ENVIRONMENTAL ANALYSIS OF THE SEDIMENTS OF SOUTHERN MONTEREY BAY, CALIFORNIA

GORDON M. MONTEATH

ENVIRONMENTAL ANALYSIS OF THE SEDIMENTS OF SOUTHERN MONTEREY BAY, CALIFORNIA

by

Gordon M. Monteath, Jr.

Lieutenant, United States Navy

[redacted]

[redacted]

Submitted in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

United States Naval Postgraduate School
Monterey, California

1 9 6 5

[redacted]

[redacted]

ENVIRONMENTAL ANALYSIS OF THE SEDIMENTS OF SOUTHERN MONTEREY BAY, CALIFORNIA

by

Gordon M. Monteath, Jr.

This work is accepted as fulfilling
the thesis requirements for the degree of
MASTER OF SCIENCE
from the
United States Naval Postgraduate School

ABSTRACT

Thirty-eight bottom sediment samples were collected in southern Monterey Bay; these were analyzed for their textural and constituent mineral compositions using coarse fraction analyses. Nine constituents were recognized and their percentage concentrations in the various size fractions of each sample were estimated.

Charts of the bay showing the sediment texture and the percentage of each constituent in the sediments were prepared. The distribution of the constituents and the relationship of each given constituent concentration to the sediment texture and to the concentration of other constituents were examined, and yielded the following results: the constituent concentrations were found to lie in belts roughly paralleling the shoreline. In general, terrigenous constituents (quartz, feldspar, and mafics) occurred in highest concentrations along the coast in areas of medium to fine sand, whereas pelagic constituents (foraminifera and other organics) and authigenic minerals (glauconite and phosphorite) were most highly concentrated in silts and clays occupying the outer continental shelf. The area of authigenic mineral occurrence is considered to be essentially a non-depositional environment.

The factors controlling the marine depositional environment on the shelf in southern Monterey Bay are the supply of sediments derived from the Salinas River watershed and from shoreline erosion of the Monterey Peninsula, the barrier to sediment influx from the north presented by the Monterey Submarine Canyon, and the sheltering influence of the peninsula in creating a quiet area in the extreme southern end of the bay.

TABLE OF CONTENTS

Section	Page
INTRODUCTION	1
Background	1
Area description	1
Coastal physiography and geology	2
Constituent selection	8
PROCEDURE	10
Field sampling	10
Laboratory analysis	10
DATA ANALYSIS AND INTERPRETATION	15
Size distribution of sediments	15
Constituent analysis	15
Aggregates and Coprolites	17
Biotite	22
Foraminifera	26
Glauconite	31
Mafics	37
Phosphorite	44
Organic Debris	49
Quartz and Feldspar	54
Shell Fragments	57
SUMMARY AND CONCLUSIONS	61
Controlling factors	61
Distribution characteristics	61
ACKNOWLEDGEMENTS	63
BIBLIOGRAPHY	64
Appendix I Sources of Error in Estimation and Computation of Constituent Concentrations	65
Appendix II Concentration of Constituents in the Sediment Samples	69

LIST OF ILLUSTRATIONS

Figure		Page
1.	Station Pattern	3
2.	Submarine Geology	4
3.	Coastal Geology	6
4.	Sediment Distribution	16
5.	Aggregates and Coprolites Distribution Chart	19
6.	Aggregates and Coprolites Histogram	20
7.	Photograph of Aggregates, Coprolites, and Biotite	21
8.	Biotite Distribution Chart	24
9.	Biotite Histogram	25
10.	Foraminifera Distribution Chart	28
11.	Foraminifera Histogram	29
12.	Photograph of Foraminifera and Glauconite	30
13.	Glauconite Distribution Chart	34
14.	Glauconite Histogram	35
15.	Glauconite to Biotite Ratio Distribution Chart	36
16.	Mafics Distribution Chart	39
17.	Mafics Histogram	40
18.	Photograph of Mafics and Phosphorite	41
19.	Mafics to Quartz-Feldspar Ratio Distribution Chart	42
20.	Mafics-Biotite to Quartz-Feldspar Ratio Distribution Chart	43
21.	Phosphorite Distribution Chart	46
22.	Phosphorite to Organic Debris Ratio Distribution Chart	47
23.	Phosphorite Histogram	48
24.	Organic Debris Distribution Chart	51

Figure Page

25. Organic Debris Histogram 52

26. Photograph of Organic Debris and Quartz-Feldspar 53

27. Quartz and Feldspar Distribution Chart 55

28. Quartz and Feldspar Histogram 56

29. Photograph of Shell Fragments 58

30. Shell Fragments Distribution Chart 59

31. Shell Fragments Histogram 60

LIST OF TABLES

Table Page

1. Example of Percentage Computations 13

INTRODUCTION

Background

The purpose of this research was to investigate the depositional environments of the bottom sediments on the continental shelf of southern Monterey Bay, California. Too frequently in oceanographic and marine geological literature, bottom sediments are described entirely by their textural and mechanical properties. The environments of marine deposition cannot be characterized by size distributions alone, because marine sediments are commonly made up of a variety of constituents, each having different physical, chemical, and mineralogical properties.

In this study 38 surface samples were collected; these were split into coarse and fine fractions, and the coarse fractions were then analyzed for their constituent composition and their textural distribution. Nine constituents were identified in the coarse fractions of the Monterey Bay sediments, and a microscopic description, textural analysis, and percentage estimation of each was made. Possible relationships between the occurrence and amounts of each constituent were sought as indicators of the depositional environments on the shelf. The methods of coarse fraction microscopic analysis were first described by Shepard and Moore (1954) and later summarized by Shepard (1963). Some modifications of these methods, which were made by the author in this study, are described herein.

Area description

The area selected for study is located entirely on the continental shelf in the southern half of Monterey Bay, California. It is bounded

on the north and west by the Monterey Submarine Canyon, on the south by the rocky shoreline of the Monterey Peninsula, and on the east by a continuous sand beach backed by extensive sand dunes. The area, along with the locations at which bottom samples were taken, is illustrated in Figure 1.

Sampling was restricted to depths of less than 75 fathoms for the following reasons:

(1) The 75-fathom depth represents the approximate elevation of sea level during the Wisconsin, or last glacial period, and most or all of the area sampled has been transgressed by the ocean very recently. Accordingly, ancient shorelines or relict sediments may be identified on the basis of the sediment texture and composition and bottom topography.

(2) Monterey Submarine Canyon, as delineated by the 100-fathom curve in Figure 1, begins its descent on the seaward edge of the area with a steep slope approximately at the 75-fathom line. The walls of the canyon appear to be nearly devoid of sediment overburden, and represent the narrow continental slope plunging down to the abyssal environment of the deep sea floor. These environments have different characteristics from the shallow water environments of the continental shelf. The geology of the Monterey Submarine Canyon was the subject of a thorough investigation by Martin (1963).

Coastal physiography and geology

The sediments of Monterey Bay were first described in detail by Galliher (1932), and his interpretation of their textural distribution is illustrated in Figure 2. Significant features of the distribution

STATION PATTERN

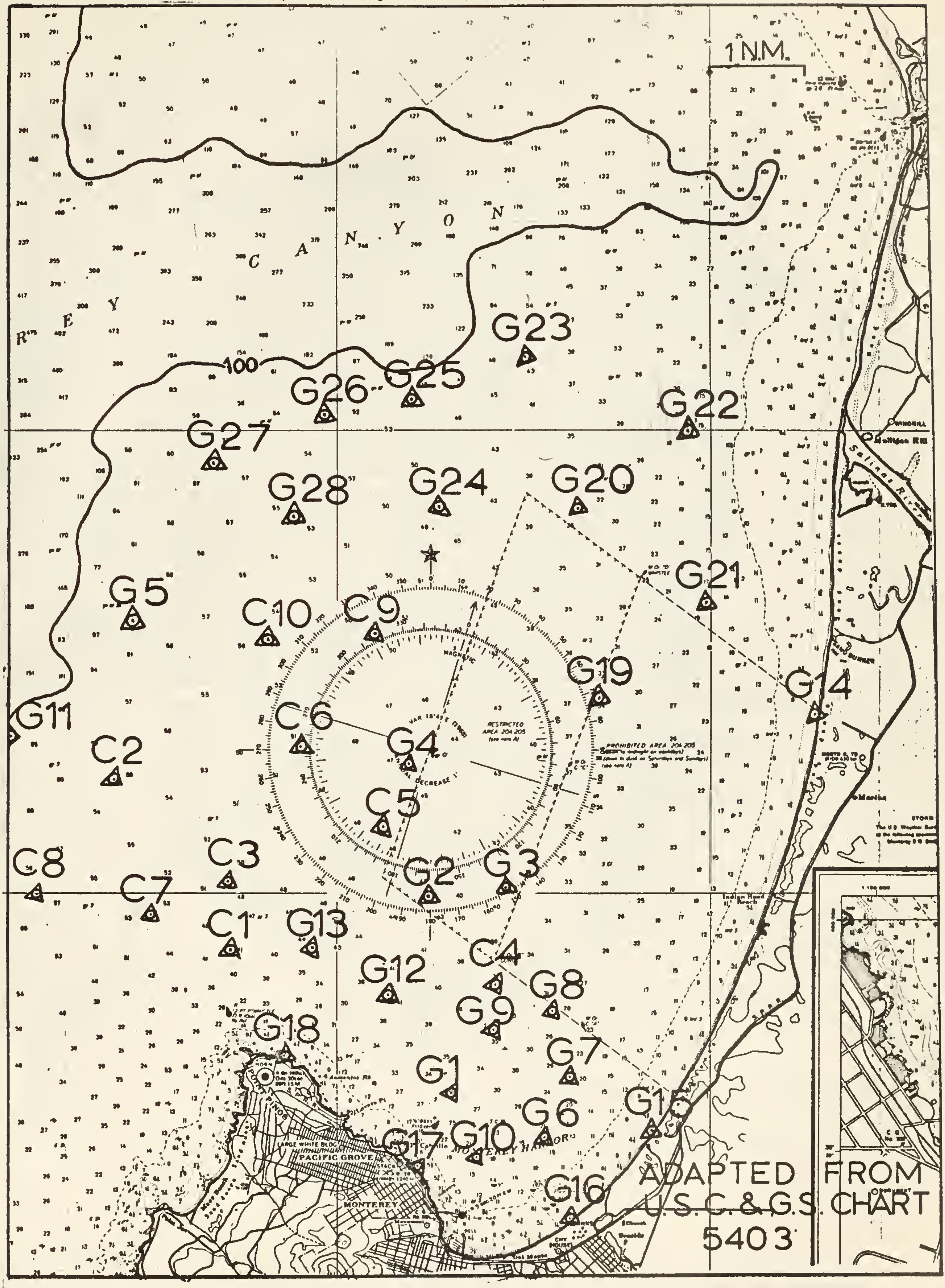


Figure 1

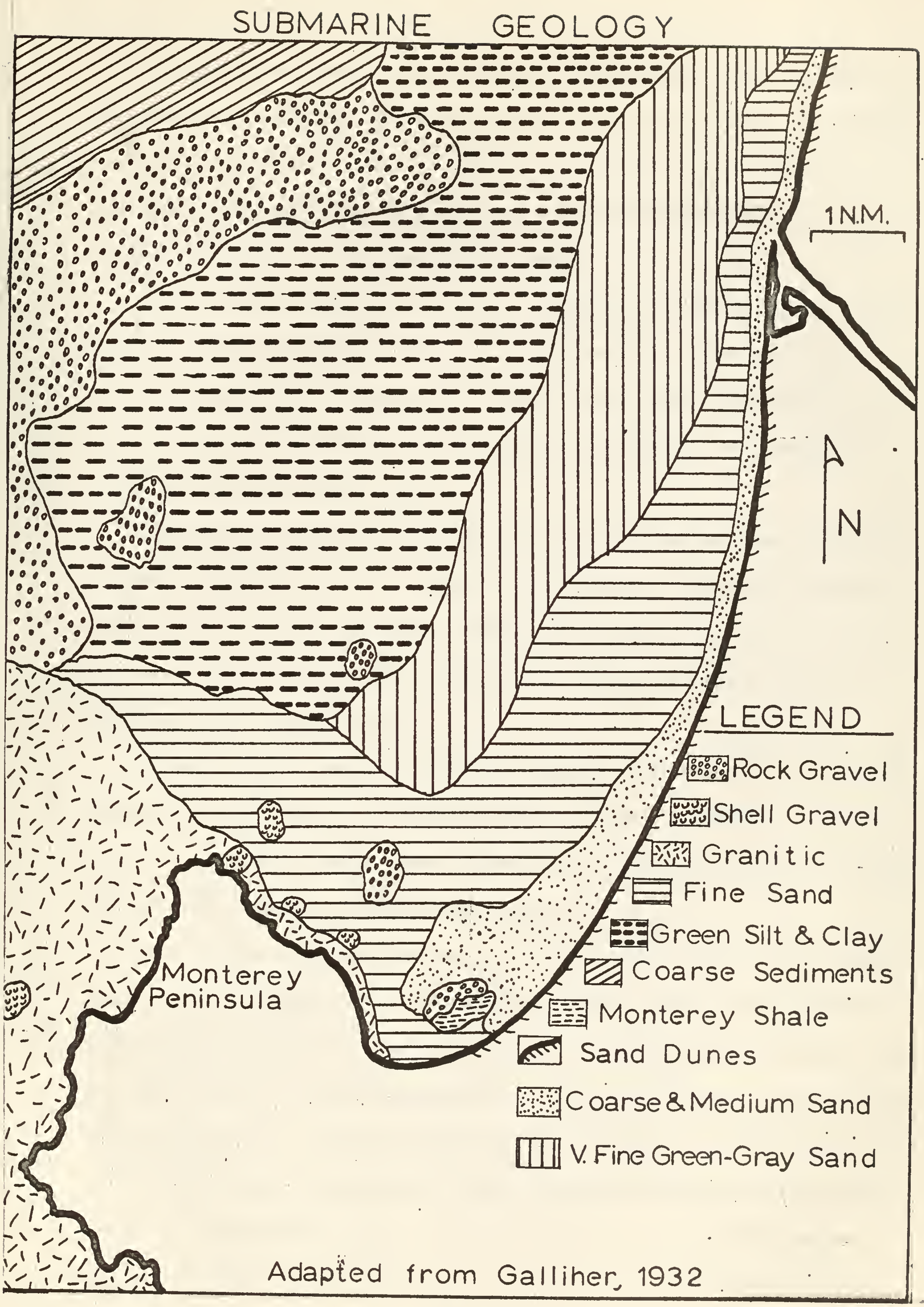

SUBMARINE GEOLOGY
1 N.M.
N
LEGEND
Rock Gravel
Shell Gravel
Granitic
Fine Sand
Green Silt & Clay
Coarse Sediments
Monterey Shale
Sand Dunes
Coarse & Medium Sand
V. Fine Green-Gray Sand
Monterey Peninsula
Adapted from Galliher, 1932

Figure 2

are the gradation toward finer sediment sizes seaward from the coast, the generally parallel transition from one size to another, the appearance of "rock gravel" near the edge of the canyon, the extensive granitic outcropping in the area west of Monterey Peninsula, and the isolated patches of "rock and shell gravel."

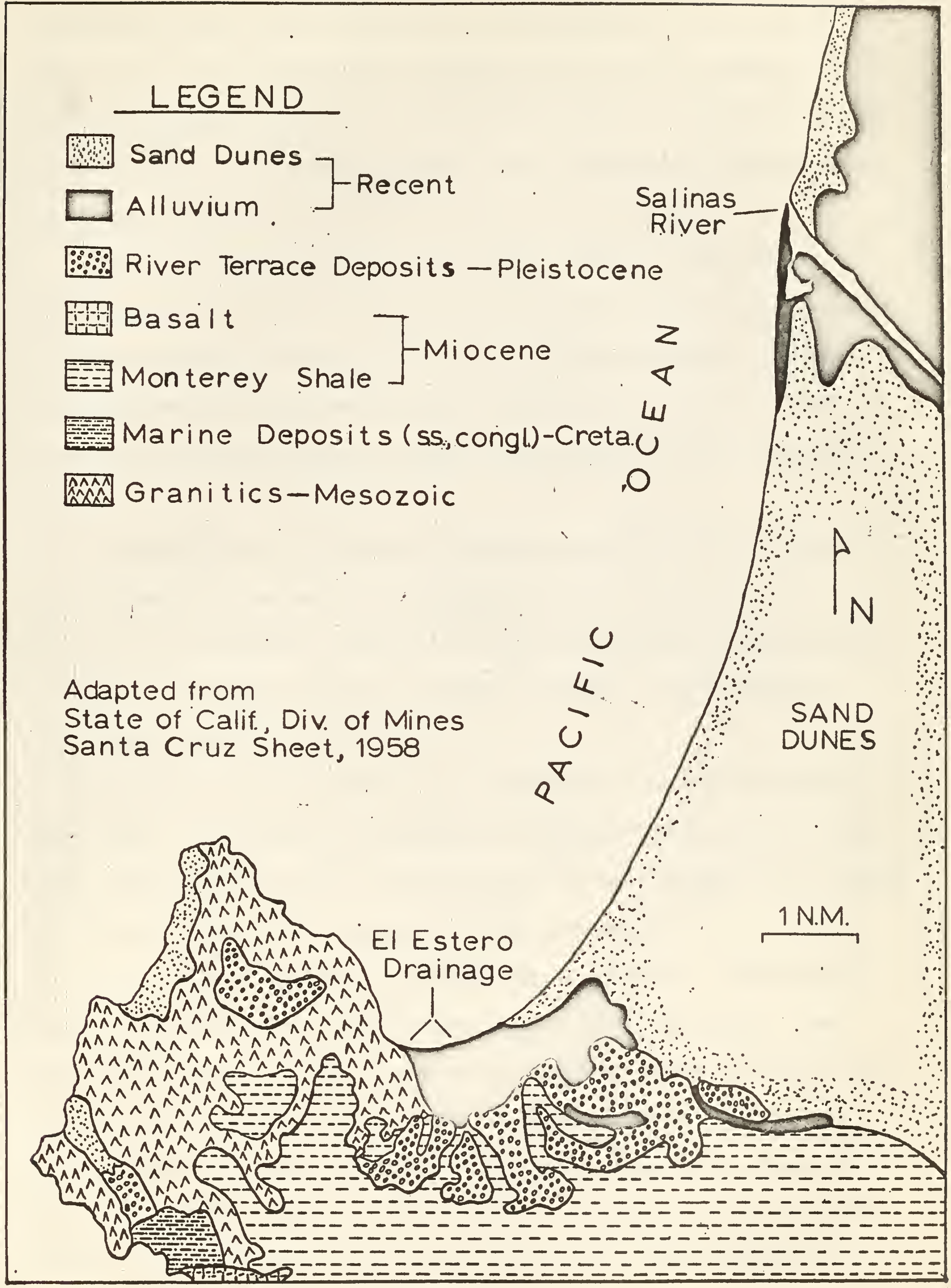
Monterey Bay sediments were also studied by Galliher (1935) in connection with the genesis of the mineral glauconite. The wide area of green silt and clay on the central shelf is of special interest in this regard and will be treated in the section concerning the glauconite distribution within the region.

Phosphorite has been obtained from Monterey Bay and was discussed by Emery and Dietz (1950). However, in the present study, the phosphorite content in most of the samples was found to be less than one percent. The rarity of phosphorite is of particular interest and is discussed in a later section.

Summarizing the marine geology studies accomplished by other investigators in the region, it is clear that Galliher's work was, and remains, a classic; however, more recent investigations have been few and the area still lacks comprehensive coverage.

The coastal and land geology surrounding the area is illustrated in Figure 3. The influence of this sediment source area on the environments within the bay is best illustrated by considering the mineral composition of the formations themselves. The Salinas River, which enters the ocean near the northern end of the area, appears to be a main source of the non-organic constituents of the sea floor sediments. The river, which is intermittent and flows only during the rainy winter season, varies widely in its discharge from year to year. It drains a large

COASTAL GEOLOGY



Adapted from
State of Calif., Div. of Mines
Santa Cruz Sheet, 1958

Figure 3

watershed in which shales, granitics, and metamorphic rocks outcrop. Much of the coarser material introduced by the river was deposited in a broad subdued delta adjacent to its mouth (Figure 1). Some of this material supplied the adjacent beaches of the inner bay and some was probably transported down the canyon to the deep sea floor.

Several drainage areas in the extreme southern end of the bay, including the El Estero drainage indicated in the figure, are very small today and supply no sediments to the bay. They were active, however, in supplying mainly marine shale erosion products to the sea floor when sea level was lower than present, during late Wisconsin and post-Wisconsin time.

The shoreline of the Monterey Peninsula itself is presently providing sediments to the bay. The mechanical action of waves, tides, and currents in eroding the granitics of the protruding peninsula apparently supplies a significant amount of quartz, feldspar, and hornblende to the bottom complex.

It is probable that there are no significant sources of sediment from areas to the north of the Monterey Submarine Canyon, since the canyon, which heads virtually at the shoreline at Moss Landing in the center of the bay, serves as a barrier to sediment transport.

It is evident that the rate of supply of sediments to the southern half of the bay has not been constant during Recent geological time. The Salinas River, as well as the minor drainages in the southern end of the bay, clearly supplied quantities of sediment during the time of lowered Wisconsin sea level when the stream gradients were steeper and the streams were incised in their channels. Wave erosion of the peninsula, on the other hand, has probably been more or less constant over

the same period; however, comparing the surface areas affected by this process with the drainage area of the Salinas River, it is clear that the contribution from the peninsula has been relatively minor compared to that from stream drainage.

Constituent selection

Microscopic examination of the sediment samples revealed that they are composed of at least nine distinctive constituents. These were thus chosen to be studied with regard to their environmental significance in the area. The constituents are:

(1) Aggregates and Coprolites--agglomerations of organic or mineral matter cemented together by silt, clay, or organic secretion; fecal pellets consisting of mineral grains are included.

(2) Biotite--a rock-forming mineral of the mica group.

(3) Foraminifera--planktonic and some benthonic tests of various genera.

(4) Glauconite--a hydrous potassium iron silicate mineral of authigenic origin.

(5) Mafics--dark relatively heavy rock-forming minerals including hornblende, tourmaline, epidote, and augite; this group excludes biotite.

(6) Phosphorite--a phosphorous mineral similar to apatite and believed to be precipitated authigenically.

(7) Organic Debris--plant fibers, wood fragments, sponge spicules, diatoms, dinoflagellates, and other extraneous organic material.

(8) Quartz and Feldspar--the dominant rock-forming silicate minerals in this area.

(9) Shell Fragments--pieces of calcareous shells of pelecypods,

gastropods, other molluscs, etc., exclusive of foraminifera.

