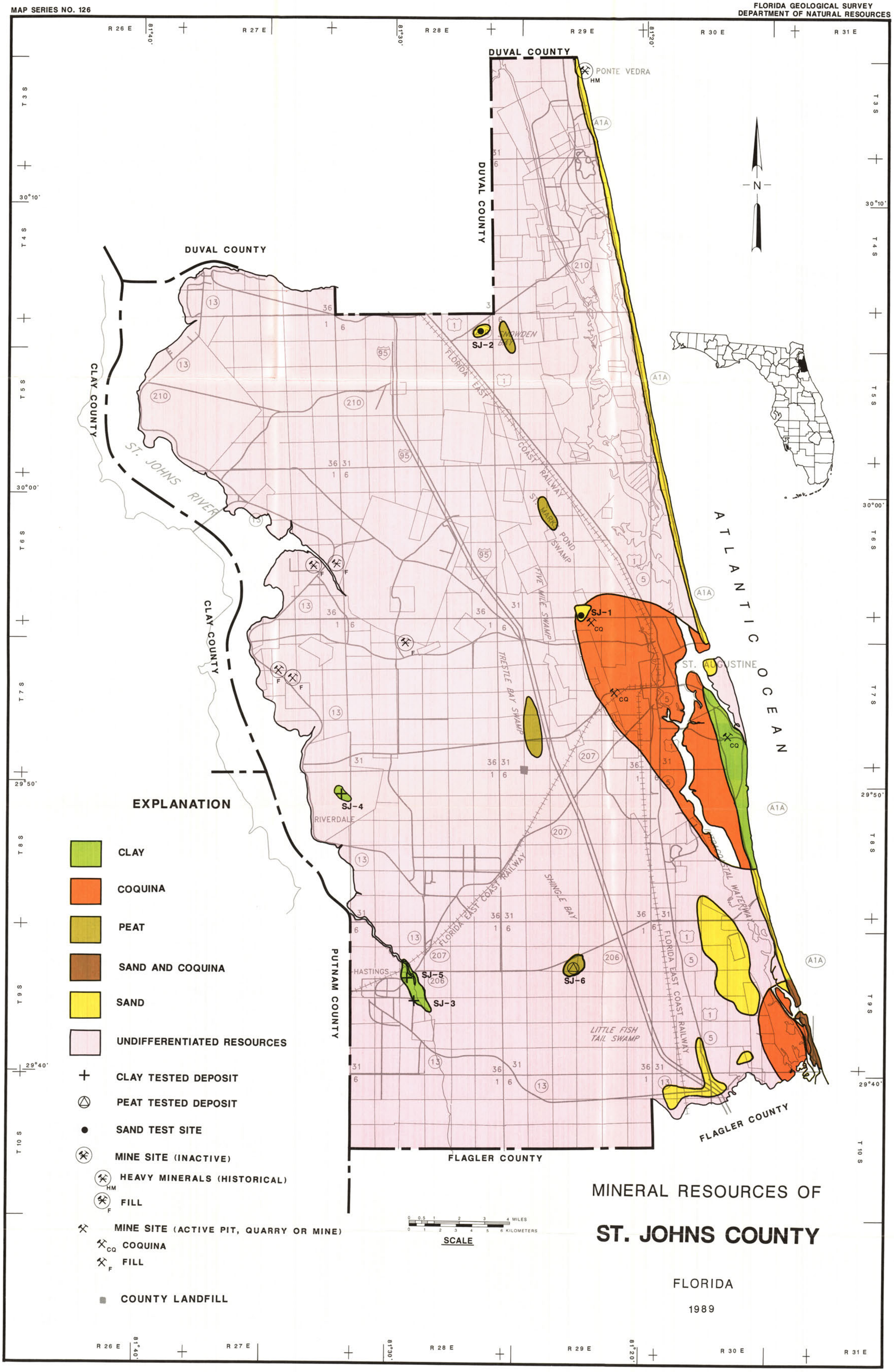
FLORIDA GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES



MINERAL RESOURCES OF

ST. JOHNS COUNTY

FLORIDA

1989

MAP SERIES NO. 126

MINERAL RESOURCES OF ST. JOHNS COUNTY, FLORIDA

BY

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ST. JOHNS COUNTY

INTRODUCTION

In recent years considerable attention has been focused on Florida's development, accompanying population increase and their effect on the state's important mineral resources. Frequently, urban development has occurred in areas underlain by known mineral deposits precluding future 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 this 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 deadlines 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 St. Johns County's mineral resources. The objective of this report is to summarize and interpret geologic data (i.e., core and well cutting descriptions and geophysical logs, and data derived from field reconnaissance) in a format appropriate for use by city and county planners.

