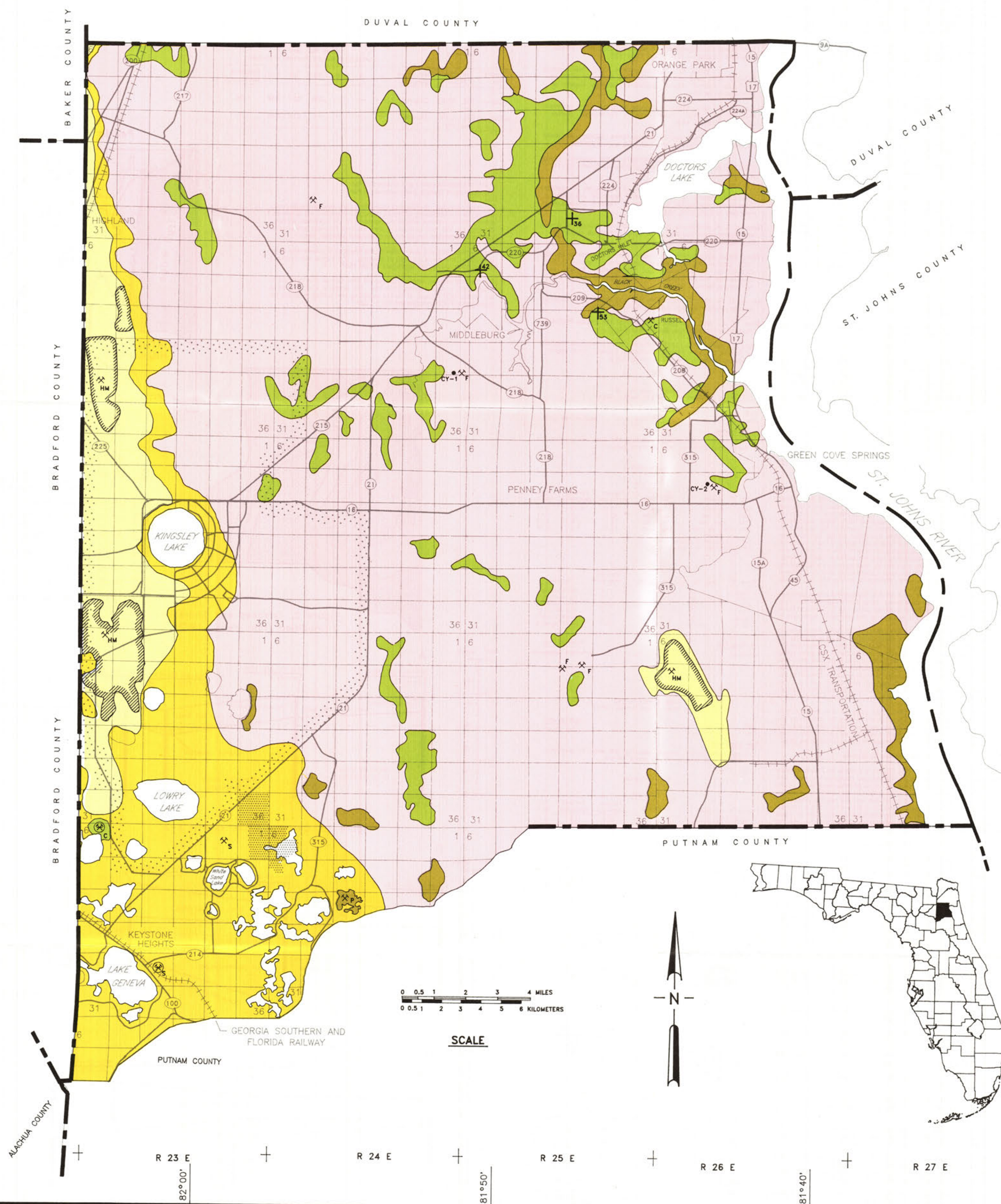


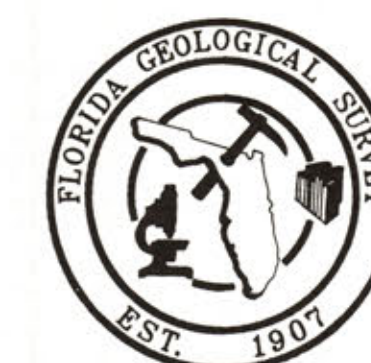


EXPLANATION

- CLAY
- HEAVY MINERALS
- PEAT
- SAND
- UNDIFFERENTIATED RESOURCES (shelly, clayey sand)
- CLAY TESTED DEPOSIT
- MINE SITE (INACTIVE)
- SAND SAMPLING LOCATION
- MINE SITE (ACTIVE PIT, QUARRY OR MINE)
- CLAY
- PEAT
- FILL
- SAND
- HEAVY MINERALS
- CAMP BLANDING MILITARY RESERVATION
- MIKE ROESS GOLD HEAD BRANCH STATE PARK

MINERAL RESOURCES OF CLAY COUNTY FLORIDA

BY
STEVEN M. SPENCER, P.G.#319, J. WILLIAM YON JR.,
RONALD W. HOENSTINE, AND ED LANE
1991



WALTER SCHMIDT
STATE GEOLOGIST AND CHIEF

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CLAY COUNTY
INTRODUCTION

In recent years considerable attention has been focused on Florida's rapid development, the accompanying population increase, and their effects on the state's important mineral resources. Frequently, this development occurred in areas underlain by known mineral deposits, precluding extraction of the minerals. These mineral resources provide 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 due dates were established by the 1986 Florida Legislature.

In response to this act and at the request of the Northeast Florida Regional Planning Council, the Florida Geological Survey initiated a study of Clay 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 Clay 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 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. The evaluation process is inherently dependant on an extensive exploration program 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 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 with the state's geological resources evaluation lends substantial confidence to the general assessment and inferences of this report.

METRIC CONVERSION FACTORS

To prevent the 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 (°F-32)	centigrade

GEOMORPHOLOGY

Located in northeast Florida, Clay County falls within White's (1970) Northern (Proximal) Zone which traverses northern Florida. This zone is characterized by a continuous broad upland which extends across the northern Florida peninsula and westward into the Western Highlands of Florida's panhandle. The Northern Zone is divided into a number of geomorphic subdivisions, several of which are present in Clay County. These include the Northern Highlands, Trail Ridge, Duval Upland, Peoria Hill and the Eastern Valley (Figure 1).

