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Preliminary grain-size and mineralogic analyses of vibracore samples from the Inner Continental Shelf offshore of Cape Canaveral, Florida

by

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INTRODUCTION

As part of a larger effort to assess the mineral resource potential of U.S. Exclusive Economic Zone sediments, grain-size distribution and mineralogic components and concentrations were determined for samples taken from 40 vibracores that were collected from the Inner Continental Shelf offshore of Cape Canaveral, Florida (fig.1). These data will be used to determine the sand, gravel, and heavy-mineral resource potentials of the offshore sediments. The vibracores were initially collected by the U.S. Army Corps of Engineers as part of a sand and gravel inventory program of the U.S. Atlantic Continental Shelf (Field and Duane, 1974).

The Inner Continental Shelf offshore of Cape Canaveral, Florida is mantled by areally and volumetrically extensive sand shoals formed by cape retreat processes (Duane and others, 1972). These shoals (fig. 1) may be potential sources of sediment for beach replenishment, maintenance and reclamation. Based on data presented in this report, these sediments may also be a source of strategic and critical heavy-minerals (including ilmenite, rutile, zircon, and monazite) as well as other heavy-mineral species of lesser economic importance (such as garnet, staurolite, sillimanite, kyanite, andalusite, and sedimentary phosphate).

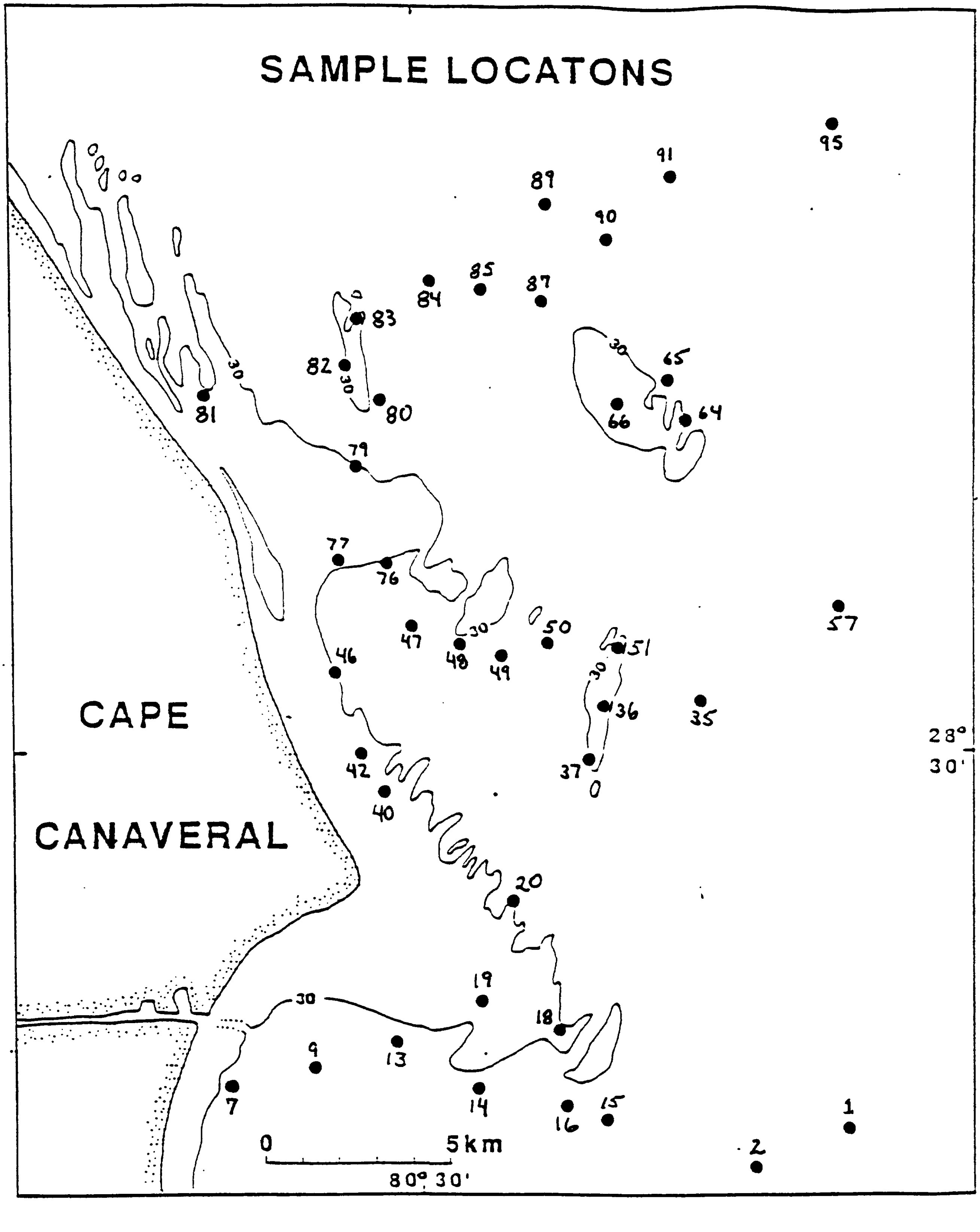

Figure 1. Map showing the locations of vibracore samples offshore of Cape Canaveral, Florida. The closed 30-foot depth contour lines generally outline shoal areas.

