STATE OF FLORIDA
DEPARTMENT OF NATURAL RESOURCES
Harmon Shields, *Executive Director*

DIVISION OF RESOURCE MANAGEMENT
Charles M. Sanders, *Director*

BUREAU OF GEOLOGY
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REPORT OF INVESTIGATION NO. 84

THE HIGHLAND HEAVY-MINERAL SAND DEPOSIT ON TRAIL RIDGE IN NORTHERN PENINSULAR FLORIDA

By
E. C. Pirkle, William A. Pirkle
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THE HIGHLAND HEAVY-MINERAL SAND DEPOSIT ON TRAIL RIDGE IN NORTHERN PENINSULAR FLORIDA

By
E. C. Pirkle[1], William A. Pirkle[2], W. H. Yoho[3]

ABSTRACT

A heavy-mineral ore body is present along Trail Ridge just north of the town of Highland in northern peninsular Florida. No reports of this ore body have been published. The deposit, called the Highland ore body, consists of loose to slightly indurated quartz sand with an average of 3 per cent heavy minerals. Approximately 45 per cent of the heavy minerals are titanium minerals which, with zircon, are the major ore minerals of the deposit.

It is hypothesized that the ore sands accumulated as part of a beach ridge which was built at the crest of an eroding, transgressing sea. The major source sediments for Trail Ridge and for the ore sands are believed to have been sands of the Northern Highlands that occur to the west of Trail Ridge and into which the transgressing seas eroded. This concept for the origin of Trail Ridge and the Highland ore body is consistent with heavy-mineral suites and with sedimentary and physiographic features of the region.

INTRODUCTION

Trail Ridge is a 130-mile long sand ridge that extends southward from the Altamaha River in southern Georgia to the southern parts of Clay and Bradford counties in northern peninsular Florida (Fig. 1). The crest elevations of the ridge range from approximately 140 to 170 feet above sea level in Georgia to slightly more than 250 feet above sea level near its southern end in northern Florida. Extensive plains areas bound the ridge on both its eastern and western sides. At most sites the plains immediately west of the ridge are about 40 to 50 feet higher than the plains at the same latitude immediately east of the ridge.

For many years heavy-mineral sands have been mined in north-

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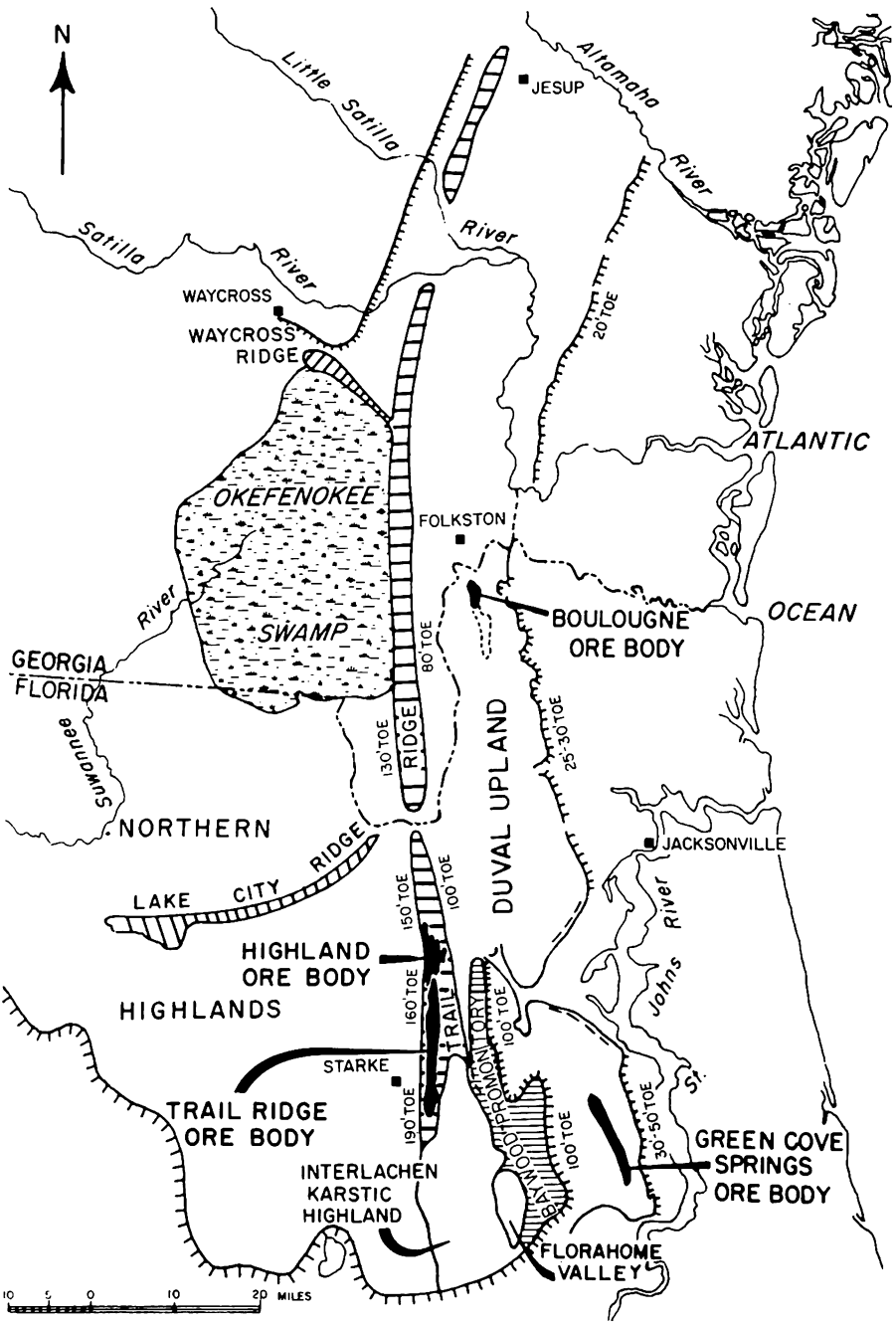

Figure 1. Location map.

ern Florida along the southern 18-mile stretch of Trail Ridge (Garnar, 1972). This deposit is the Starke Trail Ridge ore body of E. I. du Pont de Nemours and Company. Its trend is essentially north-south. Another heavy-mineral deposit along Trail Ridge is currently under study. This deposit is a northward continuation of the Starke deposit and locally is referred to as the Highland ore body (Figs. 1 and 2). The main purpose of this report is to describe the Highland ore body and to discuss its possible origin.

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Various companies have been very helpful and cooperative in studies of heavy-mineral sand deposits of northern Florida. These companies include N L Industries, Incorporated; E. I. du Pont de Nemours and Company; Humphreys Mining Company; and Titanium Enterprises. The writers are deeply grateful to these organizations. Also, thanks are due to Muriel Hunter and Joe Banks of Coastal Petroleum Company for discussing problems of the Miocene of Florida and southern Georgia with the authors and for sharing their ideas concerning the nature of these sediments. The authors are deeply indebted to T. E. Garnar, Jr., for substantial contributions through discussions of the characteristics of heavy-mineral sand deposits. Gratitude is expressed to Justin Hodges and Albert Phyllips, Jr., for the care they exercised in drilling operations and to V. M. Patterson, Jr., for drafting the figures. The P_2O_5 and Fe_2O_3 analyses given in the tables were run by Thornton and Company of Tampa, Florida. Charles W. Hendry, Jr., T. Walter Herbert, and Thomas M. Scott graciously reviewed the report and added materially to the accuracy and clarity of presentation.

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CHARACTERISTICS AND GEOLOGICAL SETTING OF THE HIGHLAND ORE BODY

The Highland heavy-mineral sand deposit has a length of 8½ miles, an average width of nearly 1½ miles, and an average thick-

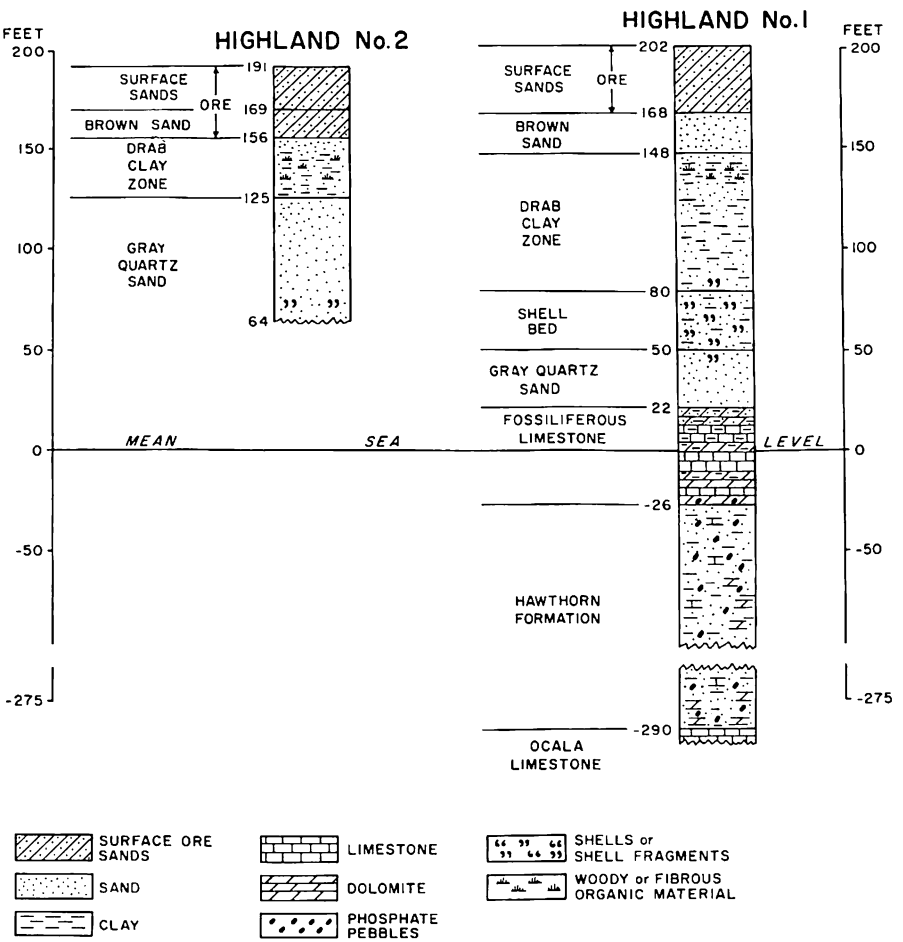

Figure 3. Lithologic logs of Highland No. 1 and Highland No. 2 drill holes.

ness of 30 to 35 feet. It consists of loose to slightly indurated quartz sands containing an average of 3 per cent heavy minerals of which about 45 per cent are the titanium minerals—ilmenite, leucoxene, and rutile. The average TiO_2 content of these titanium minerals is approximately 69 per cent. Other common heavy minerals in the deposit include staurolite, zircon, kyanite, sillimanite, and tourmaline. The most significant ore minerals are ilmenite, leucoxene, and zircon.

Two holes were drilled through the Highland ore body by the Florida Bureau of Geology (Figs. 2 and 3). Detailed logs of the materials penetrated with tables of data to illustrate the nature of

the sediments are given in Appendix I and Appendix II. The following abbreviated log summarizes the materials and formations encountered at the site of the Highland No. 1 drill hole:

Highland No. 1 Drill Hole

Depth in Feet and Inches	Materials or Formation
0 to 53′6″	Gray to moderate brown quartz sand
53′6″ to 121′9″	Drab to olive-green clay zone
	Intercalated lenses or layers of quartz sand, clayey sand, sandy clay, and massive clay
121′9″ to 152′	Shell bed
	Clayey sand with very poorly preserved shells of marine mollusks
152′ to 180′	Gray quartz sand
180′ to 227′6″	Fossiliferous limestone
227′6″ to 492′	Hawthorn Formation
492′ to 493′	Ocala Limestone
Total Depth—493′ in Ocala Limestone	

The oldest and deepest rock reached in the drilling is the Ocala Limestone of Eocene age. The upper surface of this limestone occurs at a depth of 492 feet. Approximately 265 feet of Hawthorn sediments unconformably overlie the Ocala Limestone (from 227 feet 6 inches to 492 feet). These Hawthorn sediments consist of various mixtures of carbonate (mainly dolomite), insoluble clay, and quartz sand. Sand-size particles and small pebbles of black phosphorite occur disseminated throughout all of the Hawthorn materials and as local concentrations within some beds. The Hawthorn Formation is usually considered Miocene in age (Espenshade and Spencer, 1963). A fossiliferous limestone about 48 feet thick rests on the Hawthorn Formation (from 180 feet to 227 feet 6 inches). Most investigators assign a late Miocene age to this limestone.