Quartz and feldspar, biotite, and the mafics are derived from the adjacent coast, glauconite and phosphorite are formed in situ in the ocean, shell fragments and foraminifera are formed organically and entirely in the ocean, and aggregates-coprolites and organic debris are derived both from land and marine environments.

PROCEDURE

Field sampling

Sampling was accomplished aboard the U. S. Naval Postgraduate School's hydrographic research boat, a converted 63-foot Navy aviation rescue craft. Core samples were taken using a Phleger corer which obtained 1 1/2-inch diameter cores of various lengths depending upon the size of the barrel chosen (one or two feet) and the hardness of the bottom. A Dietz-La Fond clam shell snapper was also used, especially where the presence of coarse sand or gravel bottom prevented penetration by the corer. The sampling device used at each station is designated by the letters C and G in the station nomenclature shown in Figure 1. A valuable adjunct to the study would have been a box corer or a pipe dredge, which might have supplied supplementary rock samples; however, the research vessel was not equipped to handle equipment of this size.

The author recognizes the limitations imposed upon the results through the use of these bottom samplers, primarily the problem of achieving a sufficient density of stations to give a representative picture of the bottom sediment distribution. The textural and compositional distributions of the sediments derived from this study revealed generally well-defined patterns covering extensive parts of the area; accordingly, the station density is considered adequate to reveal the larger scale aspects of the distributions.

Laboratory analysis

Standard laboratory procedures were employed in carrying out the coarse-fraction analysis of the samples. Shepard and Moore (1954) outlined the steps adequately; however, because of some minor variations

the steps are reiterated herein:

(1) Approximately five centimeters from the top of each core sample or 50 grams from a grab sample was dried and weighed.

(2) Disaggregation was accomplished using a 0.01N solution of sodium oxalate in which the sample was soaked for approximately ten minutes.

(3) The entire sample was washed through a 0.062 millimeter (250 mesh) standard Tyler sieve in order to separate the coarse fraction from the fine. Both fractions were then dried and the fine fraction was saved for possible future reference.

(4) A Tyler RoTap Sieve Shaker was used to sieve each coarse fraction into standard Wentworth grade sizes.

(5) Each fraction was weighed, a cumulative frequency distribution of the total sample was constructed, and the median grain size was determined.

Prior to submitting each size fraction of a sample to a microscopic analysis, the fraction was split into four equal parts whenever the fraction volume was sufficiently large. This was done so that an average of four visual constituent percentage estimates could be obtained, rather than relying on a single judgment.

Utilizing the binocular microscope, each size fraction or part of a fraction of each sample was examined and a visual estimate of the percentage of each of the nine constituents was made and recorded. Recording of the percentages was accomplished by the use of a tape recorder with a microphone conveniently secured near the base of the microscope. This enabled the investigator to keep his eyes on the fraction while recording successive percentage estimates. This was found to be quite

the steps are reiterated herein:

(1) Approximately five centimeters from the top of each core sample or 50 grams from a grab sample was dried and weighed.

(2) Disaggregation was accomplished using a 0.01N solution of sodium oxalate in which the sample was soaked for approximately ten minutes.

(3) The entire sample was washed through a 0.062 millimeter (250 mesh) standard Tyler sieve in order to separate the coarse fraction from the fine. Both fractions were then dried and the fine fraction was saved for possible future reference.

(4) A Tyler RoTap Sieve Shaker was used to sieve each coarse fraction into standard Wentworth grade sizes.

(5) Each fraction was weighed, a cumulative frequency distribution of the total sample was constructed, and the median grain size was determined.

Prior to submitting each size fraction of a sample to a microscopic analysis, the fraction was split into four equal parts whenever the fraction volume was sufficiently large. This was done so that an average of four visual constituent percentage estimates could be obtained, rather than relying on a single judgment.

Utilizing the binocular microscope, each size fraction or part of a fraction of each sample was examined and a visual estimate of the percentage of each of the nine constituents was made and recorded. Recording of the percentages was accomplished by the use of a tape recorder with a microphone conveniently secured near the base of the microscope. This enabled the investigator to keep his eyes on the fraction while recording successive percentage estimates. This was found to be quite

advantageous for maintaining "running" notes about various interesting items and their relationships during perusal of the fractions.

The method used in calculating the percent of each constituent within a sample, which varies slightly from that suggested by Shepard (1963), was as follows: the percent of a constituent within a size fraction was first estimated visually to at least the closest five percent; this percentage was then multiplied by the weight of the fraction to give the weight of the constituent within the fraction. These fractional constituent weights were cumulated as a sum which represented the total amount present within the coarse fraction of each sample. This sum divided by the coarse fraction sample weight gave the total percent of the constituent within the coarse fraction of a sample. An example of this method is shown in Table 1.

After computing total coarse-fraction percentages of each constituent within all samples, these values were plotted on charts of the bay. Isolines of percent were then drawn to illustrate the bottom distribution of the constituents. Figure 5 represents an example of a distribution chart, and it may be interpreted as follows: the area marked 2-10% indicates that the concentration of aggregates and coprolites in the samples within these boundaries is two to ten percent of the coarse fraction of the sediments. Similar distribution charts are discussed in the respective section for each constituent.

Histograms of the number of occurrences of percentage intervals within each fraction were drawn for every constituent. These are also discussed in the following sections.

These techniques obviously are sources for errors, the most important of which is the visual estimation of the constituent percentage in

Table 1

EXAMPLE OF PERCENTAGE COMPUTATIONS

CONSTITUENT: QUARTZ AND FELDSPAR STATION/SAMPLE NUMBER C-6

LOCATION: LATITUDE 36°41.5'N LONGITUDE 121°55.3'W DEPTH 50 FM.

DRY WEIGHT OF TOTAL SAMPLE 59.07 GM.

DRY WEIGHT OF FINE FRACTION 26.16 GM.

DRY WEIGHT OF COARSE FRACTION 32.91 GM.

FRACTION	CONSTITUENT PERCENT		FRACTION WEIGHT		TOTAL WEIGHT OF CONSTITUENT WITHIN FRACTION
2 mm.	50 %	x	1.61 GM.	=	0.8 GM.
1-2 mm.	35 %	x	1.71 GM.	=	0.6 GM.
1/2-1 mm.	20 %	x	2.13 GM.	=	0.4 GM.
1/4-1/2 mm.	10 %	x	2.64 GM.	=	0.3 GM.
1/8-1/4 mm.	40 %	x	8.70 GM.	=	3.5 GM.
1/16-1/8 mm.	50 %	x	16.12 GM.	=	8.1 GM.

TOTAL AMOUNT PRESENT IN COARSE FRACTION 13.7 GM.

CONSTITUENT PERCENT OF COARSE FRACTION 41.5 GM.

each sample. A discussion of error sources is presented in Appendix I.

A breakdown of the composition of all fractions for each sample is tabulated in Appendix II, showing percentage estimations versus grain size.

DATA ANALYSIS AND INTERPRETATION

Size distribution of sediments

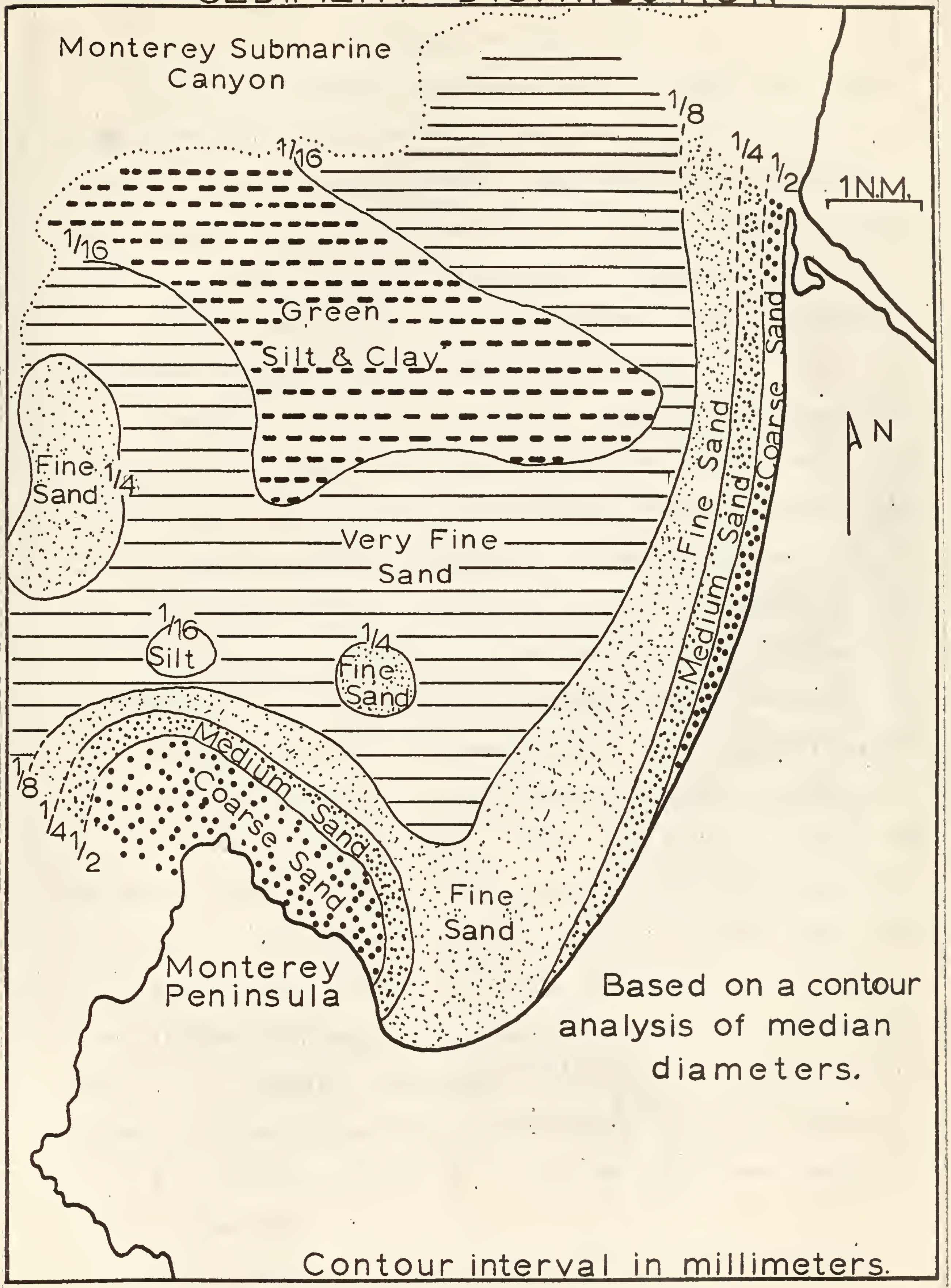
The sediment distribution found as a result of this study is shown in Figure 4. Contours corresponding to the Wentworth grain-size scale are illustrated. It may be observed that the boundaries between sand sizes approximately parallel the shoreline.

The textural distribution is very similar to that reported by Galliher (1932), shown in Figure 2. Significant differences from Galliher's study, however, are noted in the fact that the greenish very find sands and silts were found, in the present study, to cover a much larger area, and that the sediments near the edge of the canyon were found to be silty sand with a few pebbles rather than the wide strip of "rock gravel" indicated by Galliher. Only one of Galliher's isolated "rock gravel" patches was sampled (station G-1), and that was analyzed texturally as a medium sand. In several samples obtained in the area northwest of Pt. Pinos, the author found silty sand in the area described by Galliher as granitic. No granitic pebbles or fragments were found, so that confirmation of a hard rock bottom could not be made; however, granitic outcrops are abundant in the sea cliffs and surf zone around the peninsula and one might expect similar outcrops to exist some distance from shore.

Constituent analysis

Discussions of the nine constituents follow, including descriptions of their appearance and any features of particular interest, their bottom distribution, textural distributions in each sample, influences of coastal topography and geology, and relationships with other constituents. These factors contribute to the total sedimentary environment which has determined the nature of the sediments occurring on the shelf.

SEDIMENT DISTRIBUTION



Based on a contour analysis of median diameters.

Contour interval in millimeters.

Figure 4

Aggregates and Coprolites

In most bottom samples, aggregates, and to a lesser degree coprolites, consisted of accumulations of fine sand or clay sized grains cemented together by finer materials. Coprolites, or fecal pellets, were infrequent in their occurrence and the ones that were observed were of fairly large size, 1/4 to 1/2 millimeters in diameter, and either well rounded or tapered at one end. The maximum concentration of coprolites never exceeded 1% of the combined percentages.

Aggregates were of two general types. Present in lesser amounts were aggregates consisting of tiny shale particles and other well-cemented masses of fine material which randomly resisted disaggregation in the laboratory procedure. Aggregates of mineral grains bound together by organic material were found in abundance. These were in the shape of a tiny nest or tube, not larger than one or two millimeters nor smaller than half a millimeter in diameter, and were composed of an outer framework of quartz or feldspar grains. Upon first investigation the walls in the interior, as viewed through the aperture, appeared to consist of dark brown mica flakes; however, after splitting several open, it became clear that this internal coating was a dark secretion used by an organism as a cementing substance for the nest or tube. These common aggregates were most abundant in the fine sand or silt areas. None of the organisms were found occupying these tubes. Personal communication with Dr. E. C. Haderlie, Professor of Biology at Monterey Peninsula College, confirmed the author's suspicions that these nests were possibly constructed and utilized by a species of annelid worm which is common in this area.

Several examples of the aggregates and coprolites found in the

samples are pictured in the photograph in Figure 7(a).

The percentage distribution of aggregates and coprolites found in the southern Monterey Bay is shown in Figure 5. Figure 6 presents a group of six histograms, each for a given Wentworth size fraction, showing the number of samples (out of a total of 38) in which the aggregate and coprolite concentrations lie in the percentage ranges shown. From these two illustrations, it is evident that the maximum concentration of aggregates and coprolites occurs on the outer shelf in the area identified texturally as very fine and fine sandy bottom, and that there is a tendency for percentages to occur in the larger fractions. The latter conclusion is confirmed by microscopic observation.

Distance from the coast is obviously an important factor in the concentration of aggregates. It is possible that the wide area of wave action around the peninsula tends to mechanically disintegrate them; on the other hand, they may have been produced by organisms which avoid this rigorous environment.

Aggregates themselves do not appear to bear a relationship to any of the other constituents. Coprolites, on the other hand, have been tabbed by Cloud (1955), Burst (1958), and later by Shepard (1963), as one of the possible source materials for the formation of glauconite. This relationship will be discussed again in the section on glauconite.

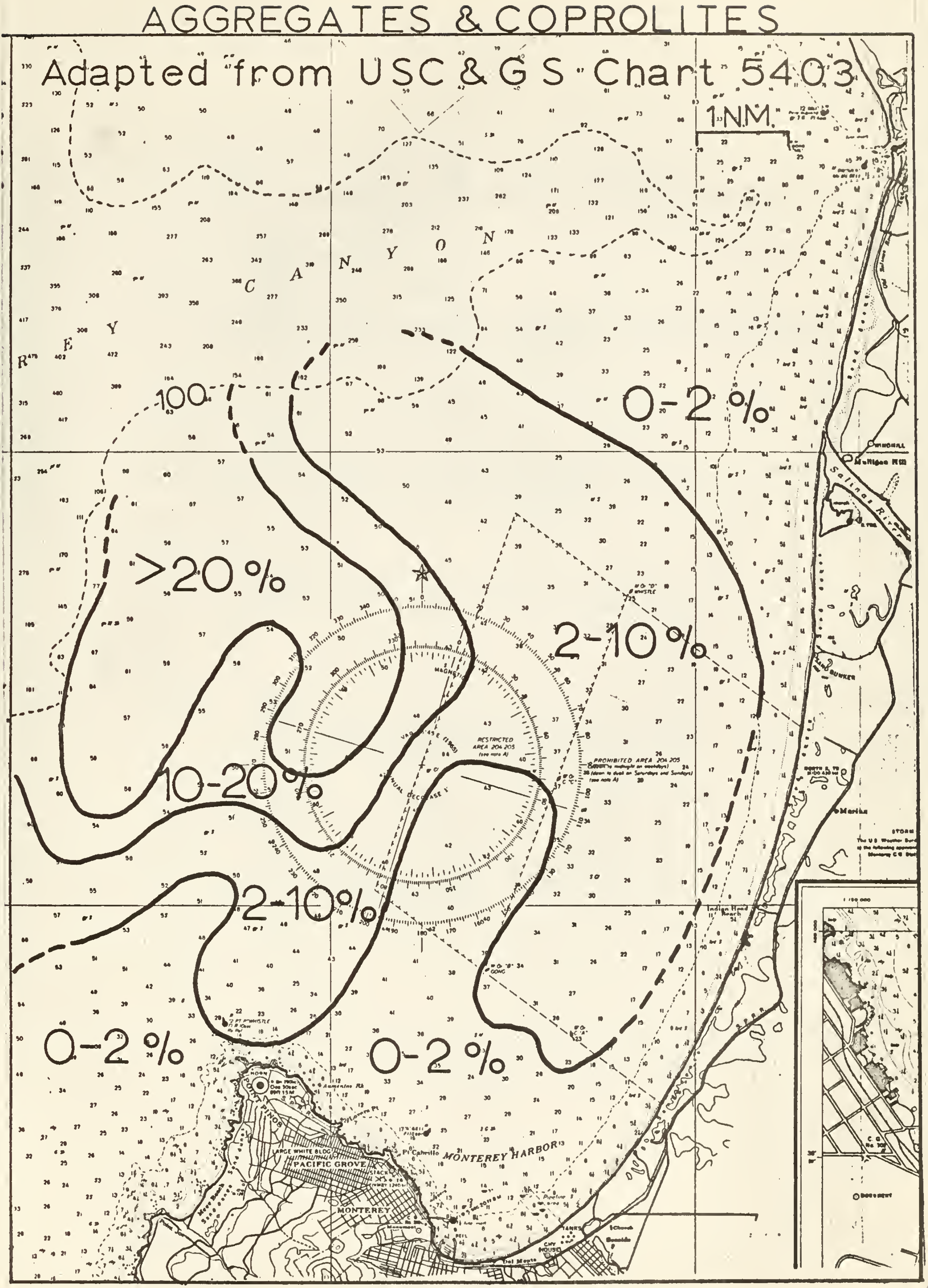

AGGREGATES & COPROLITES
Adapted from USC & GS Chart 5403
1 N.M.
R E Y C A N Y O N
100
0-2 %
>20 %
2-10 %
10-20 %
2-10 %
0-2 %
0-2 %
Salinas River
MONTEREY HARBOR
PACIFIC GROVE
MONTEREY
POINT PINOS
RESTRICTED AREA 204.205
PROHIBITED AREA 204.205

Figure 5

HISTOGRAMS OF THE NUMBER OF SAMPLES OF AGGREGATES & COPROLITES

(38 SAMPLES)

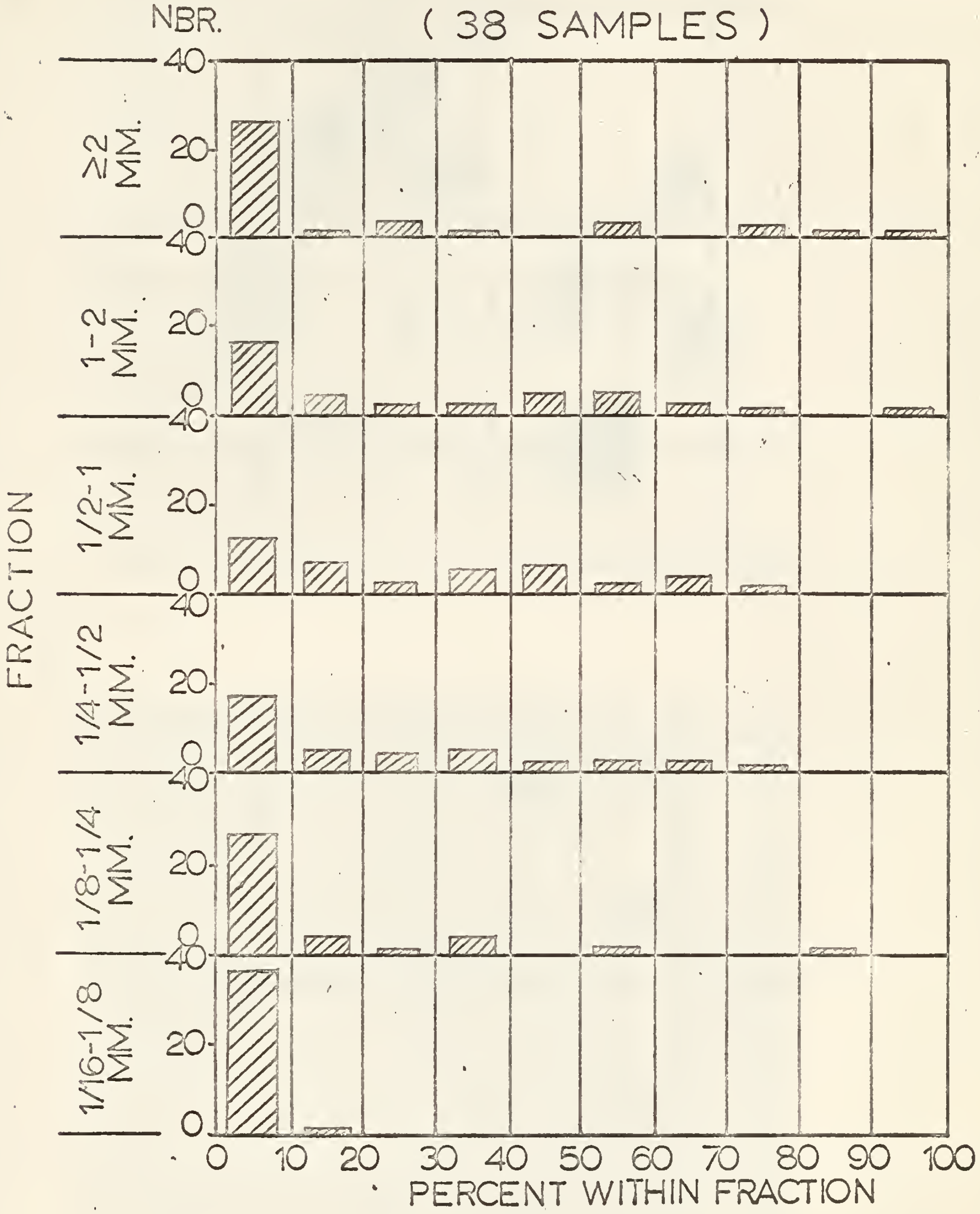
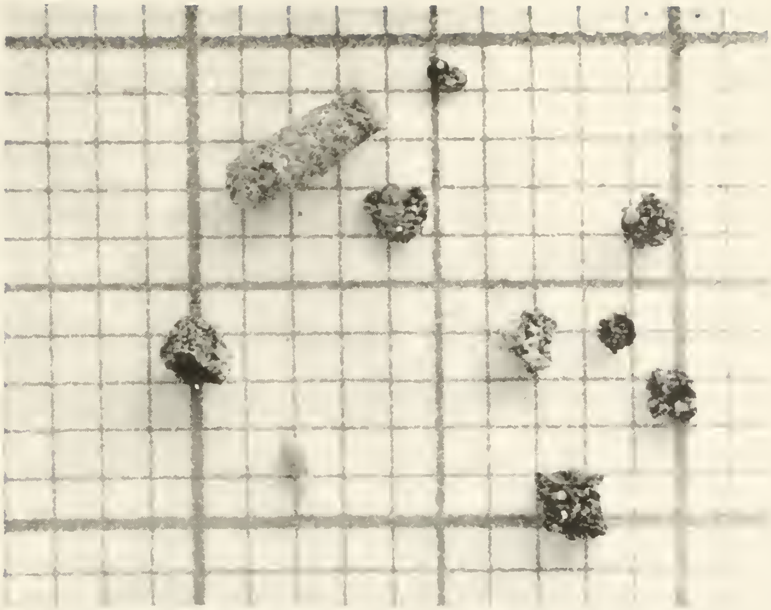
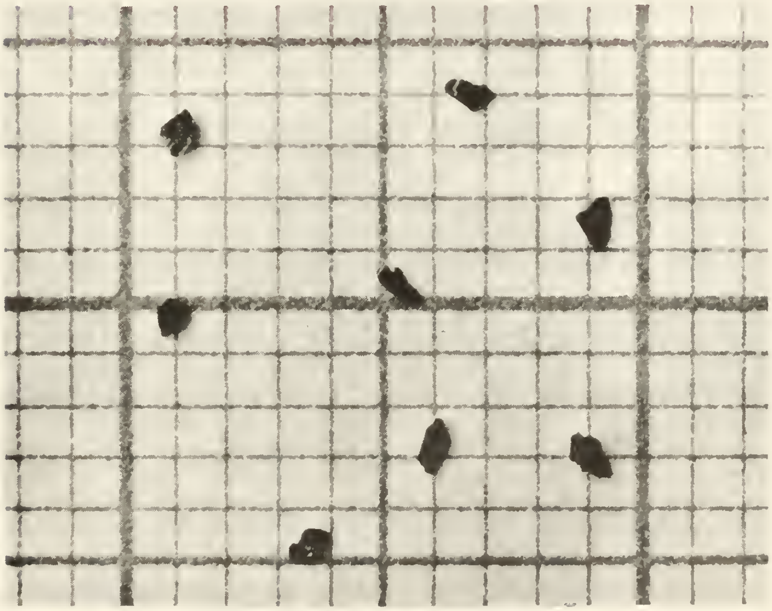


Figure 6



(a) AGGREGATES & COPROLITES



(b) BIOTITE

Figure 7.

