers
acres	2.471	hectares
fahrenheit	9/5°C + 32	centigrade

GEOMORPHOLOGY

The following discussion of geomorphology is primarily a compilation from Puri and Vernon (1964) and White (1970). Several prominent geomorphic features including the Atlantic Coastal Ridge, the Eastern Valley and Espanola Hill are recognized in Flagler County (Figure 1).

The Atlantic Coastal Ridge parallels the present coastline and is bounded on the west by the Eastern Valley. This coastal feature, which probably represented the mainland shore of the Pleistocene Epoch Pamlico Sea, is not a single coherent feature but comprises a series of relict beach ridges and bars (White, 1970). In Flagler County, the main body of the Atlantic Coastal Ridge is expressed as a broad, sandy upland which attains a maximum width of about five miles at the northern boundary of Flagler County. Northeast of Bunnell, the ridge narrows to a width of about two miles. East of this main portion of the Atlantic Coastal Ridge, and just to the west of the Intracoastal Waterway, lies a relict beach ridge which is also considered part of the Atlantic Coastal Ridge (White, 1970). The Atlantic Coastal Lagoons (Figure 1), which lie to the west of the Intracoastal Waterway, is thought by White (1970) to represent an ancient (now emergent) lagoon. White observed that this valley floor merges with the present lagoon five miles north of Flagler Beach in Flagler County.

Flagler County lies within the northern section of the Eastern Valley of White (1970). The Eastern Valley is a broad, shallow, regional valley, approximately 15-miles wide, characterized by elevations ranging from less than 5 feet to approximately 28 feet above mean sea level (MSL). Much of the Eastern Valley is occupied by wetlands. White (1970) proposed that the Eastern Valley represents an ancient beach ridge plain. This feature, which has highest elevations to the north, experienced a general reduction in elevation toward the south. This lowering or denudation is attributed to the process of dissolution of the underlying limestone (White, 1970).

Espanola Hill, an elongated topographic high, is mapped (White, 1970) in northern Flagler County. It is oriented approximately parallel to the coast and occurs in close geographic proximity to the Atlantic Coastal Ridge. Its orientation suggests that Espanola Hill may be related to the group of beach ridge plain features that make up the Atlantic Coastal Ridge.

Changes in sea level have formed several marine terraces in Flagler County. These terraces, which have highest elevations to the north, experienced a general reduction in elevation toward the south. This lowering or denudation is attributed to the process of dissolution of the underlying limestone (White, 1970). Healy (1975) recognizes three terraces based on elevation as being present in Flagler County (Figure 2). These include from highest to lowest: the Talbot Terrace (25-42 feet MSL), Pamlico Terrace (10-25 feet MSL) and the Silver Bluff Terrace (0-10 feet MSL). In addition, work on this study by the authors indicates that, based on elevation, the Penholoway Terrace (42-70 feet MSL) is present in the north-central part of the county, as part of Espanola Hill.

GEOLOGY

Flagler County is underlain at depth by igneous and metamorphic basement rocks. A deep oil test well (W-1473, section 8, Township 11S, Range 28E) encountered a fine-grained basalt and a basalt porphyry at depths of 4,624 feet and 4,636 feet below land surface, respectively (Applin, 1951). Thick accumulations of carbonates (limestones and dolomites) overlie these basement rocks and dominate the rock column. The youngest sediments are siliclastic sedimentary units comprised of sands, silts, clays, and shells.

Few water wells in the county go deeper than a few hundred feet since water quality decreases with depth (Bernes et al., 1963). For this reason information regarding the deeper rocks is scant, and the following discussion of formations does not include rocks older than Miocene age. Figure 3a shows the location of geologic cross sections used in this report. Figures 3b and 3c illustrate the stratigraphic relationships of the formations discussed below.