A knowledge of St. Johns County's mineral resources is basic and integral to the process of initiating, developing and implementing an effective comprehensive land use plan. This information and data are essential to planners and officials in their analysis of urban and rural development in such areas 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, changing, and in many instances interrelated, thus complicating 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, beneficiation, transportation, 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 numerous discussions with mining company personnel and state and federal officials. Although detailed information on company statistics is 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 lends 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
fahrenheit	5/9 (^{o}F-32)	centigrade

GEOMORPHOLOGY

All geomorphic features in St. Johns County are oriented parallel to the coast, as shown in Figure 1. This orientation reflects the origins of these features as they have evolved through geologic time. They are the result of erosional and depositional coastal processes that have operated in response to the changing sea levels of the Atlantic Ocean. These geomorphic features include the Eastern Valley, Atlantic Coastal Ridge, Atlantic Coastal Lagoons, Atlantic Beach Ridges and terraces.

The Eastern Valley is a major geomorphic feature in Florida which extends from Palm Beach County north to Duval County (White, 1970). In St. Johns County, the Eastern Valley varies in width from approximately three miles to approximately 12 miles, from the St. Johns River to the Atlantic Coastal Ridge (Figure 1). Elevations in the Eastern Valley range from a low of approximately six feet above mean sea level (MSL) along the St. Johns River to approximately 30 feet above MSL, near the western toe of the Atlantic Coastal Ridge. Perennially swampy areas are characteristic of the Eastern Valley in St. Johns County. White (1970) interpreted the Eastern Valley as representing an ancient beach ridge plain, with relict beach ridges throughout that are coast-parallel oriented. The beach ridges have average elevations that range from 25 feet MSL in the southern Eastern Valley, to approximately 50 feet MSL in the north. The lower elevations in the south are attributed to the process of dissolution of underlying limestone (White, 1970).

The Atlantic Coastal Ridge, which might have been the mainland shore of the Pamlico Sea, is not a single feature, but is a series of relict beach ridges and bars which may be single or multiple (White, 1970). In St. John's County, the Atlantic Coastal Ridge is irregular in plan view and is expressed as an extensive area of higher land which extends northward into Duval County to the south bank of the St. Johns River near Jacksonville (White, 1970). The western toe of this ridge is about 30 feet MSL; its eastern toe is approximately 25 feet MSL. Elevations of the crest vary from 35 feet MSL at the south end to over 65 feet MSL at the north end, at the St. Johns-Duval County line.

St. Johns County has a well developed barrier island system (Atlantic Beach Ridge) which has narrow, linear, coast-parallel beach ridges superimposed on it locally. The Atlantic Coastal Lagoon, which separates the Atlantic Barrier Chain from the mainland, becomes increasingly filled (derelict) to the north, so that in northeastern St. Johns County 10 miles of the Intracoastal Waterway is a canal.

Relict marine terraces, which were formed by ancient seas, are present over much of Florida. In St. Johns County, Healy (1975) identified three terraces on the basis of land surface elevations (Figure 2). In order of descending elevation, they are: Talbot Terrace (25-42 feet MSL), Pamlico Terrace (10-25 feet MSL), and Silver Bluff Terrace (less than 10 feet MSL). In addition, mapping for this report found a small area along the north-central county line with elevations between 42-70 feet above MSL, which correlates with Cooke's (1945) Penholoway Terrace.

GEOLOGY

The oldest sediments observed, to date, in St. Johns County were encountered in a deep oil test well. This well (W-11084; section 35, Township 7S, Range 28E) encountered Paleozoic age quartzitic sandstone at a depth of 4583 feet below land surface.

