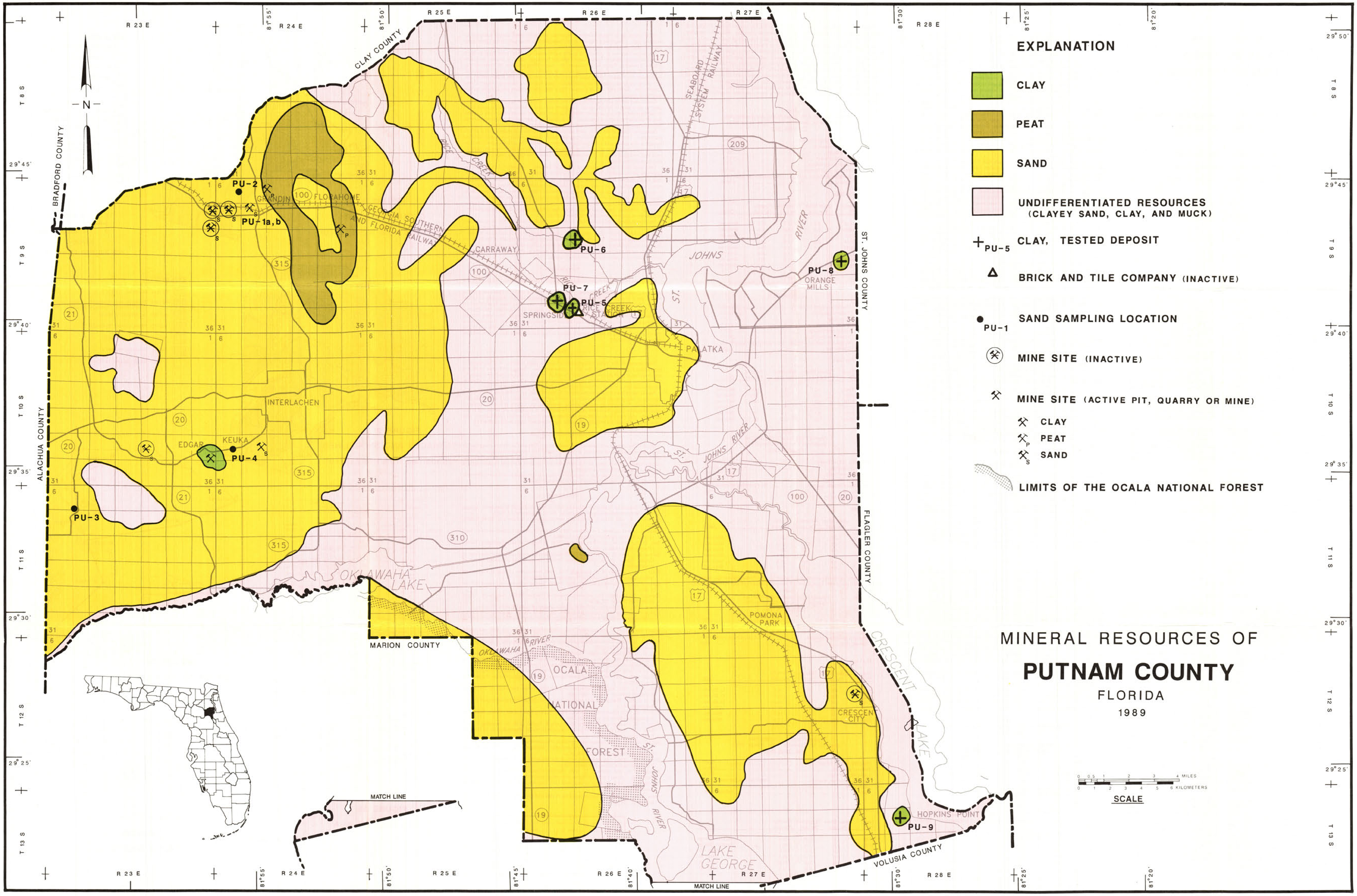
MAP SERIES NO. 128

FLORIDA GEOLOGICAL SURVEY
DEPARTMENT OF NATURAL RESOURCES



MAP SERIES NO. 128

MINERAL RESOURCES OF PUTNAM COUNTY, FLORIDA

BY

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DEPARTMENT OF NATURAL RESOURCES

TALLAHASSEE, FLORIDA
1989

ISSN 0085-0624

PUTNAM 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 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 Putnam 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 Putnam 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 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 numerous discussions with mining company personnel and state and federal officials. Additional information sources are Bermes et al., (1963) and Scott (1979, 1988). 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 assessment and inferences of this report.

Metric Conversion Factors

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	$9/5^{o}C + 32$	centigrade

GEOMORPHOLOGY

The geomorphology of Putnam County is complex. In addition to the county's numerous land forms there are a series of transitional areas separating the major geomorphic zones and surface features present in the county (Figure 1).