METHODS

The 40 vibracores, 11.4 cm diameter and about 3 m average length, were initially split lengthwise, then described, photographed, and sampled for dateable material (e.g. peat, shells), component analyses, and repository samples. A total of 71 samples (Appendix I) were collected from the 40 vibracores on the basis of lithology, or at intervals no greater than 238 cm where the sediment appeared to be uniform throughout the length of the core. The lengths of individual samples varied from 46 to 238 cm (Appendix I). These samples were then split into repository subsamples, each of approximately 300-500 grams dry weight, and subsamples for component analyses, each between 2,928 to 18,672 grams (average about 10,000 grams) dry weight. The gravel fractions (>2.00 mm size-fraction) from these latter subsamples were removed with a 10-mesh U.S. Standard stainless steel sieve, and were weighed and described. The heavy-mineral components of the <2.00 mm size-fractions were concentrated using a three-turn sampling spiral; 200-300 gram aliquots of sediment rejected by the spiral were examined to determine the amount and phases of heavy minerals not recovered by this technique. The heavy-mineral concentrates generated by the sampling spiral were further purified using tetrabromoethane (specific gravity of 2.96). These concentrates were split into three representative fractions: 12.5 volume percent for repository, 12.5 volume percent for chemical analyses, and 75 volume percent for mineralogic analyses. The splits retained for mineralogic analyses were further separated into 6 magnetic fractions, with Frantz Laboratory Magnetic Barrier Separator[1], to facilitate identification and quantification of

[1] Use of trade names does not constitute endorsement; use is strictly for descriptive purposes.

the various heavy minerals present. Each of the magnetic fractions was examined using a binocular microscope, comparison charts (e.g. Terry and Chillingar, 1955), and a modified point-counting technique, to visually estimate mineral abundances. Optical examination of nonopaque minerals with a petrographic microscope was used to verify the identification of nonopaque minerals.

RESULTS AND DISCUSSION

The data collected are summarized in Appendix I. Samples are numbered according to location (fig. 1) and position in the vibracore:.0 refers to the entire core (a short one, commonly less than 1.5 m), .1 refers to the top section of a core (commonly the upper 1.5 m section),.2 refers to the lower, or bottom section of a core. The initial dry weight of each subsample (after removal of repository subsample) is given in grams. The weight percent gravel (>2.00 mm fraction) was calculated on a dry-weight basis, and components of the gravel fraction are expressed as weight percentages of the gravel fraction. The weight percentage of recovered heavy minerals (RHM) is calculated on the basis of the spiral concentrate/heavy-liquid process only. THM (total heavy minerals) weight percentage was calculated on the basis of data obtained from heavy minerals in the aliquots (200-300 g) of sediment taken from the materials rejected by the spiral concentrator and from the heavy minerals recovered by the spiral/heavy-liquid method. The recovery percentage of heavy minerals (spiral efficiency) was calculated on the basis of THM and RHM values. The percentage of magnetite, ilmenite, epidote, tourmaline, garnet, staurolite, others, phosphate, pyroboles, sulfides, zircon, aluminosilicates (sillimanite, kyanite, and andalusite), monazite, and rutile are expressed as approximate percentages of the RHM; the densities of the different phases were not taken into account in the calculations.

Analyses of the heavy minerals rejected by the spiral concentrator have not yet been completed, therefore a rigorous assessment of the heavy-mineral resource potential for the sediments offshore of Cape Canaveral is not yet possible. A preliminary assessment of the potential for heavy minerals is given by the weight % EHM/C (EHM/C is defined as the sum of estimated weight percentages of ilmenite + monazite + rutile + zircon in the RHM). These data (Appendix I) indicate that of the heavy-mineral species present approximately 40 percent by weight are of economic value.

CONCLUSIONS

Preliminary results indicate the gravel fraction is dominated by shells and shell fragments. The heavy-mineral assemblage in the subgravel fraction is qualitatively and quantitatively different from those found off the coasts of Virginia (Grosz and Escowitz, 1983; Berquist and Hobbs, 1988), New York, New Jersey, and South Carolina (Grosz and others, 1988), and Maine (Luepke and Grosz, 1986). Preliminary geochemical analyses of heavy-mineral concentrates show that rare-earth elements and silver are present in quantities greater than those found in similarly prepared samples from elsewhere along the Atlantic Continental Shelf.