The sediments in the interval extending from a depth of 53 feet 6 inches to a depth of 180 feet consist of intercalated lenses of quartz sand, clayey sand, sandy clay, and massive clay. A segment of these materials (from 121 feet 9 inches to 152 feet) contains badly leached and fragmented marine mollusk shells. All of these post-Hawthorn clastics, like the underlying fossiliferous limestone on which they rest, are usually dated as late Miocene.

Resting on these post-Hawthorn clastics are approximately 53 feet of surface sands. The surface sands are believed by some investigators to be Miocene (Alt, 1974), by others to be Pliocene (Brooks, 1966), and by still others to be Pleistocene (Doering, 1960). A more complete discussion of post-Hawthorn sediments in the vicinity of Trail Ridge is given by William A. Pirkle (1972).

The fossiliferous limestone just above the Hawthorn Formation (from 180 feet to 227 feet 6 inches) occupies the same stratigraphic position as a fossiliferous limestone exposed just above the Hawthorn Formation at Brooks Sink in Bradford County. The limestone at Brooks Sink has been dated by Puri on the basis of ostracods as lower Choctawhatchee in age—late middle Miocene and/or late Miocene (Pirkle, 1956, p. 210). At the sites of both the Highland ore body and Brooks Sink it appears that the fossiliferous limestone and the underlying Hawthorn sediments grade into each other. A similar fossiliferous limestone is present locally just above the Hawthorn Formation at other localities in northern Florida.

The badly leached mollusk shells in the clayey sands which extend from a depth of 121 feet 9 inches to 152 feet have been examined by Muriel Hunter. In a personal communication discussing these sediments she states:

> Abundant *Rangia* shells together with a few nearshore varieties of marine mollusks suggest an estuarine or nearshore lagoonal environment with very low salinity. Few of the shells in the bed were identified specifically, and none of these was stratigraphically significant. Lacking diagnostic mollusk species, the presently available criteria for positioning this shell bed are vague at best, involving such inconclusive factors as general appearance, elevation, and possible relationship to identified stratigraphic units mapped in contiguous areas. However, the possibility that the shell bed might represent shoreline deposition during some part of Jackson Bluff/Late Tamiami time should not be overlooked. For many years, both of these formations were assigned a late Miocene age. William Akers reported the presence of Pliocene planktonic foraminifera in the Jackson Bluff Formation (1972) and mid-Pliocene nanofossils in the upper part of the Tamiami Formation (Pinecrest Sand Member) in 1974. Akers' work has been well received, and most stratigraphers now seem to have accepted a middle Pliocene age for both units. Sediments of the lower part of the Tamiami Formation and the Arca Zone of the Florida Panhandle are still generally referred to the late Miocene.

If the segment from 121 feet 9 inches to 152 feet proves to be of Pliocene age, it is conceivable that a rather thick section of Pliocene materials is present at this site, namely the sediments beginning at a depth of 53 feet 6 inches and extending downward through the shell bed, the zone of gray quartz sand, the fossiliferous limestone, and the upper part of the Hawthorn Formation.

SURFACE SANDS IN REGION OF HIGHLAND ORE BODY

The sands that compose Trail Ridge are relatively coarse and are characterized by a uniform grade-size distribution. Usually between 50 and 70 per cent of the sand falls into the medium sand fraction (½ to ¼mm) and from 20 to 40 percent of the sand falls into the fine sand fraction (¼ to ⅛ mm). This grade-size distribution of Trail Ridge sands is remarkably constant throughout the entire length and thickness of the ridge.

The sands of the surface sand blanket of the Northern Highlands west of Trail Ridge are finer than Trail Ridge sands, and the size distribution of sand grains in these high terrace sands is quite variable from one locality to another. In this respect the sands of the Northern Highlands differ considerably from those of Trail Ridge. However, the high terrace sands contain a substantial percentage of medium sand-size particles (½ to ¼ mm) and therefore are sufficiently coarse to have served as source sediments for Trail Ridge sands.

The surface sands of the Duval Upland east of Trail Ridge are different from the sands of Trail Ridge and the high terraces. These sands of the Duval Upland are notable for their fine size. Throughout most of the upland more than 90 per cent of the sand falls into the fine (¼ to ⅛ mm) and very fine (1/8 to 1/16 mm) sand fractions.

The reader is referred to a report by William A. Pirkle (1972) for additional analyses of Trail Ridge sands and for analyses of surface sands from the Northern Highlands west of Trail Ridge. Analyses of surface sands from the Duval Upland in the vicinities of the Green Cove Springs and Boulougne heavy-mineral sand deposits are given in Appendix III of this report (Tables 7-12).

SELECTED FEATURES OF HEAVY MINERALS

DISTRIBUTION OF GARNET AND EPIDOTE

A study of the heavy minerals extracted from the sediments penetrated in Highland No. 1 drill hole reveals a number of interesting features. The loose quartz sands extending from the land surface downward for 53 feet 6 inches do not contain garnet or epidote (Table 3, Spls. 1-11, Appendix II). Samples of Trail Ridge sands have been collected from many other localities along the 130-mile long ridge. Analyses of the samples show that Trail Ridge sands rarely, if ever, contain these two minerals.

In contrast, all of the post-Eocene sediments beneath the loose

surface sands contain garnet and epidote. The first garnet was encountered in Highland No. 1 drill hole at a depth of 61 feet (Table 3, Spl. 14). From that depth the mineral continues downward through all of the various types and ages of post-Eocene sediments. It increases markedly in the lower 30 feet of the Hawthorn Formation (Table 3, Spls. 63-66). An increase in garnet in the lower part of the Hawthorn Formation has been noted at other localities in northern Florida.

The distribution of epidote, likewise, is of interest. This mineral was first encountered at a depth of approximately 62 feet (Table 3, Spl. 15). It increases markedly at a depth of 96 feet (Table 3, Spl. 26) and continues downward as a common heavy mineral without interruption to a depth of 304 feet (Table 3, Spl. 44). This interval with the marked increase of epidote includes the lower 36 feet of the drab to olive-green clay sequence, all of the underlying shell bed, the zone of gray quartz sand, the fossiliferous limestone, and the upper 76 feet of the Hawthorn Formation (Table 3, Spls. 26-44). A similar distribution of epidote occurs in the same types of post-Eocene sediments at other localities in northern peninsular Florida.

Furthermore, it is of interest to note that epidote and garnet are very rare, and generally not present, in the sands underlying the Northern Highlands west of Trail Ridge. In contrast, epidote and garnet are frequently found to be a part of the heavy-mineral suite of the sands and heavy-mineral ore bodies of the Duval Upland east of Trail Ridge. The distribution of epidote and garnet in the surface sands of the region should be considered in any attempt to explan the origin of the heavy-mineral ore bodies on Trail Ridge.

DISTRIBUTION OF ILMENITE AND LEUCOXENE

The occurrences of heavy minerals may be significant in certain stratigraphic problems of the region. For example, one intriguing problem is the relationship of the surface sands (those sands extending from the land surface to a depth of 53 feet 6 inches, Table 1) to the underlying sediments. It is not known if the surface sands are of younger age than the underlying materials and separated from them by an unconformity, or if the surface sands are of the same general age and a continuation of the underlying sediments. Sufficient data are not available to draw a conclusion that would receive general acceptance.

However, the concept that the surface sands are younger than

the underlying sediments and separated from them by an unconformity is compatible with the heavy-mineral distribution. For example, the percentage of leucoxene is relatively high and that for ilmenite correspondingly low in the upper 5 feet of surface sands at the site of Highland No. 1 drill hole (Table 3, Spls. 1 and 2). A substantial amount of the leucoxene in this upper surface zone is believed to have formed from the weathering *in situ* of ilmenite. Leucoxene is a weathering product of ilmenite and always seems to be more abundant (and ilmenite correspondingly less abundant) in the upper part of sand ridges and sand blankets in the areas of the older surface sands of peninsular Florida.

Therefore, the relatively high percentages of leucoxene and the corresponding low percentages of ilmenite in the upper part of the drab to olive-green clay zone (Table 3, Spls. 12-16) suggest that this clay zone was subjected to subaerial weathering prior to the deposition of the surface sands or else that the source sediments for the drab clay zone was different from the source sediments for the surface sands. In either case the weathering to produce much of the leucoxene in the upper part of the drab clay sequence must have taken place before the deposition of the lower part of the surface sands because the ilmenite in the surface sands immediately overlying the drab clay zone has not weathered to leucoxene (Table 3, Spls. 7-11). The same relationship of leucoxene to ilmenite characterizes the upper part of the drab clay zone in Highland No. 2 drill hole (Table 6, Spls. 10-12, Appendix II) and at other sites along Trail Ridge.

Furthermore, a buried zone of tree trunks, tree limbs, and associated organic materials occurs just beneath the surface sands at the Trail Ridge ore body of the du Pont Company (Grogan et al., 1964). Many of the tree trunks occur in an upright position suggesting that the organic layer represents a forest buried in place. Such occurrences further indicate the possibility that the surface sands are separated from the underlying sediments by an old subaerial surface.

SPHERICITIES OF HEAVY MINERALS

A study was made comparing the sphericities of zircon and kyanite-sillimanite of Trail Ridge sands with sphericities of these same heavy minerals in sediments that might have served as source materials for Trail Ridge (Fredric L. Pirkle, 1975). The possible source materials investigated were thick surface sands that crop out along the Altamaha River north of Trail Ridge, sands of the high terraces west of Trail Ridge, and sands from sediments com-

prising the Lake Wales Ridge south of Trail Ridge. On the basis of the sphericity studies it was concluded that of these possible source materials, only the high terrace sands of the Northern Highlands west of Trail Ridge could be the immediate source sands for Trail Ridge.

CURRENT WORKING HYPOTHESIS ON ORIGIN OF ORE BODIES

Any hypothesis proposed to explain the origin of Trail Ridge and the Trail Ridge heavy-mineral ore bodies must be compatible with the following features. Trail Ridge sands are relatively coarse, have a very uniform grain-size distribution, do not contain epidote or garnet, and have heavy minerals with sphericities that are the same as those of similar heavy minerals in the sands of the Northern Highlands. Furthermore, Trail Ridge sands probably are separated from underlying sediments by an old subaerial surface. The following ideas and concepts are consistent with these features (Pirkle et al., 1974).

According to the hypothesis the sand blanket of the Northern Highlands was left as a plain when ocean waters retreated from the present Coastal Plain areas of southern Georgia and northern Florida. This regressing sea was later followed by a major marine transgression. The transgressing sea eroded into sediments of the Northern Highlands. Trail Ridge with its ore bodies was built as a beach ridge at the crest of this eroding, transgressing sea. According to this concept the immediate source sediments for much of Trail Ridge were sands of the high terraces of the Northern Highlands.

It is probable that only a very minute amount of epidote or garnet was originally deposited with the quartz sands that now underlie the Northern Highlands. Moreover, the sand blanket of the Northern Highlands, being relatively old, has been subjected to a rather long period of weathering. Any epidote or garnet that was deposited with the sands would have been largely destroyed during this long weathering interval. Therefore this concept for the origin of the high terrace sands and for Trail Ridge would explain the absence of epidote and garnet in Trail Ridge and the similarity of the heavy-mineral suites of the high terrace sands and Trail Ridge sands.

The size distribution of Trail Ridge sands also can be explained if the sands of the Northern Highlands were the source sediments for Trail Ridge. Along the Trail Ridge shoreline relatively fine

sands would likely have been washed seaward leaving coarser sands to comprise shoreline features. Thus the fact that Trail Ridge sands are coarser than the sands underlying the Northern Highlands would be expected. Also, with the finer fraction of the sands being washed seaward the reworked sands remaining in the shore zone would have less size-spread and would be more uniform. Therefore, the relative coarseness and the uniformity of Trail Ridge sands are consistent with the hypothesis. Moreover the slightly convex outline of Trail Ridge, with its most western curvature occurring in the region of the relatively easily erodable, unconsolidated to slightly consolidated sands of the Northern Highlands, would be explained, as would the parallelism of the trend of Trail Ridge with that of the present shoreline (Fig. 1). Furthermore the concept is consistent with the fact that the Starke heavy-mineral sand deposit of du Pont is larger and contains a higher percentage of heavy minerals than the Highland ore body. The du Pont deposit is in that part of Trail Ridge that is banked up behind, and encroaches on, the northern end of the Lake Wales remnant (the Interlachen Karstic Highland on Figure 1). This environment was conducive to the accumulation of relatively large quantities of heavy minerals and wind-blown sands (Pirkle and Yoho, 1970).