Biotite

Biotite found in the samples ranges in color from brown to bright green. The crystals of bright-green color were "inflated" and are evidently what Galliher (1935) was referring to as the transition stage in the transformation of biotite to glauconite. Examples of biotite found in the sediment are shown in Figure 7(b).

The distribution chart of biotite, Figure 8, shows a large area of high concentration lying parallel to and centered about three miles from the shoreline. This concentration is possibly a result of drainage from the Salinas River as an erosion product of metamorphics located well up in the valley. Minimal amounts of biotite are found in the surf zone and the nearshore areas. This is very likely the effect of wave action in tending to keep the flaky grains in suspension and their resultant rafting out into quieter water.

The area of maximum concentration coincides well with the areas described texturally as very fine sand and silt or clay. This is significant in view of the fact that in samples having the greatest percentages of biotite, it is concentrated in the fine and very fine fraction categories, as may be seen from the histogram in Figure 9. The conclusion can thus be reached that biotite constitutes a major contribution to the sediments in this area, and that the contribution is mainly in the fine and very fine sand sizes.

In the role of a rock-forming mineral, biotite is often closely related in its occurrence to quartz and feldspar. However, the granitics forming the peninsula contain only small amounts of biotite and it seems probable that offshore the biotite is derived primarily from metamorphics located well inland and introduced mainly by the Salinas River.

Because of the marked difference in hydrodynamic properties of biotite flakes compared with grains of quartz and feldspar, the distribution of these constituents should not necessarily be expected to be similar. This is borne out by comparison of Figures 8 and 27.

A discussion of the biotite-glauconite relationship, with regard to the study made by Galliher (1935), is covered in detail in a later section.

BIOTITE

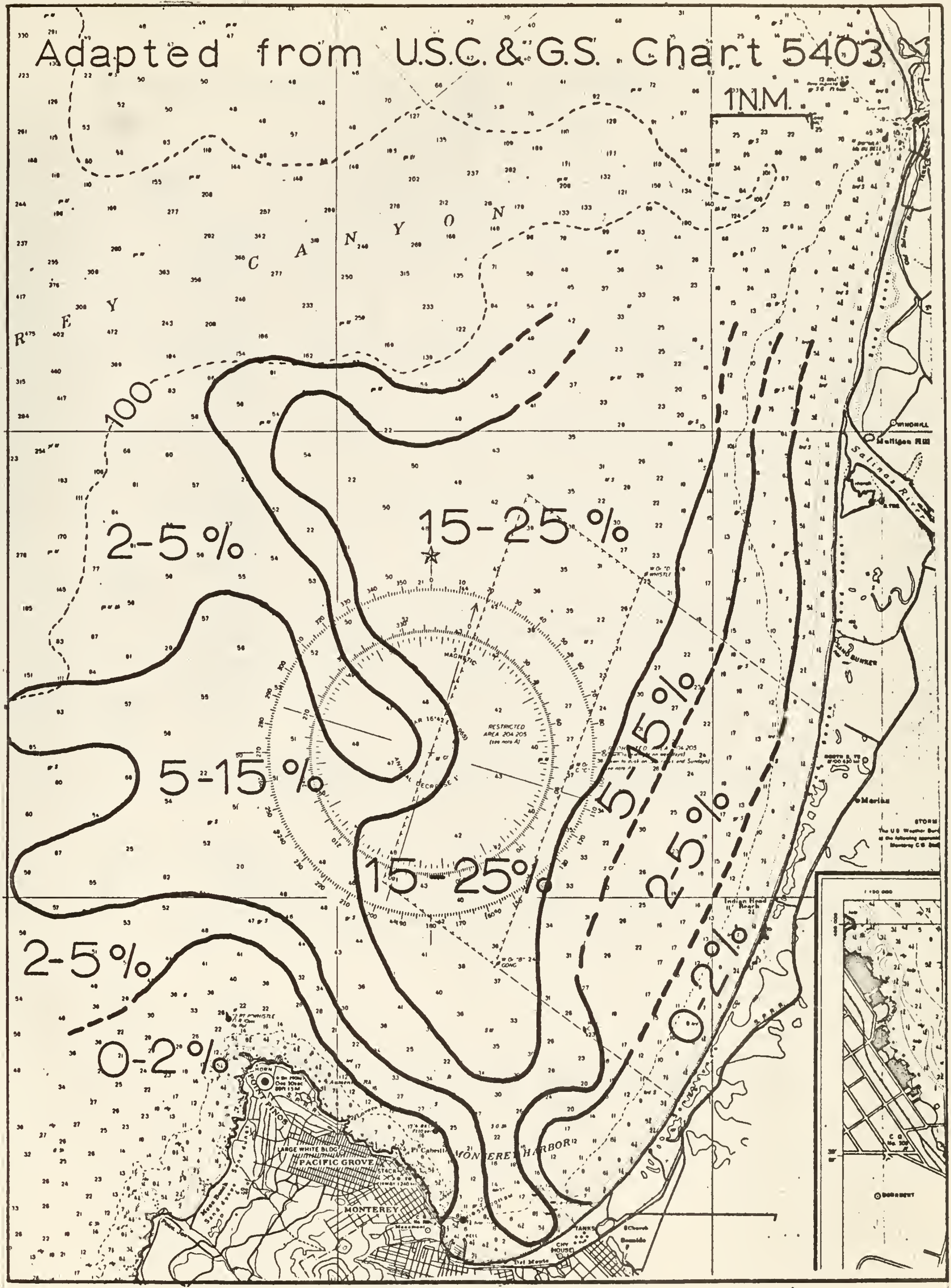


Figure 8

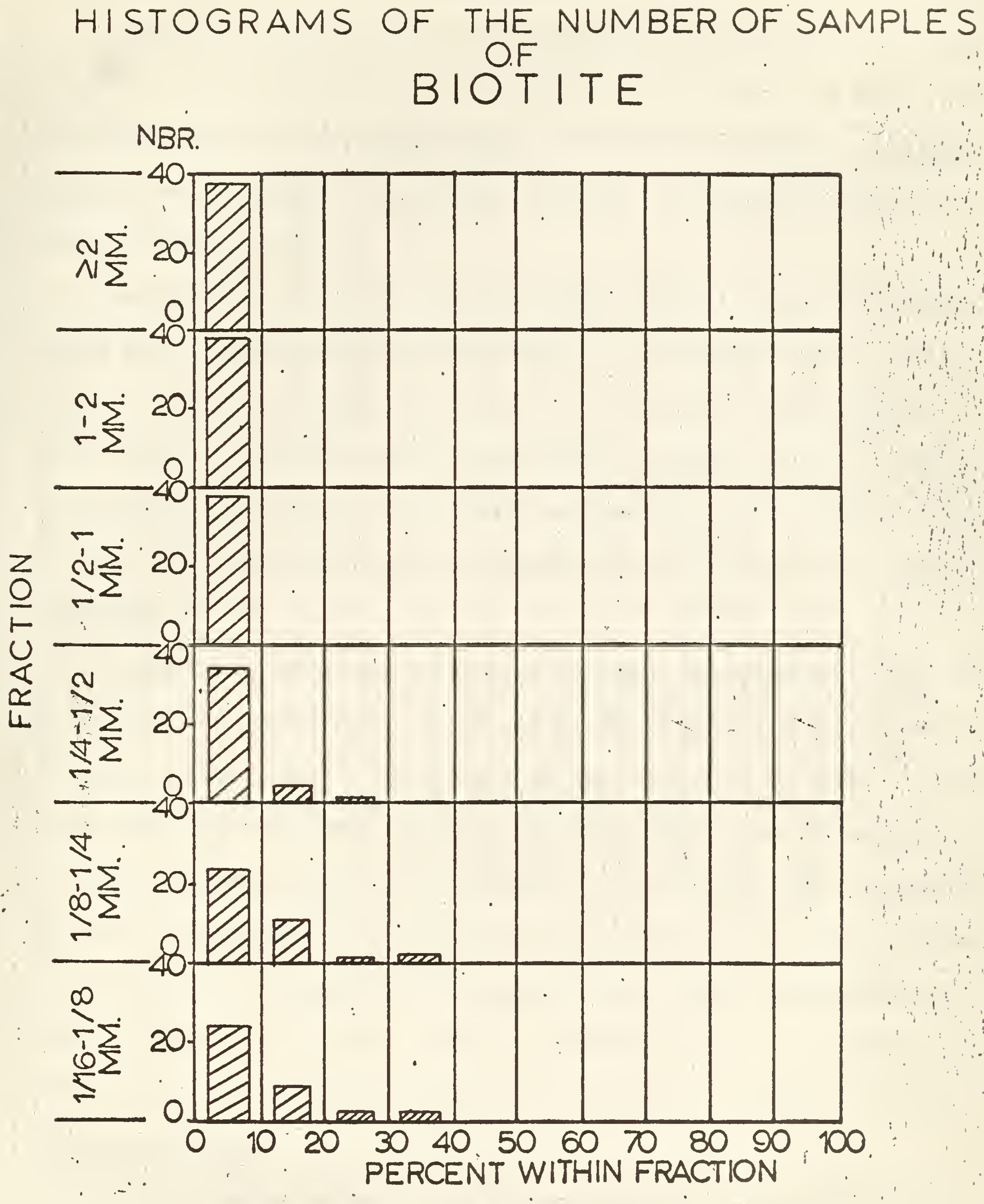

HISTOGRAMS OF THE NUMBER OF SAMPLES OF BIOTITE
NBR.
FRACTION
≥2 MM.
1-2 MM.
1/2-1 MM.
1/4-1/2 MM.
1/8-1/4 MM.
1/16-1/8 MM.
0
20
40
0 10 20 30 40 50 60 70 80 90 100
PERCENT WITHIN FRACTION

Figure 9

Foraminifera

Planktonic foraminifera were the dominant type present in all the samples in which these calcareous organisms were found. The genus most frequently observed was Globorotalia, with minor occurrences of Flabellinella and Uvigerina. Photographic examples of foraminifera found are shown in Figure 12(a).

As indicated in the distribution chart shown in Figure 10, foraminifera are a relatively minor constituent in the sediments of the southern bay. The total concentration did not exceed 10% in any sample. The areas of relatively greater concentration offshore may be a result of greater productivity, due possibly to upwelling, or to reduced rates of supply of other constituents in comparison with the rate of supply of plankton.

Foraminifera have been associated in other investigations with both glauconite and phosphorite. Burst (1958) and Shepard (1963) suggested that glauconite might be formed through the conversion of matter filling foraminifera tests. It is possible, in this region, that foraminifera tests are commonly destroyed by abrasion or solution so that the concentration of glauconite has increased in proportion to the tests. Another possibility is that glauconite is indeed formed within foraminifera tests, but that it is being formed in other ways as well. However, this origin for glauconite in Monterey Bay appears improbable for the following reasons:

(1) The concentrations of glauconite are much larger than those of foraminifera, and the two occupy somewhat different areas of the bottom.

(2) The observed foraminiferal tests were, in the majority, clean and empty of any material. In those containing a filling, no glauconite

or transitional material was found.

From studies of phosphorite oolites and nodules, tests of foraminifera have been identified by Shepard (1963), Dietz, Emery, and Shepard (1942), and Mero (1960), as a commonly occurring nucleus around which the mineral phosphorite may be precipitated. The minor amounts of phosphorite found in this study were in the form of precipitation coatings on quartz and feldspar grains, and the relationship with foraminifera in this area is considered insignificant.

FORAMINIFERA

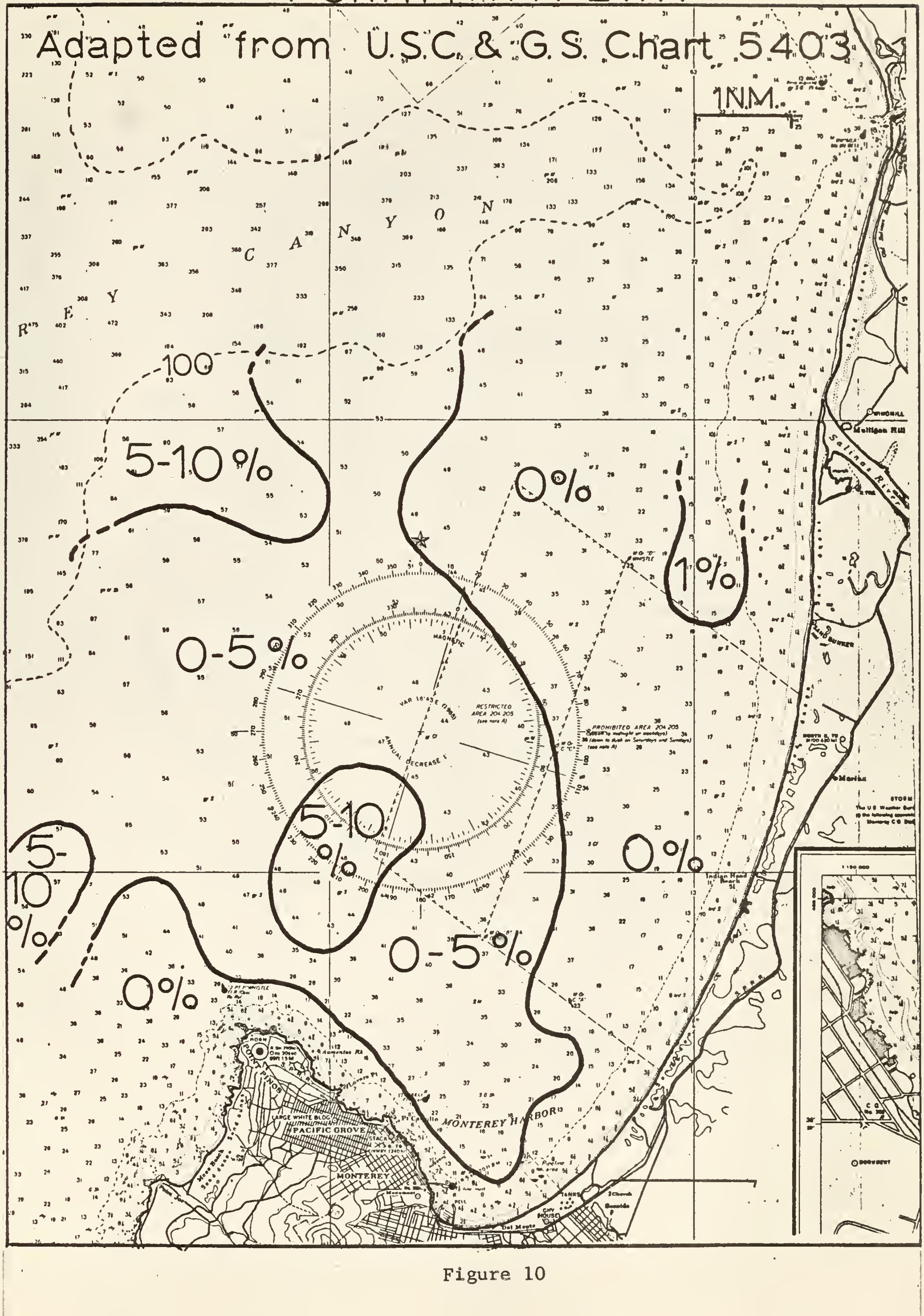
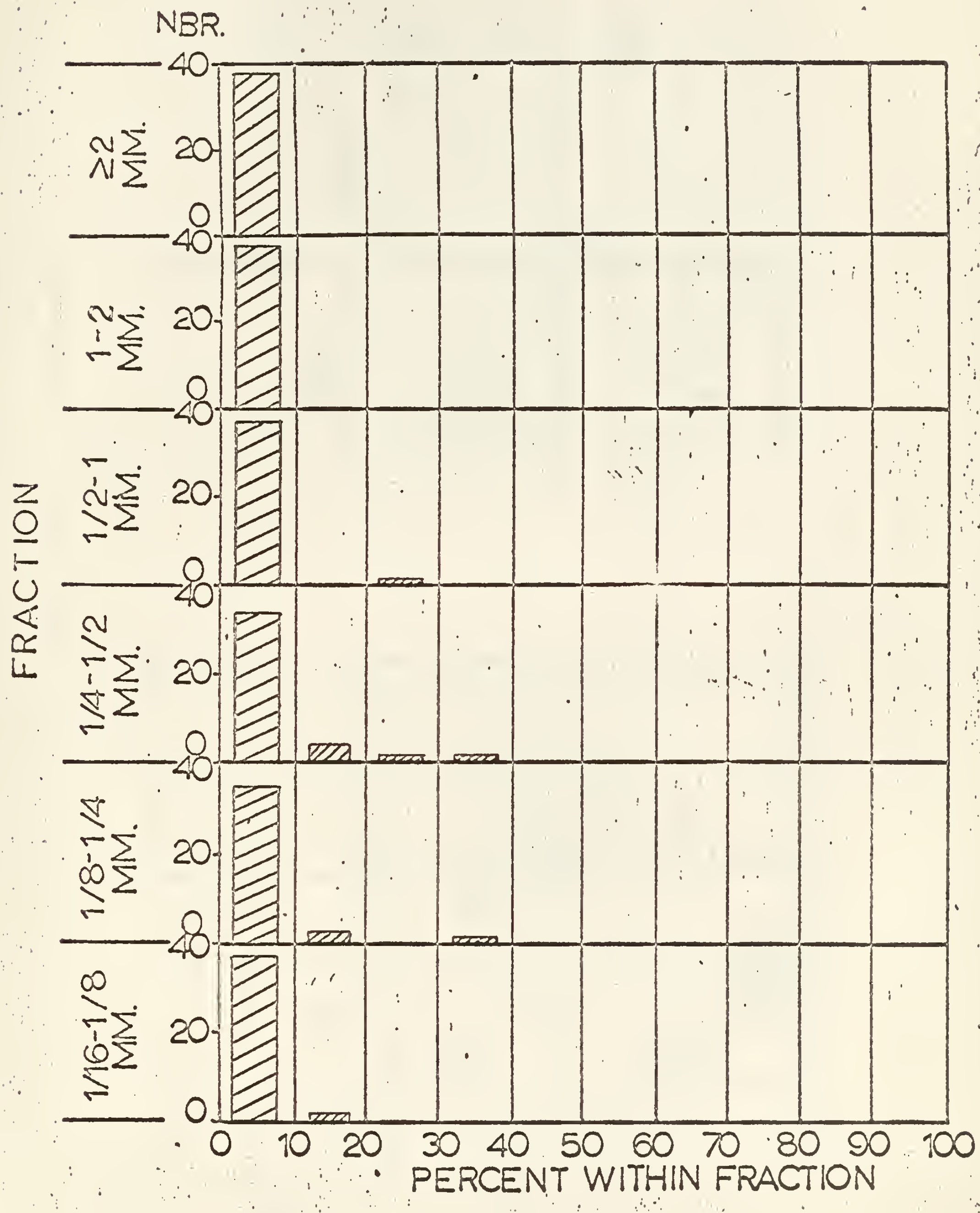
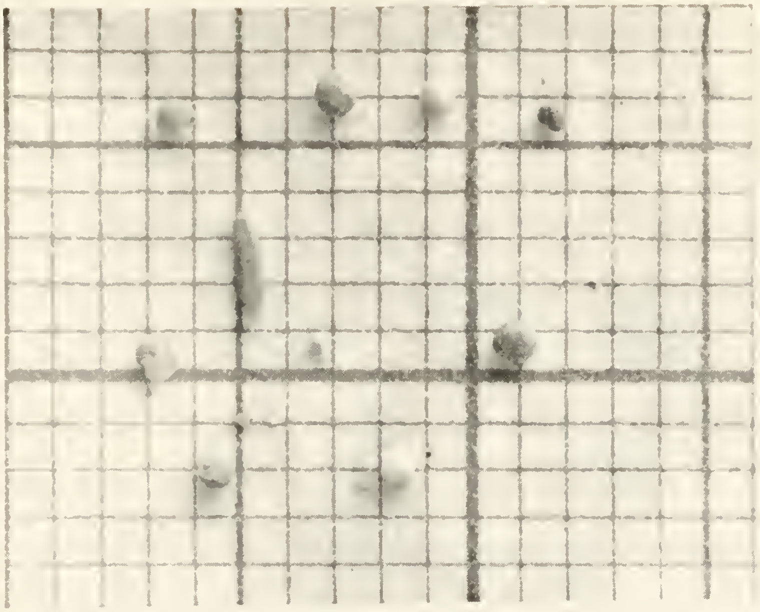


Figure 10

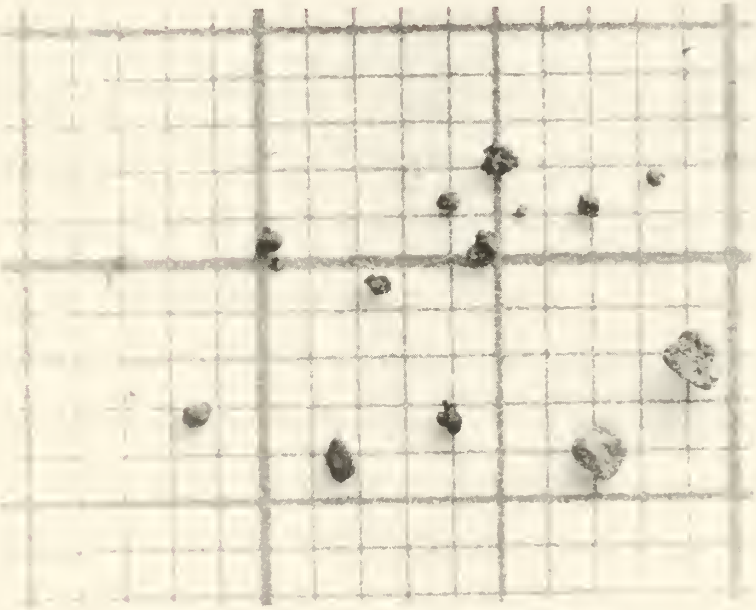


HISTOGRAMS OF THE NUMBER OF SAMPLES OF FORAMINIFERA

Figure 11



(a) FORAMINIFERA



(b) GLAUCONITE

Figure 12.