Putnam County falls within the Northern (proximal) and Central (mid-peninsular) physiographic zones of White (1970). The former zone is characterized as a highland area that extends from the Trail Ridge westward to the Apalachicola River Valley. The latter zone can be described as a series of ridges and valleys trending approximately parallel to the Atlantic Coast.

White (1970) notes that the Northern and Central Highlands are apparently remnants of a once continuous highland altered by erosion and karst processes. The Northern Highlands section extends into the northwest corner of Putnam County and represents an intact portion of this once continuous terrain. Within these two major regions are geomorphic subdivisions, some of which are named for nearby towns or geographic areas (Figure 1).

The landforms associated with the Northern Highlands include the Florahome Valley, a distinct north-south feature located near the Putnam-Clay county line (Figure 1). This feature is situated almost entirely within Putnam County and is considered to be a large solution valley (White, 1970).

Located to the south of this valley is the Cody Escarpment, a southward-facing Pleistocene shoreline named by Vernon (1951), which forms the southern boundary of the Northern Highlands. South of the escarpment is the Central Valley of the Central Highlands, and the Duval Upland, a landform which extends northward into Nassau County. South and east of the Duval Upland is the Eastern Valley which merges with the Central Valley in western Putnam County. The Eastern Valley is a broad flat valley which extends along much of the eastern coast of Florida. The Mount Dora Ridge separates the Central Valley from the Marion Upland (White, 1970). Located at the northern end of the Mount Dora Ridge is the Kenwood Gap.

In southern Putnam County, the St. Johns River Offset, a part of the Atlantic Coastal Lowlands, is present. White (1970) suggests that this offset is a solution cut feature influenced by the topographic control of water movement by relict Atlantic shoreline features.

Eastward and contiguous to the St. Johns River Offset is the Crescent City Ridge, which White (1970) suggests is a relict Atlantic shoreline feature and which approximately parallels the present Atlantic coastline. This feature along with the Duval Upland, may be associated with past high sea level stands.

A number of smaller topographic highs, including the San Mateo Hill, Palatka Hill, Teasdale Hill, and the Welaka Hill are present in the county. These landforms, all of which are part of the Atlantic Coastal Lowlands, may represent areas which were resistant to the effects of karst dissolution (White, 1970).

Based on elevation, Healy (1975) recognized six marine terraces (shorelines formed by ancient seas) in Putnam County (Figure 2). These depositional features with their respective elevations from highest to lowest include the Sunderland Terrace (100 to 170 feet mean sea level (MSL)), the Wicomico Terrace (70 to 100 feet MSL), the Penholoway Terrace (42 to 70 feet MSL), the Talbot Terrace (25 to 42 feet MSL), the Pamilco Terrace (10 to 25 feet MSL), and the Silver Bluff Terrace (0 to 10 feet MSL). Based on elevation mapping done for this study, scattered remnants of a seventh, and higher, terrace or shoreline may exist, the Coharie Terrace from 170 to 215 feet MSL.

GEOLOGY

Putnam County is underlain by igneous and metamorphic basement rocks which occur at depths greater than 3,000 feet below land surface. These rocks include volcanic ash, tuff and rhyolite which have been encountered in deep oil test wells. The basement rocks are overlain by a thick section of carbonates (limestones and dolomites) measuring thousands of feet. In turn, these rocks are overlain near the surface by a veneer of siliciclastic sediments including quartz sands, silts, clayey sands and clays. There are few domestic water wells in the county that are deeper than a few hundred feet because water quality decreases with depth (Bermes et al., 1963). Thus geological information for the deeper rocks is scarce, and the following discussion of formations begins with rocks of Eocene age (approximately 38 - 55 million years ago). The locations of cross sections used in this report are shown in Figure 3a. Figures 3b and 3c show the stratigraphic relationships of the formations.

Miller (1986) compiled data concerning the Floridan aquifer system for all of Florida, and many of the descriptions of deeper rocks in the county used here follow his interpretation. Miller (1986) combined the rocks of the Lake City Limestone with those of the Avon Park Limestone and named this composite unit the Avon Park Formation. Recent geologic information regarding their areal extent and lithologic similarities supports this change. The Avon Park Formation, of Middle Eocene age, consists of cream to brown pelletal limestone and interbedded brown to cream dolomite. The top of the Avon Park Formation varies from about 60 feet below MSL in the southern part of the county to about 400 feet below MSL in the north. It varies from approximately 700-feet thick in the western part of the county to 1,100-feet thick in the east.

