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# CARBONATE LAGOON AND BEACH SEDIMENTS OF TARAWA ATOLL, GILBERT ISLANDS

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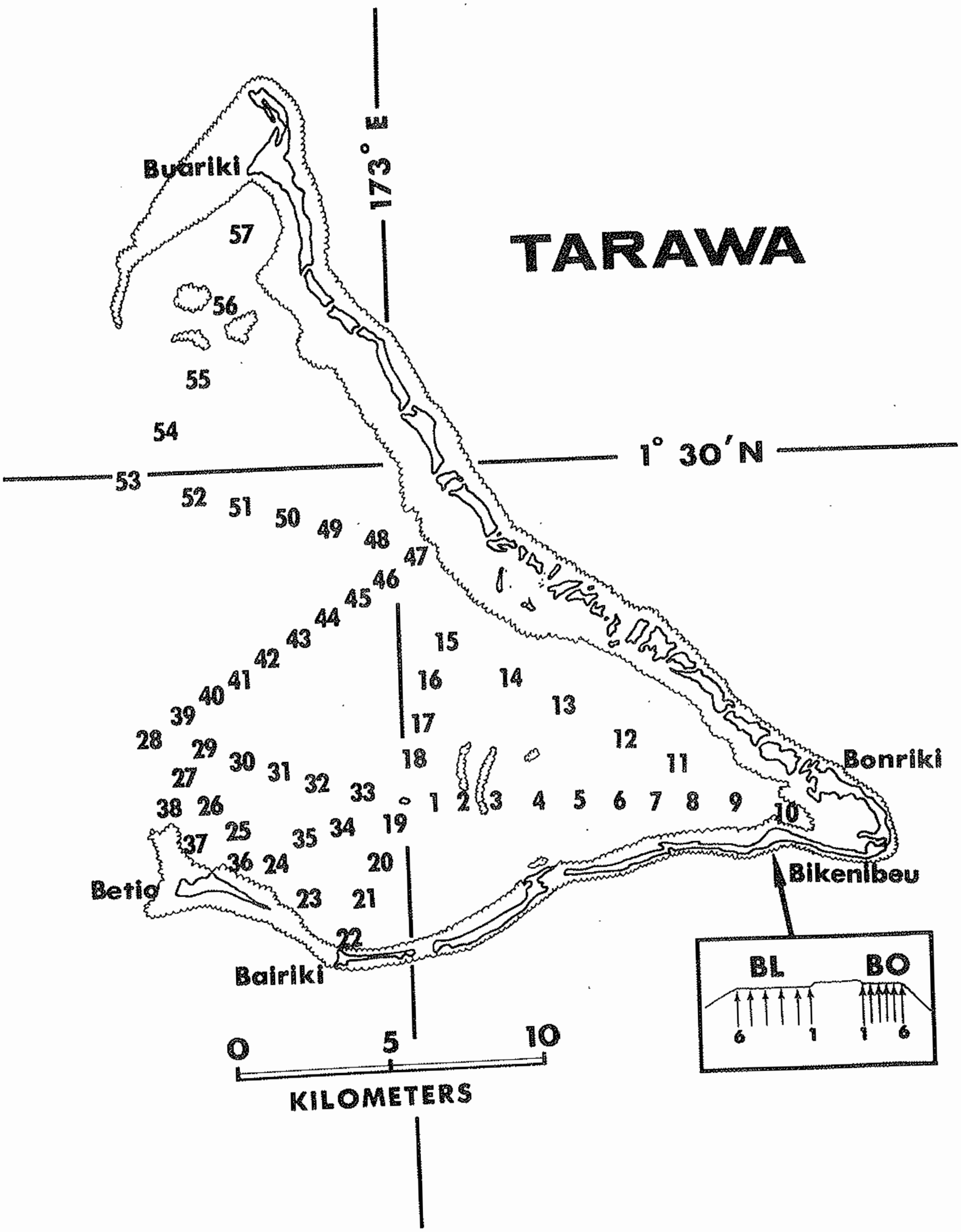


*Figure 1:* Locations of sampling stations in Tarawa Lagoon. Inset at lower right shows positions of fringing reef flat sediment samples on Bikenibeu Island. BL = lagoonal reef flat; BO = ocean reef flat; BL and BO sample numbers begin at shore ( 1) and end at reef edge ( 6).

# CARBONATE LAGOON AND BEACH SEDIMENTS OF TARAWA ATOLL, GILBERT ISLANDS

by Jon N. Weber[1] and Peter M. J. Woodhead[2]

SUMMARY

A large, shallow lagoon, almost isolated from the open ocean, distinguishes Tarawa from other atolls where carbonate sedimentation has been investigated. Passes through the atoll reef are lacking except along the western periphery. Size distribution statistics (median grain size, coefficients of sorting and skewness) were obtained for 57 sediment samples from Tarawa Lagoon and 12 samples from the fringing reef flats. Samples were subdivided into ten separate grain size fractions and the mineralogy of each fraction was determined. Component analysis of the larger grains was undertaken to identify the different sources of carbonate particles. Lime muds are accumulating in shallow water (6-10 m) over a large area of the southeastern lagoon. Evidence provided by mineralogy, carbon isotopic composition, and electron microscopy indicates that the fines consist of a mixture of algae-secreted needles and particles derived from the physical and biological breakdown of skeletal detritus. The abundance of carbonate muds in shallow water is attributed to the absence of current winnowing.

INTRODUCTION

Tarawa possesses several features which distinguish it from other atolls where carbonate sedimentation has been studied. These features especially concern the depth of the lagoon and the relatively poor connection between it and the open ocean. The water in much of Tarawa Lagoon is murky, a fact which is readily evident from the air. At the extreme southeastern corner of the lagoon, underwater visibility is less than 2 m, and associated with the high degree of turbidity are fine-grained carbonate muds accumulating in shallow water.

The lagoon at Tarawa differs significantly from those of Bikini, Eniwetok, and other atolls where detailed sediment studies were conducted by Emery *et al.* (1954). Tarawa Lagoon is shallow, averaging about 12 to 15 m, with a maximum depth of 25 m. Rongelap, Eniwetok, and Bikini Atolls, however, have lagoons averaging about 50 m in depth (maximum 70 m). Furthermore, Tarawa Lagoon is encircled by coral reefs at sea level except along the western margin where the atoll reef top is submerged to about 9 m. There is only one deep (20-25 m) pass into Tarawa, whereas Rongelap Lagoon is connected to the sea by nine passes with a maximum depth of 66 m, and Bikini has eight passes or channels with a maximum depth of 60 m.' These variations in lagoon physiography might exert considerable influence on the characteristics of sedimentary material accumulating on the atoll.

The dominant sediment contributors in most coral reef environments appear to be *Halimeda*, corals, molluscs, foraminifera, and the coralline algae. In unusual circumstances, other types of sediment may form, for example, non-skeletal carbonates in the lagoon of Hogsty Reef (Milliman, 1967) or the pelagic foraminifera, benthonic foraminifera, and mollusc sands on the Seychelles Bank (Lewis and Taylor, 1966). Considerable variations in the abundance of carbonate grains from different sources are observed from one reef to another and often within a single reef complex. *Halimeda* and foraminifera, for example, are important in the Great Barrier Reef (Maxwell, 1968) and the Florida reef tract (Ginsburg, 1956) provinces. Over large areas of the floors of Eniwetok and Bikini Lagoons, *Halimeda* is a major sediment

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component, often comprising between 75 and 100% of the total (Emery *et al.*, 1954). In Fanning Lagoon, however, foraminifera and *Halimeda* are not substantial contributors (Roy, 1970). *Halimeda* fragments are also relatively scarce in the sediments of Kure and Midway Atolls (Gross *et al.* 1969). At Pearl and Hermes Reef, carbonate of foraminiferal derivation is considerably less abundant than grains from algae, corals, and molluscs (Thorp, 1936). Thus the striking differences in the proportions of various carbonate contributors reported for Pacific islands and atolls is an additional incentive for investigating the sedimentary deposits of Tarawa.

## PHYSICAL SETTING

Tarawa Atoll, part of the Gilberts Islands group, is located in the central Pacific Ocean just north of the equator ($1^{o}30'$N, $173^{o}$E). The atoll is triangular in shape, with approximate dimensions of 25 km E-W and 30 km N-S. Although the dominant surface ocean current is from the east, the wind regime changes from NE Trades in Jan.-Feb. to SE Trades in July-Aug. The coral reef is continuous and rises to the surface on the windward side of the atoll, supporting numerous islands and islets no more than a few feet above sea level. These islands are surrounded by reef flats as much as 300 to 800 m wide on both lagoonal and seaward shores, and they are separated from each other by narrow channels which are generally emergent at low tide. Along the western margin of the atoll, the reef is submerged to depths of about 8 to 10 m. The main entrance to the lagoon is a breach in the leeward, submerged reef, located just north of Betio near sampling station TA-28 (Fig. 1). A strong (1-3 km/hr) current flows through this channel, its direction reversing with each change in the tide. Despite its size (400 sq. km) the lagoon is relatively shallow, with an average depth between 12 and 15 m, and a maximum depth of 25 m. Irregular topography characterizes the lagoon floor, and coral knolls or pinnacle reefs are fairly common.

## METHODS

A total of 57 sediment samples ("TA-series") was collected in Tarawa Lagoon by diving or by means of a modified Van Veen bottom sampler. Additional sediment was sampled on the flats of the reefs fringing Bikenibeu Island on both the lagoon ("BL-series") and ocean ("BO-series") facing sides. The locations of sampling stations are shown in Fig. 1. Sediment samples were processed by mechanical techniques described in detail by Neumann (1965), and size distribution statistics were calculated from the resulting size-frequency distributions. Central tendency is expressed by the median grain size *(Md)* in mm. Trask sorting *(So)* and skewness *(Sk)* coefficients are used to indicate dispersion and symmetry: $So = \sqrt{Q_3/Q_1}$ and $Sk = Q_1 Q_3/(Md)^2$, where $Q_1$ and $Q_3$ are the first and third quartiles of the cumulative frequency distribution. Each sample was divided into ten size fractions designated by the letters A to J in order of decreasing grain size. The limits of these size classes, in mm, are:

| | |
|---|---|
| A | 2.00 - 0.841 |
| B | 0.841 - 0.420 |
| C | 0.420 - 0.250 |
| D | 0.250 - 0.177 |
| E | 0.177 - 0.149 |
| F | 0.149 - 0.125 |
| G | 0.125 - 0.105 |
| H | 0.105 - 0.082 |
| I | 0.082 - 0.074 |
| J | $<$0.074 |

The abundances of aragonite, high-magnesium calcite (HMC), and low-magnesium calcite (LMC) in each size fraction were determined by X-ray diffraction analysis described in detail by Weber (1968). Carbon and oxygen isotopic composition data were obtained by mass spectrometric methods described by Deines (1970). Size frequency distribution statistics for each sediment sample are given in Table 1. Mineralogical data are listed in Table 2.

