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The Northern Bay of Safaga (Red Sea, Egypt): An Actuopalaeontological Approach II. Sediment Analyses and Sedimentary Facies

Die Nördliche Bucht von Safaga (Rotes Meer, Ägypten): ein aktuopaläontologisches Beispiel II. Sedimentanalysen und Faziesbereiche

by

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Abstract

During sea bottom mapping in the Northern Bay of Safaga (PILLER & PERVESLER, 1989) 148 surface samples (500 cm^3 each) were taken using SCUBA-diving. These samples were allied to 8 bottom facies ('Rock bottom', 'Sand with coral patches', 'Sand', 'Coral carpet', 'Sand with seagrass', 'Seagrass', 'Muddy sand', 'Mud') in the course of personal observations during sampling. Samples were analysed using several sedimentological methods supported by statistical methods (correlation and cluster analyses).

Grain size analysis (wet sieving, sedigraph), together with a cluster analysis, enables a subdivision of the samples into 4 main groups. One group with high mud content is restricted to basins and depressions; another — dominated by coarse sediments — frames the basinal areas and points to higher water currents; the third represents relatively good sorted sands and is restricted to coastal areas, whereas the fourth includes poorly sorted sands with a certain mud content. The different bottom facies are poorly determined by grain size parameters, as some are divided into more than one grain size group.

Sixteen component categories were separated by coarse grain analysis (> 250 μm) on 122 samples. The clearly dominating components originate from molluscs, reaching more than 50 % in the majority of the samples, in some more than 80 %, especially in muddy sediments. Additionally, foraminifers, corals, coralline algae, compound grains, and — in a more restricted distribution — terrigenous particles make up the bulk of the sediments. Supported by a cluster analysis the samples can be ordered into 9 groups based on component categories. One is dominated by molluscs and comprises mainly 'Mud' and 'Muddy sand' samples; another is characterized by the larger hyaline foraminifer *Operculina* and is related to 'Muddy sand'. The group separated by a high content of soritid foraminifers coincides with seagrass areas, whereas the coral- and coralline algal-determined group corresponds with 'Sand with coral patches', 'Coral carpet', and 'Rock bottom'. One group comprises samples with a high amount of terrigenous particles and is restricted to the coast. Four groups include only a few samples each. One group is separated by a relatively high content of echinoderms, located in mud areas, another by compound grains. One sample contains 87 % *Halimeda* and one is composed of a mixture of several component categories. The distribution of these groups traces that of bottom facies to a high degree. Correlation analyses brought forth clear connections between coarse sediments and corals and coralline algae, whereas miliolid and hyaline foraminifers, crustaceans and echinoderms are related with fine-grained sediments.

In the main part of the bay, carbonates dominate with more than 90 % in the total samples and with more than 80 % in the mud fraction. Non-carbonate minerals are represented only by quartz, plagioclase and alkali-feldspars and are mainly restricted to the coast related to the total samples; in mud fractions they are present in higher percentages also in basinal areas. Their distributional pattern reflects their terrigenous origin. Carbonate minerals are distinctly dominated by Mg-calcite, especially the mud fractions. This high content may be related to a bioclastic origin, as is supported by the mainly silty composition of mud. Aragonite reaches highest values in coarse-grained, shallow water sediments and is positively correlated to corals and compound grains. Calcite occurs most frequently in coastal areas and in mud, suggesting a terrigenous or erosional origin. Among trace elements, Sr is positively correlated to coarse sediments, aragonite, corals, and compound grains and occurs most frequently in shallow water areas, whereas Fe and Mn originate from a terrestrial source.

Eight sedimentary facies can be subdivided on the basis of grain size, coarse grain and mineral composition as well as strontium distribution, supported by a cluster analysis: Coralgal facies, Mud facies, Molluscan facies, *Operculina* facies, Soritid facies, Terrigenous facies, Compound grain facies, *Halimeda* facies. Although the bottom facies types can be recognized only to a limited extent by the applied sediment investigation methods, the distributional pattern of the sedimentary facies coincides well with the pattern produced by bottom facies.

Zusammenfassung

Im Rahmen der Meeresbodenkartierung in der Nördlichen Bucht von Safaga (PILLER & PERVESLER, 1989) wurden während der verschiedenen Tauchabstiege mittels Preßluftflaschen 148 Oberflächen-Sedimentproben (500 cm^3) entnommen. Aufgrund der dabei gemachten Beobachtungen konnten diese Proben 8 unterschiedlichen Bodentypen zugeordnet werden (subtidale Felsböden, Sand mit Buckelriffen, Sand, Korallenrasen, Sand mit Seegras, Seegras, schlammiger Sand, Schlamm). Diese Sedimentproben wurden verschiedenen sedimentologischen Analysen zugeführt, die durch statistische Methoden (Korrelations- und Cluster-Analysen) unterstützt wurden.

Die Korngrößenanalysen, zusammen mit einer Clusteranalyse, lassen die Sedimente der Bucht — vereinfacht — in 4 Gruppen zusammenfassen. Eine Gruppe beinhaltet jene Proben, die einen höheren Schlammanteil aufweisen und die auf Becken oder auf tiefere Bereiche — in Beziehung zu ihrer unmittelbaren Umgebung — beschränkt sind. Eine andere Gruppe wird durch grobkörnige Sedimente charakterisiert, die vor allem diese Becken umrahmen bzw. in Flachwasserbereichen vorkommen. Ihre Verteilung steht im Zusammenhang mit höherer Wasserenergie. Die dritte Gruppe umfaßt relativ gut sortierte Sande und erstreckt sich entlang der Küste, während die vierte Gruppe schlecht sortierte Sande mit unterschiedlich hohem Schlammanteil enthält. Ihre Verteilung deckt sich grundsätzlich mit der von Seegras. Die Bodenfaziesbereiche lassen sich anhand der Korngrößenverteilungen nicht unterscheiden, da die Proben mehrerer Bodenfaziestypen verschiedenen Korngrößengruppen zuzuordnen sind.

Die Grobfraktion (> 250 μm) von 122 Proben wurde einer Komponentenanalyse unterzogen. Dabei wurden 16 Komponentenkategorien unterschieden, unter denen Mollusken bei weitem dominieren; meist stellen sie mehr als 50 %, in vielen Fällen, besonders in Proben mit höherem Schlammanteil, sogar bis zu 80 % der Grobfraktion. Daneben bilden Foraminiferen, Korallen, coralline Rotalgen, Aggregatkörner und nichtkarbonatische Komponenten den Hauptanteil an der Grobfraktion. In Anlehnung an die Gruppierung durch eine Clusteranalyse können die Proben anhand der Komponenten in 9 Gruppen zusammengefaßt werden. Eine wird durch Mollusken dominiert und beinhaltet hauptsächlich Proben aus den Bodenfaziestypen Schlamm bzw. schlammiger Sand. Eine andere wird durch Großforaminiferen der Gattung *Operculina* charakterisiert und umfaßt Proben aus schlammigem Sand, während jene Proben, die durch hohe Anteile von soritiden Großforaminiferen zusammengefaßt werden, aus Seegrasbereichen stammen. Die Gruppe mit relativ hohen Anteilen an Korallen und/oder corallinen Rotalgen umfaßt jene Proben, die aus Sand mit Buckelriffen, Korallenrasen und Felsböden stammen. Eine Gruppe wird durch hohen Anteil von nichtkarbonatischen Komponenten bestimmt und ist auf Küstenareale beschränkt. Vier Gruppen umfassen jeweils nur eine kleine Probenanzahl. Eine davon wird durch einen relativ hohen Anteil an Echinodermen charakterisiert; diese Proben stammen aus Schlamm-Bereichen. Eine andere weist einen höheren Prozentsatz an Aggregatkörnern auf. Eine Probe besteht zu 87 % aus *Halimeda*, eine weitere repräsentiert eine Mischung aus verschiedenen Komponentenkategorien. Die Verteilung dieser Gruppen deckt sich im wesentlichen mit jener der Bodentypen. Die Korrelationsanalyse erbrachte eine klare Beziehung zwischen groben Sedimenten und der Häufigkeit von Korallen und corallinen Rotalgen bzw. zwischen Feinsedimenten und milioliden und hyalinen Foraminiferen, Crustaceen und Echinodermen.

Der Karbonatanteil, bezogen auf die Gesamtproben, beträgt im größten Teil der Bucht mehr als 90 %, bezogen auf die Schlammfraktion meist mehr als 80 %. Unter den nichtkarbonatischen Mineralien konnten nur Quarz, Plagioklas und Alkali-Feldspäte nachgewiesen werden; bezogen auf die Gesamtproben sind sie auf küstennahe Bereiche beschränkt, während in den Schlammfraktionen allein auch in den Beckenbereichen höhere Anteile festzustellen sind. Ihre Verteilungsmuster untermauern ihre terrigene Herkunft. Unter den Karbonatmineralien dominiert Mg-Calcit deutlich; diese Dominanz gilt für die Gesamtproben, im besonderen Maße aber für die Schlammfraktion. Da in der Schlammfraktion (gröberer) Silt bei weitem überwiegt, scheint der hohe Anteil von Mg-Calcit einen bioklastischen Ursprung zu haben. Aragonit erreicht in grobkörnigen Sedimenten die höchsten Häufigkeiten und ist positiv korreliert zu Korallen und Aggregatkörnern. Calcit ist in küstennahen Arealen relativ am häufigsten, sowie in der Schlammfraktion; beides weist auf eine terrigene Herkunft hin. Unter den Spurenelementen ist Sr positiv korreliert zu groben Korngrößenfraktionen, zu Aragonit, Korallen und Aggregatkörnern und kommt am häufigsten in Flachwasserbereichen vor; Fe und Mn sind aufgrund ihres Vorkommens terrigener Herkunft.

Anhand der Daten aus der Korngrößenanalyse, der Grobkornanalyse, sowie der Mineral- und Spurenelementverteilung können, basierend auf einer Clusteranalyse, 8 Faziesbereiche unterschieden werden: Korallen-Algen Fazies, Schlamm Fazies, Mollusken Fazies, *Operculina* Fazies, Soritiden Fazies, Terrigene Fazies, Aggregatkorn Fazies, *Halimeda* Fazies. Obwohl bei den verwendeten Analysenmethoden die verschiedenen Bodentypen nur in beschränktem Maße unterschieden werden können, stimmen die Verteilungen der Bodentypen mit denen der Sedimentfazies-Bereiche recht gut überein.

1 Introduction

The Northern Bay of Safaga (Fig. 1) was selected for an actuopalaeontological study due to its variety of different bottom types within a relatively small

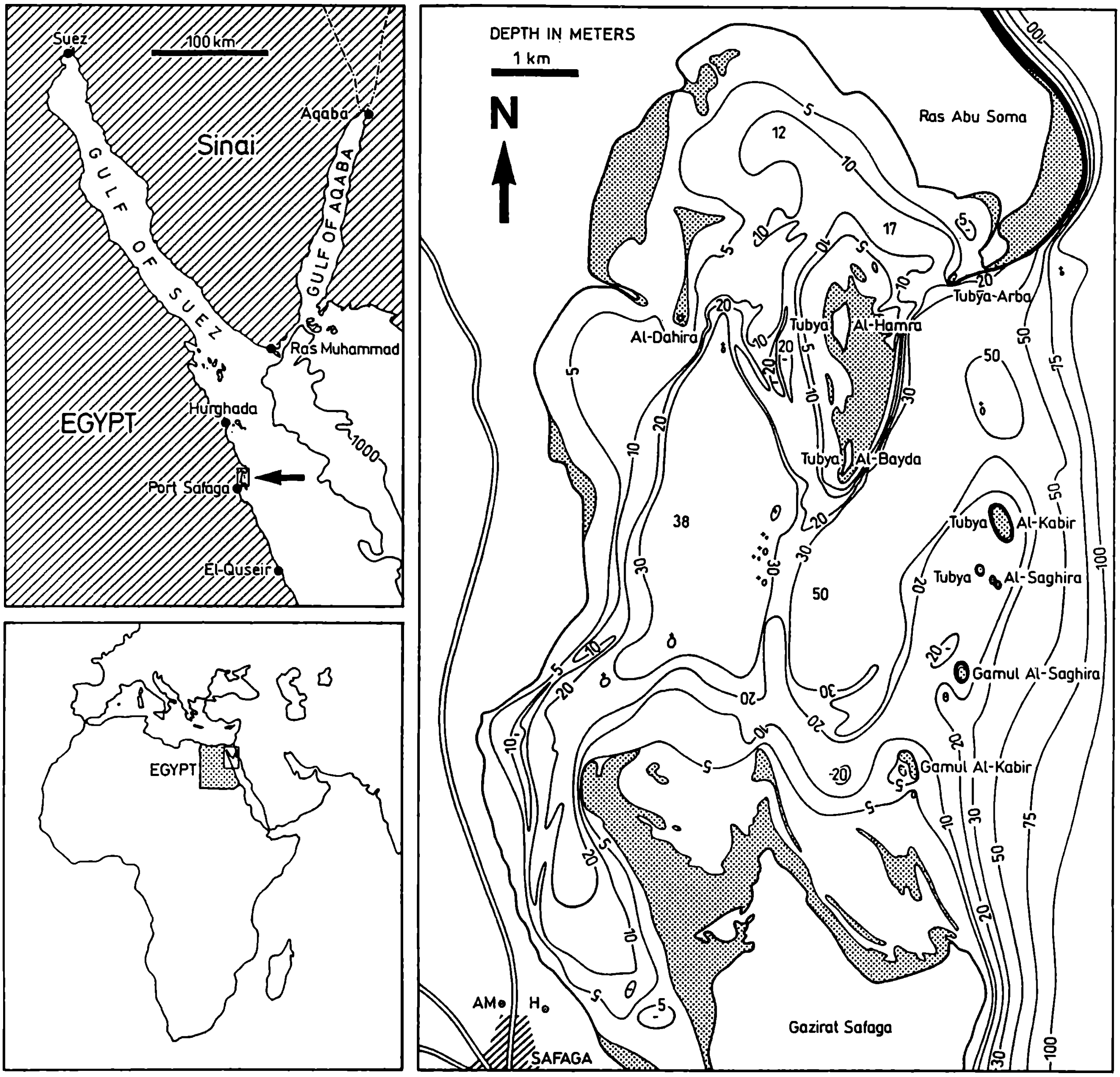


Fig. 1. Location map and general topography of study area (stippled fields in the right map represent intertidal areas).

area (PILLER & PERVESLER, 1989). Reflecting field observations, in the first step, topography and bottom facies were documented (PILLER & PERVESLER, 1989). As a further base for actuopalaeontological studies, a number of sedimentological and mineralogical investigations had to be carried out as presented in this paper.

Although a number of investigations on recent shallow water carbonate sediments have been carried out, studies on a medium scale (several kilometers), as represented by the Northern Bay of Safaga (Fig. 1), are scarce. Sedimentologic investigations in the widest sense have been carried out, on the one hand, mainly on large areas (tens to hundreds of kilometers) like the Bahama platforms (e.g., PURDY, 1963 a, b), the Belize shelf (e.g., WANTLAND & PUSEY, 1975), the Persian Gulf (PURSER, 1973), or in various areas of the Great Barrier Reef Complex (e.g., BELPERIO & SEARLE, 1988; FLOOD & ORME, 1988). On the other hand, small to medium scale studies (hundreds of meters to a few kilometers) were mainly focused on coral reefs (e.g., BRAITHWAITE, 1982, and SCHROEDER & NASR, 1983, in the Sudanese part of the Red Sea; MONTAGGIONI et al., 1986, on the Arabian coast of the Red Sea) or treat special biological or sedimentological problems. Unlike the majority of studies of recent carbonates focusing on coral reefs, the study of the Northern Bay of Safaga mainly deals with the depositional environments adjacent to the coral reefs as pointed out by PILLER & PERVESLER (1989).

The investigation of several parameters (grain size, grain composition, mineralogy, trace elements) should render on the one hand a subdivision of the sediments of the bay into clearly defined sedimentary facies. On the other hand it should show whether and to what degree the bottom facies types are documented in the sediments. The latter question is of special importance from the actualistic viewpoint in showing the possibilities of recognizing original bottom types in fossil sediments. Finally, the data detected by several methods may help to explain the distributions of several organism groups in subsequent studies (compare PILLER & PERVESLER, 1989).

2 Material

Samples were taken during the SCUBA descents while mapping bay floor (PILLER & PERVESLER, 1989). This sampling mode allowed the exact location of the sampling points (Fig. 2) and the selection of the points by personal observation; the latter makes an exact relation of sample locality to bottom facies possible (compare Appendix 1) and reduces the probability of incidental results. The maximum depth reached by this method was less than 80 m. The samples were taken by pushing a plastic box with a quadratic opening (9 x 9 cm) 6 cm deep into the sediment, collecting a sample volume of nearly 500 cm^3. The total of 148 collected samples assured not only a good spatial coverage of the bay (Fig. 2), but also a good representation of the bottom facies types. A short description of the sample localities is given in Appendix 1.

Before proceeding with the different analyses, the samples were gently washed several times with distilled water to remove salt and were subsequently oven dried. Subsamples for grain size and grain composition analyses as well as for mineralogical and chemical investigations were produced by splitting the dry samples.

The location names used in this paper are documented by PILLER & PERVESLER (1989) and in Fig. 1.

All cluster analyses in this study are computed with the $SPSS^x$-program package, with an Unweighted Pair-Group Method using arithmetic Averages (UPGMA) and the cosine coefficients as a similarity index (SCHUBÖ & UEHLINGER, 1986).

3 Sample localities versus bottom facies

Although the sample localities were visually detected and their position is therefore exactly known, some remarks due to their classification with bottom facies should be made. Theoretically, this classification should proceed very easily by comparing the sample localities with the bottom facies map (PILLER & PERVESLER, 1989). The distribution of the bottom facies in this map, however, represents a generalization and thus for some samples the character of the sample localities does not coincide with the bottom facies documented on the map. Additionally, it was useful to pool certain bottom facies or sub-facies and to separate other sub-facies more distinctly for these investigations. This procedure resulted in the separation of 8 bottom facies.

'Rock bottom' (10 samples) includes not only samples of 'Rock bottom', in terms of bottom facies, but also the samples from areas covered by Sand with macroids (B 2, B 39, C 1, C 29). This pooling of bottom facies can be justified by the fact that the samples of Sand with macroids originate from a thin, often patchy, veneer of sand on rock bottom, differing from the "true" 'Rock bottom' samples only in the occurring macroids; they also all directly adjoin 'Rock bottoms' Macroids have been omitted in this investigation and are therefore not considered in these samples.

'Sand with coral patches' represents a subfacies of 'Sand' bottom facies. The included 11 samples originate from localities which fulfill this definition in general. It was occasionally difficult to separate this subfacies from 'Sand' because of continuous transitions caused by variable coral patch densities, or from 'Sand with seagrass' because the sandy substrate between coral patches often is settled by seagrass (A 8, A 23, C 18). To avoid inclusion of an additional bottom facies type in this investigation ('Sand with coral patches and seagrass'), a classification into 'Sand with coral patches' or into 'Sand with seagrass' was preferred.

The 33 samples classified as **'Sand'** are heterogeneous and their classification was often somewhat unclear. Besides pure sands, which originate from rocky intertidal flats (A 1, A 10, B 74, C 13) as well as from different water depths, this classification also includes sand with very sparse seagrass, sand with rare coral patches, as well as samples transitional to 'Muddy sand' Mangrove area samples (A 9, A 33) are also included herein.

The samples (17) classified as **'Coral carpet'** are relatively well defined in representing either a thin sediment cover or sand (or muddy sand) in depressions in the 'Coral carpet' Only sample C 28 originates from the Coral reef of Ras Abu Soma. This

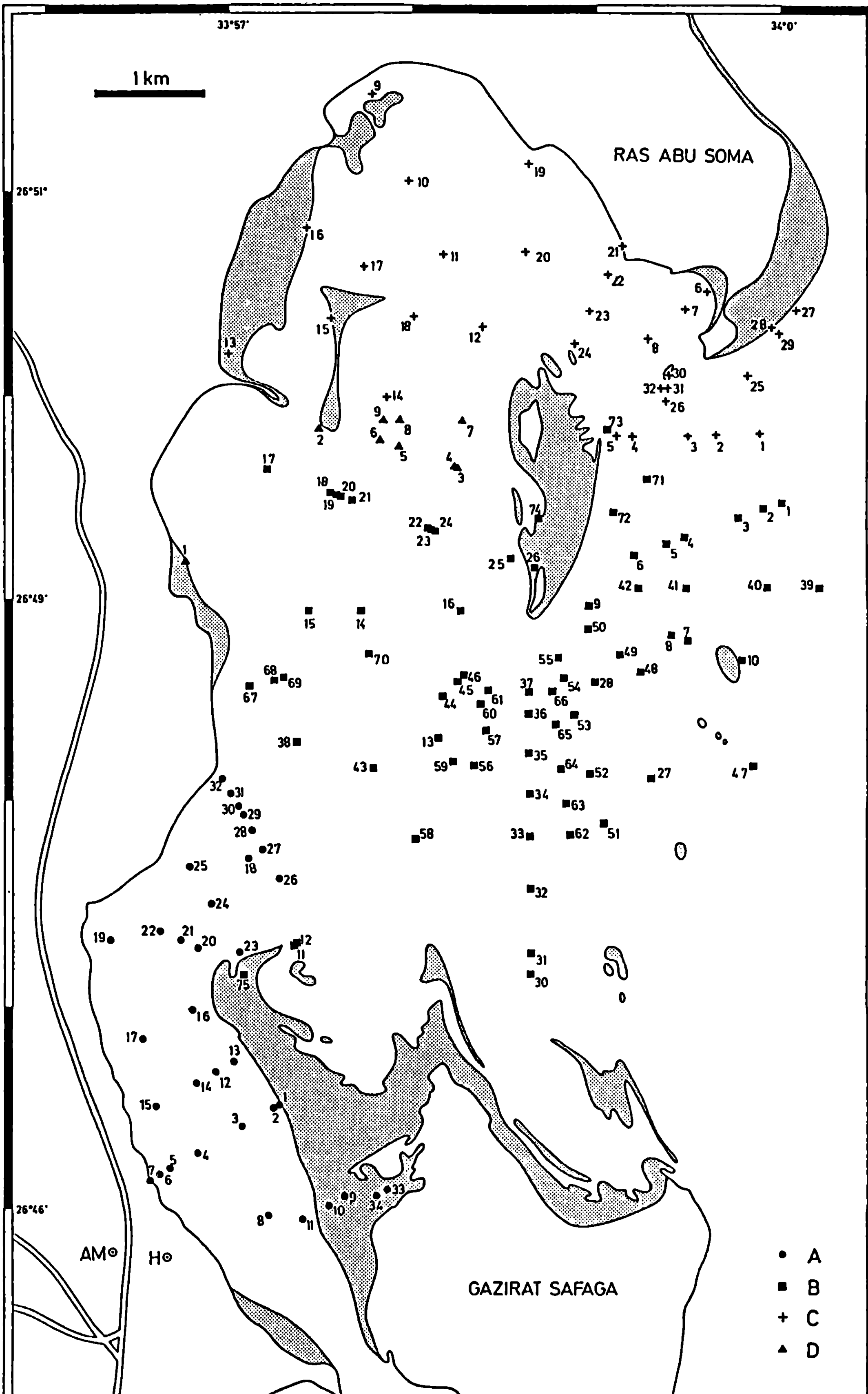


Fig. 2. Sample map (AM = Aerial mast, H = "Safaga Hotel"). (A, B, C, D: prefix of sample numbers; A: 'Southwest channel' samples, B: samples of transects starting at Tubya al-Bayda, C: samples of transects starting at Tubya al-Hamra, D: samples of transects starting at Al-Dahira).

sample was placed herein as it is the only reef sample and because of the strong similarities between coral reefs and 'Coral carpet' in general.

'Sand with seagrass' includes 11 samples, which represent transitions between pure sand and dense seagrass meadows. Their classification is sometimes highly subjective.

The 12 samples placed in **'Seagrass'** originate from dense seagrass meadows.

The largest sample group represents **'Muddy sand'** (39 samples). Although separated by a character which is difficult to define by macroscopic observation alone (mud content in sands), the majority of sample designations was clear. Some uncertainties arose with samples from areas with loose or patchy seagrass stock (B 8, C 4, C 12) and with those from sediment-filled depressions in 'Coral carpet' If the sediment areas were relatively large (a minimum of several decameters) the samples were classified as 'Muddy sand'; small sandy areas were placed into 'Coral carpet' (see above). One sample (B 51) originates from a dense *Halimeda* meadow; because of the unique occurrence of such a dense *Halimeda* stock and its muddy sand substrate this sample was placed herein. An additional compromise is made for those samples from the margin of the 'West area' basin, which, in fact, represent mud in which larger components are present.

The classification of samples as **'Mud'**, restricted to the basin of the 'West area', is relatively clear except marginal samples (see above) and a few 'East area' samples (e.g., B 53).

4 Grain size analysis

4.1 Methods

For grain size and compositional analysis, a subsample of approx. 100 g was selected from each sample for sieving. The separation was done by gentle wet sieving through eleven screens, spaced at half-phi intervals, into 12 fractions; each fraction was weighed to a precision of 0.001 g. The fine fraction of samples containing more than 5 % mud (< 63 μm) was analysed using a Sedigraph (5000 E, Micromeritics). The resulting data were processed on a personal computer using the "BASIC" program "SEDPAK" (MALECKI, 1986), determining the percentages of gravel, sand, silt, and clay, some grain size parameters, terminology and sorting of the sediments, as well as calculating the different percentiles and drawing cumulative curves.

The terminology of the sediments follows the triangular diagram after FÜCHTBAUER (1959) and MÜLLER (1961); for samples with < 50 % mud content, the diagram "gravel-sand-silt", for that with > 50 % the diagram "sand-silt-clay" was used. The grain size identification is based on the formula of DIN 4022 (gravel: 63.0 – 2.0 mm, sand: 2.0 – 0.063 mm, silt: 0.063 – 0.002 mm, clay: < 0.002 mm).