Glauconite

Glauconite grains found in the southern bay sediments during this study ranged in color from the bright-green mineral to earthy greenish-brown glauconite pellets. Examples of these grains are shown in the photograph in Figure 12(b).

The glauconite distribution in the southern bay, shown in Figure 13, is well defined although the percentage concentrations are fairly small. A center of concentration occurs approximately three miles north of Pt. Pinos. It appears probable that this area represents a non-depositional environment such as has been reported in areas off the southern California coast by Dietz, Emery, and Shepard (1942). An additional area of higher concentration is pictured to the north near the canyon edge, which also probably represents a non-depositional surface.

The histogram shown in Figure 14 indicates little tendency for glauconite grains to be predominant in any particular grain size. However, it is interesting to note that the few occurrences of greater percentage appear in the medium to fine grain sizes where there is also a preponderance of biotite grain sizes.

Glauconite is an abundant constituent of the bottom sediments in many parts of the world. Its occurrence in Monterey Bay was first reported and investigated by Galliher (1935). He concluded that a chemical transformation of biotite into glauconite takes place on the continental shelf within the bay. His conclusions were based on what he described as a transition from flat brown flaky biotite grains near shore to bright-green glauconite in deeper water. He described this transition as being characterized by a transformation stage in which the biotite

crystals become inflated, spongy grains of glauconite. Cloud (1955) upheld Galliher's findings, and further suggested that glauconite is not found in deep sea sediments because biotite or micaceous minerals come to rest on the sea floor on the continental shelves. He also suggested that the widespread distribution of biotite accounts for the common occurrence of glauconite.

The marine environment within the southern bay appears to be entirely suitable for the formation of glauconite. The minimal supply of sediments being provided at the present time by the Salinas River and the small amount of shoreline erosion of the peninsula apparently permit the non-depositional areas on the shelf that are believed to be needed for formation. The very fine sand and silt or clay in these areas were found to be low in oxygen, as indicated by the high concentrations of organic debris, shell fragments, and foraminifera, accompanied by a strong odor of H_2S.

Four relationships between glauconite and other constituents arise from the propositions set forth by Burst (1958) for the genesis of glauconite. These are as follows:

(1) Chemical alteration of fecal pellets or coprolites

(2) Transformation of materials filling foraminifera tests

(3) Conversion of shale pellets to glauconite

(4) Alteration and transition of biotite into glauconite

As mentioned in the section on aggregates and coprolites, the amount of fecal pellets was never observed to exceed one percent of the combined percentage. Since coprolites are so infrequent in their occurrence, it appears likely that this relationship is not the basis of glauconite genesis in the area. The same reasoning applies to the theory on the

conversion of shale pellets, since they also do not occur in abundance. The transformation of materials in foraminifera tests has been dismissed as an important glauconite source in the preceding discussion of foraminifera.

Galliher's theory for glauconite genesis by alteration of biotite is confirmed as the probable formation method in Monterey Bay, since there appears to be a quantitative relationship between these two constituents in the area as compared to the insignificant relationships between glauconite and the previously discussed constituents, shale pellets (aggregates), coprolites, and foraminifera. The relationship of glauconite and biotite is shown quantitatively in Figure 15 as a ratio of the percentages of the two minerals. This contoured chart delineates nicely the areas of low glauconite-high biotite concentration, a transition area where glauconite amounts to a fraction of the biotite concentration, and finally, a small area where glauconite concentration is, interestingly enough, greater than that of biotite.

In summary, the relative concentration of glauconite is minor; however, the interesting aspect of its genesis makes it an important sediment constituent as well as an environmental indicator.

GLAUCONITE

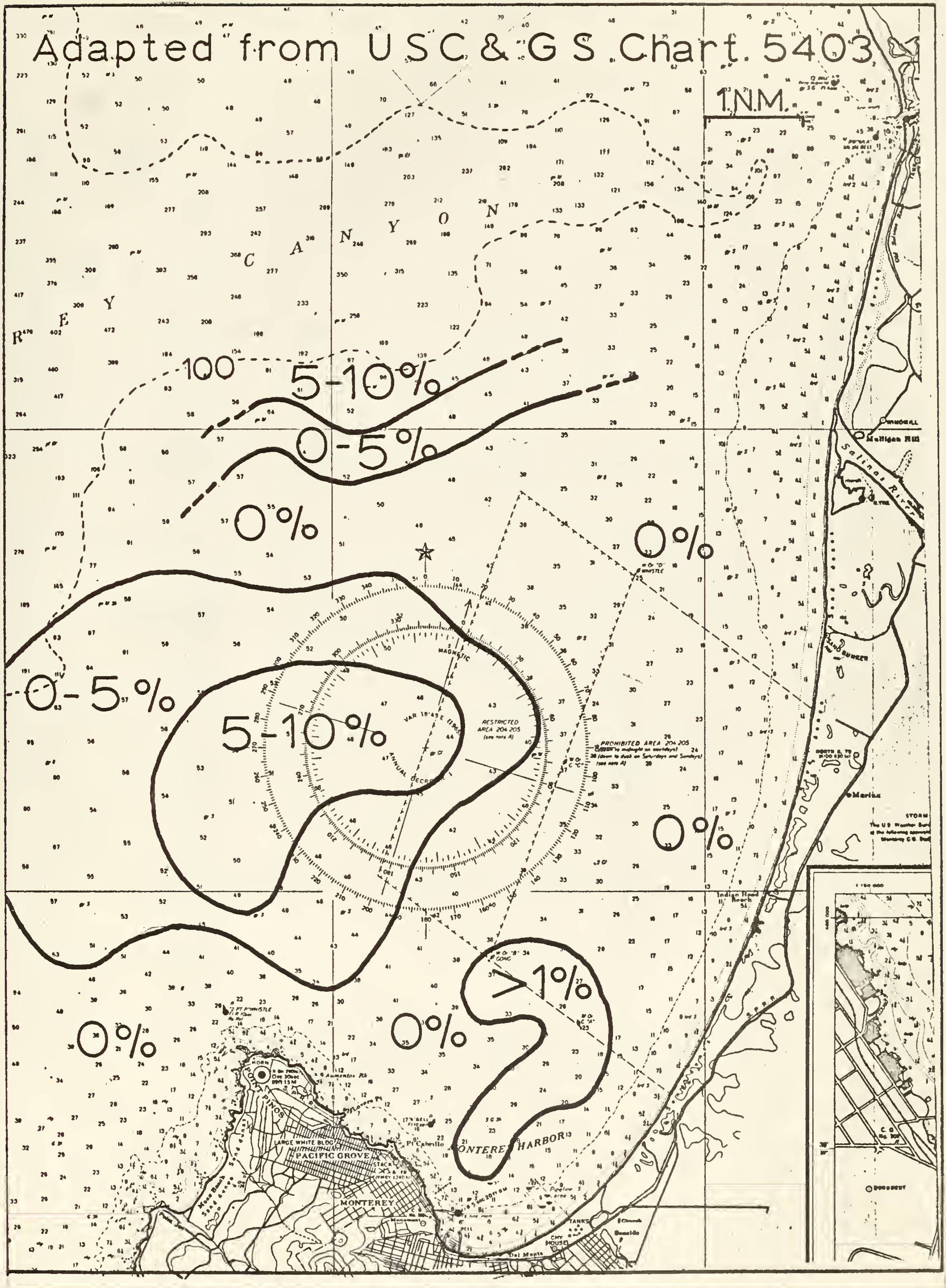


Figure 13

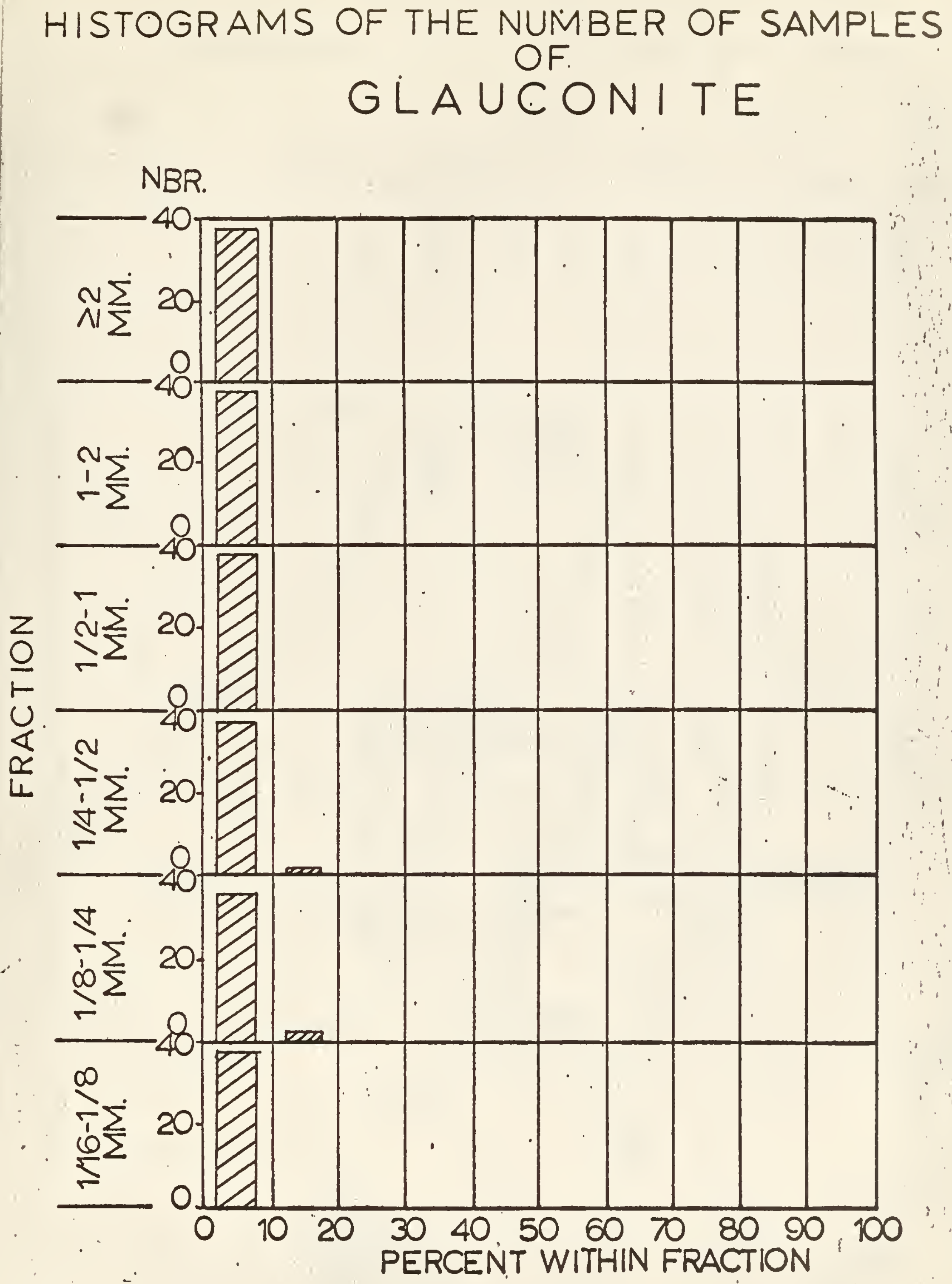

HISTOGRAMS OF THE NUMBER OF SAMPLES OF
GLAUCONITE
NBR.
FRACTION
≥2 MM.
1-2 MM.
1/2-1 MM.
1/4-1/2 MM.
1/8-1/4 MM.
1/16-1/8 MM.
40
20
0
0
10
20
30
40
50
60
70
80
90
100
PERCENT WITHIN FRACTION

Figure 14

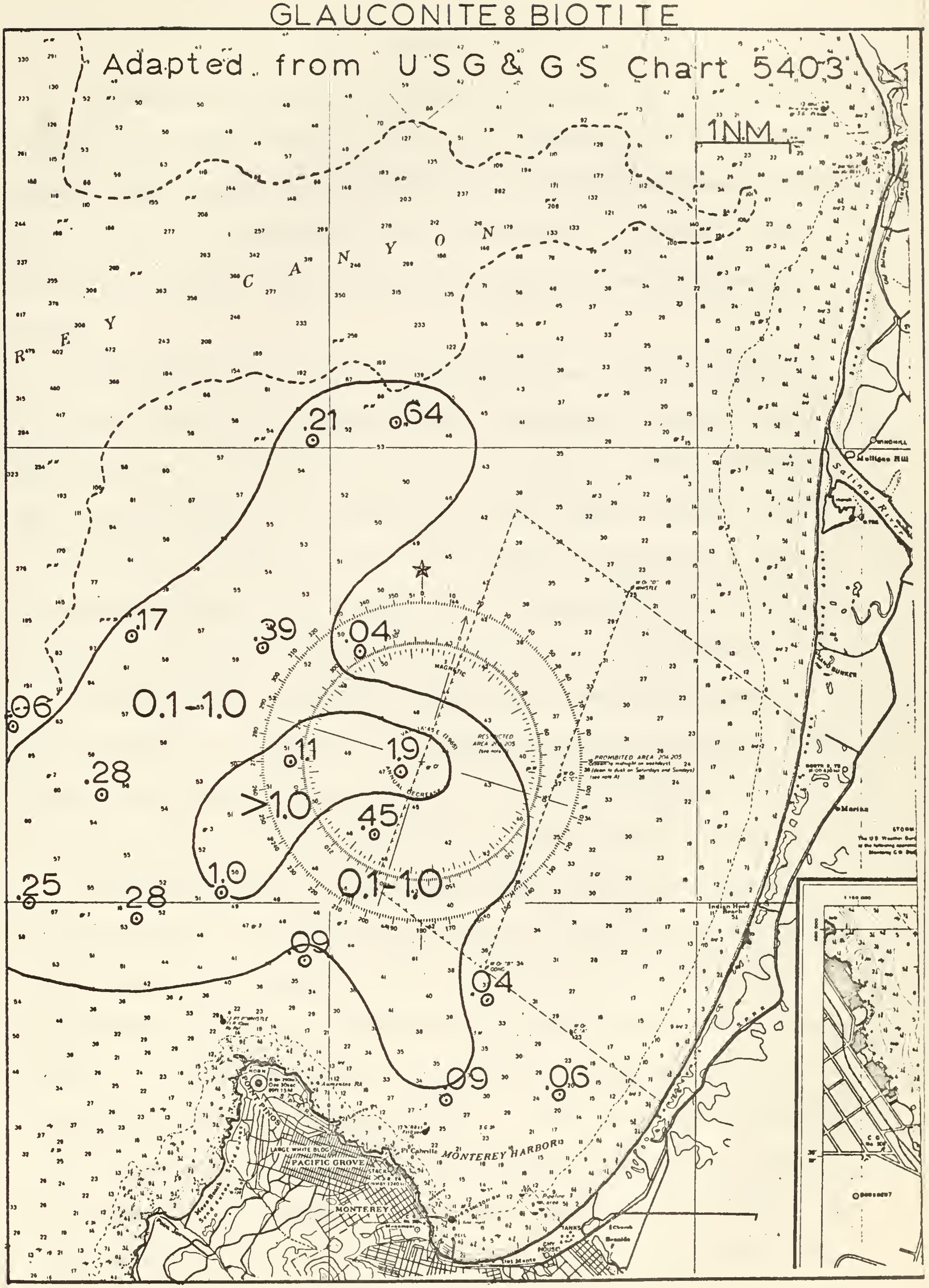

GLAUCONITE & BIOTITE
Adapted from USG & GS Chart 5403
1 N.M.
.21
.64
.17
.39
.04
.06
0.1–1.0
.28
.11
.19
>1.0
.45
1.0
.25
.28
0.1–1.0
.09
.04
.09
.06
C A N Y O N
R E Y
Salinas River
POINT PINOS
PACIFIC GROVE
MONTEREY
MONTEREY HARBOR

Figure 15

Mafics

Ferromagnesian minerals, excluding biotite, make up the majority of the dark or mafic minerals found in the sediments that were investigated. These include, for the most part, hornblende and pyroxene, with small amounts of tourmaline, olivine, and epidote also present. The photograph in Figure 18(a) illustrates a few of the mafic grains observed.

These dark minerals have as their source the granitics of the peninsula, as well as the granitics and metamorphics from the Salinas River drainage. The distribution chart in Figure 16 shows generally what one would expect considering the slightly higher specific gravity of the mafics. A maximum amount occurs along the coast in the surf zone and beach sands. The concentrations are generally less offshore, except for an anomalous area centered to the north of Pt. Pinos.

The histogram of mafic percentages shown in Figure 17 reveals a wide variation in the number of occurrences within the percentage intervals for each fraction size. There is no evident tendency toward relative concentration of the mafics in any particular size grouping.

Two relationships that appear important concerning the distribution of mafics within the area, are the relative concentration of the rock-forming mafics, as compared to quartz and feldspar, and the relative concentration of the mafics plus biotite in comparison with quartz and feldspar. The ratio of mafics to the quartz-feldspar concentration is illustrated for each station in Figure 19. The distribution is difficult to interpret. The minor amounts of mafics as compared to quartz and feldspar in the sediments around the peninsula, outlined by the less than 0.20 contour, may be due to the origin of the mafics in that area

principally from the diorite or granodiorite composition of the peninsula granitics in which ferromagnesian minerals are not highly abundant. If biotite is included with mafics, the relationship between the dark minerals and quartz and feldspar is shown in Figure 20.