## SEDIMENTS OF THE LAGOON

There is a considerable difference between the material deposited in the eastern, relatively sheltered corner of the lagoon, and that covering the floor of the more exposed western portion. The sediments in the Bonriki-Bikenibeu area are essentially carbonate muds and oozes, whereas lime sands predominate elsewhere in the lagoon. In samples TA-12, 8, and 7 (Fig. 1) for example, the percentage of grains less than 0.07mm in diameter amounts to 75, 78, and 71 respectively. Coarse-grained sediments are typical of the western lagoon margin. Sample TA-28 yielded nothing finer than 0.125mm, and grains larger than 0.18mm accounted for 98% of the total. Similarly, 95% of TA-29 and 93% of TA-53 consisted of particles with diameters greater than 0.18mm. The striking change in median grain size from east to west is illustrated in Fig. 2. The fine-grained sediments in the eastern neck of the lagoon tend to be very poorly sorted ($So = 8.49$). Progressing westwards, sorting becomes increasingly better, with the Trask index decreasing to 1.58 at station TA-28.

Aragonite is the most abundant mineral component in all samples from the lagoon. Maximum and minimum amounts were found in TA-26 (92%) and TA-28 (65%), but approximately three-quarters of the sediments sampled contained between 75 and 90%. The average concentration of aragonite increases from 66% at the eastern corner of Tarawa Lagoon to about 80-88% in the center and then decreases abruptly to 65% at the western atoll reef edge (TA-28, Fig. 1). Aragonite is distributed among all ten of the size fractions studied, but in general, the intermediate grain size categories tend to have slightly higher percentages of this mineral than do the very fine or very coarse grades (Fig. 3). Changes in the distribution of aragonite as a function of grain size are shown for the east-west transect in Fig. 4, and for the TA-53 to TA-57 transect of the northern corner of the lagoon in Fig. 5.

Low-magnesium calcite is a minor constituent of the sediment throughout the lagoon. Average concentrations are generally between 2 and 8%, and with few exceptions, the mineral appears to be more or less equally distributed among the various size fractions of a given sample. Only at the western edge of the atoll reef where lagoonal and open ocean waters mix does LMC become abundant. The increase in concentration of low-magnesium calcite as the reef margin is approached is rather abrupt, as illustrated by the sample series TA-40 (9% LCM), 39 (14%) and 28 (17%). Almost all of the additional LMC in the reef edge sediments is found in a single size fraction. For example, 82, 73, and 89% of the total LMC in samples TA-40, 39, and 28 respectively occurs in the 0.42 to 0.48mm grain size range. With the exception of the western reef margin where the LMC content is variable, the distributions of high-magnesium calcite and aragonite in the lagoon sediments are complementary.

## COMPONENT ANALYSIS OF LAGOON SEDIMENTS

Grains larger than 0.5mm from a number of samples on the east-west lagoon transect were identified and counted under a binocular microscope. The results for major components are summarized in Fig. 6. Constituent carbonate grains from the extreme western part of the lagoon (e.g. samples TA-28, 29, 39) are "fresh" in appearance, are not greatly abraded, and hence are relatively easily identified. Progressing eastward, however, the grains become increasingly abraded and are characterized by a "weathered" appearance. *Halimeda* fragments constitute a major component of the sediment throughout the lagoon but their abundance is greatest in the eastern part, for example, 63% of the $>$ 0.5mm grains in sample TA-7.

The percentage of coral debris is highest in the west near the atoll reef margin. Coral fragments decline markedly in abundance towards the east, amounting to essentially zero percent at station TA-7. There is a slight increase in the quantity of coral produced grains in the lee of the seaward (eastern) atoll reef, for example at TA-9. Skeletal detritus attributed to mollusca is also a significant sediment component, and as shown in Fig. 6, this material is most abundant in the center of the lagoon.

Compared with other carbonate sediments of coral reef environments, echinoderm debris appears to be unusually common. The percentage of this component is low in the western lagoon but it steadily increases eastwards, reaching up to 20% of the > 0.5mm grains in the region where the fine carbonate muds are accumulating (e.g. TA-6, 7, 8, 9). Skeletal ossicles of the echinoid *Echinometra*, ophiuroids, and crinoids constitute the greater portion of recognizable echinodern-derived grains from samples near the western atoll reef area, whereas elsewhere in the lagoon, heart urchin debris predominates. It is noteworthy that foraminifera contribute very little sand size carbonate throughout the lagoon except in the beach areas and along the western atoll reef zone. The 0.4 to 0.8mm size fraction of beach sands is almost exclusivey composed of the foram *Calcarina.* In sample TA-28, the benthonic foraminifera constitute 25% of the 0.84 to 2.00mm and 45% of the 0.42 to 0.84mm size fractions. Most of the smaller tests are *Amphistegina,* whereas *Heterostegina* is the major contributor of the larger shells. Pelagic foraminifera were very seldom observed, even in samples from the western atoll reef margin.

Because of their fresh appearance, alcyonarian spicules are conspicuous in sediment samples from the western lagoon. They tendto concentrate in the 0.42 to 0.84mm size fraction but did not exceed 5% of any sample. Although coralline algae amounted to 9% in one sample, this component along with bryozoa, crustacean, andannelid debris, etc. are minor constituents of the > 0.5mm grains in the lagoonal sediments of Tarawa Atoll.

Major sources of aragonite are the green algae, especially *Halimeda,* the scleractinian corals, pelecypods, and gastropods. Smaller quantities of this mineral might be derived from hydrozoans, the octocoral *Heliopora,* some bryozoans, scaphopods, cephalopods, and some annelids. Producers of high-magnesium calcite include echinoderms, the coralline and red algae, benthonic foraminifera, alcyonarians, some bryozoans, calcareous sponges, decapods, and some annelids. Among the low-magnesium calcite contributors are a few benthonic foraminifera, and some pelecypods and gastropods. The foram *Amphistegina* secretes low-magnesium calcite (Fig. 7) which accounts for the unusually high percentage of LMC in sample TA-28.

## COMPARISON OF SEDIMENTS ON REEF FLATS FACING OCEAN AND LAGOON

Reef flats around the islands extend both seaward and into the lagoon, usually for appreciable distances (Fig. 1). As a substantial proportion of the total sediment associated with the atoll is derived from these reefs, samples were collected from reef flat environments on each side of Bikenibeu Island for comparison with sediments deposited within the lagoon proper. Physical conditions as well as the relative abundance of carbonate contributors are significantly different on the two types of reef flat. That facing the ocean, for example, is subjected to constant, high-energy wave action. Coralline algae, regular echinoids, and corals such as *Pocillopora* and *Favites* are conspicuous on the exposed seaward reef flats, whereas irregular echinoids, *Porites,* and calcareous green algae are more abundant on the flats adjacent to the lagoon. The species composition of the molluscan fauna of the two environments is also different.

As expected, the seaward reef surfaces retain little sediment with the exception of the beach and the small localized deposits in isolated depressions. These sediments are relatively coarse grained throughout (av. median diameter 1.13; range of median diameter 0.53 to 1.80mm).

In contrast, the lagoonal reef flats are almost completely covered with carbonate sediment having an average median grain size of 0.48mm (range of median 0.32 to 0.67). In this environment, median grain size decreases slightly from the middle of the flat to the edge of the lagoon. Samples from both reef flats are generally well sorted as indicated by the low values of the Trask sorting coefficient (av. 1.8 for the lagoon flat and 2.1 for the ocean flat). At Bikenibeu, the degree of sorting increases from mid flat to lagoon edge but decreases from mid flat to ocean edge, probably reflecting the fact that the only significant sediment accumulations in the exposed, high-energy wave zone on the seaward flat are found in comparatively protected holes and depressions. Perhaps the most conspicuous difference between sediments of the lagoon and ocean sides of the island is the effect of abrasion caused by wave action. Carbonate grains on the seaward flats have a much higher degree of roundness and polish. The vitreous luster enhances the color of the component grains and imparts a distinctive appearance to the sediment.

Aragonite is the most abundant mineral in all reef flat samples (Fig. 8) and in general, the lagoonal reef flat sediments contain a higher percentage than those on the seaward flat. From Bikenibeu beach to the edge of the lagoon there is a regular increase in the aragonite content from 50 to 84%, whereas on the ocean size of the island, the percentage of aragonite tends to decrease from 65% at the shore to 45% at the reef edge. Low-magnesium calcite constitutes from 1 to 2% of the sediments on the lagoon reef flat but was seldom detected in samples collected on the seaward flat. Thus the aragonite and high-magnesium calcite distribution patterns can be considered complementary.

## ORIGIN OF THE LIME MUDS

The quantitative importance of lime mud in the stratigraphic record has been emphasized by Matthews (1966) who found it paradoxical that studies of Recent carbonate sediments generally have concentrated on the genesis of the sand size particles rather than on the origin of the fine-grained constituents. In some major coral reef provinces, carbonate sands are clearly much more abundant than carbonate silts or muds. Sediments of the Capricorn reef complex of Australia, for example, seldom contain more than 2% mud (Maiklem, 1970). According to Maxwell (1968), very little fine carbonate is produced in the Great Barrier Reef system of Australia, and the mud present in sediments of that region is predominantly of terrigenous origin. Elsewhere the deficiency of fine particles and the high proportions of sand and gravel may be explained by removal of the fines into deeper water, as at Pearl and Hermes Reef (Thorp, 1936). Gross *et al.* (1969) found that particles less than 125 microns in diameter are relatively rare on Kure and Midway Atolls except in the deeper parts of the lagoons. Much of the fines apparently remains in suspension and is transported out of the lagoon, leaving behind the coarse-grained sediment in shallow water. Calcareous oozes are reported in the deepest parts of Kapingamarangi Lagoon, between 50 and 80 m. but McKee (1958) concludes that the mud is not likely derived primarily from the residue of sediments occurring in shallower water.

The situation at Fanning Island appears quite different in that fine-grained carbonates are unusually abundant. Muddy sediments in the lagoon at Fanning are reported by Roy (1970) who attributes most of the material to physical and biological abrasion or comminution of corals, molluscs, and calcareous red algae. Water in Fanning Lagoon is characterized by a high degree of turbidity, with underwater visibility often limited to 2 m or less. According to Bakus (1968) the suspended particles are generally between 5 and 15 microns in diameter. Hence the presence or absence of carbonate fines may be controlled more by the degree of current winnowing than by actual production of the grains. This is demonstrated in the case of Palmyra Atoll, at least, by the drastic changes in the lagoon following the construction of inter-island causeways in the early 1940's. Dawson (1959) reported that reef growth in the lagoon ceased after being deprived of circulating water. The lagoon became murky throughout due to the suspension of fine calcareous sediment, and inshore reef areas which once supported luxuriant coral growth are now deeply covered with carbonate mud.