4.2 Grain size parameters

Grain size parameters were calculated not only using graphical methods after FOLK & WARD (1957), but also using moment methods after FRIEDMAN (1962). Some essential differences in the results of these methods justify a few comments. The values of graphic mean (M_Z) and 1st moment were nearly identical, those for sorting (σ_I and 2nd moment) similar; the values for the 2nd moment were generally higher. Their spatial distribution can be more easily explained and fit better to bottom topography than the inclusive graphic standard deviation. This and the sorting classification of FRIEDMAN (1962), allowing a better differentiation of the investigated material, favoured usage of the 2nd moment. The spatial distribution of the values of the inclusive graphic skewness (SK_I) and the third moment revealed widely diverging patterns. Comparing the distribution curves of the samples with maximum and minimum values clearly demonstrated that the 3rd moment values must be incorrect with respect to the statistical requirements of skewness, whereas those of the SK_I were in accordance. The opposite was the case with kurtosis, because the very leptokurtic values of the graphic kurtosis (K_G) included not only samples with pronounced peaks in their distribution but also very flat curves; on the contrary, high values of the fourth moment were only found in samples with a clear peak and low values occurred only together with flat or bi- or polymodal curves.

4.2.1 Mean grain size

The distribution of the mean diameter (graphic mean, M_Z, FOLK & WARD, 1957) (Fig. 3) shows a clear dependence on sea bottom topography (Fig. 1). The coarsest sediments (< 1 Φ) are found on the submarine ridge between Tubya al-Bayda and Gazirat Safaga, around submarine elevations like Tubya Arba and Tubya al-Kabir as well as in some isolated samples (A 7, A 17, A 28, A 31, B 19, B 67, C 18, D 4). Values between 1 – 2 Φ are present in shallow water areas around the Tubya islands and the area north of Gazirat Safaga, on the tidal flats on the western side of Gazirat Safaga and in the protected, shallow northwestern part of the 'North area' Not only the shallow water area from Gamul al-Kabir to Tubya al-Kabir, but also its northern continuation to Ras Abu Soma (reaching down to > 70 m) are covered by relatively coarse-grained sediments (1 – 2 Φ).

Finer sediments (> 3 Φ) dominate in the deeper parts of the bay (> 20 m), including the southern

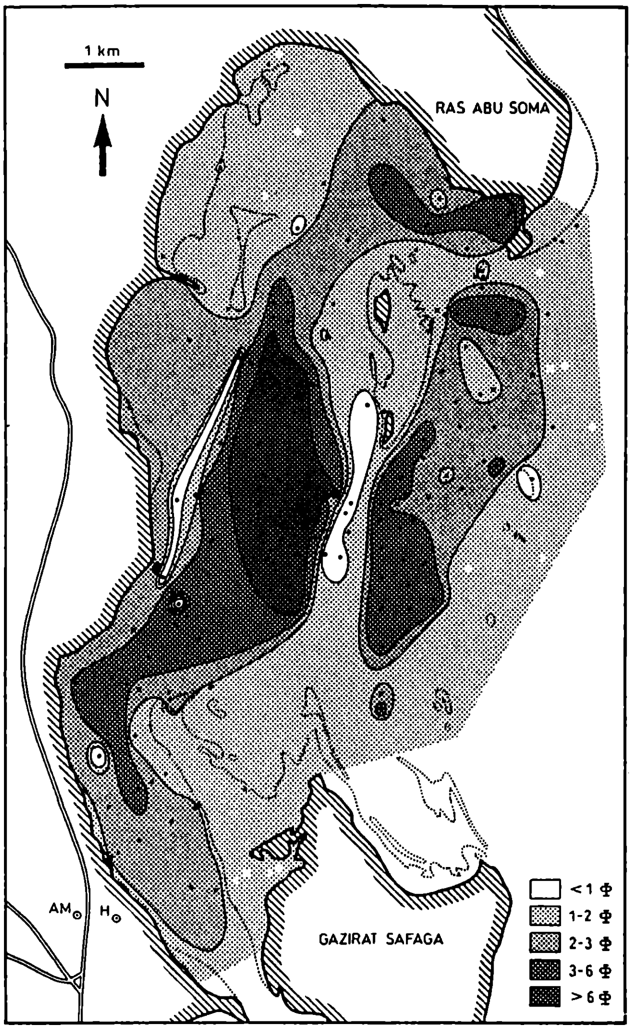


Fig. 3. Distribution of mean grain size (M_Z).

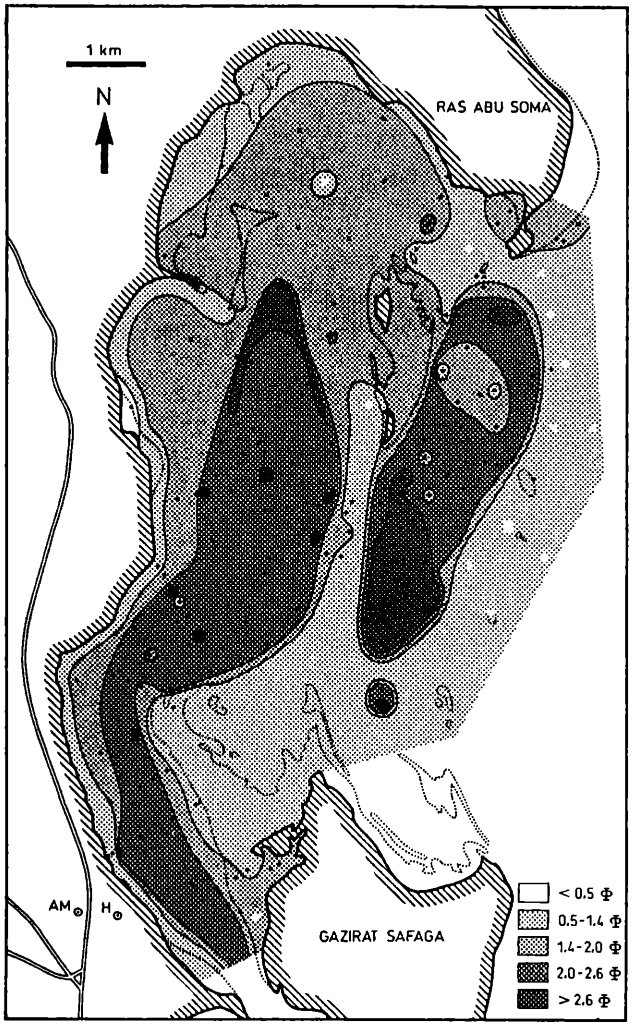


Fig. 4. Distribution of the 2nd moment (sorting).

basin and some parts of the northern basin of the 'East area', the basin of the 'West area' and the main part of the 'Southwest channel' along the channel axis. Besides these deeper occurrences, one larger area in shallower water with mean grain sizes > 3 Φ is present in the eastern part of the 'North area'; a small occurrence is also found in a shallow depression (29 m) in the shallow water area north of Gazirat Safaga (B 30). Whereas most of these samples have values between 3 and 5 Φ, in the 'West area' basin the mean values are > 6 Φ and represent by far the finest sediments of the bay.

4.2.2 Sorting

Sorting of the sediments, expressed by the inclusive graphic standard deviation (σ_I), is generally between poor and very poor following the classification of FOLK & WARD, 1957. Application of the 2nd moment and the classification after FRIEDMAN (1962), however, produced better results (compare chapter 4.2), with sorting varying mainly between moderate and extremely poor (compare Appendix 2).

Following the classification of FRIEDMAN (1962) only a single sample (D 1) is well sorted, and only one (A 7) is moderately well sorted, both coming from the main coast (Fig. 4). Moderately sorted samples (0.8 – 1.4 Φ) are present not only in the coastal areas of the 'Southwest channel', the 'West area', and the 'North area'; they also cover the entire area between the Tubya islands and Ras Abu Soma including Tubya Arba, reaching southward on the submarine ridge between Ras Abu Soma and Tubya al-Kabir, and further south including the shallow water area north of Gazirat Safaga. This latter area consists completely of moderately sorted sediments, as does the submarine ridge between Gazirat Safaga and Tubya al-Bayda (Fig. 4).

Except for some isolated samples, the basins and the 'Southwest channel' are characterized by very poorly and extremely poorly sorted sediments. The largest continuous area of extremely poorly sorted sediments is located in the south basin of the 'East area'. Most of the other extremely poorly sorted samples originate from boundary areas between to-

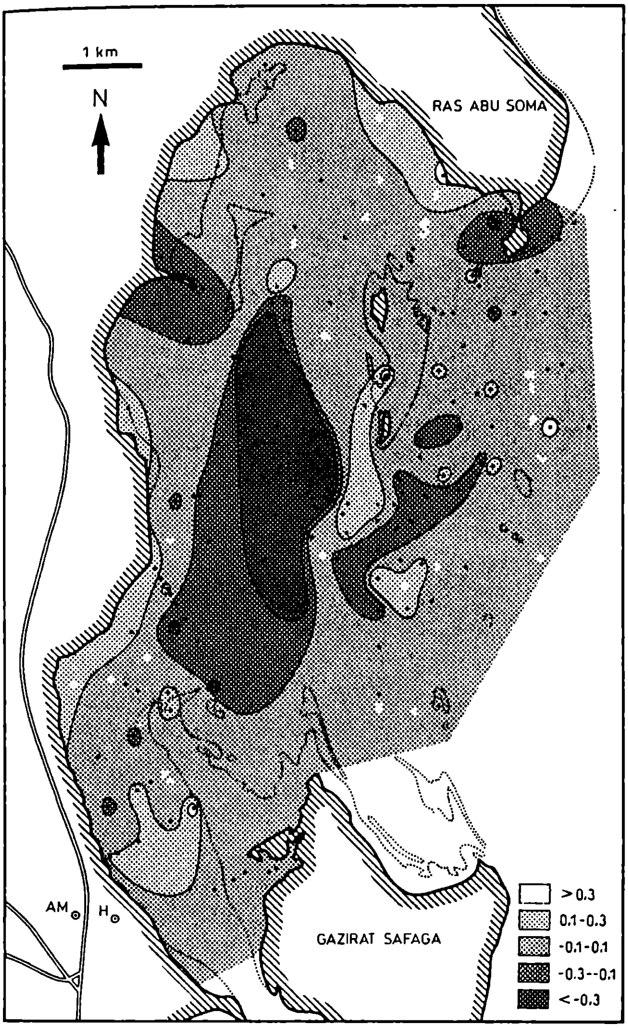


Fig. 5. Distribution of skewness (SK_I).

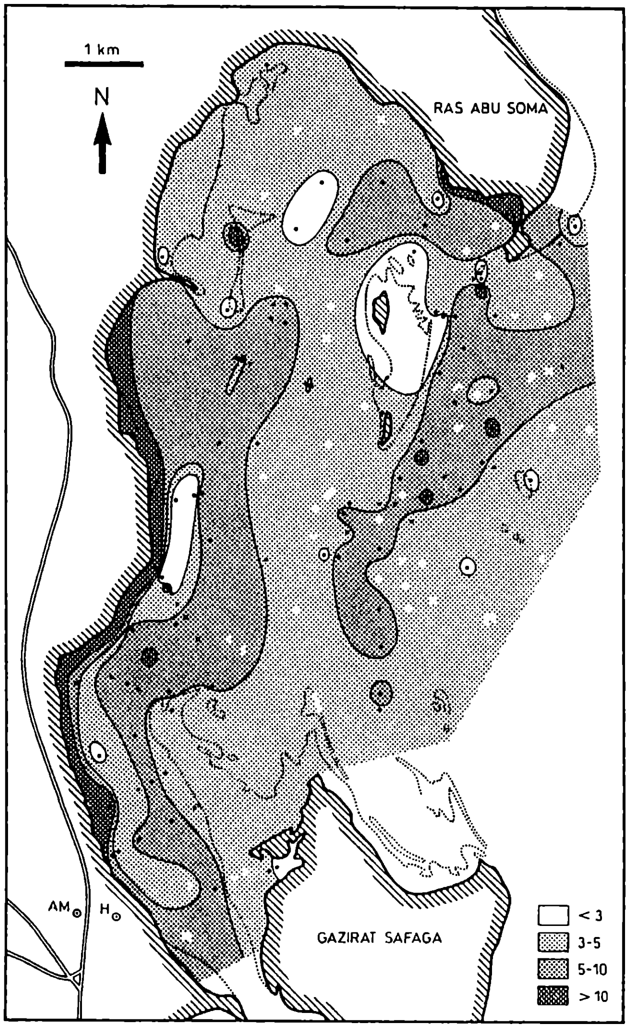


Fig. 6. Distribution of the 4th moment (kurtosis).

pographic highs and basin bottoms. This is most obvious along the northern rim of the basin of the 'West area', where a narrow strip of extremely poorly sorted sediments frames the basin.

A general correspondence is obvious when comparing the distributions of the sorting (Fig. 4) with those of the mean values (Fig. 3). This implies that the finer sediments are also the poorer sorted ones, and that both are related to topographic depressions. Comparing the extreme values, some differences exist: the by far finest sediments (mean > 6 Φ) cover the main part of the 'West area' basin, whereas the most poorly sorted sediments occur in the southern basin of the 'East area' and in a narrow strip along the northern border of the 'West area' basin. The coarsest sediments come from the ridge between the Tubya islands and Gazirat Safaga, whereas the best sorted one occur in coastal areas.

4.2.3 Skewness

The distribution of the inclusive graphic skewness (SK_I) exhibits a more differentiated pattern (Fig. 5) than that of M_Z and the 2nd moment. Most samples show nearly symmetrically skewed sediments. Only the central part of the 'West area' basin contains very positively skewed sediments surrounded by positively skewed ones. An area of positive skewness is also present in the southern basin of the 'East area', in the shallow water area south of Al-Dahira in the 'West area', as well as around Ras Abu Soma.

Negatively skewed sediments are distributed along the main coast of the bay and west and south of Tubya al-Bayda as well as in the southern part of the 'Southwest channel' and on the intertidal area northwest of Gazirat Safaga. In addition to some isolated samples from the 'East area', a small continuous area is negatively skewed in its southern basin. Only three isolated samples are very negatively skewed (A 2, B 74, C 21).

Although the distributional pattern is more complex than that of M_Z and the 2nd moment, a good correspondence exists between the finest (> 6 Φ) and the very positively skewed sediments of the 'West area' basin. In contrast, no such clear relation is

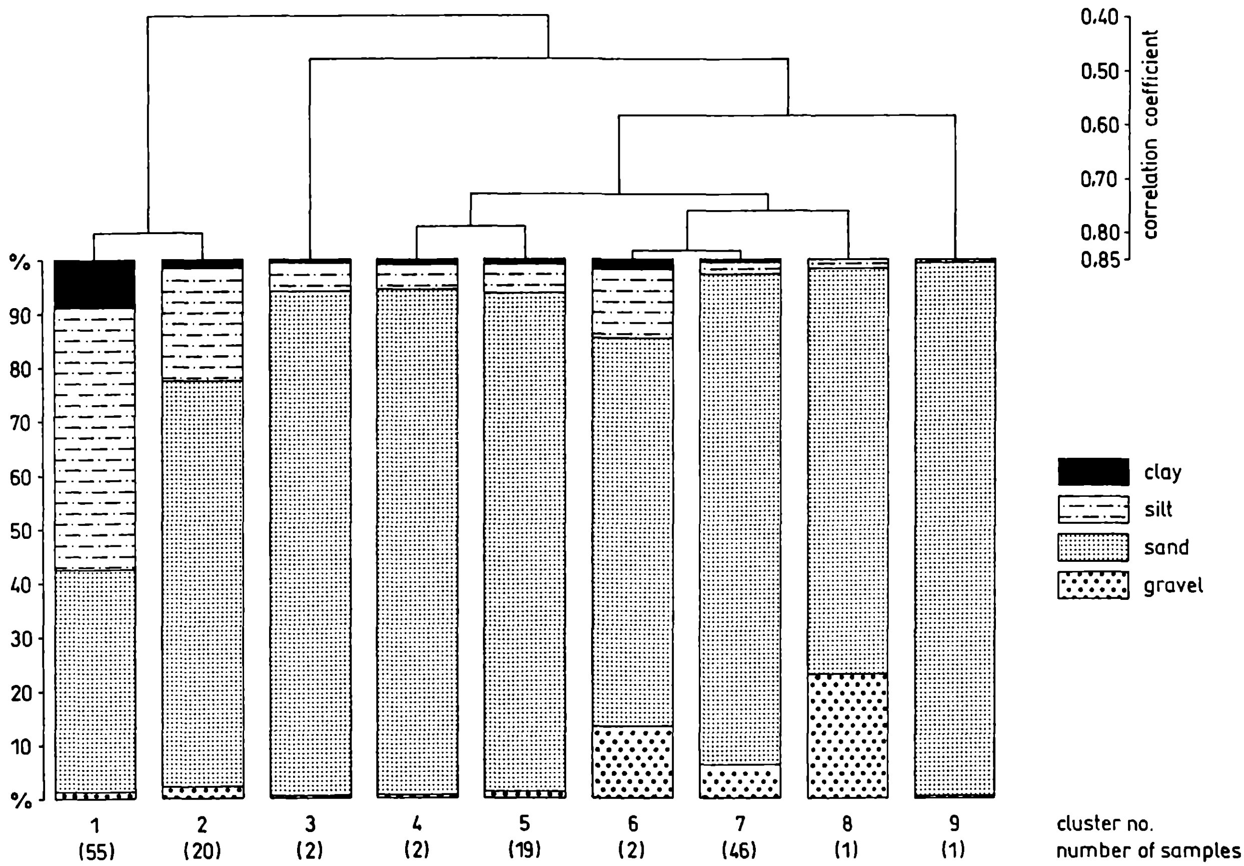


Fig. 7. Dendrogram of a hierarchical UPGMA cluster analysis of grain size data combined with the frequency distribution of gravel, sand, silt, and clay in each cluster at a correlation coefficient level of 0.85.

obvious between coarse and negatively skewed sediments. A good coincidence is evident in the area west and south of Tubya al-Bayda, where very coarse sediments ($M_Z < 1\ \Phi$) are negatively skewed. The three very negatively skewed samples originate from intertidal to very shallow subtidal sites. Remarkable is that the continuously fine-grained southern basin of the 'East area' contains positively as well as negatively skewed samples.

4.2.4 Kurtosis

The distribution of the kurtosis (expressed by the 4th moment, FRIEDMAN, 1962) is presented in Fig. 6. The highest values (> 10) are attained in samples from the west coast of the 'Southwest channel' and the 'West area' as well as by those from the west coast of Ras Abu Soma. Some isolated samples are located in the 'East area' (B 28, B 41, B 50, C 26), one on the intertidal area north of Al-Dahira (C 15), and one in the 'Southwest channel' (A 24). The lowest values (< 3) are found around Tubya al-Hamra, at the western slope of the 'West area' basin, and in some isolated samples in all bay-areas.

The peaks of the distributions with high kurtosis values are between 1 and 3.5 Φ; the lowest values characterize samples with bi- or polymodal distributions. Most samples with high kurtosis values originate from coastal or shallow water areas.

4.3 Cluster analysis

A hierarchical UPGMA cluster analysis was carried out with all grain size data (sieving and sedigraph) (Fig. 7, Tab. 1) in order to obtain more objective results than by comparing the distributions of grain size parameters. Nine clusters were distinguished (Fig. 7) at a correlation coefficient level of 0.85. Of these clusters only 4 have a high number of samples; five contain only one or two.

The correlation of cluster distribution with sea bottom topography (Fig. 8) reveals a clear relation of cluster 1 to the basins and the central part of the 'Southwest channel'. Only 2 samples (C 7, C 23) are located in shallow water (7 m, 17 m) of the 'North area'. The distribution of samples of cluster 2 is more complex and no clear dependence on bottom morphology is discernible. Besides deeper water areas between the basins of the 'East area', many samples originate from shallow water. In Fig. 8, clusters 3, 4 and 5 are pooled because they are clearly characterized by a high sand content (Fig. 7,

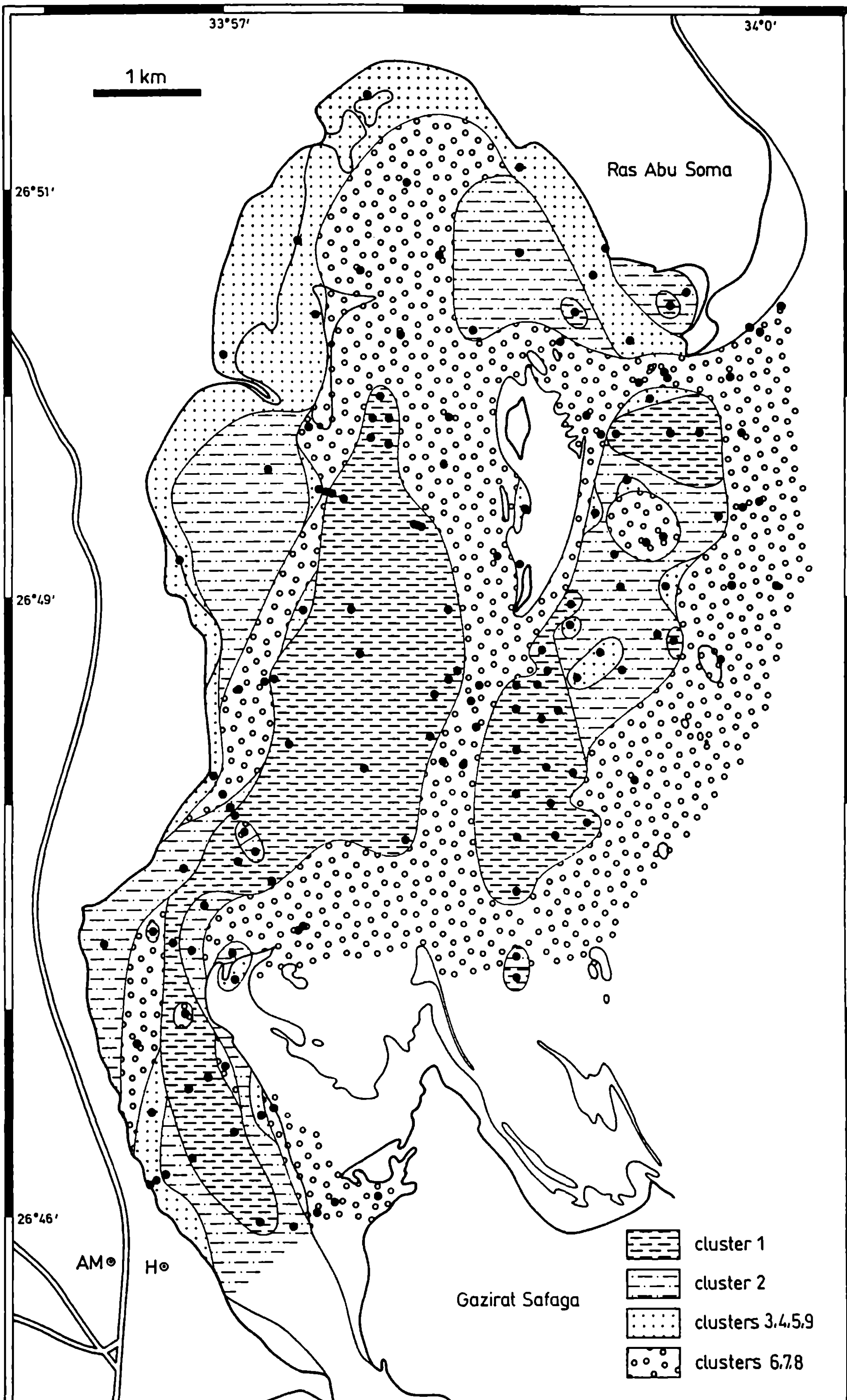


Fig. 8. Distribution of the clusters at a correlation coefficient of 0.85 of the cluster analysis of grain size data.