Overlying these deep sediments are vast accumulations of Mesozoic Era carbonates (limestones and dolomites) and clastics measuring thousands of feet in thickness. These in turn are overlain by more recent Cenozoic Era sediments comprised of carbonates and clastics including the near-surface Ocala Group limestone, a primary unit of the Floridan aquifer system in St. Johns County.

The Ocala Group limestones of Late Eocene age are present in the subsurface throughout St. Johns County occurring at depths of approximately 100 to 140 feet below MSL (Figures 3a, 3b and 3c). The Ocala Group varies in thickness from less than 50 feet in southern Flagler County to approximately 250 feet in eastern St. Johns County. These sediments, which can frequently be identified by the presence of the distinctive Foraminifera genus Lepidocyclina (Puri, 1957), commonly contain numerous mollusks, bryozoa, and echinoids. Although these sediments are generally soft and porous, they can be dolomitic or highly indurated and dense due to cementation by calcite. The Ocala Group is the principal source of potable water in the county (Bermes et al., 1963).

The Oligocene Suwannee Limestone is missing in St. Johns County due to either nondeposition or erosion. As a result, the Miocene Hawthorn Group overlies the Ocala Group. The Hawthorn Group underlies the surface sediments in all parts of the county (Scott, 1988). Variable in lithologic character, the Miocene Series Hawthorn sediments consist of interbedded gray to olive-green, phosphatic sand, sandy clay, dolomite and sandy limestone. The contact separating the Hawthorn Group and the overlying surface sands may appear gradational due to reworking of sediments. The top of the Hawthorn Group is placed at the first significant occurrence of phosphate included in a sandy, clayey dolomite to dolomitic, clayey sand. A minimum thickness of 51 feet of Hawthorn was encountered in a core hole from the extreme southeastern part of the county (W-13844; section 37bb, Township 10S, Range 30E) and a maximum thickness of 219 feet was observed in another core hole from the northern part of St. Johns County (W-1375; section 11cb, Township 5S, Range 28E).

The sands and carbonate sediments of the Hawthorn Group comprise the intermediate aquifer system in the county and serve as a local source of potable water, yielding moderate amounts of water to some domestic wells. Higher yields of water are especially pronounced along the St. Johns River where the sand and limestone lenses seem to be more continuous (Bermes et al., 1963). This is in contrast to the Hawthorn clays which act as confining beds for the underlying water-bearing limestone units of the Floridan aquifer system.

Overlying the Hawthorn Group are Pliocene/Pleistocene age deposits consisting of coquina and clayey sands which represent the oldest sediments exposed in the county. The coquina is a limestone composed of whole and broken shells and quartz sand grains that have been cemented together. The clayey sands are diverse in lithology containing various percentages of silt and a fine to coarse quartz and/or shell sand in a clay matrix.

Coquina, which occurs at or near the surface along the coast from St. Augustine southward to Palm Beach County, has been mapped and identified as part of the Anastasia Formation (Cooke, 1945). In St. Johns County, these sediments, which are generally less than 20 feet in thickness, form part of the surficial aquifer system and occur in a narrow band that generally parallels the coast. This band, which varies in width, extends inland a maximum distance of approximately seven miles in the east-central part of the county (Schmidt et al., 1979).

Contiguous with and westward of the Anastasia Formation are surficial sands containing varying amounts of silt and clay that cover the western two-thirds of the county. These sands, which also form part of the surficial aquifer system, are variable in thickness throughout the county. Data derived from five Florida Geological Survey cores drilled in St. Johns County give a minimum thickness of 57 feet of sand in north-central St. Johns County (W-13744; section 8d, Township 6S, Range 28E) and a maximum thickness of 116 feet of sand in the extreme southeastern part of the county (W-14413; section 20bb, Township 8S, Range 28E).

MINERAL RESOURCES

Introduction

The purpose of the following discussion is to provide information on the occurrence of mineral resources in St. Johns County, the types of tests performed and the analyses of samples collected. The information presented is not intended to be an exhaustive investigation leading to immediate industrial development; rather, the data represents information on a single location, pit or mine. However, the data, where favorable, would indicate that certain areas might warrant further investigation. 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 resources 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 St. Johns County are sand, coquina, clay, heavy minerals, peat and undifferentiated resources.