The Duval Upland east of Trail Ridge (Fig. 1) is believed to be a regressional beach ridge plain. It is younger than Trail Ridge and is the remnant of a much larger plains area, much of which has been destroyed through subaerial erosion and later marine transgressions. While this regressional beach ridge plain was forming there were temporary halts in regression, and perhaps even slight trangressions. During these intervals more prominent beach ridges were built. Some of these ridges contain concentrations of heavy-mineral sands. Examples of these concentrations are the commercial Green Cove Springs and Boulougne deposits (Fig. 1).

In summary, the high terraces of the Northern Highlands are believed to have been left as a plain when ocean waters retreated from the present areas of southern Georgia and northern Florida. At a later time transgressing seas eroded into these high terrace deposits. Trail Ridge with its heavy-mineral sand deposits was built as a beach ridge at the height of this transgression. The Duval Upland is younger than Trail Ridge. It is believed to be a part of an ancient, regressional beach ridge plain. During its formation there were temporary halts in regression, perhaps even slight transgressions, during which times heavy-mineral ore bodies were formed.

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APPENDIX I

Detailed Lithologic Logs of Highland No. 1
and Highland No. 2
Drill Holes

HIGHLAND DRILL HOLE NO. 1[4]

SE¼, NE¼, Section 25, T. 4 S., R. 22 E., Bradford County, Florida
Approximately 1 Mile Northwest of Highland
Surface Elevation - 202 Feet

Unit	Description	Thickness In Feet & Inches
Surface Sands[5]		
40	Loose quartz sand, coarse to very fine. Gray to brown to black.	
	Gray to brown soil zone from land surface to depth of 1 foot 3 inches. White sand from 1 foot 3 inches to 4 feet. Black sand from 4 feet to 20 feet. Variable from gray with brown tint to dark brown with black tint from 20 feet to 25 feet 6 inches. White sand from 25 feet 6 inches to 27 feet. Dark brown sand with black tint from 27 feet to 33 feet 9 inches.	
	The black color is due to finely divided organic matter. Most of these black sediments are loose to moderately indurated. At a few places, however, the black zones are well cemented and constitute "hard pan." The black organic zones are especially prominent from 5 feet to 8 feet 6 inches and from 14 feet to 19 feet 6 inches. The black sands are exceptionally hard from 13 feet 6 inches to 14 feet	33′9″
	(From land surface to 33′9″)	
	Spl. 1 - Channel sample from land surface to depth of 5 feet.	

[4]This hole was drilled by the Bureau of Geology, Florida Department of Natural Resources. The drilling was completed June 12, 1974. Analyses of the samples are given in Tables 1 through 3, Appendix II.

[5]A specially designed core barrel was used in sampling the loose sands, clayey sands, and sandy clays that occur from the land surface to a depth of 121 feet 9 inches. With the aid of this core barrel a very high per cent of recovery of undisturbed samples of these loose sands and soft sediments was obtained. The small intervals from which sediments were not recovered are indicated in the descriptions of the samples.

Spl. 2 - Channel sample from depth of 5 feet to depth of 10 feet.
Spl. 3 - Channel sample from 10 feet to 15 feet.
Spl. 4 - Channel sample from 15 to 20 feet.
Spl. 5 - Channel sample from 20 to 25 feet.
Spl. 6 - Channel sample from 25 to 30 feet.

Moderate Brown Sand

39 Quartz sand, medium to fine. Moderate brown with zones stained black with organic matter. Black-stained zones are present from 41 feet to 46 feet, 48 feet 6 inches to 49 feet 6 inches, 51 feet 6 inches to 52 feet 9 inches, and from 53 feet to 53 feet 6 inches ..... 19′9″
(From 33′9″ to 53′6″)
Spl. 7 - Channel sample from 30 feet to 35 feet.
Spl. 8 - Channel sample from 35 to 40 feet.
Spl. 9 - Channel sample from 40 to 45 feet. Sediments not sampled from 41 feet 6 inches to 42 feet 6 inches.
Spl. 10 - Channel sample from 45 to 50 feet.
Spl. 11 - Channel sample from 50 feet to 53 feet 6 inches.

Drab to Olive-Green Clay Zone

38 Intercalated lenses or layers of quartz sand, clayey sand, sandy clay, and massive clay. Quartz sand is very fine to coarse. Most of the sand, however, is very fine. Sands are white, gray, tan to light brown, and black. Clay is gray, drab, olive-green, and black.
Clay in the more massive lenses is sectile.
Small particles and specks of brown to reddish-brown wood are present in the drab and black clays and are especially prominent at depths of 61 feet to 62 feet 3 inches, 63 feet to 64 feet, and from 64 feet 6 inches to 67 feet. Wood material, one inch in thickness, occurs at 66 feet.
In some of the clayey sediments tubes and pockets

of white sand are present (apparently filled burrows) .....68′3″

(From 53′6″ to 121′9″)

Spl. 12 - Channel sample from 53 feet 6 inches to 54 feet 6 inches. Loose, white sand.

Spl. 13 - Channel sample from 54 feet 6 inches to 61 feet. Clayey sand, sandy clay, and sand. Gray to drab clay content is relatively high from 56 feet to 59 feet. Mainly gray-white sand from 59 feet to 61 feet.

Spl. 14 - Channel sample from 61 feet to 62 feet 3 inches. Black, massive clay with particles of wood.

Spl. 15 - Channel sample from 62 feet 3 inches to 63 feet. Small intercalated lenses or stringers of white quartz sand and black quartz sand.

Spl. 16 - Channel sample from 63 feet to 64 feet. Black quartz sand and clayey sand with particles of wood.

Spl. 17 - Channel sample from 64 feet 6 inches to 67 feet. Massive drab clayey sediments with particles of wood and occasional stringers of fine white quartz sand. Sediments not sampled from 64 feet to 64 feet 6 inches.

Spl. 18 - Channel sample from 67 feet to 70 feet. Clayey sand or sandy clay with stringers and small lenses of massive, drab clay. Sediments not sampled from 67 feet to 67 feet 6 inches.

Spl. 19 - Channel sample from 70 to 75 feet. Gray, relatively coarse, loose sand.

Spl. 20 - Channel sample from 75 to 77 feet. Loose, relatively coarse quartz sand.

Spl. 21 - Channel sample from 77 feet to 77 feet 9 inches. Massive drab clay with small pockets of fine sand.

Spl. 22 - Channel sample from 77 feet 9 inches to 78 feet 3 inches. Relatively fine, white sand.

Spl. 23 - Channel sample from 78 feet 3 inches to 85 feet. Massive, olive-drab, clayey sediments. No sample from 79 feet 6 inches to 80 feet.

Spl. 24 - Sample of clayey sand to massive gray clay. Representative of interval from 85 feet to 88 feet 6 inches.

Spl. 25 - Channel sample from 88 feet 6 inches to 96 feet 3 inches. Light gray to white quartz sand or clayey sand with stringers and small lenses of massive clay.

Spl. 26 - Channel sample from 96 feet 3 inches to 101 feet 6 inches. Massive black to olive-green or drab clay. No sample from 97 feet to 97 feet 6 inches.

Spl. 27 - Channel sample from 101 feet 6 inches to 107 feet 6 inches. Dark gray clayey sand to sandy clay.

Spl. 28 - Channel sample from 107 feet 6 inches to 110 feet. Gray clayey sand with stringers of massive clay.

Spl. 29 - Channel sample from 110 feet to 115 feet. Gray clayey sand with stringers of massive clay.

Spl. 30 - Channel sample from 115 feet to 121 feet 9 inches. Gray clayey sand with stringers of massive clay from 120 to 121 feet and small, white, marine mollusk shells from 116 feet 9 inches to 117 feet.

Shell Bed

37 Clayey sand with abundant badly leached, white shells of marine mollusks. Gray to light gray. Quartz sand is coarse to very fine.

Zone from 121 feet 9 inches to 132 feet is very fossiliferous. These sediments contain numerous fragments of relatively large mollusk shells.

No sample obtained from the interval extending

from 132 feet to 140 feet. The material within this interval probably is fine sand.

Sediments from 140 feet to 148 feet are very fossiliferous. These materials include abundant fragments of relatively small mollusk shells.

The sediments from 148 feet to 152 feet contain numerous fragments of relatively large mollusk shells ..... 30′3″

(From 121′9″ to 152′)

Spl. 31 - Channel sample from 121 feet 9 inches to 132 feet. Clayey sands characterized by fragments of relatively large mollusk shells.

Spl. 32 - Channel sample from 140 feet to 148 feet. Clayey sands characterized by fragments of relatively small mollusk shells.

Spl. 33 - Channel sample from 148 feet to 152 feet. Clayey sands with fragments of relatively large mollusk shells.

Gray Quartz Sand

36 Quartz sand, fine to coarse. Gray. A few fragments of fossil shells are present in the sands ..... 5′0″

(From 152′ to 157′)

Spl. 34 - Channel sample of gray quartz sand.

35 No recovery. This interval contains sands like those in the above interval (152 feet to 157 feet). However, the sands of this lower zone are probably finer with silt-size particles increasing with depth ..... 23′0″

(From 157′ to 180′)

Fossiliferous Limestone

34 Fossiliferous limestone. Light gray. Soft. Numerous shell impressions.

Locally the limestone contains a considerable amount of quartz sand and insoluble clay ..... 6′0″

(From 180′ to 186′)

Spl. 35 - Channel sample of fossiliferous limestone.

33 Impure limestone with a very high content of insoluble clay. Gray to light gray. Firm but soft ....16′3″
(From 186′ to 202′3″)

Spl. 36 - Channel sample of limestone.

32 Fossiliferous limestone. Brownish gray. Porous and rock-like, hard.
A mass of fossil impressions .....10′3″
(From 202′3″ to 212′6″)

Spl. 37 - Channel sample of hard, fossiliferous limestone.

31 Impure limestone. Contains much insoluble clay. Gray. Firm but soft.
A few fossil impressions .....3′0″
(From 212′6″ to 215′6″)

Spl. 38 - Channel sample of limestone.

30 Fossiliferous limestone. Gray.
A mass of mollusk impressions. Porous and rock-like, hard.
At 227 feet 6 inches black particles of phosphorite becomes common to abundant .....12′0″
(From 215′6″ to 227′6″)

Spl. 39 - Channel sample of fossiliferous limestone.

Hawthorn Formation[6]

29 Impure carbonate bed or mixture of carbonate, quartz sand, and insoluble clay. Light gray to gray. Firm.
Common black, shiny, sand-size grains and small pebbles of phosphorite.
Quartz sand is very fine to medium .....18′6″
(From 227′6″ to 246′)

Spl. 40 - Channel sample of impure carbonate sediments.

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[6]Much of the carbonate material in the Hawthorn Formation is dolomite. No attempt was made in this study to distinguish between calcic limestones, dolomitic limestones, or dolomite. In most cases the various types of limestones and dolomites are simply referred to as carbonate beds. The reader is referred to the work of Espenshade and Spencer (1963) for descriptions of the carbonate beds of the Hawthorn Formation.

28 Impure carbonate bed. Contains much quartz sand and some insoluble clay. Light gray to gray. Firm.

A phosphate zone. Sand-size grains and small pebbles of black phosphorite are abundant.

This zone is similar to overlying and underlying beds except for a higher content of phosphorite ....16′6″
(From 246′ to 262′6″)

Spl. 41 - Channel sample of carbonate bed.

27 Impure carbonate bed or mixture of carbonate, quartz sand, and insoluble clay. Light gray. Firm.

Common black phosphorite, mainly of sand size but some of small pebble size.

Quartz sand is very fine to medium .....17′0″
(From 262′6″ to 279′6″)

Spl. 42 - Channel sample of sediments.

26 Mixture of quartz sand, carbonate, and insoluble clay. Dark Gray. Firm but soft.

Black shiny grains and small pebbles of phosphorite occur throughout the sediments. The phosphorite content increases from a depth of 290 feet to the base of the bed.

Quartz sand is fine to coarse.

These are the first Hawthorn sediments encountered that were so soft they could be cut with a knife while sampling .....15′9″
(From 279′6″ to 295′3″)

Spl. 43 - Channel sample of sediments from 279 feet 6 inches to 295 feet 3 inches.

25 Mixture of quartz sand, carbonate, and insoluble clay. Gray. Firm with soft zones.

Black grains of phosphorite are common.

Quartz sand is fine to coarse .....8′3″
(From 295′3″ to 303′6″)

Spl. 44 - Channel sample of mixture of quartz sand, carbonate, and insoluble clay.

24 Impure carbonate bed. Contains much quartz sand and some insoluble clay. Light gray. Rock-like.

Common shiny grains of black phosphorite.

These sediments grade into underlying materials .....9′3″
(From 303′6″ to 312′9″)

Spl. 45 - Channel sample of sediments.