Rocks of Miocene age belonging to the Hawthorn Group overlie the Eocene age sediments throughout only the northern half of the county. This is thought to be a result of either erosion or non-deposition of the Miocene sediments in the southern part (Scott, 1988). Based on cores, Scott (1988) subdivided the Hawthorn Group in northern Flagler and southern St. Johns Counties into three formations; from oldest to youngest they are: the Penney Farms Formation, the Marks Head Formation, and the Coosawhatchie Formation. However, because the highly variable nature of the Hawthorn sediments in this area makes identification of the individual units difficult using well cuttings, Scott recommended that these sediments be referred to as Hawthorn Group undifferentiated; this designation is followed in this report. The Hawthorn Group undifferentiated consists of complexly interbedded siliclastics (sands, silts, clays) and carbonates (limestones and dolomites), with ubiquitous phosphatic sand sometimes making up as much as 50 percent of the sediments (Scott, 1988). The gray and green colors of the Hawthorn sediments are distinctively different from those of the formations that underlie and overlie the Hawthorn Group. Some units are sparsely fossiliferous, containing mollusks, shark teeth, or diatoms. The top of the Hawthorn dips slightly from south-to-north, ranging from about 50 feet below MSL in central Flagler County to greater than 100 feet below MSL in southern St. Johns County (Scott, 1988). Similarly, the Hawthorn sediments thicken south-to-north, ranging from zero in central and southern Flagler County to approximately 75 to 100-feet thick in southern St. Johns County (Scott, 1988).

In northern Flagler County, the Hawthorn is overlain by undifferentiated interbedded units of marine sands, shells, and green, calcareous, silty clay (Bernes et al., 1963). In southern Flagler County, where the Hawthorn is missing, these undifferentiated units overlie the Ocala Group carbonates. Bernes et al. (1963) classified these sediments as Late Miocene or Pliocene in age. Some units are fossiliferous, containing mollusks, echinoids, and Foraminifera. These deposits dip slightly from south-to-north, from approximately mean sea level in southern Flagler to about 80 feet below MSL in northern Flagler (Figure 3c). Thicknesses vary throughout the county from about 30 feet to 90 feet (Bernes et al., 1963). Surficial sediments that blanket the county range in age from Pleistocene to Recent and consist of quartz sand, clay, and shell. Their combined thicknesses range from about 20 feet in south-central Flagler County to over 100 feet in the northern part of the county (Bernes et al., 1963). These units are complexly interbedded and their lithologies can change rapidly, both vertically and laterally. The ancient shorelines and terraces shown on Figure 2 are developed in these sediments. Shell beds, cemented to form a coquina, occur in a band three to six-miles wide along the eastern side of the county (Bernes et al., 1963). This coquina is assigned to the Anastasia Formation, of Pleistocene age. Younger, Recent sediments, such as sands and clays, occur along streams, and sand dunes occur along the coast.

MINERAL RESOURCES

INTRODUCTION

The following discussion is intended to provide the reader with a generalized knowledge of the near-surface mineral resources of Flagler County. Several localities were visited, including an operating coquina mine and borrow pits, and other areas where resources might occur (Mineral Resources Map). Additionally, geologic sampling and subsequent tests were performed to determine the need for further investigations of potential sites. Occasional variations between the geologic cross sections and the Mineral Resources Map may occur. The Mineral Resources Map is designed to present an overview of the major mineral commodities in an area. Factors such as thickness of overburden, quality and quantity of the deposit could affect the mining of the mineral commodity at any specific site. In contrast, geologic cross sections are extrapolated from cores and/or well cuttings to show the distribution and thickness of surface and near-surface stratigraphic units. The mineral resources discussed in Flagler County are sand, clay, coquina, peat and undifferentiated resources.

Sand

Sand occurrences in Flagler County commonly contain shell, silt and clay. A maximum observed thickness of 140 feet occurs in the northwestern part of the county (W-5036, section 29ab, Township 11S, Range 28E). In addition, deposits of very coarse to fine sand and silt occur locally as a thin veneer. Scott et al. (1980) presented a summary of occurrences and uses of sand as a commodity in Florida.

During the course of this study, several sand samples (FG- 1, 2a, 2b and 3, Mineral Resources Map) were collected and analyzed for grain size distribution. The following methodology was used. The samples were dried then quartered using a riffle type sample splitter. One quarter was then weighed and screened using a U. S. Standard Sieve Series.

