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# MINERAL RESOURCE POTENTIAL OF THE NATURAL AREA ROADLESS AREA, OSCEOLA NATIONAL FOREST, BAKER COUNTY, FLORIDA

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Studies Related To Wilderness

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Co ress. This report discusses the results of a mineral survey of the Natural Area Roadless Area, Osceola National Forest, Baker County, Fla. The area was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

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## MINERAL RESOURCE POTENTIAL SUMMARY STATEMENT

The Natural Area Roadless Area, which is in the Osceola National Forest in Baker County, Fla., is underlain by sedimentary rocks containing phosphate deposits that are not a potential mineral resource by todays standards. The region has a low potential for oil and gas and virtually no potential for other valuable minerals. The phosphate deposits are either slightly low in tonnage and $P_2O_5$ content, high in MgO and/or $Fe_2O_3$ + $Al_2O_3$, or the ratio of CaO to $P_2O_5$ is too high for deposits that can be mined profitably at the present time. A low potential for oil and gas is indicated by the numerous dry holes in the region and the absence of the formations that contain these hydrocarbons in southern and westernmost Florida. The only mineral material that has been produced in the study area is clayey sand, used in stabilizing Forest Service roads. This type of clayey sand has no particular value because there are virtually unlimited quantities in the surrounding region. The peaty material in the area is too high in ash content to be mined. Large quantities of limestone underlie the area but are too deeply buried to be quarried. Heavy-mineral and clay deposits, which are mined elsewhere in northern peninsular Florida, are not present in the study area.

## INTRODUCTION

The Natural Area Roadless Area (figs. 1 and 2) comprises 4,380 acres in the north-central part of the Osceola National Forest in Baker County, about 18 airline miles northeast of Lake City, Fla. It is bounded by Forest Service roads 277 on the south and 235 on the west, by the northern lines of secs. 21, 22, 23, and 24, T. 1 S., R. 19 E. on the north, and by the eastern lines of secs. 24, 25, and 36 in the same township on the east (fig. 3). The area can be reached by traveling 17.5 mi on Florida highway 250 northeast from its junction with U.S. highway 441, north of Lake City to the junction of highway 250 and Forest Service road 235; thence north 1.5 mi on the Forest Service road to the southwest corner of the area.

The Natural Area Roadless Area is a nearly flat, forested tract. Two road junctions, one at the southwest corner and one near the northwest corner, have altitudes of 133 ft and are the highest points. The lowest altitude, about 124 ft, is at the point where the Middle Prong St. Marys River crosses the east boundary of the study area. The Middle Prong St. Marys River is an anastomosing stream flowing through channels choked with vegetation. The drier parts of the study area are covered with pine and palmetto forests; swampy areas support the cypress, black gum, and bay vegetation types of plant growth. Peaty material and swamp muck extended over much of the surface of the larger swamps.

### Previous Investigations

A report by Miller (1978) outlines the geology of the region as related to water resources and some of the geologic information in this report is taken from his work. A lengthy environmental impact statement (U.S. Bureau of Land Managment, 1974) contains much

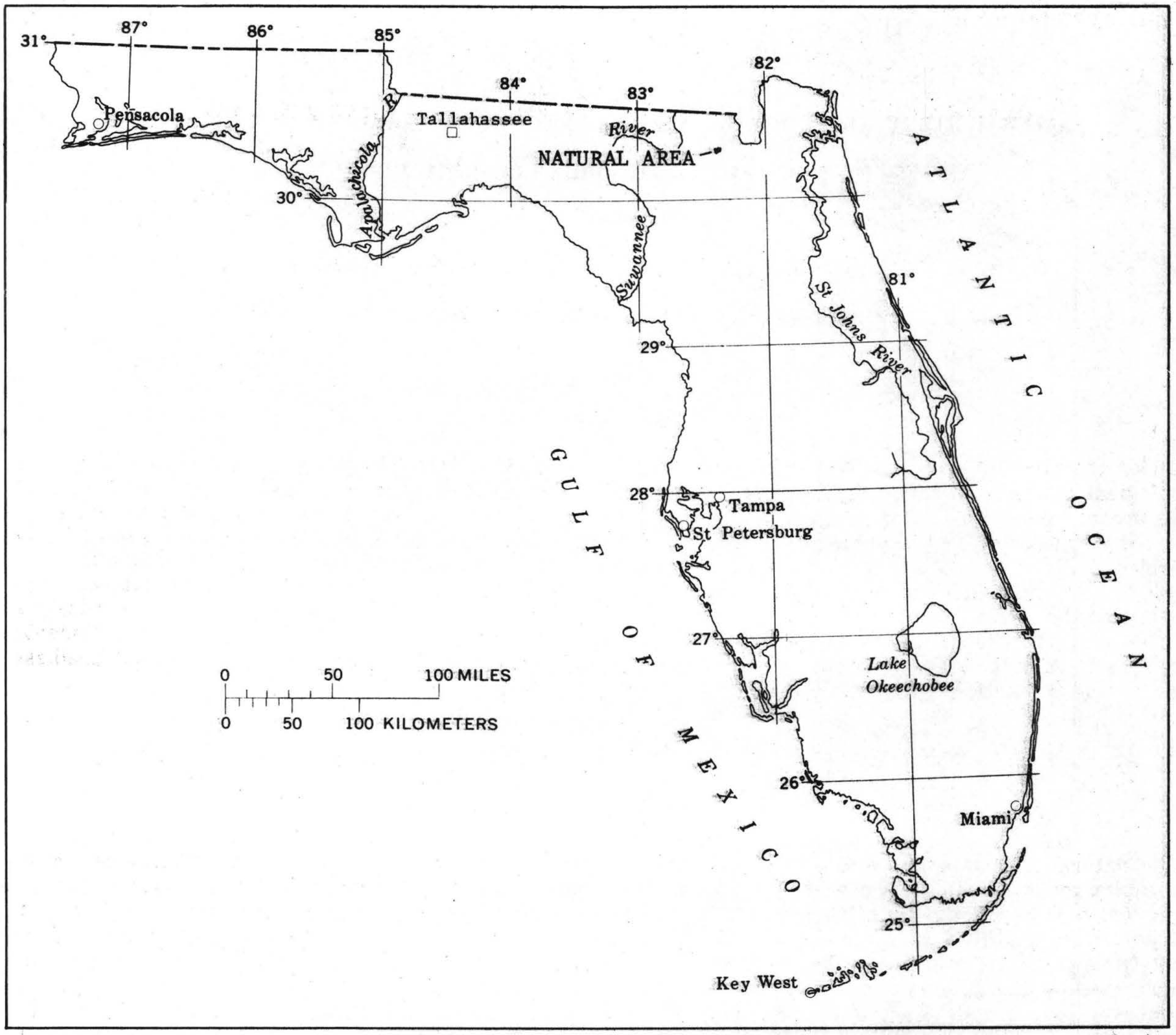
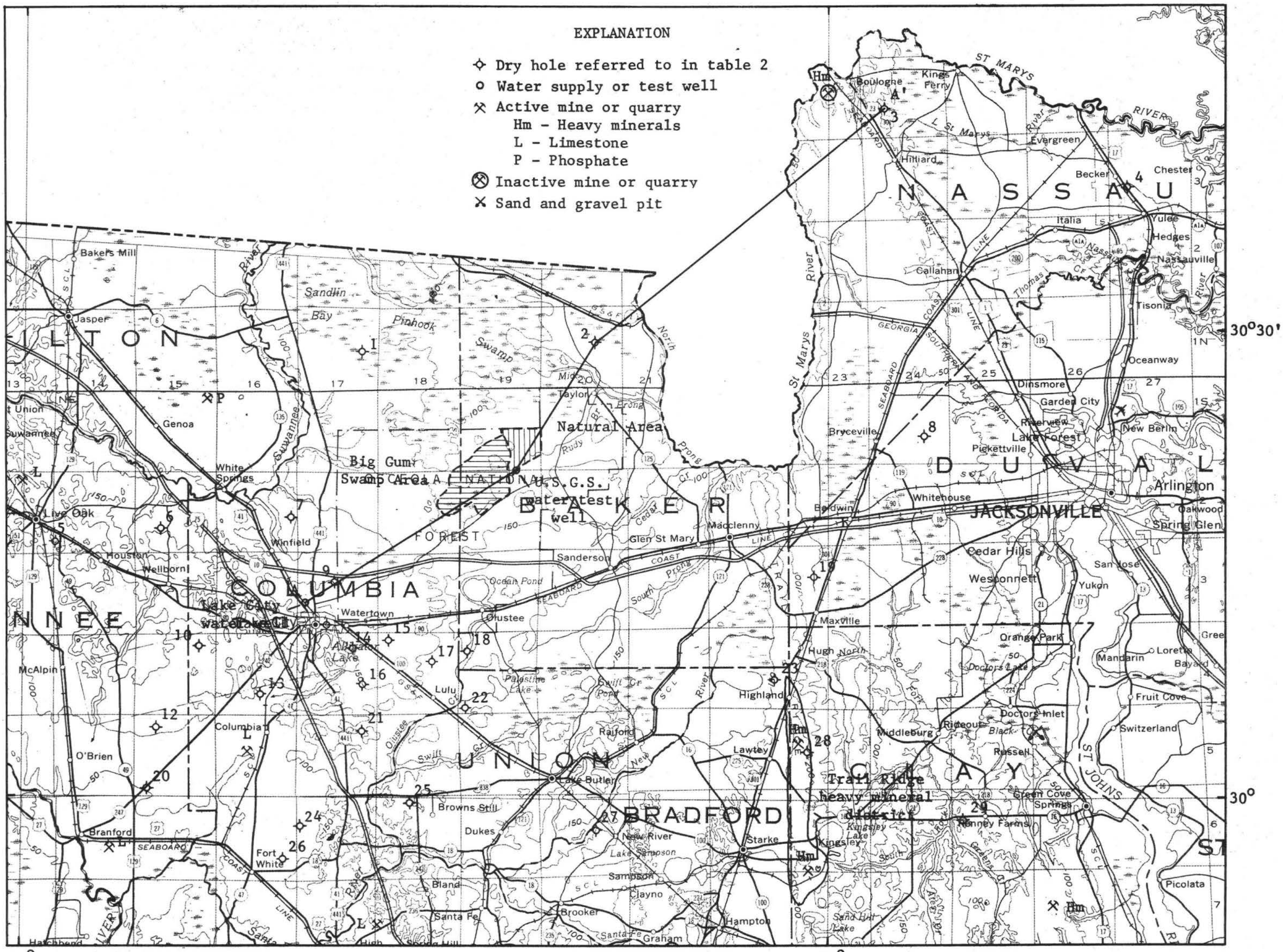



