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HYDROGRAPHIC SURVEY IN THE BOSTON AREA, MINERALOGY OF A FEW SED--ETC(U)
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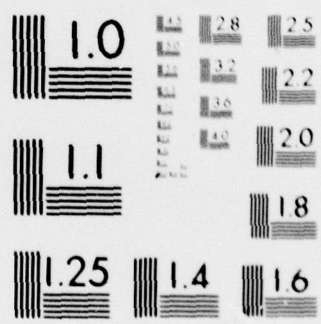

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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, Massachusetts

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(6) Hydrographic Survey in the Boston Area,

Mineralogy of a Few Sediment Samples from Boston Harbor.

By

(10) William S. Butcher

(9) Interim Report No. 15,

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INTRODUCTION

The mineralogy of 26 samples of sediments from Boston Harbor has been investigated to determine the mineralogic composition of the sediments, significant differences within the area, and any change during the time required to deposit the sediment in the cores. Figure 1 shows the position of the samples studied; they are in 5 groups dividing the areas of special interest into outer, middle, and a common inner area. In addition one sample from 8 feet below the surface of a core has been analyzed as representing the mineralogy of the earlier sedimentation. All samples with the exception of the core were collected by means of an "orange peel" dredge. The core sample was obtained with a Kullenberg corer.

The size 2.5 - 3.0 ø (0.180 - 0.125 mm.) has been analyzed for each sample with the exception of sample 44 which contained all the material greater than -2 ø (<4 mm.). This size was chosen because it was large enough to examine with ease under the microscope and because it was small enough to give monomineralic grains. The samples were mounted in Canada balsam and the individual grains identified with a petrographic microscope. About 200 grains were examined and identified for each slide giving an error of about ±2% for the frequencies reported (Krumbein and Pettijohn, 1938, p. 472). Frequencies of less than 2% are not significant. No attempt was made to isolate individual grains for exact determination of the optical properties and the identification of infrequently occurring grains is doubtful.

Russell (1937) showed that the Mississippi River sediments had a constant mineralogy as a whole but that the frequency distribution within any given grade size was not constant. The frequencies reported here for a standard grade size may not be exact for the sediment as a whole but probably indicate the general distribution.

MINERALOGY OF THE INDIVIDUAL SAMPLES

Table I lists the frequency of occurrence of the mineral species for each sample. The table shows that the samples are remarkably similar, being composed mostly of quartz, alteration products, orthoclase, and plagioclase. Biotite, hornblende, microcline, and opaque minerals are occasionally of importance. The alteration products are microcrystalline aggregates, probably clay minerals, that are not identifiable with the petrographic microscope.

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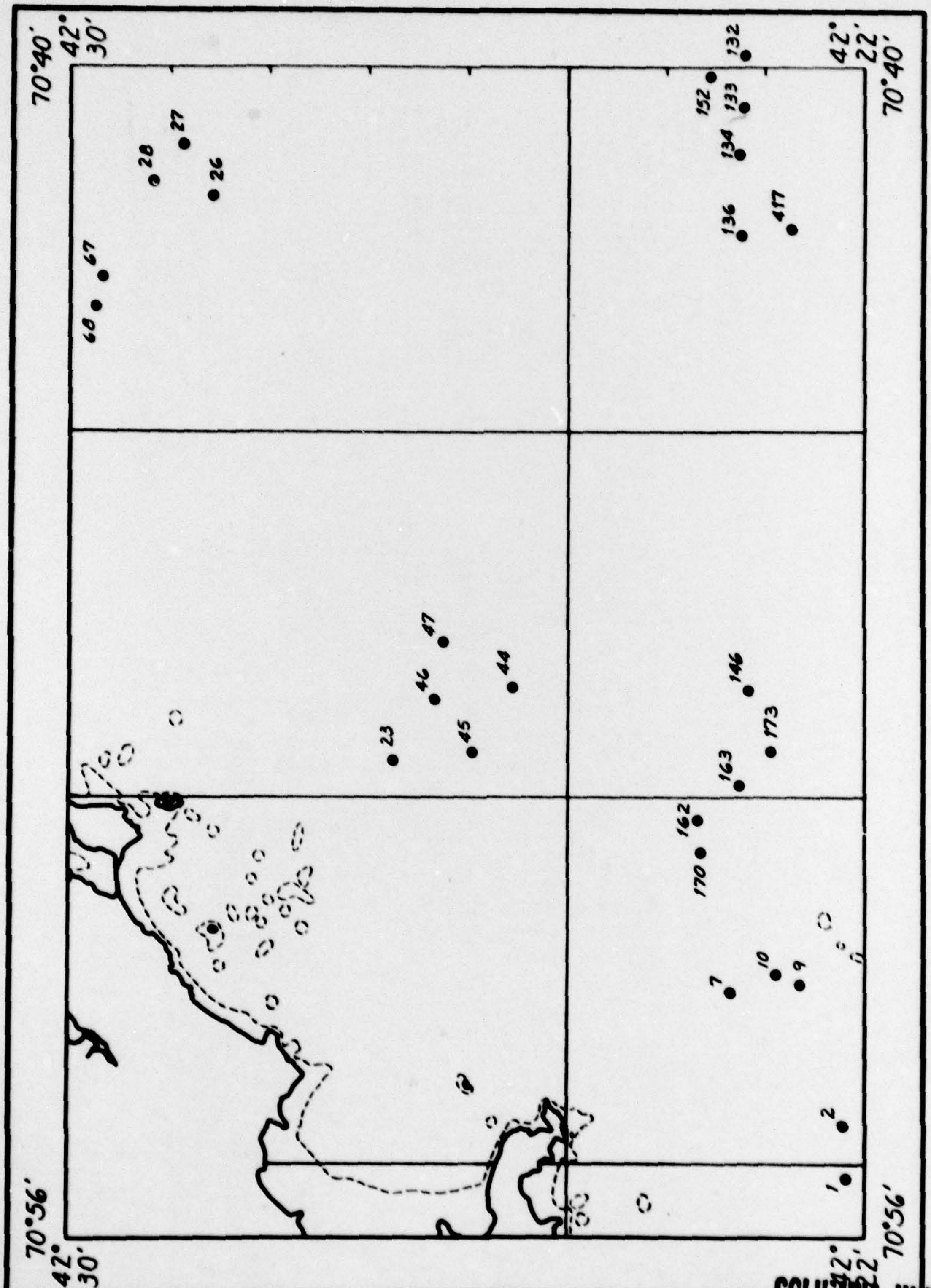