23 Impure quartz sand or mixture of quartz sand, carbonate, and insoluble clay. Light gray.
Quartz sand is very fine to medium.
Fine black phosphorite is common .....4′3″
(From 312′9″ to 317′)

Spl. 46 - Channel sample of sediments.

22 Insoluble clay. Contains much carbonate and some quartz sand. Dark gray.
Clay is banded.
A few sand-size grains of black phosphorite .....8′9″
(From 317′ to 325′9″)

Spl. 47 - Channel sample of dark gray clay.

21 Mixture of insoluble clay, carbonate, and quartz sand. Dark gray to light gray.
Shiny black phosphate particles are common.
Quartz sand is very fine to fine ..... 13′3″
(From 325′9″ to 339′)

Spl. 48 - Channel sample of mixture of clay, carbonate, and quartz sand.

20 Mixture of quartz sand, insoluble clay, and carbonate. These sediments are cut by stringers of more nearly pure carbonate. Gray to light gray.
Shiny black phosphorite, mostly of sand-size, is abundant.
Quartz sand is coarse to fine .....8′0″
(From 339′ to 347′)

Spl. 49 - Channel sample of sediments.

19 Mixture of quartz sand, carbonate, and insoluble clay. Light gray. Firm and rock-like.
Shiny grains of black phosphorite are common.
Quartz sand is fine to coarse .....20′0″
(From 347′ to 367′)

Spl. 50 - Channel sample of rock-like mixture of sand, carbonate, and clay.

18 Quartz sand with disseminated carbonate and insoluble clay. Dark olive to gray.
Sediments are much softer than those of overlying bed.
Sand-size, black phosphorite is common. Phos-

phorite increases markedly at a depth of 372 feet.

Quartz sand is very fine to medium .....5'0"
(From 367' to 372')

Spl. 51 - Channel sample of Unit 18.

17 Impure carbonate bed or mixture of carbonate, quartz sand, insoluble clay, and phosphorite. Light gray to gray. Firm.

The phosphorite occurs as black, sand-size grains and as small pebbles.

Quartz sand is coarse to fine.

Clay increases at a depth of 382 feet .....10'0"
(From 372' to 382')

Spl. 52 - Channel sample of impure carbonate bed.

16 Mixture of carbonate, insoluble clay, and quartz sand. Gray.

Black grains of phosphorite are common.

Pockets containing a mixture of quartz sand and phosphorite are present in the sediments.

Quartz sand is very fine to coarse.

Clay decreases at a depth of 386 feet .....4'0"
(From 382' to 386')

Spl. 53 - Channel sample of mixture of carbonate, clay, and quartz sand.

15 Impure carbonate bed or mixture of carbonate, insoluble clay, quartz sand, and phosphorite. Gray. Firm.

The sediments in this interval are similar to the sediments in the interval from 372 feet to 382 feet.

Phosphorite is abundant and occurs as shiny black, sand-size particles and small black pebbles.

Quartz sand is fine to coarse .....2'0"
(From 386' to 388')

Spl. 54 - Channel sample of Unit 15.

14 Impure carbonate bed. Contains a high percentage of insoluble clay and a little quartz sand. Light gray to gray.

Small lenses and stringers of relatively pure carbonate cut the sediments.

Locally the materials have the appearance of a breccia.

Fine black phosphorite is disseminated through the sediments and concentrated with quartz sand in pockets.

This impure carbonate rock grades downward into hard limestone or dolomite at 400 feet 9 inches ..... 12′9″

(From 388′ to 400′9″)

Spl. 55 - Channel sample of impure carbonate bed.

13 Impure carbonate bed. Contains insoluble clay and quartz sand. Gray. Hard and rock-like.

Black grains of phosphorite are present and are especially abundant in the lower six inches of the sediments ..... 1′0″

(From 400′9″ to 401′9″)

Spl. 56 - Channel sample of carbonate bed.

12 Impure carbonate bed or mixture of carbonate and quartz sand. Light gray. Firm but soft.

Common black sand-size grains and small pebbles of phosphorite.

Quartz sand is medium to fine.

The interval from 401 feet 9 inches to 432 feet consists of intercalated zones of hard, massive, impure dolomite or limestone and softer zones consisting of a mixture of quartz sand, insoluble clay, and carbonate. Black, shiny, sand-size grains and small black pebbles of phosphorite are present throughout the sediments. The hard, massive dolomites contain pockets filled with quartz sand, clay, and phosphorite. The losses in sampling in this interval are of the softer mixtures of sediments ..... 6′3″

(From 401′9″ to 408′)

Spl. 57 - Channel sample of a 2-foot core from Unit 12.

11 No recovery from this interval ..... 9′0″

(From 408′ to 417′)

10 Very impure carbonate bed or a mixture of carbonate and quartz sand. Light gray to gray. Soft.

Black sand-size particles of phosphorite are common.

Quartz sand is medium to fine ..... 8′6″

(From 417′ to 425′6″)

Spl. 58 - Channel sample of a 2-foot 6-inch core obtained from Unit 8.

9 Impure carbonate bed containing insoluble clay and quartz sand. Light gray to gray. Hard and rock-like.

A few grains of black phosphorite are disseminated through the sediments.

Lenses consisting of quartz sand, insoluble clay, carbonate, and phosphorite are present in the carbonate bed ..... 6′6″

(From 425′6″ to 432′)

Spl. 59 - Sample of representative chips of the hard carbonate bed.

8 Impure clay or a mixture of insoluble clay, quartz sand, and carbonate. Dark gray-green. Massive.

A few grains of black phosphorite are present in the clay.

Quartz sand is very fine.

A 2-inch thick lens of hard limestone or dolomite is present at a depth of 434′3″. This hard carbonate rock was not included in the sample taken of these sediments.

Quartz sand increases at a depth of 441 feet ..... 9′0″

(From 432′ to 441′)

Spl. 60 - Channel sample of impure clay.

7 Quartz sand with high content of insoluble clay and carbonate or a mixture of quartz sand, insoluble clay, and carbonate. Gray.

Some cross bedding is present.

Occasional sand-size particles of black phosphorite.

Quartz sand is very fine ..... 5′0″

(From 441′ to 446′)

Spl. 61 - Channel sample of the mixture of quartz sand, insoluble clay, and carbonate.

6 Mixture of insoluble clay, silt, carbonate, and quartz sand. Greenish-black to black.

Occasional sand-size grains of black phosphorite.
Quartz sand is very fine to fine .....16′0″
(From 446′ to 462′)
Spl. 62 - Channel sample of sediments.
5 Impure carbonate bed. Contains much quartz sand. Gray. Hard and rock-like.
Abundant impressions of mollusks.
Phosphorite is disseminated through the sediments .....8′6″
(From 462′ to 470′6″)
Spl. 63 - Channel sample of impure carbonate bed.
4 Impure carbonate bed or mixture of carbonate, quartz sand, and insoluble clay. Light gray. Hard.
Black sand-size particles of phosphorite are present.
Quartz sand is coarse to fine .....11′6″
(From 470′6″ to 482′)
Spl. 64 - Channel sample of impure carbonate bed.
3 Impure carbonate bed. Contains much quartz sand and some insoluble clay. Gray.
Common sand-size grains and small pebbles of black phosphorite.
Only 9 inches of sample obtained from this interval .....5′0″
(From 482′ to 487′)
Spl. 65 - Sample of 9-inch core of carbonate bed.
2 Impure carbonate bed containing much quartz sand. Light gray. Hard and rock-like.
Common mollusk impressions.
There are numerous mollusk borings in the limestone or dolomite. Also, "brecciated" zones are present. Some of the fragments in the breccia zones are limestone or dolomite masses, several of which apparently are mollusk-bored. The borings are filled with various combinations of quartz sand, clay, and phosphorite.
Fine black phosphate grains and small phosphate pebbles are abundant .....5′0″
(From 487′ to 492′)
Spl. 66 - Channel sample of carbonate rock.

Limestone of the Ocala Group

1	Ocala Limestone. Pure. White to cream. The top of the limestone is mollusk bored or solution riddled and the borings or solution openings are filled with the overlying gray carbonate sediments (From 492′ to 493′)	1′0″
	Spl. 67 - Channel sample of Ocala Limestone.	
	Total depth of hole	493′0″

HIGHLAND DRILL HOLE NO. 2[7]

NE¼, SE¼, Section 12, T. 4 S., R. 22 E., Baker County, Florida
Approximately 3½ Miles Slightly West of North of Highland
Surface Elevation — 191 Feet

Unit	Description	Thickness In Feet & Inches
Surface Sands		
9	Quartz sand. White to gray to black. Gray to brown soil zone from land surface to depth of 3 feet 6 inches. The sands are black from 4 feet to 10 feet 6 inches and from 15 feet to 22 feet 6 inches. The black color is due to the presence of finely divided organic matter. Quartz sand is medium to fine (From land surface to 22′6″)	22′6″

[7]This hole was drilled by the Bureau of Geology, Florida Department of Natural Resources. The drilling was completed June 26, 1974. Analyses of the samples are given in Tables 4 through 6, Appendix II. A specially designed core barrel was used in sampling the sediments penetrated in this drill hole. A high recovery of undisturbed samples was obtained. The intervals from which sediments were not recovered are indicated in the descriptions of the samples.

Spl. 1 - Channel sample of white to gray surface sand from land surface to depth of 1 foot 9 inches.
Spl. 2 - Channel sample of brown to gray sand from 1 foot 9 inches to 5 feet.
Spl. 3 - Channel sample from 5 feet to 10 feet.
Spl. 4 - Channel sample from 10 to 15 feet.
Spl. 5 - Channel sample from 15 to 20 feet.
Spl. 6 - Channel sample from 20 feet to 22 feet 6 inches.

Moderate Brown Sand

8 Quartz sand. Moderate brown.
Sand is medium to fine .....12′6″
(From 22′6″ to 35′)
Spl. 7 - Channel sample of moderate brown sand from 22 feet 6 inches to 25 feet.
Spl. 8 - Channel sample from 25 to 30 feet.
Spl. 9 - Channel sample from 30 to 35 feet.

Gray to Olive-Drab Clay Zone

7 Quartz sand. Yellow brown to white. Upper 3 feet are yellow brown; lower 2 feet are white.
Sand is medium to very fine.
A 3-inch zone of black sand is present from 37 feet 3 inches to 37 feet 6 inches .....5′0″
(From 35′ to 40′)
Spl. 10 - Channel sample of quartz sand.
6 Clayey sand. Tan to gray.
Stringers or small lenses of sandy clay are present in the clayey sand.
Wood fragments are common, especially from 43 feet 6 inches to 45 feet 3 inches.
Quartz sand is very fine to medium .....8′0″
(From 40′ to 48′)
Spl. 11 - Channel sample from 40 feet to 42 feet 6 inches.
Spl. 12 - Channel sample from 42 feet 6 inches to 45 feet.
Spl. 13 - Channel sample from 45 feet to 48 feet.

5 Massive clay. Quartz sand is disseminated through the clay and also occurs in stringers cutting the clay. Dark gray to nearly black at top.
Abundant wood fragments (reddish brown). A relatively large fragment (1½ inches across) occurs at a depth of 52 feet 3 inches ..... 4′6″
(From 48′ to 52′6″)
Spl. 14 - Channel sample of massive clay.

4 No recovery ..... 3′0″
(From 52′6″ to 55′6″)

3 Sandy clay to massive clay. Dark gray to olive-drab.
The clay is dark gray on a fresh surface. In the lower part of the unit the gray color readily oxidizes to an olive-drab color. From 59 feet to 60 feet 6 inches the clay is mottled dark gray and olive-drab.
Stringers and small lenses of quartz sand or clayey sand are present in the clay. These sandy sediments occur from:
55 feet 6 inches to 56 feet 9 inches
58 feet to 58 feet 9 inches
61 feet 6 inches to 63 feet 3 inches
64 feet 6 inches to 65 feet.
Large wood fragments are present at a depth of approximately 56 feet.
The quartz sand is very fine to medium ..... 10′0″
(From 55′6″ to 65′6″)
Spl. 15 - Channel sample from 55 feet 6 inches to 59 feet.
Spl. 16 - Channel sample from 59 feet to 60 feet 6 inches.
Spl. 17 - Channel sample from 60 feet 6 inches to 65 feet 6 inches.

Quartz Sand

2 Quartz sand, loose. Gray.
Quartz sand is very fine to coarse.
The coarsest sand occurs from a depth of 81 feet 6 inches to a depth of 82 feet 6 inches. A small

discoid quartz or quartzite pebble was noted in these coarse sands ..... 55′0″

(From 65′6″ to 120′6″)

Spl. 18 - Channel sample from 65 feet 6 inches to 69 feet 6 inches.

Spl. 19 - Channel sample from 70 to 74 feet 6 inches.