**Figure 1.—Location of the Natural Area Roadless Area.**




83° Base from U.S. Geological Survey Florida State map 1967, 1:500,000.

0 1 MILE

82° Selected exploratory oil and gas data are on accompanying map.

Figure 2.—Location of the Natural Area and the Big Gum Swamp Roadless Areas and dry holes, pits, mines, and quarries.

information on the entire Osceola National Forest and the affect of possible phosphate mining. Reports by Puri and Vernon (1964), Milton (1972), Bridge and Berdan (1952), Applin (1951), Applin and Applin (1944, 1965, 1967), Cole (1944), and Rainwater (1971) outline the subsurface geology of the region. Available information on the mineral resources in northern Florida include the following references: limestone (Schmidt and others, 1979), phosphate (Cathcart, 1968; Mansfield, 1942; Sever, Cathcart, and Patterson, 1967), and heavy minerals (Garner, 1972, 1981; Pirkle and Yoho, 1970; Pirkle, Pirkle, and Yoho, 1977).

### Present Investigation

Cathcart and Patterson reviewed the published information on the geology of the Osceola National Forest region and reconnoitred the area in the early spring of 1980. A drilling program was carried out jointly with the U.S. Bureau of Mines in October 1980. During this program two holes were drilled near the boundaries of Big Gum Swamp, which extends westward from the Natural Area, and one along the south boundary of the study area (fig. 3, hole 3). Core and cuttings were logged at the drill hole sites and samples were collected for later analyses in the laboratory. Cornelia C. Cameron, assisted by Paul C. Schruben, investigated both areas for peat resources (defined as organic material having an ash content not exceeding 25 percent on a dry-weight basis and 4 ft or more in thickness) in December 1980. During this work, peaty material was examined with a Davis peat sampler[1] (a tubular piston device) at 11 localities in the study area. One sample was collected and its ash and moisture contents and pH were determined in the laboratory. Peaty material at other localities was evaluated by the empirical hand-squeeze-ball-forming test, which is a practical method of estimating ash content. Crandall (1981) examined swampy areas and probed surficial material to evaluate the peat potential.

Information on oil and gas exploration holes in this report is based primarily on published reports and records on file in the Florida Bureau of Geology. The term "dry hole" means that no significant amounts of oil and gas were found.

No geochemical survey was necessary during the work leading to this report because any potentially valuable non-metallic minerals are deeply buried. Therefore, stream-sediment and soil sampling would yield no information of value in assessing the mineral resource potential of the area, and the metallic and other heavy minerals in the exposed strata do not occur in sufficient concentrations to form valuable mineral deposits.

### Acknowledgments

The authors are grateful for the cooperation of the Florida Bureau of Geology, U.S. Forest Service and U.S. Bureau of Land Management. Thomas M. Scott, geologist with the Florida Bureau, worked with Patterson during the drilling program and assisited in logging core and interpreting lithologies. David Curry and Felipe A. Pontigo, Jr., of the same Bureau, aided in gathering information on oil and gas. R. J. Bonyata, District Ranger of the Osceola National Forest, provided maps and storage facilities for drilling equipment and samples. William R. Waite, soil scientist, U.S. Forest Service office, Tallahassee, Fla., and Edward W. Read, geologist, U.S. Forest Service Office, Atlanta, Ga., provided maps and background information on the region. Walter T. Lewieki of the U.S. Mineral Management Service provided the nonproprietary phosphate-drilling records of the Osceola National Forest. The authors are grateful to AMAX Phosphate, Inc., Lakeland, Fla. for information given to the U.S. Bureau of Mines concerning phosphate exploration in and near the Natural Area Roadless Area. Permission to publish these data was granted by AMAX Exploration, Inc., Golden, Colo., a subsidiary of American Metal Climax, Inc.

## SURFACE - AND MINERAL-RIGHTS OWNERSHIP

The Federal Government owns all surface and mineral rights in the Natural Area Roadless Area. They were acquired under the authority of the Weeks Act in the 1930's by the U.S. Department of Agriculture, Forest Service.