Rocks of Late Eocene age that overlie the Avon Park Formation throughout the county are collectively referred to here as the Ocala Group (Puri, 1957). The lower part of the Ocala Group is a cream to tan, granular limestone that locally may vary from a finely crystalline, indurated limestone or dolomite, to a coquina consisting entirely of small Foraminifera. The upper part of the Ocala Group consists of white coquina of large, discoid Foraminifera, *Lepidocyclina* sp., and fragments of echinoids, bryozoans, and mollusks, usually in a soft, friable, chalky matrix of micritic limestone. The Ocala Group is a primary unit of the Floridan aquifer system and is the principal source of potable water in Putnam County (Bermes et al., 1963). The top of the Ocala Group varies from about 25 feet below MSL in the southern part of the county to more than 200 feet in the northern part. From south-to-north, it thickens from approximately 50 feet to over 150 feet (Bermes et al., 1963).

Sediments of Oligocene age do not occur in Putnam County (Miller, 1986). Although once present, these sediments have been eroded. Sediments of Miocene age belonging to the Hawthorn Group unconformably overlie the Ocala Group throughout most of the county. Hawthorn sediments are missing in the southeastern part of the county, as a result of either erosion or nondeposition (Scott, 1988b). Based on cores, Scott (1988) subdivided the Hawthorn Group in Putnam County into three formations, from older to younger: the Penney Farms Formation, the Marks Head Formation, and the Coosawhatchie Formation. However, the highly variable nature of the Hawthorn sediments in this area makes identification of the individual units difficult using well cuttings. Scott (1988b) recommended that these sediments be referred to as Hawthorn Group undifferentiated. That designation is followed in this report. The Hawthorn Group (undifferentiated) consists of complexly interbedded siliciclastics (sands, silts, clays) and carbonates (limestones and dolomites), with ubiquitous phosphatic sand sometimes making up as much as 50 percent of the sediments (Scott, 1988b). 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, diatoms, or foraminifera.

The top of the Hawthorn Group dips gently from west-to-east, from about 75 feet above MSL at the western county line to about 120 feet below MSL in the eastern part of the county (Scott, 1988). Hawthorn sediments thicken south-to-north, from zero thickness in the southeastern corner of the county to over 150-feet thick along the northern county line (Scott, 1988). In most of eastern Putnam County the Hawthorn Group is overlain by interbedded lenses of marine, fine to medium sand, shell, and calcareous, silty clay. They may be Late Miocene or Pliocene in age (Bermes et al., 1963). In extreme southeastern Putnam County, where the Hawthorn Group is absent, these units overlie the Ocala (Scott, 1988b).

In western Putnam County the sediments overlying the Hawthorn are yellow to red, nonmarine beds of coarse, poorly sorted sand, clay and sandy clay (Bermes et al., 1963). These siliciclastics, formerly included in the Citronelle Formation of possible Pliocene age by Cooke (1945), have recently been included in the Cypresshead Formation (Scott, 1988a). Cypresshead Formation sediments are exposed in various borrow pits, with an excellent example in the county borrow pit near Grandin. These units are classified as undifferentiated sand and clay on Figures 3b and 3c.

Various thicknesses of Pleistocene/Holocene quartz sands, silts, clayey sands, and clays have been deposited, weathered, and reworked during the past 10,000 years since the end of the Pleistocene Epoch (the Ice Ages). In places, they reach thicknesses of approximately 150 feet (Figures 3b and 3c). Deposits of peat and organic-rich sediments occur in Florahome Valley, along the St. Johns River floodplain, and near lakes or other perennially wet areas (Mineral Resource Map). These units are included with the undifferentiated sand and clay on Figures 3b and 3c.

MINERAL RESOURCES

INTRODUCTION

The purpose of the following discussion is to provide information on the occurrence of economic mineral resources in Putnam County, to describe the types of tests performed and the results of analyses of samples collected. The information presented is not intended to be an exhaustive investigation leading to immediate industrial development, because in many cases the data represent information on a single location, pit, or mine. However, where favorable, the data may indicate that certain areas might warrant further investigation. Occasional variations between the geologic cross sections and the Mineral Resource Map may occur. The Mineral Resource 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 commodities discussed are clay, sand, peat and heavy minerals.

Clay

The U.S. Bureau of Mines classifies clay into six categories: kaolin, bentonite, ball clay, fullers earth, and common clay (Ampian, 1985). Two of these clays, kaolin and common clay, are or have been mined in Putnam County (Calver, 1949). Kaolin is mined near Edgar (section 25, Township 10S, Range 23E) by The Feldspar Corporation. Located along the southernmost extension of the Northern Highlands geomorphic province, the kaolin is mined from the lower portion of the Cypresshead Formation. The thickest sequence of kaolinitic sand which occurs in the Edgar mining district measures, from the bottom to surface, 20 to 45 feet of white, clayey (kaolin) sand. This, in turn, is overlain by 10 feet of red to reddish-orange clayey sands, then overlain by yellowish unconsolidated sands typically ranging in thickness up to 10-feet (Pirkle, 1960).