MAFICS

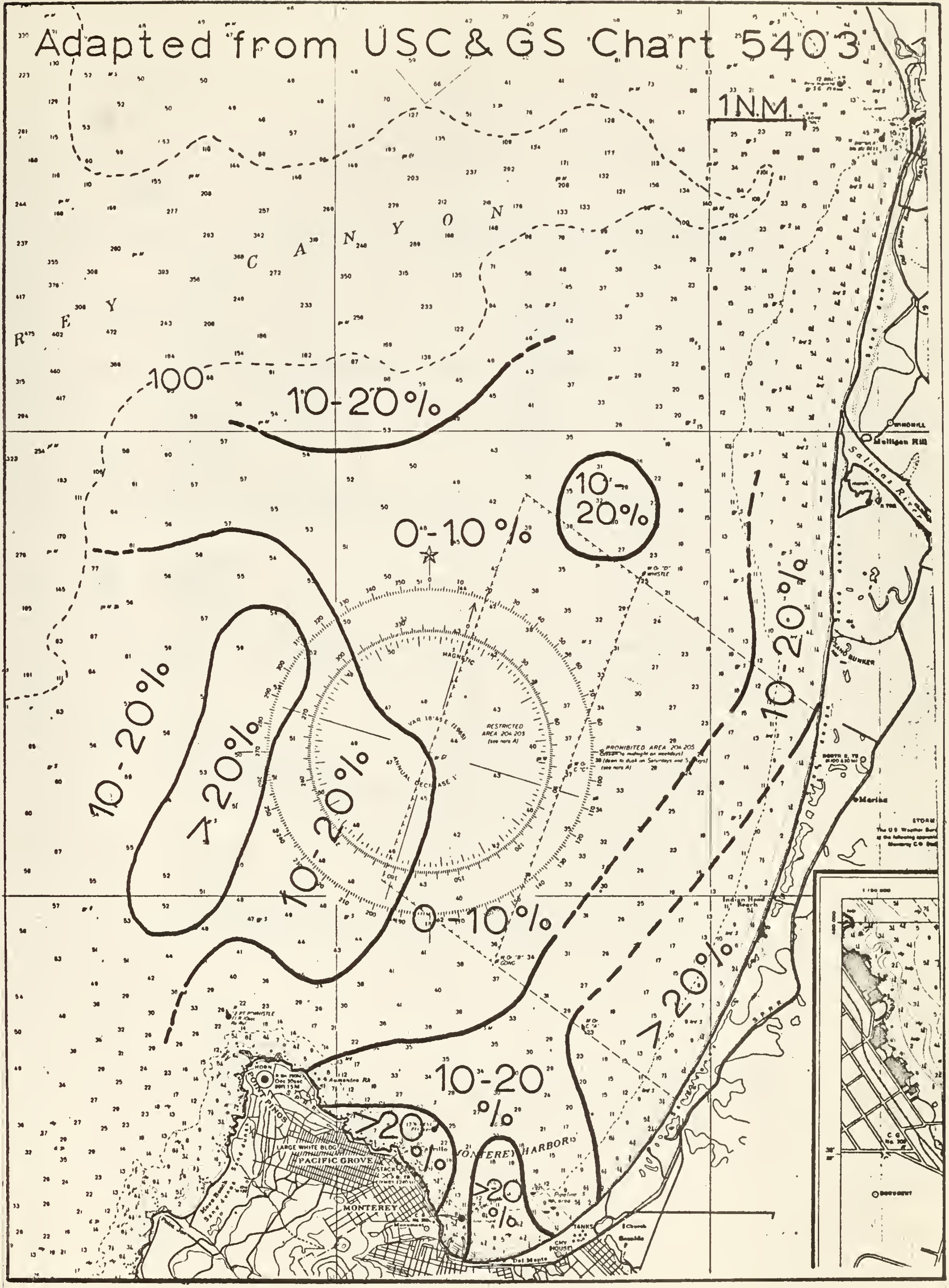


Figure 16

HISTOGRAMS OF THE NUMBER OF SAMPLES OF MAFICS

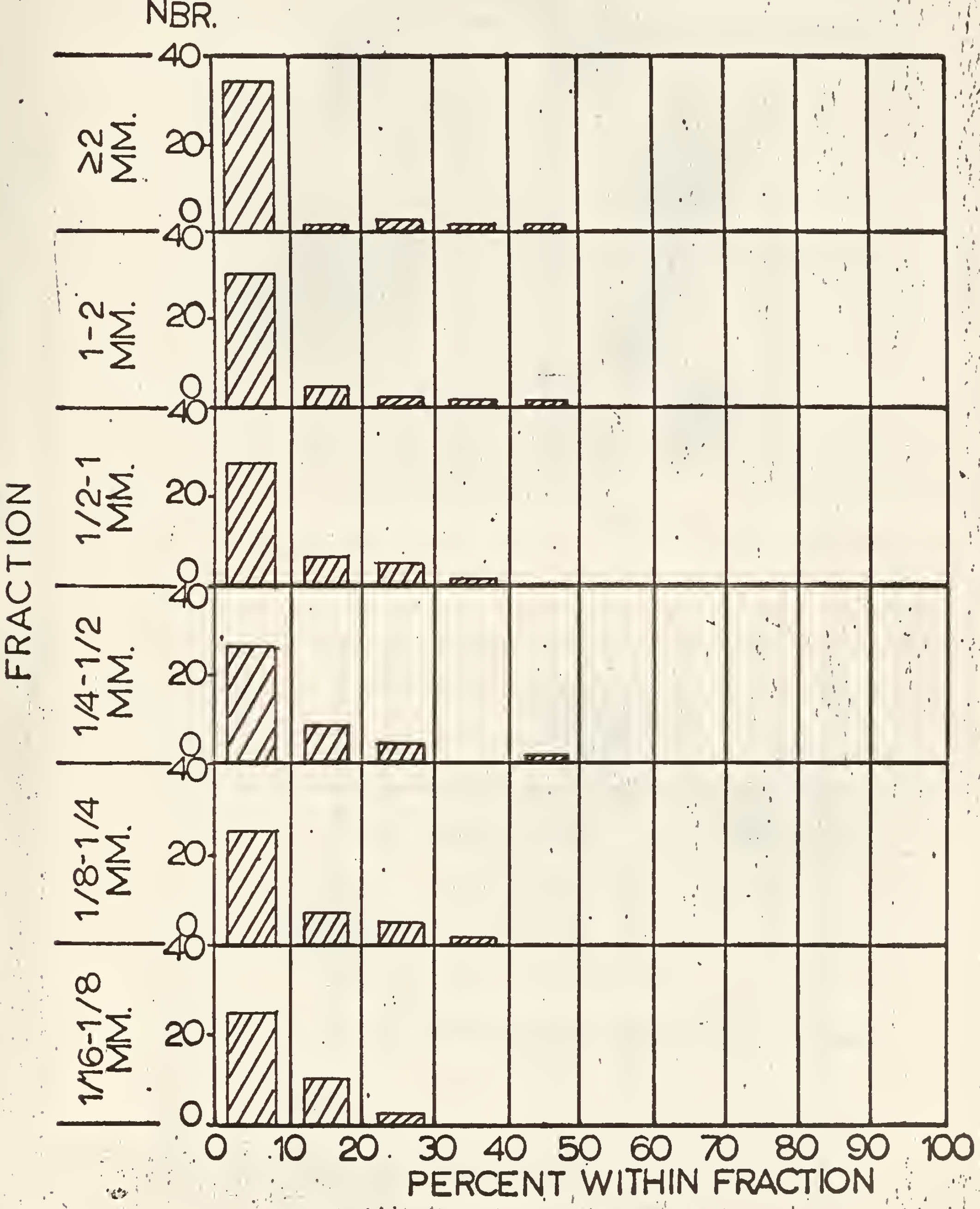
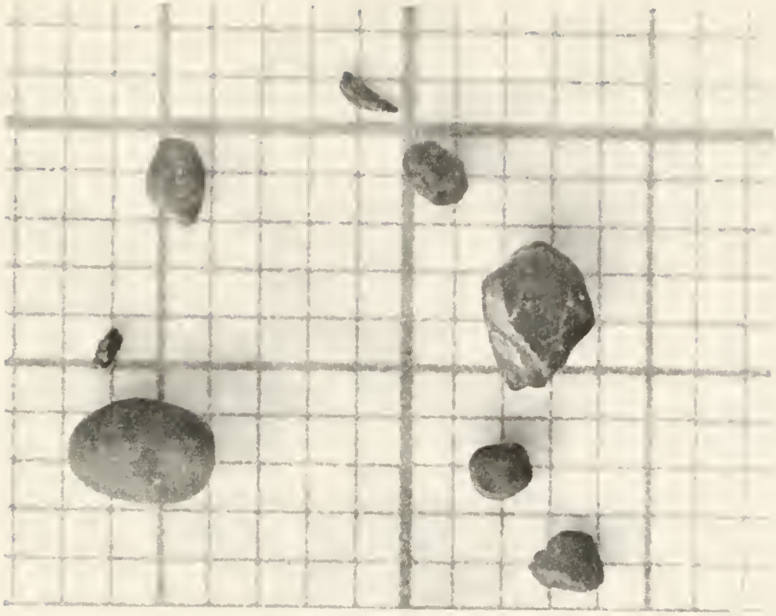
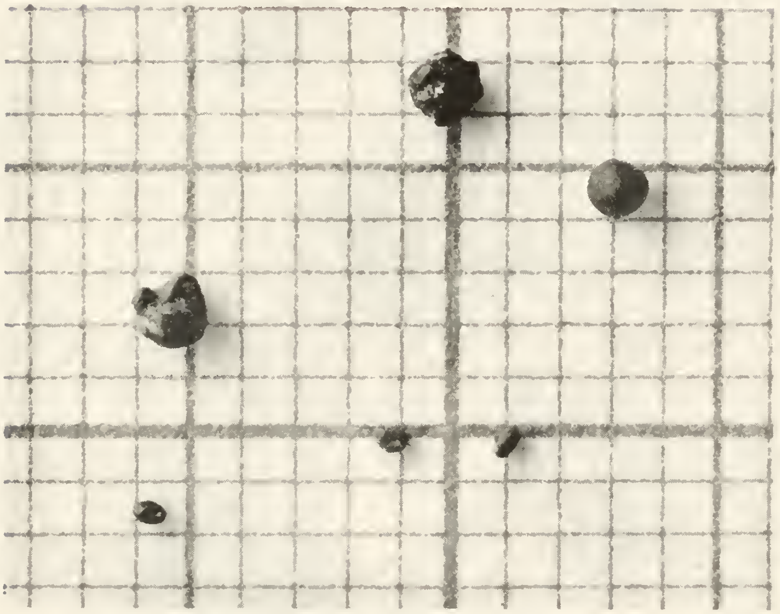


Figure 17



(a) MAFICS



(b) PHOSPHORITE

Figure 18.

MAFICS : QUARTZ & FELDSPAR

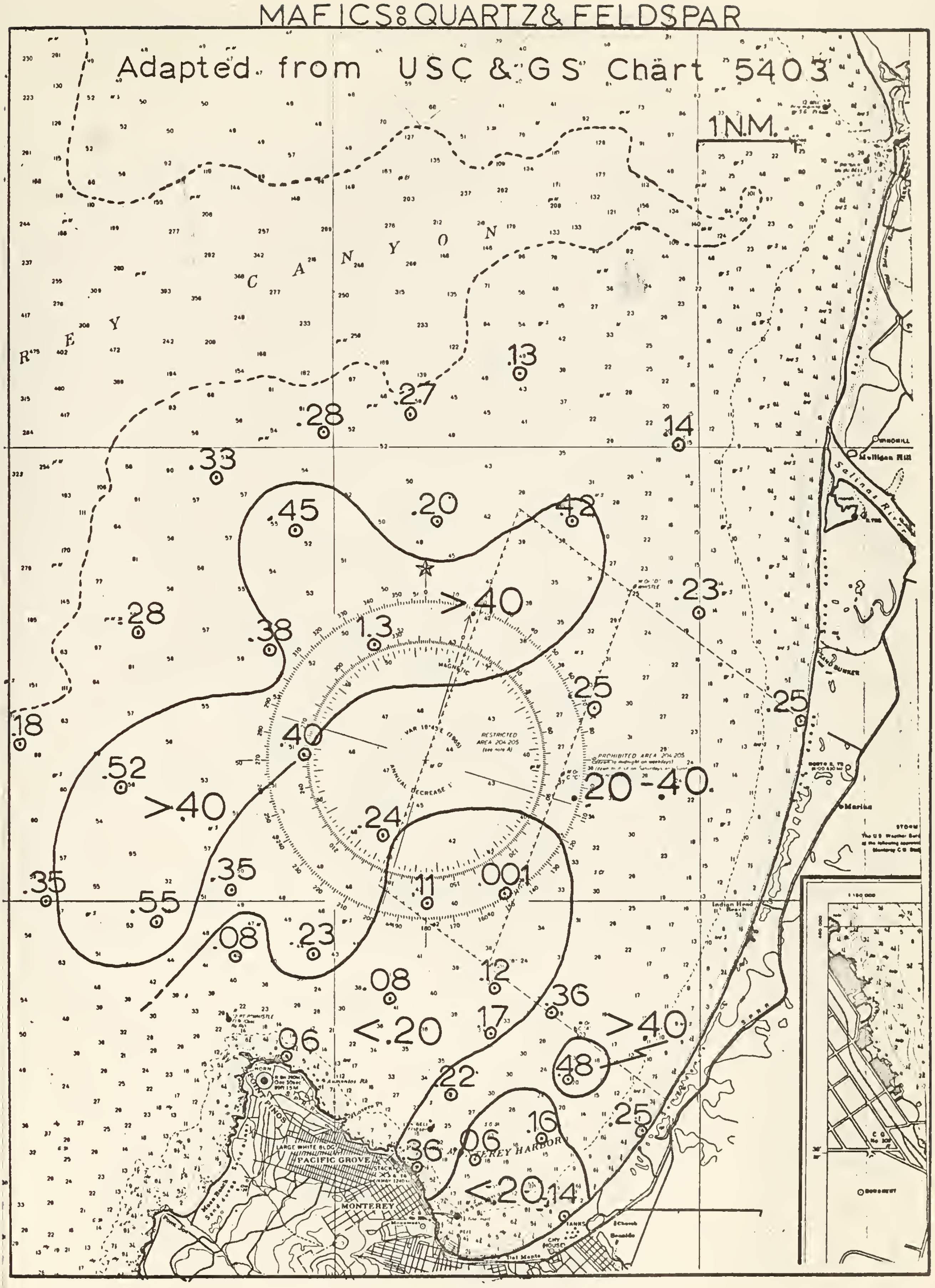


Figure 19

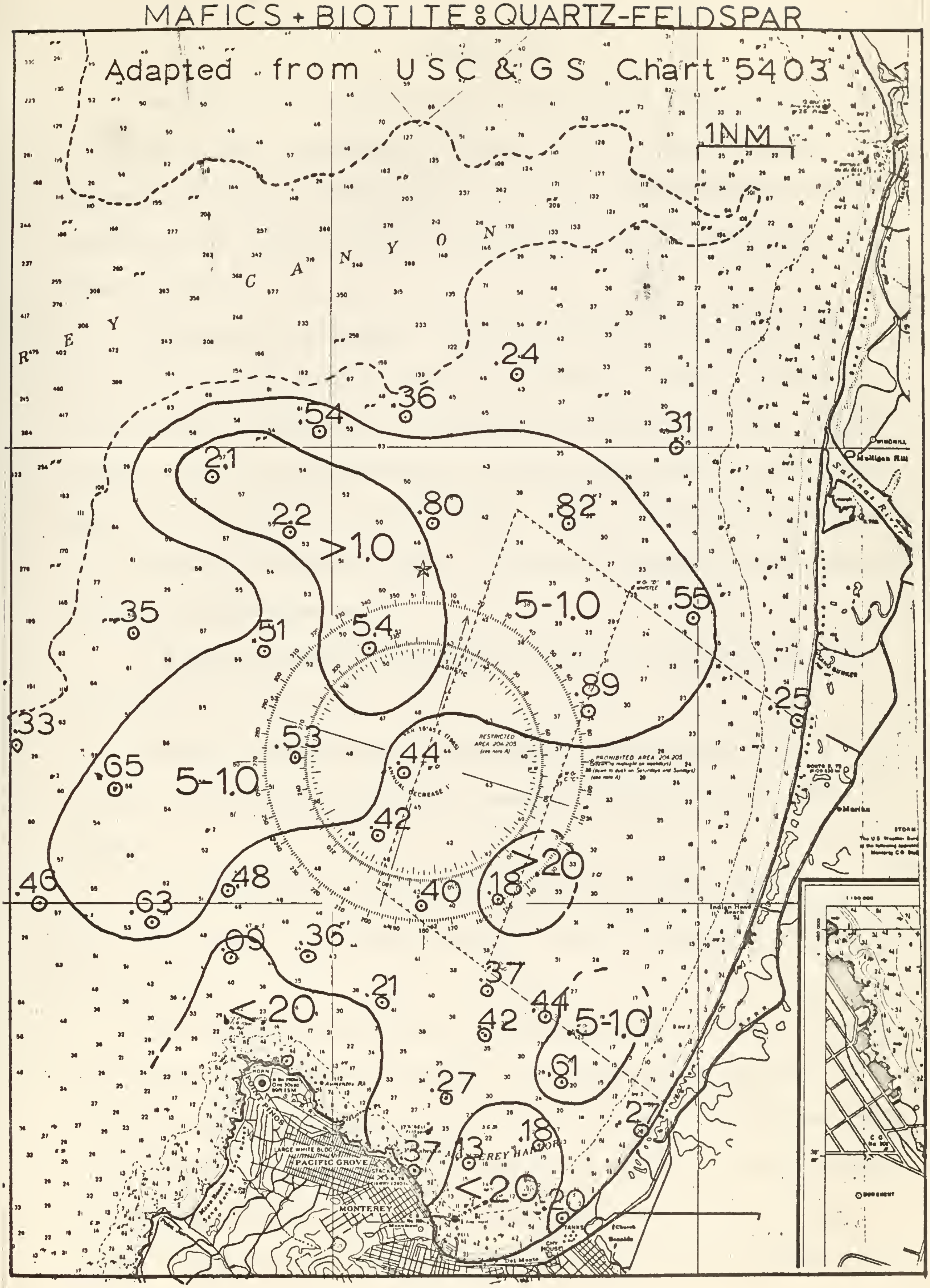

MAFICS + BIOTITE : QUARTZ-FELDSPAR
Adapted from USC & GS Chart 5403
1NM
C A N Y O N
R E Y
.24
.36
.54
.31
.21
.22
.80
.82
>1.0
5-1.0
.55
.35
.51
.54
.89
.25
.33
.53
.44
.65
5-1.0
.42
>20
.46
.63
.48
.40
.18
.09
.36
.37
.21
<20
.44
.42
5-1.0
.61
.27
.27
.37
.13
.18
<20
.20
Salinas River
POINT PINOS
PACIFIC GROVE
MONTEREY
MONTEREY HARBOR

Figure 20

Phosphorite

The discovery of phosphorite off the coast of California was reported by Dietz, Emery, and Shepard in 1942. In 1950, Emery and Dietz indicated an occurrence of phosphorite within Monterey Bay in the form of oolites, as a result of their investigation along the California and Mexico coasts.

Phosphorite, an authigenic mineral precipitated from sea water directly onto some nucleus, occurs in the form of slabs, nodules, oolites, and, occasionally, as coatings on foraminiferal tests and sand grains. The conditions necessary for the precipitation of phosphorite have been discussed in detail by Dietz, Emery, and Shepard (1942), and more recently by Mero (1960,1961). The most important of these requirements are iterated below:

(1) The environment of precipitation must be non-depositional in character, or nearly so.

(2) The environment must have reducing characteristics, as a result of low oxygen content in the immediate vicinity of the precipitation.

(3) The precipitation must take place around some nucleus.

(4) A source of nutrient rich (particularly phosphate) waters must be available.

The non-depositional nature of the environment and the low oxygen or reducing characteristics appear to be satisfied and were discussed in the section concerning glauconite. The presence of nuclei obviously satisfies the third requirement, and here it should be noted that the phosphorite that was observed was precipitated as coatings on sand grains. The presence of nutrient-rich waters, which are brought into

the surface layers during the spring and summer by seasonal upwelling, appears to be one of the prime reasons for expecting phosphorite to occur abundantly in the area. The Monterey Submarine Canyon very likely serves to channel upwelled water to the continental shelf from the deep sea floor.

In spite of the fact that the necessary conditions appear to be met, the maximum amount of phosphorite found in any sample was less than one percent. As stated above, the phosphorite found in the samples was in the form of a precipitate on sand grains. Its composition was confirmed by an ammonium molybdate-nitric acid test. Typical examples of the phosphorite observed are shown in the photograph in Figure 18(b).

The bottom distribution of phosphorite is shown in Figure 21. The area of concentration coincides fairly well with the high concentration of organic debris shown in Figure 24. A high concentration of organic material is conducive to the precipitation of phosphorite for two reasons: first, its presence favors an anaerobic environment which, through oxidation of the organic material, creates low oxygen in the vicinity. Secondly, the action of the decomposition process releases phosphate to the water which is then available for precipitation as phosphorite. The relation between phosphorite and organic debris is illustrated in Figure 22 in the form of a ratio between the percentages of phosphorite to those of organic debris.

Little information can be obtained from the histogram shown in Figure 23, other than a confirmation that the overall percentage amounts of phosphorite are low and in the interval of 0-10%. The few grains of phosphorite observed were in the coarser grain sizes.