No applications for preference right leases for phosphate exist in the study area (U.S. Mineral Managment Service, written commun., 1982). The phosphate drilling done in the area presumably was done under Forest Service prospecting permits. Lease applications are on file for numerous tracts to the west and south of the area (fig. 4).

On January 14, 1982, the President vetoed a bill that would have created a 50,000 acre wilderness in the Osceola National Forest (Public Land News, 1983). Revised legislation on Florida wilderness area is still pending in Congress.

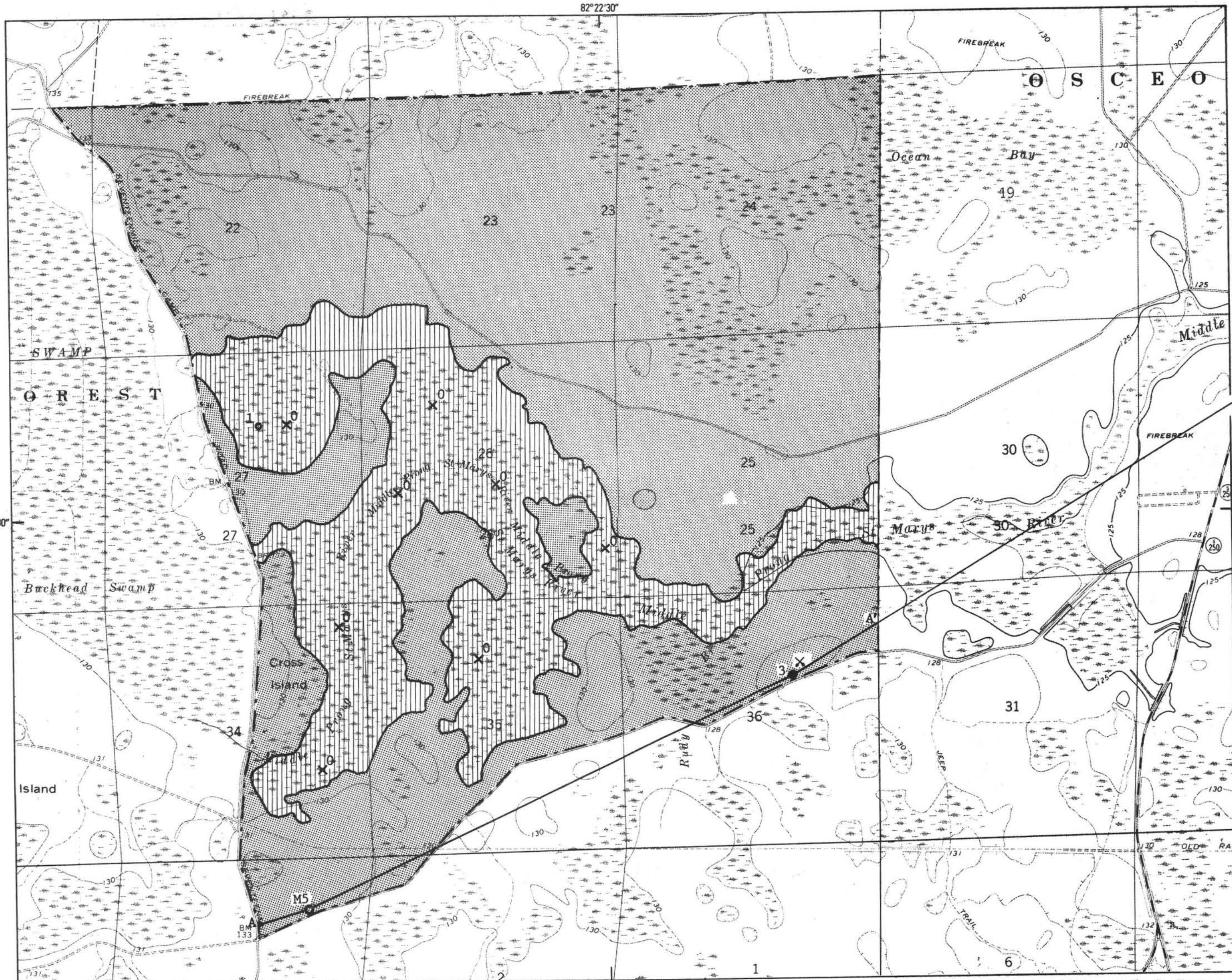
## GEOLOGY

### SURFICIAL DEPOSITS

All of the Natural Area Roadless Area is blanketed by unconsolidated sediments of Pleistocene and Holocene age. The sediments in swamps consist of peaty material and organically rich muck (Avers and Bracy, 1973). The A-horizon soils, rarely more than one foot thick, cover the dry areas and consist of clayey and sandy material containing minor amounts of disseminated organic matter and root remains.

The surficial blanket of peaty material, muck, and soil is underlain over the entire area by 25-35 ft of unconsolidated sand and clayey sand that contains some phosphate grains and dark, heavy minerals near the base. The age of these unconsolidated sediments is uncertain because they contain no diagnostic fossils. They rest unconformably on an unnamed upper Miocene formation. This unnamed formation forms, in a sense, the bedrock under the study area and extends under the entire Osceola National Forest (Patterson and others, 1983). The phosphate-bearing Hawthorn Formation that underlies the unnamed formation is 125-280 ft thick. About 3,300 ft of sedimentary rocks,

[1]Use of trade names is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.




Base from U.S. Geological Survey 1:24,000
Sanderson SW, Taylor, Big Gum Swamp, Sanderson North, 1969