The Feldspar Corporation operates a 25-acre mine site near Edgar (C. DesRosier, personal communication, 1988). Mine operators recovering kaolinitic sand to a depth of 35 feet below land surface are mining 3 to 5 acres per year. The mine operation utilizes a floating hydraulic dredge system which pumps sediment into a series of classifiers. This step removes sand and other undesirable materials from the clay. The clay and water mixture is thickened by dewatering and drying. The clay may be further dried and classified prior to bagging.

Mine operators, in 1988, report that reserves are sufficient to last well beyond the year 2,000. Shipping is by rail and truck to domestic markets in the United States. Additionally, Florida kaolin is shipped to foreign markets.

Typical uses of kaolin from Putnam County include ceramic tile, electrical insulators, plumbing fixtures, dinnerware and appliances. The varied uses, ample reserves, and good quality of Putnam County's kaolin suggest that future economic activity for this commodity is favorable. Analyses of some samples of Edgar kaolin are listed in Table 1 as follows:

Table 1
Analyses of Blocks of Kaolin and Properties of the Kaolinite
(From Pirkle, 1960)

	Model Estimates from X-ray Analysis (approx.)	Physical Properties
Kaolin	75-85%	Type: Kaolin
Quartz	6-8%	pH: 6.5
Hydrous mica	5-8%	Unfired color: off-white
Iron hydroxides	2-3%	Unfired strength: high
Less than	1%	montmorillonite

Very plastic and smooth working requiring 44% water for plasticity with 6.5% drying shrinkage, no defects.

Fire Tests:

Temp., ^{o}F	Color	Hardness	Percent Shrinkage	Percent Absorption	App. Specific Gravity
1,800	Slight Ivory	Soft/Crumbly	6.6	37.6	2.56
2,000	White	Soft/Crumbly	6.5	37.0	2.72
2,100	White	Soft/Crumbly	7.0	36.1	2.72
2,200	White	Soft/Crumbly	9.5	34.1	2.71
2,300	White	Soft/Crumbly	10.0	30.0	2.75
2,400	White	Soft/Crumbly	14.5	25.5	2.75

Surface checking indicating fineness of grain. Pyrometric cone equivalent approximately Cone 36 (290^{o}F).

In the extensive flood-plain region of the St. Johns River in eastern Putnam County, Bell (1924) reported on clay deposits suitable for commercial purposes. Bell (1924) reported that the thickness of the clay varied from 12 feet with one foot of overburden for two localities in the Rice Creek area just northwest of Palatka, to 12 to 20-feet thick near Springside. Other localities where clay was reported to be suitable for commercial applications include the region between Crescent Lake and Lake George. Bell (1924) reports that common brick, face brick, hollow brick, fire-proofing and drain tile were the primary products of these flood-plain clay deposits. The physical properties of the Rice Creek and Springside clay samples are given in Tables 2, 3 and 4 and shown on the Mineral Resources Map as PU-5, PU-6 and PU-7 respectively. These deposits occur in an area designated on the Mineral Resources Map as undifferentiated resources. In order to prove that these sites would be economic once again a more extensive investigation will be required.

Table 2
Physical Properties of Rice Creek Station Clay (inactive Utica Brick and Tile Co., section 33, Township 9S, Range 26E)
(From Bell, 1924)

Plasticity, judged by feel....................Excellent.
Water of plasticity....................24.2 %
Pore water....................0.5 %
Shrinkage water....................23.7 %
Linear air shrinkage....................7.7 %
Volume air shrinkage....................30.5 %
Modulus of rupture, average... 776.3 pounds per square inch.
Slaking test....................6 hours.

Fire Tests:

Temp. ^{o}F	Linear Sheer Per cent	Absorption Per cent	Porosity Per cent	Color
1742	0.2	12.3	30.4	Brick red.
1922	0.3	13.9	30.6	Brick red.
2102	0.3	12.6	28.0	Brick red.
2174	0.3	11.6	26.0	Brick red.
2246	1.3	10.8	26.4	Brick red.
2390	-	11.5	28.6	Brick red.
2498	-	11.0	28.0	Brick red.
2606	-	8.2	19.1	Brick red.

Table 3
Physical Properties of Herman Brown Clay, Rice Creek
(section 16, Township 9S, Range 26E)
(From Bell, 1924)

Plasticity, judged by feel....................Excellent.
Water of plasticity....................22.3 %
Pore water....................1.3 %
Shrinkage water....................20.9 %
Linear air shrinkage....................10.0 %
Volume air shrinkage....................26.5 %
Modulus of rupture, average ...546.2 pounds per square inch.
Slaking test....................3 hours.