The Northern Highlands covers the western one-third of Clay County (Figure 1). The topography of this area is characterized by numerous lakes and elevations that frequently exceed 200 feet above mean sea level (MSL). The eastern boundary of the Northern Highlands in Clay County is marked by the Cody Scarp, the toe of which approximates the 100 feet above MSL elevation contour. White (1970) describes this break as the best known relict marine scarp of the Atlantic Coastal Plain.

Trail Ridge is located along the northwestern and west-central border of Clay County. This distinctive feature is a subunit of the Northern Highlands. Elevations here are among the highest in northeastern Florida, averaging over 200 feet above MSL. The heavy-mineral deposits present in the area represent one of the largest concentrations in the United States and are the focus of Florida's heavy-mineral industry.

The Duval Upland is located to the east of Trail Ridge and the Northern Highlands. This north-south approximately linear geomorphic feature is characterized by elevations much lower than those of Trail Ridge, averaging 100 feet above MSL. The gently sloping topography of the Duval Uplands includes much of the central one-third of Clay County.

The Eastern Valley occupies the eastern portion of Clay County. Although placed by White (1970) in the Central Highlands, this feature extends into the Northern (Proximal) Zone and lies contiguous to the eastern boundary of the Duval Upland in Clay County. A number of swampy areas are present in the Eastern Valley. In general, this area has the lowest elevations in the county, ranging from a few feet above MSL near the eastern edge of the Duval Upland (Figure 1). White (1970) interpreted the Eastern Valley as representing an ancient beach-ridge plain with relict beach ridges throughout that are coast-parallel.

Peoria Hill is a small, irregular shaped feature identified by White (1970) as being present in the northeastern part of Clay County along the St. Johns River. Its elevations are distinctly higher than the surrounding Eastern Valley.

In addition to the above geomorphic features a number of relict terraces formed by ancient seas are present in the county. Healy (1975) identified seven terraces in Clay County based on land surface elevations (Figure 2). In order of descending elevation, they are: Hazelhurst Terrace (215-320 feet above MSL), Coharie Terrace (170-215 feet above MSL), Sunderland Terrace (100-170 feet above MSL), Wicomico Terrace (70-100 feet above MSL), Penholoway Terrace (42-70 feet above MSL), Talbot Terrace (25-42 feet above MSL) and Pamlico Terrace (10-25 feet above MSL).

