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Preliminary Textural and Mineralogical Analyses of Cretaceous and Holocene Sediments from the Northern New Jersey Coastal Plain

by
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Introduction

Significant mining of economic heavy minerals has taken place since 1962 in the New Jersey Coastal Plain (Markewicz, 1969). Mining has been exclusively in the Cohansey Formation, and possibly the Kirkwood Formation, because of a relatively large concentration of ilmenite. Investigations for occurrences of economic heavy mineral have also been conducted from grab samples and vibracores of Pleistocene sediments on the Atlantic Continental Shelf to determine the location and potential of strategic and critical mineral deposits in the Exclusive Economic Zone (EEZ; Grosz and others, 1989; Uptegrove and others, 1991).

Heavy mineral studies in the Cretaceous sand bodies in the New Jersey Coastal Plain have been primarily focused on their utility in interpretations of provenance, depositional environments, and weathering characteristics (Owens and Sohl, 1969; Owens and others, 1977). Few, if any, investigations have been aimed at the economic potential of Cretaceous sand bodies in the New Jersey Coastal Plain.

In this paper, we will present the results of textural and mineralogical analysis of samples of Cretaceous sands from the Northern New Jersey Coastal Plain (Fig. 1) to assess their potential as sources of economic heavy minerals. Additionally, we will compare these results with mineralogical data from a Pleistocene corehole at Island Beach State Park (Fig. 1), and existing data from recent sediments offshore of the Northern New Jersey Coastal Plain (Uptegrove and others, 1993). This will allow us to evaluate not only potential sources of economic heavy minerals in the New Jersey Coastal Plain and Continental Shelf, but will also give us information on concentration of heavy minerals in deeply weathered profiles.

Geological Setting

Cretaceous Geology

Samples were collected from well studied outcropping Cretaceous sediments (Ries and others, 1904; Barksdale and others, 1943; Owens and Sohl, 1969; Owens and others, 1977; Sugarman and others, 1994). A generalized stratigraphic section for Cretaceous formations in the Northern New Jersey Coastal Plain is given in fig. 2. Depositional settings for Cretaceous strata in New Jersey have been well documented in Owens and Sohl (1969) and Owens and others (1977). The Englishtown and Magothy Formations were deposited in delta front and lower delta plain environments. In general, the formation consists of light-colored cross bedded sands and intercalated dark carbonaceous-rich silty clay (Owens and Sohl, 1969). The Magothy has been subdivided into a series of informal members, which includes, from oldest to youngest, the following informal members: South Amboy Fire Clay, Old Bridge Sand, Amboy Stoneware Clay, Morgan beds, and Cliffwood beds (Owens and others, 1977; Sugarman and others, 1994). Only the sample from the Shrewsbury Member of the Red Bank Formation was deposited in a shelf environment with little to no deltaic influence. It is consequently a massive to cross-bedded sand with no interbedded dark clays and carbonaceous material, which is characteristic of the deltaic facies comprising the Raritan, Magothy, and Englishtown Formations.

Pleistocene Geology

A corehole was drilled at Island Beach State Park (figs. 1 and 3) to sample the surficial or Pleistocene sediments for mineralogical data. A second corehole was drilled just south

for a separate study which helped provide stratigraphic information for intervals which were not recovered. Seventy eight feet of nearshore and fluvial Holocene sediment was recovered (Fig. 3). The base of the hole just penetrated the Miocene Kirkwood Formation.

Field And Laboratory Procedures

Because the relative low grade of heavy minerals in the sediments of the Atlantic Coastal Plain, large concentrations of sample are required (Grosz and others, 1990). Outcrop samples were collected by digging a shallow 1.5 ft vertical trench. Surficial sediments from the Island Beach site were cored with the Christensen 94-mm (HQ) system, with a 4 1/2 inch hole diameter and 2 1/2 inch core diameter. Samples were sieved for textural analyses (Table 2). Heavy-mineral concentrates were collected from the <2-mm-size fraction using a three-turn spiral concentrator, and further processed using sodium polytungstate liquid.
Samples were further separated into six magnetic fractions using a Frantz magnetic barrier laboratory separator, with the dominant mineral phases shown below:

Fraction one: magnetite, ilmenite, and pyroboles (pyroxenes and amphiboles)
Fraction two: ilmenite, garnet, and pyroboles
Fraction three: ilmenite, garnet, pyroboles, tourmaline, epidote, and leucoxene
Fraction four: pyroboles, tourmaline, leucoxene, staurolite
Fraction five: leucoxene, aluminosilicates (silimanite, kyanite, and andalusite).
Fraction six: aluminosilicates, leucoxene, zircon, and rutile

Each subfraction was independently studied for mineral abundance. Long- and short-wave ultraviolet illumination was used to help in the identification of zircon and monazite.
The data for each individual mineral phase in each magnetic subfraction are given in Table 3.