Sand

Quartz sand accumulations, which have been deposited and modified by different sea level stands, form a surface deposit over nearly all of St. Johns County (Scott et al., 1980). Data from five Florida Geological Survey core holes (W-13744, W-13751, W-13765, W-13844 and W-14413) and numerous well cuttings in St. Johns County show that the undifferentiated sands, clays and coquina, which overlie the Hawthorn Group sediments, vary from 57 to 117 feet in thickness (Figures 3b and 3c). Deposits of fine to medium grained sand and silt occur locally. These sediments may range up to 10 feet or greater in thickness (particularly those deposits associated with dunes along the coast).

During the course of this study sand samples were collected and analyzed (sampling sites SJ-1 and SJ-2, Mineral Resources Map). In addition, the geologic characteristics of the sampled deposits were described. The method used to analyze the sands included repeatedly putting the sediment through a riffle splitter until a 100-gram sample was obtained. The samples were treated to remove organic material and clay, and wet sieved before drying. The samples were then rotapped and weighed using U. S. Standard Sieve Screens.

Test data results from the sieve analysis (Table 1) represent one set of samples only and not the entire deposit. Information derived from this table may aid the reader in determining the general usefulness of the particular deposit for industrial purposes.

The test results indicate that the sands are not suitable for use as construction sand or brick masonry. Where no specific usage requirements are required, the sand can be used as fill material.

No tests were performed to determine if the sands in the county are suitable for glass manufacturing. However, impurities such as heavy minerals and various oxides will probably preclude their use for this purpose.

The Florida General Soils Atlas (Kolb, 1974) indicates that of the 17 soil associations present in St. Johns County, 12 are rated good as a source for roadfill. Four soil associations are good sources of sand. The areas rated as good sources of sand are labeled as such on the Mineral Resources Map. Areas which do not meet the criteria to be labeled a good sand source include swamps, along rivers, and along the Intracoastal Waterway. The soil scientists conducting the study sampled the uppermost 80 inches of the sediment profile.

Coquina

Coquina, as it occurs in St. Johns County, is a moderately friable limestone comprised of broken shells, other biogenic debris and quartz sand, and is cemented with calcite. It comprises the Pleistocene Series Anastasia Formation, which sporadically crops out along the Atlantic Coast line, or may be found in the near-surface sediments (Mineral Resources Map). It is limited areally to about six or seven miles inland from just north of St. Augustine, south to the county line (Schmidt et al., 1979).

Coquina was first mined by the early settlers of the region and used as a building stone. After the coquina is extracted from the ground and subjected to areal weathering, it case hardens and becomes a durable building material. The well known Fort Castillo De San Marcos near St. Augustine is constructed almost entirely of coquina.

Bulldozers, front-end loaders and small draglines are used to mine the coquina. Occasionally, blasting is used to loosen the rock for mining. After mining it may be stockpiled for future markets or sold immediately. The sized coquina product generally ranges from 1 1/8 to 3/8 inches in size and is sold in bulk by the ton. Material, which is coarser than 3/8 inches, is sold as aquarium fill. A large amount of the shelly material is mixed with concrete to make decorative exterior building panels. Coquina is mined by Seamount Ventures Company (section 14, Township 7S, Range 29E), S. J. Mills Company (sections 34 and 3, Townships 6S and 7S respectively, Range 29E) and in Anastasia State Park (section 28, Township 7S, Range 30E) by the state's park service for use in refurbishing existing buildings.

The demand for coquina products has waned over the years to a point where it is unlikely this commodity will become a major industry. However, the potential for small scale operations exists, particularly in areas where markets and transportation routes are favorable.

Clay

Clay of limited extent was shown by Bell (1924) to be present in southwestern St. Johns County near Hastings (section 21, Township 9S, Range 28E, sampling site SJ-3 on Mineral Resources Map). Bell (1924) sampled the clays and found them to be good for common and face brick, and other structural materials. Analyses of the clay's physical properties follows.

Table 2
Physical properties for Minton Clay, Hastings, Florida
(from Bell, 1924).