THM concentrations for the Cape Canaveral area are low, averaging 0.36 weight percent. The composition of the heavy-mineral assemblage is suggestive of a potential for resources; ongoing studies seek to outline areas of high concentration for additional sampling.

The samples collected from the major sand shoals contain relatively low percentages of mud and gravel; these sands may be suitable for beach nourishment and reclamation use.

ACKNOWLEDGMENTS

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APPENDIX I

Table showing locations of samples, composition of gravel fractions,
and heavy-mineral content and composition
for sediments offshore of Cape Canaveral, Florida

Explanation of superscripts for Appendix I

1 Sample numbers correspond to sample locations in Figure 1
Sample number modifiers: .0 indicates entire core
.1 indicates upper (top) section of a core
.2 indicates lower (bottom) section of a core

2 CERC No.: U.S. Army Corps of Engineers (Field and Duane, 1974) core number

3 Gravel fraction: Components expressed as a weight percentage of the gravel fraction. P = present, less than 1.0 weight percent

4 Heavy-mineral (HM) recovery %: Recovered heavy minerals (RHM) as a percentage of total heavy minerals (THM). HM recovery is a measure of the efficiency of the spiral concentrator

5 Defined on the basis of magnetic susceptibility, luster, and streak. Nd = none determined, T = trace (<0.5 wt. %), P = present (0.5-1.0 wt. %)

6 Undifferentiated pyroxene and amphibole

7 Aluminosilicates: sillimanite, kyanite, and andalusite

8 Economic heavy minerals (EHM = the sum of weight percentages of ilmenite + monazite + rutile + zircon) expressed as a percentage of RHM

SAMPLE NUMBER [1]	CERC NO. [2]	LATITUDE NORTH (degrees)	LONGITUDE WEST (degrees)	SECTION LENGTH (cm)	BULK SAMPLE WT (g)	WT% GRAVEL
1.1	107	28.37096	80.33040	157	8661	22.88
1.2	107	28.37096	80.33040	137	7841	12.21
2.1	108	28.35790	80.36950	131	9371	13.79
2.2	108	28.35790	80.36950	135	9354	23.79
7.1	110	28.38500	80.57700	215	10454	8.32
7.2	110	28.38500	80.57700	194	14522	15.67
9.1	109A	28.39288	80.54380	168	6491	1.32
9.2	109A	28.39288	80.54380	198	8934	4.82
13.1	194	28.40066	80.51090	195	10144	2.77
13.2	194	28.40066	80.51090	154	8736	1.66
14.0	101	28.38515	80.47730	238	13899	6.72
15.0	192	28.37344	80.42780	160	7996	8.52
16.1	193	28.37828	80.44390	165	8231	2.49
16.2	193	28.37828	80.44390	146	8654	10.72
18.1	114	28.40561	80.44550	167	11844	3.88
18.2	114	28.40561	80.44550	180	13244	5.30
19.1	102	28.41437	80.47710	164	12574	21.33
19.2	102	28.41437	80.47710	160	11749	3.45
20.1	123	28.44996	80.46490	178	13424	19.70
20.2	123	28.44996	80.46490	128	10209	7.18
35.1	118	28.51752	80.38880	114	8226	3.57
35.2	118	28.51752	80.38880	125	8226	21.80
36.1	176	28.51423	80.42800	212	11139	3.89
36.2	176	28.51423	80.42800	211	18672	8.75
37.1	122	28.49636	80.43330	183	13299	1.74
40.0	124	28.48624	80.51410	174	11319	7.01
42.1	125	28.49930	80.52300	149	10434	8.30
42.2	125	28.49930	80.52300	138	7951	7.73
46.1	126	28.52759	80.53380	159	8381	0.73
46.2	126	28.52759	80.53380	154	7316	3.87
47.1	129	28.54242	80.50350	149	8791	13.45
47.2	129	28.54242	80.50350	150	9036	24.34
48.1	164	28.53741	80.48320	173	13854	4.20
48.2	164	28.53741	80.48320	126	9251	1.91
49.1	130	28.53331	80.46760	139	8256	5.32
49.2	130	28.53331	80.46760	144	9381	6.15
50.0	175	28.53719	80.44870	158	9424	0.89
51.1	150	28.53574	80.42160	117	8431	4.15
51.2	150	28.53574	80.42160	121	6786	3.76
57.1	120	28.55056	80.33330	154	9236	1.43
57.2	120	28.55056	80.33330	131	7801	10.64
64.1	147	28.61413	80.39410	174	10849	15.28
64.2	147	28.61413	80.39410	170	12129	19.62

