STUDIES RELATED TO WILDERNESS
WILDLIFE REFUGES

OKEFENOKEE, GEORGIA; PASSAGE KEY, ISLAND BAY, CEDAR KEYS, AND PELICAN ISLAND, FLORIDA

GEOLOGICAL SURVEY BULLETIN 1260-N, O

Summary Report on the Geology and Mineral Resources of the—

Okefenokee National Wildlife Refuge, Georgia

By JACK E. SMEDLEY

Passage Key, Island Bay Cedar Keys, and Pelican Island National Wildlife Refuges, Florida

By CHARLES L. PERDUE, JR.

STUDIES RELATED TO WILDERNESS—WILDLIFE REFUGES

GEOLOGICAL SURVEY BULLETIN 1260-N, O

A compilation of available geologic information

UNITED STATES GOVERNMENT PRINTING OFFICE WASHINGTON : 1968

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STUDIES RELATED TO WILDERNESS

WILDLIFE REFUGES

The Wilderness Act (Public Law 88–577, Sept. 3, 1964) directs the Secretary of the Interior to review roadless areas of 5,000 contiguous acres or more, and every roadless island, within the national wildlife refuges and game ranges under his jurisdiction and to report on the suitability or nonsuitability of each such area or island for preservation as wilderness. As one aspect of the suitability studies, existing published and unpublished data on the geology and the occurrence of minerals subject to leasing under the mineral leasing laws are assembled in brief reports on each area. This bulletin is one such report and is one of a series by the U.S. Geological Survey and the U.S. Bureau of Mines on lands under the jurisdiction of the U.S. Department of the Interior.

Summary Report on the Geology and Mineral Resources of the Okefenokee National Wildlife Refuge Georgia

By JACK E. SMEDLEY

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SUMMARY REPORT ON THE GEOLOGY AND MINERAL RESOURCES OF THE OKEFENOKEE NATIONAL WILDLIFE REFUGE, GEORGIA

By Jack E. Smedley

SUMMARY

The Okefenokee National Wildlife Refuge occupies parts of Charlton, Clinch, and Ware Counties, Ga., and includes approximately 323,000 acres of the Okefenokee Swamp and 9,000 acres of the adjacent uplands. The swamp is in a broad basin on the Atlantic Coastal Plain bounded on the east by a large sand ridge (Trail Ridge). It is drained by the Suwannee and St. Marys Rivers. Surface formations consist of unconsolidated Pleistocene and Recent sediments. Marine rocks of Paleozoic(?), Cretaceous, Paleocene, Eocene, Miocene, and Pliocene ages occur in the subsurface.

No minerals have been mined in the refuge area. Several oil and gas test wells have been drilled on the Atlantic Coastal Plain in southeastern Georgia and northern Florida, but no commercial production has resulted. Although heavy minerals are being mined 7 miles to the east, on Trail Ridge, economic concentrations of these minerals are unknown in the refuge area. The Okefenokee Swamp is filled with vast quantities of peat, but attempts to mine the peat were economically unsuccessful. Great reserves of peat are readily available in other parts of Georgia and parts of Florida.

The Pleistocene sands and Tertiary rocks underlying the peat deposits in Okefenokee Swamp presumably contain phosphate just as in the surrounding region. Phosphate deposits have yet to be worked in the surrounding region; thus information on them is limited. The extent and grade of possible deposits under the refuge cannot be known without extensive exploration by drilling. These deposits would be covered by 40–110 feet of water, peat, and other overburden. Whether they could be mined economically is unknown.

INTRODUCTION

PURPOSE AND SCOPE

This study summarizes available information on the geology and mineral-resource potential of the Okefenokee National Wildlife Refuge to aid in determining whether the area is suitable for incorporation into the National Wilderness Preservation System.

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No fieldwork was undertaken in support of this study. The study and its conclusions are based on a review of published and unpublished sources of information.

In the absence of mineral production, the U.S. Bureau of Mines did not have occasion to examine the refuge, but the Bureau is informed of the findings and conclusions of the Geological Survey and concurs in them.

LOCATION AND SIZE OF AREA

The Okefenokee National Wildlife Refuge is in parts of Charlton, Clinch, and Ware Counties in southeastern Georgia near the Florida boundary (fig. 1), and occupies about four-fifths of the Okefenokee Swamp. It extends about 38 miles from north to south and is about 25 miles across at its widest. Approximately 323,000 acres of the swamp and 9,000 acres of the lower slopes of adjacent uplands are included in the refuge. The area is shown on the Waycross and Valdosta U.S. Geological Survey topographic quadrangle maps (1:250,000 series) published in 1958 and 1959.

TOPOGRAPHY

The swamp is a vast depression on the Atlantic Coastal Plain and ranges from about 105 feet above sea level on the southwest side to about 130 feet on the northeast side.

The uplands adjoining the swamp, the lower slopes of which lie within the refuge, reach altitudes of about 160 feet above sea level. The principal surface features of the swamp are of four sorts: "prairies," "houses," "bays," and regular islands (Zahner, 1954, p. 4, 5).

The "prairies" are vast open spaces of water, covered with low water plants and grasses. "Houses" are large and small floating islands of peat scattered throughout the prairies, where the mat of decayed vegetation has become detached from the bottom and has risen to the surface. The floating peat mats make a solid enough base to support a growth of trees and dense underbrush.

The "bays" represent the real swamp, as the word is commonly understood, and include heavy stands of immense trees growing out of the water. The "bays" cover many square miles and make up the greater part of the Okefenokee Swamp area. About 85 percent of the swamp is thus covered more or less densely with these forests, which are predominantly of cypress and black gum (Cypert, 1961, p. 486).

The regular islands are solid ground rising to an average height of about 5 feet above the surrounding water. They are covered with dense timber (largely pine), vines, and underbrush.