FIG. 1 LOCATION OF MINERALOGIC SAMPLES

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TABLE I

Mineral frequency in a few sediment samples from Boston Harbor

	Sample No.										
	1	2	7	9	10	23	26	27	28	44	45
Mineral	Percent (of Total Number Counted)										
Quartz	52	31	53	12	49	52	53	22	47	52	14
Alteration	24	51	26	64	28	27	17	70	39	32	75
Orthoclase	6	8	12	6	14	11	5	4	7	10	4
Plagioclase	4	4	4	5	0.9	0.9	4	2	0.8	3	0.5
Actinolite	0	0	0.4	0	0	0	0	0	0	0	0
Allanite	0	0	0	0	0	0	0	0	0	0	0
Apatite	0	0	0	0	0	0.4	0	0	0	0	0
Biotite	1	0.4	0	1	2	0	2	0.6	0.4	0	1
Calcite	0.4	0.4	0	0.4	0	0	0	0	0	2	0
Chlorite	0	0.4	0.4	0	0.4	0.4	0	0	0	0	0.9
Clinozoisite	0	0	0	0	0	0	0	0	0	0	0
Corundum	0.4	0	0	0	0	0	0	0	0	0	0
Diopside	0	0	0	0	0	0	0	0	0	0	0
Epidote	0	0	0	0	0	0	0.4	0	0	0	0
Garnet	0.8	0.4	0.4	0.4	0.4	2	0.4	0	0.4	2	0.5
Glaucophane	0	0	0	0	0	0	0	0	0	0	0
Hypersthene	0	0	0	0	0	0	0	0	0	0	0
Hornblende	2	0.7	0	2	2	0	0	0	0.8	0	0
Kyanite	0	0	0	0	0.4	0	0.4	0	0.4	0	0.5
Microcline	0.8	0.4	2	0.4	0.9	0.9	0.8	0.6	0	0	0
Opaque	7	3	1	5	2	4	15	1	0.8	0	2
Sillimanite	0	0	0	0.4	0	0	0	0	0	0	0
Staurolite	0	0	0.4	0	0	0	0.4	0	0	0	0
Titanite	0.8	0	0	2	1	0.4	0.4	0	2	0	0
Tourmaline	0.4	0.4	0	0.4	0	1	0.4	0	0.8	0	0.5
Zircon	0	0	0	0	0	0.4	0	0	0	0	0.5
Zoisite	0	0	0	0	0	0	0	0.6	0.4	0	0
No. Counted	250	270	270	245	234	224	261	171	243	62	215

[redacted]

TABLE I (Cont'd.)