Results and Discussion

Heavy Minerals

RHM (the weight percentage of recovered heavy minerals) from the spiral concentrate/heavy liquid process are reported below:

	Average	Standard deviation	Median	Range
Outcrop Samples (1-15)				
RHM	0.32	0.17	0.25	0.05-0.64
EHM	0.22	0.13	0.17	0.03-0.51
Core				
RHM	1.38	0.11	1.4	1.26-1.48
EHM	0.90	0.08	0.86	0.81-0.94

Economic Heavy Minerals

Economic Heavy Minerals (EHM) include the sum of ilmenite, leucoxene, rutile, zircon, monazite, and aluminosilicates). Individual economic heavy minerals as percentages of RHM are:

	ILM	LEU	MON	SKA	ZIR	RUT
Outcrop Samples						
Average	34.43	20.04	0.08	7.91	5.52	2.35
Standard deviation	6.69	11.06	0.21	5.92	3.11	1.13
Median	34.08	17.28	0.00	6.95	4.98	2.13
Minimum	21.96	4.13	0.00	0.95	1.47	0.44
Maximum	47.57	42.38	0.59	19.60	10.97	4.17
Core (25-65')						
Average	47.93	6.68	0.44	9.58	6.40	1.30
Standard deviation	7.49	4.08	0.74	1.49	2.60	0.48
Median	45.11	5.15	0.03	9.04	7.29	1.15
Minimum	42.25	3.59	0.00	8.44	3.47	0.92
Maximum	56.41	11.31	1.30	11.26	8.43	1.84
Core (80')	20.98	12.61	0.00	14.68	2.31	0.78

Surficial sediments from the IBSP corehole have a much higher percentage of recovered heavy minerals than the outcropping Cretaceous formations (median of 1.4 vs. 0.25). In addition, they have a higher percentage of economic heavy minerals (median of 0.86 vs. 0.17).

High percentages of EHM in the surficial sediments include ilmenite, aluminosilicates, and zircon. The extended weathering of the Cretaceous sediments results in higher concentrations of leucoxene (median value of 17.3; maximum value of 42.4 vs. median value of 5.2; maximum value of 11.3) and rutile (median value of 2.1; maximum value of 4.2 vs. median value of 1.2; maximum value of 1.8). High concentrations in the Cretaceous sands of tourmaline (average 10.9 vs. 1.5), and the depletion of labile heavy minerals from the Cretaceous sands including garnet (average of 0.6 in the Cretaceous sediments vs. 9.8 in the surficial sediments) and pyroboles (average of 0.1 in the Cretaceous sediments vs. 4.8 in the surficial sediments) are also an indicator of extended weathering.

In order to evaluate the economic potential of these deposits, each mineral phase can be evaluated as the weight percentage of the bulk weight, as given below:

	ILM	LEU	MON	SKA	ZIR	RUT
Outcrop Samples						
Average	0.11	0.06	0.00	0.02	0.02	0.01
Standard deviation	0.07	0.05	0.00	0.02	0.01	0.01
Median	0.09	0.04	0.00	0.02	0.01	0.01
Minimum	0.02	0.01	0.00	0.00	0.00	0.00
Maximum	0.28	0.23	0.00	0.08	0.05	0.02
Core (25-65')						
Average	0.58	0.08	0.01	0.12	0.08	0.02
Standard deviation	0.05	0.04	0.01	0.12	0.08	0.02
Median	0.60	0.07	0.00	0.12	0.08	0.01
Minimum	0.52	0.04	0.00	0.11	0.05	0.01
Maximum	0.62	0.12	0.02	0.12	0.10	0.02
Core (80')	0.31	0.19	0.00	0.22	0.03	0.01

Note: Average is percent of RHM

These values indicate that there is limited potential in economic mining of heavy minerals from either the Cretaceous or Holocene sediments analyzed in this study.