Fire Tests:

Temp. ^{o}F	Linear Sheer Per cent	Absorption Per cent	Porosity Per cent	Color
1742	0.5	13.1	36.5	Brick red.
1922	1.0	13.1	36.2	Brick red.
2102	2.0	13.2	34.2	Brick red.
2174	2.6	11.1	31.7	Brick red.
2246	2.1	11.8	28.7	Brick red.
2390	3.0	12.3	30.7	Brick red.

Table 4
Physical Properties of Springside Clay
(section 29, Township 9S, Range 26E)
(From Bell, 1924)

Plasticity, judged by feel....................Excellent.
Water of plasticity....................25.1 %
Linear air shrinkage....................11.1 %
Volume air shrinkage....................28.6 %
Modulus of rupture, average....................791.4 pounds per square inch.
Slaking test....................1 hour.
Overfires at cone 12.

Fire Tests:

Temp. ^{o}F	Linear Sheer Per cent	Absorption Per cent	Porosity Per cent	Color
1742	0.1	12.6	29.7	Brick red.
1922	0.9	13.7	31.0	Brick red.
2102	0.6	12.3	29.4	Brick red.
2174	1.4	11.5	29.8	Brick red.
2246	1.4	10.4	25.8	Brick red.
2390	1.4	8.7	17.5	Brick red.

Calver (1949) tested clay sediments in Putnam County. These analyses are shown in Tables 5 and 6 and shown on the Mineral Resources Map as PU-8 and PU-9 respectively.

Table 5
Physical Properties of Orange Mills Clay
(section 24, Township 9S, Range 27E)
(From Calver, 1949)

Plasticity, judged by feel....................Fair
Water of plasticity....................38.0 %
Linear air shrinkage....................10.5 %
Modulus of rupture, average.................... 470.0 pounds per square inch.
Slaking test....................Fast

Fire Tests:

Temp. ^{o}F	Linear Sheer Per cent	Absorption Per cent	Porosity Per cent	Color
1742	0.5	15.4	34.8	Lt. Bk. red.
1922	1.0	13.6	33.4	Lt. Bk. red.
2102	2.0	12.2	34.0	Lt. Bk. red.
2174	2.0	11.7	31.1	Lt. Bk. red.
2246	1.5	11.1	31.7	Brick red.
2390	2.5	11.3	31.3	Brick red.

Table 6
Physical Properties of Hopkins Point
(section 8, Township 13S, Range 28E)
(From Calver, 1949)

Plasticity, judged by feel....................Good
Water of plasticity....................32.0 %
Linear air shrinkage....................9.0 %
Modulus of rupture, average....................470.0 pounds per square inch.
Slaking test....................Fast
Color....................Yellowish gray

Fire Tests:

Temp. ^{o}F	Linear Sheer Per cent	Absorption Per cent	Porosity Per cent	Color
1742	1.0	10.9	28.0	Reddish Orange
1922	1.5	9.4	26.1	Reddish Orange
2102	2.5	6.8	23.2	Brick red.
2174	2.0	7.4	24.4	Brick red.
2246	1.5	6.9	23.8	Brick red.
2390	2.5	7.9	23.9	Brick red.

Sand

Sand covers all of Putnam County. However, this sand is not always adequate for industrial use. The Florida Department of Transportation Road and Bridge Construction manual (1986) dictates specific criteria for construction purposes.

The largest reserves of commercial quality quartz sand come from thick deposits found along the western side of Putnam County (Mineral Resource Map). At present, sand from this unit is mined by Florida Rock Industries, Inc. (Keuka Mine) in section 29, Township 10S, Range 24E and by the Feldspar Corporation in section 25, Township 10S, Range 23E. Additionally, the Putnam County road department operates borrow pits in the western portion of the county near Interlachen and Grandin. Sand from these locations is used for road construction. South and east of Crescent City a few local operators use available surface sand for fill material.

Quartz sand mining utilizes both dry and wet mining methods. A barge mounted pump is used to mine sand in flooded areas. Draglines are used in areas where the sand is not below the water surface (Campbell, 1986). Typically, the sand is pumped in slurry to classifiers where size fractions are separated. The fine fraction is pumped into settling areas while the more desirable coarse fractions are loaded or stockpiled (Scott et al., 1980).

During the course of this study, sand samples were collected and analyzed for grain size distribution. The following methodology was used. Sand samples were repeatedly put through a riffle splitter until a 100 gram sample was obtained. The samples were then treated to remove organic and clay materials, then wet sieved before drying. The sand samples were then rotapped using U. S. standard testing sieves. The final step included weighing and recording the results.

Test result data (Table 7) represent one set of samples. Information derived from this table may aid the reader in determining the general usefulness of a particular sand deposit. Test results indicate most samples are suitable for brick masonry, concrete, sand-cement riprap, sand-asphalt hot mix, and as a sand seal coat according to the Florida Department of Transportations Road and Bridge Construction manual (1986). No tests were performed to determine the suitability of sands for the manufacturing of glass. The widespread occurrence of impurities (heavy minerals, iron oxides) typically preclude its use for glass products. However, beneficiation technology may alleviate some of the potential problems and enable its use in the production of glass products.