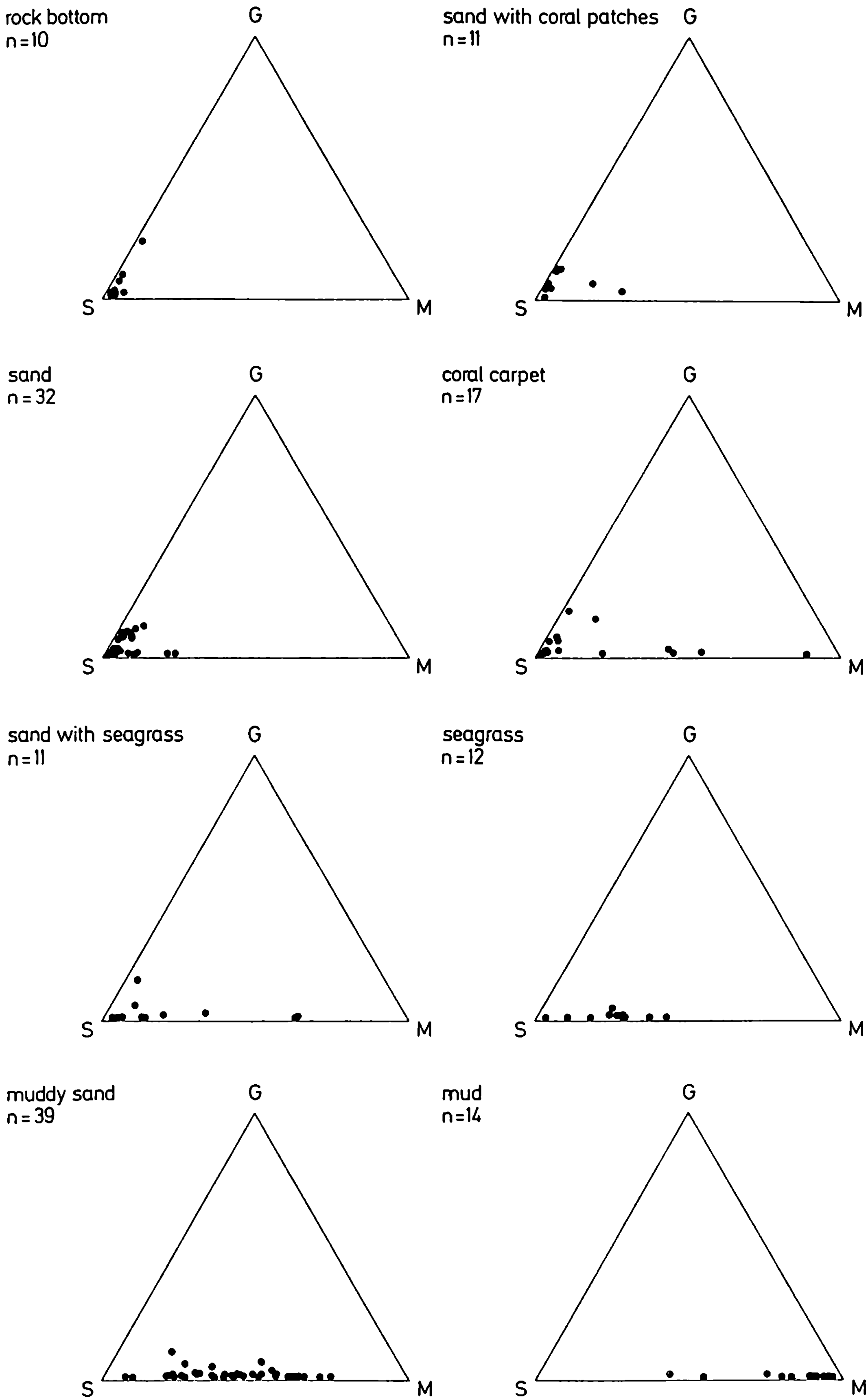


Fig. 9. Gravel–sand–mud triangular diagrams related to bottom facies.

	gravel	sand	silt	clay
cluster 1 (55 samples)				
m	1.57	41.35	48.45	7.34
s	1.47	19.77	17.18	4.12
min.	0.00	20.24	25.23	1.72
max.	7.33	68.20	70.94	17.88
cluster 2 (20 samples)				
m	2.22	74.96	23.93	2.47
s	1.99	3.20	13.88	2.46
min.	0.21	69.72	14.76	0.79
max.	7.26	81.56	82.66	12.41
cluster 3 (2 samples)				
m	0.55	93.61	5.64	0.22
s	0.27	0.64	0.26	0.11
min.	0.27	92.96	5.38	0.11
max.	0.82	94.25	5.90	0.32
cluster 4 (2 samples)				
m	0.26	94.58	4.67	0.51
s	0.14	5.01	4.38	0.51
min.	0.39	89.56	9.05	1.01
max.	0.12	99.59	0.29	0.00
cluster 5 (19 samples)				
m	1.85	92.06	5.46	0.63
s	1.97	3.94	3.17	0.63
min.	0.01	85.64	0.62	0.00
max.	7.56	98.72	12.27	1.84
cluster 6 (2 samples)				
m	13.28	72.30	12.55	1.89
s	1.91	0.54	1.79	0.67
min.	11.36	71.76	14.33	2.56
max.	15.19	72.84	10.76	1.21
cluster 7 (46 samples)				
m	6.30	91.12	2.48	0.11
s	4.14	4.70	1.73	0.26
min.	1.05	80.17	0.10	0.00
max.	18.25	98.15	9.23	1.27
cluster 8				
B 56	23.08	75.55	1.37	0.00
cluster 9				
A 7	0.28	99.49	0.06	0.17

Tab. 1. Some statistical parameters of the main grain size categories of the clusters computed by an UPGMA cluster analysis (m = mean value; s = standard deviation).

Tab. 1). The samples of these clusters are mainly from coastal areas. Cluster 9, containing only sample A 7, is also included in this group because its separation is based only by its very high sand fraction. It is also located on the coast. Clusters 6, 7 and 8 are also combined in Fig. 8; they are characterized by a relatively high gravel content (Fig. 7, Tab. 1). In general, the samples of this group frame the basinal areas of the bay, occurring not only in shallow water (e.g., 'North area', north of Gazirat Safaga, around the Tubya islands, between Gamul al-Kabir and Tubya al-Kabir), but also on the submarine ridges south of Tubya al-Bayda and between Tubya al-Kabir and Ras Abu Soma.

4.4 Grain size versus bottom facies

4.4.1 Distribution of main grain size categories

A simple comparison of triangular diagrams of gravel–sand–mud of each bottom facies (Fig. 9) yields interesting results (for sediment terminology see Tab. 2). **'Rock bottom'** samples consist homogeneously of sand, except for one sample (B 56) which represents gravelly sand. The samples of **'Sand with coral patches'** are also basically sand (3 samples are gravelly sand); only A 23 is silty sand, A 8 siltsand. The sample distribution of **'Sand'** bottom is also homogeneous, with only two samples (A 20, B 3) containing a higher silt content. The most inhomogeneous samples are found in **'Coral carpet'** Of 17 samples, 9 are sand, one is gravelly sand, one silty sand, 3 are siltsand, one is silty-gravelly sand, one is sandy silt sand, and one is even sandy silt. **'Sand with seagrass'** also shows an inhomogeneous sample composition ranging from gravelly sand to sandsilt; the 2 sandsilt samples (B 62, C 3) are the most striking ones. The samples of the **'Seagrass'** bottom facies are more homogeneous than those of 'Sand with seagrass', comprising silty sand (6 samples), siltsand (4 samples), and only 2 sand samples (A 6, B 12). **'Muddy sand'** samples are located near the sand–mud line of the triangle representing silty sand to clayey sandsilt. Only one sample (A 16) is a silty gravelly sand and three more samples have a gravel content > 5 % (B 15, B 45, B 51). With the exception of 2 siltsand samples (B 13, B 20), all other samples (12) of the **'Mud'** bottom facies are close to the mud corner (sandsilt to clayey silt).

Summarizing these results, it is obvious that the samples of 'Rock bottom', 'Sand with coral patches', and 'Sand' are similar and clustered around the sand corner. Samples of 'Coral carpet' and 'Sand with seagrass', although mainly sand, show a wider dispersion, especially in the direction of the mud corner. 'Seagrass', 'Muddy sand', and 'Mud' samples are located in a narrow zone along the sand–mud line, the former near the sand corner, the latter near that of mud, with 'Muddy sand' lying in between.

4.4.2 Distribution of cumulative curves

In order to obtain a more differentiated picture of the grain size distributions in the various bottom facies, the cumulative frequency curves (plotted on probability scale; Fig. 10) as well as the mean curves for each bottom facies (Fig. 11) of each sample were compared. Additionally, the curves are divided into linear segments demonstrating different grain size populations and sub-populations following a terminology modified after VISHER (1969). This is necessary as the concept and terminology of VISHER (1969, p. 1076), based on the three modes of sedi-

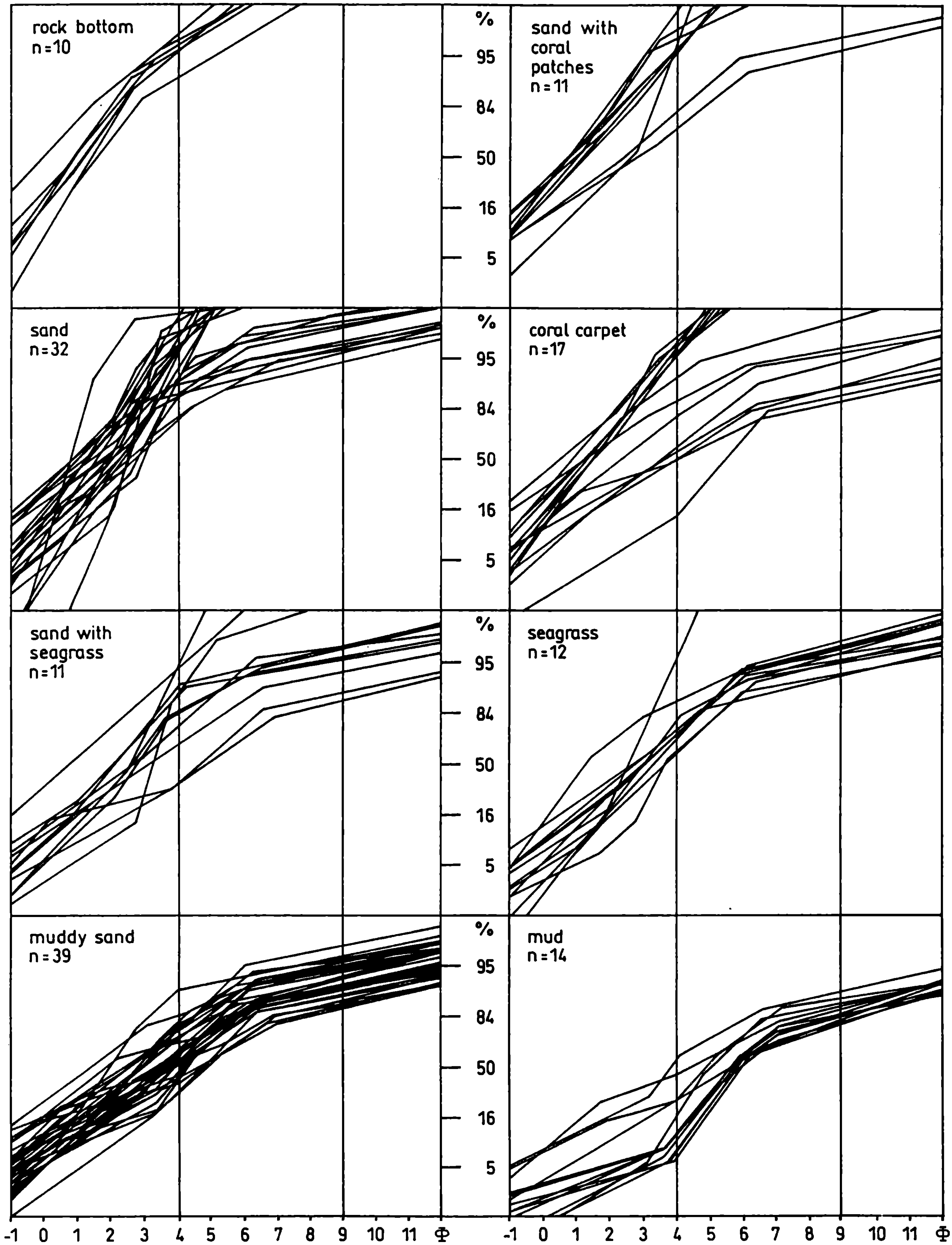


Fig. 10. Cumulative grain size frequency curves plotted on probability paper related to bottom facies.

Rock bottom (10 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_Z	2.mom.	Sk_I	4.mom.
B 1	1.45	94.94	3.62	0.00	sand	moderate	1.52	1.23	0.02	7.04
B 2	1.98	95.77	1.72	0.53	sand	moderate	1.08	1.20	0.01	7.28
B 4	3.10	95.68	1.22	0.00	sand	moderate	1.25	1.13	-0.13	3.57
B 39	3.94	94.47	1.59	0.00	sand	moderate	1.13	1.26	0.01	3.89
B 40	3.19	94.55	2.26	0.00	sand	moderate	1.11	1.31	0.14	3.25
B 56	23.08	75.55	1.37	0.00	gravelly sand	moderate	0.10	1.34	0.20	6.31
B 60	7.87	90.05	2.09	0.00	sand	moderate	0.84	1.39	-0.11	5.10
C 1	3.88	94.24	1.56	0.32	sand	moderate	1.20	1.26	-0.04	4.22
C 27	9.71	88.31	1.98	0.00	sand	poor	1.05	1.43	-0.06	2.93
C 29	3.37	91.46	4.89	0.29	sand	poor	1.55	1.47	0.02	9.63
m	6.16	91.50	2.23	0.11			1.08	1.30	0.01	5.32
s	6.14	5.83	1.09	0.18			0.38	0.10	0.10	2.07
min.	1.45	75.55	1.22	0.00			0.10	1.13	-0.13	2.93
max.	23.08	95.77	4.89	0.53			1.55	1.47	0.20	9.63

Sand with coral patches (11 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_Z	2.mom.	Sk_I	4.mom.
A 2	0.85	98.53	0.62	0.00	sand	moderate	2.47	1.16	-0.38	3.26
A 8	4.50	68.80	25.35	1.35	siltsand	v. poor	2.62	2.28	-0.10	4.70
A 17	12.61	85.02	2.37	0.00	gravelly sand	poor	0.89	1.48	-0.05	2.71
A 23	7.26	77.20	14.76	0.79	silty sand	v. poor	2.21	2.09	-0.13	5.03
A 31	11.77	86.74	1.49	0.00	gravelly sand	poor	0.71	1.42	0.09	2.76
B 10	6.76	93.14	0.10	0.00	sand	moderate	0.68	1.09	0.03	2.75
B 25	5.49	93.60	0.91	0.00	sand	moderate	0.95	1.14	-0.17	4.22
B 73	5.25	91.44	3.32	0.00	sand	poor	1.17	1.41	0.00	4.02
C 11	6.19	91.72	2.09	0.00	sand	moderate	1.25	1.36	0.06	2.96
C 18	12.75	85.68	1.37	0.20	gravelly sand	poor	0.63	1.46	0.10	2.94
C 30	7.63	91.86	0.51	0.00	sand	moderate	0.70	1.22	0.08	2.81
m	7.37	87.61	4.81	0.21			1.30	1.46	-0.04	3.47
s	3.52	8.03	7.58	0.43			0.73	0.37	0.14	0.82
min.	0.85	68.80	0.10	0.00			0.63	1.09	-0.38	2.71
max.	12.75	98.53	25.35	1.35			2.62	2.28	0.10	5.03

Coral carpet (17 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_Z	2.mom.	Sk_I	4.mom.
A 13	6.47	91.91	1.62	0.00	sand	poor	1.19	1.44	-0.07	3.08
A 18	0.01	11.29	79.77	8.93	sandy silt	v. poor	5.44	2.33	0.37	6.12
A 29	2.75	44.39	41.17	11.69	sandy silt sand	extr. poor	4.05	3.70	0.07	3.00
B 5	6.80	89.27	3.93	0.00	sand	poor	1.11	1.44	-0.07	4.20
B 7	3.64	54.74	39.09	2.53	siltsand	v. poor	3.37	2.36	-0.14	4.21
B 24	0.96	47.89	44.43	6.73	siltsand	extr. poor	3.99	2.73	0.08	3.95
B 27	2.76	95.42	1.82	0.00	sand	moderate	1.49	1.27	-0.07	2.92
B 31	2.24	77.08	19.21	1.46	silty sand	v. poor	2.40	2.21	0.05	8.19
B 47	1.24	96.97	1.79	0.00	sand	moderate	1.40	1.16	0.05	3.46
B 59	18.25	80.25	1.51	0.00	gravelly sand	poor	0.57	1.56	0.06	2.88
B 61	7.01	91.49	1.50	0.00	sand	moderate	0.92	1.28	-0.01	4.00
B 68	8.30	88.89	2.82	0.00	sand	poor	1.11	1.47	-0.03	2.73
C 25	2.22	95.41	2.37	0.00	sand	moderate	1.55	1.25	-0.05	3.33
C 28	3.27	91.20	5.22	0.31	sand	poor	1.30	1.53	0.21	7.34
C 32	1.05	98.15	0.80	0.00	sand	moderate	1.44	1.04	-0.11	3.48
D 3	15.19	72.84	10.76	1.21	silty-gravelly sand	v. poor	1.24	2.43	0.08	5.88
D 8	2.43	54.33	36.74	6.50	siltsand	extr. poor	3.72	3.00	0.19	5.91
m	4.98	75.38	17.33	2.32			2.13	1.89	0.04	4.39
s	4.90	23.85	22.18	3.62			1.38	0.74	0.13	1.62
min.	0.01	11.29	0.80	0.00			0.57	1.04	-0.14	2.73
max.	18.25	98.15	79.77	11.69			5.44	3.70	0.37	8.19

Tab. 2. Frequency (%) of mean grain size categories, terminology and sorting, as well as mean (M_Z), sorting (2nd moment), skewness (SK_I), and kurtosis (4th moment) of the sediments related to bottom facies. (m = mean value; s = standard deviation)

ment transport — suspension, saltation and surface creep — , cannot be applied to carbonate sediments, which are largely autochthonous. Thus, only the descriptive neutral terms lower, middle and upper population are introduced instead of traction, saltation and suspension population. The data of the populations for the mean curves are documented in Tab. 3.

The curves of '**Rock bottom**' samples (including samples of Sand with macroids) are very similar. They show only a single, well sorted, middle population within a narrow size range (0 – 3 Φ) representing 76 % of the distribution; the portion of the lower (18 %) and upper population (5 %) is small.

In '**Sand with coral patches**' the curves are divided into two groups. The larger group (group A:

Sand (32 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
A 1	2.33	97.05	0.45	0.17	sand	moderate	1.29	1.02	-0.11	4.45
A 7	0.28	99.49	0.06	0.17	sand	mod.well	0.76	0.54	0.05	16.56
A 10	7.28	91.35	1.36	0.00	sand	poor	1.05	1.42	-0.08	3.11
A 15	0.39	89.56	9.05	1.01	sand	poor	2.68	1.40	0.25	18.39
A 20	1.61	75.78	21.01	1.60	silty sand	poor	2.82	1.97	0.02	7.12
B 3	1.68	78.32	17.58	2.42	silty sand	v. poor	2.57	2.33	0.01	7.63
B 11	3.85	94.69	1.46	0.00	sand	moderate	1.32	1.24	0.00	3.02
B 19	12.56	80.45	5.72	1.27	gravelly sand	v. poor	0.92	2.14	0.19	8.35
B 26	1.78	97.50	0.72	0.00	sand	moderate	1.49	1.03	0.02	3.61
B 28	2.47	87.51	8.18	1.84	sand	poor	2.02	1.94	0.14	10.18
B 41	1.00	92.06	5.82	1.13	sand	poor	2.16	1.64	-0.02	13.04
B 57	9.93	86.43	3.64	0.00	sand	poor	1.14	1.59	-0.15	3.24
B 67	8.35	89.28	2.37	0.00	sand	poor	0.96	1.48	0.12	2.69
B 71	0.74	93.78	5.09	0.39	sand	poor	1.93	1.48	-0.03	8.66
B 72	0.01	89.48	9.97	0.53	sand	moderate	2.66	1.30	-0.11	9.87
B 74	7.56	90.13	2.31	0.00	sand	poor	1.51	1.52	-0.36	2.54
C 5	2.48	96.30	1.22	0.00	sand	moderate	1.34	1.20	-0.01	2.93
C 8	0.64	92.84	6.32	0.20	sand	moderate	2.03	1.38	0.11	6.12
C 9	0.03	98.72	1.06	0.20	sand	moderate	1.90	0.88	0.01	3.99
C 10	8.03	86.24	5.53	0.20	sand	poor	1.59	1.70	0.12	4.33
C 13	3.57	93.30	3.13	0.00	sand	poor	1.93	1.47	0.28	2.67
C 16	0.80	95.93	2.98	0.29	sand	moderate	2.25	1.08	-0.19	3.82
C 17	8.30	86.34	5.20	0.16	sand	poor	1.37	1.71	-0.03	4.12
C 19	1.88	90.49	6.77	0.86	sand	poor	2.30	1.47	-0.18	3.28
C 21	0.82	92.96	5.90	0.32	sand	moderate	2.67	1.30	-0.45	10.48
C 22	3.13	92.93	3.95	0.00	sand	poor	1.88	1.48	-0.15	2.63
C 24	1.50	96.46	2.05	0.00	sand	moderate	1.72	1.25	-0.07	2.95
C 31	10.23	89.00	0.77	0.00	gravelly sand	moderate	0.80	1.35	-0.04	2.63
D 1	0.12	99.59	0.29	0.00	sand	well	2.41	0.47	-0.17	12.48
D 2	2.28	95.47	2.25	0.00	sand	moderate	1.22	1.37	0.14	2.71
D 4	10.16	87.05	2.79	0.00	gravelly sand	poor	0.87	1.50	0.03	3.00
D 7	11.37	83.85	4.24	0.53	gravelly sand	poor	1.09	1.70	-0.06	3.10
m	3.97	90.95	4.66	0.42			1.71	1.42	-0.02	6.05
s	3.87	5.82	4.59	0.61			0.62	0.39	0.15	4.27
min.	0.01	75.78	0.06	0.00			0.76	0.47	-0.45	2.54
max.	12.56	99.59	21.01	2.42			2.82	2.33	0.28	18.39

Sand with seagrass (11 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
A 11	2.88	78.56	17.62	0.93	silty sand	poor	2.39	2.00	-0.02	6.78
A 21	3.45	64.61	28.69	3.25	siltsand	v. poor	3.02	2.52	0.01	5.78
A 28	15.71	80.17	4.11	0.00	gravelly sand	poor	0.69	1.72	0.14	3.31
A 32	0.27	94.25	5.38	0.11	sand	moderate	3.15	0.84	-0.14	16.86
B 18	1.82	85.73	11.44	1.01	silty sand	poor	2.38	1.79	-0.07	8.06
B 49	6.12	86.01	6.12	1.75	sand	v. poor	1.78	2.13	-0.13	9.08
B 62	1.78	35.39	55.57	7.26	sandsilt	extr. poor	3.84	3.15	-0.20	4.18
B 75	0.50	96.15	3.34	0.00	sand	moderate	2.26	1.13	-0.29	3.63
C 3	1.19	36.25	53.11	9.45	sandsilt	extr. poor	4.66	2.92	0.12	4.26
C 15	1.84	91.87	5.47	0.83	sand	poor	1.96	1.67	-0.07	10.97
C 26	0.57	85.64	12.27	1.52	silty sand	poor	2.66	1.75	0.09	11.19
m	3.28	75.88	18.47	2.37			2.62	1.97	-0.05	7.65
s	4.24	20.59	18.33	2.99			1.01	0.66	0.13	3.97
min.	0.27	35.39	3.34	0.00			0.69	0.84	-0.29	3.31
max.	15.71	96.15	55.57	9.45			4.66	3.15	0.14	16.86

Seagrass (12 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
A 5	5.66	72.24	20.98	1.12	silty sand	v. poor	2.57	2.21	-0.10	4.10
A 6	0.63	96.44	2.93	0.00	sand	moderate	2.61	0.93	-0.11	5.77
A 19	1.43	70.04	27.07	1.46	siltsand	poor	3.19	1.94	-0.13	9.40
A 25	2.08	72.30	23.56	2.07	silty sand	v. poor	2.90	2.13	-0.13	7.00
A 30	2.33	70.98	24.28	2.42	silty sand	v. poor	3.01	2.19	-0.12	7.92
B 12	1.79	87.95	9.23	1.04	sand	poor	1.60	1.91	0.33	8.78
B 17	0.85	75.03	22.66	1.47	silty sand	poor	2.99	1.86	0.11	7.00
B 48	2.53	74.52	19.02	3.93	silty sand	v. poor	2.77	2.51	0.22	6.40
C 6	0.21	81.56	16.02	2.22	silty sand	poor	3.05	1.80	0.06	11.46
C 7	0.42	61.89	33.90	3.80	siltsand	poor	3.91	1.95	0.35	9.57
C 20	0.43	71.40	27.32	0.86	siltsand	poor	3.21	1.58	0.03	6.97
C 23	1.58	56.38	40.13	1.90	siltsand	v. poor	3.66	2.02	-0.03	7.35
m	1.66	74.23	22.26	1.86			2.96	1.92	0.04	7.64
s	1.42	10.21	9.59	1.10			0.55	0.37	0.17	1.86
min.	0.21	56.38	2.93	0.00			1.60	0.93	-0.13	4.10
max.	5.66	96.44	40.13	3.93			3.91	2.51	0.35	11.46