GEOLOGY

The geology of Clay County is characterized by surface and near-surface occurrences of siliciclastic sediments (quartz sand, silt, clay, sand and clay) underlain by thick sequences of carbonates (limestone and dolomite). In turn, these sediments overlie Paleozoic Era basement rocks at depths of more than 3,000 feet below land surface. Deep oil test wells (W-1590, section 4, Township 6S, Range 25E) drilled by Humble Oil and Refining Company encountered a Paleozoic age quartzitic sandstone at a depth of approximately 3,600 feet below MSL (Applin, 1951).

Figure 3a is a map showing the location of geologic cross sections used in this report. Figures 3b, 3c and 3d are the geologic cross sections of sedimentary rocks of Late Eocene and younger age. The Ocala Group limestone is an important and productive part of the

Florida aquifer system in Clay County. Deposited during the Eocene Epoch, 57 to 36 million years before the present (BP), these rocks generally consist of a soft, white, chalky, relatively pure limestone containing abundant fossils (foraminifera, mollusks, bryozoans and echinoids). The top of the Ocala Group is typical of a karst surface with numerous sinkholes and depressions. Present throughout Clay County, the Ocala Group occurs at varying depths ranging from 80 to 300 feet below MSL (Florida Geological Survey well data). A maximum observed thickness of 254 feet was encountered in W-10533 (section 4, Township 4S, Range 25E) in northeastern Clay County near Orange Park.

Hawthorn Group lithologies, which were deposited during the Early to Middle Miocene (23 to 15 million years BP) overlie the Ocala Group limestone throughout the county. The lithology of these sediments is diverse, consisting of interbedded phosphatic clay, silt, clayey quartz sand and dolomite. Three formations comprise this group in Clay County (Scott, 1988a). They are, from oldest to youngest, the Penney Farms Formation, the Marks Head Formation and the Coosawatchee Formation.

The highly variable nature of the Hawthorn lithologies in this area makes identification of the individual units difficult. Therefore, these rocks are referred to as Hawthorn Group undifferentiated in the cross sections of this report (Figures 3b and 3c).

The top of the Hawthorn Group is variable in depth averaging approximately 25 to 50 feet above MSL. The thickness varies from less than 225 feet in the northwestern part of the county to as much as 370 feet in north-central Clay County (W-14219, section 27, Township 4S, Range 24E). Approximately 15 feet of Hawthorn Group sediments (that are overlain by 7 to 10 feet of undifferentiated sands and clays) can be observed at the Florida Solite Mine (section 39, Township 5S, Range 25E).

Poorly indurated, clayey, silty quartz sands overlie the Hawthorn Group in western Clay County. These Pleistocene age siliciclastics, formerly included in the Citronelle Formation by Cooke (1945), have recently been placed in the Cypresshead Formation (Scott, 1988b).

The Nashua Formation overlies the Hawthorn Group in the northeastern part of Clay County. The lithologies of this unit range from an unconsolidated calcareous shelly sand to a sandy shelly bed. Huddleston (1988) dates this formation as Late Pliocene in age based on planktonic foraminifera. The lower surface of this unit occurs at elevations which range from approximately 8 to 6 feet below MSL, while its thickness varies from 10 to 55 feet in W-14193 (section 13, Township 4S, Range 25E) and W-14476 (section 17, Township 6S, Range 25E), respectively (Figure 3d).

Undifferentiated sand, clay and shell with maximum thicknesses of over 100 feet cover Clay County (Figure 3c). These Pleistocene and Holocene age deposits are composed of a clayey sand with occurrences of shell material. An exception is northern Clay County where the surface sediments are predominantly a sandy clay.

MINERAL RESOURCES

INTRODUCTION

The mineral resources map and following discussion of the economic geology of Clay County is not intended to be a complete investigation leading to immediate industrial development because, in many cases, the data represents information on a single outcrop, pit or mine. Favorable data, however, may indicate that certain areas warrant further investigation. 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 volume of the deposit, all have an effect on mining of a mineral commodity at any one specific site. Geologic cross sections (Figures 3b, 3c and 3d) were generated from core and well cuttings to show the general distribution and thickness of surface and near-surface stratigraphic units. The following is a discussion of the clay, heavy minerals, peat, phosphate, sand and the undifferentiated resources of Clay County.

