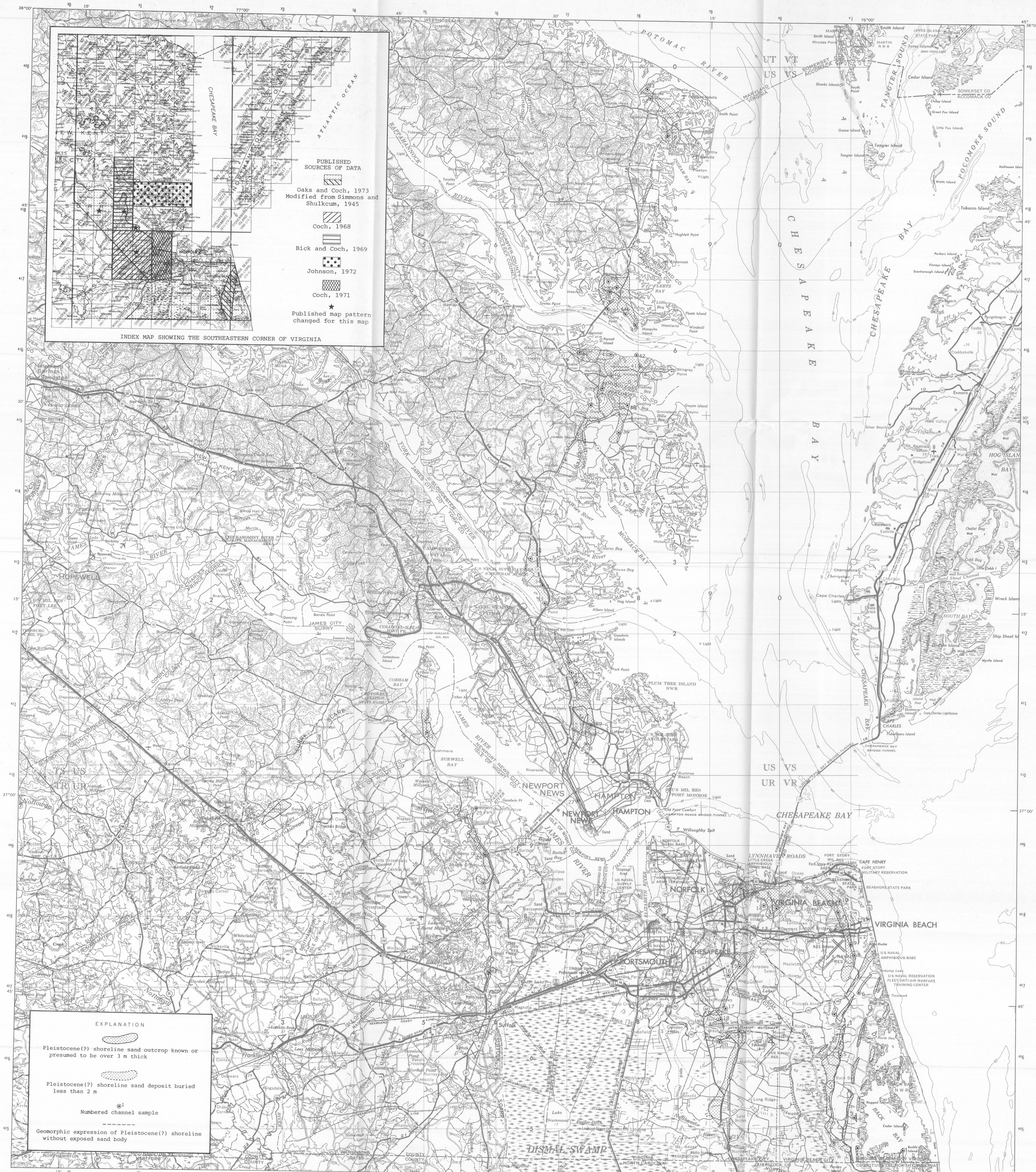

Base by U.S. Geological Survey, 1:250,000, Richmond, Norfolk, Eastville quadrangles

10,000-metre Universal Transverse Mercator grid ticks, zone 18

MAP SHOWING HEAVY MINERALS IN PLEISTOCENE(?) SHORELINE SAND BODIES OF SOUTHEASTERN VIRGINIA

By

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The purpose of this map is to evaluate the possibility of heavy mineral deposits in Pleistocene(?) shoreline sands in southeastern Virginia. Such deposits in Florida are commercial sources of heavy minerals in four mines. Inasmuch as the James River drains an ilmenite-rich terrane, heavy mineral concentrations formed on beaches near its mouth were expected to be high in ilmenite.

PREVIOUS WORK

The work of Oaks and Coch (1973) and Johnson (1972) provides a stratigraphic framework and map pattern for sand deposits formed on Pleistocene shorelines for much of southeastern Virginia. In the preparation of this map, their mapping was extended and modified, and samples were taken and analyzed to estimate heavy mineral resources.