The Florida General Soils Atlas (Kolb, 1974) states that sand suitable for construction may be obtained from the Astatula, Candler-Apopka, and Tavares-Myakka-Basinger Soil Associations. The Atlas further notes that many of Putnam County's soil associations are rated good as roadfill material. Exceptions to this include the flood-plain regions of the St. Johns River and the northwest portions of the county where substantial peat deposits occur. It should be noted that the soil scientists examine a maximum of 80 inches (from depth to ground surface) to determine the various soil ratings.

Heavy Minerals

Heavy minerals can be found in most of Florida's sand sediments. However, at the present time mining of heavy minerals is restricted to localities on the Trail Ridge and south of Green Cove Springs in Clay County. As part of a regional study on heavy minerals in Florida, the U. S. Bureau of Mines investigated the occurrence of this commodity in Putnam County. Several drill holes were made in the Interlachen area along State Road 20 and on State Road 100 from Carraway in the east, west through Grandin and into Clay County. Results of the study were published in Thoenen and Warne (1944). The heavy mineral contents typically ranged from less than one percent to about two percent. The low content of heavy minerals in Putnam County sediments, based on research by Thoene and Warne (1944), and compared to similar deposits mined in Clay County, precludes them from future economic development.

Peat

Peat represents the partly decomposed remains of plant material. It accumulates in waterlogged areas in which the pH is generally low. These conditions allow the accumulation of plant material to exceed the rate at which it is decomposed by organisms. Waterlogged surface conditions occur when topographic relief is low and topographic barriers exist which restrict the flow of water and allow it to pond (Bond et al., 1986).

Peat is mined from the Florahome area of Putnam County by Traxler Peat, Inc. (multiple sections of Township 9S, Range 24E) and R&R Peat Farms, Inc. (section 5 of Township 9S, Range 24E). To prepare an area for mining, dewatering and clearing of surface vegetation must take place. The peat is then removed by draglines or bulldozers and stockpiled to dry. Lastly, the peat may be shredded and additives mixed in to consumers specifications. Like most peat in Florida, it is primarily utilized for agricultural and horticultural applications.

Undifferentiated Resources

Much of the surface and near-surface sediments of Putnam County are comprised of clayey sands, and lesser deposits of organic muck. The hetrogeneous nature of these sediments in the county would tend to preclude there large scale economic marketability. Locally however, where costs are not prohibitive and the need is present for uses such as top soil or road fill, extraction is feasible.

The possibility does exist that a future comprehensive investigation of these undifferentiated sediments may lead to economic or industrial applications.

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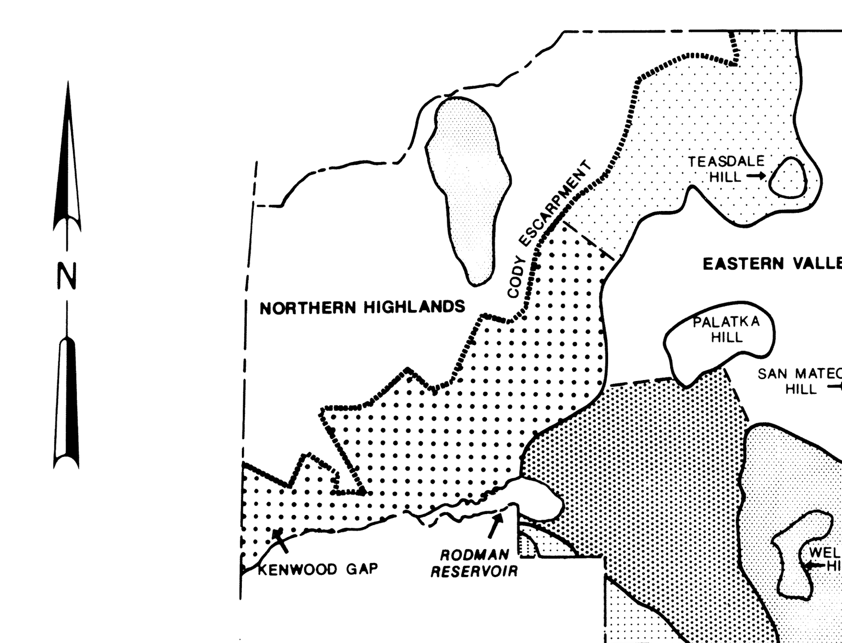
The well and quarry system used in this report uses the rectangular system of section, township and range for identification. The well or outcrop number consists of six parts: W for well or L for quarry, county abreviation, the Township, Range, and Section, and the quarter/quarter location within the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