Spl. 20 - Channel sample from 75 feet to 80 feet except for 6-inch interval from 74 feet 6 inches to 75 feet and a 6-inch interval from 77 feet to 77 feet 6 inches.

Spl. 21 - Channel sample from 80 to 85 feet.

Spl. 22 - Channel sample from 85 to 90 feet.

Spl. 23 - Channel sample from 90 to 95 feet.

Spl. 24 - Channel sample from 95 to 100 feet.

Spl. 25 - Channel sample from 100 to 105 feet except for a 1-foot interval from 102 feet 6 inches to 103 feet 6 inches.

Spl. 26 - Channel sample from 105 to 110 feet except for a 1-foot interval from 107 to 108 feet.

Spl. 27 - Channel sample from 110 feet to 112 feet combined with spot samples from 112 feet to 115 feet.

Spl. 28 - Channel sample from 115 to 118 feet.

1 Quartz sand, loose. Gray.

Sands contain fragments of white mollusk shells. These shells are especially noticeable from a depth of 120 feet 6 inches to a depth of 124 feet.

Quartz sand is medium to fine ..... 6′6″

(From 120′6″ to 127′)

Spl. 29 - Channel sample from 120 feet 6 inches to 124 feet of loose sands with white shell fragments.

Spl. 30 - Channel sample from 125 to 127 feet.

Total depth ..... 127′0″

APPENDIX II

Characteristics of Highland No. 1 and
Highland No. 2 Sediments

TABLE 1
Highland Drill Hole #1
SE¼, NE¼, Section 25, T. 4 S., R. 22 E., Bradford County, Florida
Approximately 1 Mile Northwest of Highland
Surface Elevation - 202 Feet

Spl.[8]	Depth in Feet and Inches	Insoluble Residue: Quartz Sand in %	Insoluble Residue: Coarse Silt (-230 mesh +325 mesh) in %	Insoluble Residue: Fine Silt and Clay (-325 mesh) in %	Soluble and Organic in %	P_2O_5 in %	Fe_2O_3 in %	Heavy Minerals (1/8 to 1/16 mm Fraction) in %	Total Heavy Minerals in %
	Gray to Moderate Brown Surface Sands (Elev. 202 Ft.)								
1	0 - 5'	94.11	1.28	3.61	1.00	0.51	1.26	7.66	1.44
2	5' - 10'	97.27	0.34	1.20	1.20	0.32	1.29	15.11	2.62
3	10' - 15'	98.12	0.08	1.40	0.40	0.27	1.40	17.33	2.35
4	15' - 20'	91.62	0.22	2.29	5.88	0.39	1.33	19.17	2.72
5	20' - 25'	95.19	0.92	3.89	0.00	0.29	1.16	18.12	4.43
6	25' - 30'	94.36	0.66	2.29	2.69	0.29	1.01	27.61	4.20
7	30' - 35'	96.43	0.18	1.89	1.50	0.24	1.17	35.71	3.72
8	35' - 40'	98.24	0.16	1.00	0.60	0.10	1.29	21.88	1.73
9	40' - 45'	94.76	0.16	3.29	1.79	0.15	1.36	26.12	1.33
10	45' - 50'	95.71	0.20	2.90	1.20	0.15	1.58	12.29	0.94
11	50' - 53'6"	95.45	0.36	0.60	3.59	0.15	1.38	5.18	0.65
	Drab to Olive-Green Clay Zone (Elev. 149 Ft.)								
12	53'6"- 54'6"	88.50	8.30	2.80	0.40	0.15	0.66	1.34	1.62
13	54'6"- 61'	88.05	3.47	7.68	0.80	0.17	0.75	0.74	0.72
14	61' - 62'3"	31.49	3.67	62.94	1.90	0.34	1.98	0.90	0.20
15	62'3"- 63'	90.43	3.76	5.11	0.70	0.19	1.22	0.86	0.81
16	63' - 64'	82.91	2.71	12.77	1.60	0.27	1.48	1.01	0.70
17	64'6"- 67'	52.32	4.66	39.80	3.22	0.22	2.01	1.26	0.45
18	67' - 70'	61.51	15.07	20.82	2.60	0.22	1.12	0.77	0.61
19	70' - 75'	94.55	1.24	4.20	0.00	0.73	1.12	10.63	0.47
20	75' - 77'	98.98	0.02	1.00	0.00	1.46	0.91	14.11	0.27
21	77' - 77'9"	25.47	11.44	56.92	6.17	0.29	1.56	0.67	--
22	77'9"- 78'3"	83.43	8.13	8.44	0.00	0.19	1.04	1.26	0.70
23	78'3"- 85'	46.31	9.00	40.02	4.68	0.27	1.48	0.70	0.26
24	85' - 88'6"	26.08	9.76	56.87	7.38	1.70	1.14	0.59	0.06
25	88'6"- 96'3"	71.06	10.99	16.13	1.81	1.71	1.40	0.79	0.51
26	96'3"-101'6"	14.62	5.73	72.88	6.77	0.34	1.60	1.24	0.14
27	101'6"-107'6"	21.33	5.52	64.06	9.09	0.56	1.52	1.32	0.28
28	107'6"-110'	55.53	13.85	25.54	5.09	0.32	1.17	1.26	0.58
29	110' -115'	76.36	6.33	13.11	4.20	1.71	1.38	1.95	0.93
30	115' -121'9"	64.97	3.04	24.59	7.40	0.24	1.55	2.32	0.51
	Shell Bed (Elev. 80 Ft.)								
31	121'9"-132'	36.42	0.62	6.58	56.39	1.95	0.90	2.87	0.41
	132' -140'	No Sample							
32	140' -148'	65.46	0.34	4.99	29.22	0.29	0.84	3.27	0.38
33	148' -152'	44.48	0.24	3.99	51.29	0.29	0.70	6.21	0.24
	Gray Quartz Sand (Elev. 50 Ft.)								
34	152' -157'	91.77	0.20	4.22	3.81	0.41	0.60	8.15	0.43
	157' -180'	No Sample							
	Fossiliferous Limestone (Elev. 22 Ft.)								
35	180' -186'	11.31	0.14	10.46	78.09	0.27	0.96	3.76	--
36	186' -202'3"	0.40	0.12	45.13	54.35	0.32	1.25	6.22	--
37	202'3"-212'6"	1.52	0.08	4.30	94.11	0.32	0.31	1.42	0.03
38	212'6"-215'6"	0.94	0.08	23.52	75.46	0.29	0.99	--	--
39	215'6"-227'6"	4.48	0.06	3.40	92.06	0.66	0.34	4.60	0.05
	Hawthorn Formation (Elev. -26 Ft.)								
40	227'6"-246'	37.93	0.26	8.80	53.01	2.66	0.87	1.26	0.17
41	246' -262'6"	28.33	0.16	7.67	63.84	7.93	1.14	1.89	0.16
42	262'6"-279'6"	38.44	0.32	8.10	53.13	3.24	0.79	1.05	0.13
43	279'6"-295'3"	46.91	0.40	20.26	32.44	4.46	1.52	2.96	0.18
44	295'3"-303'6"	48.78	0.10	5.18	45.93	3.76	1.04	2.03	0.13
45	303'6"-312'9"	34.17	0.18	4.98	60.67	3.34	0.82	1.82	0.08
46	312'9"-317'	51.02	0.46	13.05	35.47	3.20	0.95	0.92	0.26
47	317' -325'9"	6.93	1.88	63.96	27.23	1.48	1.80	0.32	0.02
48	325'9"-339'	21.20	0.42	41.63	36.75	2.11	1.43	0.55	0.07
49	339' -347'	30.78	0.24	20.61	48.38	5.98	1.59	1.43	0.07
50	347' -367'	47.46	0.44	7.17	44.93	2.81	0.94	1.35	0.10

TABLE 1 (Continued)

Spl.	Depth in Feet and Inches	Insoluble Residue: Quartz Sand in %	Insoluble Residue: Coarse Silt (-230 mesh +325 mesh) in %	Insoluble Residue: Fine Silt and Clay (-325 mesh) in %	Soluble and Organic in %	P_2O_5 in %	Fe_2O_3 in %	Heavy Minerals (1/8 to 1/16 mm Fraction) in %	Total Heavy Minerals in %
51	367' -372'	71.29	2.46	11.48	14.77	2.47	0.97	0.77	--
52	372' -382'	34.60	0.20	7.48	57.73	9.76	0.95	2.88	0.10
53	382' -386'	10.21	0.22	40.51	49.06	4.46	1.30	2.17	0.05
54	386' -388'	20.72	0.12	20.78	58.37	8.55	1.21	3.60	0.10
55	388' -400'9"	2.57	0.06	36.58	60.79	1.48	0.85	1.48	0.03
56	400'9"-401'9"	6.97	0.08	20.51	72.44	2.11	1.07	3.17	0.14
57	401'9"-408'	46.64	0.04	1.69	51.62	3.22	0.52	3.35	0.14
	408' -417'	No Sample							
58	417' -425'6"	45.33	0.10	2.79	51.78	2.83	0.48	2.17	0.15
59	425'6"-432'	12.44	0.32	13.76	73.48	1.14	0.42	0.68	0.04
60	432' -441'	22.12	4.29	51.81	21.76	1.31	1.20	0.30	0.07
61	441' -446'	50.26	9.04	29.01	11.69	1.16	1.00	0.20	0.13
62	446' -462'	13.95	21.88	49.75	14.41	1.14	1.33	0.29	0.04
63	462' -470'6"	19.60	0.18	2.30	77.92	1.50	0.67	3.94	0.32
64	470'6"-482'	40.72	0.34	5.50	53.43	1.65	0.70	5.30	0.23
65	482' -487'	29.60	0.40	5.78	64.22	3.68	0.71	2.49	0.51
66	487' -492'	14.63	0.14	2.50	82.73	4.89	0.46	2.37	0.15
				Ocala Limestone (Elev. -290 Ft.)					
67	492' -493'	0.22	0.02	0.20	99.02	0.44	1.4ppm	1.25	--

[8]The value listed under the insoluble residue as the per cent quartz sand is the percentage of the original sample consisting of quartz and heavy-mineral sand. The figure given under the coarse silt column is the per cent of the original sample consisting of sediments that passed through a 230-mesh screen and were retained on a 325-mesh screen (62 microns to 44 microns). The per cent fine silt and clay represents that part of the original sample consisting of insoluble sediments that passed through a 325-mesh screen (−44 microns). Because of techniques used in separations, some of the finely divided organic matter present in the surface sands (Spls. 1-11) may be recorded in the figure for fine silt and clay. The percentage figure given under the heading "Soluble and Organic" reflects mainly finely divided organic matter in the surface sands (Spls. 1-11) and carbonate and phosphate content in all samples beneath the surface sands (Spls. 12-67). The P_2O_5 and Fe_2O_3 values are the percentages of P_2O_5 and Fe_2O_3 in the original samples. The value for the ⅛ to 1/16 mm heavy minerals is the per cent of the ⅛ to 1/16 mm fraction of the sediments consisting of heavy minerals. The value given for the total per cent heavy minerals is the per cent of the original sample consisting of heavy minerals. The values for the heavy minerals do not include phosphorite, mica, pyrite, or iron concretions.