METHOD

Pleistocene(?) shoreline sands in Virginia commonly show strong relict beach morphology. In particular, the steep gradient of the former beach faces, locally called scarps, exemplifies this morphology. Intensive search for beach sand deposits was limited to areas where the morphology suggested their existence and to areas where county soil maps showed soil types with predominant sand in the C horizon. Mapping was accomplished by examining artificial excavations and river banks and by shallow hand augering. Criteria for mapping a deposit as a Pleistocene(?) shoreline sand deposit include 1) the close relation of the deposit to a morphologic feature suggestive of a raised shoreline, 2) the approximate parallelism of the deposit with the present coast, and 3) the predominance of loose well-sorted fine to coarse sand with mostly low-angle crosslamination. Similar deposits with high-angle crossbedding were observed and are believed to be Pleistocene(?) inlet or dune deposits (depending on relations to adjacent shoreline sands). All sandy environments of the shore and barrier complex are probably included in the bodies mapped and sampled.

Most samples collected were from sand pits, large road cuts, and river bluffs. These are continuous channel samples taken from cleaned surfaces. In some of the samples, the lowermost part was taken below the water table.

Heavy minerals were separated without size analysis from samples in a funnel with methylene iodide (sp. gr. = 3.3). Thus the heavy fraction is smaller than would be reported for the same sample separated with bromoform (sp. gr. = 2.85). This was done in order to eliminate noneconomic middle-density minerals. On selected samples (those with relatively high heavy-mineral content or those otherwise geologically interesting), the heavy fraction was further separated with a hand magnet and a Frantz isodynamic magnetic separator into magnetite, ilmenite, and nonmagnetic (at 0.35 - 0.4 A) fractions. Ilmenite was analyzed for TiO_2 content by X-ray fluorescence by J. R. Lindsay of the U.S. Geological Survey. He used standards from locality 36 (see map) that had been analyzed by wet chemical methods by John Marinenko and Leung Mei of the Survey. In two samples, the ilmenite fraction contained garnet and amphibole impurities. The amount of ilmenite was determined by correcting the percentage of the ilmenite magnetic fraction with modal analyses of several size intervals, recalculated to weight percent. The TiO_2 content of ilmenite in these two samples was determined by a similar correction. The amounts of rutile, leucoxene, monazite, and zircon are based on modal analyses of several size intervals of the nonmagnetic fraction. Grains were identified in oils with a petrographic microscope and counted under a binocular microscope. Minimum values for zircon are listed because many grains were indeterminable. Identification of monazite was aided by its absorption of unfiltered mercury-vapor light.

PALEOGEOGRAPHIC RELATIONS

In tables 1 and 2, samples are arranged in approximate order of increasing age. The stratigraphy as discussed by Oaks and Coch (1973) is too complex for detailed discussion here. Little beach sand remains on the Surry scarp, the oldest feature in the area. Sample 54 is from an estuarine(?) shoreline which probably predates the Suffolk scarp. Samples 26 through 53 are from features believed to be spits attached to headlands of older material, which together form fossil winged headlands. The spits are of such large volume with such coarse sand that they were probably formed by a partly open sea. They predate a scarp (roughly of Suffolk-scarp age) which cuts their eastern edge. Sand deposits to the south (samples 22 through 25) associated with the Suffolk scarp are found mostly at the base of that scarp and were formed at the base of a sea cliff. Younger sand deposits (samples 1 through 21) in the Norfolk-Virginia Beach area underlie gentle rises and were apparently formed on barrier islands.

MINERALOGY OF HEAVY FRACTION

Table 2 shows the amount of ilmenite, rutile, leucoxene, monazite and zircon in the heavy mineral concentrates. Other minerals commonly present are garnet, kyanite (1 to 5 percent of concentrate), staurolite, epidote, "limonite," amphibole, and magnetite (0 to 2 percent of concentrate).

The younger deposits (samples 1 through 21) contain much more magnetite, epidote, amphibole, and garnet (and correspondingly less ilmenite) than do the older deposits. Table 2 shows that ilmenite of samples 4 and 20 contains less TiO_2 than does ilmenite in older deposits. The contrast is attributed to in-place weathering (material was principally collected above the water table). The least stable minerals progressively dissolved, and iron was leached out of the ilmenite.

ECONOMIC SIGNIFICANCE

Ilmenite forms a large part of the heavy mineral fraction of the sands. The TiO_2 content of the older sands (51 to 55 percent) is sufficiently high to be considered for pigment manufacture. However, heavy mineral content of channel samples is everywhere below 1.6 percent; none of the samples shows concentrations of heavy minerals as great as those presently mined elsewhere. There is some suggestion that heavy-mineral grade is highest in south-directed spits and the southern segments of barrier islands.

A comparison of these samples (tables 1 and 2) with sand from the Trail Ridge ilmenite mines of Florida (Spencer, 1948, and Pirkle and Yoho, 1970) shows that heavy mineral concentration is much higher in Trail Ridge sand. However, heavy mineral concentrates of sands at Trail Ridge are lower in ilmenite, although higher in rutile, leucoxene, and zircon. Virginia ilmenite is lower in TiO_2 than the more heavily weathered Trail Ridge ilmenite.