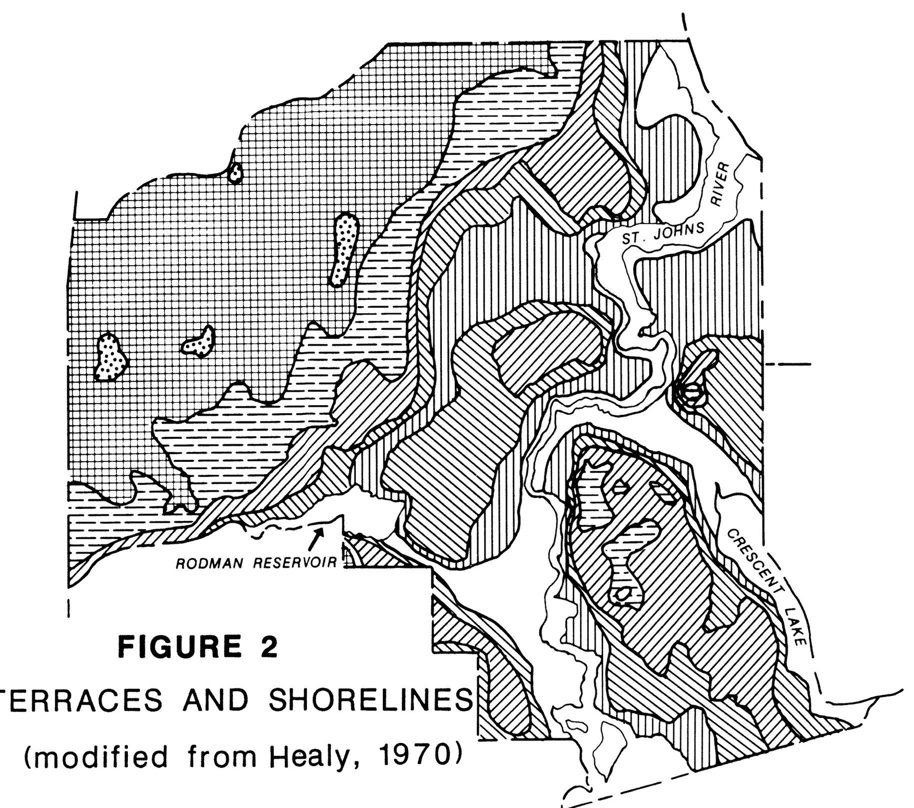


EXPLANATION

NORTHERN HIGHLANDS
FLORAHOME VALLEY
CENTRAL HIGHLANDS
MARION UPLAND
MOUNT DORA RIDGE
CENTRAL VALLEY
ATLANTIC COASTAL LOWLANDS
CRESCENT CITY RIDGE
WELAKA HILL
EASTERN VALLEY
PALATKA HILL
SAN MATEO HILL
DUVAL UPLAND
TEASDALE HILL
ST. JOHNS RIVER OFFSET

FIGURE 1
GEOMORPHOLOGY
(modified from White, 1970)

0 4 MILES
0 6 KILOMETERS
SCALE
FOR FIGURES 1,2, and 3a



EXPLANATION

170'-215'	COHARIE TERRACE
100'-170'	SUNDERLAND TERRACE (COOKE, 1939)/ OKEFENOKEE TERRACE (MACNEIL, 1950)
70'-100'	WICOMICO TERRACE
42'-70'	PENHOLOWAY TERRACE
25'-42'	TALBOT TERRACE
10'-25'	PAMLICO TERRACE
0-10'	SILVER BLUFF TERRACE

FIGURE 2
TERRACES AND SHORELINES
(modified from Healy, 1970)

Table 7. Screen analyses of sand in Putnam 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*
Pu-1a	sec 7db T9S, R24E	Channel	0.834	3.099	12.963	30.294	50.367	100.000	1.98
Pu-1b	sec 7db T9S, R24E	Channel	--	0.759	6.232	22.518	42.094	100.000	1.72
Pu-2	sec 6db T9S, R24E	Channel	--	--	1.032	18.548	74.323	100.000	1.94
Pu-3	sec 6cd T11S, R23E	Channel	--	--	0.205	3.520	34.022	100.000	1.38
Pu-4	sec 30d T10S, R24E	Channel	--	0.382	4.007	19.852	57.783	100.000	1.82

*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 C 136-84a. The reader is also referred to the Florida DOT manual of Florida sampling and testing methods for aggregates, designation FM 1-T 027.