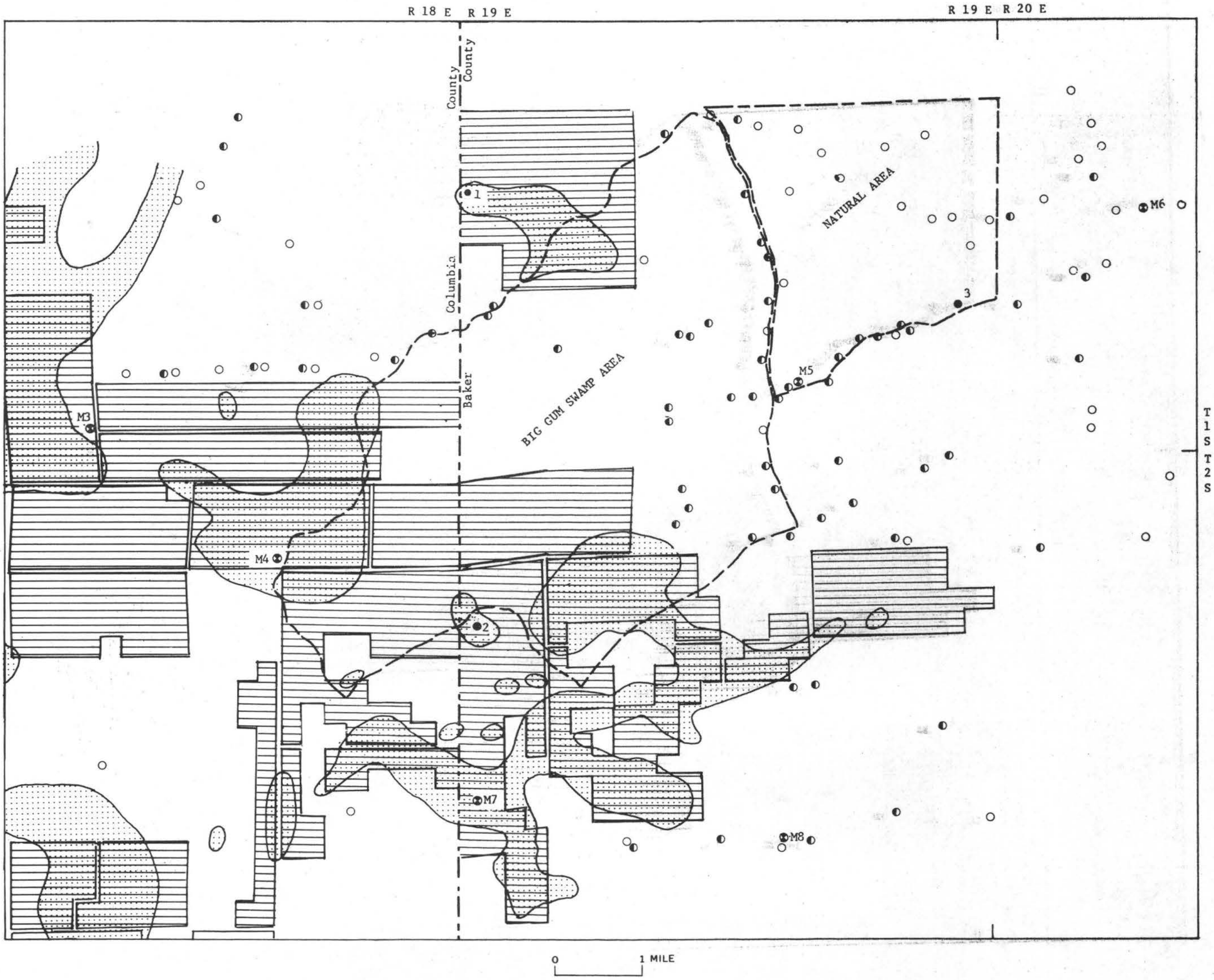
0 — 1 MILE

Peaty material mapped by Cornelia C. Cameron

EXPLANATION

- Swamp containing peaty material (ash content generally greater than 25 percent) as much as 4 ft thick
- Sandy soil, locally waterlogged and enriched with organic materials
- ×0 Probe site, number indicates thickness of peat (ash content less than 25 percent), in ft
- ●3 Drill hole and number, this study
- oM5 Drill hole and number, log and samples described by Miller(1978)
- o1 Site of peaty-material sample referred to by number in text
- × Clayey sand pit

Figure 3.—Mineral resources and geologic map of the Natural Area Roadless Area.




EXPLANATION

Area shown by U.S. Bureau of Land Management (1974 XI-5) as containing large or small phosphate deposits of non-commercial value

Area for which mining lease applications were filed as of 1973 (U.S. Bureau of Land Management, 1974, XI-5)

Company phosphate prospect hole (Crandall, 1981) and U.S. Minerals Management Service unpublished nonproprietary data

◐ Hole from which samples were collected and tested

○ Hole for which no test data was reported, includes those penetrating no rich phosphatic materials

M4 Ground-water research well, core described by Miller (1978) referred to in text by number

●3 Drill hole, this investigation, referred to in text by number

——— Study area boundary

Figure 4.—Locations of areas containing large and small phosphate daposits of non-commercial value, mining lease applications, and drill holes in the vicinity of the Natural Area and Big Gum Swamp Roadless Areas.

ranging in age from Cretaceous to Eocene, underlie the Hawthorn and rest unconformably on Paleozoic-age crystalline and sedimentary rocks (table 1).

## STRATIGRAPHY

### Paleozoic Era

The Paleozoic-age crystalline and sedimentary rocks that underlie the Natural Area Roadless Area have been penetrated by two dry holes. One (fig. 2, hole 1) intersected six sills of diabase and amygduloidal basalt intruded into black shale that is thought to be Late Silurian or Early Devonian age (Milton, 1972, p. 18-19). They occur in the 3,529-4,270-foot interval below the surface. The second hole (fig. 2, hole 3) bottomed in diabase at 4,817 ft (Cole, 1944, p. 30). Several holes in the region have penetrated Paleozoic sedimentary rocks at depth (Applin, 1951; Puri and Vernon, 1964, plate 1; Bridge and Berdan, 1952). The lithologies and ages of these rocks and the dry holes in which they were intersected include the following: a) quartzite or quartzitic sandstone or Ordovician age (fig. 2, holes, 2, 10, 13, 14, 20, 17, and 29), b) shale of Ordovician age (fig. 2, holes 14, 20), c) black shale of Middle or Late Silurian age (fig. 2, holes 6 and 7), and d) quartzite of Paleozoic age, period unknown (fig. 2, hole 10).

### Mesozoic Era

Cretaceous System—Lower Cretaceous rocks are absent in the region of the Osceola National Forest (Applin and Applin, 1965; Rainwater, 1971), but a thick series of Upper Cretaceous beds unconformably overlies lower Paleozoic rocks (Applin and Applin, 1967). The Upper Cretaceous strata are grouped in four major stratigraphic units. The lowest one, the Atkinson Formation, consists mainly of sandstone and shale that were deposited in a shallow marine environment. The Atkinson was penetrated by a dry hole (fig. 2, hole 3) located about 35 mi northeast of the study area; however, it was not found in hole 2 only 7 mi to the northeast. Therefore, the Atkinson may not be present in the subsurface of the study area. Unnamed beds of Austinian age overlie the Atkinson; they consist of calcareous sandstone in the lower part, marl, chalk, and shale in the middle part, and are dominantly chalk in the upper part. Overlying these are beds of Tayloran Age, consisting of dolomite in the lower part, chalk with gypsum inclusions in the middle, and dolomite in the upper part. The uppermost Cretaceous formation, the Lawson Limestone, consists of two members. The lower member is chalk containing some dolomite, and the upper member is dolomite containing inclusions of anydrite and gypsum.

### Cenozoic Era

Paleocene Series—The Paleocene beds in the region of the Natural Area are assigned to the Cedar Keys Limestone (Applin and Applin, 1944, p. 1703-1708; Puri and Vernon, 1964, p. 42). The Cedar Keys Limestone is 535 ft thick (2,215-2,750 ft depths) where dry hole 3 (fig. 2) intersected it. The formation consists of cream- to tan-colored, hard limestone containing distinctive foraminifers.

Eocene Series—Applin and Applin (1944, fig. 23) recognized four Eocene formations in the region. The lowermost, the Oldsmar Limestone, is lithologically similar to the overlying Lake City Limestone from which it is separated primarily by a distinctive microfauna. The Oldsmar and the Lake City consist of alternating layers of dark brown and chalky limestone. The beds above the Lake City form an unnamed nonfossiliferous formation that consists of cream-colored to white, hard, dense, sacchroidal and porous varieties of limestone. The Ocala Limestone is the uppermost Eocene formation. In many places in northern peninsular Florida it can be divided into a lower member of light-cream-colored limestone containing abundant molds and casts of small foraminifers and an upper member of soft, white, chalky, porous coquina made up mainly of large foraminifers.

Miocene Series—The Hawthorn Formation, the lower of the Miocene formations in the vicinity, unconformably overlies the Eocene units. The Hawthorn consists mainly of interbedded clayey sand, hard sandy phosphatic dolomite, sandy clay, thin layers of chert, and opaline silica, while minor quantities of limestone are present locally. Well-rounded, highly polished, black, brown, gray, and white phosphate particles are present in varying amounts in all lithologies. Colors of the sand and limestone beds include various shades of brown, yellowish brown, brownish yellow, and brownish gray, and most of the clayey layers are shades of bluish gray when natural moisture is present but light gray when dry. The Hawthorn is 242 ft thick (30-272 ft depths) where penetrated by hole M5, drilled near the southwest corner of the study area and 283 ft thick (33-316 ft depths) where intersected by hole M6, 1.8 mi to the east (Miller, 1978, p. 39-60).