Tab. 2. continued

Muddy sand (39 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
A 3	3.23	68.20	26.85	1.72	siltsand	v. poor	2.76	2.31	-0.08	7.92
A 4	1.98	62.98	32.93	2.12	siltsand	v. poor	2.98	2.40	-0.11	6.52
A 12	2.17	67.87	27.84	2.12	siltsand	v. poor	2.99	2.23	-0.09	5.53
A 14	0.91	54.84	41.57	2.69	siltsand	v. poor	3.47	2.26	-0.15	4.42
A 16	11.36	71.76	14.33	2.56	silty gravelly sand	extr. poor	1.54	2.64	0.29	6.05
A 22	1.05	37.06	56.89	5.00	sandsilt	v. poor	4.44	2.33	0.08	5.71
A 24	0.48	78.39	19.42	1.71	silty sand	poor	3.02	1.86	0.02	10.13
A 26	0.61	55.64	37.89	5.85	siltsand	extr. poor	3.97	2.61	0.28	6.89
A 27	0.37	73.27	23.72	2.65	silty sand	v. poor	3.14	2.19	0.11	9.44
B 6	0.80	78.62	18.50	2.09	silty sand	poor	2.95	1.91	0.08	8.76
B 8	1.22	75.76	20.23	2.79	silty sand	v. poor	2.96	2.10	0.17	6.75
B 9	0.13	38.23	56.05	5.60	sandsilt	v. poor	4.53	2.14	0.29	7.56
B 15	6.84	69.72	21.33	2.12	silty sand	v. poor	2.37	2.54	0.11	5.56
B 30	2.60	49.80	39.97	7.64	siltsand	extr. poor	3.53	3.13	0.02	3.64
B 32	1.18	28.49	63.24	7.09	sandsilt	extr. poor	4.62	2.81	-0.03	5.38
B 33	1.04	57.35	36.18	5.43	siltsand	extr. poor	3.75	2.66	0.22	5.56
B 34	2.11	41.99	50.79	5.11	sandsilt	extr. poor	3.64	2.91	-0.18	4.16
B 35	0.72	55.35	38.20	5.73	siltsand	extr. poor	3.82	2.71	0.17	7.26
B 36	1.12	56.57	38.02	4.29	siltsand	v. poor	3.70	2.39	0.07	5.29
B 37	1.06	48.82	46.59	3.53	siltsand	v. poor	3.67	2.42	-0.14	4.86
B 38	0.89	59.78	35.34	3.99	siltsand	v. poor	3.62	2.44	0.14	5.94
B 42	1.91	75.31	18.65	4.13	silty sand	v. poor	2.91	2.44	0.15	6.85
B 45	5.78	61.81	26.23	6.18	siltsand	extr. poor	2.64	3.24	0.40	3.59
B 50	0.94	91.63	5.97	1.46	sand	poor	2.03	1.76	0.06	13.00
B 51	7.33	44.85	37.71	10.11	clayey siltsand	extr. poor	3.64	3.82	0.08	3.24
B 52	2.42	47.47	44.08	6.03	siltsand	extr. poor	3.43	3.09	-0.11	3.88
B 53	0.95	38.78	46.33	13.93	clayey sandsilt	extr. poor	4.94	3.42	0.18	3.19
B 54	0.72	50.82	42.61	5.84	siltsand	v. poor	3.91	2.53	0.13	5.27
B 55	1.66	42.51	49.04	6.80	sandsilt	extr. poor	4.26	2.77	0.14	5.93
B 63	1.16	33.62	55.68	9.52	sandsilt	extr. poor	4.16	3.27	-0.14	3.03
B 64	1.83	52.91	38.65	6.61	siltsand	extr. poor	3.38	3.30	0.00	4.68
B 65	0.88	55.03	38.10	5.99	siltsand	extr. poor	3.64	2.78	0.20	5.00
B 66	2.91	67.23	25.23	4.66	siltsand	extr. poor	2.74	3.00	0.08	6.39
B 69	2.06	59.04	33.59	5.32	siltsand	extr. poor	3.70	2.60	0.14	6.25
C 2	0.64	35.79	52.02	11.54	clayey sandsilt	extr. poor	4.71	3.18	0.08	3.28
C 4	1.44	62.96	32.38	3.23	siltsand	v. poor	3.51	2.17	0.07	6.18
C 12	1.53	73.19	24.39	0.89	silty sand	poor	2.94	1.80	-0.08	6.37
C 14	3.97	43.14	49.16	3.73	sandsilt	extr. poor	3.59	2.66	-0.22	4.41
D 9	1.59	24.91	63.18	10.33	clayey sandsilt	extr. poor	5.15	3.29	0.20	5.12
m	2.09	56.19	36.64	5.08			3.51	2.62	0.07	5.87
s	2.20	15.29	13.69	2.93			0.76	0.48	0.14	2.01
min.	0.13	24.91	5.97	0.89			1.54	1.76	-0.22	3.03
max.	11.36	91.63	63.24	13.93			5.15	3.82	0.40	13.00

Mud (14 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
B 13	1.37	44.70	44.12	9.81	siltsand	extr. poor	4.27	3.30	0.08	3.26
B 14	0.03	4.91	21.32	2.12	clayey silt	v. poor	6.12	2.17	0.41	4.94
B 16	0.10	9.78	79.17	10.95	clayey silt	v. poor	5.86	2.55	0.41	5.63
B 20	2.10	55.50	35.98	6.42	siltsand	extr. poor	3.94	2.69	0.48	4.90
B 21	0.00	20.24	70.94	8.81	sandy silt	v. poor	5.22	2.44	0.43	6.89
B 22	0.13	4.78	82.63	12.47	clayey silt	v. poor	6.19	2.16	0.46	4.72
B 23	2.27	24.03	55.82	17.88	clayey sandsilt	extr. poor	5.81	3.42	0.06	2.67
B 43	0.00	5.30	81.39	13.31	clayey silt	v. poor	6.20	2.35	0.45	4.91
B 44	0.30	3.69	80.52	15.49	clayey silt	v. poor	6.54	2.33	0.50	4.25
B 46	0.32	4.35	80.90	14.43	clayey silt	v. poor	6.43	2.44	0.48	4.76
B 58	0.02	10.15	76.23	13.60	clayey sandy silt	v. poor	6.07	2.55	0.43	4.51
B 70	0.00	8.37	75.06	16.57	clayey silt	extr. poor	6.49	2.67	0.44	3.75
D 5	0.54	27.18	64.27	8.01	sandsilt	extr. poor	4.85	2.69	0.15	5.87
D 6	0.10	11.21	76.20	12.50	clayey sandy silt	extr. poor	5.80	2.79	0.41	5.53
m	0.52	16.73	66.04	11.60			5.70	2.61	0.37	4.76
s	0.76	15.56	18.74	4.11			0.79	0.36	0.15	1.04
min.	0.00	3.69	21.32	2.12			3.94	2.16	0.06	2.67
max.	2.27	55.50	82.63	17.88			6.54	3.42	0.50	6.89

Tab. 2. continued

9 samples) is characterized by a very large, fairly sorted lower population (80 % of the distribution), a well sorted middle population (18.5 %) and a fairly sorted upper population (1.5 %). Group B (comprising only 2 samples: A 8, A 23) is quite different, with a poorly sorted middle population of 57 % and a poorly sorted lower population of 40 %. The upper population is twice as large as in group A and very poorly sorted. Whereas the fine truncation point of the middle population of group A occurs in fine sand (4 Φ), that of group B lies in medium silt (6.2 Φ).

The **'Sand'** samples are also clearly divided into two groups. Group A (20 samples) again has a large, fairly sorted, lower (62 %) and a single, well

BOTTOM FACIES		LOWER POPULATION		MIDDLE POPULATION										UPPER POPULATION	
				First				Second			Third				
		%	So	%	So	C.T.ϕ	F.T.ϕ	%	So	F.T.ϕ	%	So	F.T.ϕ	%	So
Rock bottom		18	+	76	++	0	3							5	-
Sand with coral patches	a	80	+	18.5	++	2.4	4							1.5	+
	b	40		57		2	6.2							3	
Sand	a	62	+	33	++	2	3.5							5	+
	b	30		61	+	1.5	4	6.8		6				2.2	
Coral carpet	a	70	+	24	+	2	3.2							6	+
	b	32	+	33		1.2	4	27		6.7				8	
Sand with seagrass		45	-	32	+	2.5	3.7	19		6.8				4	
Seagrass		4		32		0	2.5	43	+	4.2	17.5		6.3	3.5	
Muddy sand		11		28		0.5	3	61		6.5				10	
Mud		12		58		3.5	6.5	10	+	7				20	

- = poor = very poor + = fair ++ = good a = group A b = group B
so = sorting C.T. = coarse truncation point F.T. = fine truncation point

Tab. 3. Grain size characteristics according to VISHER (1969) related to bottom facies

sorted, middle population (33 %) with a fine truncation point in very fine sand (3.5 Φ). Group B (12 samples) has a poorly sorted lower population of only 30 %, but a middle population containing two sub-populations. The first sub-population (between 1.5 and 4 Φ) is fairly sorted and represents 61 %, the second one represents only 6.8 % and is very poorly sorted. Whereas in group A the upper population is fairly sorted and contains 5 % of the distribution, in group B it is only 2.2 % and very poorly sorted; the fine truncation point of the (finest) middle population is at 3.5 Φ in group A and at 6 Φ in group B.

As also demonstrated in the triangular diagrams (Fig. 9), the dispersion of the '**Coral carpet**' samples is high; nevertheless, two separate groups of cumulative curves can be distinguished. Group A contains a large lower population (70 %), a single middle population of 24 % and an upper population of 6 %; all populations are fairly sorted. Group B has a smaller lower population (32 %) and a middle population with two similar-sized sub-populations (33 %, 27 %); both are poorly sorted. The upper population is larger (8 %) than in group A and is very poorly sorted. The variance of the percentage of the upper population is high (approx. 5 – 15 %). The truncation point of the (finest) middle population is at 3.2 Φ and 6.7 Φ.

The curves of '**Sand with seagrass**' are not only widely spread but also differ in shape. A clear separation into groups is not possible. However, all curves show two middle sub-populations, the first (32 %) fairly, the second (19 %) poorly sorted. The lower population represents 45 %, the upper 4 %; the former is poorly, the latter very poorly sorted.

Except for one sample (A 6), the curves of the '**Seagrass**' bottom facies are very similar in the presence of three sub-populations in the middle population; the latter contains > 90 %. The lower, poorly sorted, population represents only 4 % of the distribution. The first sub-population (32 %) ranges between coarse and fine sand (0 – 2.5 Φ), the largest, second sub-population (43 %), mainly fine and very fine sand, is the only fairly sorted one, and the third sub-population (17.5 %) reaches down to medium silt. The small upper population (3.5 %) is very poorly sorted.

The '**Muddy sand**' samples are characterized by 4 populations, and the distribution of the curves is relatively homogeneous. All populations are poorly sorted, except the upper which is very poor. Clearly dominant is the second middle sub-population (61 %), ranging between very fine sand and medium silt (3 – 6.5 Φ). The lower population comprises 11 % and the first middle sub-population 28 %; the latter ranges between 0.5 – 3 Φ. The upper population represents 10 %.

All samples of the '**Mud**' bottom facies have four populations: a very poorly sorted lower one (12 %), an also very poorly sorted first middle sub-population containing 58 % of the distribution, a fairly sorted second middle sub-population, and a very poorly sorted upper population of 20 %. Most characteristic is the size range of the populations, as the middle populations range between 3.5 and 7 Φ (very fine sand to medium silt), with only the 12 %

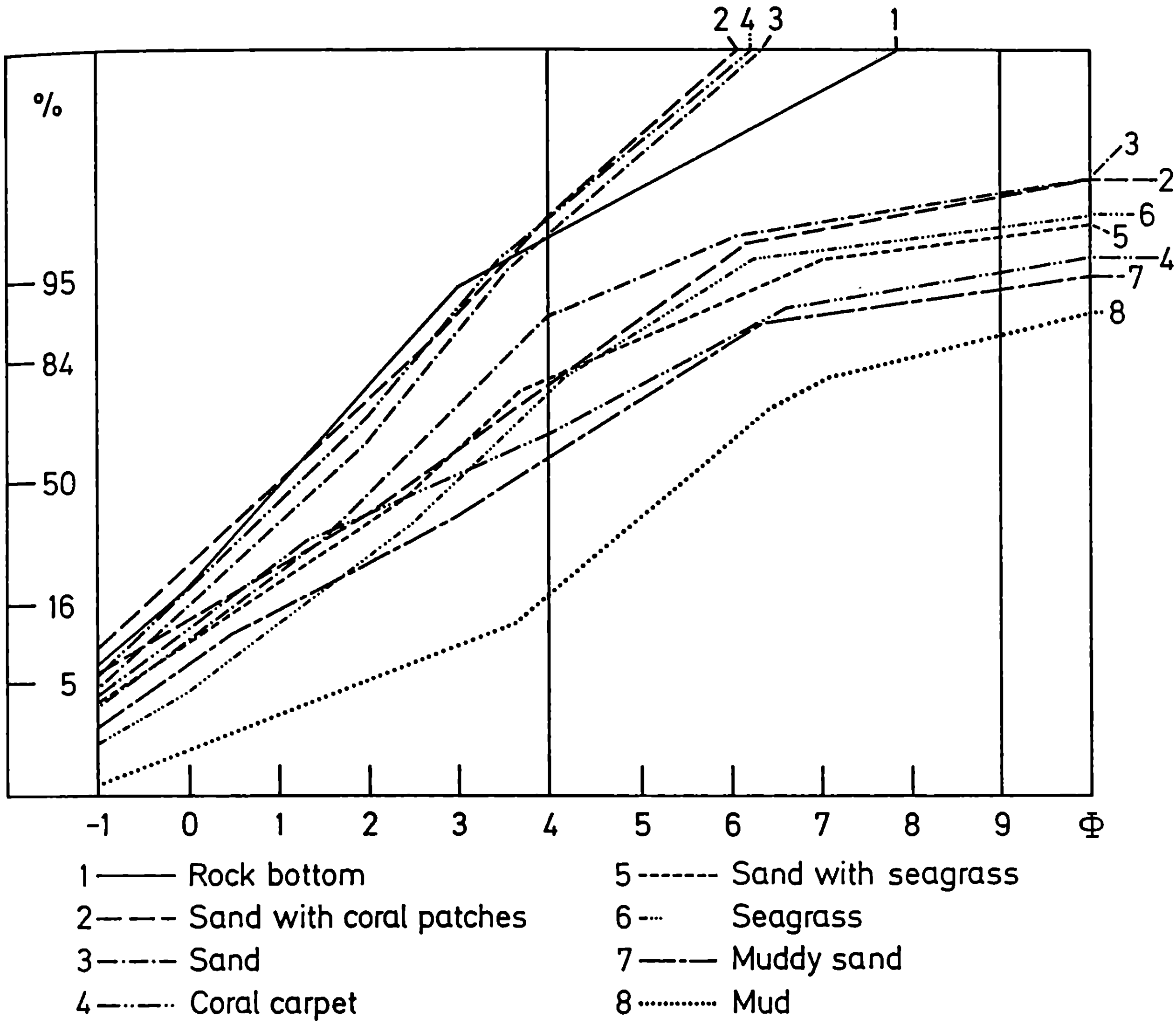


Fig. 11. Mean cumulative grain size frequency curves plotted on probability paper of sample groups related to bottom facies.

of the lower population containing grain sizes coarser than very fine sand.

Comparing the mean curves of the bottom facies reveals 3 (or 4) groups (Fig. 11):

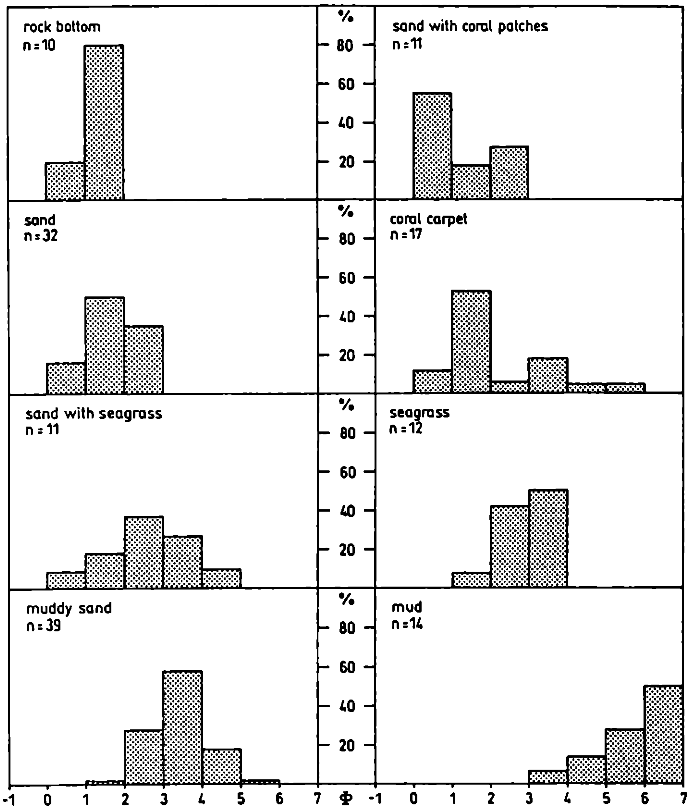
Group 1 combines the samples of **'Rock bottom'** and those of group A of **'Sand with coral patches'**, **'Sand'**, and **'Coral carpet'**; however, 'Rock bottom' shows some deviations and therefore could be separated as an individual group. All curves are composed of three populations, with a lower population including 62 to 80 % of the distribution, except that of 'Rock bottom' (only 18 %). Sorting of all lower populations is fair, that of the middle populations is good to fair. The fine truncation point of the middle population lies between 3 and 4 Φ, and the coarse truncation point between 2 and 2.4 Φ, except for 'Rock bottom' (0 Φ).

Group 2 includes the samples of **'Sand with seagrass'**, **'Seagrass'**, and **'Muddy sand'** as well as those of group B of **'Sand with coral patches'**, **'Sand'**, and **'Coral carpet'**. Although most characteristics of the mean curves are highly variable, the most unifying one is the fine truncation point of the (finest) middle population. It consistently lies between 6 and 6.8 Φ (Tab. 3) and separates this group from group 1.

Group 3 consists exclusively of the samples of **'Mud'** bottom facies and is separated from groups 1 and 2 by a very high (3.5 Φ) coarse truncation point of the middle population, a high amount of the upper population (20 %), and a very poorly sorted lower population and first middle sub-population.

4.4.3 Distribution of grain size parameters

The frequency of the **Mean** values (M_Z) (Fig. 12) shows a unimodal distribution in most of the bottom



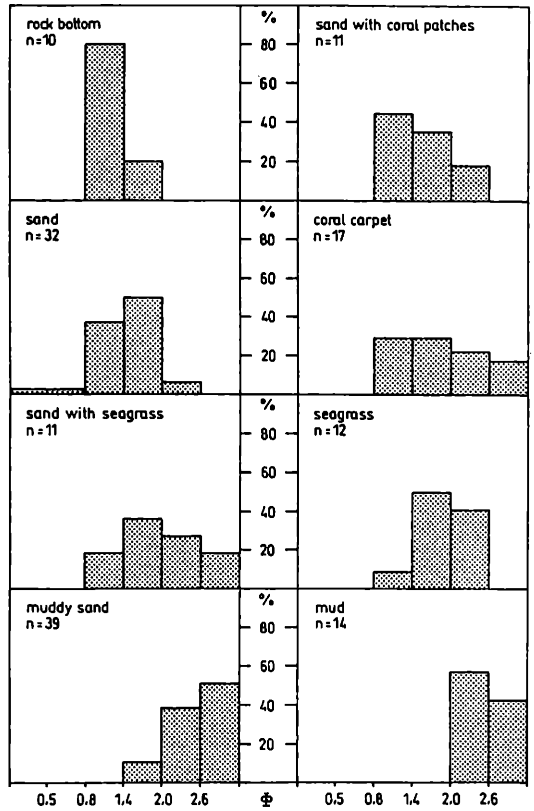
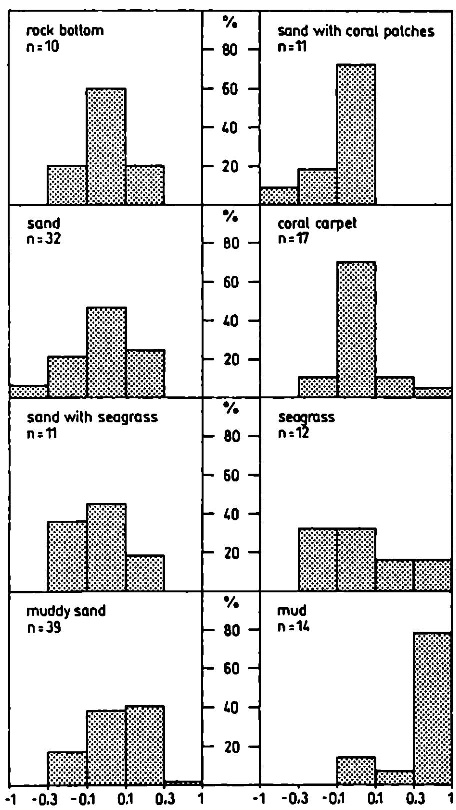


Fig. 12. Distribution of mean grain size (M_Z) related to bottom facies.
Fig. 13. Distribution of sorting (2nd moment) related to bottom facies.



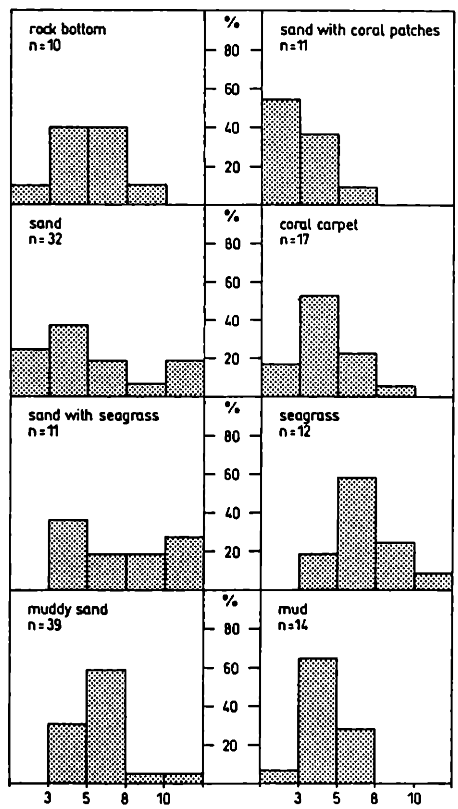


Fig. 14. Distribution of skewness (SK_I) related to bottom facies.
Fig. 15. Distribution od kurtosis (4th moment) related to bottom facies.

BOTTOM FACIES	GRAIN SIZE PARAMETERS															
	M_Z Φ				sorting (2nd mom.)				Sk_I				kurtosis (4th mom.)			
	mean	st.d.	min.	max.	mean	st.d.	min.	max.	mean	st.d.	min.	max.	mean	st.d.	min.	max.
Rock bot.	1.08	0.38	0.10	1.55	1.30	0.10	1.13	1.47	0.01	0.10	-0.13	0.20	5.32	2.07	2.93	9.63
S.patches	1.30	0.73	0.63	2.62	1.46	0.37	1.09	2.28	-0.04	0.14	-0.38	0.10	3.47	0.82	2.71	5.03
Sand	1.71	0.62	0.76	2.82	1.42	0.39	0.47	2.33	-0.02	0.15	-0.45	0.28	6.05	4.27	2.54	18.39
Coral c.	2.13	1.38	0.57	5.44	1.89	0.74	1.04	3.70	0.04	0.13	-0.14	0.37	4.39	1.62	2.73	8.19
S. seagr.	2.62	1.01	0.69	4.66	1.97	0.66	0.84	3.15	-0.05	0.13	-0.29	0.14	7.65	3.97	3.31	16.86
Seagrass	2.96	0.55	1.60	3.91	1.92	0.37	0.93	2.51	0.04	0.17	-0.13	0.35	7.64	1.86	4.10	11.46
M. sand	3.51	0.76	1.54	5.15	2.62	0.48	1.76	3.82	0.07	0.14	-0.22	0.40	5.87	2.01	3.03	13.00
Mud	5.70	0.79	3.94	6.54	2.61	0.36	2.16	3.62	0.37	0.15	0.06	0.50	4.76	1.04	2.67	6.89

Tab. 4. Grain size parameters related to bottom facies.

facies except for that of 'Sand with coral patches' and 'Coral carpet' The lowest mean of M_Z, together with the lowest standard deviation, is found in 'Rock bottom' (including samples of Sand with macroids) (Tab. 4). Although the samples from the latter do not contain macroids they include the coarsest sediments. Increasing mean M_Z values are observable in the sequence 'Rock bottom', 'Sand with coral patches', 'Sand' bottom facies, 'Coral carpet', 'Sand with seagrass', 'Seagrass' bottom facies, 'Muddy sand', to 'Mud' bottom facies (Fig. 12, Tab. 2). However, as mentioned, in 'Sand with coral patches' and in 'Coral carpet' the distribution of the mean M_Z values is bimodal. In the former, the main cluster of M_Z values is between 0 and 1 Φ (coarse sand) and the second, smaller one, between 2 and 3 Φ (fine sand) (Fig. 12). In the latter, the first and larger cluster occurs between 1 and 2 Φ (medium sand), the second, distinctly smaller one between 3 and 4 Φ (very fine sand) (Fig. 12).

Although **sorting** of the bay sediments is generally poor, certain differences between the bottom facies exist (Fig. 13). Table 4 shows that the mean value for 'Rock bottom' represents moderate sorting. 'Sand with coral patches', 'Sand', 'Coral carpet', 'Sand with seagrass', and 'Seagrass' bottom facies, with values between 1.4 and 2 Φ, are poorly sorted. The mean values for 'Muddy sand' and 'Mud' bottom facies are > 2.6 Φ, reflecting extremely poorly sorted sediments. Whereas in most of the bottom facies the variance of the values of the 2nd moment is distributed in 3 or 4 categories (Fig. 13), in 'Rock bottom' and 'Mud' only two categories are present. In the former, only moderately sorted and poorly sorted sediments occur, in the latter, very and extremely poorly sorted ones. 'Sand' is the only bottom facies exhibiting 5 categories; nevertheless, the standard deviation of the samples is low. The highest variance in sorting occurs in 'Coral carpet' and 'Sand with seagrass'; this coincides with the results of the distribution of the mean values (Tab. 4).

Although the mean values of **skewness** (SK_I) (Tab. 4) of the various bottom facies are, with the exception of 'Mud', very similar and symmetrical, the distribution of the samples shows certain differences (Fig. 14): very negatively skewed sediments occur only in 'Sand with coral patches' and 'Sand', whereas in 'Mud' no negatively skewed samples are present. The very high amount of very positively skewed samples in 'Mud' (> 70 %, mean 0.37) is remarkable.

The mean values of **kurtosis** (4th moment) show the most leptokurtic distributions in 'Sand with seagrass' and 'Seagrass' (Tab. 4); the highest minimum values also occur in these two groups. The lowest mean value combined with the lowest standard deviation is present in 'Sand with coral patches'; 'Coral carpet' and 'Mud' exhibit low kurtosis values as well.