SAMPLE NUMBER [1/]	CERC NO. [2/]	LATITUDE NORTH (degrees)	LONGITUDE WEST (degrees)	SECTION LENGTH (cm)	BULK SAMPLE WT (g)	WT% GRAVEL
65.0	146	28.62803	80.40004	125	8031	14.26
66.1	139	28.61887	80.42040	215	14967	3.41
66.2	139	28.61887	80.42040	215	14014	11.15
76.1	165	28.56380	80.51280	191	14762	3.56
76.2	165	28.56380	80.51280	149	10929	3.61
77.1	166	28.56517	80.53220	206	14214	4.54
77.2	166	28.56517	80.53220	194	14162	4.50
79.1	159	28.59793	80.52430	160	10789	8.11
79.2	159	28.59793	80.52430	181	12399	16.68
80.1	169	28.61995	80.51480	159	10174	3.84
80.2	169	28.61995	80.51480	142	8931	21.55
81.1	158	28.62225	80.58280	150	9984	2.90
81.2	158	28.62225	80.58280	145	9749	31.03
82.1	157	28.63113	80.52740	148	11259	13.28
82.2	157	28.63113	80.52740	129	9321	4.24
83.1	156	28.64940	80.52300	140	8621	4.91
83.2	156	28.64940	80.52300	226	14897	28.42
84.1	170	28.66197	80.49440	142	9784	45.22
84.2	170	28.66197	80.49440	137	9834	29.51
85.0	155	28.65940	80.47290	205	14927	14.65
87.1	138	28.65493	80.44920	179	13059	33.75
87.2	138	28.65493	80.44920	182	13244	31.06
89.1	136	28.68740	80.44770	136	9884	33.69
89.2	136	28.68740	80.44770	168	13756	17.61
90.0	135	28.67579	80.42580	187	13004	26.51
91.1	134	28.69793	80.39890	182	14882	14.43
91.2	134	28.69793	80.39890	162	11419	6.64
95.0	132	28.71640	80.33480	46	2928	0.85

COMPOSITION OF THE GRAVEL FRACTION 3/

SAMPLE NUMBER	WHOLE SHELL 20-80 mm	WHOLE SHELL 4-20 mm	WHOLE SHELL 2-4 mm	SHELL FRGMNTS 20-80 mm	SHELL FRGMNTS 4-20 mm	SHELL FRGMNTS 2-4 mm
1.1	P	P	P	P	55	40
1.2		5	5	P	40	30
2.1	P	10	5	P	50	30
2.2	P	5	5	5	30	30
7.1		5	P	P	60	20
7.2	P	5	P	P	50	40
9.1	P	20	P	P	50	20
9.2	5	25	5	15	30	15
13.1	P	5	P	5	10	P
13.2	P	15	P	30	35	5
14.0	P	20	5	5	35	25
15.0	P	15	10		25	30
16.1	P	15	P	P	35	15
16.2	P	10	P	P	60	20
18.1	P	10	5	P	40	40
18.2	P	20	10	P	35	30
19.1	P	10	P	P	70	15
19.2		10	5	P	45	35
20.1	P	5	P	P	50	40
20.2	5	25	15	5	25	20
35.1	P	10	5	P	55	25
35.2	P	15	P	P	55	25
36.1	P	20	P	P	65	10
36.2	P	15	P	P	60	20
37.1	P	30	5	P	40	20
40.0	P	5	P	P	75	15
42.1		10	P	P	65	20
42.2		5	P	P	40	35
46.1	P	15	P	15	40	15
46.2	P	15	P	P	50	30
47.1	P	20	5	P	50	20
47.2	P	10	5	5	60	15
48.1	P	15	P		60	15
48.2	P	15	5	P	35	40
49.1	P	5	P	P	75	15
49.2	P	5	P	P	45	40
50.0		15	P		30	50
51.1	P	5	P	P	40	50
51.2	P	15	15	P	35	30
57.1		5	5	P	70	15
57.2	5	10	5	P	30	15
64.1	P	P	P	P	55	40
64.2	P	P	P	P	15	15

COMPOSITION OF THE GRAVEL FRACTION [3/]

SAMPLE NUMBER	WHOLE SHELL 20-80 mm	WHOLE SHELL 4-20 mm	WHOLE SHELL 2-4 mm	SHELL FRGMNTS 20-80 mm	SHELL FRGMNTS 4-20 mm	SHELL FRGMNTS 2-4 mm
65.0	P	5	P	P	50	20
66.1	P	5	P	P	60	30
66.2	P	15	5	P	50	25
76.1	P	20	15	P	35	25
76.2	P	25	20	P	30	20
77.1	P	5	P	P	60	30
77.2	P	20	5	5	35	30
79.1	P	5	P	P	50	40
79.2	P	35	5	P	35	20
80.1	P	15	5	P	40	30
80.2		P	P	5	65	25
81.1	P	30	5	P	35	25
81.2	P	10	P	P	45	40
82.1	P	10	P	P	50	35
82.2	5	10	5	5	40	30
83.1	P	15	5	P	45	30
83.2	P	P	P	P	70	15
84.1	P	5	P	P	45	40
84.2	P	P	P	P	15	10
85.0	P	10	P	P	55	15
87.1	P	10	P	P	50	30
87.2	P	15	P	P	60	20
89.1	P	5	P	P	45	40
89.2	P	5	P	P	35	35
90.0	P	P	P	5	40	40
91.1	P	5	P	P	50	40
91.2	P	15	10	P	30	20
95.0		P	P	P	30	65