Clay

Clay minerals (smectite and kaolinite) are common to abundant in various regions of Clay County. Miocene age Hawthorn Group clays and Pleistocene to Holocene age undifferentiated alluvial deposits dominate the surface and near-surface sediments in the northeastern portion of the county. Sediments of the southwestern part of the county consist of kaolin-bearing sands associated with the Pleistocene age Cypresshead Formation.

Kaolinite, a hydrous aluminosilicate, is used in the manufacture of such items as china ware, paper, coating, glaze, and pottery. The clay, which comprises a matrix material of the Cypresshead, was analyzed by Calver (1949). The samples were taken from an old, abandoned kaolin mine (Chalk Hole) located in section 6, Township 8S, Range 23E. Results of the tests indicated the kaolin to be of high quality similar to the finest produced in Florida at the time. There are no active kaolin mines in Clay County at the present time.

Bell (1924) conducted a study of the clay resources in a number of Florida counties. He analyzed samples of common clay and kaolin for their physical properties. In Clay County, Bell (1924) analyzed samples from what were then established common clay production areas such as Doctors Inlet, Middleburg and Green Cove Springs. Bell also tested the kaolinitic quartz sands near White Sand Lake north of Keystone Heights. Results of Bell's numerous tests indicate that the clay from Doctors Inlet was satisfactory for a good grade of common brick and drain tile manufacturing. The clay sample (Kaolin) from near White Sand Lake was suitable, if washed, for some grades of white ware.

Calver (1949) tested clays from the Green Cove Springs area, Russell and Middleburg. The results from the Green Cove Springs deposit indicated the clay would be unsuitable for common brick. The Russell deposit was found to be suitable for face brick, drain tile, and common brick. The Middleburg clay was found to be suitable for hollow ware in addition to the Russell deposit usages.

Hickman and Hamlin (1954) conducted a study on clay sediments from several northeastern Florida counties. Within Clay County their study centered on 59 test holes in the Doctors Inlet to Middleburg region along State Highway 21 and County Highway 220. Their findings were similar to previous investigations indicating that the clays could be used in the manufacture of common brick. Additionally, due to positive results during bloating tests, potential uses included lightweight aggregate in hole 36 (section 34, Township 4S, Range 25E) Table 1, Town 4S, Range 25E, (Section 34, Township 4S, Range 25E) Table 2, and hole 53 (section 14, Township 5S, Range 25E) Table 3.

Florida Solite Corporation, located near Russell in section 39, Township 5S, Range 25E, is the only company actively mining clay in (1970) describes this break as the best known relict marine scarp of the Atlantic Coastal Plain.

Trail Ridge is located along the northwestern and west-central border of Clay County. This distinctive feature is a subunit of the Northern Highlands. Elevations here are among the highest in northeastern Florida, averaging over 200 feet above MSL. The heavy-mineral deposits present in the area represent one of the largest concentrations in the United States and are the focus of Florida's heavy-mineral industry.

Heavy Minerals

Heavy-mineral sands occur as a small fraction in nearly all of Florida's sand deposits. The source region for pebbles in Florida's Piedmont and Blue Ridge region of the Appalachian Mountains. The weathering products of the Appalachians were transported by streams which deposited them in alluvial, deltaic, and longshore environments (Pirkle et al., 1974).

The first commercial production of heavy-mineral sands began in 1915 at Mineral City, now called Ponte Vedra, St. Johns County. Mr. H. Buckman and Mr. G. Pritchard began a mining and milling operation at the site for the manufacture of titanium tetrachloride, used for war purposes.

The United States Bureau of Mines (Thoenen and Warne, 1949) conducted a study and drilled over 700 test holes in 1947 to 1949 in northeastern Florida. Much of that investigation was centered around the Trail Ridge region. The U.S. Bureau of Mines (USBM) drilled holes along State Highway 100 near Keystone Heights, along State Highway 221 near the Mike Ross Gold Head Branch State Park near the Clay-Bradford county line, and in northwestern Clay County near Highland. Thoenen and Warne (1949) indicated that the Gold Head Branch State Park contains sediments with over 6 percent heavy minerals. Partially, as a result of the USBM study of that area, the E.I. duPont de Nemours Company ultimately began mining heavy-mineral sands in the Camp Blanding Military Reservation.