4.5 Summary of results

The distribution of grain size parameters partly reflects the bottom morphology of the bay as fine-grained, very to extremely poorly sorted, positively skewed sediments generally occur in basinal areas deeper than 20 m. The distribution of the coarsest sediments is not directly related to shallow water or to high water movement (neither waves nor currents) (compare with Fig. 5 in PILLER & PERVESLER, 1989). Well and moderately well sorted sediments are very scarce and restricted to the coast; moderately sorted sediments are widely distributed, but do not exhibit a simple relation to bottom morphology. A correlation to water movement is suggested because not only areas near the coast with higher wave energy, but also those with stronger water currents (Fig. 5 in PILLER & PERVESLER, 1989) range in this category. These are the submarine ridges between Ras Abu Soma and Tubya al-Kabir, between Tubya al-Bayda and Gazirat Safaga, and the shallow submarine platform with Tubya al-Kabir, Tubya al-Saghira, Gamul al-Saghira, and Gamul al-Kabir, as well as the area between Ras Abu Soma and Tubya al-Hamra. A good positive correlation between extremely poor sorting and bottom morphology exists in those areas where basins are sharp-bordered by steep-walled topographic highs; sediment- and rock-fall probably causes this bad sorting. The distribution of skewness, except the very positively skewed samples of the 'West area' basin, cannot be explained by bottom morphology or physical factors alone. The occurrence of some of the most leptokurtic samples along the coast may be caused by wave action, although other very leptokurtic samples also occur in deeper and quiet water ruling out such a simple explanation. Generally, on the base of kurtosis, a differentiation of the relatively better sorted sediments is possible: those better sorted samples, being leptokurtic, originate from coastal areas with high wave energy, whereas those of the submarine ridges exhibit low kurtosis values.

Although nine clusters were distinguished by cluster analysis, a classification of the sediments into four groups can be deduced. Similar to the distribution of the grain size parameters, the fine-grained sediments (cluster 1 and 2) are generally restricted to the basinal areas and the 'Southwest channel', although cluster 2 is also very widespread in some shallow water areas. A differentiation of the coarser sediments by grain size was not possible as is expressed by the wide distribution of the fourth group composed of clusters 6, 7 and 8.

Finally, on the base of grain size alone it is neither possible to explain the depositional environment nor is it possible to reconstruct the various bottom facies in the investigated area. These general results coincide well with the conclusions of MONTAGGIONI et al. (1986, p.148).

Very interesting results were obtained by working the opposite direction: characterizing the bottom facies by various grain size parameters. A comparison of the main grain size categories (gravel, sand, mud) shows that **'Rock bottom'**, **'Sand with coral patches'** and **'Sand'** are very similar in being composed mainly of sand with only little variance. The **'Coral carpet'** and **'Sand with seagrass'** samples are the most variable. This coincides well with the field observations, especially in the case of 'Coral carpet' where, between areas dominated by corals and other larger organisms, patches or troughs of finer grained sediment occur (PILLER & PERVESLER, 1989). Fine-grained sediments are not only present in **'Muddy sand'** and **'Mud'** but also in **'Seagrass'** bottom facies, representing the retention of fine fraction by the plants.

The cumulative curves can be subdivided into three groups; the two larger groups do not correspond to individual bottom facies, with some bottom facies ('Sand with coral patches', 'Sand', 'Coral carpet') occurring in both groups (Fig. 11). For 'Sand with coral patches' and 'Coral carpet' this separation coincides with field observations, because the sediment grain size decreases with increasing distance from coral patches or larger frame-builders. For the 'Sand' samples, a greater variability was visible in the field, although generally not a clear separation into two (grain size determined) groups. However, comparing the localities of the fine-grained group of the 'Sand' samples clearly shows that they originate either near seagrass meadows or from large sand areas in 'Coral carpet'; they may also be transitional to 'Muddy sand', as is also evidenced by the occurrence of enteropneusts mounds. The difficulties in separating "pure sands" and 'Muddy sand' in the field was also mentioned by PILLER & PERVESLER (1989, p. 115). Only the 'Mud' bottom facies is clearly separated, whereas 'Muddy sand' is grouped together with 'Seagrass', 'Sand with seagrass' and the finer grained groups of 'Sand with coral patches', 'Sand' and 'Coral carpet'

The comparison of grain size parameters with bottom facies supports some of the results obtained by the other methods. The distribution of the mean values, for example, exhibits a bimodal distribution for 'Sand with coral patches' and 'Coral carpet' as shown also by the cumulative curves, but not for 'Sand'; the separation of the 'Mud' samples is also clearly reflected in the distribution of mean values, but also in sorting and skewness. Sorting is not a very useful parameter in characterizing the bottom facies, except in separating 'Rock bottom' from 'Mud'; as far as skewness is concerned, only 'Mud' is clearly distinct from the other facies. 'Sand with seagrass' and 'Seagrass' are relatively clearly separated from the other groups by the highest kurtosis values (Tab. 4). This high kurtosis, based mainly on the predominance of fine and very fine sand fractions, seems to suggest a size filtering action of the seagrass, although such an effect was not supported by the investigations of ALMASI et al. (1987).

A comparison of the map of the group distribution obtained by cluster analysis (Fig. 8) and the bottom facies map (PILLER & PERVESLER, 1989, enclosure 1; Fig. 54) reveals that cluster 1 comprises 'Mud' and most 'Muddy sand' areas. Besides the remaining 'Muddy sand', cluster 2 coincides in general with seagrass areas. Group 3 (comprising the "sand clusters") shows a weak correspondence with 'Sand'; all other bottom facies are combined in group 4.

In conclusion, grain size analysis produces some remarkable results with a few parameters being able to characterize some bottom facies (e.g., 'Mud' bottom is clearly separated by a high M_Z value and a high percentage of the upper grain size population;

'Sand with seagrass' and 'Seagrass' are characterized by high kurtosis values). However, only strongly hydrodynamically determined distributions can be explained.

5 Component analysis

5.1 Methods

The compositional analysis has been carried out on 122 samples, including the coarsest seven fractions (> 250 μm = 2 Φ) resulting from wet sieving for grain size analysis. This grain size represents the lower limit at which particles could be identified with a high probability using a binocular microscope. The percentage of these fractions related to total sediment volume is highly variable in the samples (chapter 4). Taking only gravel and sand (> 0.063 μm) as a base for the computation, the percentage of the > 250 μm fraction ranges between 4 and approx. 98 %. As demonstrated in Fig. 16, > 250 μm fraction represents more than 70 % of the samples around the Tubya islands and their southward submarine continuation to the shallow water area north of Gazirat Safaga, on the submarine ridge south of Ras Abu Soma and its southward shallow water continuation, as well as in isolated samples scattered over the bay. The lowest percentages (< 30 %) are in the 'West area' basin, in the northern basin of the 'East area', in coastal areas dominated by fine sand, as well as in some isolated areas.

In order to obtain statistical validity, the first two fractions (> 2 mm and 2 – 1.5 mm) of each sample were completely analysed; they were mostly present in small amounts. The smaller fractions were reduced using a microsplitter. The minimum number of grains counted was 250. This 250 grain minimum is sufficient for statistical reliability (UJIIE, 1962).

The diversity of different grains was classified into 16 categories (see chapter 5.2). The grains of each category in each fraction were collected together and weighed; the values were then calculated as weight percentages (Appendix 3). The 16 grain categories were also taken as variables in the cluster analyses (Chapters 5.4 and 8).

5.2 Component categories

Foraminifers were separated into three groups according to the main test wall structures. **Agglutinated foraminifera** are mostly smaller than 250 μm; only large specimens of the genera *Textularia* and *Spiroplectammina* range in this size category. **Miliolina** are represented with 'larger' forms by two genera of soritines, *Sorites* and *Amphisorus*, by *Borelis*, and by peneroplids (according to HOTTINGER, 1977, and REISS & HOTTINGER, 1984).

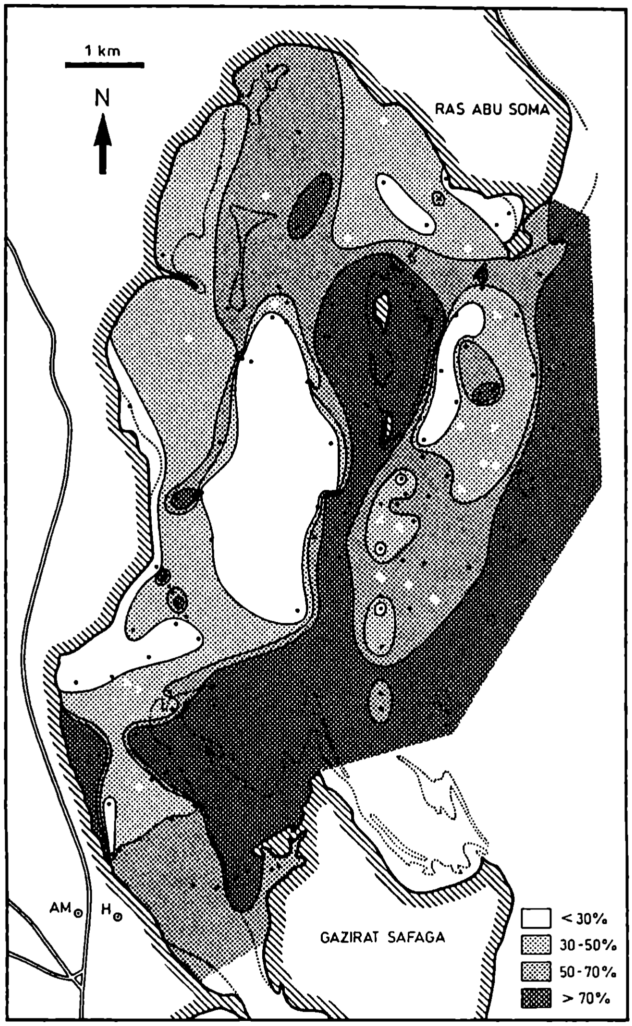


Fig. 16. Distribution of the grain size fraction > 250 μm.

'Smaller' porcellaneous forms are only present in the investigated size fraction in subordinate quantities. 'Larger' **hyaline foraminifera** include *Amphistegina*, *Operculina* and *Heterostegina*, while 'smaller' ones are represented by rotaliids (e.g., *Ammonia*), cibicidids (especially *Planorbulinella*), and elphidiids. Cemented sessile forms are of subordinate importance as individual particles because they mainly occur together with their substrate and were therefore not separated (see below).

Sponge remnants occurred exclusively as siliceous spicules, yet only in very small quantities in a few samples.

Corals: this category encompasses all remnants of Coelenterata. The by far highest percentage are scleractinians and their fragments; hydrozoans (*Millepora*) are extremely rare as are *Tubipora* fragments. Although sometimes relatively abundant, alcyonarian spicules were not classified separately.

Molluscs were predominantly represented by gastropod and bivalve shells. In some samples, scaphopods were abundant. Extremely rare are chiton fragments.

Although relatively uncommon, the category **worm tubes** was distinguished in order to represent irregularly coiled serpulid tubes.

The category **Crustacea** mainly includes remnants of Decapoda (mostly parts of pincers); ostracods are fairly rare; balanid fragments occur only in negligible quantities.

Echinoderms are represented mainly by echinoids (very small coronae, isolated plates of coronae, spines) and by elements of ophiurids. Holothurian ossicles are extremely rare in the studied fractions.

Vertebrates were present in the investigated samples only in the form of fish teeth (very small quantities; Appendix 3).

Calcareous algae are represented only by Rhodophyta and Chlorophyta. *Padina*, although frequently observed in the field (PILLER & PERVESLER, 1989), was lacking in the sediment samples. **Rhodophyta** are documented only by Corallinaceae. They include mainly crust fragments and branches (or parts of them) of nongeniculate forms. Geniculate Corallinaceae were not observed in the samples. Among the **Chlorophyta** only Codiaceae were found and represented exclusively by the genus *Halimeda*.

The category **plants**, i.e., higher plants, includes seagrass (leaves or rhizome sections) and — very rare — remnants of the mangrove plant *Avicennia marina*.

Pellets were present in only very low percentages. This category includes ovoidal grains of different origin, partly representing fecal pellets, partly probably also micritized grains. Ooids were observed in very small quantities and are also included here.

The category **compound grains** is inhomogeneous: aggregates of grains of different origin. One genetic group is represented by aggregates sensu MILLIMAN (1974) and FLÜGEL (1982) including grapestones and lumps; another group is formed by fragments of agglutinated tubes of sediment inhabiting organisms. In some samples, fragments of beachrock or of the underlying coral limestone may also be included. A clear distinction of these subgroups was not always possible, leading to the fusion into one group.

The category **quartz** includes all single noncarbonatic grains. They are represented mainly by quartz and only to a lesser degree by feldspars. Additional minerals were not observed.

The same problems as cemented sessile foraminifers present other sessile organisms. This is especially true in the case of Bryozoa, which were found exclusively as encrusting colonies; only in rare cases colony fragments were found as particles. Fusion with their substrate prevented separate weight determination. Thus, Bryozoa were not elevated to a separate category in this study. Other — separated — groups also contain cemented sessile forms (e.g., worm tubes, vermetid gastropods, balanids, as well as coralline algae); these attached forms were only weighed when their weight was obviously higher than that of the substrate.

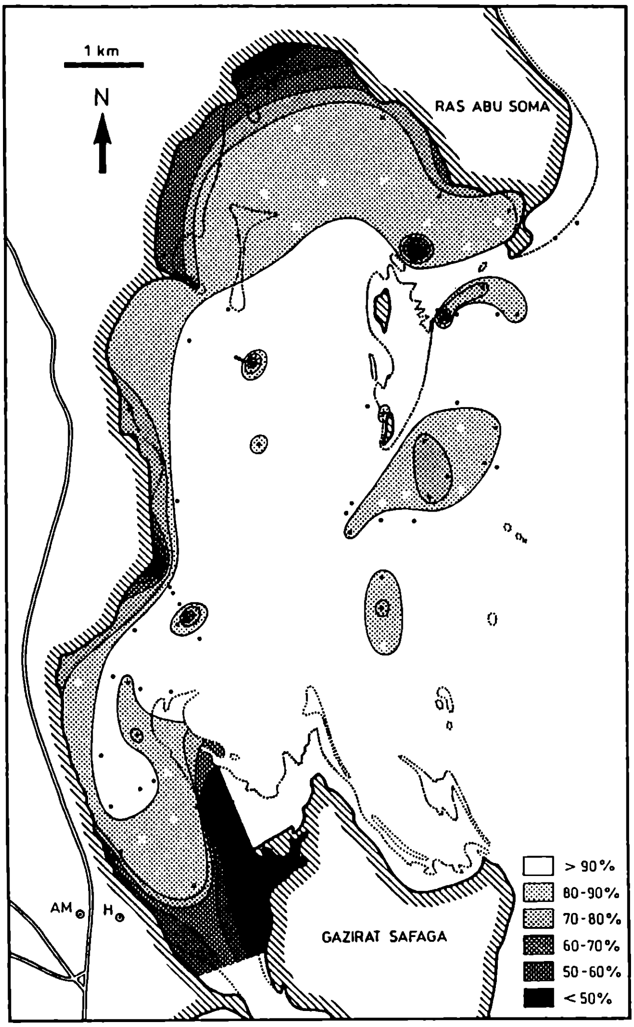


Fig. 17. Frequency distribution of skeletal components (> 250 μm).

A very interesting group of particles is represented by dark stained grains which may be interpreted as relict grains. Similar components are reported from various localities, e.g., the Persian Gulf (SARNTHEIN, 1971), where they can contribute remarkable amounts to the sediment. In the now studied material no clear determination and separation of these grains was possible and therefore no separate category was established; their investigation will be the subject of future studies.

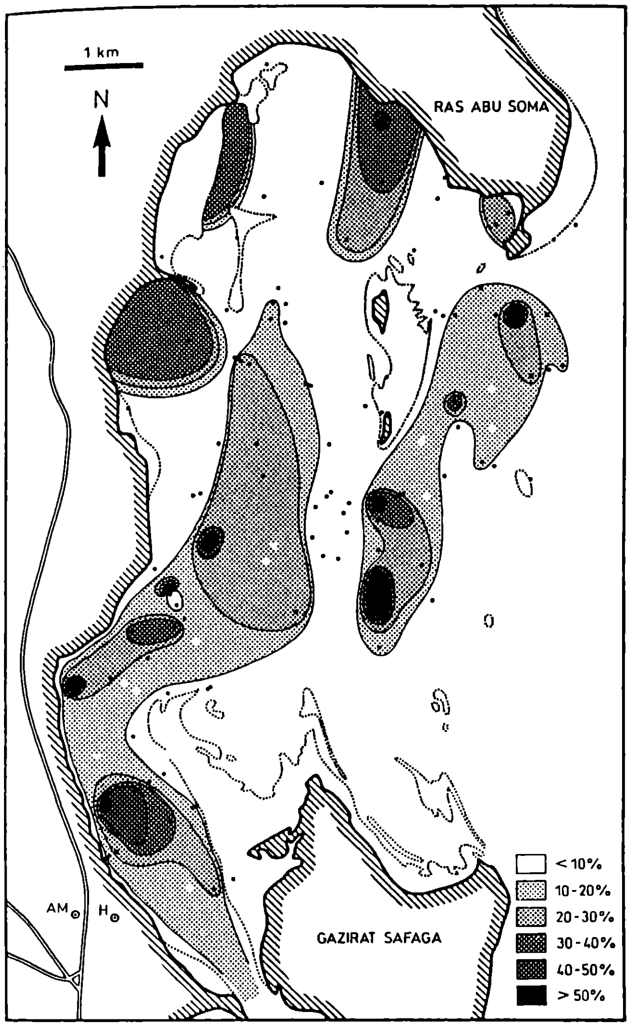


Fig. 18. Frequency distribution of foraminifers (> 250 μm).

Fig. 19. Frequency distribution of miliolid foraminifers (> 250 μm).

5.3 Distribution of particles (> 250 μm)

Thirteen of the 16 distinguished grain categories represent skeletal particles. The total amount of skeletal particles and their distribution is therefore of particular interest. As shown in Figure 17, the sediments of the main part of the bay are composed of more than 90 % skeletal particles, only 8 samples (A 1, A 7, A 9, A 10, C 9, C 11, C 13, C 24) contain less than 50 %. The amount of skeletal particles generally decreases towards the coast (Fig. 17), producing a relatively small strip with < 90 % along the 'West area' coast and the northern west coast of the 'Southwest channel' The southern 'Southwest channel' as a whole is less rich in skeletal particles again, with very low amounts directly along the coast (A 7: ca. 11 %) and in the intertidal area west of Gazirat Safaga (A 9: ca. 8 %, A 10: ca. 9 %). Almost the entire 'North area' has a percentage < 90 %. Remarkable are the three larger areas with lower values in the deeper parts of the 'East area', whereas a few additional lower values in deeper water occur only in isolated samples.

Of the 16 grain categories, sponges, worm tubes, vertebrates, plants, and pellets occur in such small quantities (comp. Appendix 3) that their general distribution is not discussed.

5.3.1 Distribution of foraminifers

The amount of foraminifers is highly variable, ranging from < 1 % up to more than 60 % of the fraction > 250 μm. The average amount makes this organism group the second most abundant of all particle categories. Pooling all three foraminiferal groups reveals a distribution pattern clearly related to bottom topography: on the one hand, the basins and the 'Southwest channel' exhibit a percentage > 10 % and, on the other, so do some clearly delineated, flat, shallow water areas (Fig. 18). Whereas 'West area' basin samples have values below 30 % (except B 38: 41 %) 'East area' values — especially in the southern basin — reach more than 60 %. In the 'Southwest channel', two areas have higher amounts, one in the

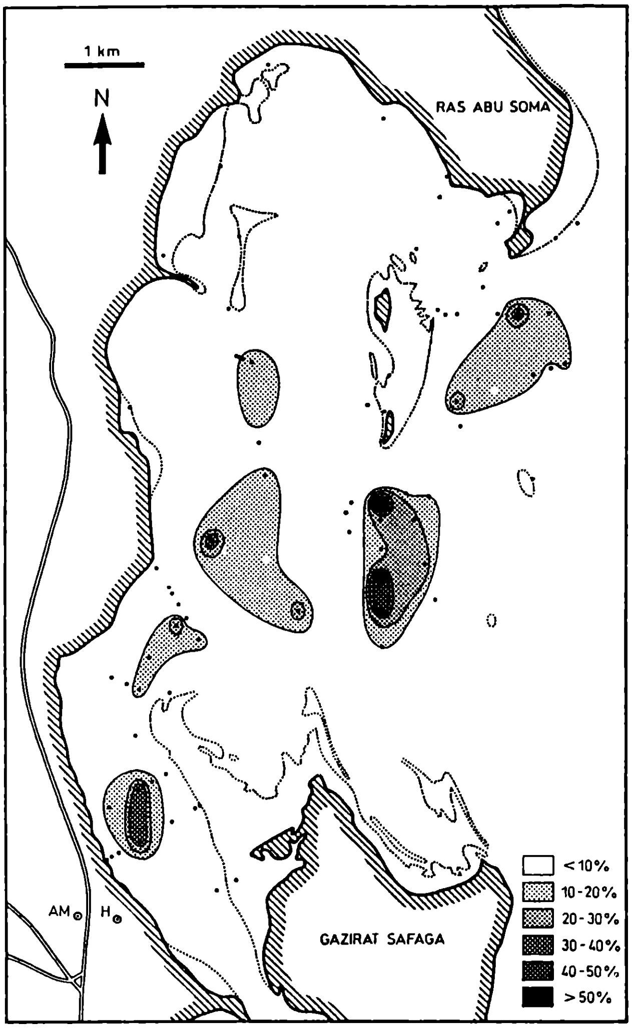


Fig. 20. Frequency distribution of hyaline foraminifers (> 250 μm).

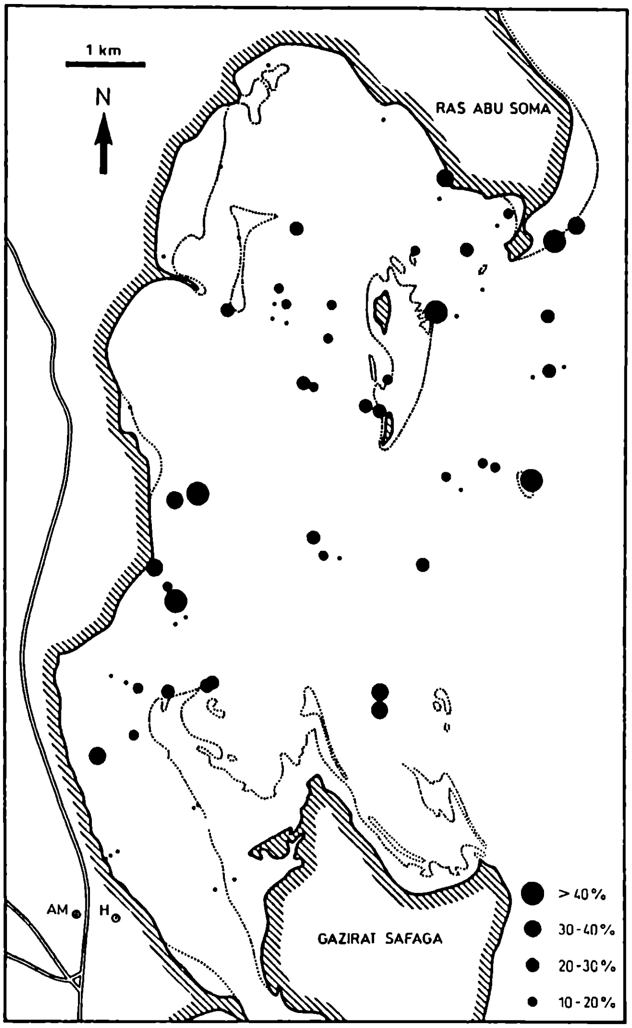


Fig. 21. Frequency distribution of corals (> 250 μm).

north closer to the northwest coast and the other in the southern part closer to the west coast. The distinct shallow water areas with higher percentages are in the 'West area' west of the basin and in the 'North area' between the intertidal ridge north of Al-Dahira and the west coast, in the centre of this area between Tubya al-Hamra and the main coast, and in the little bay west of Ras Abu Soma.

Least abundant are **agglutinated foraminifers**; they mainly range below 1 % and reach more than 5 % only in a few samples (A 18, B 6, B 8, B 14, B 18, B 32, B 70, C 4, C 26), never exceeding 10 % (Appendix 3). The higher values are found in basinal samples.

The two abundant groups nearly exclude one another. The **miliolid foraminifers** (Fig. 19) are generally more abundant in shallow water such as in the 'North area', west of the 'West area' basin, near the northwestern coast of the northern 'Southwest channel' and in its southern part. Only a single sample with a greater amount of miliolids originates from water deeper than 30 m (C 2: 19.89 %). In contrast, **hyaline forminifers** reach their highest values in the southern basin of the 'East area' (nearly 60 %), but are also abundant in its northern basin, in the 'West area' basin and in the deeper parts of the 'Southwest channel' (Fig. 20). Only very few samples exhibit moderately high values of both miliolids and hyaline forms (A 4, A 15, C 2; Appendix 3).