COMPOSITION OF THE GRAVEL FRACTION[3]

SAMPLE NUMBER	LITHIC FRGMNTS 20-80 mm	LITHIC FRGMNTS 4-20 mm	LITHIC FRGMNTS 2-4 mm	QUARTZ 1-2 mm	OTHERS
1.1	P	P	P		5
1.2		10	5		5
2.1		P	P		5
2.2	10	5	5		5
7.1		10	P		5
7.2	P	P	P		5
9.1		5	P		5
9.2	P	P	P		5
13.1		5	70		5
13.2			10		5
14.0		5	P		5
15.0	P	5	10		5
16.1		P	30		5
16.2		P	5		5
18.1			P		5
18.2		P	P		5
19.1					5
19.2		P	P		5
20.1					5
20.2	P	P			5
35.1		P	P		5
35.2	P	P	P		5
36.1					5
36.2		P	P		5
37.1					5
40.0		P	P		5
42.1		P	P		5
42.2	P	5	10		5
46.1			10		5
46.2					5
47.1		P	P		5
47.2					5
48.1		5	P		5
48.2		P	P		5
49.1	P	P	P		5
49.2	P	5	P		5
50.0					5
51.1					5
51.2					5
57.1			P		5
57.2		15	15		5
64.1	P	P	P		5
64.2	20	30	15		5

COMPOSITION OF THE GRAVEL FRACTION [3/]

SAMPLE NUMBER	LITHIC FRGMNTS 20-80 mm	LITHIC FRGMNTS 4-20 mm	LITHIC FRGMNTS 2-4 mm	QUARTZ 1-2 mm	OTHERS
65.0	P	20	P		5
66.1					5
66.2		P	P		5
76.1		P	P		5
76.2		P	P		5
77.1		P	P		5
77.2					5
79.1	P	P			5
79.2					5
80.1		P	5		5
80.2		P			5
81.1		P			5
81.2		P	P		5
82.1					5
82.2		P	P		5
83.1					5
83.2	P	10	P		5
84.1	P	5	P	P	5
84.2	20	40	10		5
85.0		5	10		5
87.1		5	P		5
87.2	P	P	P		5
89.1	P	5	P		5
89.2	P	15	5		5
90.0	P	5	5		5
91.1		P	P		5
91.2		10	10		5
95.0					5

SAMPLE NUMBER	WEIGHT % RHM	WEIGHT % THM	HM RECOVERY %[4/]
1.1	0.10	0.11	92.81
1.2	0.11	0.13	83.80
2.1	0.13	0.14	89.78
2.2	0.15	0.21	74.32
7.1	0.12	0.30	41.39
7.2	0.02	0.03	70.66
9.1	0.52	0.62	82.83
9.2	0.05	0.14	32.67
13.1	0.65	1.61	40.13
13.2	0.32	1.12	28.79
14.0	0.34	0.52	66.23
15.0	0.15	0.16	88.68
16.1	0.26	0.45	57.82
16.2	0.14	0.27	50.96
18.1	0.07	0.08	83.80
18.2	0.12	0.14	87.60
19.1	0.09	0.10	88.66
19.2	0.15	0.17	86.29
20.1	0.09	0.11	86.91
20.2	0.18	0.20	88.78
35.1	0.07	0.12	56.30
35.2	0.26	0.37	72.25
36.1	0.10	0.14	70.79
36.2	0.09	0.13	68.26
37.1	0.08	0.12	68.16
40.0	1.09	1.38	78.98
42.1	0.71	0.92	77.07
42.2	0.87	1.05	83.22
46.1	0.37	0.68	54.11
46.2	0.13	0.24	52.59
47.1	0.56	0.82	67.69
47.2	0.24	0.26	92.35
48.1	0.18	0.21	86.41
48.2	0.17	0.19	93.05
49.1	0.43	1.16	37.06
49.2	0.54	0.98	55.21
50.0	0.24	0.29	82.87
51.1	0.18	0.21	83.99
51.2	0.09	0.10	94.26
57.1	0.41	0.60	68.52
57.2	0.33	0.43	76.77
64.1	0.20	0.23	87.48
64.2	0.26	0.37	69.48