TABLE 2
Highland Drill Hole #1
Mechanical Analyses of Quartz Sand Extracted from Sediments

Spl.	Quartz Sand in %	Percent of Quartz Sand Retained on Mesh						Mean Grain Size in mm
		10 (4 to 2 mm)	18 (2 to 1 mm)	35 (1 to 1/2 mm)	60 (1/2 to 1/4 mm)	120 (1/4 to 1/8 mm)	230 (1/8 to 1/16 mm)	
Gray to Moderate Brown Surface Sands								
1	94.11		0.04	6.13	55.81	26.77	11.24	0.32
2	97.27		0.04	5.99	50.32	33.92	9.73	0.31
3	98.12		0.04	4.86	58.40	31.01	5.69	0.32
4	91.62			3.63	62.87	26.00	7.50	0.32
5	95.19		0.04	4.75	51.24	28.57	15.40	0.30
6	94.36		0.19	12.23	59.27	21.66	6.65	0.36
7	96.43		0.08	8.12	59.48	25.84	6.47	0.34
8	98.24		0.12	8.80	58.64	27.35	5.08	0.34
9	94.76		0.06	9.10	67.75	20.00	3.09	0.36
10	95.71		0.10	8.66	63.53	23.64	4.07	0.35
11	95.45		0.06	9.19	62.01	23.66	5.08	0.35
Drab to Olive-Green Clay Zone								
12	88.50			0.45	4.05	11.78	83.72	0.12
13	88.05			0.32	2.60	11.55	85.53	0.11
14	31.49			0.70	5.54	13.18	80.59	0.13
15	90.43		0.02	1.13	11.87	21.25	65.73	0.15
16	82.91		0.02	1.16	12.18	21.83	64.81	0.16
17	52.32		0.04	1.73	16.71	25.36	56.17	0.18
18	61.51			0.78	8.01	7.97	83.24	0.13
19	94.55			7.33	67.86	21.43	3.39	0.35
20	98.98		0.02	12.27	73.81	11.97	1.93	0.39
21	25.47		0.08	1.02	8.59	15.63	74.69	0.14
22	83.43	0.07	0.36	3.78	29.95	25.08	40.76	0.23
23	46.31		0.26	0.73	7.39	8.60	83.02	0.13
24	26.08			0.46	8.11	5.43	86.00	0.12
25	71.06		0.17	1.50	7.07	13.22	78.04	0.14
26	14.62		0.14	1.09	8.04	12.13	78.61	0.14
27	21.33		0.28	1.22	9.84	13.68	74.98	0.15
28	55.53		0.04	1.47	2.37	8.98	87.14	0.12
29	76.36		0.24	3.46	18.72	29.99	47.59	0.20
30	64.97		0.77	6.74	23.85	38.86	29.78	0.25
Shell Bed								
31	36.42		0.77	7.28	29.38	42.72	19.86	0.28
	No Sample for 8-foot Interval							
32	65.46	0.64	0.52	13.07	56.83	17.46	11.49	0.38
33	44.48	1.84	2.83	19.83	57.87	12.61	5.02	0.49
Gray Quartz Sand								
34	91.77		0.83	12.99	46.13	35.19	4.86	0.35
	No Sample for 23-foot Interval (Material similar to Spl. 34)							
Fossiliferous Limestone								
35	11.31	1.94	2.82	14.44	54.23	20.25	6.43	0.46
36	0.40		4.87	15.03	20.10	24.93	35.07	0.34
37	1.52		1.32	6.58	18.42	27.63	46.05	0.23
38	0.94			6.38	17.02	23.40	53.19	0.21
39	4.48		0.45	3.13	27.23	57.14	12.05	0.25

TABLE 2 (Continued)

Spl.	Quartz Sand in %	Percent of Quartz Sand Retained on Mesh						Mean Grain Size in mm
		10 (4 to 2 mm)	18 (2 to 1 mm)	35 (1 to 1/2 mm)	60 (1/2 to 1/4 mm)	120 (1/4 to 1/8 mm)	230 (1/8 to 1/16 mm)	
Hawthorn Formation								
40	37.93		0.21	2.43	15.30	47.20	34.86	0.20
41	28.33		0.49	4.36	23.98	53.66	17.51	0.25
42	38.44		0.68	3.85	18.74	49.19	27.54	0.23
43	46.91		1.62	14.21	42.04	33.79	8.34	0.36
44	48.78	0.16	2.00	10.38	47.10	34.60	5.76	0.36
45	34.17		0.82	21.05	49.97	21.17	7.00	0.40
46	51.02		0.12	1.99	11.72	50.94	35.23	0.19
47	6.93		0.87	2.02	3.76	8.38	84.97	0.14
48	21.20		0.09	0.56	3.85	29.14	66.35	0.13
49	30.78	0.39	7.76	30.01	44.05	15.14	2.65	0.55
50	47.46	0.21	1.22	15.03	59.24	16.25	8.06	0.40
51	71.29		0.11	3.39	29.94	18.26	48.31	0.22
52	34.60		1.33	25.94	53.66	14.99	4.09	0.45
53	10.21		0.78	10.18	40.90	28.18	19.96	0.31
54	20.72		0.68	10.72	48.02	33.82	6.76	0.34
55	2.57		2.34	4.69	15.63	32.03	45.31	0.23
56	6.97		1.12	12.08	56.74	20.22	9.83	0.37
57	46.64		0.51	9.83	59.87	26.03	3.76	0.36
No Sample for 9-foot Interval								
58	45.33		0.66	9.31	59.89	23.99	6.15	0.36
59	12.44		0.16	1.90	42.86	16.83	38.25	0.24
60	22.12		0.09	0.45	1.62	7.04	90.79	0.11
61	50.26			0.04	0.12	2.26	97.58	0.10
62	13.95		0.72	4.73	6.74	13.92	73.89	0.17
63	19.60		1.63	10.30	49.44	30.07	8.56	0.36
64	40.72		0.64	23.24	57.35	16.07	2.70	0.43
65	29.60	0.34	4.45	21.83	42.59	18.53	12.26	0.45
66	14.63			3.69	59.23	22.98	14.09	0.31
Ocala Limestone								
67	0.22			18.18	36.36	27.27	18.18	0.34

TABLE 3
Highland Drill Hole #1
Percentages of Selected Heavy Minerals in
1/8 to 1/16 mm Fraction

Spl.	Leucoxene[9] in %	Ilmenite in %	Epidote in %	Garnet in %	Hornblende in %
Gray to Moderate Brown Surface Sands					
1	31.86	13.88	0.00	0.00	0.00
2	12.16	40.12	0.00	0.00	0.00
3	2.65	50.00	0.00	0.00	0.00
4	1.21	58.18	0.00	0.00	0.00
5	5.66	52.52	0.00	0.00	0.00
6	6.15	44.00	0.00	0.00	0.00
7	1.45	58.26	0.00	0.00	0.00
8	1.46	45.91	0.00	0.00	0.00
9	1.21	49.70	0.00	0.00	0.00
10	2.02	49.16	0.00	0.00	0.00
11	3.52	48.78	0.00	0.00	0.00
Drab to Olive-Green Clay Zone					
12	14.50	29.91	0.00	0.00	0.00
13	11.50	22.36	0.00	0.00	0.00
14	11.56	35.03	0.00	0.25	0.00
15	13.14	23.43	2.06	1.04	0.00
16	10.03	36.05	1.57	0.00	0.00
17	6.69	38.80	0.00	0.94	1.00
18	9.70	36.45	0.00	1.07	0.00
19	0.70	50.35	0.00	0.35	0.00
20	1.89	53.14	0.00	1.10	0.00
21	6.59	31.78	1.16	0.67	0.39
22	4.99	46.26	0.00	2.15	0.55
23	7.62	37.09	0.00	1.03	0.00
24	8.89	33.89	0.00	0.88	0.00
25	2.38	38.44	3.06	1.79	0.00
26	2.92	24.45	17.15	2.11	0.00
27	2.29	25.14	30.86	0.79	0.29
28	0.99	25.83	30.79	0.98	0.99
29	2.90	27.54	38.55	1.00	1.16
30	2.17	23.91	26.09	2.01	2.48
Shell Bed					
31	1.28	33.01	19.55	0.33	2.24
	No Sample				
32	1.03	24.32	30.82	1.17	6.51
33	0.67	24.58	24.24	0.61	3.37
Gray Quartz Sand					
34	1.21	28.79	15.45	1.40	6.06
	No Sample				
Fossiliferous Limestone					
35	2.78	21.94	27.22	0.26	0.83
36	2.17	7.61	16.30	0.00	0.00
37	1.35	24.24	27.27	1.74	0.35
38	0.00	17.14	28.57	3.57	0.00
39	1.80	16.19	32.37	5.05	0.36

TABLE 3 (Continued)

Spl.	Leucoxene in %	Ilmenite in %	Epidote in %	Garnet in %	Hornblende in %
		Hawthorn Formation			
40	0.62	11.15	25.39	6.56	0.00
41	1.36	21.77	22.79	10.12	0.00
42	1.58	31.96	16.77	5.88	0.00
43	3.24	27.18	11.65	9.25	0.00
44	1.32	29.80	17.22	4.08	0.00
45	2.55	35.13	9.63	4.11	0.00
46	0.85	25.35	6.48	6.94	0.00
47	0.54	20.16	3.00	4.93	0.00
48	1.55	25.47	1.86	6.12	0.00
49	2.43	34.95	3.34	4.46	0.00
50	1.55	36.65	5.28	4.56	0.00
51	3.94	38.48	5.76	5.70	0.00
52	1.34	29.77	7.36	7.43	0.00
53	1.19	43.32	1.78	6.61	0.00
54	1.24	41.49	3.10	4.38	0.00
55	2.15	30.77	4.92	3.27	0.00
56	2.27	33.50	12.59	3.28	0.00
57	2.45	33.03	9.79	5.47	0.00
	No Sample				
58	2.32	36.81	9.86	6.95	0.00
59	2.77	50.46	1.54	4.96	0.00
60	3.00	45.67	1.33	5.72	0.00
61	3.83	45.05	3.19	4.61	0.00
62	7.57	37.85	3.47	5.25	0.00
63	1.56	19.31	19.31	21.27	0.00
64	1.58	32.91	2.22	23.64	0.00
65	4.67	41.33	1.33	14.52	0.00
66	0.62	27.08	8.00	14.51	0.00
		Ocala Limestone			
67	1.05	15.79	5.26	4.76	0.00

[9]Per cent of the 1/8 to 1/16 mm heavy-mineral fraction that consists of leucoxene.

TABLE 4
Highland Drill Hole #2
NE¼, SE¼, Section 12, T. 4 S., R. 22 E., Baker County, Florida
Approximately 3½ Miles Slightly West of North of Highland
Surface Elevation - 191 Feet

Spl.	Depth in Feet and Inches	Insoluble Residue: Quartz Sand in %	Insoluble Residue: Coarse Silt (-230 mesh +325 mesh) in %	Insoluble Residue: Fine Silt and Clay (-325 mesh) in %	Soluble and Organic in %	Heavy Minerals (1/8 to 1/16 mm Fraction) in %	Total Heavy Minerals in %
Gray to Moderate Brown Surface Sands (Elev. 191 Ft.)							
1	0 - 1'9"	95.15	1.03	2.52	1.31	11.54	2.32
2	1'9"- 5'	92.97	0.94	4.19	1.90	13.58	2.20
3	5' - 10'	97.14	0.46	1.20	1.20	22.06	4.43
4	10' - 15'	98.46	0.64	0.40	0.50	30.33	3.38
5	15' - 20'	91.43	0.18	6.29	2.10	34.64	4.30
6	20' - 22'6"	91.70	0.40	5.40	2.50	29.16	4.02
7	22'6"- 25'	96.22	0.38	1.20	2.20	32.88	4.75
8	25' - 30'	96.60	0.10	1.20	2.10	34.40	4.13
9	30' - 35'	97.17	0.22	1.10	1.50	41.08	4.38
Gray to Olive-Drab Clay Zone (Elev. 156 Ft.)							
10	35' - 40'	92.44	3.46	2.50	1.60	4.75	2.86
11	40' - 42'6"	83.04	3.89	9.18	3.89	1.19	0.90
12	42'6"- 45'	86.12	5.18	8.60	0.10	1.33	0.76
13	45' - 48'	90.76	2.85	5.89	0.50	1.98	0.87
14	48' - 52'6"	37.69	5.40	51.42	5.50	1.82	0.36
15	55'6"- 59'	50.20	14.44	30.65	4.71	2.66	0.81
16	59' - 60'6"	19.31	7.64	70.56	2.50	1.19	0.36
17	60'6"- 65'6"	64.56	8.16	26.37	0.90	1.23	0.54
Gray Quartz Sand (Elev. 125 Ft.)							
18	65'6"- 69'6"	89.38	3.39	6.72	0.50	2.02	0.86
19	70' - 74'6"	92.32	1.89	5.28	0.50	2.19	0.91
20	75' - 80'	94.74	0.48	4.38	0.40	2.65	0.77
21	80' - 85'	93.12	0.40	4.79	1.70	4.23	0.58
22	85' - 90'	95.48	0.38	3.64	0.50	4.50	0.90
23	90' - 95'	96.90	0.40	2.10	0.60	6.05	0.76
24	95' -100'	96.40	0.40	2.70	0.50	3.33	0.88
25	100' -105'	96.00	0.58	1.73	1.69	3.32	0.70
26	105' -110'	96.99	0.44	1.48	1.10	3.13	0.82
27	110' -115'	98.00	0.24	0.96	0.80	3.93	0.46
28	115' -118'	94.91	0.26	2.25	2.59	4.38	0.52
29	120'6"-124'	94.25	0.14	1.92	3.69	5.94	0.60
30	125' -127'	91.49	0.20	3.13	5.18	5.29	0.72

TABLE 5
Highland Drill Hole #2
Mechanical Analyses of Quartz Sand Extracted from Sediments