Several possible mechanisms may be important in generating carbonate fines: inorganic precipitation; algal secretion of aragonite needles; and attrition of larger calcareous skeletons by mechanical or biological processes. The first of these, inorganic precipitation, is controversial. Fine-grained sediments covering large portions of the Bahama Banks, for example, are believed to be of inorganic origin by some investigators (Cloud, 1962; Illing, 1954; Newell *et al.* 1960; Broecker and Takahashi, 1966) while others consider green algae to be the dominant source (Lowenstam and Epstein, 1957). Milliman (1967) reports that most of the lagoonal sediment at Hogsty Reef is "non-skeletal" and probably precipitated inorganically. After studying sedimentation on Serrana Bank, Milliman (1969) later postulated that non-skeletal carbonates might form in open lagoon conditions only where biogenic carbonate secretion is lacking.

Lowenstam's (1955) discovery of alga-secreted aragonite needles established an important endemic biogenic source of carbonate fines. Acicular crystals of aragonite, about 2 to 9 microns in length, are produced in large numbers by species in the Codiaceae, Dasycladaceae, Nemalionaceae, and Chaetangiaceae. Fine-grained sediments from Bermuda, Jamaica, Kayangle Atoll, Johnston Island, Guam, Ifalik, Eniwetok, and Bikini were found to contain such needles (Lowenstam and Epstein, 1957) and Lowenstam (1955) predicted that quiet water sediments in equatorial regions should carry them wherever the algae are present. Stockman *et al.*, (1967) attribute most of the lime mud in the south Florida area to the skeletal disintegration of calcareous algae.

Although experimental destruction of large invertebrate skeletons by boring organisms and abrasion tend to demonstrate the difficulty in comminuting shells to very fine particle sizes (Driscoll, 1970), it appears that physical and mechanical breakdown is an important mechanism of mud formation in some areas. Matthews (1966) described lime muds of British Honduras which contain both calcite and aragonite but are virtually devoid of aragonite needles. His analyses indicate that mechanical comminution in shoal waters and breakage of fragile mollusc and hyaline foraminifera skeletons in the lagoon are important processes in the production of these muds. Other significant mechanisms include mastication by echinoids and holothurians, and trituration of carbonates by scarid, chaetodontid, acanthurid, and pomacentrid fish (Cloud, 1952). Land (1970) reports that appreciable quantities of carbonate mud may be produced by epibiotic growth of coralline red algae and serpulid worms on the turtle grass *Thalassia.*

At Tarawa, lime muds are presently accumulating in the extreme southeastern corner of the lagoon in relatively shallow water (6-10 m). These sediments are cream to very light green in color, are extremely plastic, and poorly consolidated. The unusually soft bottom created minor sampling problems in that the sediment grab, which is triggered on contact, would not always "fire". Despite replicated sampling of this area, heart urchins *(Brissopsis* and *Maretia ?)* and sand dollars *(Laganum* sp.) were the only living macrobenthos recovered. The two spatangoids were considerably more abundant than *Laganum,* and the significant concentrations of echinoderm skeletal debris in these sediments indicate that heart urchins are an important *in situ* source of carbonate (Fig. 6).

Up to 80% of the material in the eastern lagoon is found in the $<$0.074mm size fraction, and examination by both electron microscopy and scanning electron microscopy indicates that the bulk of the fines actually lies in the particle size range of 1 to 10 microns. Although needles, presumably aragonite (Fig. 9) are not uncommon, electron photomicrographs show a variety of grain shapes including fragments of laths and needles, platy and tabular forms, and nondescript particles. Between 60 and 75% of the carbonate and mud consists of aragonite. Low-magnesium calcite amounts to 4-8%, and high-magnesium calcite accounts for the remainder.

In much of Tarawa Lagoon, the water is turbid, and this is especially true in the region of lime mud accumulation where underwater visibility is limited to a few feet. The abundance of carbonate fines, the shallowness of the water, and the high degree of turbidity suggest the possibility of inorganic precipitation, although like the "whitings" in the Bahamas (Broecker and Takahashi, 1966), the turbidity is probably due to the suspension and resuspension of previously formed carbonate rather than *in situ* precipitation by inorganic mechanisms. Nevertheless, carbon and oxygen stable isotope ratio data were obtained to examine this possibility.

The isotopic composition of the "J" size fraction ($<$0.078mm) was determined for four samples in the area of lime mud deposition. $\delta 13_C$ and $\delta 18_O$ values, with respect to the PDB $CO_2$ standard,* are:

| | $\delta 13_C$ ‰ | $\delta 18_O$ ‰ |
|---|---|---|
| TA-8 | + 1.95 | - 2.53 |
| TA-9 | + 1.70 | - 2.77 |
| TA-10 | + 1.86 | - 2.55 |
| TA-12 | + 1.53 | - 2.79 |

Admittedly the J size fraction is a mixture of aragonite, HMC, and LMC, each of which may have a different isotopic composition. A plot of $\delta 13_C$ and $\delta 18_O$ *vs.* mineralogy, however, indicated no correlation. The average $\delta 18_O$ for the four lime muds in -2.66 ‰, which corresponds to a crystallization temperature of 28.9° C using the "paleotemperature" equation of Epstein *et al.* (1953) and assuming precipitation of the carbonate in oxygen isotopic equilibrium. The $18_O$ content of the ambient seawater also enters into this equation, and since this was not determined, specimens of calcareous coelenterates which precipitate skeletal $CaCO_3$ in apparent oxygen isotopic equilibrium with surrounding seawater (Weber and Woodhead, 1970) were analyzed: *Millepora* (N = 16), *Tubipora* (5), and *Heliopora* (13). The average $\delta 18_O$ of these 34 specimens is -2.29 (standard deviation 0.17 ‰) which corresponds to a calculated crystallization temperature of 27.1°C. The mean annual temperature of surface seawater at Tarawa, as obtained from monthly temperature distribution maps of the central Pacific, is 28.1°C.

While the oxygen isotope ratios are similar to those predicted for inorganically precipitated carbonate, $\delta 13_C$ data for the lime muds are several permil lower than the theoretical values, and are in the range of carbon isotopic compositions typical of biogenic carbonates. The presence of HMC and LMC in addition to aragonite further suggests that the lime muds in Tarawa Lagoon are derived from the breakdown of skeletal detritus. It is noteworthy that while the occurrence of aragonite needles is indicated by electron microscopy, numerous other grain shapes are also evident. It appears likely that the fines are a mixture of algal needles and particles produced by attrition of larger skeletal debris. On atolls, fine-grained carbonate is generally found to be accumulating only in the deepest portions of the lagoon, e.g. between 50 and 80 m at Kapingamarangi (McKee *et al.* 1959). According to McKee *et al.* a "shallow-water environment favorable for such fine-grained deposits has not been reported from any of the Pacific atolls". Tarawa, however, has extensive deposits of carbonate mud which are accumulating in shallow water. This can be attributed to protection of the sediment from current winnowing, which in turn results from the near absence of deep channels connecting lagoon and ocean, and the windbreak provided by the reef islands.

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*Using the well known $\delta$ notation, where:

$$\delta C^{13} = \left(\frac{C^{13}/C^{12}_{sample} - C^{13}/C^{12}_{standard}}{C^{13}/C^{12}_{standard}}\right) 1000$$

in per mil, relative to the PDB standard $CO_2$.

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TABLE 1: SIZE DISTRIBUTION STATISTICS

| Sample | Depth(m) | Md | So | Sk |
|---|---|---|---|---|
| TA - 1 | 13 | 0.45 | 1.94 | 0.94 |
| 2 | 12.5 | 0.33 | 2.64 | 0.84 |
| 3 | 12.5 | 0.34 | 2.05 | 0.82 |
| 4 | 16 | 0.13 | 2.98 | 1.06 |
| 5 | 14 | 0.17 | 2.01 | 1.24 |
| 6 | 14.5 | 0.062 | 2.45 | 0.62 |
| 7 | 10 | 0.028 | 4.14 | 1.40 |
| 8 | 9 | 0.009 | 8.49 | 0.89 |
| 9 | 6 | 0.080 | 2.07 | 1.68 |
| 10 | 5 | 0.090 | 1.29 | 0.74 |
| 11 | 7 | 0.12 | 1.79 | 1.08 |
| 12 | 9.5 | 0.010 | 3.16 | 6.40 |
| 13 | 10 | 0.19 | 1.92 | 0.98 |
| 14 | 8 | 0.20 | 2.15 | 1.15 |
| 15 | 10 | 0.27 | 2.95 | 1.01 |
| 16 | 18.5 | 0.30 | 2.15 | 0.87 |
| 17 | 21 | 0.22 | 2.17 | 0.97 |
| 18 | 16 | 0.23 | 1.95 | 0.87 |
| 19 | 11.5 | 0.35 | 1.95 | 1.12 |
| 20 | 8 | 0.46 | 2.01 | 1.01 |
| 21 | 9.5 | 0.22 | 2.70 | 0.92 |
| 22 | 0. | 2.10 | 1.55 | 0.85 |
| 23 | 6.5 | 0.63 | 2.03 | 0.88 |
| 24 | 8.5 | 0.53 | 2.14 | 0.72 |
| 25 | 20.5 | 0.37 | 2.45 | 0.82 |

table 1 (continued)

| | | | | |
|---|---|---|---|---|
| TA- 26 | 8 | 0.63 | 1.80 | 1.12 |
| 27 | 8 | 0.71 | 1.54 | 0.92 |
| 28 | 9.5 | 0.90 | 1.58 | 1.11 |
| 29 | 8 | 0.87 | 1.70 | 0.96 |
| 30 | 13 | 0.80 | 1.79 | 0.89 |
| 31 | 10.5 | 0.63 | 1.73 | 0.98 |
| 32 | 21.5 | 0.50 | 1.46 | 1.09 |
| 33 | 9 | 0.56 | 2.27 | 0.84 |
| 34 | 22.5 | 0.16 | 1.76 | 1.38 |
| 35 | 15.5 | 0.53 | 2.52 | 0.90 |
| 36 | 10 | 0.36 | 2.60 | 0.69 |
| 37 | 10 | 0.35 | 2.50 | 0.86 |
| 38 | 5 | 1.20 | 2.07 | 1.18 |
| 39 | 10.5 | 0.72 | 2.05 | 0.78 |
| 40 | 18.5 | 0.68 | 1.83 | 0.78 |
| 42 | 19.5 | 0.73 | 2.45 | 0.70 |
| 43 | 18.5 | 0.30 | 2.83 | 1.08 |
| 44 | 13 | 0.76 | 1.89 | 0.95 |
| 45 | 12.5 | 0.46 | 2.75 | 0.97 |
| 46 | 7 | 0.22 | 2.45 | 1.31 |
| 47 | 8 | 0.24 | 2.84 | 0.75 |
| 48 | 6 | 0.63 | 2.08 | 0.91 |
| 49 | 12.5 | 0.39 | 2.95 | 0.76 |
| 50 | 12 | 0.57 | 1.88 | 0.74 |
| 51 | 19 | 0.70 | 1.84 | 0.71 |
| 52 | 17 | 0.35 | 2.67 | 0.99 |
| 53 | 6 | 0.82 | 1.62 | 1.05 |

table 1 (continued)

| | | | | |
|---|---|---|---|---|
| TA- 54 | 5.5 | 0.52 | 1.82 | 1.03 |
| 55 | 4.5 | 0.53 | 1.63 | 1.29 |
| 56 | 4 | 0.63 | 2.10 | 0.87 |
| 57 | 1.5 | 0.22 | 2.77 | 1.17 |
| BL- 1 | | 0.40 | 1.82 | 1.09 |
| 2 | | 0.47 | 1.88 | 1.00 |
| 3 | | 0.57 | 2.06 | 0.96 |
| 4 | | 0.67 | 1.93 | 0.70 |
| 5 | | 0.42 | 1.73 | 1.15 |
| 6 | | 0.32 | 1.31 | 1.05 |
| BO- 1 | | 0.84 | 1.35 | 0.99 |
| 2 | | 1.00 | 1.83 | 1.08 |
| 3 | | 1.40 | - | - |
| 4 | | 0.53 | 1.69 | 1.45 |
| 5 | | 1.80 | 2.50 | 0.60 |
| 6 | | 1.48 | 2.98 | 0.53 |