In this report, unnamed upper Miocene clastic beds 2 to 20 ft thick, consisting mainly of phosphatic, clayey sand, are assigned formational rank. This unnamed formation was considered to be the upper part of the Hawthorn Formation by Miller (1978), but it differs from the Hawthorn in the following ways: it contains more and coarser phosphate grains (many in pebble size) than the underlying Hawthorn, the phosphate grains are higher in $P_2O_5$ content and lower in CaO content than the phosphate grains in the underlying rocks, and the unit commonly contains clasts of green or blue-green clay, reworked from the underlying beds. In addition, the unit is lithologically identical to and in the same stratigraphic position as beds in which fossils of late Miocene age have been found (Olson, 1966; Cathcart, unpub. data) in the phosphate mines of Occidental Chemical Co. in Hamilton County, west-northwest of the Osceola National Forest.

The phosphate deposits in the unnamed formation also differ from those in the Hawthorn Formation. The deposits in the unnamed formation do not contain calcite or dolomite whereas almost all of the Hawthorn deposits contain dolomite, and calcite is present in some. Apatite in the Hawthorn deposits also contains considerably more $CO_2$ than the apatite in the unnamed formation. These characteristics of the unnamed formation are similar to occurrences in both the Pliocene Bone Valley Formation in south Florida and equivalent beds in Hamilton County. In both districts, dolomite, calcite, and $CO_2$-enriched apatite are present in the Hawthorn Formation, but are missing in the overlying formations.

Table 1.--*Generalized stratigraphic section in northern peninsular Florida.*[1]

| Era | Series | Formation or rock unit | Thickness in feet | Lithology |
|---|---|---|---|---|
| Cenozoic | Pliocene to Holocene | Soil and swamp deposits | 1-10 | Sandy soil, peat, peaty material, and muck |
| | | unnamed beds | 25-35 | Sand and clayey sand, contains minor quantities of phosphate and heavy-mineral grains in lower part |
| | Miocene | unnamed formation | 2-20 | Clayey sand, containing clasts of green or blue-green clay, phosphate commonly occurs in pebble-size grains |
| | | Hawthorn Formation | 125-280 | Clayey sand and sandy dolomite, phosphate commonly occurs in sand-sized grains |
| | Eocene | Ocala Limestone | 275 | White chalky and light-cream-colored limestone |
| | | unnamed formation | 110 | Hard, white, dense, saccharoidal, and porous limestone |
| | | Lake City Limestone | 520 | Brown chalky limestone |
| | | Oldsmar Limestone | 770 | Dark brown chalky limestone |
| | Paleocene | Cedar Keys Limestone | 535 | Cream- to tan-colored limestone, contains distinctive foraminifers |
| Mesozoic | Upper Cretaceous | Lawson Limestone | 530 | Chalk and dolomite containing inclusions of anhydrite and gypsum |
| | | Beds of Tayloran age | 620 | Dolomite, chalk, gypsum |
| | | Beds of Austinian age | 350 | Calcareous sandstone, chalk, marl, and shale |
| | | Atkinson Formation | 350 | Sandstone and shale |
| Paleozoic | Upper Silurian or Lower Devonian(?) | unnamed beds | 740+ | Sandstone, quartzite, black shale, diabase, amygduloidal basalt |

[1]Modified from Applin and Applin, 1944, 1965, 1967; Miller, 1978.

## STRUCTURE

The Mesozoic and Cenozoic sedimentary rocks underlying the Natural Area dip gently and thicken considerably in an eastwardly direction (fig. 5). The area is on the eastern flank of the Peninsular Arch, a broad anticline the axis of which extends from Hamilton County, west-northwest of the area, to Palm Beach County to the south, a distance of nearly 300 mi (Applin and Applin, 1967, p. 30). In the vicinity of the study area, the Cenozoic rocks are about 2,100 ft thick and the Cretaceous beds are 1,200 ft thick. The St. Mary's River Oil Co. dry hole, 35 mi northeast of the Natural Area, penetrated Cenozoic beds 2,740 ft thick and Cretaceous rocks 1,800 ft thick (Applin and Applin, 1967, plate 7).

No faults have been recognized in the Natural Area Roadless Area. However, strata have undoubtably been disturbed in many places by slumping into solution cavities.

## ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Phosphate, clay, heavy minerals, limestone, peat, and sand are produced in northern peninsular Florida, the region in which the Natural Area Roadless Area is located. Inferred subeconomic phosphate deposits probably underlie most of the study area, but the total tonnage cannot be estimated from existing exploration data. Clays having the required physical properties or heavy-mineral concentrations rich enough for mining are not known to occur in the area. Extensive deposits of limestone in the area are too deeply buried for economic recovery. The only mining activity in and near the study area is for clayey sand, which was dug from several shallow borrow pits and used to stabilize Forest Service roads. Some of the swamps in the region contain peat, but only uneconomic peaty material is present in the study area. There is a low potential for the discovery of oil and gas.

## PHOSPHATE

Phosphate deposits of northern peninsular Florida are in the north Florida-south Georgia district. Deposits occur as lenticular and irregularly-shaped bodies in the Hawthorn Formation and upper Miocene unnamed formation. The phosphate deposits have been the subject of geologic investigation for many years; some of the more comprehensive reports include those by Mansfield (1942), Sever, Cathcart, and Patterson (1967), and Cathcart (1968). These reports contain additional information on the economic geology of the deposits, as well as extensive bibliographies.

### Phosphate-Exploration Activities

According to the U.S. Bureau of Land Management (1974, p. 1-6), in the period 1969 through 1972, companies exploring for phosphate filed applications for preference right leases on 52,253.38 acres in the Osceola National Forest. The companies filing the lease applications were Pittsburgh and Midway Coal Mining Co., Monsanto Chemical Products Co., Global Exploration and Development Corp., and Kerr-McGee Oil Industries, Inc. Other companies that prospected for phosphate in the Osceola National Forest included American Metal Climax, Inc., New Jersey Zinc Co., and Sinclair Oil and Gas Co. Many of the tracts for which lease applications were filed, and more than 100 nonproprietary drill-hole locations, are shown on figure 4. The U.S. Mineral Management Service (written commun., 1982) states that no phosphate lease application exists in the Natural Area Roadless Area.

Phosphate exploratory drilling on the Osceola National Forest and adjoining private land west and north of the national forest boundary resulted in the discovery of phosphate deposits containing several hundred million tons of reserves (U.S. Bureau of Land Management, 1974, p. II-1). The major portion of these deposits was located on privately owned land in Hamilton and Columbia Counties, west of the national forest. Exploratory drilling on national forest lands identified 100 million tons of proven reserves which underlie the western half, and it is in this area that three companies applied for phosphate preference right leases. The average thickness of the phosphate deposits in the western part of the national forest is 8 to 10 ft, overburden is 25 to 30 ft thick, and the average grade of separated phosphate particles is 31.2 percent $P_2O_5$. The deposits are more discontinuous and under thicker overburden in the eastern part of the national forest where the study area is located.