Test data results from the screen sieve analysis (Table 1) represents only one set of samples from each location. Information derived from this table may aid the reader in determining the general usefulness of the particular deposit for industrial purposes. The tests indicate that the sands are suitable for brick masonry, sand-cement riprap, sand-asphalt hot mix, and as sand seal coat. In addition, microscopic inspection of near-surface well cutting samples in the southeastern corner of the county showed the presence of coarse sand. This sand may be suitable for construction material and may warrant further study to determine its geographic extent. No tests were performed to determine if the sand in the county is suitable for glass sand. However, the widespread occurrence of impurities (i.e., heavy minerals, iron oxides) will probably preclude its use for manufacturing glass.

The Florida General Soils Atlas (Kolb, 1974) states that the Paola-Pomello, Palm Beach-Canaveral, Candler-Tavares, Myakka-Pomello-Businger, Myakka-Wauchula-Piccoli, Walabacanal, and Myakka-Felda and Pompano-Anclote soil associations are rated good as a source for roadfill. The atlas further states that the Paola-Pomello, Palm Beach-Canaveral and Candler-Tavares associations are rated good as sources for general fill purposes. This latter group of soil associations include a majority of Flagler County. Notable exceptions are the northwestern portion of the county and regions adjacent to Crescent Lake and Haw Creek. The Soil Conservation Service utilizes the uppermost 80 inches of sediments to determine soil type and usefulness of the material.

Table 1. Screen analyses of sand in Flagler County, Florida.

Deposits				Laboratory Test Data							
				Screen Analysis							
				Sieve No. and Cumulative Weight Percent Retained							
Sample No.	Section Township, Range	Method of Sampling	4	8	16	30	50	100	Fineness Modulus*		
fg-1	sec 32bd 1115, 830E	Spot									
		Spot	--	--	0.053	0.305	3.122	99.999	1.05		
fg-2a	sec 54bd 1115, 831E	(stockpile)	0.086	0.156	0.793	5.787	19.433	99.999	1.36		
		Spot									
fg-3b	sec 54bd 1115, 831E	(stockpile)	0.107	4.020	13.485	26.348	48.720	100.000	1.93		
		Spot									
	sec 17cd 1125, 831E	(stockpile)									
		(stockpile)					0.132	2.254	100.000	1.05	

*Fineness Modulus: A means of evaluating sand and gravel deposits which consists of sieving samples through a standardized set of sieves, adding the cumulative weight percentage of the individual fractions, dividing by 100, and comparing the resultant fineness modulus number to various specification requirements (Bates and Jackson, 1980).

The fineness modulus is an index to the fineness or coarseness of an aggregate, but gives no indication of the grading. The higher the fineness modulus the coarser the aggregate (ASTM, 1987).

The method of sieve analysis presented here follows that outlined in ASTM 1987, v. 4.02, section C 136-B1a. The reader is also referred to the Florida DOT Manual of Florida sampling and testing methods for aggregates, 1987, designation FM 1-1-227.

Clay

Studies conducted in 1923 suggest that clay deposits occur in the western part of the county in an area bordering Crescent Lake (Bell, 1924). A gray clay with a thickness of more than eight feet and underlying three feet of sand was found by Bell (1924) in borings in the vicinity of Shell Bluff (FG-4, Mineral Resources Map). Results of tests conducted on this clay are as follows:

Table 2 Physical Properties of Shell Bluff Clay (section 29, Township 11S, Range 28E) (From Bell, 1924)				
Plasticity, judged by feel.....	Excellent.			
Water of plasticity.....	22.3 %			
Pore water.....	1.2 %			
Shrinkage water.....	21.1 %			
Linear air shrinkage.....	10.5 %			
Volume air shrinkage.....	28.3 %			
Modulus of rupture, average.....	789.9 pounds per square inch.			
Slaking test.....	3 minutes.			

Fire Tests:				
Temperature °F	Linear Shear Per Cent	Absorption Per Cent	Porosity Per Cent	Color
1742	0.5	12.86	31.50	Brick red
1922	0.5	12.20	30.50	Brick red
2102	0.5	11.36	29.70	Brick red
2174	0.5	11.27	29.40	Brick red
2246	0.5	10.75	28.30	Brick red
2390	1.0	10.15	28.20	Brick red

The tests suggest that this clay may be used for brick, drain tile and hollow-block ware (Bell, 1924).