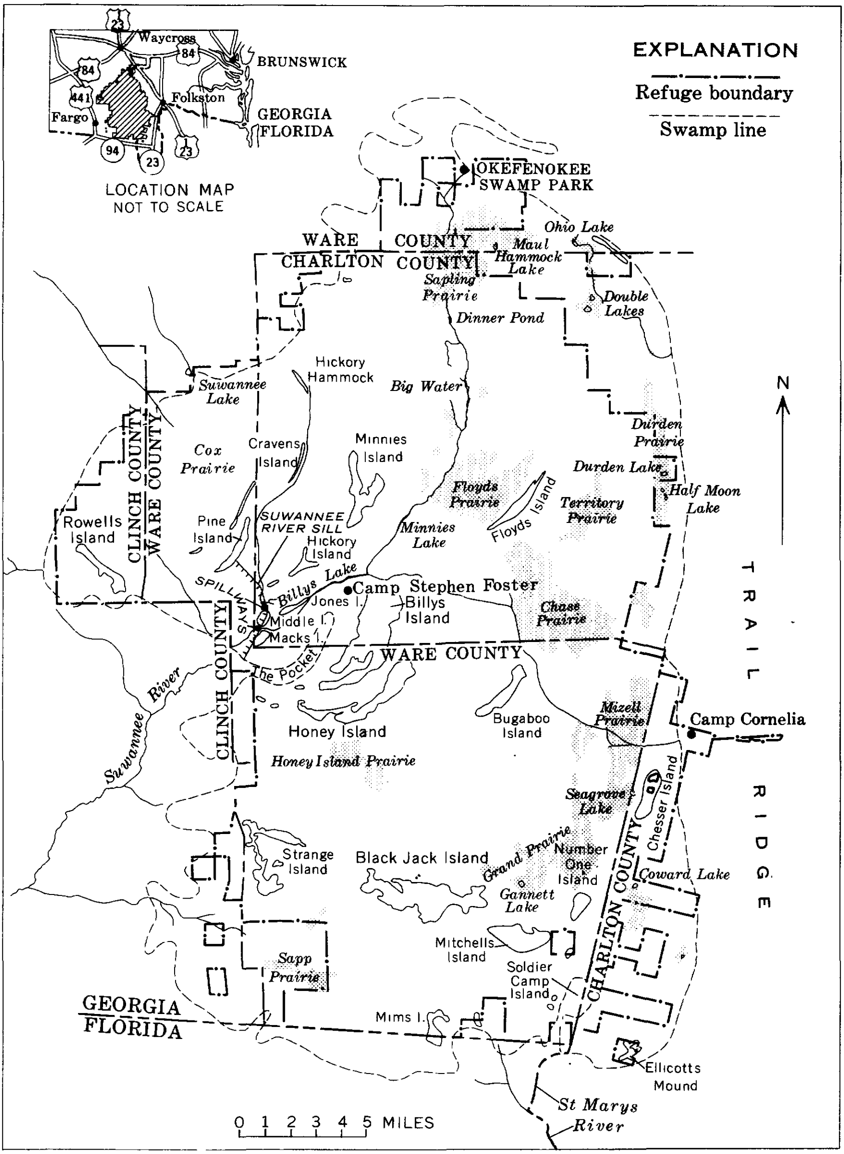

FIGURE 1.—Map of Okefenokee National Wildlife Refuge.

Most of the swamp is covered by water ranging from 1 to 5 feet deep, but scattered throughout are several small lakes, completely free of vegetation, and with considerably greater water depths. During periods of extremely dry weather, vast areas of the swamp have been known to dry up except for the lakes and channelways.

The swamp is drained toward the southwest by the Suwannee River and in a lesser degree to the southeast by the St. Marys River. Streams flow into the swamp from the northwest.

ACCESS

State and Federal highways, as well as a gravel service road maintained by the U.S. Fish and Wildlife Service, surround the Wildlife Refuge (fig. 1). Public access into the refuge, however, is afforded at only three points, from the west, east, and north.

The road to the west entrance leaves U.S. Highway 441 about half a mile southeast of Fargo, Ga., and terminates 19 miles to the northeast at Camp Stephen Foster within the refuge.

The road to the east entrance leaves State Highway 23 about 7 miles southwest of Folkston, Ga., and terminates about 4 miles to the west at Camp Cornelia, which is about 1 mile inside of the refuge boundary.

The northern approach to the refuge is from Okefenokee Swamp Park, a Georgia State Park, which is 8 miles south of Waycross on State Highway 177. Boats can be rented and guides may be employed at the park, as well as at the two previously mentioned camps, for trips into the more remote parts of the Okefenokee Swamp.

In the early part of the present century a railroad was extended into the swamp to exploit the vast stands of cypress and other hardwoods. It has since been dismantled.

GEOLOGY

STRATIGRAPHY

Surface formations within the study area consist of unconsolidated Pleistocene and Recent sediments and are typical coastal plain deposits. Descriptions and approximate thicknesses of surface and subsurface formations are given in table 1.

Straitigraphic information represented in table 1 was derived from an interpretation of the lithologic log of the St. Marys River Oil Corp's. Hilliard Turpentine Co. test oil well 1 (Applin and Applin, 1944, p. 1745). The well is located in sec. 19, T. 4 N., R. 24 E., Tallahassee Meridian, Nassau County, Fla., about 10 miles east of Camp Cornelia.

STRUCTURE

The structure of the coastal plain deposits in the refuge area is that of a comparatively simple homocline. Several miles southwest of the area is the axis of the elongate Peninsular arch which trends northwest

TABLE 1.—*Generalized stratigraphic section of subsurface rocks as determined from oil-well log*

[Adapted from Applin and Applin, 1944, p. 1745]