### Characteristics of Minable Phosphate Deposits

The economic limits for phosphate deposits of Florida are listed below. The maxima and minima listed are estimates of industry standards, based on current company practice.

1. The amount of phosphorus necessary for mining is expressed as percent phosphorus pentoxide, $P_2O_5$, or percent bone phosphate of lime (BPL). BPL is equal to percent $P_2O_5$ x 2.185. The minimum in minable deposits is 60 percent BPL, or about 28 percent $P_2O_5$.
2. Excessive amounts of iron, aluminum, magnesium, and calcium oxides in the deposits have a deleterious effect on processing the phosphate rock. The maximum $Fe_2O_3$ + $Al_2O_3$ allowable in commercial deposits is 5 percent and the maximum MgO is 1.0 percent. CaO (expressed as a ratio of percent CO to percent $P_2O_5$) occurs in the mineral apatite, which contains the phsophorus, in ratios ranging from 1.4 to 1.55. The maximum ratio allowable is 1.60, and higher ratios indicate excessive amounts of calcite, dolomite, or both.
3. Minimum minable tonnage is 400 tons per acre-foot, which is equal to about 20 percent, by weight, of recoverable phosphate particles. Tonnage is expressed as tons per acre per foot of thickness of the phosphate bed.
4. Minimum minable thickness for a phosphate bed is 3 ft; this is the least thickness that can be mined with large draglines.
5. The thickness of overburden that can be removed in profitable mining is expressed as the ratio of this thickness to thickness of the phosphate bed. The maximum is 5 to 1.
6. The present maximum thickness of overburden plus phosphate that can be

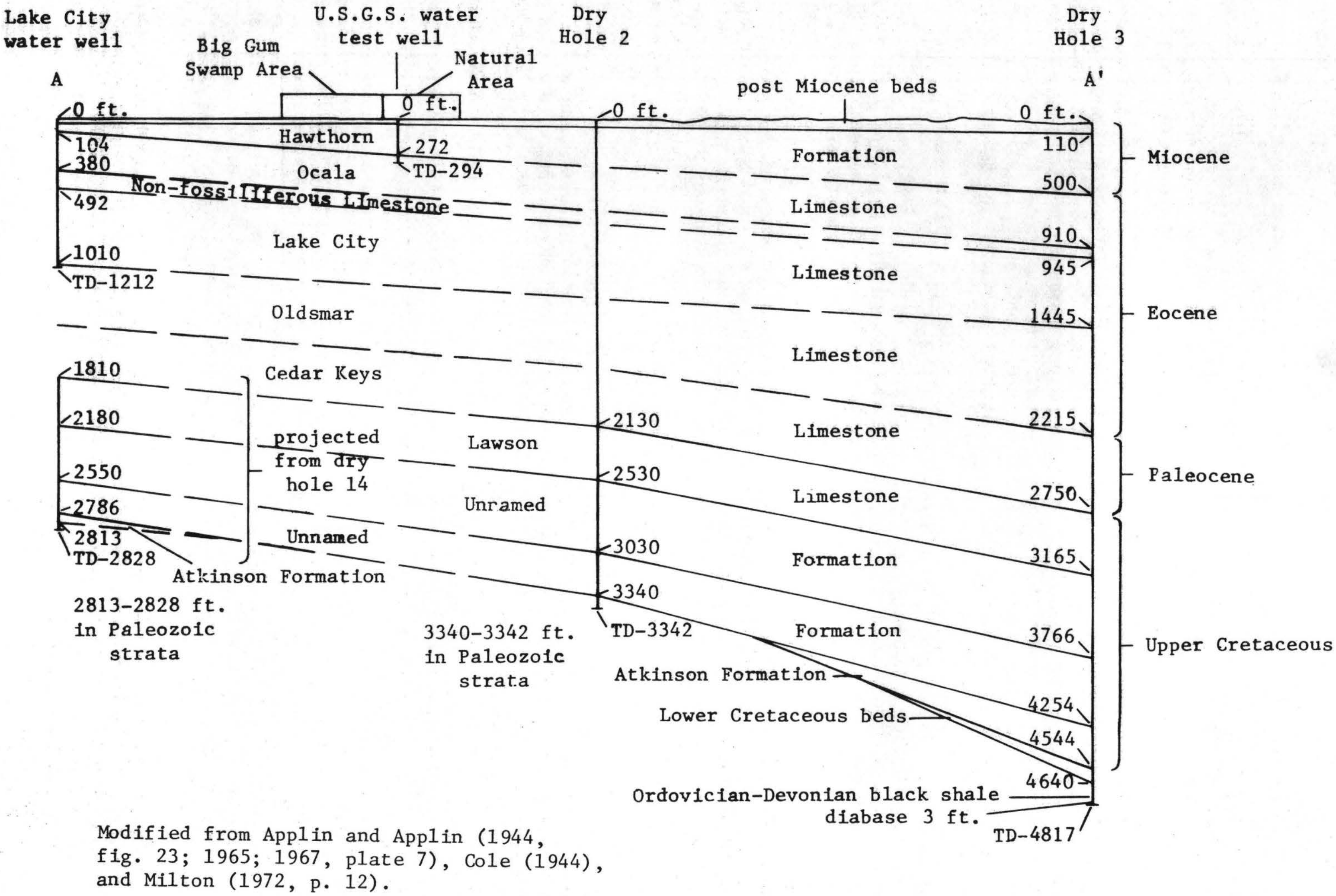



Figure 5.—Correlation of rocks in the region of the Osceola National Forest.

profitably mined in Florida is 200 ft; however, the maximum applies only to high-grade deposits where the phosphate bed is more than 25 ft thick. Maximum limits of depth of phosphate strip mining in northern peninsular Florida are presently no more than 150 ft.

### Characteristics of the Phosphate Deposits in the Natural Area Roadless Area

Overburden—The overburden includes all of the noneconomic materials that overlie the phosphate deposit. Stratigraphically, it includes unconsolidated sediments of possible Miocene and Pliocene age and of Pleistocene and Holocene age. The overburden ranges from 15 to about 70 ft in thickness, and the only systematic variation is a tendency for thickness to increase from west to east. Thus, in the western part of the forest, the overburden averages about 30 ft in thickness, while in the study area it is closer to 50 ft in average thickness, as indicated by the data from hole 3 where the top of the analyzed sample was at 55 ft below surface. The basal part of the overburden includes rocks of the Hawthorn Formation.

Phosphorite—Thickness of the phosphate-bearing rock (phosphorite) intersected by the company prospect holes drilled in and around the study area ranges from 0 to 66 ft (Crandall, 1981, table 1), and the average is about 23 ft. The total thickness of the overburden plus phosphorite penetrated by all drill holes is less than 100 ft, and the ratio of the thickness of the overburden to phosphorite in most of the area explored is less than 5 to 1.

Evaluation of the phosphorite—Thirteen of 17 holes drilled along boundary roads and in the central part of the study area (fig. 4) by American Metal Climax, Inc. penetrated phosphate beds (Crandall, 1981). The average thickness of this phosphate is 26 ft, and the average thickness of the overburden above it is 47 ft. Of the material analyzed, 13 samples contained an average of 1.6 percent pebble (+ 20 mesh or 1 mm) phosphate and 10 samples contained an average of 21.96 percent concentrate (-20 to 150 mesh or -1 mm to 0.1 mm) phosphate. The average $P_2O_5$ composition of the pebble phosphate was 18.1 percent and the average for the concentrate phosphate was 29.77 percent. The thickness ratio of overburden to phosphorite in the strata penetrated by the 13 drill holes ranges from 1.1 to 1 to 10.5 to 1, and the average is only 2.2 to 1.