Calve (1949) reported on the location of several clay deposits in Flagler County including St. Johns Park (section 36, Township 12S, Range 28E) and Black Point (section 17, Township 12S, Range 30E). Physical properties of the Black Point clay (FG-5, Mineral Resources Map) are shown in Table 3. Calve also reported that clays exposed along Haw Creek were suitable for common brick, hollow-block and drain tile.

Tests were performed by the University of Florida on a number of clay samples from Flagler County for the United States Department of Agriculture Soil Conservation Service. The results of these tests indicate that the predominant clay mineral is smectite (Calve, 1949; Readle, 1988, personal communication).

Table 3 Physical Properties of Clay Sample from Near Black Point (section 17, Township 12S, Range 30E) (From Calve, 1949)				
Plasticity, judged by feel.....	Good.			
Water of plasticity.....	30.0 %			
Linear air shrinkage.....	9.3 %			
Modulus of rupture, average.....	530.0 pounds per square inch.			
Slaking test.....	Fast			
Color.....	Dark Gray			

Fire Tests:				
Temperature °F	Linear Shear Per Cent	Absorption Per Cent	Porosity Per Cent	Color
1742	2.0	12.0	30.5	Reddish orange
1922	2.0	10.5	29.2	Reddish orange
2102	2.0	7.9	24.2	Brick red
2174	1.5	8.1	24.6	Brick red
2282	1.5	8.6	24.9	Brick red

The test results indicate that this material is suitable for common brick, however, the clay does contain an excessive amount of water (Calve, 1949).

The Soil Conservation Service mapped several areas in Flagler County as being underlain by the Cody Soil (Readle, in preparation). This soil type is a clay found at various localities throughout the county including the general vicinity of Haw Creek, the Graham Swamp and an area around St. Johns Park. These areas, as delineated on the Mineral Resources Map, are defined on the basis of 80-inch soil probes and further site-specific investigations involving cores would be necessary to prove their actual value.

Coquina

Coquina is a type of limestone which is composed mainly of shells and shell fragments. In Flagler County, coquina is mined from the Anastasia Formation. The Anastasia Formation extends south from Anastasia Island (St. Johns County) approximately 150 miles in a narrow band paralleling the coast.

Lithologically, the coquina of the Anastasia Formation is a sandy coquina of fragmented and whole mollusk shells which are cemented to various degrees with calcium carbonate (Puri and Vernon, 1964). In one active pit (section 9b, Township 12S, Range 31E) which was visited in conjunction with this study, approximately 10 feet of indurated coquina is overlain by sands varying in thickness up to 2 feet. The coquina at this site is sandy, poorly sorted and contains both whole and fragmented mollusk shells. It varies in color from white to tan to reddish brown on fresh surfaces, is dark gray on weathered surfaces, and case-hardens on exposure to weathering.

Areas of potential development of coquina in Flagler County have been delineated by Schmidt et al. (1979). These areas fall into a strip which is approximately two to three miles wide and extends the length of Flagler County.

The potential for development of coquina is dependent on a number of factors including the variable nature of the lithology and variations in the amount of sand which must be removed before coquina can be mined. Utilization of coquina resources is further complicated by real estate development and possibly environmental considerations. Areas which are located near the coast are considered extremely desirable for real estate development. Since the coquina of the Anastasia Formation is situated near the coast in Flagler County, land development will have a major impact on prospective utilization of coquina.

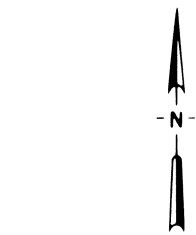
Peat

Peat, a product of partial decomposition of organic materials such as sedges, mosses and other plants, accumulates when the depositional rate exceeds decomposition (Bond et al., 1968). Wetland areas of low topographic relief and reducing environments facilitate the process of peat formation. Conditions for accumulation of potentially mineable peat deposits exist in several areas of Flagler County (Mineral Resources Map), including Hull Cypress Swamp and Lake Swamp in the southeastern part of the county, a large area incorporating Big Cypress Swamp in northwest Flagler County and regions bordering Crescent Lake. These localities are mapped by the Soil Conservation Service as being underlain by the Samusia and Hontoon type soils. The Hontoon soil is currently being mined as peat in Putnam County (Readle, in press).