There are three ore bodies in Clay County: the Trail Ridge and the Highland ore deposit along the western boundary of Clay County, and the Green Cove Springs ore deposit in the southeastern part of the county. E.I. duPont de Nemours has mined large amounts of heavy minerals in western Clay County. RMC (USA) Minerals, Inc. formerly Associated Minerals, mines the Green Cove Springs deposit.

Heavy minerals present in the Trail Ridge area characteristically include the titanium minerals ilmenite, rutile and leucocane which comprise approximately half of the total volume of recovered heavy minerals (RHM) (Reeves, 1962). Zircon is next in abundance at 10-15 percent RHM; the other minerals include monazite, staurolite, kyanite, sillimanite, tourmaline, andalusite, pyroxene, spinel and corundum, all of which comprise about 40 percent of the remainder RHM (Reeves, 1962).

The Highland Ore body averages about three percent heavy minerals with the titanium minerals accounting for about 45 percent of the RHM ore minerals (Pirkle et al., 1977). The average TiO₂ content of the titanium minerals is 69 percent. Other minerals present in the deposit include staurolite, zircon, kyanite, sillimanite and tourmaline (Pirkle et al., 1977).

The Green Cove Springs deposit has, in addition to those minerals found in the other two deposits, lesser amounts of epidote and garnet (Pirkle et al., 1974). This deposit of heavy minerals occurs at the top

of a scarp whose toe is at an approximate elevation of 40 feet above MSL (Pirkle et al., 1974).

Although company statistics are confidential as to the amount of material produced and the value of those minerals, the USBM reports that Florida is the leading producer of heavy minerals in the United States. Geologists continue to explore areas for new deposits to add to their reserves as old deposits are mined out. The heavy mineral sands of Clay County continue to hold promise for future operations.

Peat

Peat is the accumulation of decomposed organic material, which collects in perennially wet areas (Davis 1946; Bond et al., 1986). Other factors of importance for the accumulation of peat include climate and topography. Specific areas in Clay County are suited for the accumulation of this commodity and, in fact, peat is presently mined in southwestern Clay County by Stricklin Peat Inc. (section 16, Township 8S, Range 24E) (Mineral Resources Map). The areal extent of the Stricklin mine is approximately 100 acres with a maximum depth of 28 feet.

Griffin et al. (1982) mapped several peat deposits in Clay County. However, detailed information on the deposits are not available. The United States Soil Conservation Service (1989) interim report on the soils of Clay County shows numerous locations of highly organic soils. It is the organic-rich Maurepas Muck that is mined as peat in southern Clay County. Pamlico Muck, another soil type, is also a potential source for peat.

The Mineral Resources Map shows the location of the previously mentioned soils which are associated with peat or peaty muck as well as areas where peat has been or is now mined. In addition to deposits scattered throughout the county, many highly organic (peaty) soils are located in the swampy lowlying areas along the St. Johns River, and Black Creek and its tributaries.

Mining procedures generally used by peat operators include removal of surface vegetation followed by site dewatering and subsequent removal of the peat by dragline or bulldozer. The material is shredded and stockpiled for future use. Currently, all Florida peats are used for horticultural purposes.

Phosphate

Economic deposits of phosphate are known to exist in several counties throughout Florida. Clay County is situated in the Northeastern Phosphate District (Scott, 1988b). Phosphate sediments in this district are of the pebble and sand-sized variety and are from the Hawthorn Group. Characteristics of the phosphatic sediments are as follows:

NORTHERN PHOSPHATE DISTRICT

Overburden thickness in Feet 50-150

Ore zone thickness in Feet 5-50

Bone Phosphate of Lime (BPL) in percent 62-65

(Source: Zellars and Williams, 1978).

The low economic value of the Clay County phosphatic sediments probably precludes mining in the near future.

Sand

Quartz sand occurs over most of Clay County. It is a primary component of the Cypresshead Formation and the Pleistocene-Holocene deposits occurring in the county. The known deposits of commercial quartz sand found in the county come from the Northern Highlands area in the southwestern part of Clay County.