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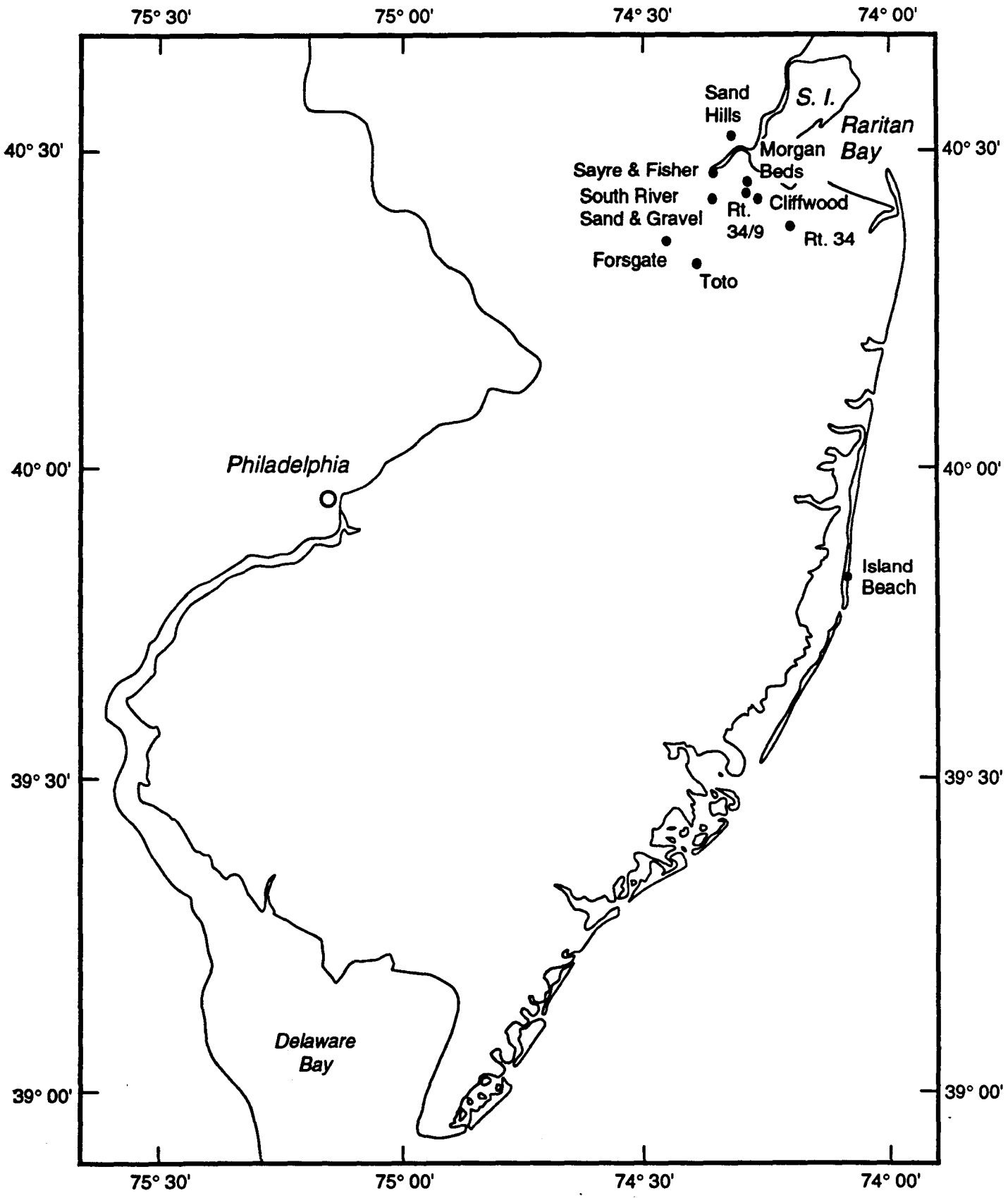