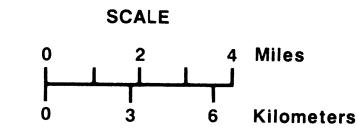
A majority of the surface and near-surface sediments of Flagler County are comprised of sand, clayey sand, clay, mud, and organic muck. The clays and muck are ordinarily inundated by water. The sand and clayey sand have widespread occurrences. They are especially important as a source of fill in Flagler County because large areas throughout the county are subject to flooding. The general availability of sand and clayey sand in the county enable the low areas, which ordinarily would have limited usage, to be filled in and utilized for residential and commercial purposes. In addition, the organic sands have value as top soil. The possibility does exist that a future comprehensive investigation of these undifferentiated sediments may lead to additional economic or industrial applications.

REFERENCES

- American Society for Testing and Materials, 1987, Annual book of ASTM standards, section 4, v. 4.02 Concrete and Mineral Aggregates: ASTM, Philadelphia, PA, 997 p.
- Applin, P. L., 1951, Preliminary report on buried pre-Mesozoic rocks in Florida and adjacent states: U. S. Geological Survey Circular 91, 28 p.
- Bates, R. L., and Jackson, J. A., editors, 1980, Glossary of Geology (second edition): Falls Church, Virginia, American Geological Institute, 751 p.
- Bell, O. G., 1924, A preliminary report on clays of Florida: Florida Geological Survey Fifteenth Annual Report, 266 p.
- Bernes, B. J., Leve, G. W., and Turner, G. R., 1963, Geology and ground-water resources of Flagler, Putnam, and St. Johns Counties, Florida: Florida Bureau of Geology Report of Investigation 32, 97 p.
- Bond, P. A., Campbell, K. M., and Scott, T. M., 1986, An overview of peat in Florida and related issues: Florida Geological Survey Special Publication 27, 151 p.
- Calver, J. L., 1949, Florida kaolins and clays: Florida Geological Survey Information Circular 2, 59 p.
- Florida Department of Transportation, 1984, Manual of Florida sampling and testing methods, sieve analysis of fine and coarse aggregates: FDOT, designation FM 1-T 027, 6 p.
- Healy, H. G., 1975, Terraces and shorelines of Florida: Florida Bureau of Geology Map Series 71, scale 1:2,000,000.
- Kolb, W. C., (coordinator) 1974, The Florida General Soils Atlas with interpretation for Regional Planning Districts III & IV: Florida Department of Administration, Division of State Planning, Bureau of Comprehensive Planning, 48 p.
- Puri, H. S., and Vernon, R. O., 1964, Summary of the Geology of Florida and a guidebook to the classic exposures: Florida Geological Survey Special Publication 5 (revised), 312 p.
- Readle, E. L., in press, Soil survey of Putnam County, Florida: United States Department of Agriculture, Soil Conservation Service, in cooperation with the University of Florida Institute of Food and Agricultural Sciences.
- _____, in preparation, Soil survey of Flagler County, Florida: United States Department of Agriculture, Soil Conservation Service, in cooperation with the University of Florida Institute of Food and Agricultural Sciences.
- Schmidt, W., Hoenstine, R. W., Knapp, M. S., Lane, E., Ogden, G. M., Jr., and Scott, T. M., 1979, The limestone, dolomite, and coquina resources of Florida: Florida Bureau of Geology Report of Investigation 88, 54 p.
- Scott, T. M., 1979, Environmental geology series, Daytona Beach sheet: Florida Bureau of Geology Map Series 93, scale 1:250,000.
- _____, 1988, The lithostratigraphy of the Hawthorn Group (Miocene) of Florida: Geological Survey Bulletin 59, 148 p.
- _____, Hoenstine, R. W., Knapp, M. S., Lane, E., Ogden, G. M., Jr., Deuerling, R., and Neel, H. E., 1980, The sand and gravel resources of Florida: Florida Bureau of Geology Report of Investigation 90, 41 p.
- White, W. A., 1970, The geomorphology of the Florida peninsula: Florida Geological Survey Bulletin 51, 164 p.