Age	Stratigraphic unit	Lithology	Depth to formation base (feet)
Recent and Pleistocene		Brown sand.	30
Pliocene		Greenish-gray argillaceous sand with limestone nodules.	110
Miocene	Hawthorn Formation	Coarse-grained greenish-gray sand with phosphate pebbles; occasional beds of sandy clay and limestone.	500
Late Eocene	Ocala Limestone	White and cream limestone with beds of coarse-grained sandstone in upper part.	860
Late middle Eocene	Avon Park Limestone	Chalky fossiliferous limestone.	910
		Nonfossiliferous limestone.	945
Early middle Eocene	Lake City Limestone	Cream to brown chalky limestone.	1, 370
?	?	?	1, 445
Early Eocene	Oldsmar Limestone	White limestone with beds of chert, selenite, clay, and obsidian bed.	2, 115
Paleocene	Cedar Keys Limestone	Cream and gray porous limestone with gypsum in middle part; reef limestone beds in part.	2, 750
Late Cretaceous	Lawson Limestone	Limestone, interbedded with gypsum in part.	3, 280
	Beds of Taylor age	Cream limestones; green, gray, and white bentonitic shales; soft gray marl.	3, 900
	Beds of Austin age	Green shales, green to gray marls, gray limestone and marl at base.	4, 245
	Tuscaloosa Formation	Gray argillaceous sandstone, nodular limestone, interbedded greenish-gray shale and coarse sand.	4, 600
Early Cretaceous(?)		Red, greenish-gray, purple mottled clay.	4, 640
Paleozoic(?)		Black noncalcareous shale and quartzitic sandstone.	4, 808
		Diabase.	4, 821

from Florida. The arch was a topographic high at the beginning of Late Cretaceous time (Toulmin, 1955, p. 210). Accordingly, the coastal plain deposits of the refuge area have gentle northeasterly regional dips away from the arch toward the coast (Applin and Applin, 1944, figs. 21–23).

Following Tertiary deposition the general area of the arch was again raised as the Ocala uplift (Vernon, 1951, p. 53), which gave the Cretaceous and Tertiary rocks within the study area their present dips.

SURFACE FEATURES

The Okefenokee Swamp is on and near the eastern margin of the broad Okefenokee terrace, which, in turn, is in the eastern part of the Coastal Plain physiographic province. The terrace is constructed on Pleistocene deposits lying between altitudes of 100 and 160 feet above sea level (MacNeil, 1950, p. 101). These deposits form a wedge-shaped block that is thickest at the coast and thins westward. They have a coastward dip of about 2 feet per mile (Herrick, 1965, p. 6).

A narrow elongate ridge (Trail Ridge) parallels the eastern margin of Okefenokee Swamp. It is composed mostly of white sand and is considered an offshore bar which developed on the Pleistocene terrace (MacNeil, 1950, p. 101).

The lagoon which formed to the west of the bar (the present Okefenokee Swamp) had a maximum depth of about 30 feet, being generally deeper in the northern parts (MacNeil, 1950, p. 101). Most of the lagoon subsequently filled with dead organic matter (peat) and minor amounts of detrital sediments which became overgrown by dense vegetation, resulting in the "houses" and "bays" described above.

The "prairies" and at least some of the lakes represent areas where the dense cover of vegetation on "houses" or "bays" was destroyed by fire, and holes burned into the peat floor of the swamp. The burns occurred during periods of extreme droughts. Records of such droughts and the associated fires, dating as far back as 1844 (Cypert, 1961, p. 487), indicate that much of the Okefenokee Swamp has been known to dry up allowing the peat to become very flammable.

Islands within the swamp are remnants of Pleistocene sand dunes and bars that extended northeast across the area (Fortson, 1961, p. 10; MacNeil, 1950, p. 101).

MINERAL RESOURCES

PETROLEUM AND NATURAL GAS

Several oil and gas test wells have been drilled on the Atlantic Coastal Plain in southeastern Georgia and northern Florida, but no commercial production has been attained to the present.

Most of the wells terminate in the Upper Cretaceous rocks. Below these rocks, the lithologic log of one well (table 1) indicates the presence of a thin interval of Paleozoic(?) clastic rock which probably was deposited near the northeastern margin of the Suwannee River basin described by Braunstein (1959, p. 14). Although Braunstein indicates that these lower rocks show some promise of possible future production, no oil shows have been found.

HEAVY MINERALS

Cannon (1950, p. 205) states that most of the sands of late Pliocene and younger age on the coastal plain contain one-half of one percent or more heavy minerals. However, it is only where these heavy minerals were concentrated at the time of deposition that they might constitute economic deposits.

Concentrations of as much as 1 percent of heavy minerals, which may be economically significant, are reported from some of the surface sediments along the eastern margin of Okefenokee Swamp by Whitlatch and others (1962, p. 98). The location given for these deposits indicates that they probably are on Trail Ridge. No such concentrations are known within the wildlife refuge.

In 1965, Humphreys Mining Co. opened a heavy minerals mine in the surface sands northeast of Folkston, Ga. (fig. 1), and constructed a beneficiation plant from which it is producing titanium, monazite, and zirconium concentrates (Vallely and Furcron, 1966, p. 9). The mine, which is about 7 miles east of the refuge on Trail Ridge, represents the closest known economic deposit of heavy minerals to the refuge.

About 40 miles south-southeast of the refuge, in Clay County, Fla., east of the town of Starke, sands near the crest of Trial Ridge are being mined extensively, principally for ilmenite.

According to MacNeil (1950, p. 95), "The outer shores of the coastal bars of all sea level stages are regarded as more favorable locations for heavy mineral prospecting than the inner lagoonal shores."

PEAT

Most areas of the wildlife refuge except the islands, lakes, deeper channelways, lower western slope of Trail Ridge, and a narrow strip along the northwest boundary are covered by peat which occupies the vertical interval between the sandy Pleistocene terrace and the overlying water and vegetation. The thickness ranges from less than 1 foot to more than 20 feet locally but averages about 5 feet in most areas (Fortson, 1961, p. 11). In areas of former burns ("prairies" and lakes), thicknesses of the peat layers are appreciably thinner.

The peat is generally thicker toward the east side of the Okefenokee Swamp. South of the swamp, along Georgia Highway 94, it is commonly less than 1 foot thick (Fortson, 1961, p. 11).

Not all the Okefenokee peat deposits are within the wildlife refuge. Privately owned properties bound the refuge on all sides, and most are underlain by peat. The only peat mining operation known to have been atempted in the Okefenokee Swamp was on the King property of more than 20,000 acres, covering a part of the northeastern Okefenokee area about 3 miles N. 45° W. of the center of Folkston, Ga. (Fortson, 1961, p. 16). Although the peat has an average thickness of 10 feet at all places tested on the property and is generally of a better quality than the material found in ponds to the west, the operation was terminated after 2 years because of excessive operational costs of maintaining long waterways and of recovering peat from under water with draglines (Fortson, 1961, p. 16). Fortson states that "The reserves on this property alone would seem sufficient to meet all market needs."