Fig. 1 Sample Location Map

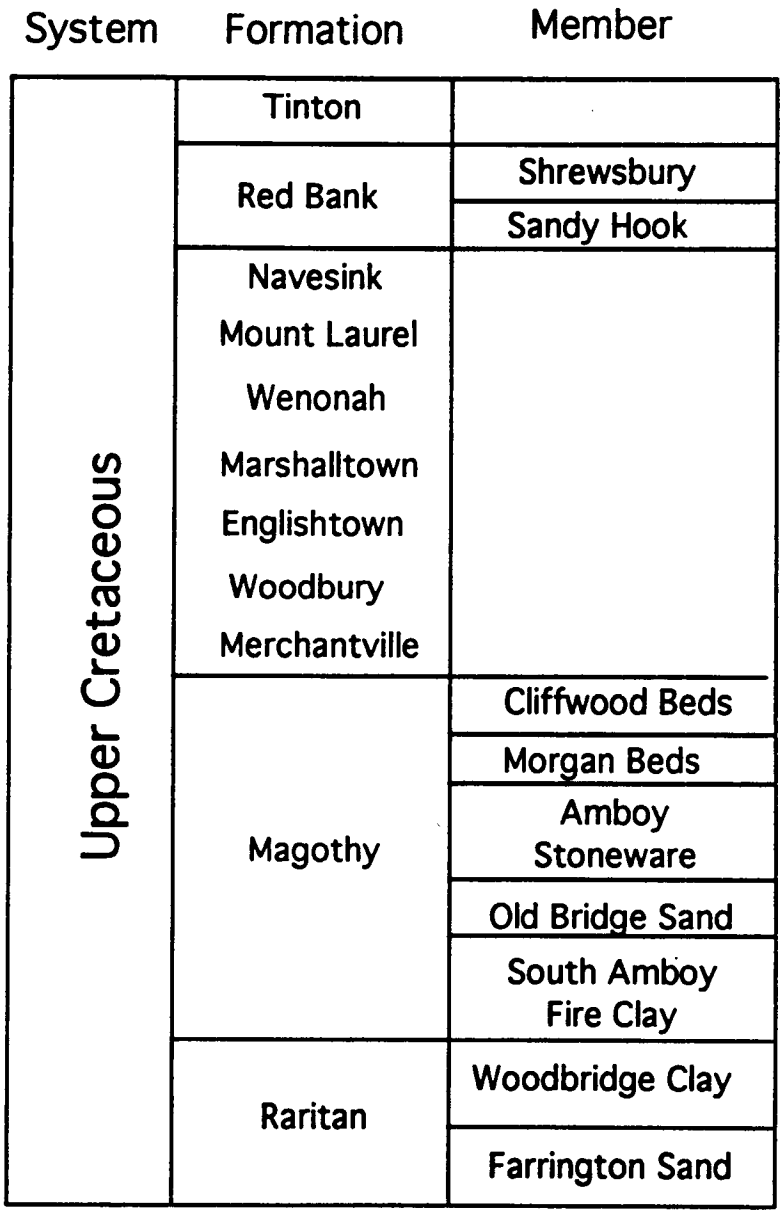

Fig. 2 Generalized stratigraphic section of study area

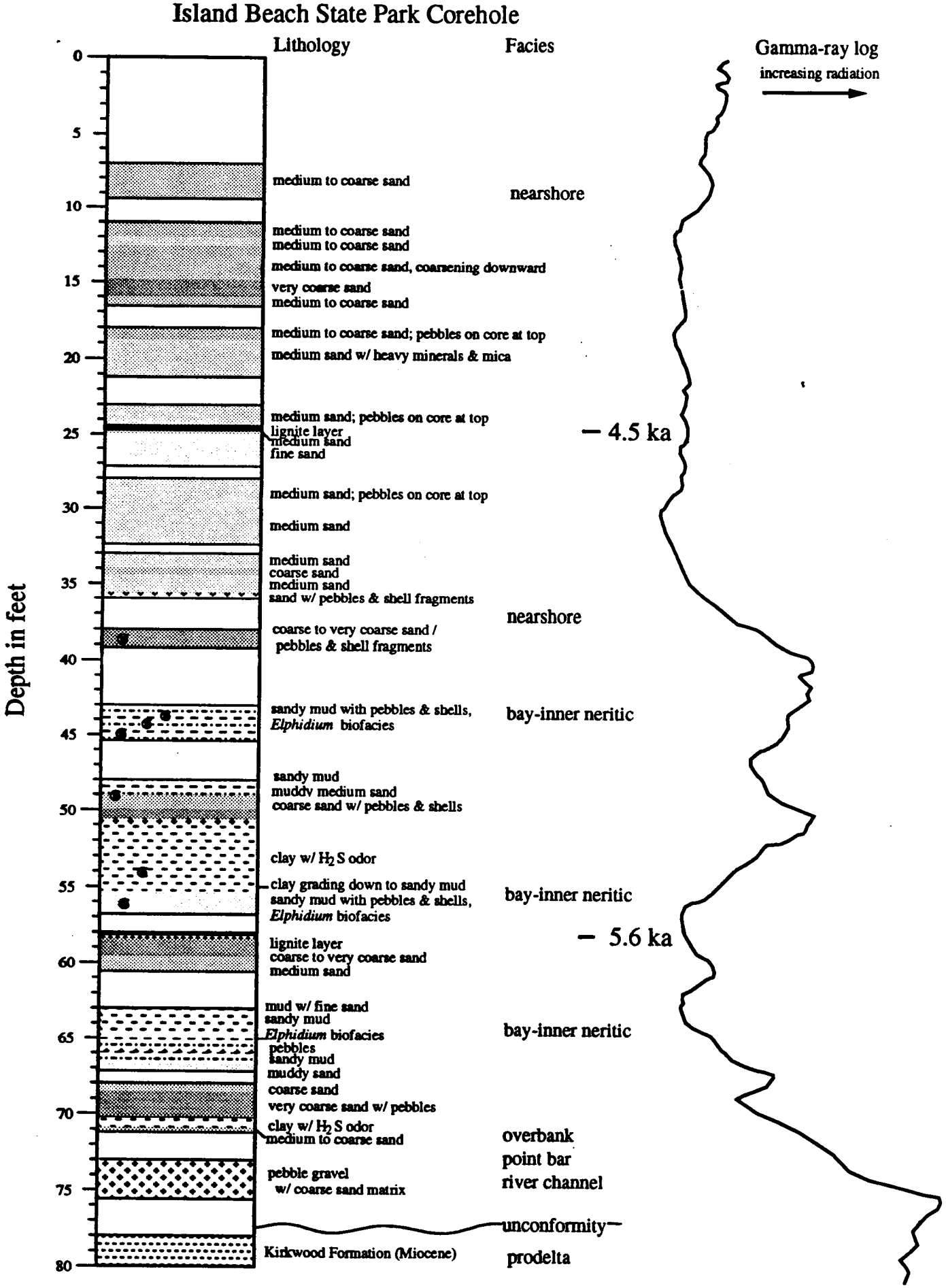

Fig. 3 Stratigraphic summary of Island Beach State Park corehole with carbon isotope dates (Modified from Miller and others, 1994).