SCALE FOR FIGURES 1,2, and 3a



SCALE FOR FIGURES 3b and 3c

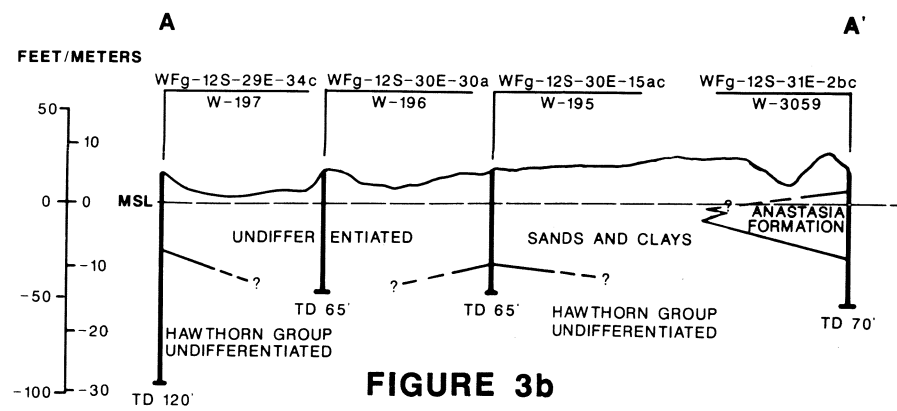


FIGURE 3b
CROSS SECTION A-A'

VERTICAL EXAGGERATION IS APPROXIMATELY 422 TIMES TRUE SCALE.

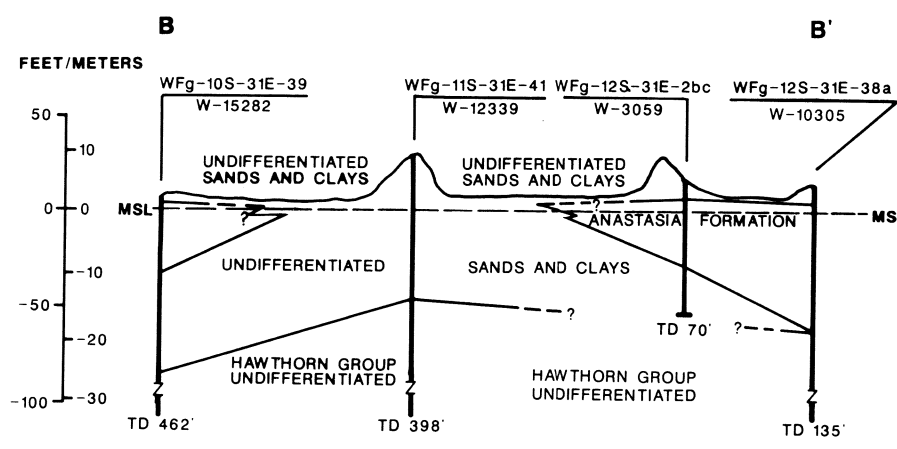


FIGURE 3c
CROSS SECTION B-B'