Extensive areas in many of the southern counties of Georgia and parts of Florida (Fortson, 1961, fig. 1) have potential for peat production. Several deposits, with sizable resources, have considerably greater economic potential than the deposits of the wildlife refuge, mainly because they are not faced with water problems. Peat in the Okefenokee Swamp probably would have to be mined under water.

The work of eliminating woody materials, such as tree limbs, twigs, and stumps, from the peat also adds appreciably to operational costs, and such materials are commonly associated with the Okefenokee deposits.

PHOSPHATE

Phosphate deposits occur over a very broad area across southeastern Georgia from Florida to South Carolina, including the area of Okefenokee Swamp. Logs of water wells drilled in and around the margins of the Okefenokee Swamp (Herrick, 1961, p. 74–76) and of holes drilled as part of a phosphate exploration program in parts of Lowndes, Echols, Clinch, and Charlton Counties, Ga. (Olson, 1966), show that most of the Miocene and Pliocene(?) beds that underlie the area are phosphatic in some degree. However, with rare exceptions, there are little data on the phosphate deposits in these beds, which lie beneath 40–110 feet of overburden.

Olson (1966, p. vi, 47) reported that zones of commercial phosphate were noted in only two of several test holes drilled in the vicinity of Fargo, 7 miles west of the refuge. He concluded that the phosphate of commercial grade occurs almost entirely in the western part of the area studied by him, more than 30 miles west of the refuge.

Well logs also show that the Pleistocene sand that blankets the region is sparsely phosphatic. Phosphatic pebbles are sometimes present in the sand, particularly in the basal part, suggesting reworking from underlying Tertiary formations. Although commercially unproved, local concentrations of phosphate within the Pleistocene sand are considered of potential economic importance by Herrick (1965, p. 1).

In 1965 there was no reported commercial production of phosphate in the State of Georgia (Vallely and Furcron, 1966). The nearest producing mine is about 25 miles southwest from the refuge, and north of White Springs in Hamilton County, Fla., where there are large reserves of relatively high grade phosphate at or very near the surface (C. L. Perdue, oral commun., 1967).

According to J. B. Cathcart (written commun., 1967), economic deposits of phosphate do not occur continuously throughout the Georgia-Florida phosphate field, but as discrete areas of as much as 30,000 acres. These areas contain as much as 70–100 million short tons of phosphate. The total resources of phosphate rock of all grades in these deposits may measure in the billions of tons. Phosphate-bearing sediments probably underlie Okefenokee Refuge, but the extent and quality of these deposits is not known and could not be determined without widespread exploration, as by drilling. Most such deposits in the refuge would lie beneath both water and 40–110 feet of overburden. Whether output from such deposits would be economically competitive with output from known deposits in Florida is unknown.

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Summary Report on the Geology and Mineral Resources of Passage Key, Island Bay, Cedar Keys, and Pelican Island National Wildlife Refuges Florida

By CHARLES L. PERDUE, JR.

STUDIES RELATED TO WILDERNESS—WILDLIFE REFUGES

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SUMMARY REPORT ON THE GEOLOGY AND MINERAL RESOURCES OF PASSAGE KEY, ISLAND BAY, CEDAR KEYS, AND PELICAN ISLAND NATIONAL WILDLIFE REFUGES, FLORIDA

By Charles L. Perdue, Jr.

SUMMARY

The Passage Key, Island Bay, Cedar Keys, and Pelican Island National Wildlife Refuges consist of islands and associated sandbars along coastal Florida. The surface of the islands is composed mostly of mangrove swamps or sand and sea shells. The refuges are underlain by a thick sequence of limestone, clay, sand, chalk, shale, and anhydrite that ranges in thickness from at least 5,000 feet under Cedar Keys to more than 13,000 feet under Island Bay. No mineral deposits are known in this thick sequence of sedimentary rocks in nearby parts of Florida, and there is no evidence to suggest any at minable depths on the refuges.

No mining of any kind is known to have taken place on any of the refuges. Heavy minerals have been mined from placer deposits near Pelican Island, but such deposits are not known on the refuge. On Anna Maria Key, near the Passage Key Refuge, small amounts of shell have been quarried for local use.

The Miocene Hawthorn Formation, which underlies three of the refuges (absent under Cedar Keys), is sparsely phosphatic over most of its occurrence and could be a future source of phosphate.

The Lower Cretaceous Sunniland Limestone, from which oil is produced in the Sunoco-Felda and Sunniland fields in south Florida (the only areas of oil production in the State), underlies the Passage Key and Island Bay Refuges at depths of 10,000–11,000 feet. It is either absent or not yet identified beneath the Cedar Keys and Pelican Island Refuges. No oil is produced within 55 miles of Island Bay or within 100 miles of Passage Key. Great thicknesses of sedimentary rocks beneath all the refuges and oil or gas may eventually be produced from these rocks, but their potential is unknown.

INTRODUCTION

This study summarizes available information on the mineral-resource potential of Passage Key, Island Bay, Cedar Keys, and Pelican Island National Wildlife Refuges to aid in determining whether these areas are suitable for inclusion in the National Wilderness Preservation System. No fieldwork was done in support of this study; all conclusions are based on a review of published and unpublished information.

The four wildlife refuges covered by this report consist of islands and associated sandbars along coastal Florida (fig. 1). All the refuges are less than 52 feet above sea level, and most are less than 15 feet. The surface of the islands is composed mostly of mangrove swamps or sand and sea shells.

In the absence of mineral production or known deposits, the U.S. Bureau of Mines has not had occasion to examine the refuges, but the Bureau is informed of the findings of the Geological Survey and concurs in them.

GEOLOGIC SETTING

All four refuges covered by this report are within the Florida peninsula sedimentary province (Pressler, 1947, p. 1851) which is characterized by nonclastic sedimentary rocks.

FIGURE 1.—Index map of Florida showing locations of Passage Key, Island Bay, Cedar Keys, and Pelican Island National Wildlife Refuges.