5.3.2 Distribution of corals

Although dominant (> 50 %) in some samples, corals are very patchily distributed over the bay; therefore their frequency is demonstrated by frequency dots rather than by an isoline map (Fig. 21). This patchiness makes a general statement about distribution nearly impossible on the basis of the available samples. Only in five samples (A 28, B 10, B 68, B 73, C 28) do coral fragments represent more than 40 % of the fraction > 250 μm. Of these, three samples — from east of Ras Abu Soma, east of Tubya al-Kabir and from the northern end of the 'Southwest channel' — contain more than 50 %. Larger continuous

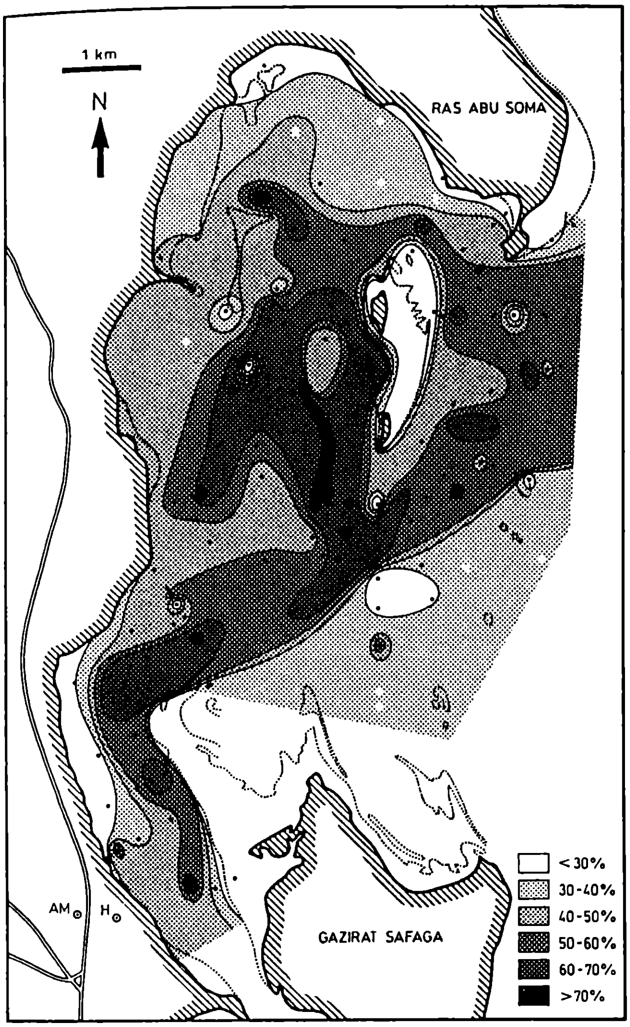


Fig. 22. Frequency distribution of molluscs (> 250 μm).

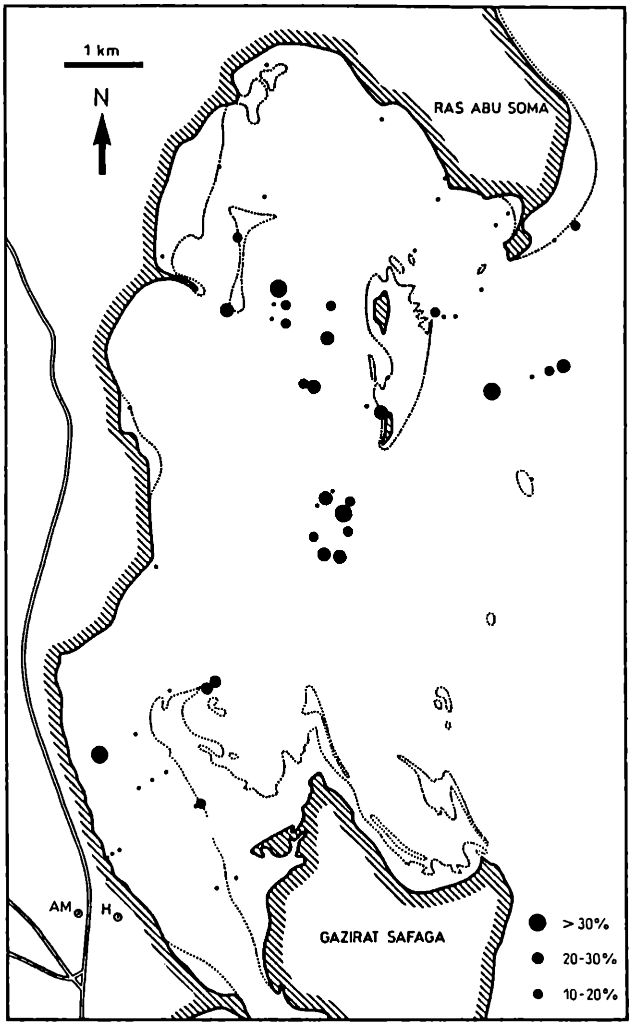


Fig. 23. Frequency distribution of red algae (> 250 μm).

areas with percentages > 10 % are present around the Tubya islands, between Tubya al-Hamra and Al-Dahira, near the southern main coast of the 'West area', around the northwest cusp of the intertidal area of Gazirat Safaga, as well as east of Ras Abu Soma. Although most localities with higher coral abundances are located in shallow water, some samples are from below 50 m (B 2, C 1).

5.3.3 Distribution of molluscs

Molluscs and their fragments are by far the most dominant particles in the bay, generally comprising more than 50 %, although occasionally exceeding 80 %. Very low values were registered along the coast, in areas characterized by high percentages of non-skeletal particles. In addition to some isolated samples, a very large continuous area with values exceeding 60 % is developed in the 'West area', including not only the main part of the basin but also the shallow water area west of the Tubya islands, parts of the submarine ridge southward and also some samples in the southern basin of the 'East area' (Fig. 22). A second, smaller area is located north of the northwest cusp of the intertidal area of Gazirat Safaga in the northernmost part of the 'Southwest channel' The highest values (> 80 %) were obtained exclusively at the margin of the 'West area' basin against the wall in the east (B 16, B 44, B 46) or the slope in the west (B 69).

5.3.4 Distribution of crustaceans

The frequency of crustacean fragments is small; only one sample in the 'North area' (C 20) contains more than 10 %. Two larger areas with percentages > 5 % are present in the 'Southwest channel'; isolated samples occur in the 'West area' and 'East area' basins.

5.3.5 Distribution of echinoderms

Although this group is quantitatively insignificant, the distribution of samples containing > 5 % echino-

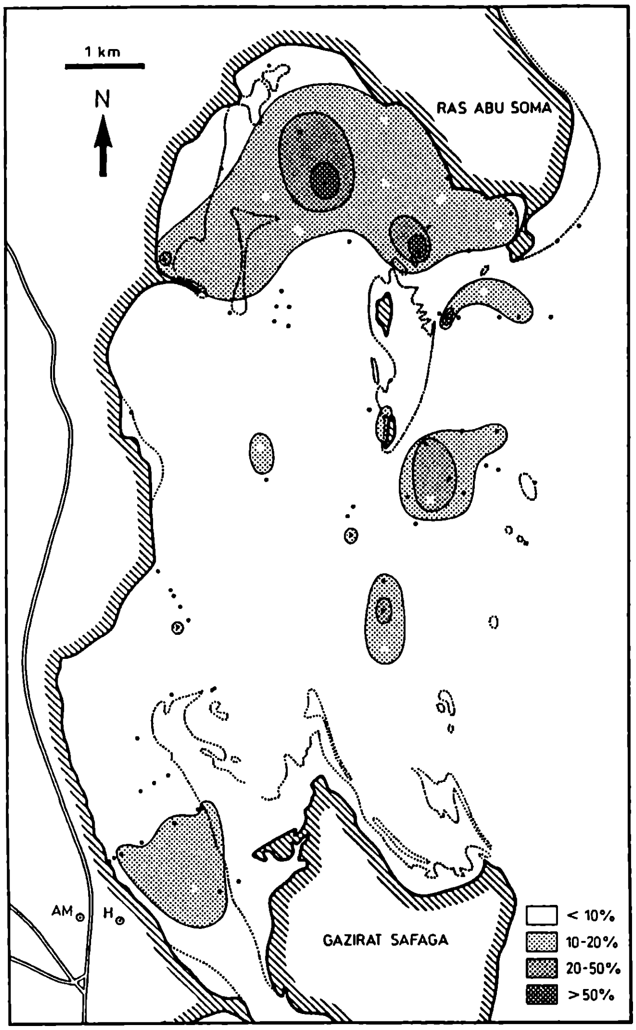


Fig. 24. Frequency distribution of compound grains (> 250 μm).

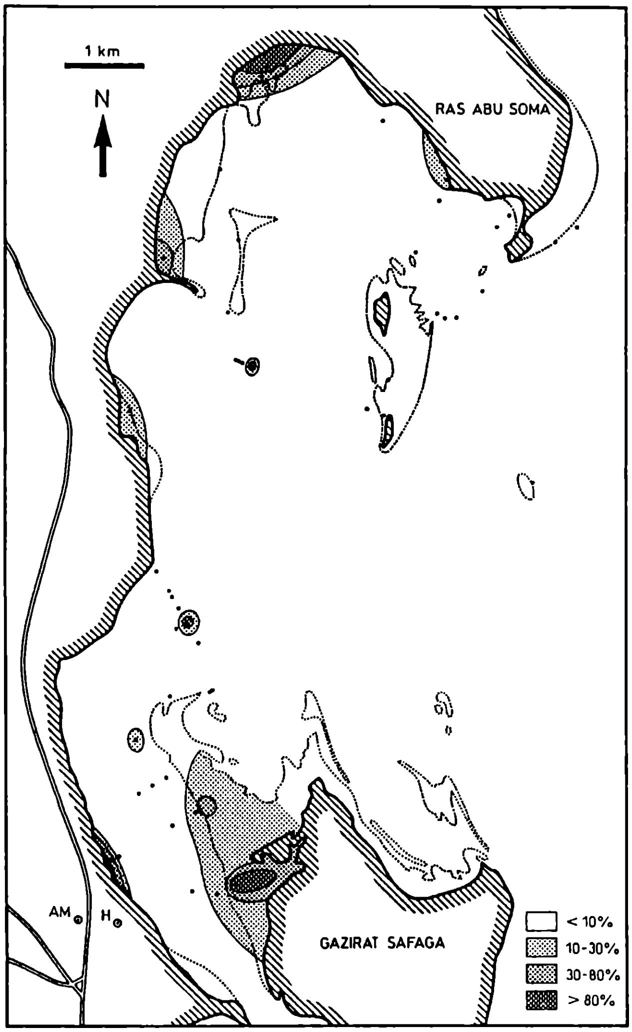


Fig. 25. Frequency distribution of quartz and feldspars (> 250 μm).

derms coincides with the 'West area' basin, which contains the single sample (D 6) with more than 10 %.

5.3.6 Distribution of red algae

Similar to corals, red algae also show a very patchy distribution, reaching maximum values somewhat exceeding 30 % in only 4 samples (A 17, B 4, B 60, C 14). Larger areas with a content above 10 % are present between Al-Dahira and the Tubya islands as well as on the submarine ridge between Tubya al-Bayda and Gazirat Safaga and south of Ras Abu Soma (Fig. 23).

5.3.7 Distribution of green algae

The frequency of *Halimeda* is very low, with only two samples containing more than 10 % (Appendix 3). Sample C 3 (13.25 %) originates from the western margin of the northern basin of the 'East area' at a depth of 47.5 m (comp. Appendix 1). The second (B 51) is remarkable in that it comes from the only dense *Halimeda* meadow, observed south of the southern basin of the 'East area' in 34 m; here, segments and fragments compose more than 87 % of the investigated fraction (> 250 μm).

5.3.8 Distribution of compound grains

In four areas of the bay, compound grains make up more than 20 %. One is located in the protected, shallow western part of the 'North area', another northeast of Tubya al-Hamra, the third in the center of the 'East area', and the fourth, represented by a single sample, south of the southern basin of the 'East area' (Fig. 24). Whereas the two in the 'East area' reach less than 30 %, one sample in both 'North area' sites reaches more than 50 % (C 11, C 24). Less than 5 % compound grains are present east of the 'East area' basins, in the shallow water area north of Gazirat Safaga, in the 'West area' basin and west of the Tubya islands as well as in some coastal samples.

5.3.9 Distribution of quartz

Quartz (and feldspars) remain below 10 % in most samples; in some sharply defined areas (Fig. 25), however, they are present in remarkably high quantities (maximum of > 94 %). These areas are located on the main coast, especially in the 'Southwest channel' (A 7) and in the 'North area' (C 9), as well as in or west of the intertidal area northwest of Gazirat Safaga. One isolated sample stems from the western margin of the 'West area' basin (B 21), one from the northern end of the 'Southwest channel' (A 27).

5.4 Cluster analysis

A hierarchical UPGMA cluster analysis was carried out based on the 16 variables of 7 fractions of 122 samples. The objective was to group the samples according to the different components. Fifteen clusters were distinguished at a correlation coefficient level of 0.7 (Fig. 26; Tab. 5).

Although molluscs are abundant or dominate in several clusters, **cluster 1**, consisting of 44 samples and thus being the largest, is characterized by this category ($\bar{x}$=62.63 %, s=10.62 %). The second abundant group (compound grains) amounts to only 10.26 %, while none of the others reach 10 %. The characterizing components for **cluster 2** (13 samples) are hyaline foraminifers ($\bar{x}$=28.60 %, s=16.22 %), although molluscs are more abundant ($\bar{x}$=44.28 %, s=14.86 %). **Cluster 3** also includes 13 samples and is separated by the high percentage of miliolid foraminifers ($\bar{x}$=30.77 %, s=8.45 %) in addition to abundant molluscs ($\bar{x}$=38.20 %, s=7.45 %). Although the most abundant components by far of **cluster 4** (22 samples) are molluscs ($\bar{x}$=52.19 %, s=10.26 %), the separating character is the co-occurrence of red algae ($\bar{x}$=18.60 %, s=8.56 %) and corals ($\bar{x}$=14.60 %, s=7.04 %). **Clusters 5** and **6**, both including only one sample, are related to cluster 4 and are clearly dominated by corals (38.79 %, 47.82 %) and red algae (34.99 %, 15.42 %); cluster 6 (sample A 17) additionally contains 6.97 % echinoderms. **Cluster 7** also includes only one sample (D 1), representing a mixture of different components (miliolid foraminifers, corals, red algae, quartz) between 8 and 19 %, as well as a high mollusc percentage (46.69 %). **Cluster 8** contains 3 samples and is separated due to the highest agglutinated foraminifer ($\bar{x}$=5 %, s=1.49 %) and echinoderm content ($\bar{x}$=7.70 %, s=1.61 %). The most abundant components are molluscs ($\bar{x}$=42.32 %); the quartz value (10.89 %) is highly variable (s=15.40 %). Corals ($\bar{x}$=29.11 %, s=7.51 %) characterize **cluster 9** (9 samples), which is dominated by molluscs ($\bar{x}$=47.87 %, s=12.34 %); red algae are relatively abundant ($\bar{x}$=8.29 %, s=8.65 %). The 4 samples of **cluster 10** are separated by the highest percentage of corals ($\bar{x}$=49.34 %, s=8.73 %); red algae comprise 11.12 % (s=6.96 %), molluscs 28.14 % (s=4.25 %). **Cluster 11** unites the 3 samples with the highest percentages of compound grains ($\bar{x}$=44.09 %, s=18.81 %); molluscs, corals and red algae are present in higher percentages. **Cluster 12** includes only a single sample (A 1) and is dominated by quartz (43.55 %) as well as relatively large amounts of several components (compound grains, red algae, molluscs, corals). The extraordinarily high hyaline foraminifer (45.32 %) and compound grain values (27.17 %) isolates sample B 33 as **cluster 13**. The 8 samples of **cluster 14** are united by the high amount of quartz ($\bar{x}$=66.10 %, s=27.87 %); molluscs, compound grains and corals follow. **Cluster 15**, represented by sample B 51, is clearly characterized by 87.31 % *Halimeda*, the unique occurrence of this green algae in such high quantities.

5.4.1 Distribution of clusters

Cluster distribution (Fig. 27) reveals that **cluster 1** — the molluscs cluster — dominates the basins and the center of the 'Southwest channel' in the north and south, but also covers large parts of the 'North area' **Cluster 2** and **13** are pooled because the single sample (B 33) of cluster 13 shows the same characteristics — high hyaline foraminifer and compound grain content — as cluster 2 samples, only in much higher percentages. This group shows a very distinct distribution in three larger areas: two in the 'East area' — one each in the northern and southern basin — and the third in the center of the 'Southwest channel' One cluster 2 sample stems from the western margin of the 'West area' basin. **Cluster 3**, characterized by a high amount of miliolid foraminifers, is clearly restricted to shallow water areas near the main coast and covers large parts of the 'North area', the flat, shallow water plain in the west of the 'West area' and nearly the complete west coast of the 'Southwest channel' One smaller area is developed west of Gazirat Safaga. **Clusters 4**, **5**, **6**, **9**, and **10** are combined into a single group. These clusters are closely related by cluster analysis and characterized by relatively high coral and red algae content. The large area occupied by this group spreads from Ras Abu Soma southward along the submarine ridge and its shallow water continuation, and in the other direction to the west over Tubya Arba to the Tubya islands, which are framed by this cluster, running to the south along the submarine ridge to the shallow water area north of Gazirat Safaga. Several smaller occurrences (single samples) as well as another area along the western slope of the 'West area' basin, running from Al-Dahira south to the main coast of the 'Southwest channel' belong to this group. **Cluster 7**, containing only one sample (D 1) lacking a distinct component category, is located

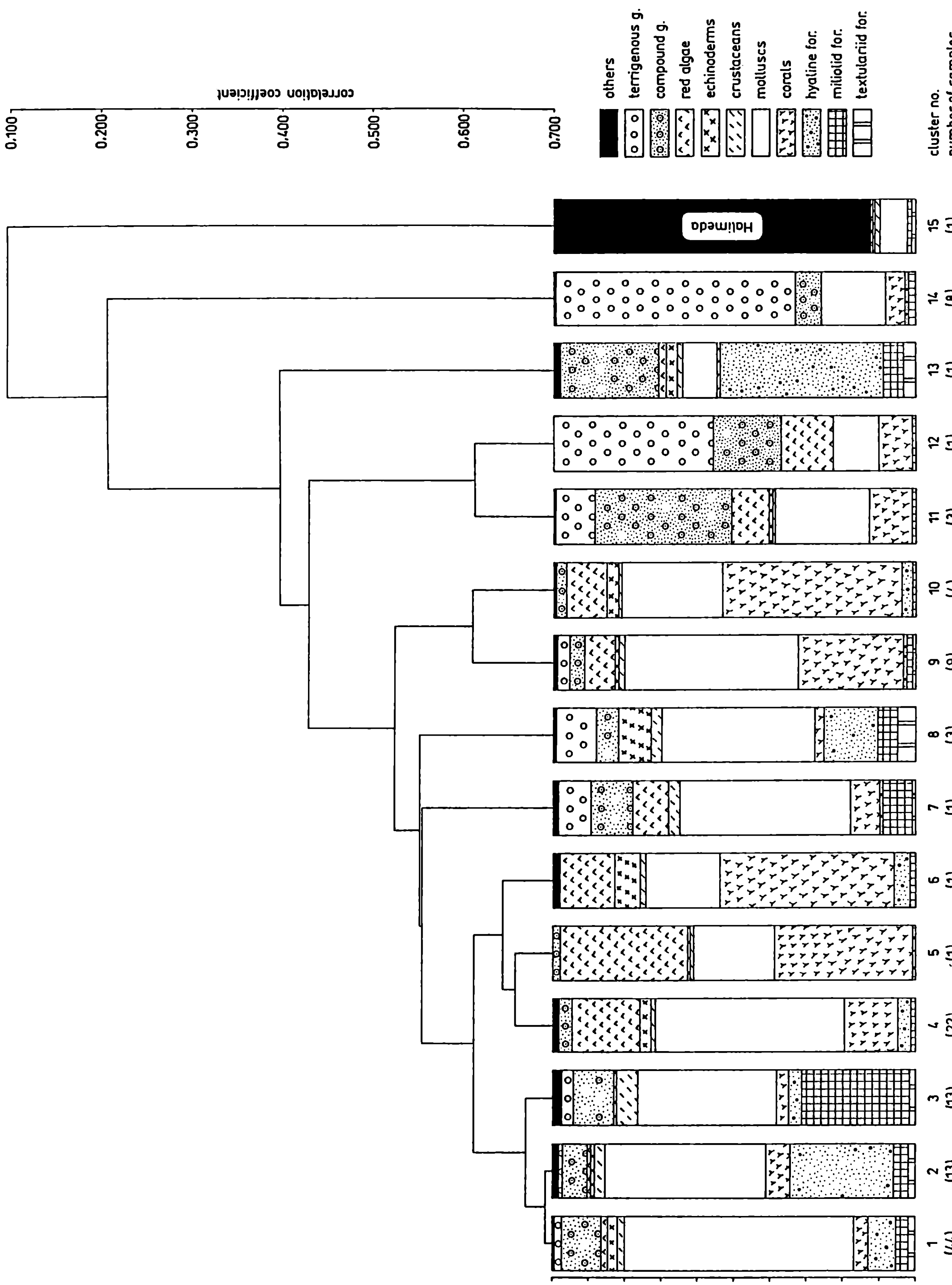


Fig. 26. Dendrogram of a hierarchical UPGMA cluster analysis of component data combined with the frequency distribution of the components in each cluster at a correlation coefficient level of 0.7.

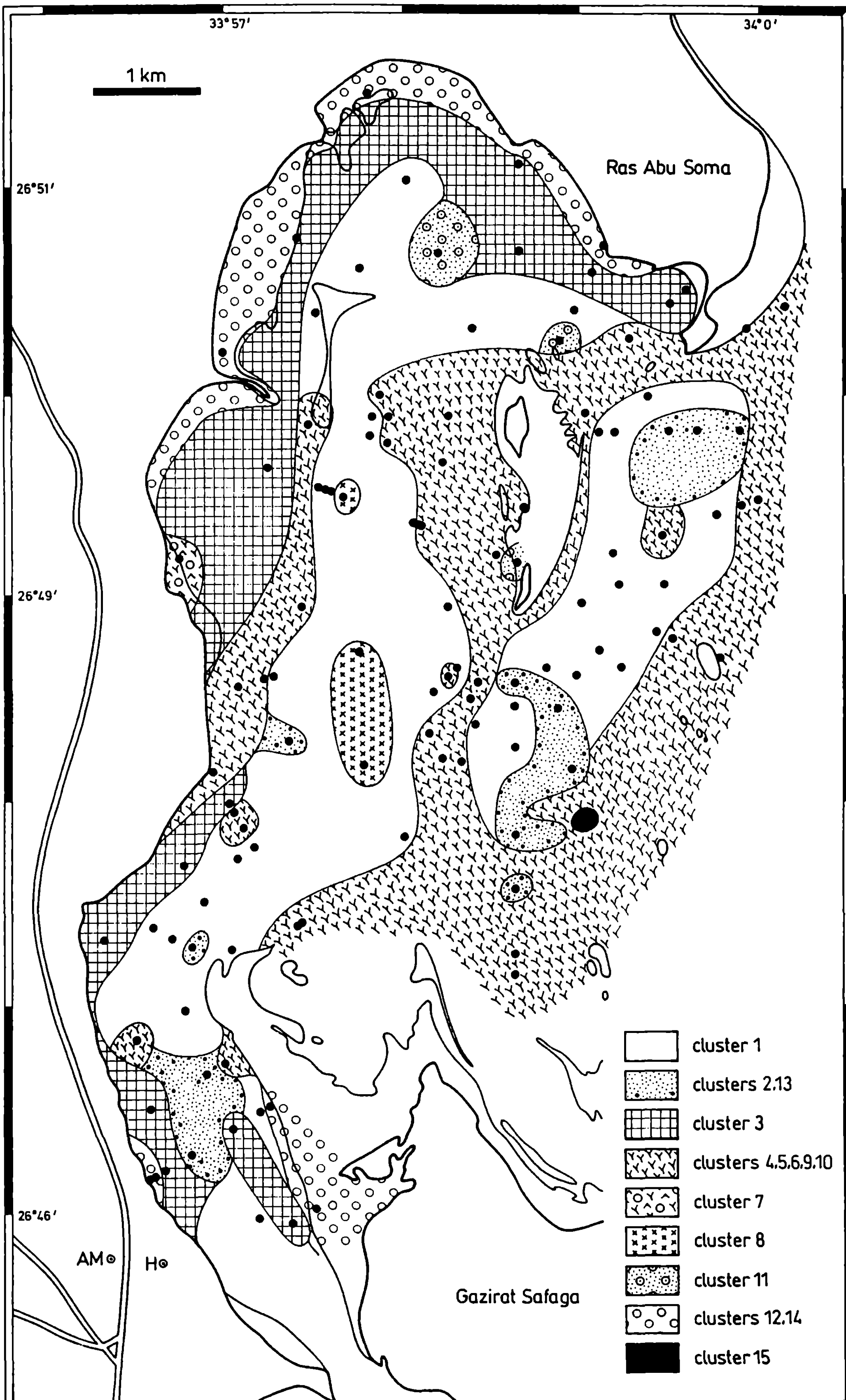


Fig. 27. Distribution of clusters of the cluster analysis (level: r=0.7) of components > 250 μm.