All TA samples are from Tarawa Lagoon except TA-22 which is beach sediment from Bairiki Island. BL = lagoonal reef flat at Bikenibeu Is.; BO = ocean reef flat a Bikenibeu Is.; Md = median diameter in mm; <u>So</u> = Trask sorting coefficient; <u>Sk</u> = Trask coefficient of skewness.

TABLE 2: MINERALOGICAL COMPOSITION OF SIZE FRACTIONS *

| | | A | B | C | D | E | F | G | H | I | J | Av. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TA-1 | A | 87 | 89 | 86 | 83 | 86 | 83 | 80 | 78 | 77 | 68 | 85 |
| | HMC | 10 | 9 | 12 | 15 | 13 | 14 | 17 | 20 | 19 | 28 | 13 |
| | LMC | 3 | 2 | 2 | 2 | 1 | 3 | 3 | 2 | 4 | 4 | 2 |
| TA-2 | A | 88 | 89 | 90 | 91 | 88 | 86 | 88 | 81 | 78 | 79 | 87 |
| | HMC | 9 | 7 | 7 | 7 | 9 | 11 | 9 | 14 | 17 | 17 | 10 |
| | LMC | 3 | 4 | 3 | 2 | 3 | 3 | 3 | 5 | 5 | 4 | 3 |
| TA-3 | A | 89 | 89 | 89 | 88 | 91 | 86 | 86 | 84 | 79 | 78 | 87 |
| | HMC | 7 | 7 | 8 | 9 | 7 | 12 | 11 | 12 | 16 | 18 | 10 |
| | LMC | 4 | 4 | 3 | 3 | 2 | 2 | 3 | 4 | 5 | 4 | 3 |
| TA-4 | A | 84 | 87 | 90 | 90 | 89 | 88 | 82 | 82 | 76 | 76 | 83 |
| | HMC | 13 | 9 | 7 | 8 | 8 | 8 | 14 | 15 | 18 | 18 | 13 |
| | LMC | 3 | 4 | 3 | 2 | 3 | 4 | 4 | 3 | 6 | 6 | 4 |
| TA-5 | A | 83 | 89 | 86 | 94 | 91 | 83 | 87 | 82 | 83 | 75 | 85 |
| | HMC | 14 | 7 | 10 | 4 | 6 | 13 | 9 | 14 | 13 | 19 | 11 |
| | LMC | 3 | 4 | 4 | 2 | 3 | 4 | 4 | 4 | 4 | 6 | 4 |
| TA-6 | A | 76 | 76 | 76 | 88 | 95 | 96 | 94 | 86 | 76 | 73 | 77 |
| | HMC | 20 | 8 | 5 | 9 | 4 | 3 | 5 | 10 | 16 | 19 | 15 |
| | LMC | 4 | 16 | 19 | 3 | 1 | 1 | 1 | 4 | 8 | 8 | 8 |
| TA-7 | A | 73 | 69 | 87 | 77 | 83 | 84 | 84 | 77 | 75 | 70 | 72 |
| | HMC | 25 | 25 | 9 | 17 | 14 | 11 | 11 | 17 | 19 | 23 | 22 |
| | LMC | 2 | 6 | 4 | 6 | 3 | 5 | 5 | 6 | 6 | 7 | 6 |
| TA-8 | A | 73 | 71 | 72 | 78 | 74 | 85 | - | - | - | 64 | 66 |
| | HMC | 20 | 24 | 23 | 17 | 25 | 11 | - | - | - | 29 | 27 |
| | LMC | 7 | 5 | 5 | 5 | 1 | 4 | - | - | - | 7 | 7 |

table 2 (continued)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TA-9 | A | 79 | 79 | 84 | 84 | 83 | 81 | 76 | 72 | 68 | 63 | 71 |
| | HMC | 16 | 15 | 13 | 14 | 14 | 18 | 19 | 24 | 28 | 32 | 25 |
| | LMC | 5 | 6 | 3 | 2 | 3 | 1 | 5 | 4 | 4 | 5 | 4 |
| TA-10 | A | 66 | 74 | 78 | 79 | 68 | 62 | 62 | 65 | 58 | 67 | 66 |
| | HMC | 33 | 23 | 19 | 20 | 31 | 37 | 37 | 34 | 39 | 29 | 31 |
| | LMC | 1 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 4 | 3 |
| TA-11 | A | 80 | 83 | 85 | 84 | 83 | 75 | 78 | 76 | 74 | 74 | 78 |
| | HMC | 17 | 14 | 13 | 13 | 14 | 21 | 19 | 19 | 20 | 21 | 18 |
| | LMC | 3 | 3 | 2 | 3 | 3 | 4 | 3 | 5 | 6 | 5 | 4 |
| TA-12 | A | 84 | 85 | 93 | 85 | 88 | 83 | 77 | 74 | 73 | 71 | 75 |
| | HMC | 13 | 10 | 6 | 12 | 9 | 13 | 19 | 22 | 22 | 22 | 19 |
| | LMC | 3 | 5 | 1 | 3 | 3 | 4 | 4 | 4 | 5 | 7 | 6 |
| TA-13 | A | 83 | 89 | 92 | 93 | 89 | 87 | 88 | 78 | 81 | 78 | 87 |
| | HMC | 15 | 9 | 7 | 6 | 9 | 11 | 10 | 16 | 16 | 19 | 11 |
| | LMC | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 6 | 3 | 3 | 2 |
| TA-14 | A | 81 | 84 | 88 | 84 | 81 | 79 | 78 | 71 | 72 | 70 | 79 |
| | HMC | 18 | 13 | 11 | 15 | 17 | 19 | 19 | 24 | 24 | 26 | 18 |
| | LMC | 1 | 3 | 1 | 1 | 2 | 2 | 3 | 5 | 4 | 4 | 3 |
| TA-15 | A | 75 | 73 | 82 | 81 | 78 | 74 | 73 | 72 | 70 | 75 | 76 |
| | HMC | 24 | 22 | 16 | 18 | 19 | 23 | 26 | 24 | 24 | 21 | 21 |
| | LMC | 1 | 5 | 2 | 1 | 3 | 3 | 1 | 4 | 6 | 4 | 3 |
| TA-16 | A | 89 | 84 | 89 | 89 | 85 | 81 | 80 | 79 | 82 | 77 | 85 |
| | HMC | 9 | 13 | 9 | 9 | 12 | 15 | 17 | 16 | 17 | 18 | 12 |
| | LMC | 2 | 3 | 2 | 2 | 3 | 4 | 3 | 5 | 1 | 5 | 3 |

table 2 (continued)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TA-17 | A | 86 | 86 | 84 | 83 | 82 | 75 | 78 | 72 | 75 | 69 | 79 |
| | HMC | 11 | 11 | 13 | 13 | 14 | 18 | 17 | 23 | 18 | 24 | 16 |
| | LMC | 3 | 3 | 3 | 4 | 4 | 7 | 5 | 5 | 7 | 7 | 5 |
| TA-18 | A | 84 | 88 | 88 | 88 | 86 | 83 | 79 | 76 | 74 | 77 | 84 |
| | HMC | 14 | 9 | 9 | 10 | 11 | 16 | 20 | 19 | 24 | 18 | 13 |
| | LMC | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 5 | 2 | 5 | 3 |
| TA-19 | A | 83 | 80 | 90 | 85 | 81 | 82 | 82 | 76 | 81 | 77 | 83 |
| | HMC | 14 | 18 | 8 | 12 | 16 | 16 | 17 | 20 | 15 | 18 | 14 |
| | LMC | 3 | 2 | 2 | 3 | 3 | 2 | 1 | 4 | 4 | 5 | 3 |
| TA-20 | A | 86 | 88 | 90 | 87 | 89 | 85 | 82 | 84 | 81 | 81 | 87 |
| | HMC | 9 | 10 | 8 | 11 | 10 | 12 | 16 | 13 | 16 | 14 | 10 |
| | LMC | 5 | 2 | 2 | 2 | 1 | 3 | 2 | 3 | 3 | 5 | 3 |
| TA-21 | A | 76 | 80 | 89 | 85 | 71 | 77 | 77 | 80 | 79 | 80 | 81 |
| | HMC | 23 | 16 | 10 | 13 | 27 | 19 | 21 | 17 | 17 | 16 | 16 |
| | LMC | 1 | 4 | 1 | 2 | 2 | 4 | 2 | 3 | 4 | 4 | 3 |
| TA-22 | A | 19 | 11 | 31 | 34 | 31 | 27 | 35 | 44 | 57 | 50 | 18 |
| | HMC | 81 | 89 | 69 | 66 | 69 | 72 | 63 | 56 | 43 | 49 | 82 |
| | LMC | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 0 |
| TA-23 | A | 80 | 82 | 89 | 89 | 85 | 83 | 84 | 85 | 79 | 82 | 84 |
| | HMC | 17 | 16 | 9 | 9 | 13 | 15 | 14 | 13 | 17 | 13 | 14 |
| | LMC | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 5 | 2 |
| TA-24 | A | 71 | 89 | 92 | 90 | 87 | 85 | 82 | 83 | 79 | 76 | 86 |
| | HMC | 27 | 9 | 7 | 9 | 11 | 14 | 15 | 14 | 16 | 20 | 12 |
| | LMC | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 5 | 4 | 2 |