Table 1. Sample Locations

Sample No.	Location	Latitude Longitude	Formation/ Member	Description/ Sample Loc.
1.	Toto Bros. Monroe	40° 19' 15" 74° 23' 35"	Englishtown	med. sand with 1" clay layers
2.	Toto Bros.	"	Englishtown	just above #1
3.	Toto Bros.	"	Englishtown	just below #1
4.	Ernston Rd. Pit Morgan Beds	40° 27' 20" 74° 16' 36"	Magothy- Morgan Beds	fine sand, micaceous, w/ clay laminae
5.	Ernston Rd. Pit	"	Morgan Beds	"
6.	Forsgate Pit	40° 21' 20" 74° 27' 30"	Magothy Fm.	medium sand
7.	Route 34 Pit	40° 22' 42" 74° 12' 30"	Red Bank Fm. Shrewsbury member	medium sand
8.	Route 34 Pit	"	"	"
9.	Cheesequake	40° 25' 35" 74° 16' 10"	Magothy Fm. Cliffwood Beds	fine sand with int. clay
10.	South River Sand & Gravel	40° 25' 28" 74° 21' 42"	Magothy Fm. Old Bridge Sand	fine-med. sand w/ fine lignite
11.	South River Sand	"	"	20' above 10
12.	Sayre & Fisher Pit	40° 27' 25 74° 21' 32"	Magothy Fm South Amboy Fire Clay	medium sand
13.	Sayre & Fisher Pit	"	"	fine-medium sand
14.	Route 34/ Rt. 9 Pit	40° 26' 16" 74° 19' 10"	Magothy Fm.	fine-medium sand
15.	Sand Hills Perth Amboy	40° 31' 30" 74° 19' 10"	Raritan Fm.	medium sand
16.	Island Beach S.P.	39° 48' 18" 74° 05' 40"		corehole location

Table 2. Textural data

Sample Number	>2.0	1-2	0.5-1.0	0.25-0.5	0.125-0.25	0.063-0.125	<0.063mm
1	0.4	0.2	2.3	85.6	10.4	0.5	0.5
2	0.4	0.2	3.4	72.2	22.0	1.0	0.8
3	0.1	0.2	5.8	81.6	10.8	0.8	0.7
4	0.04	0.2	0.8	5.0	70.4	11.4	12.1
5	0.02	0.04	0.5	2.4	79.2	13.1	4.7
6	0.6	0.8	3.0	72.5	19.9	2.4	0.8
7	0.8	2.0	7.2	7.3	67.7	17	0.0
8	0.5	2.0	10.4	69.2	16	0.8	1.0
9	0.6	0.3	0.8	43.6	44.6	5.5	4.5
10	0.7	8.0	81.1	7.0	2.0	0.6	0.6
11	0	0	2.4	90.1	6.7	0.5	0.2
12	1.0	0.8	6.8	37.8	44.3	6.1	3.2
13	0.3	6.9	28.3	32.2	28.8	2.2	1.2
14	0.1	0.1	0.8	57.4	36.3	2.5	2.8
15	0	0.2	10.7	75.3	10.6	1.9	1.3
16 Island Beach State Park Corehole							
25-30'	3.9	3.2	11.9	42.8	32.5	2.8	2.9
45-50'	0.7	3.2	22.2	13.8	14.8	31.5	13.8
60-65'	15.1	6.8	6.6	13.4	32.7	13.8	11.6
80-85'	4.6	3.5	3.6	6.1	32.0	17.9	32.4