The refuges are underlain by 5,000–13,000 feet or more of limestone, clay, sand, chalk, shale, and anhydrite (tables 1–3) that range in age from Cretaceous to Recent and by an undetermined thickness of older sedimentary and igneous rocks that are chiefly Precambrian(?) and early Paleozoic in age (Applin and Applin, 1965, p. 16).

Two formations in the Florida peninsula which may potentially contain mineral resources are the Hawthorn Formation, phosphate, and the Sunniland Limestone, oil and gas.

The Hawthorn Formation of Miocene age is composed of interbedded clay, sand, and sandy or clayey limestone or dolomite and contains varying quantities of phosphatic nodules (Cathcart, 1963, p. 21). It was deposited widely over the Florida peninsula but has been eroded from the general area of the Ocala uplift in the west-central part of the peninsula.

The Sunniland Limestone of Early Cretaceous age is a subsurface unit in southern Florida and is composed of limestone, dolomite, and shale (Applin and Applin, 1965, p. 46). It is the reservoir rock of the Sunniland and Sunoco-Felda oil fields.

The dominant structural features of the Florida peninsula are the Peninsular arch, a subsurface Paleozoic-Mesozoic structure, which trends south-southeast and extends from southeastern Georgia to the vicinity of Lake Okeechobee; the Ocala uplift, a surface and near-surface anticline of Tertiary age, that trends south-southeast and extends from Madison County on the north to Polk County on the south; and the south Florida shelf, a broad flat area of rocks of Comanche age located southwest of the Peninsular arch along the coast of the Gulf of Mexico, between Charlotte Harbor on the north and Key Largo on the south.

MINERAL RESOURCES OF PENINSULAR FLORIDA

Mineral production from the Florida peninsula has included oil, heavy minerals, peat, phosphate, clay of various sorts, stone, sand and gravel. Aluminum, fluorine, and diatomite may become commercially important in the future but only as byproducts of the recovery of phosphate. Mineral commodities of past or potential significance in areas near or on the refuges are oil and gas, heavy minerals, phosphate, clay, and stone.

THE NATIONAL WILDLIFE REFUGES

PASSAGE KEY

Passage Key (fig. 2) is a flat uninhabited island of about 20 acres, in Manatee County, Fla, near the mouth of Tampa Bay. The refuge is accessible by boat from Anna Maria Key, about 1 mile to the south.

Passage Key is shown on the Anna Maria 7½-minute topographic map of the U.S. Geological Survey.

Passage Key is on the southwest flank of the Ocala uplift (Applin and Applin, 1965, fig. 1). The surface of the island consists of deposits of sand and sea shells of Recent age, underlain by more than 11,000 feet of sedimentary rocks. Subsurface formations and their approximate thicknesses and descriptions are given in table 1.

Mineral commodities which are, or have been, of importance in the general area of Passage Key are fuller's earth, lightweight aggregate, dimensional stone, and crushed stone. Commodities of potential significance are phosphate and oil and gas.

TABLE 1.—*Subsurface geologic formations in the Passage Key area*

[Modified from Peek, 1958]

System	Series	Unit	Lithology	Thickness (feet)
Quaternary	Recent		Sand, shells.	0–20
	Pleistocene	Pamlico Sand	Sand, shells, limestone.	0–20
Tertiary	Pliocene	Caloosahatchee(?) Marl	Marl, sand and gravel of quartz and phosphate, shells, bone fragments.	0–10
	Miocene	Hawthorn Formation	Clay and marl. gray, greenish and bluish-gray, sandy, phosphatic, calcareous; interbedded with sandy limestone, silt, sand, and shells.	350
		Tampa Limestone	Limestone, white, gray and tan, generally hard, dense, sandy; phosphatic in part; silicified in part; fossiliferous.	125
	Oligocene	Suwannee Limestone	Limestone, creamy white and tan, soft to hard, granular, porous, crystalline; dolomitic in part; very fossiliferous.	325
	Eocene	Ocala Limestone	Limestone, white, cream tan, chalky, soft, granular; coquinoid in part; with some hard, dense layers and some thick beds of brown crystalline dolomite.	325
		Avon Park Limestone	Limestone, cream, tan, and brown, soft to hard; granular and coquinoid in part; crystalline and dolomitic in part; very porous.	700
		Lake City Limestone	Limestone, cream and tan, chalky to granular; dolomitic and gypsiferous in part; very fossiliferous in part.	500
		Oldsmar Limestone	Limestone, tan and brown, granular, porous; interbedded with chert, anhydrite, and tan to brown crystalline porous dolomite.	950
	Paleocene	Cedar Keys Limestone	Limestone, cream to tan, fairly hard, granular, gypsiferous; interbedded with tan to brown crystalline dolomite; fossiliferous in part.	2,000
Cretaceous	Gulf		Limestone, shale, anhydrite.	2,500
	Comanche		Limestone, shale, anhydrite.	3,350+