Spl.	Quartz Sand in %	Percent of Quartz Sand Retained on Mesh						Mean Grain Size in mm
		10 (4 to 2 mm)	18 (2 to 1 mm)	35 (1 to 1/2 mm)	60 (1/2 to 1/4 mm)	120 (1/4 to 1/8 mm)	230 (1/8 to 1/16 mm)	
Gray to Moderate Brown Surface Sands								
1	95.15		0.02	4.53	61.96	24.06	9.44	0.32
2	92.97		0.02	5.35	60.04	25.13	9.45	0.32
3	97.14		0.12	4.89	59.31	28.32	7.36	0.32
4	98.46		0.02	4.36	52.50	33.38	9.74	0.30
5	91.43		0.02	6.14	62.02	26.05	5.77	0.33
6	91.70		0.02	4.82	59.06	27.49	8.61	0.32
7	96.22		0.08	6.46	57.06	27.49	8.91	0.32
8	96.60		0.08	6.61	65.44	23.51	4.35	0.34
9	97.17		0.02	5.53	62.48	25.01	6.96	0.33
Gray to Olive-Drab Clay Zone								
10	92.44		0.11	7.16	45.80	21.58	25.35	0.29
11	83.04			0.62	13.12	33.77	52.49	0.17
12	86.12		0.02	2.95	23.68	24.45	48.90	0.20
13	90.76		0.02	0.33	16.93	48.42	34.30	0.19
14	37.69		0.05	1.13	20.53	31.23	47.06	0.19
15	50.20		0.04	1.00	28.77	26.54	43.66	0.21
16	19.31		0.31	1.86	18.94	19.46	59.42	0.18
17	64.56		0.65	3.82	15.47	23.21	56.85	0.19
Gray Quartz Sand								
18	89.38		0.63	6.40	23.27	43.79	25.92	0.25
19	92.32		1.08	6.67	20.88	44.55	26.82	0.25
20	94.74	0.91	1.82	9.69	23.92	47.37	16.30	0.32
21	93.12	0.71	2.74	12.43	20.18	52.86	11.08	0.34
22	95.48		0.73	6.03	22.54	58.75	11.95	0.26
23	96.90		0.58	6.41	34.37	51.59	7.05	0.29
24	96.40		0.10	1.43	15.79	64.12	18.56	0.21
25	96.00		0.15	2.74	24.98	53.44	18.69	0.23
26	96.99		0.16	3.95	36.38	44.12	15.39	0.27
27	98.00	0.04	0.41	7.23	59.87	26.71	5.74	0.34
28	94.91	0.08	0.54	6.87	67.57	19.28	5.66	0.36
29	94.25		0.44	4.06	64.14	25.91	5.44	0.33
30	91.49	0.11	0.22	3.55	49.04	38.99	8.09	0.30

TABLE 6
Highland Drill Hole #2
Percentages of Selected Heavy Minerals in
1/8 to 1/16 mm Fraction

Spl.	Leucoxene in %	Ilmenite in %	Epidote in %	Garnet in %	Hornblende in %
Gray to Moderate Brown Surface Sands					
1	29.74	18.30	0.00	0.00	0.00
2	24.84	26.45	0.00	0.00	0.00
3	15.87	41.32	0.00	0.00	0.00
4	6.98	47.88	0.00	0.00	0.00
5	0.00	58.63	0.00	0.00	0.00
6	2.02	60.69	0.00	0.00	0.00
7	1.54	57.85	0.00	0.00	0.00
8	0.00	55.22	0.00	0.00	0.00
9	0.32	63.46	1.60	0.00	0.00
Gray to Olive-Drab Clay Zone					
10	6.10	45.06	0.58	0.00	0.00
11	17.42	30.97	0.00	0.00	0.00
12	21.49	17.01	0.30	0.00	0.00
13	5.31	48.01	0.00	0.27	0.00
14	3.36	41.97	0.00	1.51	0.00
15	4.84	46.45	0.00	0.62	0.00
16	7.52	39.47	0.38	1.13	0.38
17	1.23	75.00	4.32	0.68	0.00
Gray Quartz Sand					
18	3.08	34.93	22.26	1.23	0.00
19	1.96	26.80	22.88	2.67	0.33
20	1.64	29.67	23.13	1.52	0.23
21	1.88	30.63	28.13	1.16	2.81
22	0.68	23.05	18.64	0.95	3.05
23	1.28	15.38	27.44	1.83	5.38
24	2.10	24.32	23.72	0.99	2.10
25	0.32	26.03	20.32	2.27	4.13
26	1.26	25.55	24.92	1.43	3.47
27	0.96	19.61	21.54	0.95	6.09
28	0.88	31.76	25.29	1.30	3.24
29	1.99	29.90	28.90	1.14	2.33
30	0.92	29.05	20.80	1.15	3.98

APPENDIX III

Characteristics of Surface Sands
in Study Area

TABLE 7

Analyses of Surface Sediments Collected
in Vicinity of Green Cove Springs Ore Body
Sample Sites Shown on Figure 4

Spl.	Insoluble Residue: Quartz Sand in %	Insoluble Residue: Coarse Silt (-230 mesh +325 mesh) in %	Insoluble Residue: Fine Silt and Clay (-325 mesh) in %	Soluble and Organic in %	Heavy Minerals (1/8 to 1/16 mm Fraction) in %	Total Heavy Minerals in %	Mean Grain Size of Quartz Sand in mm
1	90.13	1.66	7.81	0.40	1.87	0.88	0.15
2	96.70	0.50	2.80	0.00	5.93	1.66	0.20
3	95.98	1.02	3.00	0.00	1.89	0.65	0.18
4	87.69	2.32	8.69	1.30	1.23	0.69	0.15
5	90.51	2.20	6.69	0.60	1.44	0.68	0.15
6	94.85	0.86	4.30	0.00	1.89	0.75	0.17
7	94.39	0.72	4.80	0.10	1.63	0.49	0.17
8	93.73	0.88	5.09	0.30	1.75	0.65	0.17
9	95.90	0.80	3.30	0.00	1.47	0.75	0.18
10	95.21	0.56	4.02	0.20	1.57	0.70	0.17
11	95.38	0.82	3.50	0.30	3.18	1.11	0.15
12	90.34	0.26	6.60	2.80	4.50	1.30	0.18
13	85.54	1.78	11.38	1.30	1.18	0.51	0.17
14	95.39	0.80	3.51	0.30	1.65	0.36	0.18
15	90.97	1.44	6.50	1.10	2.04	0.74	0.17
16	93.23	0.54	4.62	1.61	3.42	1.12	0.17
17	93.68	1.12	4.70	0.50	2.95	1.10	0.17
18	92.50	0.72	6.18	0.60	1.67	0.58	0.18
19	94.75	0.24	4.01	1.00	1.65	0.34	0.18
20	95.54	1.36	3.10	0.00	1.86	0.71	0.16
21	93.72	0.98	5.00	0.30	2.77	1.09	0.16
22	94.21	1.68	4.01	0.10	6.99	2.61	0.17
23	90.30	0.50	6.80	2.40	1.58	0.42	0.17
24	97.61	0.58	1.81	0.00	1.92	0.77	0.19
25	91.08	2.43	5.49	1.00	1.41	0.49	0.16
26	98.26	0.64	1.10	0.00	1.22	0.52	0.16
27	97.48	0.42	1.80	0.30	6.48	2.15	0.17
28	95.45	0.76	3.29	0.50	5.02	1.54	0.16
29	95.87	0.62	2.50	1.00	1.07	0.56	0.16
30	89.78	1.04	7.78	1.40	1.31	0.63	0.15
31	95.80	1.00	2.80	0.40	2.13	0.72	0.17
32	94.41	1.80	2.99	0.80	0.80	0.50	0.14
33	95.79	0.62	3.50	0.10	1.44	0.47	0.17
34	94.73	0.98	4.09	0.20	1.20	0.47	0.16
35	96.60	0.80	2.50	0.10	2.01	0.56	0.22
36	96.88	0.32	2.50	0.30	1.79	0.61	0.17
37	96.64	0.56	2.20	0.60	2.25	0.86	0.19
38	97.15	0.84	1.60	0.40	1.38	0.40	0.18

TABLE 8

Mechanical Analyses of Surface Sands Collected in Vicinity of Green Cove Springs Ore Body

Spl. No.	Quartz Sand in %	Percent of Quartz Sand in Various Sand Fractions						Mean Grain Size in mm	Approximate Elevation in Feet
		Granules (4 to 2 mm)	Very Coarse (2 to 1 mm)	Coarse (1 to 1/2 mm)	Medium (1/2 to 1/4 mm)	Fine (1/4 to 1/8 mm)	Very Fine (1/8 to 1/16 mm)		
1	90.13		0.02	0.09	2.80	55.32	41.77	0.15	92
2	96.70		0.04	1.32	14.91	55.16	28.56	0.20	87
3	95.98		0.29	1.54	8.60	55.63	33.94	0.18	35
4	87.69		0.02	0.05	2.48	47.95	49.50	0.15	101
5	90.51			0.09	2.87	51.41	45.63	0.15	103
6	94.85			0.11	5.27	63.24	31.39	0.17	120
7	94.39			0.08	5.16	60.37	34.48	0.17	108
8	93.73		0.04	0.30	6.41	62.31	30.93	0.17	65
9	95.90		0.21	1.61	10.25	46.56	41.38	0.18	17
10	95.21		0.06	0.76	8.19	52.86	38.12	0.17	22
11	95.38			0.04	2.87	63.61	33.48	0.15	93
12	90.34			0.13	7.00	67.12	25.75	0.18	118
13	85.54		0.02	0.21	7.54	54.20	38.03	0.17	71
14	95.39		0.02	0.15	7.31	66.22	26.30	0.18	11
15	90.97			0.09	4.28	65.19	30.43	0.17	96
16	93.23			0.09	5.71	61.24	32.97	0.17	112
17	93.68			0.11	5.34	61.60	32.96	0.17	108
18	92.50		0.02	0.24	8.50	64.88	26.37	0.18	65
19	94.75			0.04	4.90	77.24	17.82	0.18	12
20	95.54		0.02	0.10	4.42	60.58	34.88	0.16	95
21	93.72		0.02	0.04	2.80	57.89	39.25	0.16	112
22	94.21		0.02	0.15	6.29	60.71	32.83	0.17	98
23	90.30			0.22	6.91	57.53	35.34	0.17	70
24	97.61		0.06	0.56	11.55	58.29	29.54	0.19	31
25	91.08		0.02	0.13	2.69	57.81	39.34	0.16	100
26	98.26			0.12	3.68	55.24	40.96	0.16	100
27	97.48			0.12	5.04	64.99	29.84	0.17	100
28	95.45			0.10	5.54	58.13	36.23	0.16	85
29	95.87			0.36	6.33	51.94	41.37	0.16	20
30	89.78			0.07	2.56	49.00	48.38	0.15	81
31	95.80		0.02	0.17	6.51	60.16	33.15	0.17	39
32	94.41		0.02	0.42	4.80	30.61	64.14	0.14	5
33	95.79			0.60	7.13	59.98	32.28	0.17	11
34	94.73			0.06	5.14	58.20	36.59	0.16	25
35	96.60		0.19	1.87	18.40	58.63	20.91	0.22	27
36	96.88		0.02	0.31	8.29	57.65	33.73	0.17	63
37	96.64			1.59	11.69	60.99	25.73	0.19	20
38	97.15			0.10	7.70	69.50	22.70	0.18	13

TABLE 9

Percentages of Selected Heavy Minerals in 1/8 to 1/16 mm Heavy-Mineral Fraction of Surface Sands Collected in Vicinity of Green Cove Springs Ore Body

Spl.	Leucoxene in %	Ilmenite in %	Epidote in %	Garnet in %	Hornblende in %
1	18.49	34.73	0.00	0.00	0.00
2	14.05	39.52	0.00	0.00	0.00
3	9.29	40.71	0.00	0.00	0.00
4	41.82	16.98	0.00	0.00	0.00
5	51.32	8.88	0.00	0.00	0.00
6	25.95	23.42	0.00	0.00	0.00
7	25.00	22.19	0.00	0.00	0.00
8	23.23	35.02	1.01	0.00	0.00
9	6.89	44.26	0.00	0.00	0.00
10	7.62	38.08	3.97	0.00	0.00
11	29.87	22.15	0.00	0.00	0.00
12	13.64	44.81	0.00	0.00	0.00
13	23.13	34.06	0.00	0.00	0.00
14	9.63	31.44	1.98	0.00	0.00
15	35.24	17.14	0.00	0.00	0.00
16	45.55	16.79	0.00	0.00	0.00
17	31.53	18.31	0.00	0.00	0.00
18	21.45	26.02	0.00	0.00	0.00
19	12.69	22.96	1.21	0.00	0.00
20	27.36	20.95	0.00	0.00	0.00
21	30.82	18.36	0.00	0.00	0.00
22	35.03	16.56	0.00	0.00	0.00
23	20.87	24.93	0.29	0.00	0.00
24	9.72	45.14	0.00	0.00	0.00
25	42.41	11.46	0.00	0.00	0.00
26	29.39	7.49	0.00	0.00	0.00
27	29.91	20.56	0.00	0.00	0.00
28	21.41	18.59	0.00	0.00	0.00
29	16.51	35.56	0.00	0.00	0.00
30	31.82	19.52	0.00	0.00	0.00
31	33.33	8.99	0.00	0.00	0.00
32	9.84	31.91	0.00	0.00	0.00
33	10.09	23.55	0.00	0.00	0.00
34	21.53	28.77	0.00	0.00	0.40
35	11.58	36.01	0.00	0.00	0.00
36	10.67	40.17	0.00	0.00	0.00
37	15.12	30.81	0.00	0.00	0.00
38	16.09	22.71	0.00	0.00	0.00