PHOSPHORITE

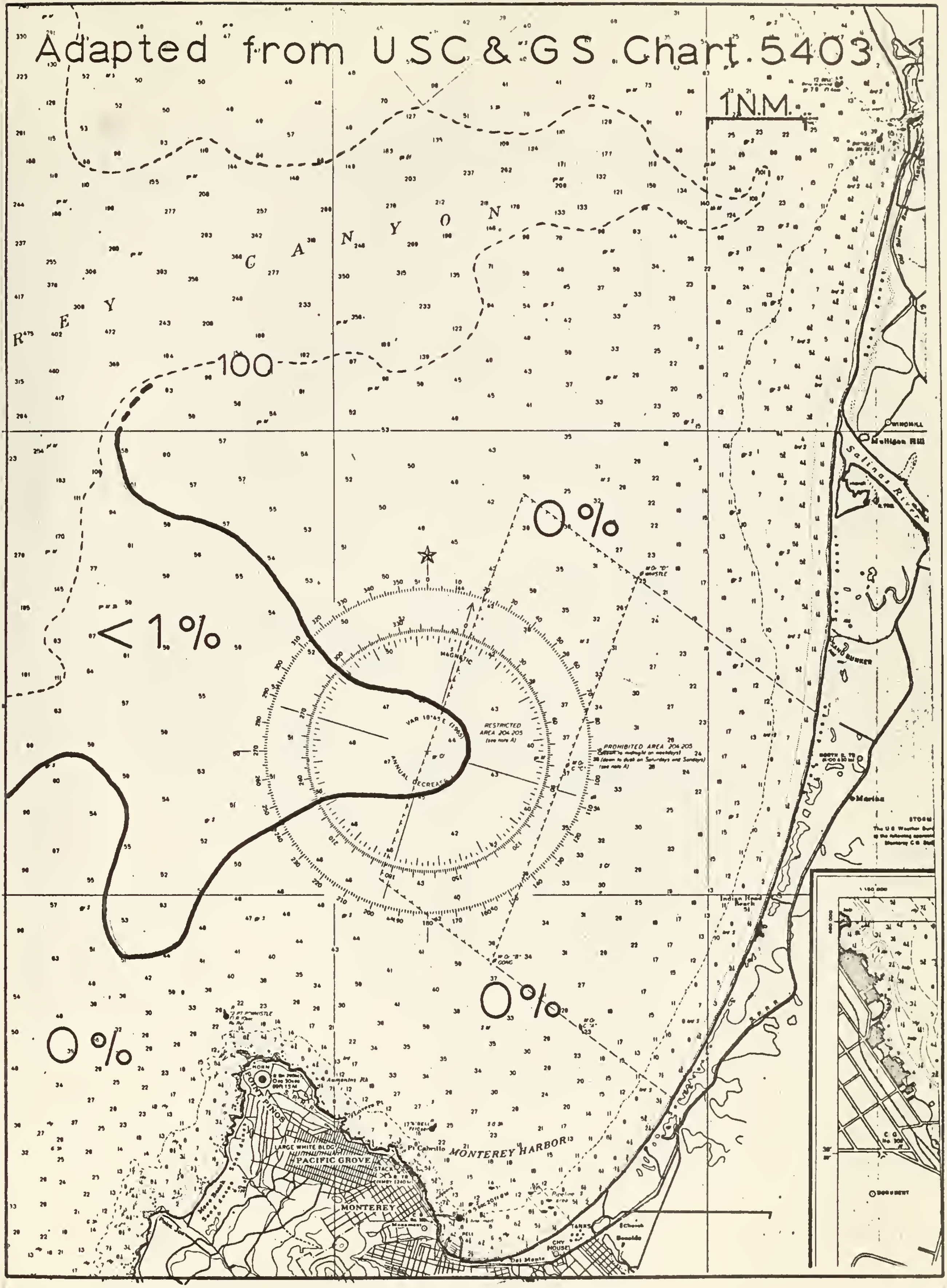


Figure 21

PHOSPHORITE:ORGANIC DEBRIS

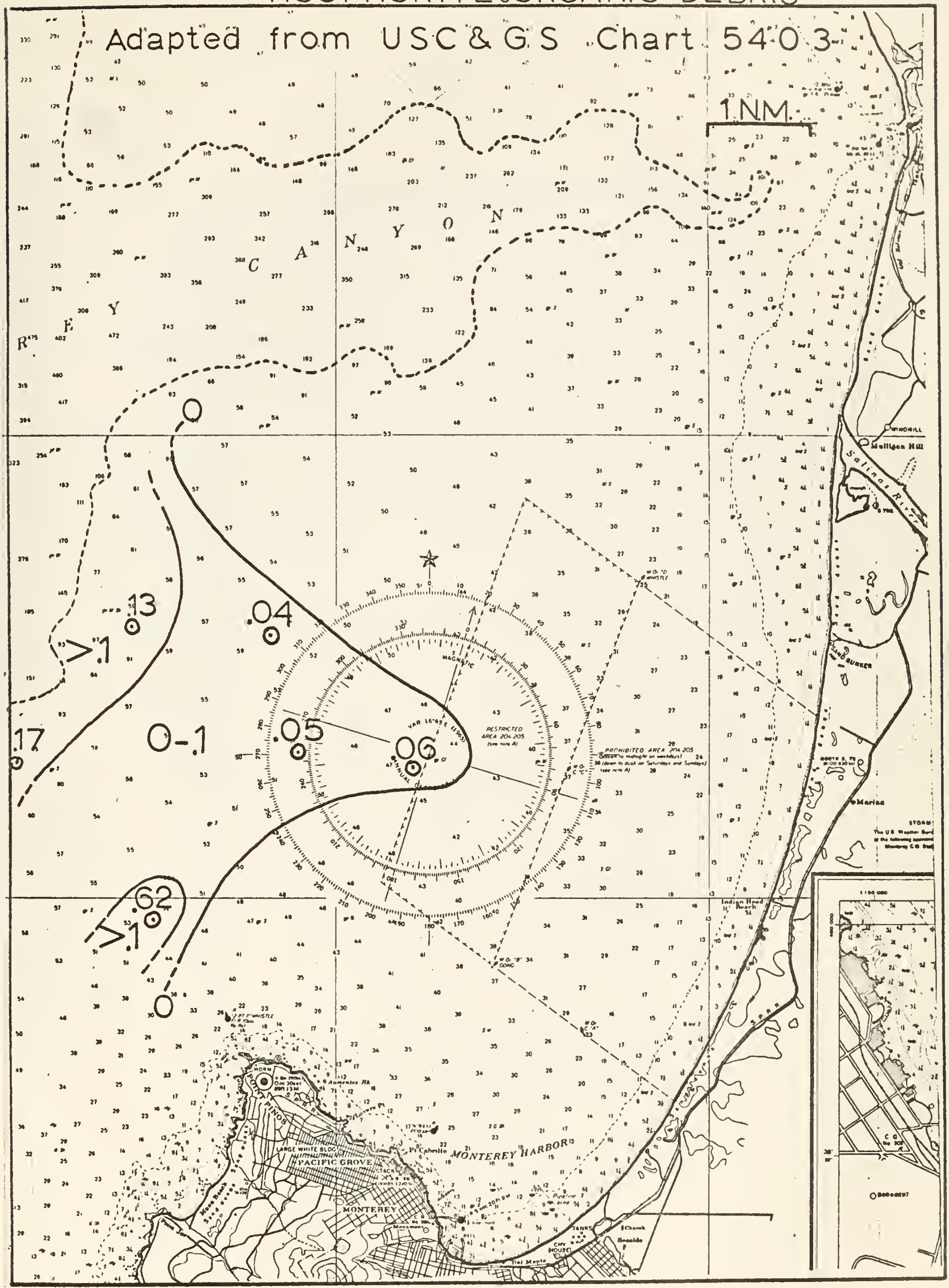


Figure 22

HISTOGRAMS OF THE NUMBER OF SAMPLES OF PHOSPHORITE

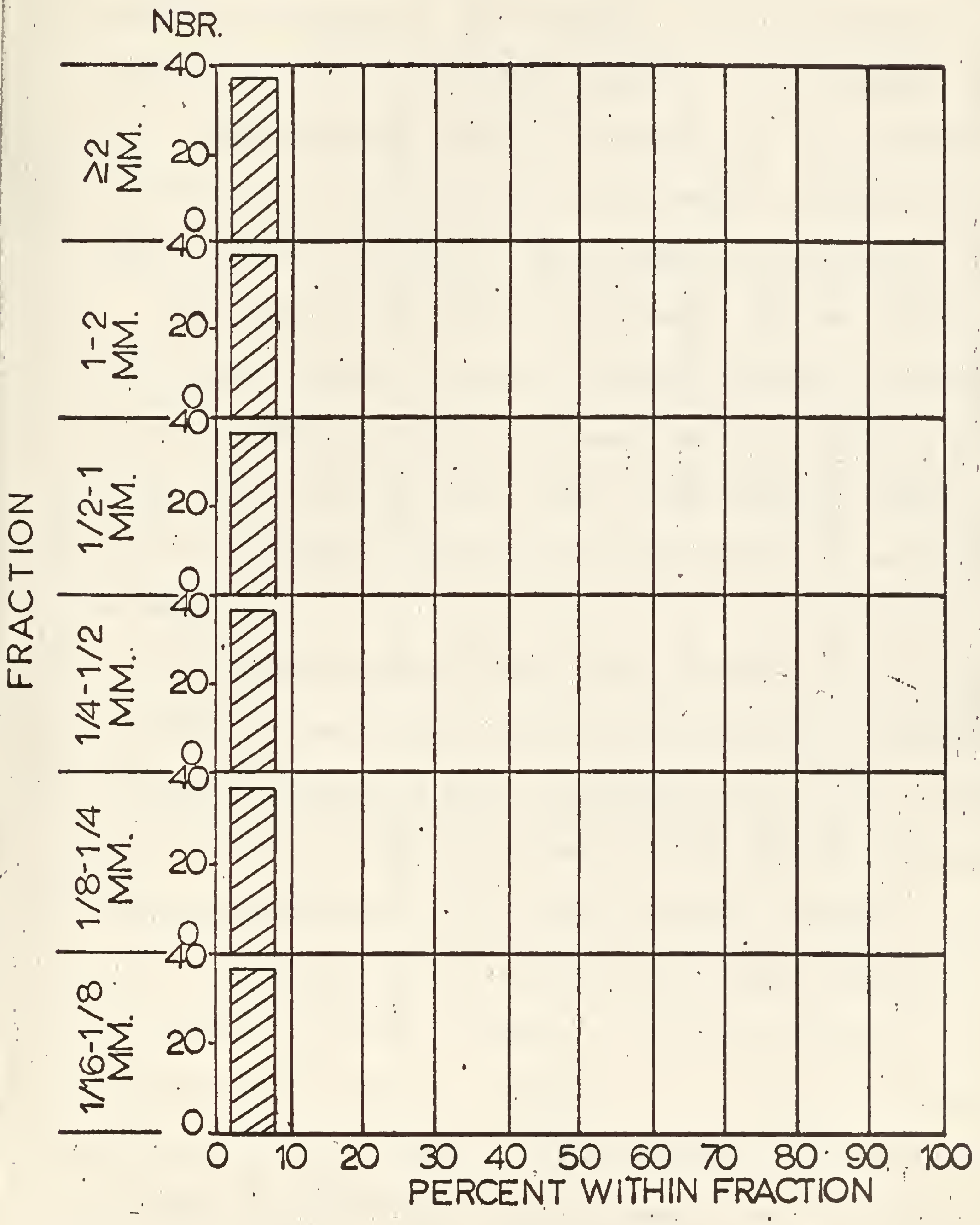


Figure 23

Organic Debris

This constituent was chosen to include the remainder of the organic matter present in the samples which could not be grouped under shell fragments and foraminifera. This material consisted largely of unidentified plant or wood fibers, and other organisms such as diatoms, dinoflagellates, sponge spicules, as well as segments of the appendages of brittle stars that were commonly found in the samples. Examples of the types of organic material included in this category are pictured in Figure 26(a).

The plant and wood fibers are probably derived from rivers draining into the bay; however, kelp beds frequently found on the hard rock bottom in shallow depths around the peninsula are very likely an additional important source for the plant fibers. The remaining organics are mainly the tests of pelagic organisms that have settled to the ocean floor in the area.

The distribution of organic debris, illustrated in Figure 24, shows the effects of wave action near shore in preventing these materials from settling out because of their low density or fine size. It may be noted that the zone of significant organic content extends into shore in the sheltered southern end of the bay. The area of maximum concentration seaward of the mouth of the Salinas River could be the result of debris introduced by the river, although it is more likely due to the abundance of benthonic and planktonic organisms constituting the organic debris in that area. With regard to the general water circulation in the bay, the tongue of high organic content shown in the figure may trace the average path of offshore water into the southern end of the bay, with its high concentration of pelagic organisms.

The size distribution of the organic matter is shown in the

histogram in Figure 25, and indicates that the majority of the debris is concentrated in the medium and coarse sizes.

The only significant relationship to other sediment constituents, is the relative amount of organic debris found in the areas of phosphorite occurrence. This relationship was discussed in the section concerning phosphorite.

ORGANIC DEBRIS

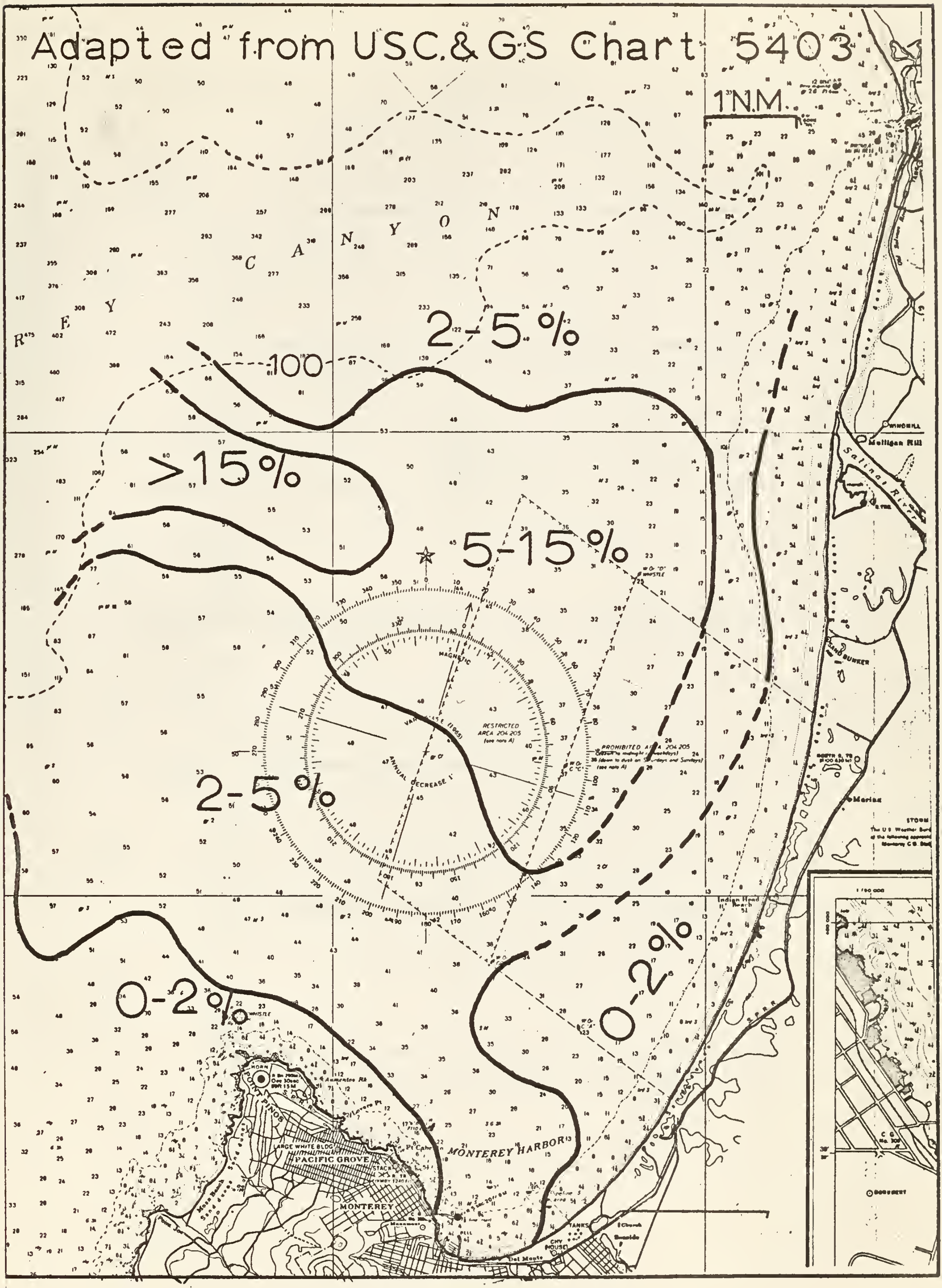


Figure 24

HISTOGRAMS OF THE NUMBER OF SAMPLES
OF
ORGANIC DEBRIS

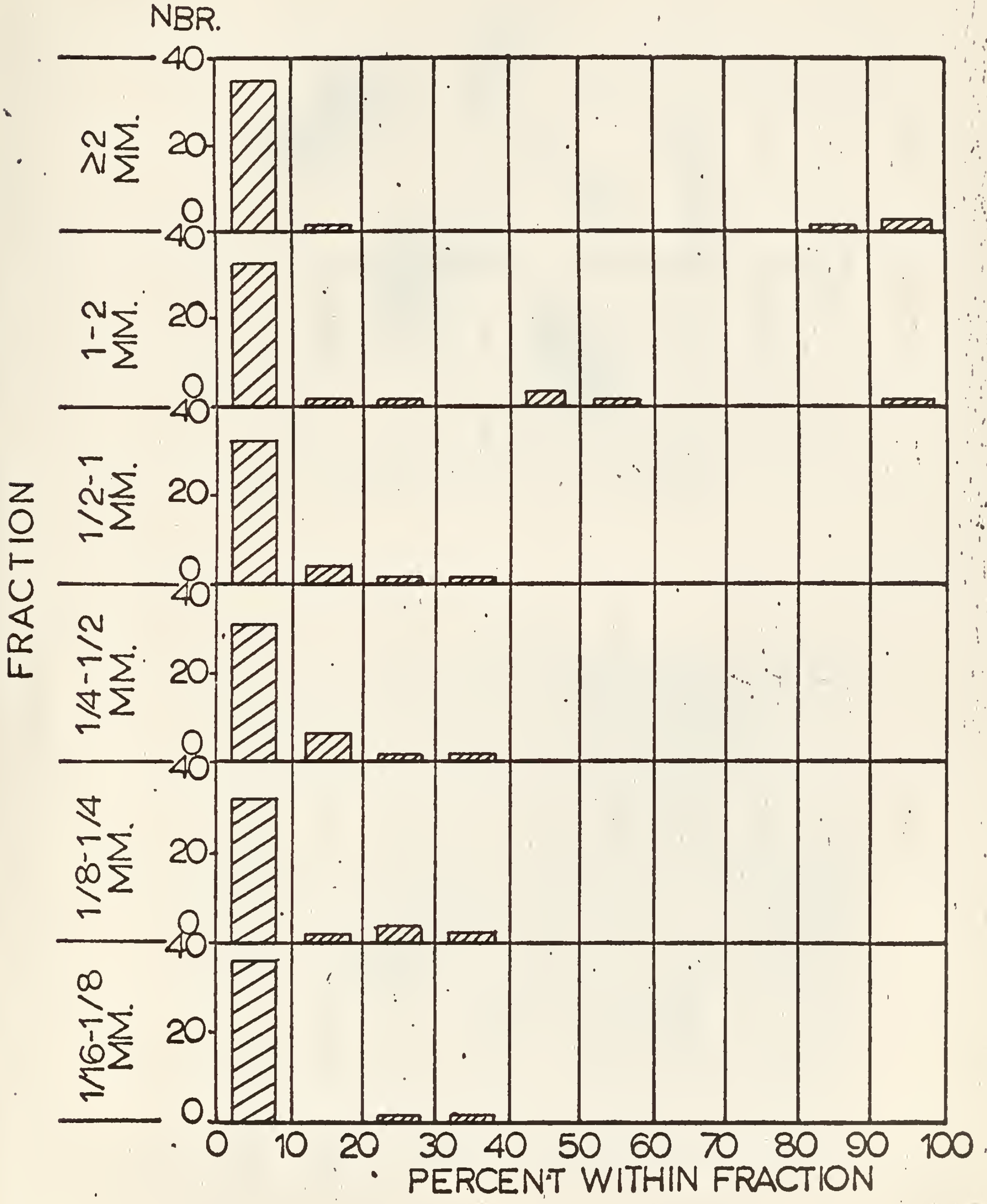
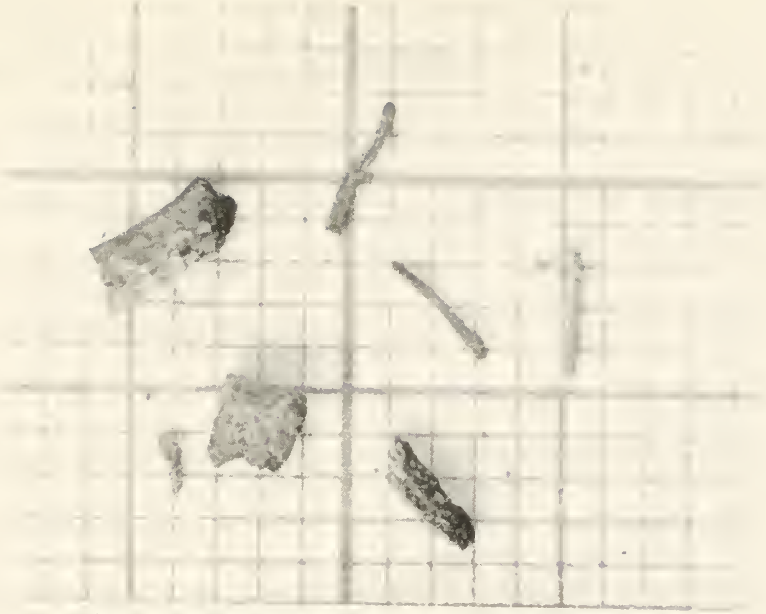
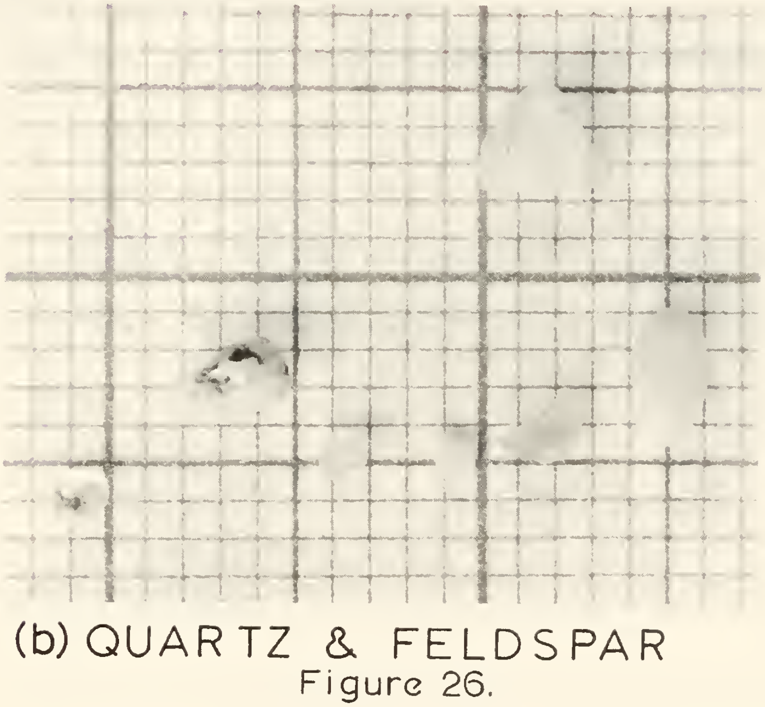


Figure 25



(a) ORGANIC DEBRIS



(b) QUARTZ & FELDSPAR

Figure 26.

Quarts and Feldspar

All light colored minerals in the sediments were grouped together under the heading of quartz and feldspar. Quartzites are included and the feldspar crystals were predominately plagioclase. Examples of the mineral grains included in this category are pictured in Figure 26(b).

These two most common rock-forming minerals occur abundantly throughout the area, and constitute more than 70% of the extensive beach and dune sands along the coast. In general, there is a decrease in concentration with distance from shore, primarily due to the increase in organics. This distribution is pictured on the chart in Figure 27. The granitics of the peninsula are obviously a source for these minerals, but the Salinas River undoubtedly has supplied the most sediment to the bay. The sand beaches and dunes along the coast of the inner bay probably derived their sediment from the river source.

The size distribution of the quartz-feldspar constituent is shown in Figure 28, and points out that the greater percentages, in general, occur in the finer size fractions.

The relationships between the rock-forming minerals--mafics, biotite, and quartz-feldspar--were discussed in the section concerning the distribution of mafics in the bay.