Mineral frequency in a few sediment samples
from Boston Harbor

	Sample No.										
	46	47	67	68	132	133	134	136	146	162	163
Mineral	Percent (of Total Number Counted)										
Quartz	54	50	7	40	45	49	53	59	53	52	23
Alteration	22	29	80	40	32	27	16	16	25	26	34
Orthoclase	16	14	3	8	10	17	25	15	16	15	10
Plagioclase	0.8	1	4	1	4	2	2	4	0.4	2	0.3
Actinolite	0	0	0	0	0	0	0	0	0	0	0
Allanite	0	0	0	0	0.9	0	0	0.3	0.4	0	0
Apatite	0	0	0	0	0	0	0	0	0	0	0
Biotite	0.8	0.5	3	1	0.9	0.4	0.4	0.3	0.4	0	3
Calcite	0	0	0	0	0	0	0.4	0	0	0	0
Chlorite	0	0.8	2	0	0	0	0	0	0	0.4	1
Clinozoisite	0	0	0	0	0	0	0	0	0	0	0
Corundum	0	0.4	0	0	0	0	0	0	0.4	0	0
Diopside	0	0	0	0	0	0	0	0	0	0	0
Epidote	0.4	0	0	0	0	0	0.8	0.6	0.4	0	0.3
Garnet	0.4	0.5	0	1	0.4	0	0.4	0.3	0.4	0	0.3
Glaucophane	0	0	0	0	0.4	0	0	0	0	0	0
Hypersthene	0	0.5	0	0	0	0	0	0	0	0	0
Hornblende	0.8	0.5	0.4	2	0	0.4	0.8	1	1	0.4	0.6
Kyanite	0	0	0	0	0	0	0	0	0	0	0
Microcline	0.8	0.5	0	0	0	0.4	0	0.3	0.4	0.9	1
Opaque	4	3	0.8	2	4	2	2	3	1	3	25
Sillimanite	0	0	0	0	0	0	0	0	0	0	0
Staurolite	0.4	0	0	0	0	0	0	0	0	0	0
Titanite	0	0	0	0	0	0	0	0	0.4	0	0.3
Tourmaline	0	0.5	0.4	0	0.4	0.4	0.4	0.3	0.4	0	0
Zircon	0	0	0	2	0.4	0	0	0	0.4	0	0.3
Zoisite	0	0	0	0	0.4	0.8	0	0	0	0	0
No. Counted	257	218	262	171	233	242	251	343	244	223	315

TABLE I (Cont'd.)

Mineral frequency in a few sediment samples from Boston Harbor

Mineral	Sample No. 170	173	417	152 (core at -8')
	Percent (of Total Number Counted)			
Quartz	49	55	61	51
Alteration	27	22	11	24
Orthoclase	17	15	20	13
Plagioclase	1	2	5	8
Actinolite	0	0	0	0
Allanite	0	0	0	0.4
Apatite	0	0	0	0
Biotite	0.5	0	0	0
Calcite	0	0	0	0
Chlorite	0	0	0.5	0
Clinozoisite	0	0	0	0.4
Corundum	0	0	0	0
Diopside	0	0	0	0.4
Epidote	0.5	0.8	0.5	0
Garnet	0.9	0.8	0	0.8
Glaucophane	0	0	0	0
Hypersthene	0	0	0	0
Hornblende	0.9	1	0.5	0.4
Kyanite	0	0	0.5	0
Microcline	0	0	0	0
Opaque	2	2	1	2
Sillimanite	0	0	0	0
Staurolite	0	0.4	0	0
Titanite	0	0.4	0	0.4
Tourmaline	0	0	0	0.4
Zircon	0	0.4	0	0
Zoisite	0	0	0	0
No. Counted	219	247	202	239

[redacted]

The largest variation in frequency occurs between alteration products, quartz, and opaque minerals. The relatively high frequency of opaque minerals in a few samples (cf. 26) probably represents a local concentration of the heavier opaque minerals under normal sedimentary processes. The high frequency of alteration products in a few samples (cf. 45) could be due to dilution of the original sediment, as represented by the core sample, during redeposition with more highly weathered materials. The quartz/feldspar ratio of the original sediment should not be increased if dilution is the effective process. A greater ratio with greater alteration frequency would indicate that decomposition of the feldspars was providing the alteration products. If we assume that the core sample and all other samples with quartz greater than 50% are undiluted samples, the quartz/feldspar ratio has a mean of 3.4 with a standard deviation of 1.0. To be significantly different the quartz/feldspar ratio would have to differ from the mean by 3x the standard deviation or by 3.0. Since only two of the ratios (9 and 67) differ by more than this amount from the mean, dilution can account for most of the variation in the frequency of alteration products. In samples 9 and 67 there is a significantly lower ratio which probably is an indication of a greater original amount of feldspar maintained through dilution.