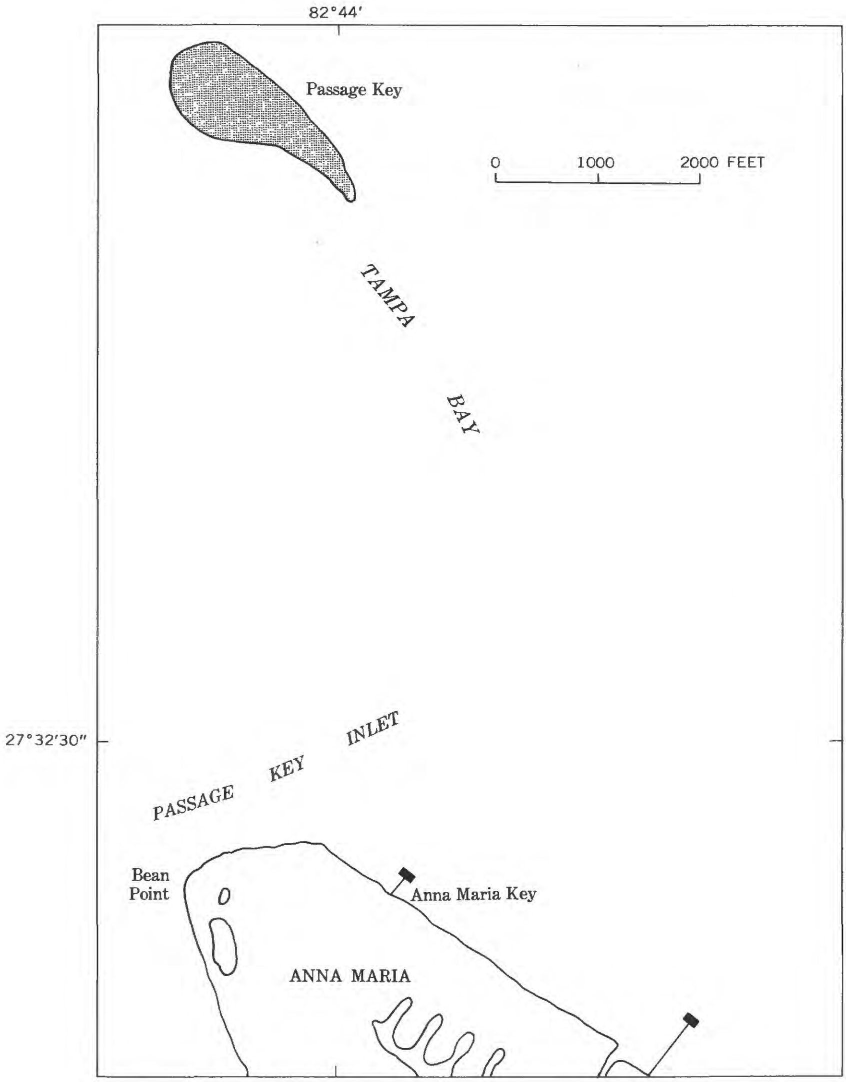

FIGURE 2.—Passage Key National Wildlife Refuge, Manatee County, Fla.

Fuller's earth refers to certain clays that have a marked ability to adsorb coloring materials from oils of animal, vegetable, and mineral origin (Calver, 1957, p. 61). Before World War II, fuller's earth was produced near Ellenton, about 15 miles east of Passage Key. Apparently, the source material was clay in the Hawthorn Formation. More extensive and higher grade deposits of fuller's earth occur in Gadsden County in northern Florida. Most of the Florida production in recent years has come from these deposits. The possibility of a commercially significant deposit of fuller's earth on Passage Key is remote.

During the period 1943–46, fuller's earth mined in Florida was manufactured into a lightweight aggregate called nodulite, which was used in making self-propelled concrete cargo carriers for the war effort (Calver, 1957, p. 80). The plant was sold after the war and dismantled. The Florida Geological Survey and the U.S. Bureau of Mines, after a series of tests, have compiled a list of selected localities in Florida where clay occurs that would be satisfactory for the production of lightweight aggregate (Calver, 1957, p. 79). The closest locality to Passage Key is about 80 miles north in Citrus County. The possibilities of developing a lightweight aggregate industry, based on material mined from Passage Key, are nil.

Dolomite of the Hawthorn Formation is being quarried near Bradenton (about 13 miles southeast of Passage Key) and shaped into various types of dimensional stone. It is not known whether the dolomite being quarried near Bradenton also occurs in the subsurface of Passage Key, but if it does, the small size of the island and its low relief would make any quarrying operation economically unattractive.

Crushed stone, sand and gravel, and crushed shell have all been produced locally near Passage Key, and there will, no doubt, continue to be a small market for these commodities in Manatee County but similar materials can be found in more accessible parts of the county.

Florida produced 19.3 million long tons of phosphate in 1965 valued at almost $140 million—about 73 percent of the total United States output (Shirley and Vernon, 1967). More than 92 percent of Florida's production came from the land-pebble phosphate field in Polk and Hillsborough Counties. The land-pebble field is known to extend into several other counties, including Manatee, but the Pliocene Bone Valley Formation, from which most of the phosphate is produced, does not occur in western Manatee County. The Hawthorn Formation is sparsely phosphatic and may possibly at some future date be mined as a source of phosphate, although on Passage Key the formation is at a depth of at least 50 feet.

Florida has two producing oil fields; both produce from the Lower Cretaceous Sunniland Limestone. Production nearest to Passage Key is from the Sunoco-Felda field in Hendry County, about 100 miles southeast of the refuge. About 400 oil tests have been drilled in Florida, but only three-fourths of these wells were deep enough to reach the Cretaceous rocks that are the primary oil objectives. A well drilled about 24 miles southeast of Passage Key in 1955 penetrated the Sunniland Limestone between depths of 10,200 and 10,370 feet, but no indications of oil were found (Applin and Applin, 1965, p. 10–11). The Sunniland Limestone and other potential petroleum reservoirs probably occur beneath Passage Key and, under suitable stratigraphic or structural conditions, might contain oil and (or) gas.

ISLAND BAY

The Island Bay National Wildlife Refuge (fig. 3) consists of parts of Gallagher Key, Bull Key, and two nearby unnamed keys. Two small tracts of the refuge are Cash and John Quiet Mounds which are dominated by large Indian middens. The surface of the refuge is composed mostly of mangrove swamps, the aggregate area of which is about 20 acres. The islands are about 7 miles southeast of Placida on the north side of Charlotte Harbor in Charlotte County, Fla. The