Martens (1928) collected and analyzed a number of sand samples from the following locations in Clay County:

LOCALITY	1/4 inch	10	20	50	80	100	200
One mile west of Green Cove Springs	100.0	---	96.80	55.80	---	12.70	3.80
Green Cove Springs	100.0	---	100.00	97.30	---	8.80	0.60
Kingsley Lake	100.0	---	99.90	52.90	---	0.90	0.02
Two and one-half miles southwest Lake Geneva	100.0	---	99.90	71.20	---	13.60	1.70

In his analyses of the above samples Martens (1928) determined that the sample from two and one-half miles southeast of Lake Geneva was satisfactory for use in the manufacture of concrete. Florida Rook Products currently mines sand from similar deposits at their Goldhead Mine located in section 2, Township 8S, Range 23E. Sand is mined at the Goldhead Mine by suction dredge from an open water-filled pit. From the sand is pumped in a slurry to screen shakers where the sand is separated into several size fractions. These sands are utilized for manufacturing concrete and as a masonry sand.

Bell (1924) conducted a study of the clay resources in a number of Florida counties. He analyzed samples of common clay and kaolin for their physical properties. In Clay County, Bell (1924) analyzed samples from what were then established common clay production areas such as Doctors Inlet, Middleburg and Green Cove Springs. Bell also tested the kaolinitic quartz sands near White Sand Lake north of Keystone Heights. Results of Bell's numerous tests indicate that the clay from Doctors Inlet was satisfactory for a good grade of common brick and drain tile manufacturing. The clay sample (Kaolin) from near White Sand Lake was suitable, if washed, for some grades of white ware.

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Undifferentiated Resources

A large percentage of Clay County's surface and near-surface sediments are comprised of undifferentiated clayey sands, marl, and organic muck. The heterogeneous nature of these sediments would tend to preclude any large scale economic marketability. Locally, however, where conditions are not prohibitive and the material is present in uses such as fill or top soil, extraction on a small scale may be feasible. If, in the future, a comprehensive investigation of these undifferentiated sediments is undertaken, those data may lead to economic or industrial applications.

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Table 1. Hole No. 36
(from Hickman and Hamlin, 1964)

Type	Unfired color
Clay	Medium red gray
Row properties	
Longworking, plastic, smooth, requiring 35% water for plasticity, 9.0% drying shrinkage, with no drying defects.	

Fired properties

Temp. °F	Color	Hardness	Percent shrinkage	Percent absorption	App. Sp.Gr.
1800	Lt. Salmon	Hard	13.5	11.0	2.52
2000	Lt. red	Very hard	13.5	5.4	2.41
2100	Med. red	Very hard	16.0	4.4	2.42
2200	V. dk. red	Very hard	16.0	3.5	2.36
2300	Brown	Expanded	---	---	---
2400	Expanded & Glazed	---	---	---	---

Quick Fire

Temp. °F	Bulk density	lb. cu. ft.	Percent absorption	Remarks
1800	1.48	92.2	17.1	No bloating
1900	1.29	80.4	17.1	No bloating
2000	1.06	66.0	16.9	Poor bloating
2100	1.06	66.0	16.9	Fair bloating
2200	0.72	44.9	20.2	Good bloating
2300	0.70	43.6	08.3	Good bloating

Bloating Test

Positive

Potential use

Lightweight aggregate

Table 2. Hole No. 42
(from Hickman and Hamlin, 1964)

Type	Unfired color
Clay	Dark Brown
Row properties	
Longworking, plastic, smooth, requiring 29% water for plasticity, 10% drying shrinkage, with no drying defects.	

Fired properties

Temp. °F	Color	Hardness	Percent shrinkage	Percent absorption	App. Sp.Gr.
1800	Lt. Salmon	Hard	13.5	11.0	2.51
2000	Lt. red	Very hard	13.5	6.7	2.41
2100	Med. red	Very hard	14.5	5.0	2.42
2200	Dk. red brown	Very hard	15.0	4.1	2.42
2300	Dk. brown	Expanded	11.0	8.8	2.08

Quick Fire

Temp. °F	Bulk density	lb. cu. ft.	Percent absorption	Remarks
1800	1.17	72.9	22.2	No bloating
1900	1.12	68.7	19.7	