QUARTZ & FELDSPAR

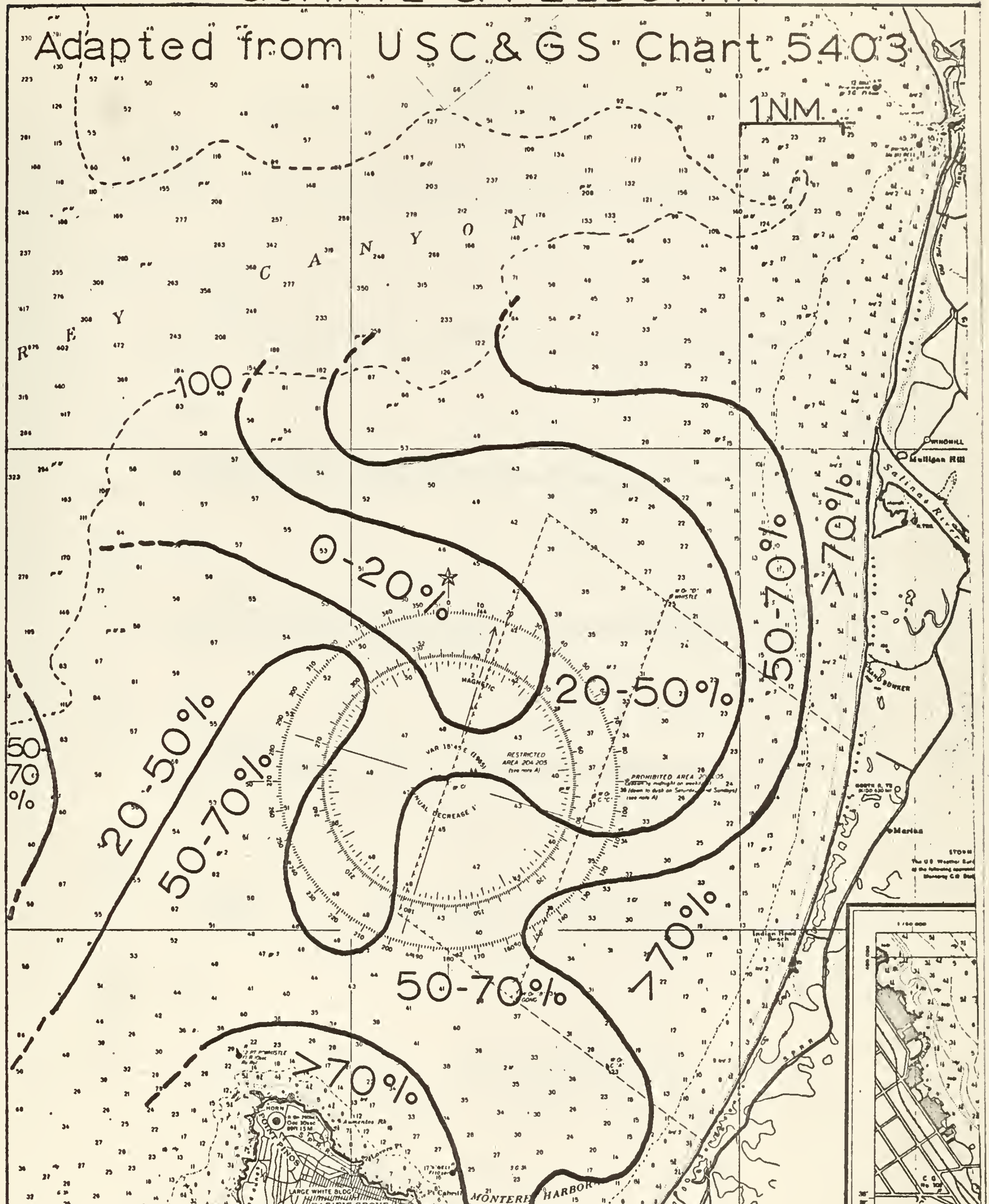
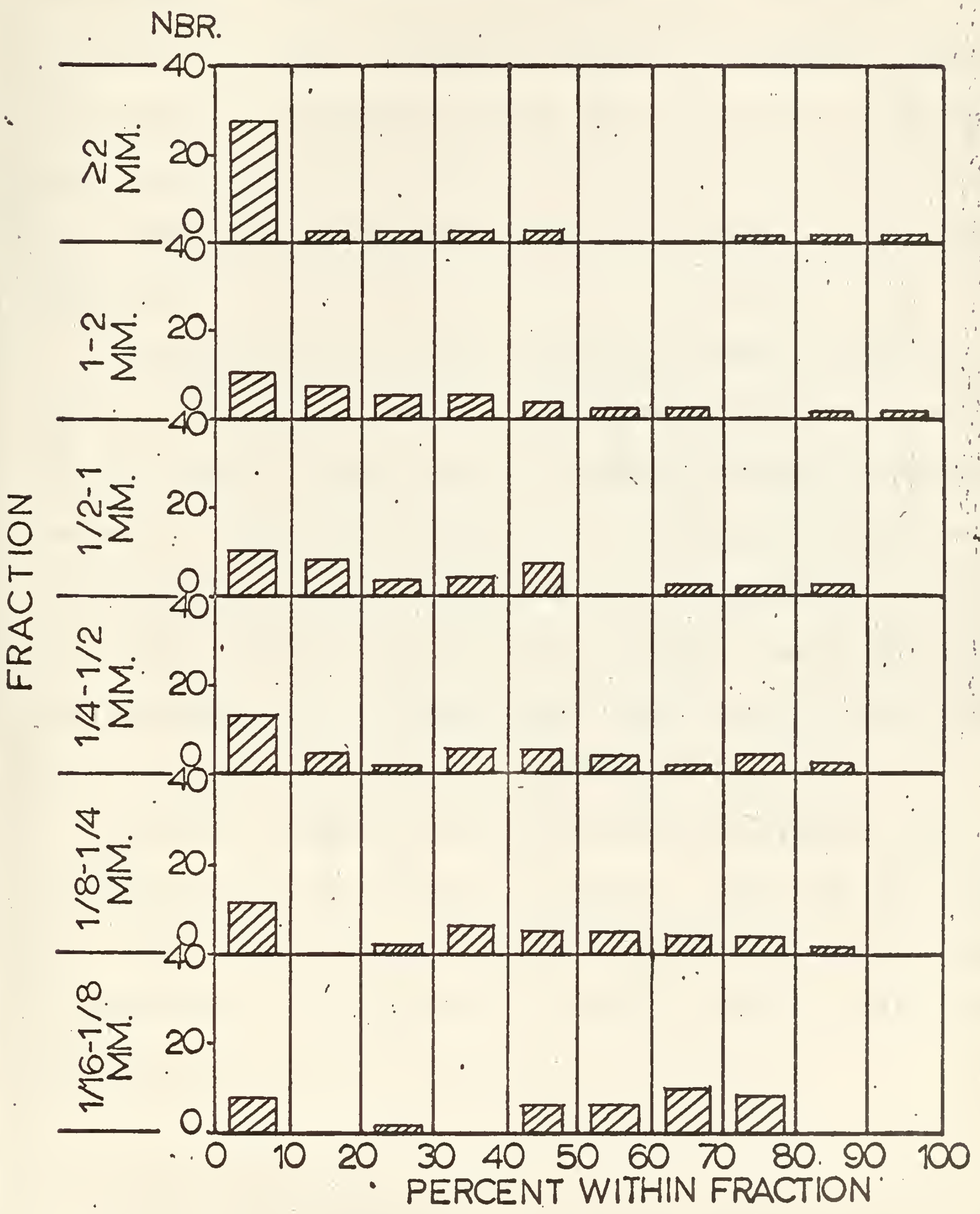


Figure 27



HISTOGRAMS OF THE NUMBER OF SAMPLES OF QUARTZ & FELDSPAR

Figure 28

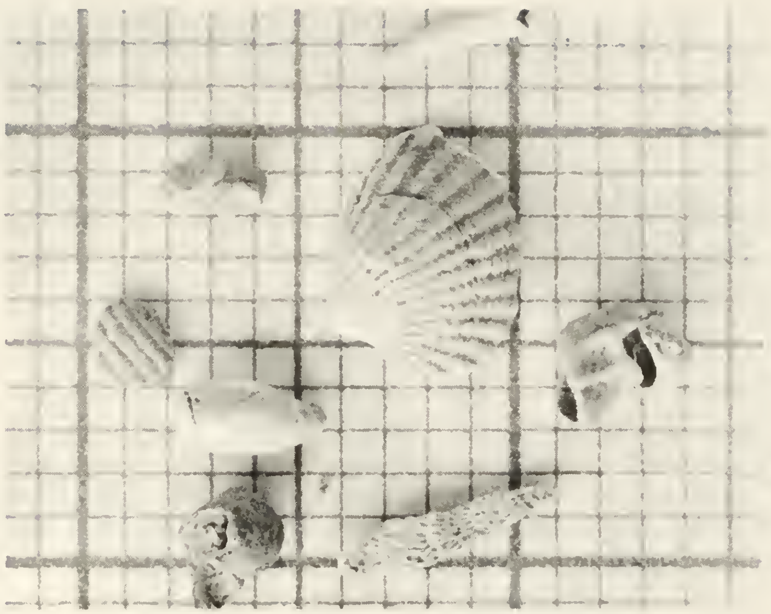
Shell Fragments

Fragments of shells were found in the sediments in varying amounts throughout the area; these included gastropods, pelecypods, and other molluscs. No attempt was made to identify the organisms, since most found were only fragments or pieces and it would have been difficult in many cases to determine their characteristics for identification. Several examples of these fragments are illustrated in the photograph in Figure 29.

The distribution of shell fragments is shown in Figure 30, and reveals a highly patchy pattern. In samples in which the concentration was greater than 20%, shells clearly represented a major contribution to the sediment. There is a relatively small concentration along the coast, due probably to the effects of wave action and a lack of local supply of the shells. The area of 10-20% shell fragments immediately north of Pt. Pinos coincides well with two "shell gravel" locations indicated by Galliher. This may be observed by referring to Figure 2.

The size-frequency distribution of shell fragments, shown in Figure 31, reveals that the greatest percentages of shells are very coarse.

Aside from the obvious connection between shell fragments and other organic matter, no significant relationship appears to exist between shell fragments and other constituents in the area.



SHELL FRAGMENTS
Figure 29.

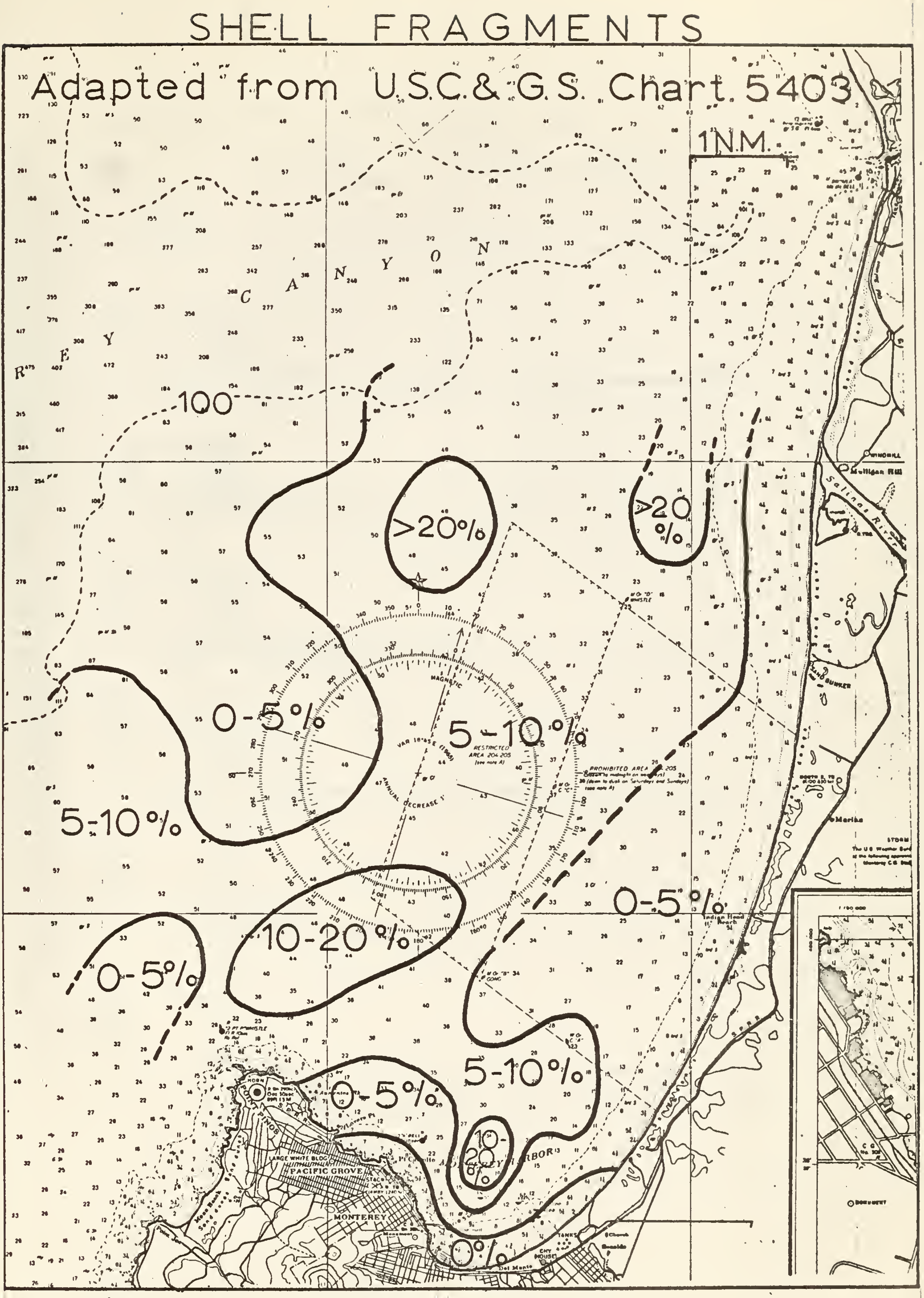

SHELL FRAGMENTS
Adapted from U.S.C.& G.S. Chart 5403
1N.M.
CANYON
100
>20%
>20 %
0-5%
5-10%
5-10%
10-20%
0-5%
0-5%
0-5%
5-10%
10-20%
0%
PACIFIC GROVE
MONTEREY
Salinas River
RESTRICTED AREA 204.205
PROHIBITED AREA 205

Figure 30

HISTOGRAMS OF THE NUMBER OF SAMPLES OF SHELL FRAGMENTS

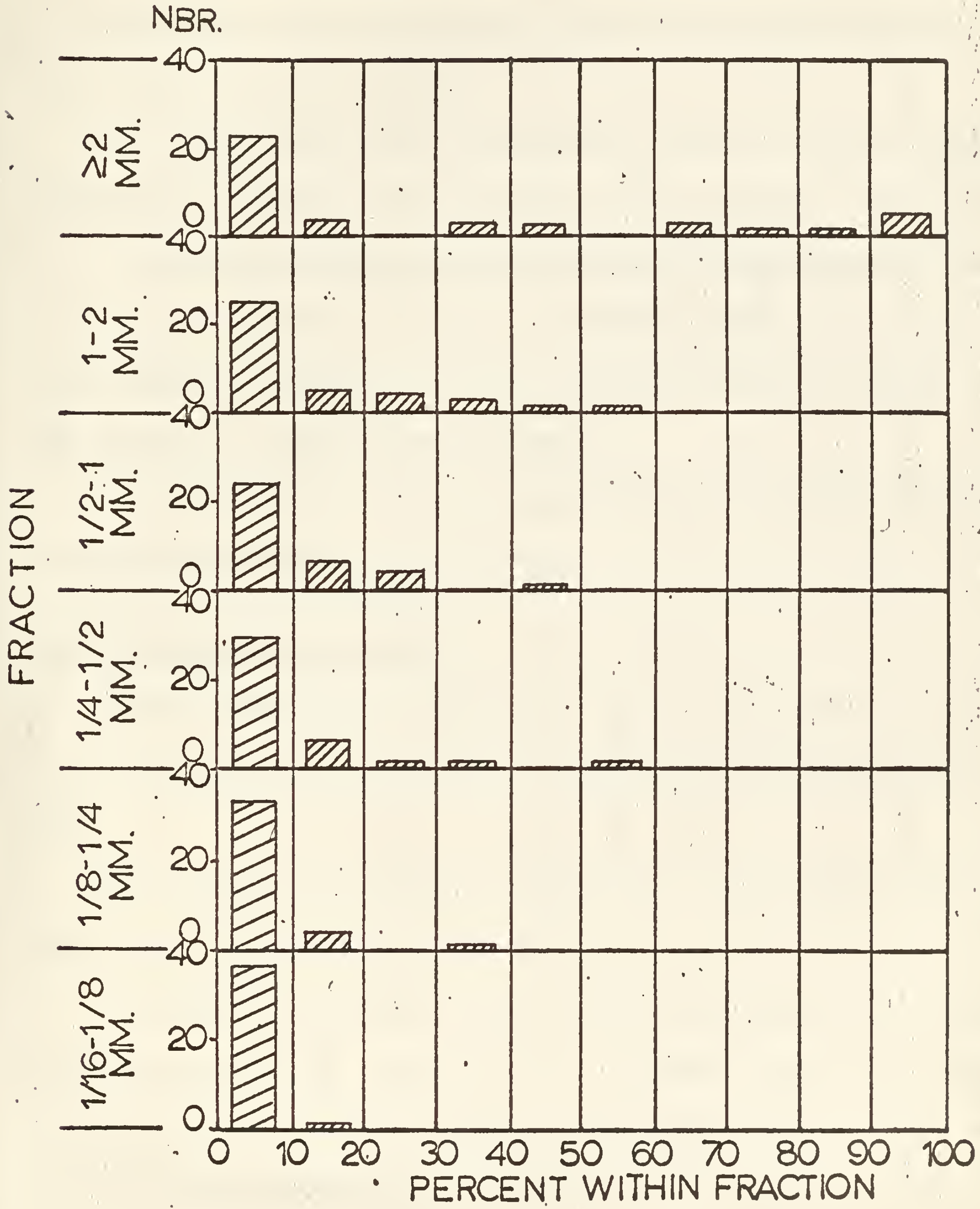


Figure 31

SUMMARY AND CONCLUSIONS

Controlling factors

In general, the controlling factors of the depositional environments of southern Monterey Bay are:

(a) The Salinas River drainage which supplies erosion products from sedimentary, igneous, and metamorphic rocks located in the watershed.

(b) Shoreline erosion of the granitics forming Monterey Peninsula.

(c) The presence of Monterey Submarine Canyon which serves to channel sediment to the deep sea floor and also acts as a barrier to prevent the influx of sediment from the north.

(d) Wave action around the peninsula and the marked wave shadow in the extreme southern end of the bay.

Distribution characteristics

These influences are manifested in the distributions of all nine constituents selected for the area, the principal characteristics of which are:

(a) The concentrations of constituents tend to form belts roughly paralleling the shoreline.

(b) Some constituents, such as the rock-forming minerals, quartz-feldspar, and mafics, tend to occur in highest concentration along the coast. Others, such as glauconite, phosphorite, and organics tend to occur in least concentration along the coast.

(c) Another area of distinctive concentration is centered several miles north of Pt. Pinos, where glauconite, phosphorite, aggregates, and organics reach their maximum concentrations. This area possibly represents a non-depositional environment region of relict sediments.

(d) An anomalous area in the concentrations occurs in the extreme southern end of Monterey Bay, where the distribution of constituents is more representative of that out on the shelf. This is attributed to the presence of quieter water due to the sheltering effect of the peninsula.

(e) Terrigeneous sediments dominate the southern bay but pelagic sediments compose as much as 50% of the sediments on the outer shelf.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Prof. Warren C. Thompson, U. S. Naval Postgraduate School, for his patience and advice throughout this investigation. An Office of Naval Research Institutional Grant to Dr. Thompson provided funds for the purchase of much of the needed laboratory equipment. The initial interest in the sediments of Monterey Bay was instilled in the writer during a week-long cruise in the bay aboard the Scripps Institution of Oceanography R. V. HORIZON, working under Dr. Francis P. Shepard, whose counsel is gratefully acknowledged. The author also wishes to thank Assoc. Prof. Charles L. Taylor, U. S. Naval Postgraduate School, for taking the photographs of examples of the nine constituents, and Mr. Harold Hess, U. S. Bureau of Mines, Marine Mineral Technology Center, for his advice and for background material and information on phosphorite and glauconite.

BIBLIOGRAPHY

Burst, J. F. Glauconite pellets: Their mineral nature and applications to stratigraphic interpretations. Bulletin of American Association of Petroleum Geologists, v. 42, 1958: 310-327.

Cloud, P. E., Jr. Physical Limits of Glauconite Formation. Bulletin of American Association of Petroleum Geologists, v. 39, April 1955: 484-492.

Dietz, R. S., Emery, K. O., and Shepard, F. P. Phosphorite Deposits on the Sea Floor off Southern California. Geological Society of America Bulletin, v. 53, 1942: 815-848.

Emery, K. O., and Dietz, R. S. Submarine Phosphorite Deposits off California and Mexico. California Journal of Mines and Geology, v. 46, 1950: 7-15.

Galliher, E. W. Sediments of Monterey Bay, California. State Mineralogist of California, Report 28, v. 28, 1932: 42-71.

Galliher, E. W. Glauconite Genesis. Geological Society of America Bulletin, v. 46, 1935: 1351-1366.

Martin, B. D. Geology of the Monterey Submarine Canyon. Ph. D. Thesis, University of Southern California, 1963.

Mero, J. L. An Economic Analysis of Mining Deep-Sea Phosphorite. Ph. D. Thesis, Institute of Marine Resources, University of California, 1960.

Mero, J. L. Sea Floor Phosphorite. California Division of Mines and Geology, Mineral Information Service Bulletin, v. 14, 1961.

Shepard, F. P., and Moore, D. G. Sedimentary Environments Differentiated by Coarse Fraction Studies. Bulletin of the American Association of Petroleum Geologists, v. 38, August 1954: 1792-1802.

Shepard, F. P. Submarine Geology. Harper and Row, 1963.

APPENDIX I

SOURCES OF ERROR IN ESTIMATION AND COMPUTATION OF CONSTITUENT CONCENTRATIONS

In visual estimation, as pointed out by Shepard and Moore (1954), the quantity of a constituent in a given grain size fraction of a sediment sample is best described in terms of a volume percentage rather than a weight percentage, due to the difficulty of visually estimating weights in contrast to volumes. Since the total quantity of a fraction is characteristically measured in terms of weight, errors can be introduced by multiplying volume percentages by weight, because of the differences in the density of the grains composing the different constituents in the fraction.

An idea of the magnitude of this error may be approximated in the following manner: by multiplying the estimated volume percent of a constituent within a size fraction by its specific gravity, a constituent unit weight may be obtained. Summing these unit weights for all constituents within the fraction produces a total unit weight. Finally, individual weight percentages may be computed by dividing constituent unit weights by the total unit weight. In the following pages, the magnitude of this error for a randomly selected station, C-10, is shown in the right hand column labeled "variation." The average variation of the volume percentages from the weight percentages was found to be ± 1.1% for this sample.

If it is assumed that an error of ± 5% may occur in visually estimating the volume of a constituent in a given size fraction, it is immediately apparent that this type of error is significantly larger than the volume-weight conversion error.