NJGS NUMBER	BULK WEIGHT(	SL SPLIT WT (g)	SH grams	SHSTS grams	WT % RHM	WEIGHT 203 (g)	WEIGHT 204 (g)	WEIGHT 205 (g)	WEIGHT 206 (g)	WEIGHT 207 (g)	WEIGHT 208 (g)	WEIGHT SLSTS (g)	WEIGHT GRAVEL (g)	SUM WTS MAGFRA	WT % MAG	SUM grams ILM	WT % ILM	SUM grams GAR	WT % GAR	SUM grams PYR	WT % PYR	SUM grams EPI	WT % EPI	SUM grams STA
T1	5006.8	335.6	211.9	13	0.22	0.04	3.32	5.42	1.00	1.25	1.83	0.6	5.9	12.857	0.00	4.21	32.74	0.00	0.00	0.16	1.26	0.00	0.00	1.96
T2	4523.7	306.4	166.7	10.8	0.24	0.15	3.46	4.09	0.71	0.87	1.39	0.95	4.3	10.867	0.00	4.47	41.93	0.00	0.00	0.04	0.38	0.00	0.00	1.37
T3	4929.4	382.8	236.3	10.1	0.20	0.22	2.12	3.97	0.66	0.84	1.84	0.86	1.7	9.743	0.00	3.27	33.56	0.00	0.00	0.00	0.00	0.00	0.00	1.37
T4	4413.6	306.3	364.1	14.9	0.34	0.05	4.02	4.89	1.02	1.35	2.82	3.817	0.4	14.149	0.00	4.49	31.72	0.00	0.00	0.00	0.00	0.00	0.00	0.62
T5	2762.2	313.6	320.4	13.45	0.49	0.56	1.53	5.94	0.97	2.30	2.42	2.52	0.3	13.719	0.00	4.21	30.70	0.07	0.54	0.00	0.00	0.00	0.00	1.27
T6	5250.3	246.2	144.9	9.52	0.18	0.01	0.60	5.03	0.60	0.90	2.33	3.031	11.4	9.469	0.00	2.79	29.46	0.00	0.00	0.00	0.00	0.01	0.06	0.91
T7	4514.8	340.2	316.1	17.67	0.39	0.004	3.93	6.29	1.39	2.13	3.93	3.186	10.6	17.677	0.00	3.88	21.96	0.00	0.00	0.00	0.00	0.00	0.00	1.54
T8	4848.8	351.5	228.7	12.34	0.25	0.01	2.26	3.43	0.76	0.96	4.86	1.666	5.9	12.291	0.00	3.10	25.22	0.00	0.00	0.00	0.00	0.00	0.00	0.97
T9	4967.8	276.8	390	21.97	0.44	0.03	11.25	5.67	1.21	1.67	2.11	1.467	6.1	21.932	0.00	10.43	47.57	1.41	6.44	0.00	0.00	0.13	0.57	0.59
T10	5283.2	359	258.8	2.39	0.05	0.01	0.17	1.19	0.31	0.34	0.37	0.0695	8.2	2.365	0.00	0.82	34.33	0.01	0.57	0.00	0.00	0.00	0.00	0.04
T11	5218.6	360	345.6	9.79	0.19		0.62	6.22	0.86	1.37	0.59	0.4711	0	9.863	0.00	3.66	37.13	0.00	0.00	0.00	0.00	0.00	0.00	0.31
T12	4512.4	401.3	371.4	28.92	0.60		2.10	15.21	3.34	2.27	3.24	2.695	11.6	28.157	0.00	8.92	34.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T13	5316.3	431.5	337.2	8.56	0.16		0.41	4.00	0.29	1.10	1.66	0.75	4.1	7.46	0.00	2.66	36.36	0.00	0.00	0.00	0.00	0.00	0.00	0.04
T14	5657.3	391.8	307.3	23.483	0.40		2.36	13.70	1.12	1.66	4.67	1.525	1.2	23.551	0.00	6.03	34.06	0.21	0.88	0.00	0.00	0.14	0.58	2.76
T15	5904.6	376.7	457.9	37.86	0.64		6.06	21.27	1.47	2.39	4.56	1.132	0.2	37.764	0.00	16.49	43.64	0.00	0.00	0.00	0.00	0.00	0.00	5.39
MIN					0.05										0		21.96		0.00		0.00		0.00	
AVG					0.32										0		34.43		0.56		0.11		0.06	
MAX					0.64										0		47.57		6.44		1.26		0.56	
STDEV(S)					0.17										0		8.69		1.65		0.33		0.20	
MEDIAN																								
25.0	332.9			4.2	1.26	0.02	1.03	2.06	0.18	0.18	0.62		13	4.066	0.00	1.73	42.25	0.57	13.99	0.40	9.80	0.13	3.11	0.05
45.0	306.2			4.3	1.40	0.00	0.96	2.316	0.15	0.26	0.475		2.1	4.185	0.00	1.89	45.11	0.36	9.05	0.39	9.21	0.13	3.00	0.02
60.0	234.4			3.476	1.46	0.05	0.61	1.34	0.07	0.12	0.31		35.3	2.491	0.16	1.41	56.41	0.06	2.42	0.04	1.61	0.01	0.57	0.02
MIN					1.26										0.00		42.25		2.42		1.61		0.57	
AVG					1.36										0.05		53.56		9.84		4.79		1.77	
MAX					1.46										0.16		62.00		13.99		9.80		3.11	
STDEV(S)					0.11										0.09		10.16		6.43		4.39		1.28	
MEDIAN																								
80.0	164.7			3.386	2.06	0.00	0.67	0.21	0.12	0.61	0.61		7.5	2.417	0.00	0.51	20.96	0.06	3.33	0.01	0.26	0.02	0.71	0.04

Table 3. Mineralogic data for 15 outcrop and 4 core samples.