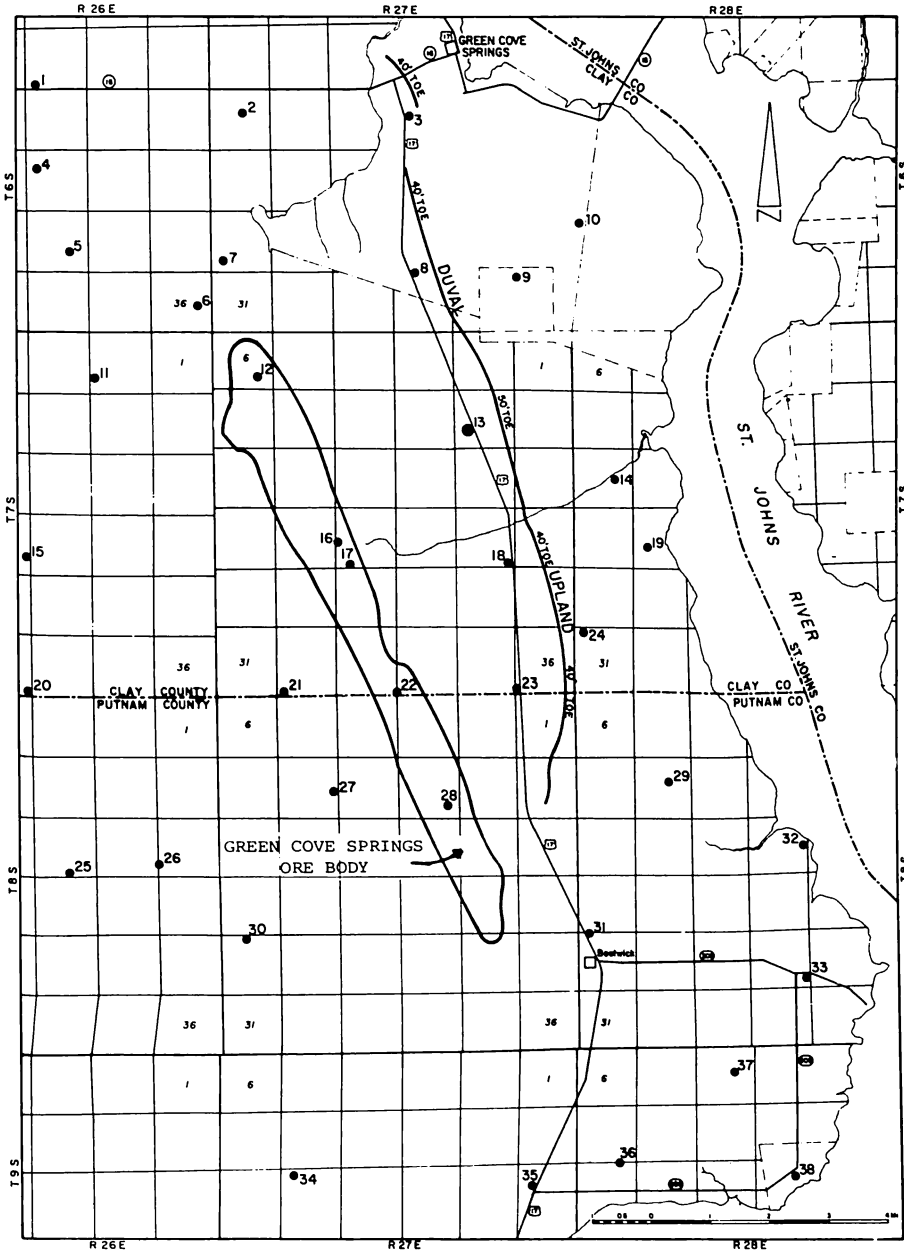

Figure 4. Sample sites of surface sands collected in the vicinity of the Green Cove Springs ore body.

TABLE 10

Analyses of Surface Sediments Collected
in Vicinity of Boulougne Ore Body
Sample Sites Shown on Figure 5

Spl.	Insoluble Residue: Quartz Sand in %	Insoluble Residue: Coarse Silt (-230 mesh +325 mesh) in %	Insoluble Residue: Fine Silt and Clay (-325 mesh) in %	Soluble and Organic in %	Heavy Minerals (1/8 to 1/16 mm Fraction) in %	Total Heavy Minerals in %	Mean Grain Size of Quartz Sand in mm
1	94.36	0.86	4.58	0.20	0.59	0.46	0.14
2	95.01	0.80	4.09	0.10	1.94	0.83	0.15
3	96.33	0.96	2.51	0.20	1.59	0.90	0.15
4	51.31	13.26	33.34	2.09	0.67	0.65	0.13
5	77.37	9.16	12.77	0.70	0.57	1.06	0.13
6	89.71	2.81	7.28	0.20	0.64	0.70	0.14
7	93.94	0.98	4.69	0.40	3.07	1.70	0.15
8	94.28	0.82	4.40	0.50	9.40	2.17	0.15
9	92.91	1.10	5.89	0.10	3.48	2.09	0.15
10	91.78	1.42	5.70	1.10	0.93	0.75	0.16
11	73.19	7.64	18.36	0.80	0.68	0.82	0.12
12	94.19	1.63	3.98	0.20	0.84	0.65	0.13
13	90.52	3.39	5.99	0.10	0.83	1.01	0.12
14	91.19	0.94	7.18	0.70	1.71	0.94	0.17
15	93.77	1.54	4.59	0.10	2.73	1.75	0.14
16	91.09	1.30	7.40	0.20	3.17	2.03	0.14
17	96.47	0.74	2.79	0.00	1.51	1.06	0.15
18	80.08	7.26	11.86	0.80	1.01	1.54	0.11

TABLE 11

Mechanical Analyses of Surface Sands Collected
in Vicinity of Boulougne Ore Body

Spl. No.	Quartz Sand in %	Percent of sand in various size fractions: Very Coarse (2 to 1 mm)	Coarse (1 to 1/2 mm)	Medium (1/2 to 1/4 mm)	Fine (1/4 to 1/8 mm)	Very Fine (1/8 to 1/16 mm)	Mean Grain Size in mm	Approximate Elevation in Feet
1	94.36		0.19	4.92	32.80	62.09	0.14	92
2	95.01		0.21	4.79	48.54	46.46	0.15	93
3	96.33	0.02	0.29	4.39	46.47	48.82	0.15	58
4	51.31	0.39	1.12	3.49	13.19	81.54	0.13	18
5	77.37	0.10	0.28	1.01	8.23	90.38	0.13	21
6	89.71		0.31	5.27	29.60	64.82	0.14	75
7	93.94		0.11	5.20	45.08	49.61	0.15	101
8	94.09		0.15	5.43	45.27	49.15	0.15	101
9	92.91	0.02	0.15	3.35	43.75	52.73	0.15	93
10	91.78	0.17	1.09	8.32	37.93	52.48	0.16	42
11	73.19	0.14	0.52	2.97	14.70	81.67	0.12	22
12	94.19		0.15	2.90	28.78	68.17	0.13	73
13	90.52		0.13	2.27	17.53	80.06	0.12	72
14	91.19	0.02	0.39	8.90	48.68	42.01	0.17	81
15	93.77	0.02	0.15	2.77	36.97	60.09	0.14	83
16	91.09		0.13	2.57	40.22	57.07	0.14	90
17	96.47	0.10	0.64	5.14	38.17	55.95	0.15	40
18	80.08		0.20	0.50	11.63	87.68	0.11	22

TABLE 12

Percentages of Selected Heavy Minerals in 1/8 to 1/16 mm Heavy-Mineral Fraction of Surface Sands Collected in Vicinity of Boulougne Ore Body

Spl.	Leucoxene in %	Ilmenite in %	Epidote in %	Garnet in %
1	12.42	37.27	8.48	0.00
2	12.06	38.24	0.00	0.33
3	1.61	47.74	0.00	0.00
4	8.88	38.68	0.86	0.00
5	8.84	42.99	9.45	0.00
6	21.14	28.29	0.00	0.00
7	33.85	21.54	0.00	0.00
8	32.93	24.17	0.00	0.00
9	16.19	45.08	0.00	0.00
10	25.31	26.56	0.63	0.00
11	7.29	41.40	2.62	0.00
12	18.75	30.06	1.49	0.00
13	20.25	27.53	0.00	0.00
14	19.87	58.94	0.00	0.00
15	31.76	29.87	0.00	0.00
16	11.46	38.85	0.00	0.00
17	4.01	50.62	4.01	0.18
18	4.64	36.07	7.65	0.16

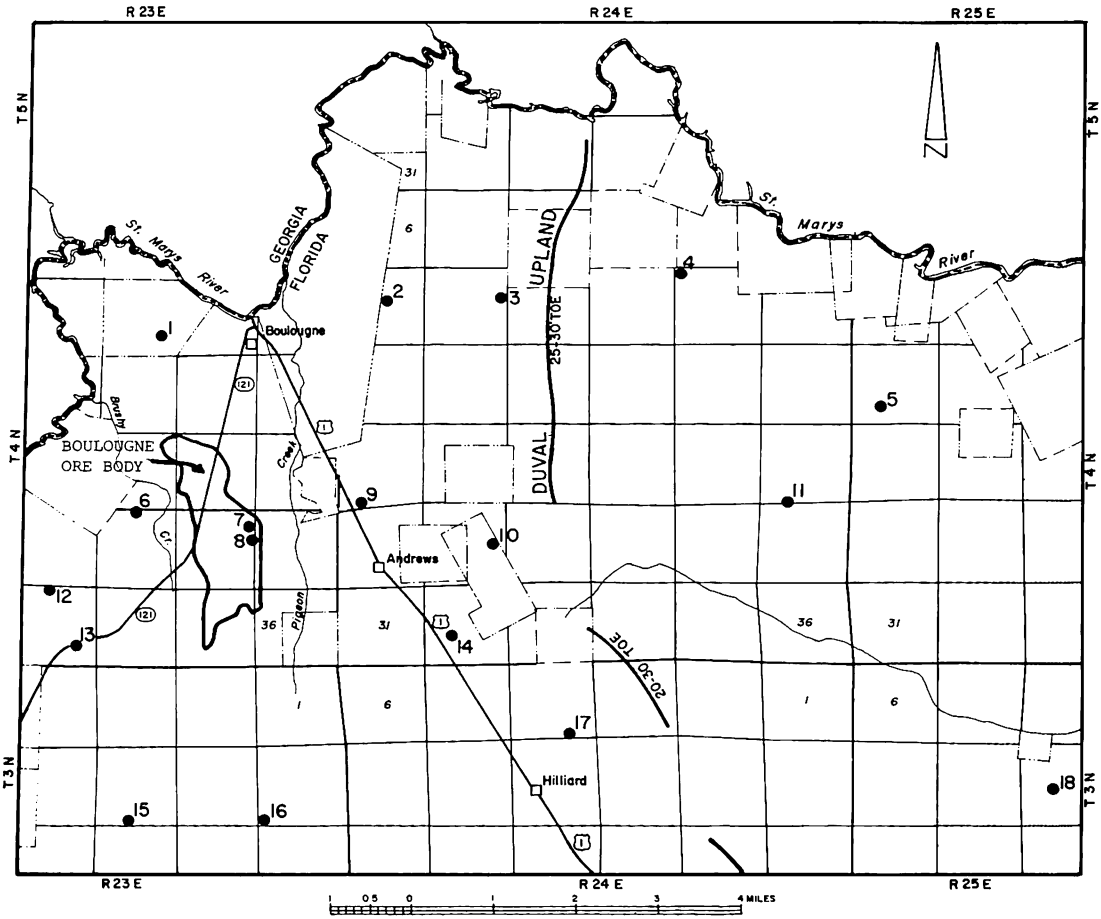

Figure 5. Sample sites of surface sands collected in the vicinity of the Boulougne ore body.

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