Plasticity, judged by feel	Excellent
Water of plasticity	23.6 %
Pore water	0.4 %
Shrinkage water	23.1 %
Linear air shrinkage	11.2 %
Volume fire shrinkage	31.2 %
Modulus of rupture, average	837.7 psi
Slaking test	2 minutes

Steel hard at cone 1.
Overfires at cone 5.

Fire tests:

Temperature (^{o}F)	Linear Per Cent	Shear Per Cent	Absorption Per Cent	Porosity Color
1742	0.7	20.4	35.8	Brick red
1922	1.2	11.4	27.4	Brick red
2102	1.2	10.8	26.5	Brick red
2174	2.2	8.6	25.5	Brick red
2246	2.2	8.3	22.5	Brick red

Additionally, Bell (1924) tested clays from the floodplain of the St. Johns River in an area near Riverdale (section 38, Township 8S, Range 27E, sampling site SJ-4 on the Mineral Resources Map). He stated that these clays may only be good for an inferior grade of common brick. An analysis of the clay taken near Riverdale follows:

Table 3
Physical properties of J.J. Goss Clay, Riverdale, Florida
(from Bell, 1924).

Plasticity, judged by feel	Excellent
Water of plasticity	21.5 %
Pore water	0.4 %
Shrinkage water	20.8 %
Linear air shrinkage	6.5 %
Volume fire shrinkage	16.1 %
Modulus of rupture, average	211.9 psi
Slaking test	10 minutes.

Fire Tests:

Temperature (^{o}F)	Linear Shear Per Cent	Absorption Per Cent	Porosity Per Cent	Color
1742	1.0	28.9	38.9	Brick red
1922	1.5	27.8	35.5	Brick red
2102	2.5	20.5	29.2	Brick red
2174	2.5	19.3	27.6	Brick red
2246	2.5	19.0	25.6	Brick red

Calver (1949) tested clay from a site east of Hastings (section 16, Township 9S, Range 28E, sampling site SJ-5 on the Mineral Resources Map). The analysis of this clay is presented in Table 4.

Table 4

Physical properties for clay, east of Hastings, Florida
(from Calver, 1949).

Plasticity, judged by feel	Fair
Water of plasticity	30.0 %
Pore water	---
Shrinkage water	---
Linear air shrinkage	9.2 %
Volume fire shrinkage	---
Modulus of rupture, average	320.0 pounds per square inch
Slaking test	Fast

Fire Tests:

Temperature (^{o}F)	Linear Shear Per Cent	Absorption Per Cent	Porosity Per Cent	Color
1742	0.0	12.0	33.3	Light Brick red
1922	1.5	11.0	31.0	Reddish Orange
2102	0.5	10.4	30.0	Light Brick red
2174	1.5	9.9	28.8	Brick red
2282	0.5	10.1	29.4	Dark red

Results of tests completed on this clay suggest that common brick could be manufactured (Calver, 1949).

Readle (1983), as part of the Soil Conservation Service's St. Johns County report, analyzed several soil samples to determine their clay mineralogies and total clay percent. Results of the analyses show that montmorillonite (smectite) is the dominant clay mineral present in the tested soils. The soils, which vary from sandy clay to clayey sand to sand, occur along numerous creeks, in swamps, and along the borders of the intracoastal waterway. In defining and mapping these soils Readle (1983) sampled to a maximum depth of 80 inches.

Lithologic logs on file at the Florida Geological Survey indicate that clays also occur deeper than mapped by the Soil Conservation Service. Clays, for the purpose of this report, occur scattered throughout at least the uppermost 100-feet of sediments both as a matrix material and a primary lithologic constituent. They are not however, limited areally to any one region nor are they, in a vertical sense, extremely thick.

Presently, no clay mining occurs in St. Johns County. The commercial clay mining operations, which occur in neighboring western Putnam County and the limited known occurrence of economic clay deposits in St. Johns County, diminishes the future potential for clay mining in this county.

Heavy Minerals

The first heavy mineral mining to occur in Florida began in 1916 at Mineral City, now called Ponte Vedra, in St. Johns County. Calver (1957) states that ilmenite, a constituent of these heavy mineral sands, was used in the manufacture of titanium tetrachloride which, in turn, was used for World War I artillery.