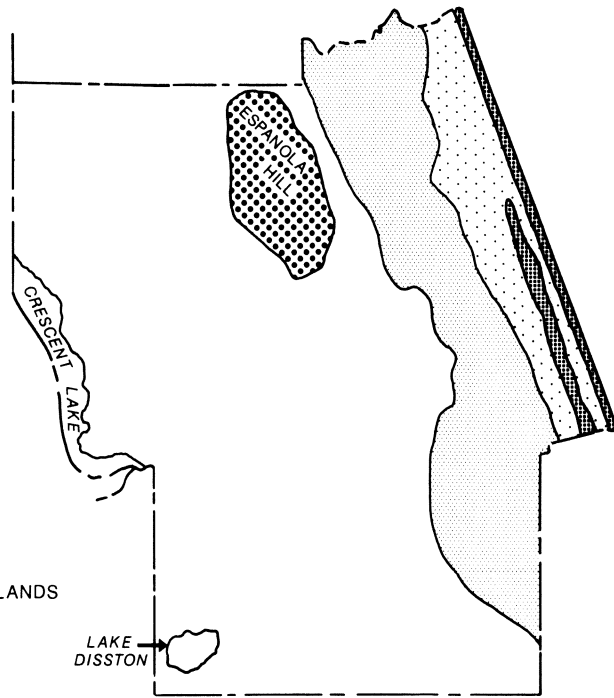


FIGURE 1
GEOMORPHOLOGY
(modified from Puri and
Vernon, 1964; and White, 1970)

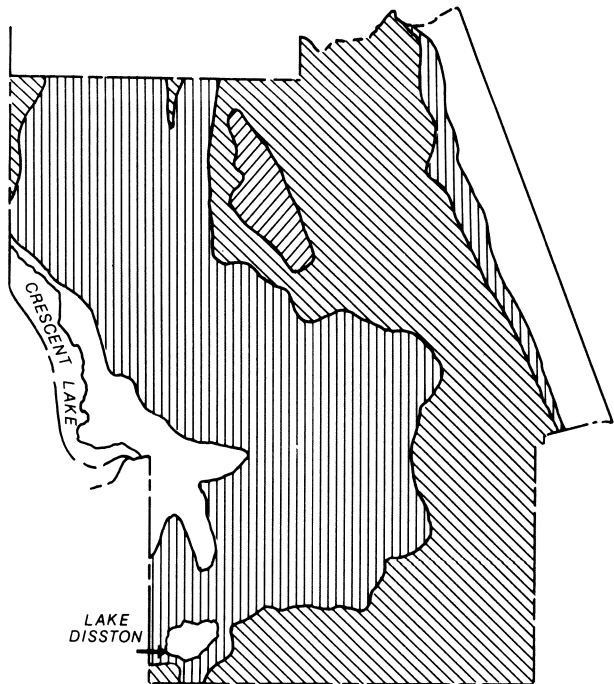


FIGURE 2
TERRACES AND SHORELINES
(modified from Healy, 1975)

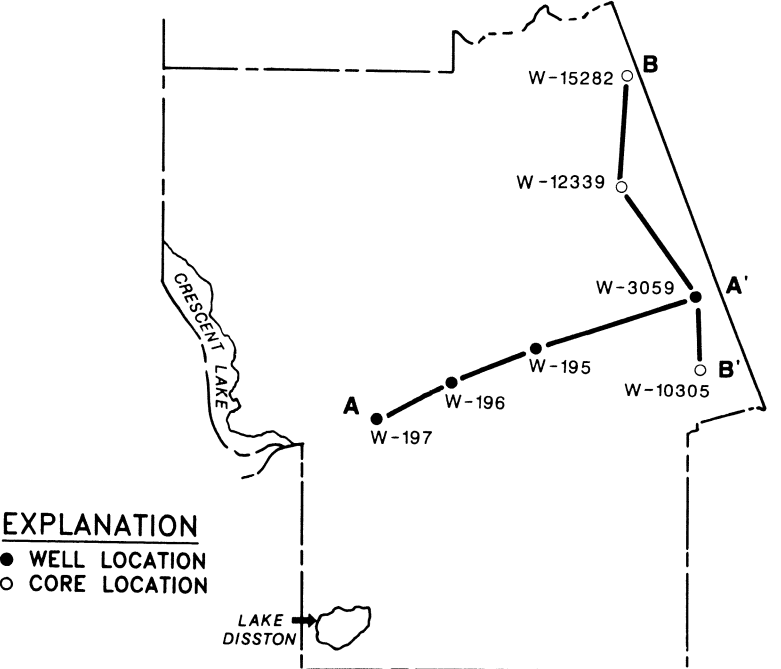


FIGURE 3a
CROSS SECTION LOCATIONS

The well and quarry system used in this report uses the rectangular system of section, township and range for identification. The well or outcrop number consists of six parts: W for well or L for quarry, county abbreviation, the Township, Range, and Section, and the quarter/quarter location within the section.