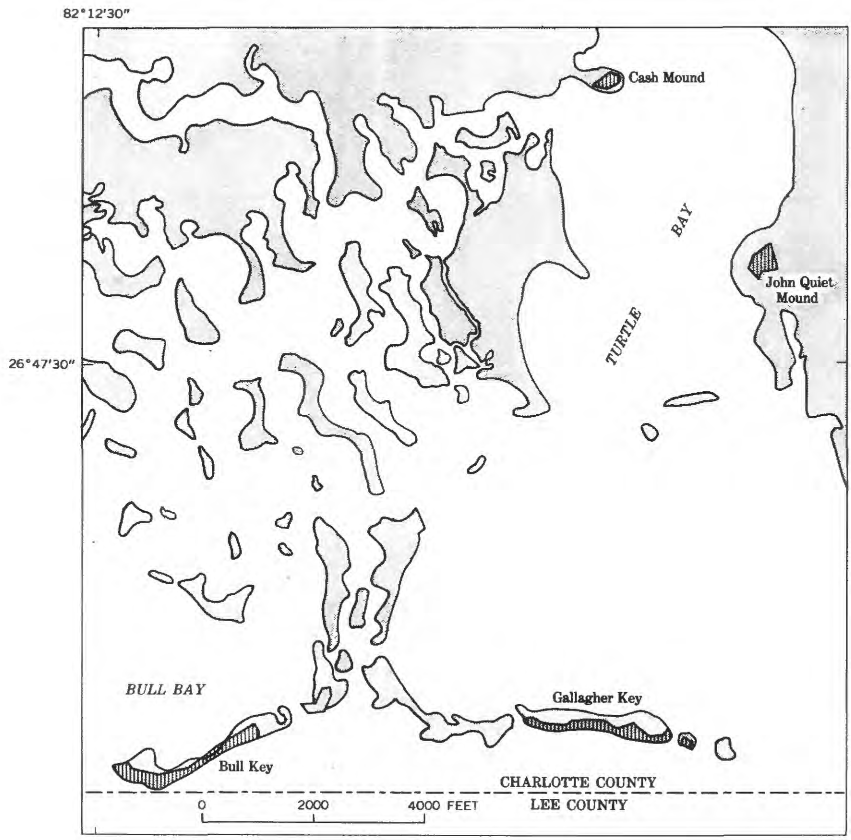

FIGURE 3.—Island Bay National Wildlife Refuge, Charlotte County, Fla. Parts of the refuge being considered for the National Wilderness Preservation System are marked by a vertical line pattern.

Island Bay area is shown on the Punta Gorda SW 7½-minute topographic map of the U.S. Geological Survey.

The Island Bay area is on the south Florida shelf (Applin and Applin, 1965, fig. 1). The surface of the islands is mostly unconsolidated sand and muck. Little is known regarding the stratigraphy of rocks beneath the Island Bay area. A barren oil and gas test well drilled in sec. 35, T. 41 S., R. 21 E. (Applin and Applin, 1965, p. 6–7), about 6 miles north of the refuge, indicates that the area is underlain by about 13,000 feet of limestone, sand, clay, and anhydrite.

No record was found of past mineral production from Charlotte County, but there may well have been some production of sand, gravel, oyster shells, and the like for local use. Oil and gas and phosphate might occur in the subsurface near the refuge. If so, they would be in the same formations and under geologic conditions similar to those described in the preceding section on the Passage Key National Wildlife Refuge.

CEDAR KEYS

The Cedar Keys National Wildlife Refuge (fig. 4) consists of the Seahorse Key, Deadmans (or Bird) Key, Snake Key, and North Key. The four Keys, or islands, aggregate about 380 acres and are in the Gulf of Mexico just off the coast of Levy County, Fla. They are shown on the Seahorse Key and Cedar Key 7½-minute topographic maps of the U.S. Geological Survey. The islands are accessible by boat from nearby Cedar Key.

The refuge is on the southwest flank of the Ocala uplift (Applin and Applin, 1965, fig. 1). Surface of the keys consists mostly of unconsolidated undifferentiated Pleistocene and Recent sands, although the Eocene Ocala Limestone may crop out in a few places. The subsurface formations and their approximate thicknesses and descriptions are given in table 2. The information contained in table 2 is derived from a log of an oil test well (Cole, 1942) and an interpretation of that log (Applin and Applin, 1944). The well is in sec. 9, T. 15 S., R. 13 E., about 5 miles from the Cedar Keys Refuge.

The Cedar Keys Refuge has little mineral potential. The phosphate-bearing formations of Florida are not present in this area, and the oil and gas potential is slight. The Ocala Limestone has been extensively mined for road metal in some parts of Levy County (Vernon, 1951, p. 217), but it is not readily amenable to mining on the keys because of the small size of the islands and the lack of a road connection to the mainland.

The Sunniland Limestone, the oil- and gas-producing formation in Florida, is not present beneath Levy County (Vernon, 1951, p. 237). Seven test wells have been drilled in Levy County, but no indications

FIGURE 4.—Cedar Keys National Wildlife Refuge, Levy County, Fla. The refuge consists of Seahorse, Deadmans, Snake, and North Keys, all marked by a vertical line pattern.

of oil or gas were found. There are, however, more than 6,000 feet of sedimentary rocks beneath the Cedar Keys area. Under suitable stratigraphic and structural conditions, some part of this sequence might contain oil or gas, but the oil and gas potential of the refuge is considered slight.

TABLE 2.—*Subsurface geologic formations in the Cedar Keys area*

[Modified from Cole, 1942; Applin and Applin, 1944]

System	Series	Unit	Lithology	Thickness (feet)
Quaternary	Pleistocene and recent		Unconsolidated surface sands.	18
Tertiary	Eocene	Ocala Limestone	Limestone, white, porous; brown and hard in part.	102
		Avon Park Limestone	Limestone.	380
			Limestone, cream, porous; brown and hard in part; lignitic in part; nonfossiliferous.	411
		Lake City Limestone	Limestone, cream, foraminiferal; porous in part; white and dense in part, brown and crystalline in part.	497
		Oldsmar Limestone	Limestone, brown and dense in part; cream and porous in part; foraminiferal in part.	743
	Paleocene	Cedar Keys Limestone	Limestone, gray, dense; hard in part, brown and crystalline in part.	438
Cretaceous	Gulf	Lawson Limestone	Limestone, soft, white; tan and hard in part; chalk in part.	750
		Beds of Taylor age	Chalk; small part near bottom is lignitic.	501
		Beds of Austin age	Argillaceous chalk.	430
		Tuscaloosa Formation	Red shale, sand, and some limestone.	1,090+

PELICAN ISLAND

The Pelican Island National Wildlife Refuge (fig. 5) consists of 616 acres of mangrove swamp on several small islands and along the eastern shore of Indian River, Indian River County, Fla. Not all the refuge is included in the study area. The refuge is shown on the Sebastian 7½-minute topographic map of the U.S. Geological Survey. It is accessible by boat from the town of Sebastian, about 2 miles to the west on the mainland.