NJGS NUMBER	WT % STA	SUM grams LEU	WT % LEU	SUM grams TOUR	WT % TOUR	SUM grams MON	WT % MON	SUM grams SILKA	WT % SKA	SUM grams ZIR	WT % ZIR	SUM grams RUT	WT % RUT	SUM grams QTZ	WT % QTZ	SUM grams OTH	WT % OTH	SUM WT %S ALL PHS	SUM GRAMS EHM	EHM AS WT % OF SHSTS	EHM AS SUM O WT %S OF THE SIX PHASES	MAGFRACS AS FRAC. OF BULK WT.
T1	15.40	2.14	16.66	2.23	17.33	0.00	0.00	0.69	6.95	0.64	4.96	0.30	2.34	0.00	0.00	0.30	2.32	100	8.1885	62.99	63.69	0.0021
T2	12.69	1.65	15.46	1.36	12.96	0.00	0.00	0.82	7.66	0.35	3.28	0.23	2.12	0.03	0.26	0.32	3.02	100	7.51645	69.60	70.46	0.0024
T3	14.02	1.66	17.26	1.46	14.67	0.00	0.00	1.40	14.39	0.16	1.64	0.14	1.47	0.00	0.00	0.27	2.77	100	9.6561	65.92	66.34	0.0020
T4	4.40	3.76	28.80	1.40	9.92	0.00	0.00	1.26	8.91	0.76	5.35	0.46	3.16	0.01	0.10	1.36	9.63	100	10.7195	71.94	75.76	0.0032
T5	9.22	3.20	23.32	1.51	11.02	0.00	0.00	0.84	6.12	1.12	8.13	0.52	3.76	0.14	0.99	0.85	6.19	100	9.86283	73.46	72.04	0.0050
T6	9.61	2.36	24.91	0.92	9.70	0.06	0.59	1.10	11.65	0.79	8.36	0.33	3.48	0.00	0.00	0.20	2.16	100	7.42966	78.04	78.47	0.0018
T7	6.71	0.73	4.13	2.11	11.92	0.00	0.00	3.46	19.60	0.26	1.47	0.19	1.05	1.16	6.66	4.33	24.50	100	8.5212	48.22	48.21	0.0039
T8	7.92	1.06	6.82	1.40	11.37	0.00	0.00	2.37	19.26	0.49	3.95	0.26	2.13	1.46	11.86	1.16	9.46	100	7.29997	59.16	59.39	0.0025
T9	2.70	2.02	9.23	1.83	8.33	0.00	0.00	0.70	3.21	0.71	3.22	0.43	1.96	0.04	0.19	3.60	16.43	99.86777	14.30016	86.09	85.20	0.0044
T10	1.63	0.50	20.90	0.16	7.36	0.00	0.00	0.02	0.95	0.17	7.23	0.03	1.20	0.06	2.33	0.56	23.46	100	1.54066	64.47	64.61	0.0005
T11	3.15	4.18	42.36	0.63	6.42	0.00	0.00	0.22	2.22	0.21	2.13	0.04	0.44	0.00	0.00	0.60	6.13	100	6.31421	84.93	84.30	0.0019
T12	0.00	10.22	39.06	1.20	4.57	0.00	0.00	0.60	2.29	2.25	8.59	1.09	4.17	0.00	0.00	1.89	7.21	100	23.07607	85.72	86.22	0.0056
T13	0.54	2.18	29.20	0.51	6.86	0.00	0.00	0.35	4.70	0.62	10.97	0.29	3.87	0.00	0.00	0.41	5.50	100	6.49617	75.89	87.06	0.0014
T14	11.73	2.86	12.10	3.25	13.80	0.14	0.58	1.66	7.12	2.32	9.87	0.58	2.48	0.00	0.00	1.59	6.76	100	15.60042	66.40	66.24	0.0040
T15	14.27	3.96	10.48	6.06	16.05	0.00	0.00	1.40	3.69	1.37	3.63	0.62	1.65	0.00	0.00	2.48	6.59	100	23.83674	62.93	63.09	0.0064
MIN	0.00		4.13		4.57		0.00		0.95		1.47		0.44		0.00		2.16		1.54	48.22	48.21	0.00
AVG	7.75		20.04		10.84		0.08		7.91		5.52		2.35		1.49		8.82		10.63	68.99	70.34	0.00
MAX	15.40		42.36		17.33		0.59		19.60		10.97		4.17		11.86		24.50		23.84	85.72	86.22	0.01
STDEV(S	5.32		11.06		3.73		0.21		5.92		3.11		1.13		3.36		7.14		6.16	9.80	10.95	0.00
MEDIAN																						
25.0	1.29	0.15	3.59	0.06	1.84	0.05	1.30	0.37	9.04	0.34	8.43	0.05	1.15	0.05	1.20	0.11	2.63	99.63289	2.6673	63.96	65.77	0.0123
45.0	0.59	0.22	5.15	0.14	3.44	0.00	0.00	0.35	8.44	0.15	3.47	0.04	0.92	0.18	4.40	0.30	7.21	100	8.99726	209.24	69.14	0.0137
60.0	0.66	0.26	11.31	0.04	1.61	0.00	0.03	0.26	11.26	0.18	7.29	0.05	1.64	0.01	0.54	0.10	4.07	100	2.19562	63.17	66.15	0.0106
MIN	0.19		1.66		1.11		0.00		4.07		1.11		0.30		0.54		2.63		2.20	63.17	65.77	0.01
AVG	0.79		5.52		1.52		0.44		8.12		5.61		1.10		1.05		5.72		4.63	112.13	74.35	0.01
MAX	1.29		11.31		1.84		1.30		11.26		8.43		1.64		1.41		10.46		9.00	209.24	86.15	0.01
STDEV(S	0.56		5.11		0.37		0.74		3.66		3.94		0.76		0.46		4.17		3.79	84.10	12.07	0.00
MEDIAN																						
80.0	1.53	0.30	12.61	0.09	3.86	0.00	0.00	0.35	14.66	0.06	2.31	0.02	0.78	0.12	5.03	0.82	33.92	100	1.24	39.67	51.37	0.01

NJGS NUMBER	EHM AS WT % OF BULK	WT % RHM	EHM AS % OF RHM
T1	0.14	0.22	62.99
T2	0.17	0.24	69.60
T3	0.14	0.20	66.92
T4	0.24	0.34	71.94
T5	0.36	0.49	73.48
T6	0.14	0.18	78.04
T7	0.19	0.39	48.22
T8	0.15	0.25	59.16
T9	0.29	0.44	65.09
T10	0.03	0.05	64.47
T11	0.16	0.19	84.93
T12	0.51	0.60	85.72
T13	0.12	0.16	75.89
T14	0.27	0.40	66.40
T15	0.40	0.64	62.93
MIN	0.03	0.05	48.22
AVG	0.22	0.32	66.99
MAX	0.51	0.64	85.72
STDEV(S	0.13	0.17	9.80
MEDIAN	0.17	0.25	NC
25.0	0.81	1.28	63.96
45.0	0.94	1.40	67.29
60.0	0.94	1.48	63.17
MIN	0.81	1.28	63.17
AVG	0.90	1.38	64.81
MAX	0.94	1.48	67.29
STDEV(S	0.06	0.11	2.18
MEDIAN	0.89	1.40	NC
80.0	0.75	2.06	36.97