During the present investigation, a 204-foot core hole was drilled adjacent to the southern boundary of the study area (fig. 3, hole 3). A 31-foot-thick phosphatic interval (from a depth of 55 to 86 ft) was sampled and analyzed. The pebble fraction (+ 20 mesh) was too low grade (table 2) to be considered a potential resource; however, the concentrate fraction (-20 to 150 mesh) contained 28.46 percent $P_2O_5$, had a CaO to $P_2O_5$ ratio of 1.6, a $Fe_2O_3$ + $Al_2O_3$ content of 4.45, and 1.26 percent MgO. The thickness ratio of overburden to phosphorite was 55 to 31 ft, or slightly less than 2 to 1.

The phosphorite in the Natural Area Roadless Area is not a potential mineral resource (minable at a profit) by today's standards, and may not become so until the phosphorite deposits in other regions that are presently mined are depleted. Much of the recoverable phosphate contains somewhat more than 28 percent $P_2O_5$ and the minimum thickness cutoff and the overburden-to-phosphorite thickness ratios are favorable, but the other criteria for minable deposits preclude commercial utilization of these deposits by current mining and beneficiation methods. The phosphorite is high in ratio of CaO to $P_2O_5$ and slightly high in MgO and $Fe_2O_3$ + $Al_2O_3$. Though not economic today, the phosphorite in the study area is a subeconomic resource that will increase in value as present reserves are exhausted. Data from scattered drill holes (fig. 4) suggests that the best phosphorite potential exists under more than a square mile in the southwestern part of the study area. These deposits are the most likely ones to increase in value in the future.

Uranium—Uranium, syngenetic in origin and substituting for calcium in apatite, is present in all marine phosphorites. Analyses of samples taken from cores at drill holes 1, 2, and 3 (fig. 4), show that the pebble samples contain more uranium than the concentrate samples, whereas the slime (-150 mesh) samples contain much less uranium than the pebble and concentrate, but about as much uranium as the total (head) samples (table 3). These generalizations, although based on only a few samples, are very similar to generalizations made for samples from the minable deposits of Florida (Cathcart, 1978).

Uranium has been recovered as a byproduct of the manufacture of phosphoric acid at several plants in the Land Pebble Phosphate District in Florida.

Trace elements—The suite of trace elements in the phosphate samples from the Osceola National Forest (table 4) is similar to that of other phosphate deposits. Elements associated with apatite have about the same abundance as in deposits of the Phosphoria Formation of Early Permian age in the western United States (Gulbrandsen, 1966), and in the Hawthorn Formation in the Ocala Forest (Cathcart, Patterson, and Crandall, unpub. data). Most of the elements thought to be associated with organic material are less abundant in phosphorite samples from the Hawthorn than in the more highly organic Phosphoria Formation, while elements in other associations may be more or less abundant. The elements in organic materials are thought to be in substitution for Ca. The Ba and Mn probably occur in discrete minerals and their presence is probably related to an oxidizing environment that existed when Miocene sediments were deposited. Virtually all of the Zr is in zircon, as this resistant mineral withstood transportation and reworking of the sediments before deposition.

## CLAY

The only present significant use of clay materials in the region of the Osceola National Forest is by the Florida Solite Corp., which operates a mine and produces lightweight aggregate near Russell in Clay County. The clay is apparently mined from extensive alluvial deposits underlying the St. Johns River flood plain. The deposits, called the Doctors Inlet clay by Greaves-Walker and others (1949, p. 12-13), have physical properties that make it suitable for use in structural-clay products.

Much very sandy clay and clayey sand and many thin beds of clay wre found in samples collected from the hole drilled during these investigations and in the two holes described by Miller (1978). The principal clay mineral in the clayey sand is montmorillonite

Table 2.--*Analytical data of phosphate samples from drill hole 3.*[1]
(Analyses by Pembroke Laboratories under contract to the U.S. Geological Survey and U.S. Bureau of Mines)

| | Weight, in percent | BPL | $P_2O_5$ | A.I.[2] | $Fe_2O_3$ | $Al_2O_3$ | CaO | MgO | $CO_2$ | F | Ratios $\frac{CaO}{P_2O_5}$ | Ratios $\frac{F}{P_2O_5}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| +20 (pebble) | 10.01 | 43.92 | 20.10 | 14.72 | 2.97 | 0.87 | 39.20 | 4.83 | 11.25 | 2.62 | 1.95 | 0.130 |
| -20-+150 (feed) | 62.19 | 14.64 | 6.70 | 76.95 | | | | | | | | |
| Concentrate | 12.93 | 62.19 | 28.46 | 5.09 | 3.49 | 0.96 | 45.57 | 1.26 | 5.22 | 3.36 | 1.60 | 0.118 |
| Tail | 49.26 | 3.06 | 1.40 | | | | | | | | | |
| -150 (slime) | 27.80 | 3.50 | 1.60 | | | | | | | | | |
| Total rock | 100.0 | 12.89 | 5.90 | 57.26 | | | | | | | | |

[1]Drill hole located on figure 2. Composite sample from beds in interval of 55-86 ft depth
[2]Acid insoluble

Table 3.--*Summary of uranium contents of samples of phosphate rock, Osceola National Forest.*

(Analyses are in parts per million uranium. Analyses: B. J. Sherlock and Nancy J. Nelson, U.S. Geological Survey.)

| Fraction | Number of Samples | Range ppm | Average ppm |
|---|---|---|---|
| Head (total sample) | 3 | 8-18 | 12 |
| Pebble (+20 mesh) | 3 | 70-110 | 89 |
| Concentrate (-20+150 mesh) | 8 | 45-98 | 62 |
| Slime (-150 mesh) | 4 | 4-24 | 11 |

Table4.--*Trace element contents of phosphate concentrates from the Hawthorn Formation in the Osceola and Ocala National Forests, Fla. and the Phosphoria Formation in the western United States.*

(N - not detected; --- - no data. Analyst: Betty Adrian, U. S. Geological Survey)

| Metal | Hawthorn Formation Osceola National Forest [1] | Ocala National Forest [2] | Phosphoria Formation (Gulbrandsen, 1966) [3] |
|---|---|---|---|
| Ag | 0.5 | 0.5 | |
| **Elements probably associated with organic material** | | | |
| Ag | 0.5 | 0.5 | 3 |
| As | --- | --- | 40 [4] |
| Cr | 150 | 200 | 1000 |
| Cu | 15 | 20 | 100 |
| Cd | N | N | 7 |
| Mo | 20 | 15 | 30 |
| Ni | 30 | 20 | 100 |
| Sb | N | N | 7 |
| S | --- | --- | 7 |
| V | 70 | 70 | 300 |
| Zn | N | N | 300 |
| **Elements assoicated with apatite** | | | |
| U | 70 [4] | 85 [4] | 90 [4] |
| Sr | 1500 | 1000 | 1000 |
| La | 200 | 200 | 300 |
| Y | 500 | 300 | 300 |
| Sc | 10 | 10 | 10 |
| **Other associations** | | | |
| Ba | 300 | 200 | 100 |
| Mn | 1000 | 1000 | 30 |
| Zr | 300 | 1000 | 300 |

[1]Composite of 4 samples (Cathcart and others, in prepration), in ppm.
[2]Composite of several samples (Cathcart and others, in prepration), in ppm.
[3]In ppm.
[4]Arithmetical average of chemical analyses.