cluster 1 (44 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	2.26	3.36	7.31	12.92	0.00	4.25	62.63	0.11	2.46	2.48	0.00	1.90	0.10	0.22	0.16	10.26	2.28
s	2.66	4.95	7.81	9.24	0.01	5.49	10.62	0.16	1.78	2.44	0.00	3.72	0.36	1.08	0.71	7.84	5.54
min.	0.07	0.06	0.06	0.44	0.00	0.00	43.13	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.84	0.00
max.	9.30	23.30	27.73	38.39	0.07	23.98	86.97	0.90	6.13	11.84	0.00	14.71	2.14	7.01	4.72	31.51	32.14

cluster 2 (13 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	2.22	4.04	28.60	34.85	0.00	6.81	44.28	0.14	2.69	1.35	0.00	0.20	1.22	0.02	0.00	7.42	1.02
s	1.61	5.57	16.22	17.50	0.00	8.94	14.86	0.17	1.83	1.41	0.00	0.52	3.50	0.06	0.01	4.65	2.17
min.	0.48	0.30	7.28	14.50	0.00	0.00	16.22	0.00	0.60	0.03	0.00	0.00	0.00	0.00	0.00	0.55	0.00
max.	5.56	19.89	59.95	64.77	0.01	26.46	62.40	0.56	6.50	5.80	0.00	1.92	13.25	0.22	0.03	17.74	8.25

cluster 3 (13 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	1.08	30.77	3.50	35.35	0.02	3.33	38.20	0.82	5.62	0.83	0.02	0.29	0.14	1.23	0.00	11.05	3.11
s	0.75	8.45	3.28	9.16	0.07	4.44	7.45	0.48	2.85	0.93	0.05	0.58	0.37	2.11	0.00	4.74	4.35
min.	0.38	19.82	0.77	23.26	0.00	0.07	26.89	0.19	3.02	0.09	0.00	0.00	0.00	0.00	0.00	4.27	0.17
max.	3.16	43.03	11.51	52.02	0.25	16.63	51.42	1.89	14.38	3.76	0.18	2.12	1.41	8.09	0.00	18.12	15.68

cluster 4 (22 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.49	0.82	4.04	5.35	0.02	14.60	52.19	1.22	1.34	2.71	0.00	18.60	0.11	0.29	0.00	3.82	0.09
s	0.39	0.74	3.40	3.74	0.02	7.04	10.26	1.82	0.95	2.34	0.00	8.56	0.26	1.24	0.00	2.59	0.13
min.	0.04	0.03	0.42	0.72	0.00	2.16	33.14	0.04	0.03	0.03	0.00	5.05	0.00	0.00	0.00	0.34	0.00
max.	1.59	3.44	13.00	14.27	0.08	27.04	70.03	8.69	3.42	8.03	0.00	32.00	1.19	0.01	0.02	10.25	0.42

cluster 5

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
A 17	0.11	0.17	0.31	0.59	0.00	38.79	22.34	0.03	0.32	1.09	0.00	34.99	0.00	0.00	0.00	1.85	0.00

cluster 6

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
B 73	0.03	1.96	4.08	6.07	0.00	47.82	20.66	0.10	1.50	6.97	0.00	15.42	1.03	0.00	0.00	0.44	0.00

cluster 7

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
D 1	0.84	8.27	0.84	9.95	0.00	8.35	46.69	0.17	3.50	0.00	0.00	9.54	0.34	0.00	0.59	1.86	19.00

cluster 8 (3 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	5.00	6.84	13.79	25.63	0.00	2.45	42.32	0.14	3.95	7.70	0.00	0.00	0.00	0.00	0.49	6.44	10.89
s	1.49	2.07	2.26	3.09	0.00	3.47	14.04	0.20	1.78	1.61	0.00	0.00	0.00	0.00	0.35	1.61	15.40
min.	3.46	3.97	10.86	23.12	0.00	0.00	23.20	0.00	2.04	5.50	0.00	0.00	0.00	0.00	0.00	4.29	0.00
max.	7.02	8.80	16.35	29.99	0.00	7.36	47.25	0.42	6.33	9.31	0.00	0.00	0.00	0.00	0.74	8.15	32.67

cluster 9 (9 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.60	2.04	1.22	3.86	0.04	29.11	47.87	0.66	1.24	1.38	0.00	8.29	0.07	0.03	0.03	3.91	2.47
s	0.46	1.91	1.43	2.87	0.10	7.51	12.34	0.79	1.16	1.12	0.00	8.65	0.12	0.09	0.09	2.31	3.33
min.	0.04	0.25	0.02	0.78	0.00	17.72	29.27	0.00	0.05	0.28	0.00	0.00	0.00	0.00	0.00	0.53	0.00
max.	1.46	5.37	5.02	8.63	0.33	41.60	62.14	2.64	3.68	3.39	0.01	27.87	0.38	0.29	0.29	8.32	8.67

Tab. 5. Some statistical parameters of the components of the clusters computed by an UPGMA cluster analysis basing on 16 variables of components.

cluster 10 (4 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.17	0.18	3.85	4.20	0.00	49.34	28.14	0.28	0.63	3.17	0.00	11.12	0.00	0.00	0.00	2.98	0.00
s	0.15	0.14	2.45	2.36	0.00	8.73	4.25	0.23	0.44	1.31	0.00	6.96	0.00	0.00	0.00	1.86	0.00
min.	0.00	0.09	2.05	2.52	0.00	34.36	24.73	0.02	0.11	1.40	0.00	1.28	0.00	0.00	0.00	0.25	0.00
max.	0.18	0.42	8.06	8.24	0.01	56.16	35.24	0.66	1.17	5.02	0.00	19.04	0.00	0.00	0.00	4.93	0.01

cluster 11 (3 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.06	0.94	0.18	1.18	0.00	12.41	31.12	0.01	0.75	1.23	0.00	9.06	0.00	0.00	0.00	44.09	0.16
s	0.04	0.34	0.23	0.34	0.00	6.99	3.10	0.01	0.68	1.08	0.00	10.96	0.00	0.00	0.00	18.81	0.23
min.	0.01	0.65	0.00	0.70	0.00	5.25	31.41	0.00	0.13	0.02	0.00	0.00	0.00	0.00	0.00	17.57	0.00
max.	0.10	1.41	0.51	1.47	0.00	21.89	34.76	0.03	1.69	2.65	0.00	24.48	0.00	0.00	0.00	59.15	0.48

cluster 12

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
A 1	0.00	0.81	0.11	0.92	0.00	9.45	12.62	0.00	0.14	0.14	0.00	14.13	0.00	0.00	0.00	19.04	43.55

cluster 13

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
B 33	3.57	5.74	45.32	54.81	0.00	0.67	9.32	1.20	1.59	2.90	0.00	2.03	0.26	0.00	0.23	27.17	0.00

cluster 14 (8 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.10	2.49	0.61	3.19	0.00	5.35	16.74	0.04	0.53	0.21	0.00	0.26	0.00	0.06	0.02	7.50	66.10
s	0.11	4.05	0.86	4.56	0.00	11.17	15.83	0.06	0.60	0.23	0.00	0.38	0.00	0.08	0.04	7.10	27.87
min.	0.00	0.00	0.04	0.24	0.00	0.08	1.43	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.57	94.52
max.	0.36	13.02	2.38	15.11	0.01	34.68	42.24	0.17	1.96	0.61	0.00	0.96	0.00	0.24	0.11	21.87	23.20

cluster 15

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
B 51	1.57	0.80	0.25	2.62	0.00	0.00	7.65	0.14	1.26	0.36	0.00	0.00	87.31	0.00	0.03	0.19	0.42

Tab. 5. continued

along the coast of the 'West area' (Fig. 27). **Cluster 8** (highest echinoderm content) is located in the center of the 'West area' basin and — one sample — near its northern margin. The 3 samples of **cluster 11** — dominated by compound grains — stems from three different shallow water localities, one in the center of the 'North area', one north of Tubya al-Hamra and one west of Tubya al-Bayda. The distribution of the quartz **clusters 12** and **14** is clearly related to coastal areas. In the 'North area' and the 'West area' it forms an elongated strip between the coast and cluster 3; it also occupies the intertidal flat west of Gazirat Safaga as well as an area on the opposite coast of the 'Southwest channel'. The single sample (B 51) of the *Halimeda*-cluster (**cluster 15**) stems from 34 m near the southern basin of the 'East area' and is surrounded by the coral-red algae cluster-group.

5.5 Relationships between components

To elucidate possible relationships between the 13 component categories, the product-moment-correlation coefficients between the components were computed; these were done not only for the total amount of the components/sample (Tab. 6) but also for the amount of each fraction/sample (122 samples).

When using the total amount, **agglutinated foraminifers** show a significant positive correlation to hyaline foraminifers, crustaceans and pellets, and a negative one to corals and red algae. Using the fractions, a positive correlation of agglutinated foraminifers of medium sand to molluscs and echinoderms of finer coarse sand and medium sand is additionally detected. A relatively high positive correlation exists between **miliolid foraminifers** and crustaceans (0.531), a slightly negative one to corals and red algae. The correlation of fractions revealed two additional relations: one with worm tubes, but only with the coarse and medium sand fractions (cor-

	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25
V14	1.000											
V15	.336	1.000										
V16	.008	-.082	1.000									
V17	-.309	-.242	-.267	1.000								
V18	.056	-.120	-.184	-.244	1.000							
V19	.275	.121	.531	-.329	.080	1.000						
V20	.162	.054	-.143	.044	.152	.171	1.000					
V21	-.092	-.119	.074	.140	-.018	.009	-.085	1.000				
V22	-.253	-.228	-.246	.386	-.106	-.278	.016	.217	1.000			
V23	.070	-.051	.057	-.197	-.096	-.040	-.130	-.122	-.239	1.000		
V24	-.124	-.157	-.066	-.162	-.508	-.210	-.211	-.113	-.187	-.100	1.000	
V25	.264	.027	-.007	-.097	.015	.060	.231	-.049	-.087	.041	-.016	1.000

V14	agglutinated foraminifera	V15	hyaline foraminifera	V16	miliolid foraminifera
V17	corals	V18	molluscs	V19	crustaceans
V20	echinoderms	V21	worm tubes	V22	red algae
V23	compound grains	V24	quartz	V25	pellets

Tab. 6. Correlation coefficients between components (122 samples). Underlined type = 1 % significance level.

relation coefficient up to 0.592). The second one is that with plants, which is restricted to fractions > 0.71 μm (corr. coeff. up to 0.481). The intensity of correlation between miliolid foraminifers and crustaceans decreases with decreasing grain size, and in the finer medium sand fraction no significant correlations exist. **Hyaline foraminifers** of the total samples are positively correlated only to agglutinated foraminifers (and slightly negative to corals). Analysis of the fractions reveals, in addition, a relatively high correlation (up to 0.471) of the hyaline foraminifers of very coarse sand to medium sand to crustaceans of coarse sand to coarser medium sand fractions; no significant correlations exist to gravel and the finer medium sand fraction.

Corals are positively correlated only to red algae (0.386) but negatively to 5 component categories (agglutinated, miliolid and hyaline foraminifers, molluscs and crustaceans). Surprisingly, no relations exist between molluscs and corals in gravel and in both very coarse sand fractions.

Using the total samples, **molluscs** show only negative correlations to two groups; a strong one to quartz (−0.508) and a weak one to corals (−0.244). Using the fractions, only weak correlations with agglutinated foraminifers and echinoderms are additionally present in medium sand.

Crustaceans show a relatively high positive correlation to miliolid foraminifers and a slight positive one to agglutinated forms, as well as a slight negative one to corals and red algae. In correlating the fractions, positive relations are also found for all fractions, except gravel, to hyaline foraminifers (but only to coarse sand and the coarser fraction of medium sand) as well as to a few fractions of plants, echinoderms and worm tubes.

A single, slightly positive correlation exists between **echinoderms** and pellets. Except for some isolated significant values, only echinoderms of the three finer grained fractions exhibit positive correlations to agglutinated foraminifers and crustaceans of medium sand.

In the total samples, **worm tubes** are not significantly correlated to any other component category. In the fractioned samples, those of coarse and medium sand are positively correlated to miliolid foraminifers and partly also to crustaceans. Worm tubes of the very coarse sand fractions are positively correlated to red algae, those of the coarse fractions to plants.

Red algae are positively correlated to corals and slightly negatively to agglutinated and miliolid foraminifers, to crustaceans and to compound grains. The positive correlation to worm tubes in very coarse fractions was mentioned above.

Compound grains exhibit an only slightly negative significant correlation to red algae; **quartz** is highly negatively related to molluscs without additional significant relations in the total samples. Fractioned samples show some slightly negative relations to hyaline foraminifers and echinoderms of the finer coarse sand fraction. Slightly positive correlations of **pellets** exist to agglutinated foraminifers and echinoderms, resulting only in correlations of a few individual fractions.

5.6 Distribution of components in grain size categories

Of the 16 differentiated component categories, 8 are present with values exceeding 5 % in, at least, one grain size fraction (of seven) (Tab. 7). **Agglutinated foraminifers**, although less abundant, increase in abundance with decreasing grain size. **Miliolid foraminifers** are bimodally distributed, with more than 6 % in gravel, a decrease between 1.41

(mm)	> 0.2	> 1.41	> 1.0	> 0.71	> 0.50	> 0.35	> 0.25
agglut. for.	0.04	1.20	2.88	2.50	5.30	7.74	7.16
miliolid for.	6.05	4.72	3.61	4.72	8.75	10.25	10.22
hyaline for.	0.72	8.78	15.77	13.40	9.33	8.96	8.94
corals	8.62	12.35	12.17	12.25	12.56	9.00	9.23
molluscs	60.26	42.87	34.48	33.86	29.51	24.75	18.87
red algae	4.57	6.54	7.29	6.72	6.28	6.49	6.95
compound gr.	7.32	9.15	9.52	11.83	11.80	15.09	18.84
quartz	4.53	6.54	6.70	7.27	8.28	8.29	9.74

Tab. 7. Mean frequency (%) of the 8 most abundant component categories in grain size fractions.

and 0.71 mm and a rapid increase to more than 10 % in medium sand (Fig. 28). A very striking distribution occurs in the **hyaline foraminifers**, which are nearly absent in gravel and reach a distinct peak (15.77 %) at 1 mm (Fig. 28). **Corals** show a more continuous distribution, with higher frequencies (around 12 %) between 1.41 and 0.5 mm (Fig. 28). **Molluscs**, generally dominant, decline drastically from 60 % in gravel down to 18.87 % at 250 μm (Fig. 28). **Red algae** are continuously distributed (Fig. 28), whereas **compound grains** increase distinctly in frequency from gravel (7.32 %) to medium sand (18.84 %) (Fig. 28). **Quartz** also increases with decreasing grain size, but with a lower intensity (from 4.53 to 9.74 %).

5.7 Grain size — component relations

As with components alone, the product-moment-correlation coefficients were computed between the grain size classes and the components for the total (Tab. 8) as well as for the fractioned samples. **Agglutinated foraminifers** are highly positively correlated to mud and slightly to the finer fraction of very fine sand. Negative correlation exists to all fractions > 250 μm. **Miliolid foraminifers** exhibit a positive correlation to the finer fraction of fine sand and the fractions of very fine sand, and a negative one to coarse sediments (> 0.71 mm); no significant relation exists to mud. **Hyaline foraminifers** are also positively correlated to the two finest fractions, negatively to fractions > 125 μm, except for the grain size between 1.41 and 1 mm. **Corals** are positively related to all fractions > 250 μm; highest values are reached with very coarse and the coarser fraction of coarse (0.513) sand; negative correlations exist to the two finest fractions. **Molluscs** lack strong correlations to grain size categories: slightly positive values occur to mud and a negative one to coarse and the coarser fraction of medium sand. Very strong correlations are developed in **crustaceans**, which show positive values to fractions < 125 μm, — especially to the finest sand fraction (90 – 63 μm: r=0.546) — and negative values to all fractions > 250 μm. The single (very strongly) positive correlation of **echinoderms** exists to mud, whereas all other grain size fractions are negatively correlated, significantly from 125 μm upward. **Worm tubes** do not show significant correlations to any grain size class in the correlations of the total samples, but exhibit two different positive relations using fractioned samples. Worm remnants in the very coarse sand fractions are slightly positive correlated to gravel and the coarser fraction of very coarse sand; those of the finer coarse sand fraction and of medium sand are positively correlated to very fine sand. A positive correlation of **red algae** is developed to grain sizes > 250 μm, a negative one to those < 125 μm. **Compound grains** lack significant correlation to grain size classes, regardless whether total or fractioned samples are used. **Quartz** is slightly positively correlated to the grain size 710 – 350 μm; in fractioned samples, quartz of the finer coarse sand fraction and medium sand is more highly positively correlated (up to r=0.472) to fine sand and slightly negatively to mud. The single significant correlation of **pellets** is a slightly positive one to mud — but only using the total samples; in fractioned samples, pellets of the coarser coarse sand fraction are highly positively correlated to fine sand alone.

5.8 Components versus bottom facies

The distribution of the components in the bottom facies types is listed in Table 9 and illustrated in Fig. 29. In each bottom facies, molluscs represent the dominant component category. Due to their relative frequency and importance for ecological interpretations, the distribution of the three foraminiferal main groups is plotted in a triangular diagram for each bottom facies (Fig. 30).

In addition to a mollusc amount of > 50 %, red algae (20.1 %) and corals (14 %) characterize **'Rock bottom'** facies. Except in one sample (C 1), where they are totally absent, red algae are consistently present, whereas the coral content is highly variable. Compound grains are present relatively consistently, with a mean value of 4.85 %. Foraminifers are clearly dominated by hyalines; only sample C 1 has a higher miliolid content. The hyaline foraminifers are rep-

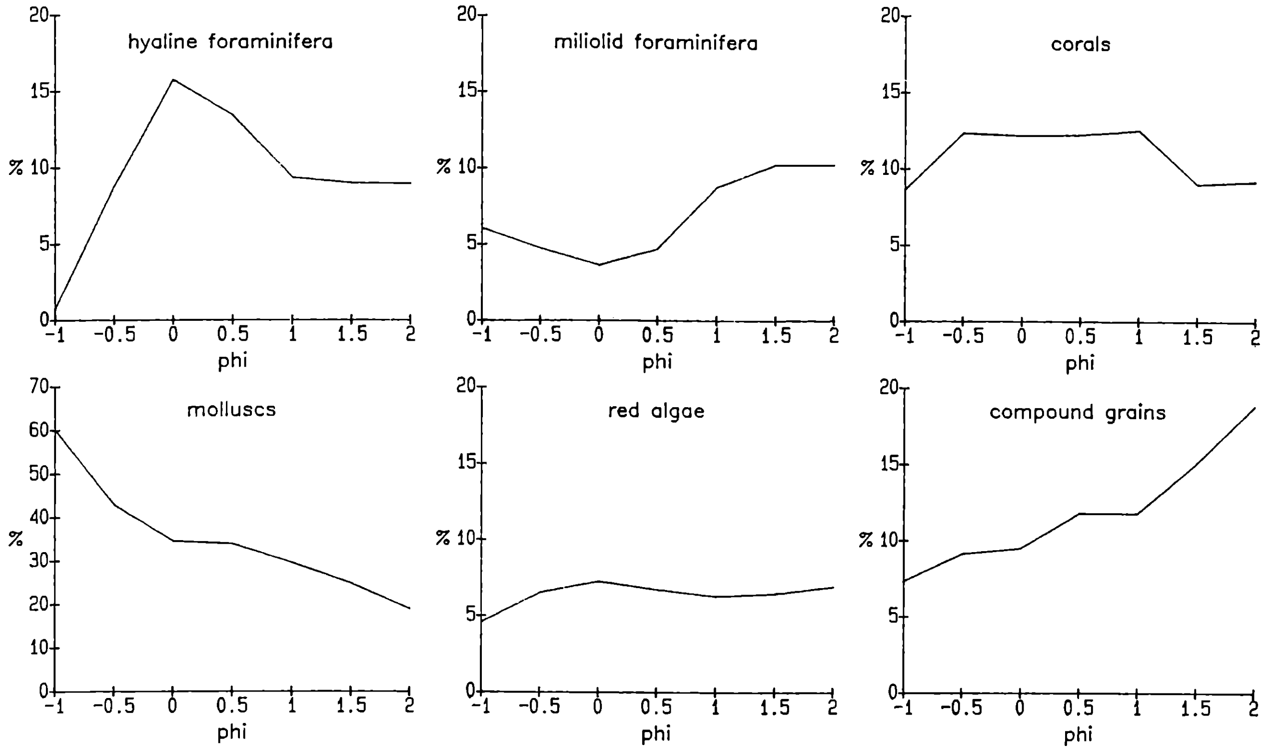


Fig. 28. Distributions of the 6 most abundant component categories in grain size fractions.

resented by a mixture of *Heterostegina* and *Operculina*.

'Sand with coral patches' exhibits the highest percentage of corals (25.57 %); its content is highly variable (s=17.22 %), reaching from approx. 5 % (C 11) up to > 53 % (B 10). A high variability is also evident in compound grains ($\bar{x}$=12.84 %, s=17.05 %) and red algae ($\bar{x}$=7.26 %, s=10.79 %). The foraminiferal content ($\bar{x}$=5.13 %) is the lowest of all bottom facies, being highly variable; in the triangular plot the samples are positioned mainly near the hyaline – miliolid line (Fig. 30).

A characteristic of **'Sand'** bottom facies is a high variability of all component frequencies. Quartz reaches its highest percentage ($\bar{x}$=15.25 %, s=28.48 %), but fluctuates from 0 to > 94 %; 20 of the 27 samples have a percentage < 5 %. Molluscs ($\bar{x}$=42.58 %, s=21.17 %) are less abundant here than in any other bottom facies. Compound grains are relatively frequent ($\bar{x}$=12.43 %, s=12.39 %), exceeding 55 % in sample C 24. Corals reach > 10 % (s=9.83 %) as the fourth category; red algae and miliolid foraminifers are above 5 %. The triangular plot of foraminifers also exhibits a wide range of the samples, mainly between miliolid and hyaline foraminifers. A few samples have a dominant group, as expressed by the triangular plots; the total amount of the samples is also high. This is especially evident in samples A 15, C 16 and C 19, with a miliolid foraminifer content of 37.35, 33.92 and 41.55 %, and in samples A 15, A 20, B 3, and B 28, with hyaline foraminifer percentages between 10.44 and 17.55 %.

In addition to molluscs ($\bar{x}$=50.04 %, s=11.50 %), **'Coral carpet'** is characterized by corals ($\bar{x}$= 21.34 %, s=15.07 %) and red algae ($\bar{x}$=12.31 %, s=7.57 %). Here, echinoderms ($\bar{x}$=2.60 %, s=2.25 %) reach their second highest abundance. Among foraminifers, the hyaline group is present with a mean of 4.13 %; the relatively high standard deviation of 6.71 % is explained by the high value of > 25 % in one sample (A 18); the remaining 11 do not reach 10 %. Sample A 18 also has many agglutinated foraminifers (9.06 %). The triangular plot reveals a clustering of the samples around the hyaline corner.

In **'Sand with seagrass'** three categories exceed 10 %: molluscs, corals and compound grains. Whereas compound grains are relatively constant ($\bar{x}$=11.89 %, s=7.88 %), corals are highly variable ($\bar{x}$=13.84 %, s=16.32 %). Miliolid foraminifers reach a mean of 6.07 % (s=6.08 %), but only sample A 11 contains more than 20 %, the remainder being below 10 %. The triangular plot shows a high variability between the samples.

In **'Seagrass'** bottom facies, molluscs are relatively less abundant ($\bar{x}$=43.89 %); the by far highest miliolid foraminifer content ($\bar{x}$=22.21 %, s=14.17 %) of all bottom facies was recorded here (> 40 %). As a third component category, compound grains reach more than 10 % and are characterized by low variance (s=4.60 %). Crustaceans are abundant here ($\bar{x}$=6.82 %, s=3.05 %); plants, totally absent in most

(mm)	V2 > 2.0	V3 > 1.41	V4 > 1.0	V5 > 0.71	V6 > 0.50	V7 > 0.35	V8 > 0.25	V9 > 0.18	V10 > 0.125	V11 > 0.09	V12 > 0.063	V13 < 0.063
V14	-.351	-.390	-.388	-.440	-.404	-.425	-.339	-.153	-.001	.056	.231	.414
V15	-.298	-.238	-.152	-.289	-.312	-.340	-.333	-.272	-.250	-.052	.272	.396
V16	-.241	-.305	-.322	-.289	-.198	-.186	-.080	.155	.299	.357	.392	-.015
V17	.362	.458	.498	.513	.357	.351	.278	.076	.009	-.083	-.336	-.370
V18	.043	-.086	-.188	-.261	-.308	-.270	-.209	-.155	-.101	-.007	.105	.261
V19	-.454	-.554	-.555	-.538	-.447	-.447	-.324	-.041	.175	.323	.546	.308
V20	-.235	-.268	-.281	-.250	-.259	-.339	-.385	-.348	-.314	-.221	-.026	.523
V21	.073	.085	.086	.070	.039	.030	.005	-.075	-.091	-.059	-.041	.001
V22	.382	.393	.363	.378	.307	.378	.335	.135	-.081	-.295	-.393	-.263
V23	-.053	-.039	.002	.024	.046	.115	.131	.089	.126	.109	.027	-.124
V24	-.063	.040	.065	.195	.341	.262	.186	.168	.107	.003	-.140	-.226
V25	-.116	-.140	-.161	-.172	-.157	-.176	-.166	-.079	-.094	-.115	-.078	.255

V14	agglutinated foraminifera	V15	hyaline foraminifera	V16	miliolid foraminifera
V17	corals	V18	molluscs	V19	crustaceans
V20	echinoderms	V21	worm tubes	V22	red algae
V23	compound grains	V24	quartz	V25	pellets

Tab. 8. Correlation coefficients between grain size fractions and components (122 samples). Underlined type = 1 % significance level.

samples, also reach a mean of 1.41 % (s=2.19 %). The extreme dominance of miliolid foraminifers is also expressed in the triangular diagram, where all samples except for two are clustered near the miliolid corner. The two exceptions (B 12, B 48) are characterized by a very low total amount of foraminifers compared with most other samples.

The **'Muddy sand'** bottom facies is characterized by a hyaline foraminifer content of 17.01 % (s=16.39 %), almost reaching 60 % in two samples (B 34, B 37). No further category, except molluscs, attains 10 %; compound grains reach 7.64 % (s=6.32 %), miliolid foraminifers 6.54 % (s=6.54 %) and corals 5.16 % (s=7.63 %). The green algae value ($\bar{x}$=2.87 %, s=14.94 %) is notable; it results from a single sample (B 51) containing > 87 % *Halimeda*. The triangular plot of the foraminifers, although showing most samples close to the hyaline corner, does not fully reflect the distinct dominance of hyaline forms expressed by the total amount. This is based on a few samples in which hyaline foraminifers are relatively rare but miliolids reach up to > 20 %, as well as on a few samples with a generally small percentage of foraminifers, but in which textulariids reach between 5 and 10 %.