table 2 (continued)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TA-25 | A | 75 | 72 | 83 | 81 | 76 | 78 | 78 | 75 | 75 | 77 | 77 |
| | HMC | 24 | 19 | 14 | 15 | 19 | 18 | 18 | 20 | 20 | 19 | 18 |
| | LMC | 1 | 9 | 3 | 4 | 5 | 4 | 4 | 5 | 5 | 4 | 5 |
| TA-26 | A | 92 | 90 | 94 | 94 | 93 | 89 | 81 | 90 | 89 | 81 | 92 |
| | HMC | 7 | 9 | 5 | 5 | 6 | 10 | 18 | 9 | 9 | 16 | 7 |
| | LMC | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 1 |
| TA-27 | A | 74 | 80 | 84 | 88 | 90 | 91 | 90 | - | - | - | 82 |
| | HMC | 23 | 17 | 14 | 11 | 9 | 8 | 9 | - | - | - | 16 |
| | LMC | 3 | 3 | 2 | 1 | 1 | 1 | 1 | - | - | - | 2 |
| TA-28 | A | 66 | 56 | 78 | 84 | 86 | 82 | - | - | - | - | 65 |
| | HMC | 32 | 13 | 16 | 13 | 11 | 14 | - | - | - | - | 18 |
| | LMC | 2 | 31 | 6 | 3 | 3 | 4 | - | - | - | - | 17 |
| TA-29 | A | 78 | 78 | 83 | 89 | 92 | 91 | 88 | 87 | 82 | 77 | 81 |
| | HMC | 20 | 15 | 13 | 9 | 7 | 7 | 10 | 11 | 14 | 19 | 15 |
| | LMC | 2 | 7 | 4 | 2 | 1 | 2 | 2 | 2 | 4 | 4 | 4 |
| TA-30 | A | 83 | 89 | 91 | 91 | 89 | 87 | 88 | 86 | 84 | 72 | 88 |
| | HMC | 14 | 9 | 7 | 8 | 10 | 11 | 11 | 12 | 13 | 22 | 10 |
| | LMC | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 3 | 6 | 2 |
| TA-31 | A | 79 | 82 | 91 | 88 | 92 | 88 | 89 | 86 | 82 | 76 | 86 |
| | HMC | 17 | 12 | 8 | 10 | 6 | 9 | 9 | 13 | 14 | 18 | 11 |
| | LMC | 4 | 6 | 1 | 2 | 2 | 3 | 2 | 1 | 4 | 6 | 3 |
| TA-32 | A | 77 | 72 | 81 | 75 | 73 | 70 | 70 | 78 | 79 | 80 | 76 |
| | HMC | 18 | 22 | 15 | 19 | 20 | 24 | 25 | 17 | 16 | 16 | 19 |
| | LMC | 5 | 6 | 4 | 6 | 7 | 6 | 5 | 5 | 5 | 4 | 5 |

table 2 (continued)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TA-33 | A | 88 | 88 | 90 | 92 | 84 | 82 | 77 | 77 | 77 | 62 | 86 |
| | HMC | 9 | 9 | 8 | 6 | 12 | 14 | 19 | 19 | 19 | 33 | 11 |
| | LMC | 3 | 3 | 2 | 2 | 4 | 4 | 4 | 4 | 4 | 5 | 3 |
| TA-34 | A | 82 | 76 | 85 | 79 | 74 | 76 | 72 | 74 | 77 | 81 | 77 |
| | HMC | 16 | 19 | 12 | 17 | 20 | 20 | 22 | 21 | 18 | 12 | 18 |
| | LMC | 2 | 5 | 3 | 4 | 6 | 4 | 6 | 5 | 5 | 7 | 5 |
| TA-35 | A | 91 | 90 | 88 | 85 | 82 | 73 | 79 | 77 | 64 | 73 | 86 |
| | HMC | 7 | 8 | 10 | 12 | 15 | 24 | 17 | 17 | 30 | 22 | 11 |
| | LMC | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 6 | 6 | 5 | 3 |
| TA-36 | A | 88 | 85 | 84 | 85 | 83 | 79 | 77 | 75 | 75 | 74 | 82 |
| | HMC | 10 | 12 | 14 | 13 | 14 | 18 | 20 | 22 | 22 | 23 | 15 |
| | LMC | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| TA-37 | A | 87 | 84 | 88 | 88 | 86 | 83 | 79 | 80 | 76 | 76 | 84 |
| | HMC | 11 | 11 | 9 | 11 | 12 | 15 | 19 | 18 | 21 | 20 | 13 |
| | LMC | 2 | 5 | 3 | 1 | 2 | 2 | 2 | 2 | 3 | 4 | 3 |
| TA-38 | A | 87 | 89 | 98 | 98 | 94 | 92 | 91 | 89 | 83 | 82 | 90 |
| | HMC | 12 | 10 | 2 | 2 | 6 | 8 | 8 | 10 | 14 | 11 | 9 |
| | LMC | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 2 | 1 |
| TA-39 | A | 59 | 55 | 74 | 84 | 87 | 90 | 85 | - | - | - | 66 |
| | HMC | 34 | 16 | 19 | 12 | 10 | 8 | 13 | - | - | - | 20 |
| | LMC | 7 | 29 | 7 | 4 | 3 | 2 | 2 | - | - | - | 14 |
| TA-40 | A | 79 | 57 | 85 | 88 | 83 | 84 | 84 | 85 | 84 | 74 | 73 |
| | HMC | 18 | 25 | 12 | 10 | 14 | 13 | 12 | 12 | 12 | 20 | 18 |
| | LMC | 3 | 18 | 3 | 2 | 3 | 3 | 4 | 3 | 4 | 6 | 9 |

**table 2 (continued)**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TA-42** | **A** | 89 | 79 | 83 | 83 | 77 | 73 | 70 | 68 | 78 | 78 | 82 |
| | **HMC** | 10 | 16 | 14 | 13 | 18 | 21 | 24 | 25 | 17 | 18 | 15 |
| | **LMC** | 1 | 5 | 3 | 4 | 5 | 6 | 6 | 7 | 5 | 4 | 3 |
| **TA-43** | **A** | 88 | 81 | 79 | 81 | 76 | 71 | 73 | 69 | 75 | 68 | 77 |
| | **HMC** | 11 | 16 | 15 | 15 | 19 | 23 | 25 | 25 | 22 | 27 | 19 |
| | **LMC** | 1 | 3 | 6 | 4 | 5 | 6 | 2 | 6 | 3 | 5 | 4 |
| **TA-44** | **A** | 89 | 79 | 88 | 89 | 82 | 83 | 81 | 77 | 80 | 83 | 84 |
| | **HMC** | 7 | 17 | 9 | 9 | 15 | 15 | 16 | 18 | 16 | 13 | 12 |
| | **LMC** | 4 | 4 | 3 | 2 | 3 | 2 | 3 | 5 | 4 | 4 | 4 |
| **TA-45** | **A** | 89 | 83 | 82 | 79 | 80 | 75 | 76 | 75 | 77 | 76 | 82 |
| | **HMC** | 9 | 13 | 15 | 17 | 16 | 22 | 20 | 21 | 18 | 18 | 15 |
| | **LMC** | 2 | 4 | 3 | 4 | 4 | 3 | 4 | 4 | 5 | 6 | 3 |
| **TA-46** | **A** | 84 | 84 | 83 | 82 | 75 | 75 | 77 | 76 | 78 | 73 | 79 |
| | **HMC** | 12 | 13 | 11 | 15 | 20 | 23 | 20 | 20 | 21 | 23 | 17 |
| | **LMC** | 4 | 3 | 6 | 3 | 5 | 2 | 3 | 4 | 1 | 4 | 4 |
| **TA-47** | **A** | 80 | 78 | 81 | 83 | 78 | 76 | 75 | 72 | 72 | 75 | 78 |
| | **HMC** | 17 | 20 | 17 | 15 | 20 | 21 | 22 | 27 | 24 | 21 | 20 |
| | **LMC** | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 1 | 4 | 4 | 2 |
| **TA-48** | **A** | 85 | 90 | 92 | 93 | 91 | 91 | 90 | 85 | 83 | 71 | 89 |
| | **HMC** | 8 | 7 | 6 | 5 | 7 | 7 | 8 | 12 | 14 | 23 | 7 |
| | **LMC** | 7 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 6 | 4 |
| **TA-49** | **A** | 87 | 84 | 84 | 84 | 83 | 79 | 78 | 77 | 77 | 78 | 83 |
| | **HMC** | 10 | 13 | 12 | 13 | 14 | 17 | 18 | 21 | 18 | 18 | 14 |
| | **LMC** | 3 | 3 | 4 | 3 | 3 | 4 | 4 | 2 | 5 | 4 | 3 |

table 2 (continued)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TA-50 | A | 88 | 79 | 87 | 84 | 79 | 75 | 75 | 75 | 74 | 73 | 81 |
| | HMC | 10 | 18 | 12 | 14 | 18 | 22 | 22 | 22 | 23 | 21 | 16 |
| | LMC | 2 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 6 | 3 |
| TA-51 | A | 89 | 80 | 88 | 86 | 85 | 81 | 79 | 78 | 75 | 79 | 83 |
| | HMC | 9 | 17 | 10 | 12 | 13 | 17 | 18 | 18 | 21 | 18 | 14 |
| | LMC | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 4 | 4 | 3 | 3 |
| TA-52 | A | 69 | 84 | 87 | 88 | 87 | 83 | 79 | 77 | 77 | 79 | 82 |
| | HMC | 26 | 14 | 11 | 11 | 12 | 14 | 18 | 22 | 20 | 19 | 16 |
| | LMC | 5 | 2 | 2 | 1 | 1 | 3 | 3 | 1 | 3 | 2 | 2 |
| TA-53 | A | 86 | 83 | 92 | 91 | 84 | 83 | 81 | 76 | 79 | 73 | 86 |
| | HMC | 13 | 15 | 7 | 9 | 15 | 17 | 19 | 24 | 19 | 24 | 13 |
| | LMC | 1 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 3 | 1 |
| TA-54 | A | 84 | 76 | 91 | 89 | 84 | 84 | 80 | 79 | 85 | 79 | 84 |
| | HMC | 14 | 19 | 8 | 10 | 16 | 16 | 18 | 21 | 13 | 18 | 14 |
| | LMC | 2 | 5 | 1 | 1 | 0 | 0 | 2 | 0 | 2 | 3 | 2 |
| TA-55 | A | 85 | 67 | 77 | 74 | 83 | 79 | 79 | 76 | 78 | 75 | 75 |
| | HMC | 13 | 33 | 21 | 24 | 16 | 19 | 20 | 21 | 20 | 21 | 24 |
| | LMC | 2 | 0 | 2 | 2 | 1 | 2 | 1 | 3 | 2 | 4 | 1 |
| TA-56 | A | 75 | 71 | 81 | 81 | 79 | 75 | 73 | 71 | 72 | 66 | 75 |
| | HMC | 24 | 27 | 19 | 17 | 19 | 23 | 26 | 28 | 26 | 29 | 23 |
| | LMC | 1 | 2 | 0 | 2 | 2 | 2 | 1 | 1 | 2 | 5 | 2 |
| TA-57 | A | 68 | 68 | 75 | 76 | 72 | 67 | 66 | 58 | 60 | 70 | 70 |
| | HMC | 31 | 29 | 24 | 22 | 27 | 31 | 33 | 39 | 37 | 27 | 28 |
| | LMC | 1 | 3 | 1 | 2 | 1 | 2 | 1 | 3 | 3 | 3 | 2 |