VOLUME PERCENTAGES COMPARED TO WEIGHT PERCENTAGES FOR SAMPLE C-10

FRACTION: ≥ 2 mm

CONSTITUENT	VOLUME PERCENT	SPECIFIC GRAVITY	UNIT WEIGHT	WEIGHT PERCENT	VARIATION
QTZ & FLDSPR	5	2.65	13.2	4.9	0.1
BIOTITE	0	3.00	0.0	0.0	0.1
MAFICS	5	3.30	16.5	6.2	1.2
ORG. DEBRIS	3	1.80	5.4	2.0	1.0
FORAMS	0	2.00	0.0	0.0	0.0
SHELL FRAGS	5	2.00	10.0	3.7	1.3
GLAUCONITE	0	3.00	0.0	0.0	0.0
PHOSPHORITE	2	3.20	6.4	2.4	0.4
AGG & COPRO	80	2.70	216.0	80.8	0.8
	100%		TOTAL 267.5	100.0%	

FRACTION: 1-2 mm

CONSTITUENT					
QTZ & FLDSPR	20	2.65	53.0	19.8	0.2
BIOTITE	0	3.00	0.0	0.0	0.0
MAFICS	8	3.30	27.4	10.2	2.2
ORG. DEBRIS	3	1.80	5.4	2.0	1.0
FORAMS	0	2.00	0.0	0.0	0.0
SHELL FRAGS	7	2.00	14.0	5.2	1.8
GLAUCONITE	0	3.00	0.0	0.0	0.0
PHOSPHORITE	2	3.20	6.4	2.4	0.4
AGG & COPRO	60	2.70	162.0	60.4	0.4
	100%		TOTAL 268.2	100.0%	

FRACTION: 1/2-1 mm

CONSTITUENT	VOLUME PERCENT	SPECIFIC GRAVITY	UNIT WEIGHT	WEIGHT PERCENT	VARIATION
QTZ & FLDSPR	25	2.65	66.2	24.5	0.5
BIOTITE	5	3.00	15.0	5.6	0.6
MAFICS	10	3.30	33.0	12.3	2.3
ORG. DEBRIS	7	1.80	12.6	4.7	2.3
FORAMS	2	2.00	4.0	1.5	0.5
SHELL FRAGS	0	2.00	0.0	0.0	0.0
GLAUCONITE	0	3.00	0.0	0.0	0.0
PHOSPHORITE	1	3.20	3.2	1.2	0.8
AGG & COPRO	50	2.70	135.0	50.2	0.2
	100%		TOTAL 269.0	100.0%	

FRACTION: 1/4-1/2 mm

CONSTITUENT					
QTZ & FLDSPR	40	2.65	106.0	38.3	2.7
BIOTITE	10	3.00	30.0	10.8	0.8
MAFICS	20	3.30	66.0	23.8	3.8
ORG. DEBRIS	4	1.80	7.2	2.6	1.4
FORAMS	2	2.00	4.0	1.4	0.6
SHELL FRAGS	2	2.00	4.0	1.4	0.6
GLAUCONITE	2	3.00	6.0	2.2	0.2
PHOSPHORITE	0	3.20	0.0	0.0	0.0
AGG & COPRO	20	2.70	54.0	19.5	0.5
	100%		TOTAL 277.2	100.0%	

FRACTION 1/8-1/4 mm

CONSTITUENT	VOLUME PERCENT	SPECIFIC GRAVITY	UNIT WEIGHT	WEIGHT PERCENT	VARIATION
QTZ & FLDSPR	50	2.65	132.5	47.3	2.7
BIOTITE	10	3.00	30.0	10.7	0.7
MAFICS	15	3.30	49.5	17.7	2.7
ORG. DEBRIS	2	1.80	3.6	1.3	0.7
FORAMS	0	2.00	0.0	0.0	0.0
SHELL FRAGS	3	2.00	6.0	2.1	0.9
GLAUCONITE	5	3.00	15.0	5.4	0.4
PHOSPHORITE	0	3.20	0.0	0.0	0.0
AGG & COPRO	15	2.70	43.5	15.5	0.5
	100%	TOTAL	280.1	100.0%	

FRACTION: 1/16-1/8 mm

CONSTITUENT					
QTZ & FLDSPR	60	2.65	159.0	55.8	4.2
BIOTITE	5	3.00	15.0	5.3	0.3
MAFICS	25	3.30	82.5	29.0	4.0
ORG. DEBRIS	2	1.80	3.6	1.3	0.3
FORAMS	0	2.00	0.0	0.0	0.0
SHELL FRAGS	1	2.00	2.0	0.7	0.3
GLAUCONITE	2	3.00	6.0	2.1	0.1
PHOSPHORITE	0	3.20	0.0	0.0	0.0
AGG & COPRO	5	2.70	16.5	5.8	0.8
	100%	TOTAL	284.6	100.0%	

APPENDIX II

CONCENTRATION OF CONSTITUENTS IN THE SEDIMENT SAMPLES

(Volume percentage estimates vs. fraction size for each constituent)

SAMPLE NUMBER C-1 — COARSE FRACTION PERCENTAGE: 94.5%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	6	40	33	13	2	1
AGG & COPRO	3	5	8	0	5	2
BIOTITE	0	0	0	3	5	3
FORAMS	0	0	0	9	35	15
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	5	7	5	5	2
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	2	5	5	3	5	3
QTZ & FLDSPR	75	70	70	50	10	60
SHELL FRAGS	20	15	10	30	35	15

SAMPLE NUMBER C-2 — COARSE FRACTION PERCENTAGE: 73.6%

CONSTITUENT						
TOTAL SAMPLE	10	14	16	7	8	19
AGG & COPRO	60	10	20	80	85	0
BIOTITE	0	0	0	2	5	15
FORAMS	0	0	5	0	0	0
GLAUCONITE	0	0	0	0	0	5
MAFICS	25	30	20	5	5	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	5	5	3	2	2
QTZ & FLDSPR	10	45	40	5	3	65
SHELL FRAGS	5	10	10	5	0	3

SAMPLE NUMBER C-3 COARSE FRACTION PERCENTAGE: 36.9%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/6mm
TOTAL SAMPLE	0	0	0	0	6	30
AGG & COPRO	25	50	60	60	0	0
BIOTITE	0	0	5	0	15	5
FORAMS	0	5	5	2	5	0
GLAUCONITE	0	0	3	0	15	5
MAFICS	25	5	5	0	20	20
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	10	5	10	0	5
QTZ & FLDSPR	0	10	10	15	40	60
SHELL FRAGS	50	20	7	13	5	5

SAMPLE NUMBER C-4 COARSE FRACTION PERCENTAGE: 86.0%

CONSTITUENT						
TOTAL SAMPLE	0	0	0	8	28	49
AGG & COPRO	60	45	25	3	5	0
BIOTITE	0	0	3	20	20	15
FORAMS	0	0	3	0	5	1
GLAUCONITE	0	0	2	0	0	1
MAFICS	5	10	10	3	5	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	5	5	15	0	2	1
QTZ & FLDSPR	10	10	17	70	60	70
SHELL FRAGS	20	30	25	4	3	2

SAMPLE NUMBER C-5 COARSE FRACTION PERCENTAGE: 71.1%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	2	1	7	13	11	36
AGG & COPRO	0	5	15	5	3	2
BIOTITE	0	0	0	5	25	10
FORAMS	0	1	5	0	2	10
GLAUCONITE	0	0	0	3	10	0
MAFICS	50	20	25	30	10	3
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	5	4	5	2	10	5
QTZ & FLDSPR	10	40	40	50	40	65
SHELL FRAGS	35	30	10	5	0	5

SAMPLE NUMBER C-6 COARSE FRACTION PERCENTAGE: 55.5%

CONSTITUENT						
TOTAL SAMPLE	3	3	4	5	15	27
AGG & COPRO	40	50	60	70	20	10
BIOTITE	0	0	0	3	10	5
FORAMS	0	0	2	0	0	0
GLAUCONITE	0	0	0	2	3	10
MAFICS	5	10	10	0	20	20
PHOSPHORITE	0	2	0	0	0	0
ORG. DEBRIS	0	0	3	5	2	2
QTZ & FLDSPR	50	35	20	10	40	50
SHELL FRAGS	5	3	5	10	5	3

SAMPLE NUMBER C-7 COARSE FRACTION PERCENTAGE: 89.8%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	0	2	9	6	31	42
AGG & COPRO	0	0	0	5	0	0
BIOTITE	0	0	0	10	5	5
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	5	0	2
MAFICS	0	50	40	30	30	30
PHOSPHORITE	0	5	5	3	0	0
ORG. DEBRIS	0	0	0	10	2	0
QTZ & FLDSPR	0	35	45	35	60	60
SHELL FRAGS	0	10	10	2	3	3

SAMPLE NUMBER C-8 COARSE FRACTION PERCENTAGE: 76.2%

CONSTITUENT						
TOTAL SAMPLE	1	1	4	6	20	45
AGG & COPRO	30	40	30	20	0	0
BIOTITE	0	0	0	10	15	10
FORAMS	0	0	30	35	20	0
GLAUCONITE	0	5	5	5	2	0
MAFICS	5	10	5	10	15	20
PHOSPHORITE	0	3	0	0	0	0
ORG. DEBRIS	5	2	5	10	3	5
QTZ & FLDSPR	20	30	20	5	40	60
SHELL FRAGS	40	10	5	5	5	5

SAMPLE NUMBER C-9 COARSE FRACTION PERCENTAGE: 2.6%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	0	0	0	1	1	1
AGG & COPRO	0	20	70	65	40	20
BIOTITE	0	0	0	0	20	55
FORAMS	0	0	10	5	0	0
GLAUCONITE	0	5	0	0	0	3
MAFICS	0	10	0	5	10	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	5	5	20	20	7
QTZ & FLDSPR	0	20	10	5	5	5
SHELL FRAGS	0	40	5	0	5	0

SAMPLE NUMBER C-10 COARSE FRACTION PERCENTAGE: 56.8%

CONSTITUENT						
TOTAL SAMPLE	0	1	3	7	16	29
AGG & COPRO	80	60	50	20	15	5
BIOTITE	0	0	5	10	10	5
FORAMS	0	0	2	2	0	0
GLAUCONITE	0	0	0	2	5	2
MAFICS	5	8	10	20	15	25
PHOSPHORITE	2	2	1	0	0	0
ORG. DEBRIS	3	3	7	3	2	2
QTZ & FLDSPR	5	20	25	40	50	60
SHELL FRAGS	5	7	0	2	3	1

SAMPLE NUMBER G-1 COARSE FRACTION PERCENTAGE: 94.3%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/4-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	0	0	3	48	32	11
AGG & COPRO	0	30	10	3	0	0
BIOTITE	0	0	0	3	4	5
FORAMS	0	0	2	5	3	5
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	10	25	20	10	5
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	10	3	5	3	2
QTZ & FLDSPR	0	20	50	60	80	80
SHELL FRAGS	100	30	10	4	0	3

SAMPLE NUMBER G-2 COARSE FRACTION PERCENTAGE: 94.1%

CONSTITUENT						
TOTAL SAMPLE	0	0	2	17	52	22
AGG & COPRO	0	5	5	5	0	0
BIOTITE	0	0	5	15	20	10
FORAMS	0	2	5	0	5	7
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	5	5	5	10	0
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	3	0	5	5	3
QTZ & FLDSPR	0	25	50	60	50	70
SHELL FRAGS	100	60	30	10	10	10

SAMPLE NUMBER G-3 COARSE FRACTION PERCENTAGE: 91.0%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	1	1	1	3	25	61
AGG & COPRO	0	40	40	15	0	0
BIOTITE	0	0	3	30	20	10
FORAMS	0	5	0	20	2	0
GLAUCONITE	0	0	2	0	0	0
MAFICS	0	15	0	2	0	0
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	5	5	10	3	5
QTZ & FLDSPR	0	30	20	20	70	80
SHELL FRAGS	100	5	30	3	5	5

SAMPLE NUMBER G-4 COARSE FRACTION PERCENTAGE: 67.2%

CONSTITUENT						
TOTAL SAMPLE	1	3	8	14	13	28
AGG & COPRO	3	7	3	0	0	2
BIOTITE	0	0	1	1	8	7
FORAMS	0	0	3	5	7	2
GLAUCONITE	0	3	3	7	15	10
MAFICS	20	25	30	30	30	5
PHOSPHORITE	0	0	0	1	0	0
ORG. DEBRIS	2	5	5	4	5	1
QTZ & FLDSPR	5	40	50	50	30	70
SHELL FRAGS	70	20	5	2	5	3

SAMPLE NUMBER G-5 COARSE FRACTION PERCENTAGE: 77.1%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	12	6	11	10	13	26
AGG & COPRO	95	70	40	60	20	5
BIOTITE	0	0	0	0	5	15
FORAMS	0	0	0	2	3	0
GLAUCONITE	0	0	0	1	2	0
MAFICS	0	5	7	10	5	20
PHOSPHORITE	0	1	1	2	0	0
ORG. DEBRIS	0	0	2	3	10	5
QTZ & FLDSPR	0	20	50	20	50	50
SHELL FRAGS	5	4	0	2	5	5

SAMPLE NUMBER G-6 COARSE FRACTION PERCENTAGE: 98.0%

CONSTITUENT						
TOTAL SAMPLE	1	1	2	30	56	8
AGG & COPRO	5	60	40	0	0	0
BIOTITE	0	0	0	0	2	3
FORAMS	0	0	2	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	5	5	15	10	20
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	5	5	3	5	5	0
QTZ & FLDSPR	20	10	25	75	80	75
SHELL FRAGS	70	20	25	5	3	2

SAMPLE NUMBER G-7 COARSE FRACTION PERCENTAGE: 96.5%

CONSTITUENT	≥2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	0	0	2	20	51	23
AGG & COPRO	60	60	40	0	0	0
BIOTITE	0	0	0	5	5	15
FORAMS	0	0	0	3	0	0
GLAUCONITE	0	0	0	2	0	0
MAFICS	0	0	10	30	35	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	0	0	0	0
QTZ & FLDSPR	40	35	40	60	50	70
SHELL FRAGS	0	5	10	0	10	5

SAMPLE NUMBER G-8 COARSE FRACTION PERCENTAGE: 95.2%

CONSTITUENT						
TOTAL SAMPLE	0	1	1	2	53	39
AGG & COPRO	100	80	70	40	5	0
BIOTITE	0	0	10	5	5	5
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	10	2	5	25	20
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	0	5	0	0
QTZ & FLDSPR	0	10	8	40	60	70
SHELL FRAGS	0	0	10	5	5	5

SAMPLE NUMBER G-9 COARSE FRACTION PERCENTAGE: 88.9%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/4-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	1	0	1	1	25	61
AGG & COPRO	80	60	50	30	0	0
BIOTITE	0	0	0	20	20	15
FORAMS	0	0	10	5	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	5	7	5	15	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	3	20	0	0
QTZ & FLDSPR	0	25	10	10	60	70
SHELL FRAGS	20	10	20	10	5	5

SAMPLE NUMBER G-10 COARSE FRACTION PERCENTAGE: 97.2%

CONSTITUENT						
TOTAL SAMPLE	1	3	4	21	54	15
AGG & COPRO	0	30	20	0	0	0
BIOTITE	0	0	0	5	5	5
FORAMS	0	0	0	15	0	0
GLAUCONITE	0	0	0	2	0	0
MAFICS	0	0	5	5	5	0
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	10	10	3	5	5
QTZ & FLDSPR	100	20	10	50	70	80
SHELL FRAGS	0	40	55	20	15	10

SAMPLE NUMBER G-11

COARSE FRACTION PERCENTAGE: 64.6%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/4-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	6	2	1	2	5	49
AGG & COPRO	10	70	45	50	60	0
BIOTITE	0	0	5	0	20	10
FORAMS	0	0	5	5	0	0
GLAUCONITE	0	0	0	3	0	0
MAFICS	10	5	10	10	5	10
PHOSPHORITE	0	0	0	2	0	0
ORG. DEBRIS	0	5	5	5	3	0
QTZ & FLDSPR	30	15	20	15	10	75
SHELL FRAGS	50	5	10	10	2	5

SAMPLE NUMBER G-12

COARSE FRACTION PERCENTAGE: 97.2%

CONSTITUENT						
TOTAL SAMPLE	0	2	0	14	59	22
AGG & COPRO	0	20	20	5	0	0
BIOTITE	0	0	1	10	10	5
FORAMS	0	0	2	5	5	3
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	5	5	7	2
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	5	2	5	3	5
QTZ & FLDSPR	0	25	30	50	70	80
SHELL FRAGS	0	50	40	20	5	5

SAMPLE NUMBER G-13 COARSE FRACTION PERCENTAGE: 96.4%

CONSTITUENT	≥2mm	2-1mm	1-1/2mm	1/4-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	0	1	2	15	59	20
AGG & COPRO	0	20	10	7	4	2
BIOTITE	0	0	0	8	7	5
FORAMS	0	5	5	5	8	3
GLAUCONITE	0	0	0	0	1	0
MAFICS	0	0	5	10	15	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	5	10	10	5	10
QTZ & FLDSPR	0	60	50	40	50	60
SHELL FRAGS	0	10	20	20	10	10

SAMPLE NUMBER G-14 COARSE FRACTION PERCENTAGE: 100%

CONSTITUENT						
TOTAL SAMPLE	0	9	67	22	2	0
AGG & COPRO	0	0	0	0	0	0
BIOTITE	0	0	0	0	5	0
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	15	20	20	30	0
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	0	0	0	0
QTZ & FLDSPR	0	85	80	75	60	0
SHELL FRAGS	0	0	0	5	5	0

SAMPLE NUMBER G-15 COARSE FRACTION PERCENTAGE: 91.6%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	0	0	10	71	10	0
AGG & COPRO	0	0	0	0	0	0
BIOTITE	0	0	0	2	5	0
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	15	20	25	0
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	0	0	0	0
QTZ & FLDSPR	0	100	80	75	70	0
SHELL FRAGS	0	0	5	3	0	0

SAMPLE NUMBER G-16 COARSE FRACTION PERCENTAGE: 100%

CONSTITUENT						
TOTAL SAMPLE	0	1	3	35	61	0
AGG & COPRO	0	0	0	0	0	0
BIOTITE	0	0	10	5	5	20
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	15	15	10	50
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	0	0	0	0
QTZ & FLDSPR	0	100	75	80	85	30
SHELL FRAGS	0	0	0	0	0	0

SAMPLE NUMBER G-17 COARSE FRACTION PERCENTAGE: 98.4%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/4-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	3	4	78	14	1	0
AGG & COPRO	10	5	0	0	0	0
BIOTITE	0	0	0	5	5	0
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	5	15	30	15	10	0
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	0	0	5	0
QTZ & FLDSPR	85	80	70	80	75	0
SHELL FRAGS	0	0	0	0	5	0

SAMPLE NUMBER G-18 COARSE FRACTION PERCENTAGE: 100%

CONSTITUENT						
TOTAL SAMPLE	0	2	79	18	1	0
AGG & COPRO	0	0	0	0	0	0
BIOTITE	0	10	0	10	5	0
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	10	5	5	10	0
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	0	0	0	0
QTZ & FLDSPR	25	65	85	85	80	0
SHELL FRAGS	75	15	10	0	5	0

SAMPLE NUMBER G-19 COARSE FRACTION PERCENTAGE: 54.8%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/4-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	0	1	1	2	9	42
AGG & COPRO	10	60	50	40	10	0
BIOTITE	0	0	0	5	40	25
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	10	15	10	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	90	25	20	20	10	10
QTZ & FLDSPR	0	10	15	10	10	50
SHELL FRAGS	0	5	5	10	20	5

SAMPLE NUMBER G-20 COARSE FRACTION PERCENTAGE: 52.8%

CONSTITUENT						
TOTAL SAMPLE	0	0	1	2	8	41
AGG & COPRO	0	10	35	40	20	0
BIOTITE	0	0	0	0	30	15
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	10	10	5	20
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	100	60	35	20	30	10
QTZ & FLDSPR	0	20	10	10	5	50
SHELL FRAGS	0	10	10	20	10	5

SAMPLE NUMBER G-21 COARSE FRACTION PERCENTAGE: 11.0%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	-	-	-	-	-	-
AGG & COPRO	0	0	20	30	30	5
BIOTITE	0	0	0	0	10	15
FORAMS	0	0	10	10	5	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	5	5	5	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	100	30	40	40	10
QTZ & FLDSPR	0	0	15	5	5	50
SHELL FRAGS	100	0	20	10	5	10

SAMPLE NUMBER G-22 COARSE FRACTION PERCENTAGE: 78.2%

CONSTITUENT						
TOTAL SAMPLE	0	0	1	1	7	70
AGG & COPRO	0	0	50	30	0	0
BIOTITE	0	0	0	20	60	5
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	0	0	5	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	100	0	0	0	10	5
QTZ & FLDSPR	0	0	10	10	10	75
SHELL FRAGS	0	100	40	40	15	5

SAMPLE NUMBER G-23 COARSE FRACTION PERCENTAGE: 65.4%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/4-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	0	0	0	0	6	61
AGG & COPRO	0	0	15	20	0	0
BIOTITE	0	0	0	5	40	5
FORAMS	0	0	5	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	10	0	5	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	50	10	10	5	0
QTZ & FLDSPR	0	50	20	5	30	80
SHELL FRAGS	0	0	40	60	20	5

SAMPLE NUMBER G-24 COARSE FRACTION PERCENTAGE: 11.5%

CONSTITUENT						
TOTAL SAMPLE	-	-	-	-	-	-
AGG & COPRO	10	50	45	40	40	0
BIOTITE	0	0	5	0	20	30
FORAMS	0	0	0	0	0	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	0	5	0	10
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	20	20	30	30	5
QTZ & FLDSPR	0	0	10	10	5	50
SHELL FRAGS	90	30	20	15	5	5

SAMPLE NUMBER G-25 COARSE FRACTION PERCENTAGE: 53.9%

CONSTITUENT	≥ 2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	0	2	3	5	14	29
AGG & COPRO	30	20	15	30	5	0
BIOTITE	0	0	0	0	10	5
FORAMS	0	0	0	5	5	0
GLAUCONITE	0	0	5	5	10	0
MAFICS	0	20	20	10	10	20
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	20	0	5	10	10	5
QTZ & FLDSPR	50	60	50	40	40	70
SHELL FRAGS	0	0	5	0	10	0

SAMPLE NUMBER G-26 COARSE FRACTION PERCENTAGE: 44.0%

CONSTITUENT						
TOTAL SAMPLE	-	-	-	-	-	-
AGG & COPRO	20	10	0	20	5	0
BIOTITE	0	0	0	0	20	15
FORAMS	0	0	10	10	5	0
GLAUCONITW	0	0	10	20	5	0
MAFICS	40	40	20	10	15	15
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	20	5	10	0
QTZ & FLDSPR	40	50	40	30	30	70
SHELL FRAGS	0	0	0	5	10	0

SAMPLE NUMBER G-27 COARSE FRACTION PERCENTAGE: 3.9%

CONSTITUENT	≥2mm	2-1mm	1-1/2mm	1/2-1/4mm	1/4-1/8mm	1/8-1/16mm
TOTAL SAMPLE	-	-	-	-	-	-
AGG & COPRO	0	100	70	45	40	0
BIOTITE	0	0	0	0	0	40
FORAMS	0	0	0	20	15	5
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	0	5	5	0
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	0	10	25	30	40
QTZ & FLDSPR	0	0	0	5	10	10
SHELL FRAGS	0	0	20	0	0	5

SAMPLE NUMBER G-28 COARSE FRACTION PERCENTAGE: 1.7%

CONSTITUENT						
TOTAL SAMPLE	-	-	-	-	-	-
AGG & COPRO	0	50	70	40	40	10
BIOTITE	0	0	0	0	0	40
FORAMS	0	0	0	25	5	0
GLAUCONITE	0	0	0	0	0	0
MAFICS	0	0	0	5	5	5
PHOSPHORITE	0	0	0	0	0	0
ORG. DEBRIS	0	50	5	15	40	30
QTZ & FLDSPR	0	0	10	10	10	10
SHELL FRAGS	100	0	15	5	0	5

[redacted]

Removed Cofk 7/29/74

[redacted]