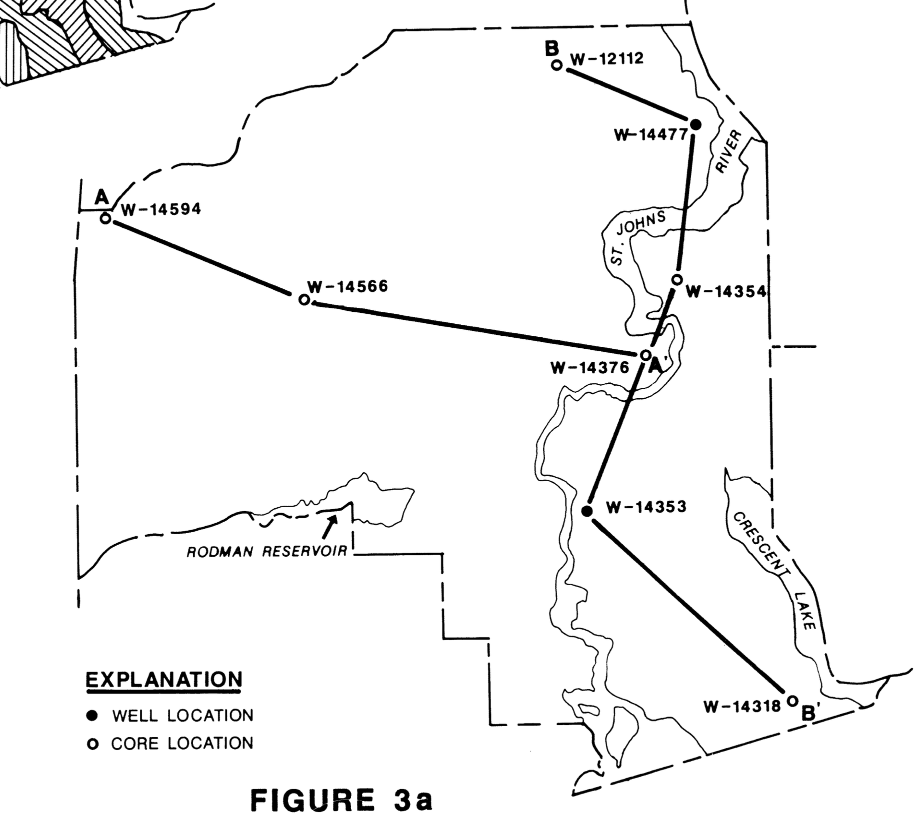


FIGURE 3a
CROSS SECTION LOCATION

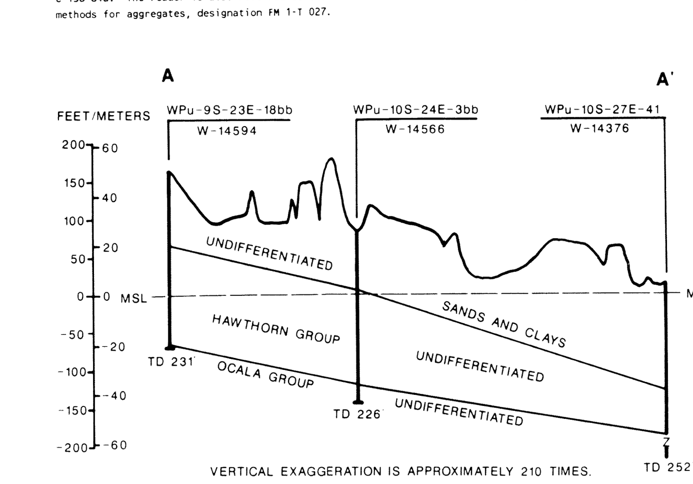


FIGURE 3b
CROSS SECTION A-A'

SCALE FOR FIGURES 3b and 3c

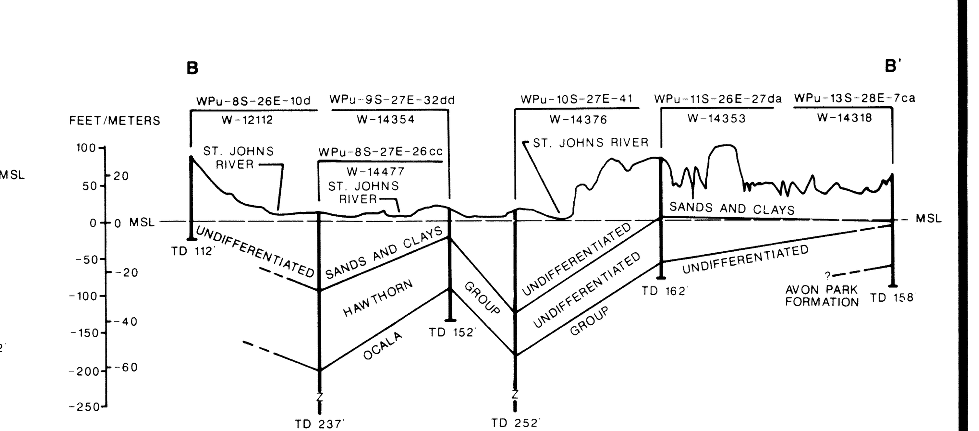


FIGURE 3c
CROSS SECTION B-B'