**table 2 (continued)**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BL-1 | A | 29 | 46 | 53 | 55 | 53 | 60 | 61 | 64 | 68 | 60 | 50 |
| | HMC | 70 | 53 | 47 | 44 | 46 | 39 | 38 | 35 | 31 | 38 | 49 |
| | LMC | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| BL-2 | A | 49 | 54 | 63 | 55 | 63 | 64 | 61 | 64 | 67 | 66 | 58 |
| | HMC | 48 | 46 | 35 | 45 | 36 | 35 | 36 | 35 | 31 | 32 | 41 |
| | LMC | 3 | 0 | 2 | 0 | 1 | 1 | 3 | 1 | 2 | 2 | 1 |
| BL-3 | A | 41 | 56 | 64 | 59 | 57 | 61 | 63 | 66 | 68 | 69 | 56 |
| | HMC | 57 | 43 | 36 | 41 | 42 | 37 | 36 | 34 | 32 | 31 | 43 |
| | LMC | 2 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 0 | 1 |
| BL-4 | A | 50 | 64 | 72 | 71 | 70 | 69 | 73 | 76 | 69 | 71 | 65 |
| | HMC | 49 | 32 | 27 | 28 | 29 | 31 | 26 | 23 | 30 | 27 | 33 |
| | LMC | 1 | 4 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 2 |
| BL-5 | A | 60 | 62 | 80 | 77 | 80 | 83 | 83 | 81 | 79 | 79 | 73 |
| | HMC | 39 | 34 | 19 | 22 | 19 | 17 | 16 | 19 | 20 | 18 | 25 |
| | LMC | 1 | 4 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 3 | 2 |
| BL-6 | A | 71 | 75 | 80 | 86 | 93 | 95 | 96 | 94 | 87 | 83 | 84 |
| | HMC | 20 | 22 | 19 | 14 | 7 | 5 | 4 | 6 | 12 | 13 | 15 |
| | LMC | 9 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 1 |
| BO-1 | A | 66 | 64 | 65 | 71 | 75 | 81 | - | - | - | - | 65 |
| | HMC | 34 | 36 | 35 | 29 | 25 | 19 | - | - | - | - | 35 |
| | LMC | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | - | 0 |
| BO-2 | A | 56 | 48 | 26 | 46 | 61 | 72 | 71 | - | - | - | 47 |
| | HMC | 44 | 52 | 74 | 54 | 39 | 28 | 29 | - | - | - | 53 |
| | LMC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | - | 0 |

table 2 (continued)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BO-3 | A | 55 | 14 | 10 | 21 | 39 | 67 | 71 | 60 | - | - | 53 |
| | HMC | 45 | 86 | 90 | 79 | 61 | 33 | 29 | 40 | - | - | 47 |
| | LMC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | 0 |
| BO-4 | A | 40 | 33 | 31 | 55 | 62 | 63 | 63 | 59 | 62 | 55 | 37 |
| | HMC | 60 | 67 | 69 | 45 | 37 | 36 | 37 | 41 | 37 | 45 | 63 |
| | LMC | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| BO-5 | A | 33 | 43 | 30 | 51 | 57 | 60 | 59 | 50 | 52 | 48 | 37 |
| | HMC | 67 | 57 | 70 | 49 | 43 | 39 | 40 | 50 | 48 | 51 | 63 |
| | LMC | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| BO-6 | A | 51 | 46 | 25 | 41 | 54 | 61 | 56 | 55 | - | - | 45 |
| | HMC | 49 | 54 | 75 | 59 | 46 | 39 | 44 | 45 | - | - | 55 |
| | LMC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | - | - | 0 |

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* mm range of size fractions specified in text. A = aragonite; HMC = high-magnesium calcite; LMC = low-magnesium calcite.

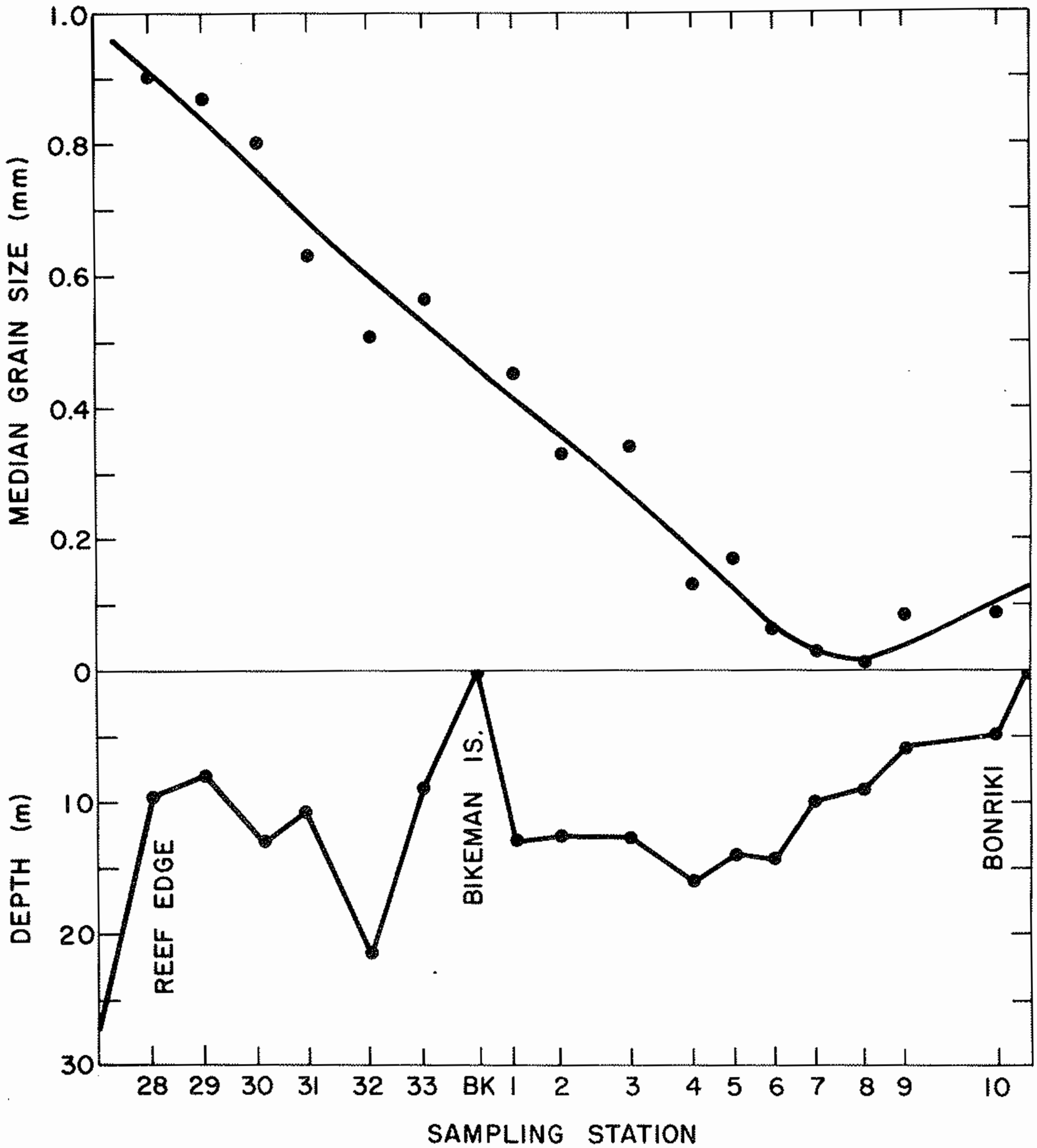


*Figure 2:* Median grain size of lagoonal sediments along the sampling traverse from Bonriki (eastern lagoon) to the western reef margin. Location of sampling stations given in Fig. 1.

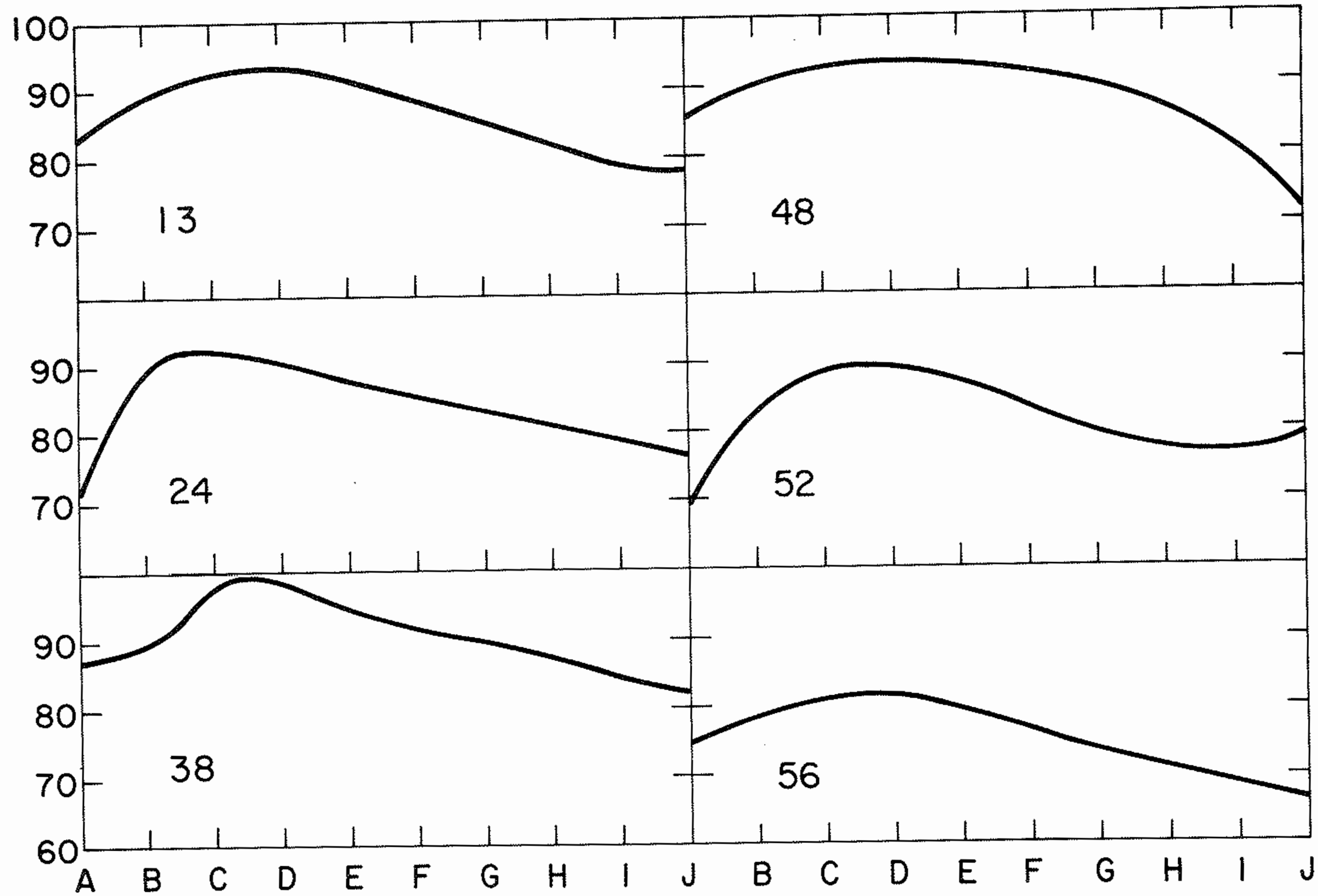


*Figure 3:* Mineralogical composition as a function of grain size for typical samples (number below curve corresponds to sampling station shown in Fig. 1). Curves represent the percentage of each grain size category that is aragonite. Grain size ranges corresponding to classes A and J are specified in text.