SAMPLE NUMBER	WEIGHT % RHM	WEIGHT % THM	HM RECOVERY % [1/]
65.0	0.13	0.15	85.61
66.1	0.08	0.09	88.45
66.2	0.14	0.14	100.00
76.1	0.20	0.22	89.37
76.2	0.35	0.60	58.22
77.1	0.36	0.39	92.64
77.2	0.14	0.18	78.89
79.1	0.50	0.51	97.79
79.2	0.32	0.35	92.65
80.1	0.39	0.54	71.48
80.2	0.20	0.22	90.85
81.1	0.28	0.34	81.69
81.2	0.13	0.27	46.87
82.1	0.12	0.14	91.61
82.2	0.20	0.22	94.30
83.1	0.25	0.26	96.88
83.2	1.10	1.48	74.09
84.1	0.08	0.12	60.60
84.2	0.16	0.21	75.21
85.0	0.13	0.14	92.74
87.1	0.05	0.08	63.98
87.2	0.04	0.08	57.16
89.1	0.09	0.10	90.57
89.2	0.13	0.14	88.81
90.0	0.09	0.14	65.58
91.1	0.06	0.11	54.35
91.2	0.15	0.21	68.89
95.0	0.15	0.19	77.34

SAMPLE NUMBER	MAGNETITE %	ILMENITE %	EPIDOTE %	TOURMALINE %	GARNET %	STAUROLITE %
1.1	Nd	21.76	37.46	3.05	5.68	2.54
1.2	T	20.68	38.56	2.89	5.64	3.03
2.1	T	21.39	38.21	3.26	4.70	2.93
2.2	Nd	26.89	33.72	3.00	2.17	2.07
7.1	T	17.28	42.36	2.01	2.11	2.15
7.2	Nd	12.15	40.08	3.31	3.79	6.77
9.1	P	24.55	31.84	1.47	0.73	1.09
9.2	P	24.32	27.93	2.20	3.62	1.87
13.1	Nd	29.67	32.26	2.08	0.66	0.86
13.2	Nd	32.99	30.79	2.55	0.76	1.19
14.0	Nd	29.82	31.76	2.10	2.76	2.31
15.0	Nd	25.74	35.25	3.56	4.47	2.99
16.1	Nd	29.22	23.48	2.79	1.17	1.20
16.2	Nd	32.70	32.26	2.57	2.87	2.21
18.1	P	22.92	37.33	3.57	3.83	3.20
18.2	T	18.02	42.86	4.02	4.91	4.84
19.1	T	26.94	34.07	3.03	4.62	2.81
19.2	T	19.64	40.51	3.12	3.67	2.76
20.1	Nd	28.30	28.05	2.93	7.12	3.98
20.2	Nd	27.26	26.14	2.76	7.58	6.84
35.1	Nd	29.07	31.57	4.22	2.95	6.04
35.2	T	26.31	33.01	2.65	1.55	3.24
36.1	Nd	26.35	21.04	4.91	5.86	12.16
36.2	Nd	30.52	19.00	4.92	6.87	10.66
37.1	P	15.65	31.44	6.66	6.52	13.54
40.0	Nd	31.00	34.83	1.05	1.34	2.06
42.1	Nd	33.58	27.18	0.85	1.06	1.56
42.2	Nd	30.72	29.83	1.27	0.33	2.06
46.1	Nd	30.22	31.48	0.67	0.70	0.98
46.2	Nd	26.36	33.61	0.96	1.72	1.33
47.1	Nd	25.82	32.16	2.57	1.71	2.53
47.2	P	22.60	31.10	3.60	2.16	3.59
48.1	Nd	28.98	18.69	5.73	5.08	12.00
48.2	Nd	28.22	30.73	4.24	1.39	4.22
49.1	Nd	31.76	25.83	2.60	2.31	2.40
49.2	Nd	26.63	32.94	3.33	2.16	2.67
50.0	Nd	23.13	28.31	5.27	2.02	7.02
51.1	Nd	26.02	17.84	6.04	6.20	13.65
51.2	Nd	18.92	24.16	9.21	3.20	9.44
57.1	T	25.96	34.48	1.02	1.03	1.90
57.2	T	25.22	33.06	1.28	0.99	2.29
64.1	Nd	30.88	26.12	4.29	2.94	3.47
64.2	Nd	25.66	30.16	3.24	1.33	3.02