MINERALOGY OF THE AREAS

Table II presents the weighted averages of the frequency distribution for each of the areas represented by the 5 groups of samples and also the core sample for comparison. The areas are again remarkably similar in composition. The relatively higher frequency of alteration products in the outer north area is due to the presence of two samples (27 and 67) in the average with high alteration frequencies. The north area is more favorably situated to receive recent sedimentation than the south area as it is a low area near land. Within the north area currents and wave action decrease seaward and, consequently, the amount of recent sedimentation should increase seaward within the area surveyed. The higher frequency of alteration products in the outer north area may reflect dilution by recent sediments.

COMPARISON OF CORE AND SURFACE MINERALOGY

Table III gives the weighted average of the frequency distribution of 25 surface samples and the frequency distribution of the core sample for comparison. There is no significant

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TABLE II

Average mineral frequency in specified areas in Boston Harbor

	Area**					
	Inner	Middle North	Outer North	Middle South	Outer South	Core
Mineral	Percent (Weighted Average of Samples in Area)					
Quartz	40	42	32	46	54	51
Alteration	38	35	48	27	20	24
Orthoclase	9	10	5	14	17	13
Plagioclase	4	1	3	1	3	8
Actinolite	t*	0	0	0	0	0
Allanite	0	0	0	t	0.2	0.4
Apatite	0	t	0	0	0	0
Biotite	0.9	0.6	2	0.9	0.4	0
Calcite	0.2	t	0	0	t	0
Chlorite	0.2	0.3	0.5	0.3	t	0
Clinozoisite	0	0	0	0	0	0.4
Corundum	t	0	t	t	0	0
Diopside	0	0	0	0	0	0.4
Epidote	0	t	t	0.4	0.4	0
Garnet	0.5	0.8	0.4	0.5	0.2	0.8
Glaucophane	0	0	0	0	t	0
Hypersthene	0	t	0	0	0	0
Hornblende	1	0.3	0.6	0.9	0.6	0.4
Kyanite	t	t	0.2	0	0	0
Microcline	0.9	0.5	0.3	0.6	0.2	0
Opaque	4	3	4	8	3	2
Sillimanite	t	0	0	0	0	0
Staurolite	t	t	t	t	0	0
Titanite	0.9	t	0.5	0.2	0	0.4
Tourmaline	0.2	0.5	0.4	t	0.3	0.4
Zircon	0	0.2	0.3	0.2	t	0
Zoisite	0	0	0.2	0	0.2	0

* t = trace

** Inner samples: 1, 2, 7, 9, and 10;
Middle North samples: 23, 44, 45, 46, and 47;
Outer North samples: 26, 27, 28, 67, and 68;
Middle South samples: 146, 162, 163, 170, and 173;
Outer South samples: 132, 133, 134, 136, and 417;
Core sample: 152 at -8'.

TABLE III

Average surface mineral frequency in Boston Harbor and mineral frequency in one core sample.

Mineral	Surface Average	Core
	Percent (Weighted Average of all Surface Samples)	
Quartz	42	51
Alteration	33	24
Orthoclase	12	13
Plagioclase	2	8
Actinolite	t*	0
Allanite	0.7	0.4
Apatite	t	0
Biotite	0.9	0
Calcite	t	0
Chlorite	0.3	0
Clinozoisite	0	0.4
Corundum	t	0
Diopside	0	0.4
Epidote	0.2	0
Garnet	0.5	0.8
Glaucophane	t	0
Hypersthene	t	0
Hornblende	0.7	0.4
Kyanite	t	0
Microcline	0.5	0
Opaque	4	2
Sillimanite	t	0
Staurolite	t	0
Titanite	0.4	0.4
Tourmaline	0.3	0.4
Zircon	0.2	0
Zoisite	t	0
No. Counted	5911	239

* t = trace

[redacted]

difference in the quartz/feldspar ratios of the surface samples and the core sample. The greater frequency of alteration products in the surface layers probably reflects the recent sedimentation.

The core sample is from a clay that has the same size distribution, color, and marine fossils as the Boston blue clay on shore. It is undoubtedly a seaward continuation of this clay. Since the Boston blue clay is a marine deposit of rock flour from the meltwaters of the glaciers, the offshore clay is also an immediately postglacial deposit. The similar mineralogy of many surface samples suggests that they are of glacial origin.

SUMMARY

1. The surface sediments of Boston Harbor are composed of quartz, alteration products, orthoclase, and plagioclase. Important accessories are biotite, hornblende, microcline, and opaque minerals. Nineteen other minerals occur less frequently.

2. The quartz/feldspar ratio does not differ significantly from sample to sample. The occasional high frequency of alteration products is thus probably due to dilution of the original sediment by highly weathered materials during redeposition.

3. There is no significant difference between the core sample and the surface samples except that the surface samples show a higher frequency of alteration products. The clay of the core sample is immediately postglacial in age, and the similar mineralogy of many surface samples suggests they are also glacial in origin.

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