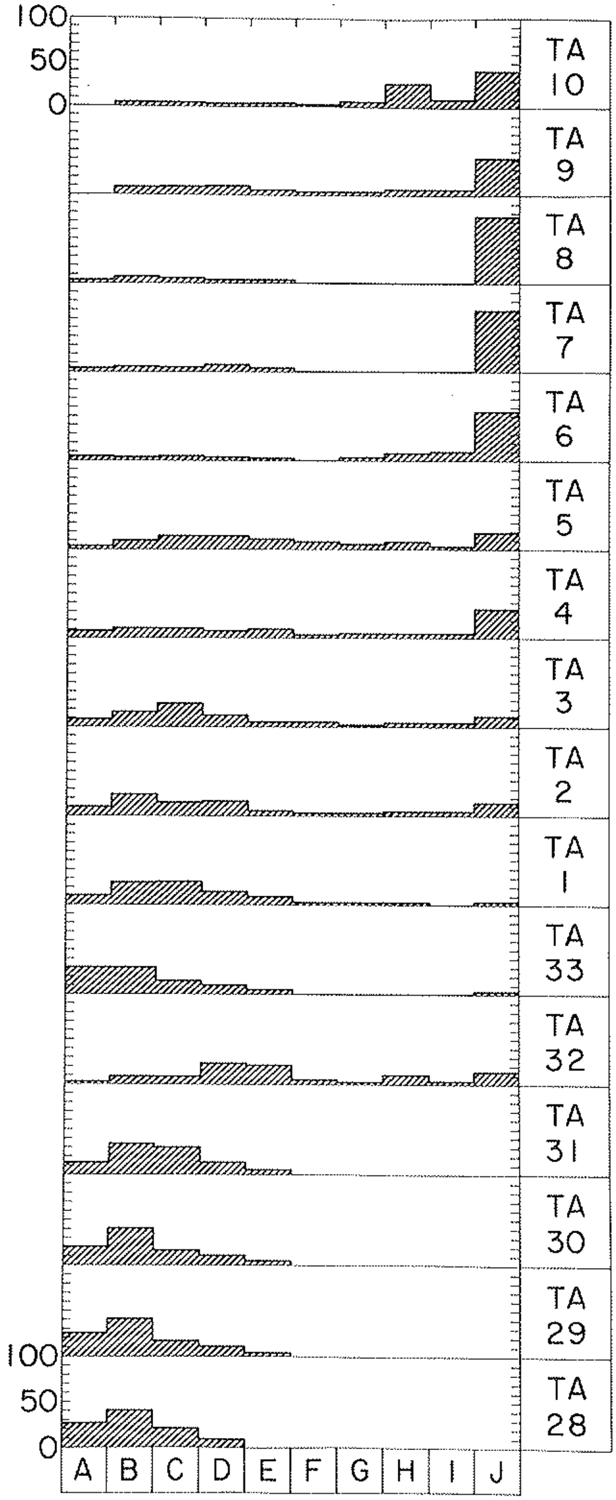


*Figure 4:* Distribution of total sample aragonite among grain size classes for sediment samples along the TA-10 (eastern lagoon) to TA-28 (western lagoonal reef margin) transect. The height of a column in a histogram indicates the percentage of the total sample aragonite that is in the grain size range designated by the corresponding alphabetic character (millimeter equivalents specified in text).

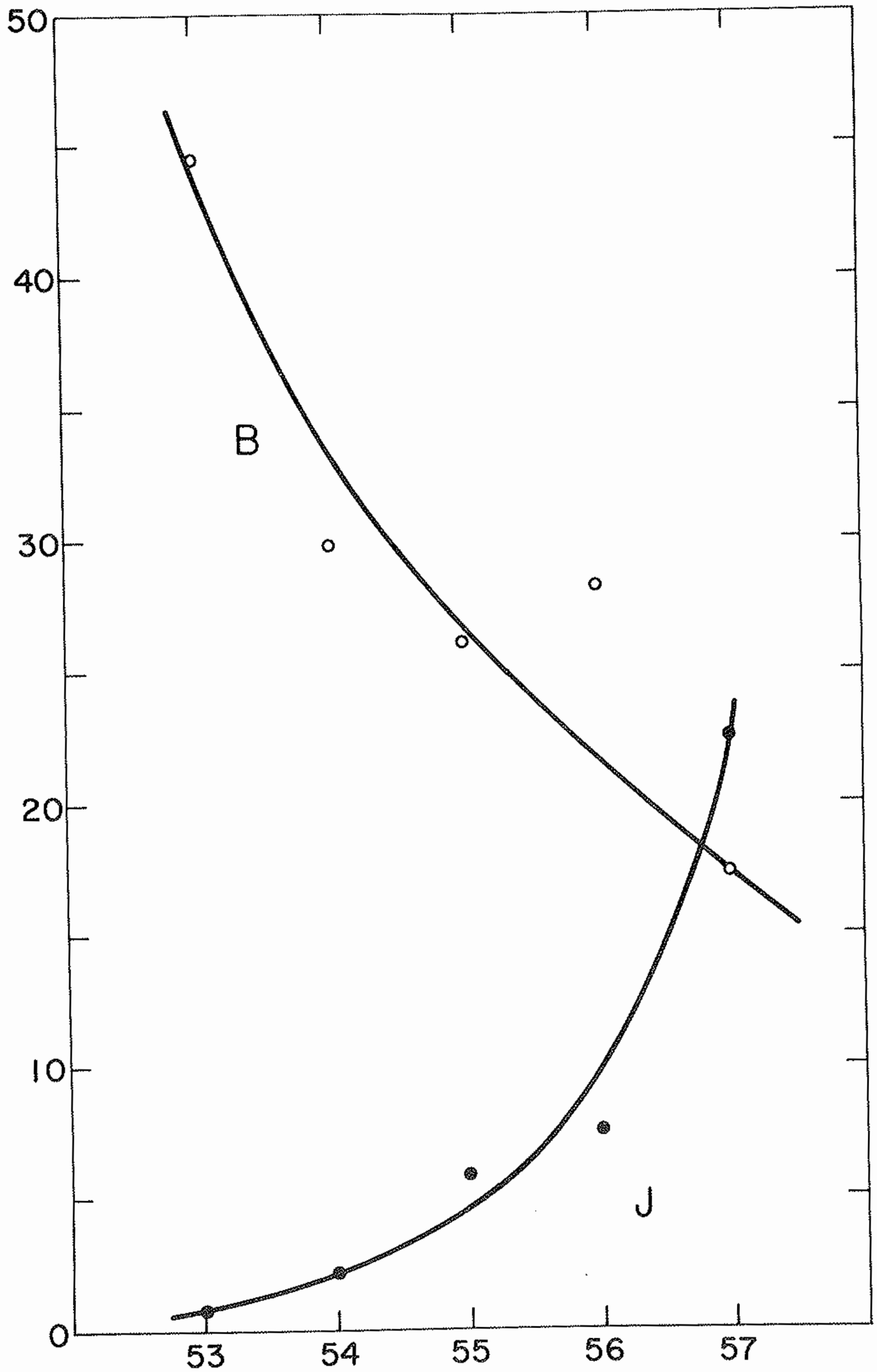


*Figure 5:* Systematic changes in the distribution of aragonite among grain size classes for sediments along the TA-53 to TA-57 transect in the northern corner of the lagoon (locations in Fig. 1). Curves B and J indicate the percentage of total sample aragonite that is in grain size classes B (coarse) and J (fine) respectively.