SAMPLE NUMBER	MAGNETITE %	ILMENITE %	EPIDOTE %	TOURMALINE %	GARNET %	STAUROLITE %
65.0	P	25.70	32.28	3.77	3.48	6.08
66.1	Nd	23.66	15.56	7.00	8.47	14.98
66.2	Nd	23.91	15.27	7.96	9.39	14.94
76.1	Nd	24.63	22.97	6.35	2.41	12.51
76.2	Nd	33.61	23.07	2.96	1.86	3.73
77.1	Nd	30.59	16.35	5.28	5.91	9.63
77.2	Nd	25.70	21.52	6.06	4.18	10.79
79.1	Nd	35.53	30.61	3.01	1.11	2.89
79.2	Nd	31.56	22.13	3.95	4.25	5.68
80.1	Nd	33.00	25.43	1.45	1.52	2.31
80.2	Nd	29.88	26.74	3.36	4.05	6.02
81.1	Nd	31.30	30.97	2.35	0.91	1.97
81.2	Nd	31.38	31.28	2.01	2.55	2.52
82.1	Nd	23.06	32.04	4.90	3.29	4.49
82.2	Nd	25.71	32.17	4.17	2.72	5.97
83.1	Nd	27.99	30.03	3.20	2.34	4.53
83.2	Nd	36.78	19.05	5.46	9.13	9.45
84.1	Nd	27.98	32.09	3.32	4.82	3.51
84.2	Nd	28.19	32.80	3.47	4.19	3.46
85.0	Nd	23.85	31.79	3.20	4.87	6.25
87.1	Nd	24.96	29.28	3.66	5.96	5.09
87.2	Nd	24.52	33.09	3.28	5.70	2.97
89.1	T	26.10	30.45	3.77	6.85	4.99
89.2	T	21.87	36.69	3.32	4.85	3.56
90.0	T	24.80	33.23	3.38	6.16	3.39
91.1	Nd	21.73	35.60	3.00	7.01	5.37
91.2	T	20.16	36.32	2.38	6.26	2.96
95.0	Nd	22.99	34.17	3.20	2.49	3.53

SAMPLE NUMBER	OTHERS %	PHOSPHATE %	PYROBOLES[6] %	SULFIDES %	ZIRCON %	ALSIL[7] %
1.1	4.99	0.23	4.61	0.00	6.35	10.71
1.2	5.37	0.43	4.51	0.00	6.74	10.01
2.1	4.68	0.03	4.58	0.00	6.32	11.63
2.2	3.91	0.08	7.88	0.00	4.42	14.09
7.1	2.05	0.53	13.08	0.00	7.54	9.33
7.2	3.71	0.80	7.15	0.00	9.83	10.59
9.1	2.41	0.00	13.90	0.00	5.14	16.92
9.2	2.79	0.00	10.40	0.00	7.11	17.95
13.1	2.34	0.12	11.47	0.00	6.49	11.88
13.2	2.23	0.05	5.20	0.00	6.43	15.43
14.0	1.60	0.04	5.63	0.00	7.17	13.27
15.0	3.86	0.04	3.89	0.00	4.11	12.65
16.1	3.03	0.05	2.77	0.00	9.59	23.04
16.2	3.10	0.00	3.98	0.00	6.17	10.99
18.1	3.16	0.25	3.45	0.00	7.25	11.83
18.2	3.10	0.03	4.19	0.00	4.08	10.80
19.1	2.07	0.00	2.65	0.00	7.60	12.38
19.2	2.62	0.30	4.58	0.00	5.17	14.21
20.1	2.65	1.34	2.91	0.00	11.50	8.71
20.2	4.23	0.37	3.09	0.00	9.10	10.59
35.1	2.86	1.44	4.69	0.00	7.48	7.47
35.2	2.38	1.49	8.61	0.00	9.00	9.51
36.1	3.38	1.24	2.28	0.00	9.60	5.55
36.2	3.26	0.87	2.69	0.00	8.98	5.27
37.1	5.18	1.03	5.18	0.00	4.84	5.71
40.0	1.83	0.91	7.28	0.00	8.63	7.87
42.1	2.40	0.79	5.42	0.00	16.12	8.29
42.2	3.71	0.75	7.25	0.08	8.99	12.86
46.1	3.88	1.26	9.73	0.16	9.32	9.85
46.2	5.06	1.08	10.51	1.23	7.98	7.90
47.1	1.92	2.28	10.50	0.00	9.32	8.53
47.2	2.92	2.60	11.77	0.00	7.84	9.54
48.1	1.64	0.99	2.32	0.00	12.16	7.29
48.2	1.37	2.80	4.67	0.00	11.23	7.86
49.1	2.24	1.95	2.39	0.00	10.96	15.80
49.2	1.59	2.11	7.99	0.28	8.53	9.15
50.0	1.38	3.43	8.42	0.00	9.34	8.02
51.1	4.17	0.80	2.45	0.00	7.02	10.06
51.2	2.89	2.65	5.94	0.00	7.97	12.54
57.1	1.55	1.54	10.93	0.00	9.70	9.44
57.2	1.96	1.43	14.58	0.00	8.26	8.73
64.1	3.37	2.67	4.00	0.00	8.36	11.31
64.2	2.53	2.36	9.94	0.00	8.43	11.06