Calver (1957) also discussed a study conducted jointly by the U.S. Bureau of Mines and the Florida Geological Survey in 1947. This study, which resulted in locating a quantity of ore material in western Duval and Clay Counties, was undertaken to establish reserves of titanium minerals. The ore body, where it was later mined, was composed of quartz sand (96%) and heavy minerals (4%). The typical assemblage of heavy minerals included:

Titanium minerals	45%
Zircon	15%
Staurolite	20%
Sillimanite	5%
Tourmaline	5%
Kyanite	4%
Other	6%

In St. Johns County, the heavy minerals which were mined at what was then called Mineral City (section 15, Township 3S, Range 29E), consisted of the following typical assemblage:

Quartz and Feldspar	11.9%
Ilmenite	49.6%
Zircon	17.2%
Rutile	6.6%
Monazite	2.1%
Staurolite	3.0%
Epidote	4.8%
Garnet	1.2%
Other	3.6%

A detailed discussion of the mining at this site is presented in the Florida Geological Survey 19th Annual Report (Martens, 1927). Production from the Ponte Vedra (Mineral City) site terminated in 1929 (Calver, 1957).

Presently, there are no heavy mineral mining operations in St. Johns County. North and west of St. Johns County, near Green Cove Springs and along the Trail Ridge in Clay County, are areas which currently produce heavy minerals. Potential for future production of heavy minerals may exist along the Atlantic Coastal regions although extensive field investigations and associated drilling would have to be made prior to any mining.

Peat

Peat is a product of partially decomposed organic materials which accumulate when the depositional rate exceeds decomposition (Bond et al., 1986). In areas that are waterlogged, organisms which normally metabolize (destroy) plant matter are inhibited and peat frequently accumulates.

Peat is not currently mined in St. Johns County; however, the low topographic relief and high water table that characterize part of St. Johns County may have led to the accumulation of peat. In particular, St. Marks Pond Swamp in central St. Johns County and Shingle Bay to the south have the best potential for peat (Taylor et al., 1920). Davis (1946) summarized his findings (Table 5) on a single deposit of peat from the Shingle Bay area (sampling site SJ-6 on the Mineral Resources Map). Readle (1983) updated Taylor's (1920) county soil map and indicated that soils located in the previously mentioned areas are comprised predominantly of decomposed organic material (muck). Organic rich soils occur along the Intracoastal Waterway (Township 3 South and Range 29 East) Snowden Bay, St. Marks Pond Swamp, Five Mile Swamp, Trestle Bay Swamp near Highway 214, the Shingle Bay Swamp, and an area about one mile west of Little Fish Tail Swamp in southern St. Johns County (Readle, 1983).

The Soil Conservation Service's Hontoon soil type, which is currently being mined as peat in neighboring Putnam County, has occurrences in St. Johns County (Mineral Resources Map). This enhances the potential for mining economical peat and warrants further investigation.

Table 5
Properties for Shingle Bay peat deposit,
section 9, Township 9S, Range 29E (from Davis, 1946).

Sample No. 112, Moisture Free Basis Proximate Analysis (Per Cent)

Volatile Matter	28.0
Fixed Carbon	17.1
Ash	54.9

Ultimate Analysis (Per cent)					BTU Per Pound (Moisture Free)
H	C	N	O	S	4450
2.3	27.7	1.0	14.0	0.1	

Undifferentiated Resources

The surface and near-surface sediments of St. Johns County are comprised of sands, sandy clays, clay, marl, and organic muck. These undifferentiated resources are present throughout much of the western two-thirds of the county. Much of the county, particularly those areas where clays and muck are present, are ordinarily inundated by water and therefore difficult to reach. The heterogeneous nature of the sediments in the county would tend to preclude their large scale economic marketability. However, sand and clayey sand used as fill are extremely valuable commodities in St. Johns County, as many areas are subject to flooding and require fill for building and development purposes. In addition, these sediments can be used for top soil and road fill. The possibility does exist that a future comprehensive investigation of these undifferentiated sediments may lead to additional economic or industrial applications.