The refuge is on the northeast flank of the Peninsular arch (Applin and Applin, 1965, fig. 1). The surface of the area is mostly unconsolidated sand and muck. Detailed information on the subsurface stratigraphy is lacking, but a generalized chart (table 3) gives such information as is available.

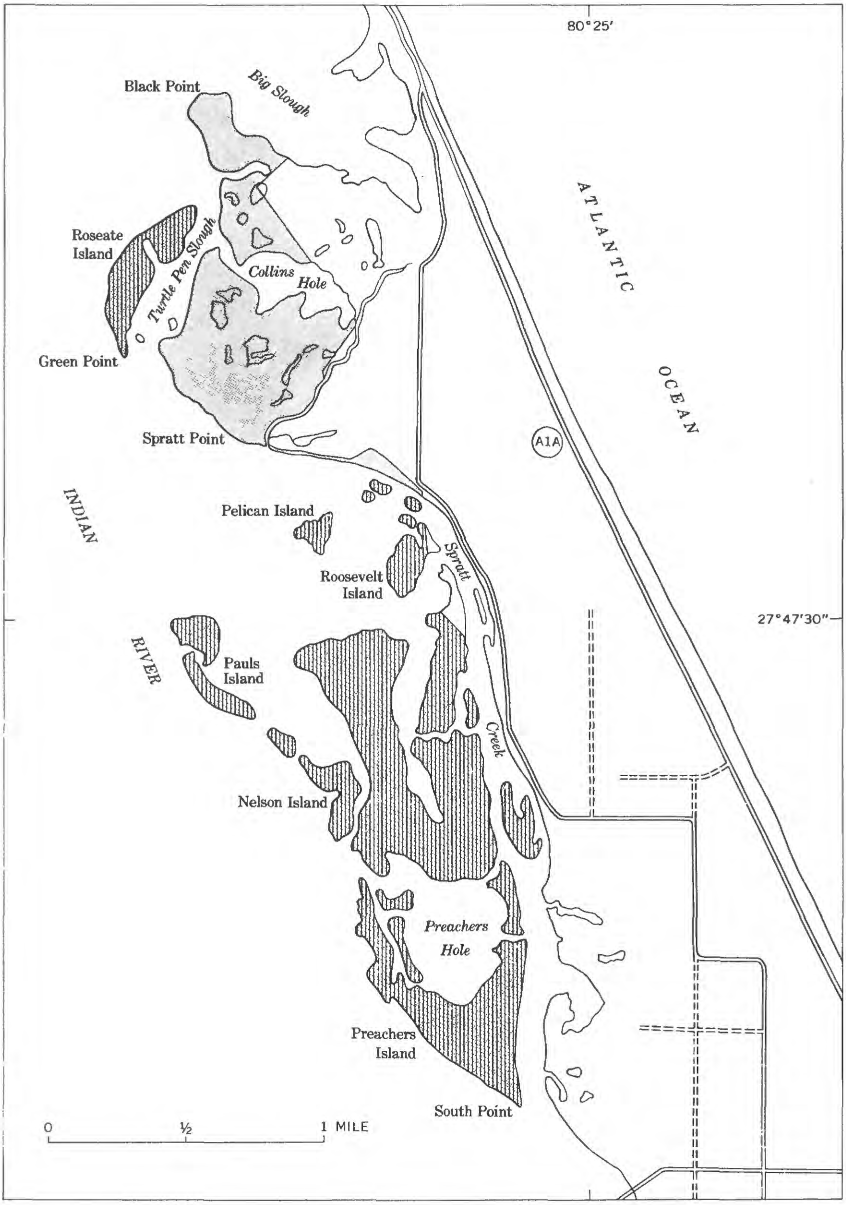

FIGURE 5.—Pelican Island National Wildlife Refuge, Indian River County. Fla. Areas being considered for inclusion in the National Wilderness Preservation System are marked by vertical line pattern.

TABLE 3.—*Subsurface geologic formations in the Pelican Island area*

[Modified from Bermes, 1958; Applin and Applin, 1965]

System	Series	Unit	Lithology	Thickness (feet)
Quaternary	Recent		Muck, soil.	?
	Pleistocene	Pamlico Sand	Unconsolidated sand.	?
		Anastasia Formation	Sand, shelly marl.	100
Tertiary	Miocene	Tamiami Formation	Clays, gray to olive-drab, sandy, fossiliferous.	60
		Hawthorn Formation	Clay and marl, green to brown, phosphatic, sandy.	225
	Oligocene		Limestone, gray to cream-colored, soft, clayey, granular.	200?
	Eocene	Ocala Limestone	Limestone, white, porous; brown; hard in part.	?
		Avon Park Limestone	Limestone.	?
		Lake City Limestone	Limestone, cream; porous in part.	?
Cretaceous	Gulf	Lawson Limestone Beds of Taylor age Beds of Austin age	Limestone and chalk?	2,500
	Comanche	?	?	3,000+

Florida has led the nation in the production of zircon for about 25 years and had produced large quantities of other heavy minerals (ilmenite, rutile, monazite, and garnet) during that time. Heavy minerals have been mined at Vero Beach about 10 miles south of the refuge since about 1941 (Calver, 1957, p. 16), but according to Shirley and Vernon (1967, p. 11), there currently is no mining at that locality. Most of the heavy mineral deposits of Florida are concentrated on beaches of various ages from late Pliocene to Recent by wave action along "storm lines" (Cannon, 1950, p. 202–210). The modern beaches have been well explored, and future sources are expected to come mostly from older beaches west of the present beach line and west of the refuge. Significant amounts of heavy minerals are not believed to occur on the refuge.

The Pelican Island area is underlain at about 200 feet by the phosphatic Hawthorn Formation which may, at some future date, be a source of phosphate. In the refuge area, however, the formation is believed to be of no significant potential value at present.

The Sunniland Limestone is not present beneath the Pelican Island area (Applin and Applin, 1965, p. 50, fig. 27). However, more than 9,000 feet of sedimentary rocks lie beneath the Pelican Island area and, under suitable stratigraphic and structural conditions, some part of this sequence might contain oil or gas, but the potential is considered slight.

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