(smectite), and some thin beds are mixtures of montmorillonite and kaolinite. A bed of attapulgite (palygorskite) was penetrated at a depth of 203 ft at the bottom of hole 3 (fig. 4).

The clays in the study area have no commercial value. The montmorillonitic and kaolinitic clays are too impure or deeply buried or both to be mined at a profit. The attapulgite, which is the principal constituent of the fuller's earth mined extensively in Gadsden County, Fla., is far too deep to be strip mined.

## HEAVY MINERALS

Heavy minerals have been mined for many years in parts of Florida east of the Natural Area Roadless Area. The principal mineral produced is ilmenite, the ore of titanium oxide, but staurolite, monazite, zircon, garnet, and kyanite are also recovered and sold (Garner, 1972, 1981). The heavy-mineral deposits are in elevated beach accumulations, where they formed by the winnowing action of ocean waves and currents. Pirkle and Yoho (1970, p. 21) describe the Trail Ridge deposits as containing 4.5-6 percent heavy minerals. In a more recent report Pirkle and others (1977, p. 5) state the Highland deposits in the Trail Ridge district contain an average of 3 percent heavy minerals.

No commerical heavy-mineral deposits are known to be present in the study area, and it is very unlikely any will be found; the approximate 10 ft of relief is evidence that no Pleistocene spit deposits, such as Trail Ridge, or elevated beach deposits are present. Therefore, the winnowing action by ocean waves or currents that is required to form heavy-mineral deposits probably did not occur in the study area. Also the post-Hawthorn sand beds in the Osceola National Forest are very low in heavy-mineral contents. Samples of this sand from a drill hole located 3.1 mi to the west and another hole 4.2 mi to the southwest were found to contain less than 1 percent heavy minerals other than phosphate. Data from studies of samples from phosphate mines in Hamilton County (Cathcart, unpub. data) indicates that the heavy minerals in surficial sand above the phosphate deposits are present in amounts that average about 0.5 percent. Heavy minerals are also present in the phosphate beds, but they are so minor in amount that they are concealed by the abundance of phosphate pellets, which are also heavy. This content of heavy minerals is similar to the low concentrations in surficial sand, other than spit and elevated beach deposits, found throughout a large region east of the study area by Pirkle and Yoho (1970, table 9). Furthermore, an aeroradioactivity map (U.S. Geological Survey, 1978) shows no anomalous radiation in the Natural Area Roadless Area, whereas prominent radiation anomalies were recorded from Trail Ridge and other areas where heavy minerals have been mined. Mineral species found include ilmenite, garnet, zircon, staurolite, rutile, sillimanite, tourmaline, and kyanite. Monazite, present in small amounts in the Trail Ridge deposits, was not identified in any of the samples.

## LIMESTONE

Limestone is quarried at many places in northern peninsular Florida (fig. 2) south and west of the study area (Schmidt and others, 1979). The Ocala Limestone is the rock quarried at the Columbia City quarry, about 30 mi to the southwest.

The Ocala underlies the entire Osceola National Forest and contains enormous quantities of very pure limestone. However, the top of the formation is at depths greater than 270 ft, and limestone cannot be quarried profitably at such depths in this area. Sandy limestone and dolomite make up the lower part of the Hawthorn Formation throughout the area, but this rock is too low quality and too deeply buried to be considered a potential resource.

## PEAT

Peat is a naturally occurring accumulation of plant remains in swamps. The term peat, as defined by the American Society for Testing Materials (1969), is applied to organic material having an ash content not exceeding 25 percent on a dry-weight basis and to be commercial must have a thickness of 4 ft or more. Organic deposits containing more than 25 percent ash are referred to as peaty material.

Muck rich in organic matter and peaty material are scattered through the extensive cypress-black gum swamps along the Middle Prong St. Marys River (Cameron and Schruben, written commun., 1981). One hand-cored hole in the NE 1/4, sec. 27, T. 1 S., R. 19 E. passed through humus peaty material 3 ft thick. A laboratory analysis of a sample of this peaty material showed 37.4 percent ash, 85.4 percent moisture, and a pH of 3.70. Peaty material as much as 4 ft thick was found in others of the 10 holes probed with a peat sampler. All of these materials were determined by the empirical hand-squeeze-ball-forming test to contain more than 25 percent ash, the maximum cutoff for commerical peat. The U.S. Bureau of Mines (USBM) team found only a few thin layers of peaty material (3.5-11 in. thick) in the 48 sites they probed (Crandall, 1981, p. 16).

Though large quantities of impure peaty material are present in the study area, no peat deposits of sufficient size and purity suitable for mining are present. This conclusion is based on the absence of commerical peat in the 11 holes that were put down by Cameron and Schruben and the negative findings of the USBM.

## SAND

Clayey sand has been dug from one pit in the study area for use in stabilizing Forest Service roads, and several pits have been opened in the Osceola National Forest for road materials. This clayey sand has no particular value because it is too fine-grained for most construction uses and there are enormous resources of similar material in northern Florida.

## OIL AND GAS POTENTIAL

According to the reports and records of the Florida Bureau of Geology, many exploratory holes have been drilled in the region surrounding the Osceola National Forest in search for oil and gas (fig. 2). To date, only a few shows of oil and gas have been found, and all of the holes have been dry. Of the 29 selected dry holes, only three holes were drilled deeper than 5,000 ft, and the deepest was 5,862 ft. One hole was 4,444 ft deep, and all other holes were less than 3,500 ft deep. Thriteen of the selected dry holes penetrated

Paleozoic strata. Cole (1944, p. 96-100) included a driller's log of the St. Mary's River Oil Corp. well, located 35 mi northeast of the study area, that noted several shows of oil at a depth between 1,812-4,795 ft and evidence of gas at two intervals.

Although there are no reasons for optimism about a discovery of oil and gas in the Natural Area Roadless Area, the possibilities cannot be completely ruled out. The principal reasons for the unfavorable outlook are the large number of dry holes in the region (fig. 2) and the lack of the formations that contain oil and gas in the fields in southern and westernmost Florida.

The oil in the southern Florida fields is in Lower Cretaceous formations, and in the Jay field in the western Florida panhandle it occurs in the Upper Jurassic Smackover Formation. In the vicinity of the Osceola National Forest, the lowermost Upper Cretaceous formation rests unconformably on Paleozoic rocks.

Some possibility remains, however, for the discovery of oil and gas in deep rocks in the study area. The Paleozoic rocks have not been adequately explored in the region of the Osceola National Forest and according to one authority (Rainwater, 1971, p. 1311), rocks of Paleozoic age in northern Florida and the adjacent continental shelf should contain 100 million bbl of oil and 0.5 trillion $ft^3$ of gas. The shows of oil and gas like those reported in Ordovician-Devonian and Cretaceous strata, (Applin and Applin, 1967, pl. 7; Cole, 1944, p. 99-100; Milton, 1972, p. 12) which are present in the St. Mary's River Oil Corp. hole located 35 mi northeast of the study area, indicate valuable quantities of oil and gas may also be present in northern Florida. The westward thinning of Upper Cretaceous and Cenozoic formations and the wedging out of Lower Cretaceous beds are excellent conditions for the occurence of updip pinch-out sedimentary traps. Whether or not traps of this type are present in the subsurface of the Osceola National Forest is unknown, but if they exist, they might contain hydrocarbons.

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