NJGS NUMBER	ILM AS WT% OF RHM	LEU AS WT% OF RHM	MON AS WT% OF RHM	SKA AS WT% OF RHM	ZIR AS WT% OF RHM	RUT AS WT% OF RHM
T1	32.74	16.88	0.00	6.95	4.96	2.34
T2	41.93	15.48	0.00	7.69	3.28	2.12
T3	33.56	17.26	0.00	14.39	1.64	1.47
T4	31.72	28.60	0.00	8.91	5.36	3.18
T5	30.70	23.32	0.00	6.12	8.13	3.76
T6	29.46	24.91	0.59	11.65	8.36	3.46
T7	21.96	4.13	0.00	19.60	1.47	1.05
T8	25.22	5.82	0.00	19.26	3.95	2.13
T9	47.57	9.23	0.00	3.21	3.22	1.96
T10	34.33	20.90	0.00	0.95	7.23	1.20
T11	37.13	42.38	0.00	2.22	2.13	0.44
T12	34.06	39.06	0.00	2.29	8.59	4.17
T13	36.35	29.20	0.00	4.70	10.97	3.87
T14	34.08	12.10	0.58	7.12	9.87	2.48
T15	43.64	10.48	0.00	3.69	3.63	1.65
MIN	21.96	4.13	0.00	0.95	1.47	0.44
AVG	34.43	20.04	0.06	7.91	5.52	2.35
MAX	47.57	42.38	0.59	19.60	10.97	4.17
STDEV(S)	6.69	11.06	0.21	5.92	3.11	1.13
MEDIAN	34.06	17.26	0.00	6.95	4.96	2.13
25.0	42.25	3.59	1.30	9.04	8.43	1.15
45.0	45.11	5.15	0.00	8.44	3.47	0.92
60.0	56.41	11.31	0.03	11.26	7.29	1.84
MIN	42.25	3.59	0.00	8.44	3.47	0.92
AVG	47.93	6.68	0.44	9.58	6.40	1.30
MAX	56.41	11.31	1.30	11.26	8.43	1.84
STDEV(S)	7.49	4.06	0.74	1.49	2.60	0.48
MEDIAN	45.11	5.15	0.03	9.04	7.29	1.15
80.0	20.96	12.81	0.00	14.66	2.31	0.76

NJGS NUMBER	ILM AS WT% OF BULK	LEU AS WT% OF BULK	MON AS WT.% OF BULK	SKA AS WT% OF BULK	ZIR AS WT% OF BULK	RUT AS WT% OF BULK
T1	0.07	0.04	0.0000	0.01	0.011	0.005
T2	0.10	0.04	0.0000	0.02	0.008	0.005
T3	0.07	0.03	0.0000	0.03	0.003	0.003
T4	0.10	0.09	0.0000	0.03	0.017	0.010
T5	0.15	0.12	0.0000	0.03	0.040	0.019
T6	0.05	0.04	0.0011	0.02	0.015	0.009
T7	0.09	0.02	0.0000	0.06	0.006	0.004
T8	0.06	0.02	0.0000	0.05	0.010	0.005
T9	0.21	0.04	0.0000	0.01	0.014	0.009
T10	0.02	0.01	0.0000	0.00	0.003	0.001
T11	0.07	0.08	0.0000	0.00	0.004	0.001
T12	0.20	0.23	0.0000	0.01	0.050	0.024
T13	0.05	0.04	0.0000	0.01	0.015	0.005
T14	0.14	0.05	0.0023	0.03	0.040	0.010
T15	0.28	0.07	0.0000	0.02	0.023	0.011
MIN	0.02	0.01	0.00	0.00	0.00	0.00
AVG	0.11	0.06	0.00	0.02	0.02	0.01
MAX	0.28	0.23	0.00	0.06	0.05	0.02
STDEV(S)	0.07	0.05	0.00	0.02	0.01	0.01
MEDIAN	0.09	0.04	0.0000	0.02	0.014	0.005
25.0	0.52	0.04	0.0160	0.11	0.103	0.014
45.0	0.62	0.07	0.0000	0.12	0.047	0.013
60.0	0.80	0.12	0.0003	0.12	0.078	0.020
MIN	0.52	0.04	0.00	0.11	0.05	0.01
AVG	0.58	0.08	0.01	0.12	0.06	0.02
MAX	0.62	0.12	0.02	0.12	0.10	0.02
STDEV(S)	0.05	0.04	0.01	0.00	0.03	0.00
MEDIAN	0.60	0.07	0.0003	0.12	0.078	0.014
80.0	0.31	0.19	0.0000	0.22	0.034	0.011