Locally, sand volume is comparable to the volume in modern placer mines of titanium minerals. Sand volume is greater in barrier island and spit-type shoreline sands than in sea-cliff-type shoreline sands (for example, the sand body which contains samples 45-50 has about 2×10^8 m^3 of sand whereas that containing samples 23-25 has about 3×10^7 m^3).

Sand itself has a considerable value and is mined in parts of the area. The map can be used as a guide to sand resources of the area, although Pleistocene(?) beach sand is probably not the only type of sand resource present.

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Table 1.--Description of samples

Sample number	Sand thickness (metres)	Sample interval (metres)	Heavy mineral content (percent, sp. gr. >3.3)
1 1/	~9.1	3.0-7.6	0.21
2 1/	~9.1	3.0-7.6	0.29
3 1/	~7.6	3.0-7.6	0.23
4	2.6	0.6-2.6	0.52
5 1/	~6.1	3.0-6.1	0.23
6	>4.6	0.9-4.6	0.51
7	1.2-10?	1.2-4.3	0.21
8	7.5?	0.4-4.7	0.14
9	>6.3	0.5-6.3	<0.1
10	>4.0	1.2-4.0	<0.1
11	>2.6	0.9-2.6	<0.1
12	>2.8	0.8-2.8	0.23
13	>2.1	0.3-2.1	0.24
14	5.1	0.4-3.9	0.32
15	8.4	0.4-8.4	0.33
16	1.2->3.5	1.2-3.5	0.31
17	0.6->2.4	0.6-2.4	0.35
18	>4.8	0.9-4.8	0.56
19	>3.4	0.4-3.4	0.34
20	>4.8	0.6-4.8	0.42
21	1.4-3.4	1.4-3.4	0.49
22	5.1	0.4-3.9	0.32
23	>2.5	0.3-1.9	1.03
24	2.9	0.3-2.9	0.18
25	3.2	1.0-3.2	0.69
26	>6.5	0.9-2.8	0.66
27	>6.3	1.5-6.3	0.23
28	2.3	0.6-2.3	0.65
29	2.5	0.5-2.5	1.55
30	2.2	0-2.2	<0.1
31	5?	0-4.1	0.21
32	5?	1.0-3.2	0.48
33	>2.7	0.2-2.7	1.28
34	>3.2	0.8-3.2	0.98
35	>4.0	0.7-4.0	0.86
36	3.2	1.0-3.2	0.69
37	7.2	0.3-6.4	1.02
38	>4.1	0.8-4.1	0.14
39	4.9	0.4-2.2	0.24
40	>8.5	0.6-2.6, 5.5-8.5	0.37
41	0.9->3.9	0.9-3.9	0.31
42	>3.4	1.2-3.4	<0.1
43	>3.2	0.9-3.2	0.24
44	>4.1	0.9-4.1	0.26
45	>4.8	1.2-4.8	0.85
46	>10.2	0.3-10.2	0.26
47	12.8	1.8-12.8	1.49
48	>2.8	0.9-2.8	0.18
49	>5.4	1.2-5.4	0.44
50	>3.8	0.6-3.8	0.20
51	>7.2	0.9-7.2	0.34
52	>4.0	0.9-4.0	0.21
53	>2.9	0.9-2.9	0.24
54	6.9	0.8-6.9	0.97
Average of Trail Ridge, Fla., samples	~10		~4

1/ Sample from Virginia Division of Mineral Resources, Charlottesville, Va.

Table 2.--Economic mineralogy of samples

Sample number	Ilmenite (percent concentrate)	TiO_2 content of ilmenite (percent)	Red rutile (percent concentrate)	Leucoxene (percent concentrate)	Monazite (percent concentrate)	Minimum zircon (percent concentrate)
4	50 1/	45.7 1/	ND 2/	ND	ND	ND
20	48 1/	46.1 1/	ND	ND	ND	ND
23	66	54.5	1	2	T	1
25	73	ND	ND	ND	ND	ND
26	66	ND	1	2	T	3
29	71	51.7	1	1	T	3
32	63	ND	ND	ND	ND	ND
33	66	55.4	1	1	T	2
34	61	ND	1	3	T	1
35	65	51.8	1	1	T	1
36	ND	52	ND	ND	ND	ND
37	71	ND	T	3	T	2
45	70	52.8	1	1	T	2
47	69	51.1	1	2	T	1
49	65	ND	ND	ND	ND	ND
51	61	ND	ND	ND	ND	ND
54	79	53.6	T	T	T	1
Average of Trail Ridge, Fla., samples	~40	~64	~2	~5	~0	~15

1/ Corrected for impurities in ilmenite magnetic fraction using modal analysis.

2/ Abbreviations used in table: T, trace (<0.5 percent); ND, not determined.

Interior—Geological Survey, Reston, Virginia—1975

For sale by U.S. Geological Survey, price 50 cents