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Table 1. Screen Analyses of Sand in St. Johns County, Florida (sampling site numbers SJ-1 and SJ-2 on the Mineral Resources Map).

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*
SJ-1	sec 34 T6S, R29E	Spot	--	--	--	0.036	2.16	100.000	1.02
SJ-2	sec 1 T5S, R28E	Channel	--	--	0.004	0.077	3.023	100.000	1.03

*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 percentages of the individual screens, 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 idea of 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 C136-84a. The reader is also referred to the Florida DOT Manual of Florida Sampling and Testing Methods for Aggregates, designation FM 1-T 027.

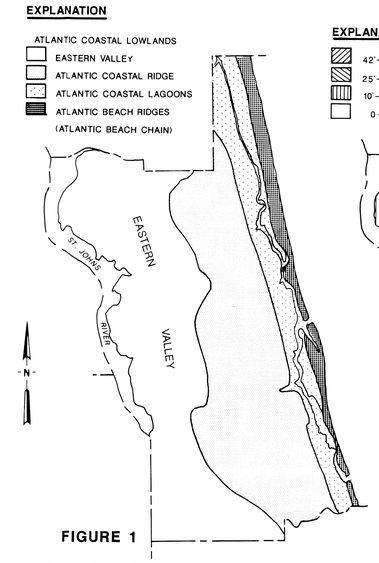


FIGURE 1
GEOMORPHOLOGY
(modified from White, 1970)

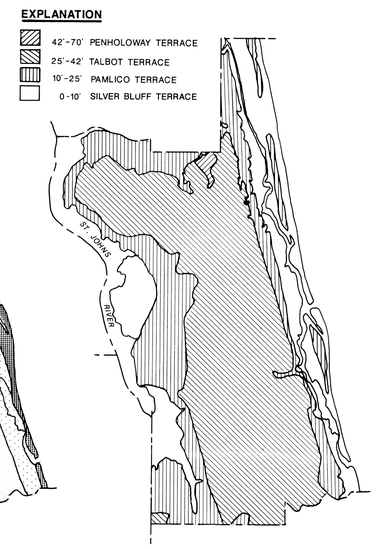


FIGURE 2
TERRACES AND SHORELINES
(modified from Healy, 1975)

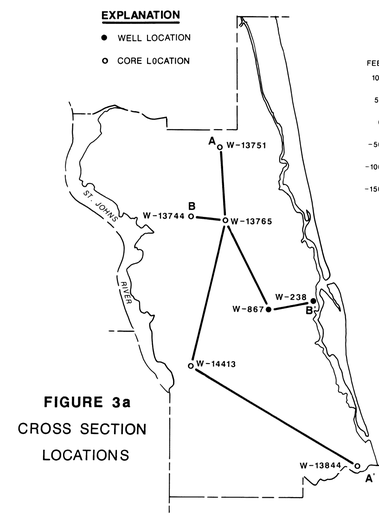


FIGURE 3a
CROSS SECTION
LOCATIONS

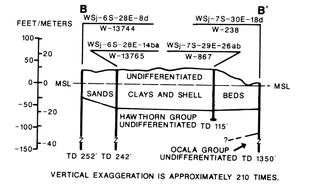
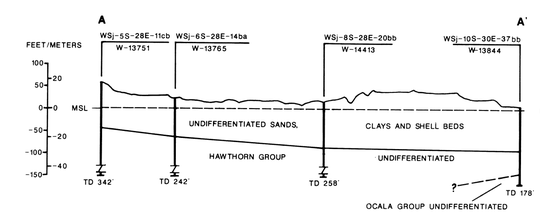


FIGURE 3c
CROSS SECTION B-B'

SCALE
0 1 2 3 Miles
0 1 2 3 4 5 6 Kilometers

SCALE FOR FIGURES 3b and 3c

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 abreviation, the Township, Range, and Section, and the quarter/quarter location within the section.



VERTICAL EXAGGERATION IS APPROXIMATELY 210 TIMES.

FIGURE 3b
CROSS SECTION A-A'

SCALE
0 1 2 3 Miles
0 1 2 3 4 5 6 Kilometers

SCALE FOR FIGURES 1,2, and 3a