SAMPLE NUMBER	OTHERS %	PHOSPHATE %	PYROBOLES[6] %	SULFIDES %	ZIRCON %	ALSIL[7] %
65.0	2.02	1.77	4.55	0.00	7.05	10.28
66.1	5.64	1.60	2.33	0.00	5.72	8.65
66.2	5.69	1.11	1.96	0.00	5.93	6.08
76.1	1.71	1.83	3.65	0.00	11.77	7.77
76.2	1.85	2.48	2.19	0.00	16.09	9.49
77.1	1.95	1.13	2.11	0.00	10.79	7.88
77.2	1.66	1.63	3.50	0.00	12.47	8.71
79.1	1.52	1.62	2.94	0.00	10.14	8.26
79.2	1.95	1.02	4.24	0.00	11.14	7.87
80.1	2.90	1.93	3.91	0.00	14.46	10.43
80.2	2.94	0.61	4.34	0.33	11.14	6.37
81.1	1.99	1.69	6.80	0.00	8.06	11.83
81.2	1.84	1.07	7.27	0.00	7.80	8.76
82.1	2.43	1.61	5.35	0.00	7.79	12.59
82.2	2.56	0.60	5.72	0.00	8.28	8.99
83.1	2.56	0.81	6.19	0.00	8.03	10.75
83.2	2.12	0.58	2.65	0.00	4.41	6.76
84.1	2.30	0.70	4.97	0.00	9.31	8.55
84.2	2.41	1.14	5.02	0.00	10.52	6.12
85.0	2.50	1.14	6.50	0.00	6.84	10.13
87.1	3.23	0.65	2.98	0.00	13.37	7.62
87.2	3.07	0.52	3.99	0.00	10.63	9.56
89.1	4.16	0.55	3.05	0.00	10.97	6.47
89.2	3.31	0.81	7.15	0.00	7.96	8.20
90.0	2.87	1.03	4.54	0.00	10.19	7.96
91.1	2.66	0.23	3.74	0.00	6.20	11.70
91.2	4.09	0.44	8.50	0.00	6.05	10.28
95.0	1.85	0.26	12.96	0.00	7.61	8.49

SAMPLE NUMBER	MONAZITE %	RUTILE %	WEIGHT % EHM/C
1.1	0.00	2.62	46.43
1.2	0.00	2.15	47.44
2.1	0.00	2.27	46.80
2.2	0.00	1.77	39.92
7.1	0.00	1.57	51.47
7.2	0.00	1.81	51.73
9.1	0.00	1.96	38.94
9.2	0.00	1.81	36.85
13.1	0.00	2.19	40.93
13.2	0.00	2.38	39.60
14.0	0.00	3.54	42.47
15.0	0.00	3.42	42.79
16.1	0.01	3.64	36.72
16.2	0.02	3.12	41.58
18.1	0.00	3.22	47.79
18.2	0.00	3.12	50.07
19.1	0.00	3.83	45.50
19.2	0.00	3.42	49.10
20.1	0.00	2.51	42.06
20.2	0.00	2.05	37.29
35.1	0.00	2.21	41.26
35.2	0.00	2.25	44.26
36.1	0.00	7.63	38.27
36.2	0.00	6.98	34.95
37.1	0.00	4.24	40.52
40.0	0.00	3.21	46.66
42.1	0.00	2.75	46.04
42.2	0.00	2.15	40.97
46.1	0.00	1.75	42.54
46.2	0.00	2.26	43.84
47.1	0.00	2.65	44.14
47.2	0.00	2.28	41.23
48.1	0.00	5.12	35.98
48.2	0.00	3.26	45.23
49.1	0.00	1.75	38.54
49.2	0.00	2.62	44.09
50.0	0.00	3.67	41.32
51.1	0.00	5.75	30.61
51.2	0.00	3.09	35.22
57.1	0.00	2.45	46.63
57.2	0.00	2.20	43.52
64.1	0.00	2.60	37.08
64.2	0.00	2.26	40.86

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SAMPLE NUMBER	MONAZITE %	RUTILE %	WEIGHT % EHM/C
65.0	0.00	3.03	42.36
66.1	0.00	6.40	27.67
66.2	0.00	7.76	28.96
76.1	0.00	4.41	39.15
76.2	0.00	2.67	41.83
77.1	0.03	8.33	35.50
77.2	0.00	3.78	37.77
79.1	0.00	2.37	43.12
79.2	0.04	6.17	39.48
80.1	0.00	2.65	42.54
80.2	0.00	4.22	42.10
81.1	0.00	2.13	41.16
81.2	0.00	3.53	42.61
82.1	0.00	2.45	42.28
82.2	0.00	3.10	43.55
83.1	0.47	3.10	41.63
83.2	0.00	3.61	27.07
84.1	0.00	2.45	43.84
84.2	0.00	2.69	46.01
85.0	0.00	2.93	41.56
87.1	0.00	3.20	45.84
87.2	0.00	2.68	46.39
89.1	0.00	2.64	44.06
89.2	0.00	2.28	46.93
90.0	0.00	2.46	45.87
91.1	0.00	2.77	44.57
91.2	0.00	2.56	44.93
95.0	0.00	2.45	44.24