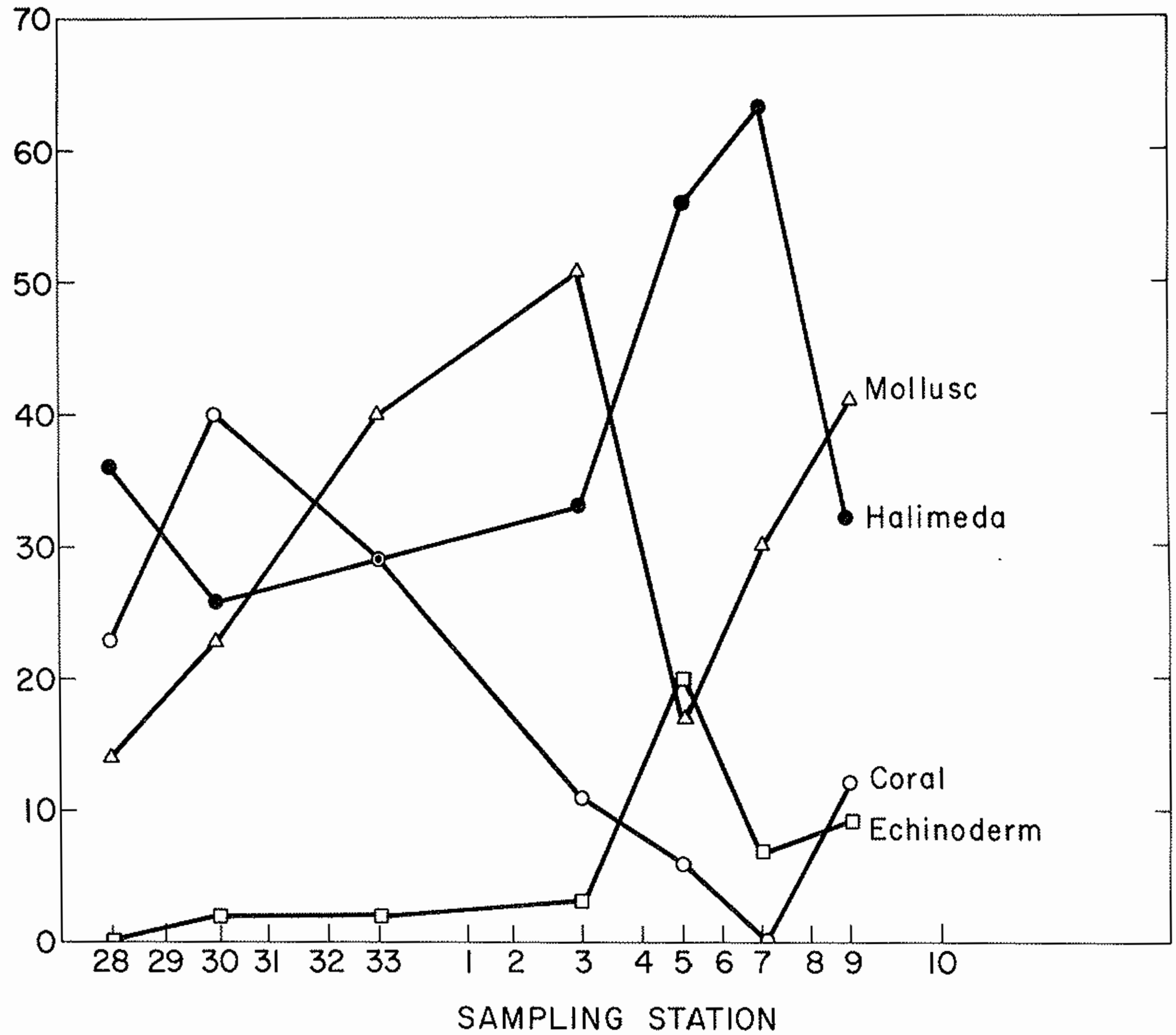


*Figure 6:* Percentage of four major components (>0.5mm grains) of the sediments in Tarawa Lagoon. Geographic locations of the sampling stations are shown in Fig. 1.

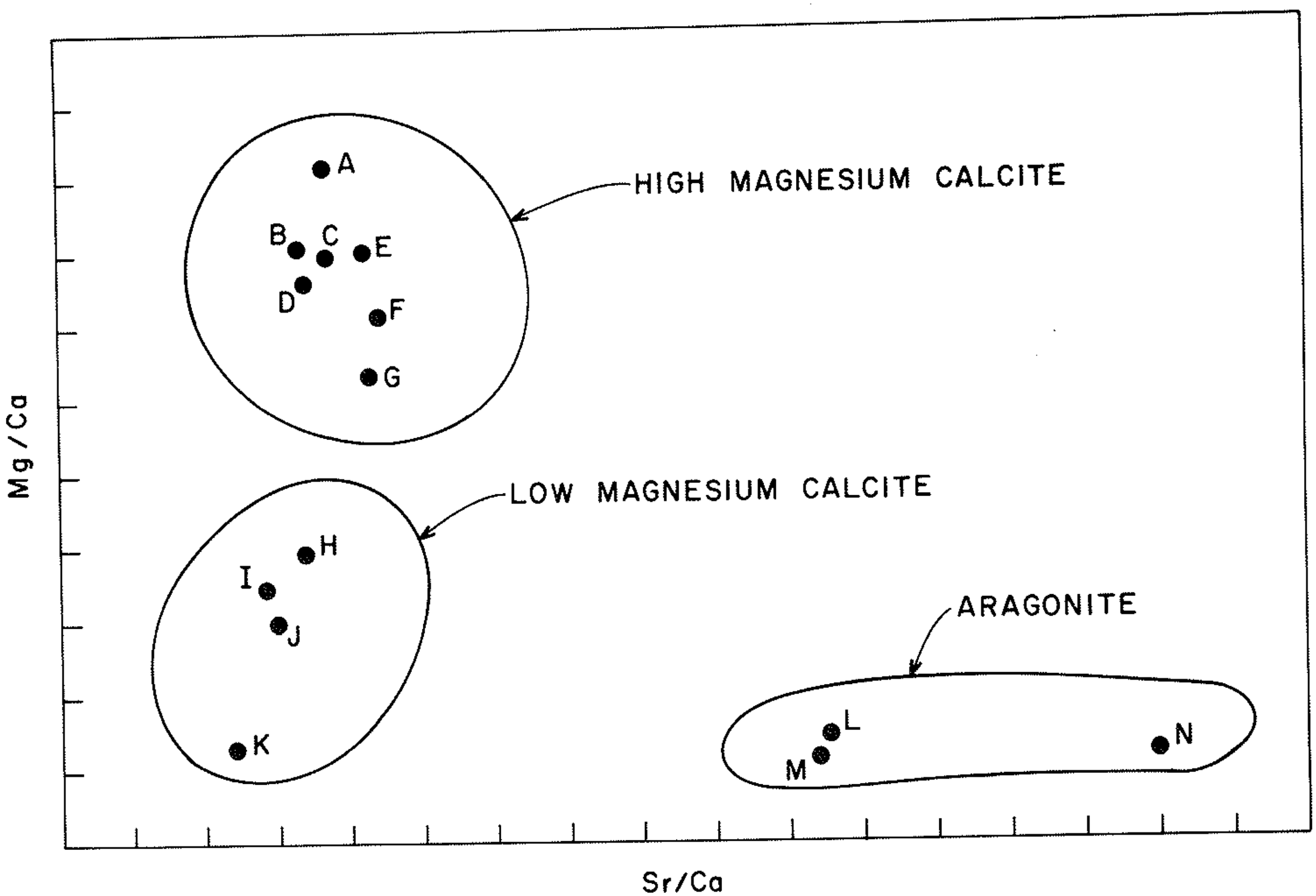


*Figure 7:* Mineralogy of sediment components determined by simultaneous analysis of Mg, Sr, and Ca by electron microprobe. - A (crinoid and ophiuroid ossicles), B *(Marginopora)*, C *(Calcarina)*, D (alcyonarian spicules), E *(Heterostegina)*, F *(Calcarina)*, G (echinoid coronal plates), H (echinoid spines, *Echinometra)*, I *(Amphistegina)*, J *(Amphistegina)*, K (mollusc fragment), L *(Halimeda)*, M *(Halimeda)*, N (coral debris). Mollusc and annelid detritus showed variable Mg/Ca and Sr/Ca ratios within single grains. All particles were extracted from sample TA-28.

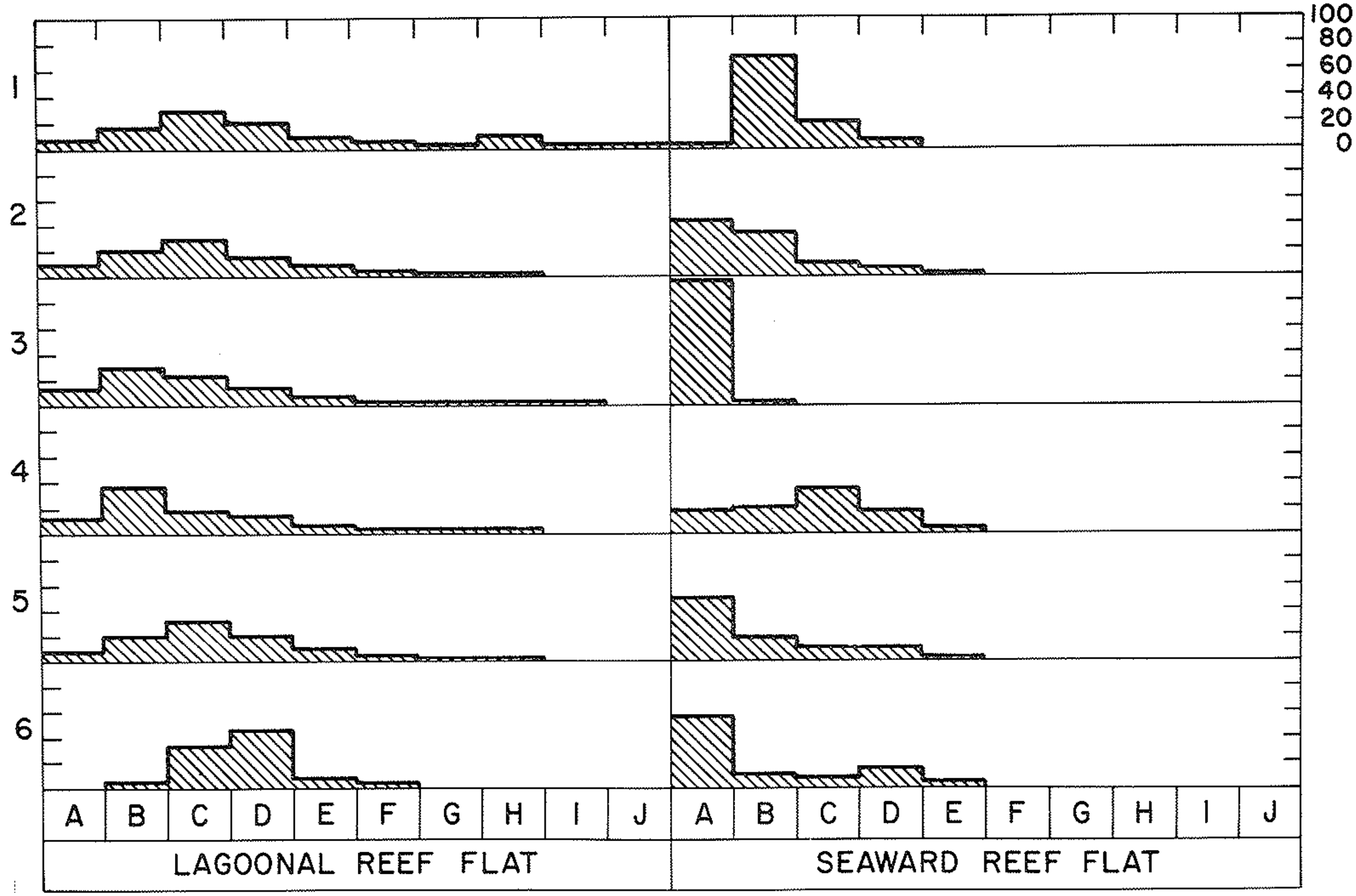


*Figure 8:* Comparison of aragonite distribution in lagoon and seaward reef flat sediments. Location of samples indicated in Fig. 1. The height of a column in a histogram indicates the percentage of the total sample aragonite that is in the grain size range designated by the corresponding alphabetic character (millimeter equivalents specified in text).

*Figure 9:* Electron photomicrograph of the fines (<0.074mm) from sample TA-8, showing whole and fragmented aragonite needles and laths. The prominent dark colored acicular crystal at lower right is between 1 and 2 microns in length.