Molluscs are more abundant in the **'Mud'** bottom facies than in any other bottom facies, with 61.61 % (s=16.63 %); echinoderms also exhibit the highest values ($\bar{x}$=5.69 %, s=2.65 %). Hyaline foraminifers occupy the second position in the frequency range ($\bar{x}$=9.51 %, s=6.43 %). Compound grains and corals make up more than 4 % each, the former occurring relatively consistently, the latter only in a few samples with higher percentages (B 13, B 23). The triangular plot of foraminifers shows a cluster near the hyaline corner, reflecting the values of the total amount.

5.9 Summary of results

The cluster analysis, supported by the distribution of the individual component categories as well as by correlation analysis, enables the explanation of some reasons for the distribution and possible co-occurrences or exclusions of component categories.

The by far dominating sediment constituents in the investigated coarse fractions are molluscs. They represent the coarsest components, decreasing with decreasing grain size (Fig. 28), but are positively correlated to fine sediment (Tab. 8). This correlation is partly reflected in their distribution, because they dominate especially in areas with fine sediments (e.g., basin of the 'West area'). The highest values (exceeding 80 %) are reached at the sharp margin between the basin bottom and its steep boundary. These high values coincide well with the worst sorting of the sediments (compare Fig. 4) and probably originate in a mixture of autochthonous molluscs, living in the mud, and shells fallen down the steep wall or slope.

The second major sediment-building component group are foraminifers. Agglutinated forms are least important, partly because they are generally smaller and therefore not represented in the investigated coarse fraction (> 250 μm); however, they are positively correlated to mud, and their main distribution coincides with basinal and/or muddy areas. The distributional pattern of miliolid foraminifers is strongly related to the occurrence of seagrass. Therefore, large shallow water areas — covered by seagrass (compare Enclosure 1 in PILLER & PERVESLER, 1989; Fig. 54) — are rich in miliolids (chiefly soritids). This relation is also supported by the positive correlation of miliolids and plant remnants in the correlation analysis. One of the best examples for

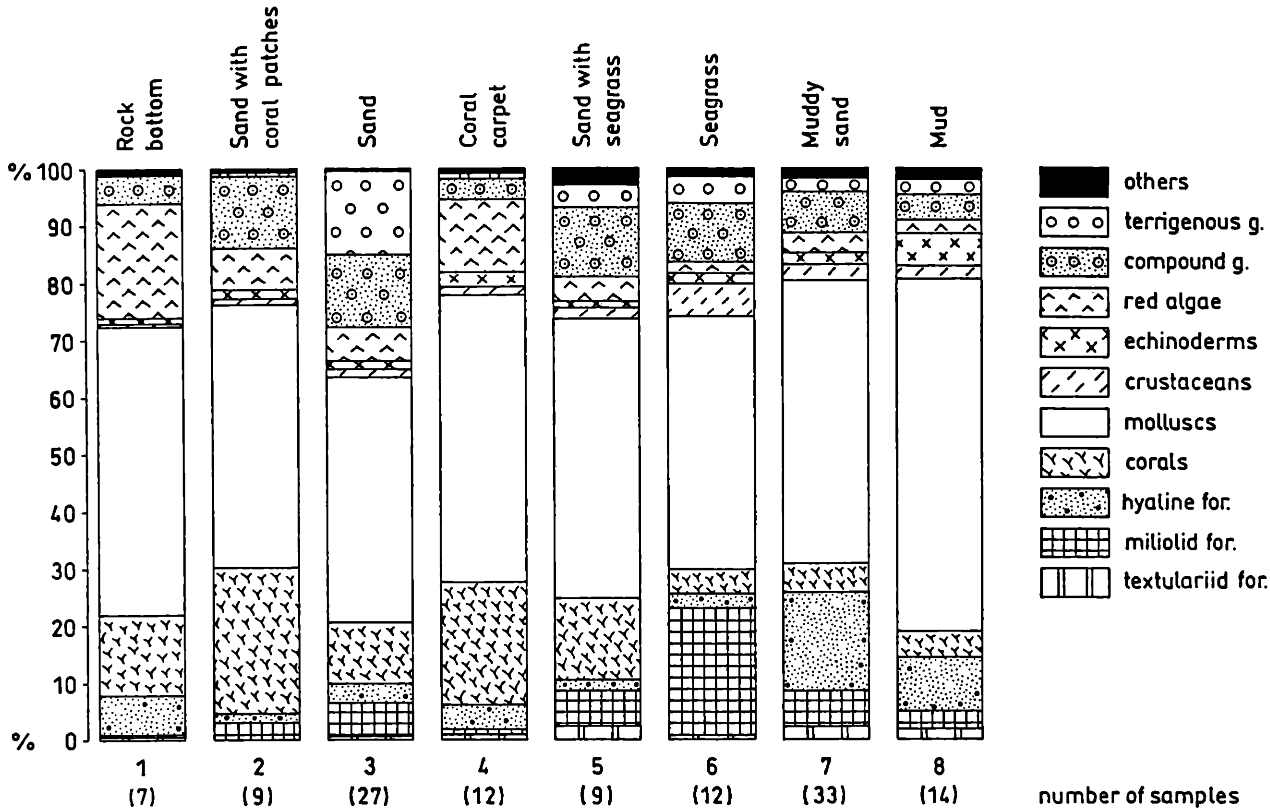


Fig. 29. Distribution of components in bottom facies.

this relation are the many miliolids (nearly 20 %) in the isolated sample C 2 (Fig. 19) from the northern basin of the 'East area' (50 m), where a sparse standing crop of small *Halophila* occurs. The positive correlation to fine and very fine sand, but not to mud, also reflects this relation: these grain size classes are dominant in the second sub-population of the distributions in 'Seagrass' bottom facies (Figs. 10, 11; Tab. 3) and seem to correspond with the grain size predominantly trapped by the plants. Hyaline foraminifer distribution is clearly grain size determined. These foraminifers are positively correlated with mud and their distributional pattern coincides with that of muddy sediments; they prefer substrates with high silt content, such in the 'Muddy sand' bottom facies (Tab. 8). In 'Muddy sand' (especially in the southern basin of the 'East area'), they can make up nearly 60 % of the sediment > 250 μm. Whereas the muddy sediments are dominated by *Operculina*, hyaline foraminifers are also abundant on some hard substrates ('Rock bottom': B 1, C 1), being mainly represented here by *Heterostegina*. The strong substrate dependence of the two abundant foraminiferal groups is demonstrated by those samples originating from 'Muddy sand' bottom covered by seagrass. Here the foraminiferal fauna is characterized by the co-occurrence of soritids and *Operculina* (e.g., A 4, C 2).

Corals contribute mainly to the coarser sediment fractions and also are positively correlated to sediments > 250 μm. Their patchy distribution demonstrates that they are deposited only in the immediate neighbourhood of their living habitat. Red algae are similarly positively correlated to coarse sediment fractions and show a patchy distribution as well. Whereas higher coral contents are mainly restricted to shallow water, the sediments of the deeper subtidal ridges (e.g., south Ras Abu Soma, south of Tubya al-Bayda) also contains higher percentages of coralline algae. The co-occurrence of corals and red algae is additionally documented by their positive correlation coefficient (Tab. 6). Their occurrence in shallow water on one hand and on the submarine ridges on the other seems to be related to higher water energy.

The distribution of compound grains, mainly consisting of medium and coarse sand grains, is not controlled by sediment grain size. They are most abundant in the very shallow water of the 'North area', although higher percentages are also present in deeper water of the 'East area'. The reason for this distribution, without any significant correlation to grain size, may be due to the heterogeneity of this group, probably comprising compound grains of different origin.

Non-carbonate particles, composed entirely of quartz and feldspar grains, are more frequent in coastal areas; this reflects a terrigenous input. The occurrence of isolated samples with higher contents

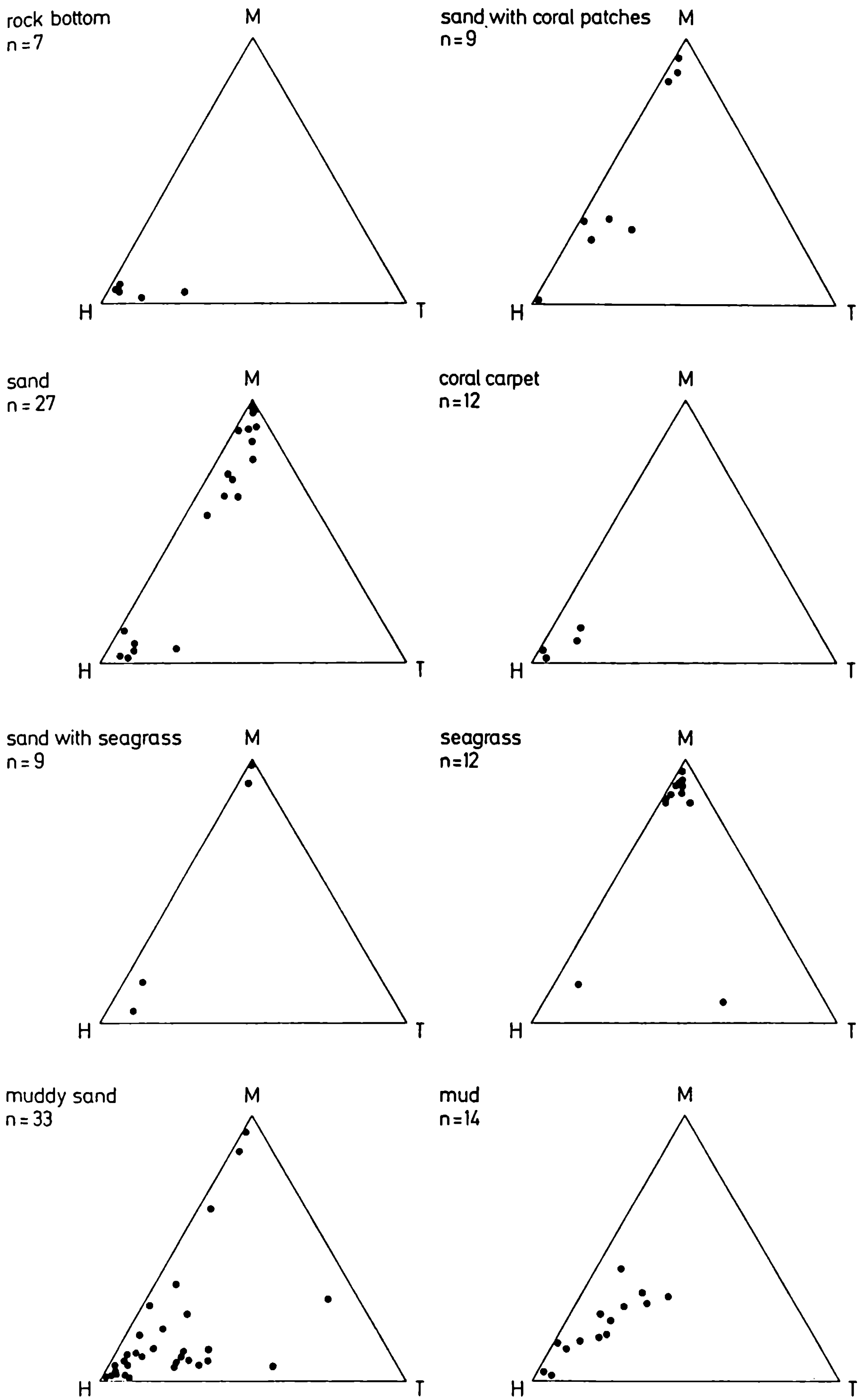


Fig. 30. Triangular diagrams of hyaline – miliolid – agglutinated foraminifers related to bottom facies.

(A 27, B 21) cannot be explained by direct terrigenous input, because adjoining samples totally lack terrigenous particles. These grains may be directly reworked from the underlying rocks or may represent relict sediments. The abundance of terrigenous grains increases with decreasing grain size; generally, a positive correlation to finer coarse and coarser medium sand fractions exists (Tab. 8). The fractioned samples show that grains of finer coarse and medium sand fractions — where terrigenous grains are most abundant — are highly positively correlated to fine sand and negatively to mud. This may be one reason for the high negative correlation to molluscs, which are positively correlated to mud; a second explanation is that molluscs normally supply the dominating particles and are therefore most reduced in those samples where terrigenous particles dominate.

Crustaceans exhibit certain clear relations to other components and grain size. Their high preference for fine sand and mud, and the rejection of all fractions > 250 μm, together with a positive correlation to miliolid foraminifers and to some fractions of plants and echinoderms, indicates that crustaceans may most frequently be found in seagrass areas and in muddy sediments.

Echinoderms are similarly related to grain size, as are crustaceans, but positively only to mud. In the total sample, relations only exist to pellets, the finer fractions are positively correlated to agglutinated foraminifers and crustaceans. Therefore their main distribution should be expected in mud bottoms.

Worm tube distribution exhibits a more complex pattern. Analyzing the total samples they are neither significantly related to any grain size class nor to a component category. The analysis of fractioned samples revealed a positive correlation to two different groups for grain size as well as for components. On the one hand, the worm tubes of very coarse sand are related to gravel and very coarse sand, and on the other to red algae. Worm tubes from coarse and medium sand fractions are positively correlated to very fine sand and to miliolids and plants, respectively. These correlations may reflect the different substrates settled by worm tubes. In the coarse fractions these substrates are either the red algae themselves or the hard bottom, which also functions as substrate for the red algae. In the finer fractions the correlations point to seagrass as a substrate.

The differentiation of the bottom facies based on the studied components is possible to a variable extent. The component distribution of 'Rock bottom' and 'Coral carpet', for example, is very similar. As expected, 'Rock bottom' samples, including the samples of Sand with macroids (omitting the macroids), exhibit a higher average amount of red algae, whereas those of 'Coral carpet' show a higher coral percentage. Both are abundant in hyaline foraminifers, represented by *Heterostegina* and *Operculina*. The very similar component distribution and the high variance of red algae and corals reflects the difficulties in delimiting both bottom facies in the field (compare PILLER & PERVESLER, 1989, p. 114). Additionally, the high variability in 'Coral carpet' can be explained by the fact that samples taken in pockets or depressions filled with fine-grained sediments are also included. In such samples (e.g., A 18) corals can be nearly absent and the muddy sand bottom has a dense *Operculina* population. From the microfacies viewpoint such samples would be classified along with 'Muddy sand', but when mapping the sea bottom, these are only little occurrences in 'Coral carpet'

'Sand with coral patches' is clearly different; here, corals reach their highest percentage. However, the amount depends directly on the distance of the sampling point from the coral colony and therefore also on patch density. The variability of red algae is very high but their general frequency is low. Compound grains are more abundant than in all other bottom facies types, but are also highly variable in abundance.

'Sand' bottom is very heterogeneous in composition, as is documented by the high variances of the components. After molluscs, quartz is the second most abundant component category as expressed by the mean value. Only 7 out of 27 samples, however, originating exclusively from coastal sites, reach values > 10 %, whereas 12 have less than 1 %. The next category in frequency are compound grains, which exhibit a more continuous distribution. The higher coral percentage can be largely explained by the occurrence of isolated coral patches or colonies or by the adjoining 'Coral carpet'; in coastal samples transportation may play a role. A similar explanation can be applied to miliolid foraminifers: they are either accumulated by wave action (C 16), the samples originate adjacent to seagrass meadows (A 15), or a sparse seagrass stock is present at the sample locality (C 19). In contrast, higher hyaline foraminifer values occur in samples (A 15, A 20, B 3, B 28) from muddy substrates; this is also expressed by the co-occurrence of enteropneusts mounds (Appendix 1; compare PILLER & PERVESLER, 1989, p. 115, pl. 7, fig. 1). In fact, these samples represent a transition to 'Muddy sand' bottom facies. Of interest is the abundance of echinoderms in some samples. These echinoderms are mainly represented by remnants of regular echinoids; the samples originate exclusively from localities close to coral reefs, coral patches or 'Coral carpet' — facies that represent the habitat of living echinoids. Red algae are more frequent in those samples originating either from localities near

Rock bottom (7 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
B 1	0.56	0.71	13.00	14.27	0.01	4.57	51.35	0.47	0.26	0.48	0.00	25.08	0.00	0.01	0.00	3.10	0.40
B 2	0.95	0.89	5.24	7.08	0.00	23.32	44.65	3.24	1.08	1.18	0.00	12.69	0.00	0.00	0.00	6.80	0.00
B 4	0.33	0.66	11.42	12.41	0.00	4.93	44.10	1.13	0.22	0.30	0.00	32.00	0.21	0.00	0.00	4.51	0.19
B 56	0.15	0.48	0.74	1.37	0.00	4.85	63.70	0.56	0.03	0.70	0.00	21.35	0.00	0.00	0.00	7.35	0.00
B 60	0.27	0.06	0.74	1.07	0.00	2.16	62.59	1.13	0.22	0.03	0.00	30.57	0.00	0.00	0.00	2.22	0.00
C 1	0.48	1.27	14.86	16.61	0.00	24.04	52.56	0.22	0.60	0.93	0.00	0.00	0.00	0.00	0.00	5.01	0.00
C 27	0.41	0.09	2.89	3.39	0.00	34.36	35.24	0.20	0.11	2.73	0.00	19.04	0.00	0.00	0.00	4.93	0.01
m	0.45	0.59	6.98	8.03	0.00	14.03	50.60	0.99	0.36	0.91	0.00	20.10	0.03	0.00	0.00	4.85	0.09
s	0.24	0.40	5.55	5.94	0.00	11.94	9.51	0.98	0.34	0.82	0.00	10.27	0.07	0.00	0.00	1.70	0.14
min.	0.15	0.06	0.74	1.07	0.00	2.16	35.24	0.20	0.03	0.03	0.00	0.00	0.00	0.00	0.00	2.22	0.00
max.	0.95	1.27	14.86	16.61	0.01	34.36	63.70	3.24	1.08	2.73	0.00	32.00	0.21	0.01	0.00	7.35	0.40

Sand with coral patches (9 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 2	0.69	14.71	1.45	16.85	0.02	6.19	52.36	0.08	3.75	2.74	0.00	6.29	0.09	0.00	0.00	7.97	3.66
A 8	0.36	9.03	1.40	10.79	0.00	6.01	61.52	0.13	1.15	0.45	0.00	2.32	0.00	0.00	0.00	17.16	0.45
A 17	0.11	0.17	0.31	0.59	0.00	38.79	22.34	0.03	0.32	1.09	0.00	34.99	0.00	0.00	0.00	1.85	0.00
A 23	0.37	0.48	0.45	1.30	0.00	23.98	63.28	0.42	0.42	0.30	0.00	1.65	0.06	0.08	0.00	8.09	0.42
B 10	0.09	0.09	8.06	8.24	0.00	53.90	27.58	0.23	0.29	3.51	0.00	1.28	0.00	0.00	0.00	4.44	0.00
B 25	0.09	0.29	0.81	1.19	0.00	27.00	62.14	0.76	0.05	0.29	0.00	3.32	0.00	0.00	0.00	5.08	0.18
B 73	0.03	1.96	4.08	6.07	0.00	47.82	20.66	0.10	1.50	6.97	0.00	15.42	1.03	0.00	0.00	0.44	0.00
C 11	0.01	0.65	0.04	0.70	0.00	5.25	34.76	0.00	0.13	0.02	0.00	0.00	0.00	0.00	0.00	59.15	0.00
C 18	0.07	0.31	0.06	0.44	0.00	21.19	66.83	0.00	0.01	0.08	0.00	0.06	0.00	0.00	0.00	11.38	0.00
m	0.20	3.08	1.85	5.13	0.00	25.57	45.72	0.19	0.85	1.72	0.00	7.26	0.13	0.01	0.00	12.84	0.52
s	0.21	4.92	2.49	5.50	0.01	17.22	18.08	0.24	1.13	2.20	0.00	10.79	0.32	0.03	0.00	17.05	1.12
min.	0.01	0.09	0.04	0.44	0.00	5.25	20.66	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.44	0.00
max.	0.69	14.71	8.06	16.85	0.02	53.90	66.83	0.76	3.75	6.97	0.00	34.99	1.03	0.08	0.00	59.15	3.66

Coral carpet (12 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 13	0.14	0.25	0.39	0.78	0.00	17.72	60.64	0.00	0.10	0.29	0.00	9.07	0.00	0.00	0.00	3.84	7.56
A 18	9.06	3.93	25.40	38.39	0.00	0.51	43.13	0.30	4.32	1.33	0.00	0.00	0.00	0.00	0.00	10.63	1.38
A 29	0.17	0.13	1.23	1.53	0.01	16.34	59.37	8.69	2.36	1.67	0.00	8.68	0.00	0.00	0.00	1.15	0.00
B 7	0.98	1.30	7.84	10.12	0.02	15.82	52.60	0.36	2.10	8.03	0.00	9.12	0.16	0.00	0.00	1.66	0.00
B 24	0.99	1.69	4.00	6.68	0.08	11.55	47.74	0.38	2.35	2.64	0.00	23.44	0.40	0.00	0.00	4.70	0.04
B 31	0.85	0.98	1.62	3.45	0.01	37.72	34.76	1.16	3.68	3.39	0.01	12.76	0.07	0.00	0.00	3.00	0.00
B 59	0.18	0.12	0.42	0.72	0.00	19.67	52.92	0.63	0.18	1.81	0.00	20.13	0.02	0.00	0.00	3.92	0.00
B 61	0.07	0.03	1.56	1.66	0.01	9.09	70.03	0.94	0.04	0.55	0.00	10.88	0.00	0.00	0.00	6.52	0.29
B 68	0.36	0.71	0.80	1.87	0.00	41.60	51.85	0.22	0.45	0.28	0.00	3.12	0.00	0.00	0.00	0.53	0.07
C 28	0.00	0.12	2.40	2.52	0.00	56.16	24.73	0.02	1.17	5.02	0.00	8.06	0.00	0.00	0.00	2.31	0.00
D 3	0.53	1.19	1.82	3.54	0.07	15.63	46.84	2.84	0.95	1.34	0.00	26.39	0.07	0.00	0.00	2.21	0.12
D 8	0.51	0.79	2.18	3.48	0.03	14.28	55.86	1.80	1.54	4.84	0.00	16.08	0.25	0.00	0.00	1.67	0.18
m	1.15	0.95	4.13	6.23	0.02	21.34	50.04	1.45	1.60	2.60	0.00	12.31	0.08	0.00	0.00	3.51	0.80
s	2.41	1.04	6.71	10.03	0.03	15.07	11.50	2.32	1.35	2.25	0.00	7.57	0.12	0.00	0.00	2.68	2.07
min.	0.00	0.03	0.25	0.72	0.00	0.51	24.73	0.00	0.04	0.28	0.00	0.00	0.00	0.00	0.00	0.53	0.00
max.	9.06	3.93	25.40	38.39	0.08	56.16	70.03	8.69	4.32	8.03	0.01	26.39	0.40	0.00	0.00	10.63	7.56

Sand with seagrass (9 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 11	0.86	21.00	1.40	23.26	0.00	3.83	34.67	0.87	3.93	1.03	0.00	0.23	0.07	0.50	0.00	15.90	15.68
A 21	2.61	7.94	1.53	12.08	0.00	5.00	64.81	0.02	2.40	1.76	0.00	0.12	0.00	0.00	0.00	7.30	6.50
A 28	0.18	0.42	2.05	2.65	0.01	52.95	25.02	0.66	0.96	1.40	0.00	16.11	0.00	0.00	0.00	0.25	0.00
A 32	1.03	5.08	1.41	7.52	0.00	31.03	40.13	0.40	1.96	2.08	0.00	3.45	0.00	0.00	0.00	4.75	8.67
B 18	5.49	1.78	2.36	9.63	0.00	11.83	62.35	0.05	3.63	1.42	0.00	0.68	0.01	0.11	0.00	8.21	2.08
B 49	0.44	0.27	4.36	5.07	0.00	11.16	51.41	0.04	0.22	1.16	0.00	1.98	0.00	0.00	0.49	28.02	0.45
C 3	3.26	3.96	7.28	14.50	0.00	0.00	58.10	0.20	2.82	1.02	0.00	0.00	13.25	0.22	0.00	9.91	0.00
C 15	0.11	9.83	0.11	10.05	0.00	6.75	48.27	0.06	0.46	0.35	0.00	13.66	0.00	7.01	0.00	13.37	0.01
C 26	8.44	4.37	3.43	16.24	0.00	1.98	54.16	0.21	1.93	1.36	0.00	0.00	0.00	0.00	0.00	19.34	4.77
m	2.49	6.07	2.66	11.22	0.00	13.84	48.77	0.28	2.03	1.29	0.00	4.03	1.48	0.87	0.05	11.89	4.24
s	2.69	6.08	2.01	5.87	0.00	16.32	12.48	0.29	1.24	0.46	0.00	5.93	4.16	2.18	0.15	7.88	5.04
min.	0.11	0.27	0.11	2.65	0.00	0.00	25.02	0.02	0.22	0.35	0.00	0.00	0.00	0.00	0.00	0.25	0.00
max.	8.44	21.00	7.28	23.26	0.01	52.95	64.81	0.87	3.93	2.08	0.00	16.11	13.25	7.01	0.49	28.02	15.68

Tab. 9. Grain composition (%) of samples related to bottom facies (m = mean value, s = standard deviation).

Sand (27 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 1	0.00	0.81	0.11	0.92	0.00	9.45	12.62	0.00	0.14	0.14	0.00	14.13	0.00	0.00	0.00	19.04	43.55
A 7	0.06	0.76	0.04	0.86	0.00	0.74	8.52	0.00	0.18	0.61	0.00	0.24	0.00	0.00	0.00	1.20	87.65
A 10	0.09	1.74	0.15	1.98	0.00	4.65	2.34	0.02	0.11	0.22	0.00	0.00	0.00	0.00	0.00	3.72	86.96
A 15	3.16	37.35	11.51	52.02	0.00	3.16	26.89	0.34	7.47	3.76	0.03	0.50	0.15	0.08	0.00	4.27	1.33
A 20	0.87	0.52	15.34	16.73	0.00	14.65	62.40	0.00	3.45	0.03	0.00	0.60	0.00	0.00	0.00	0.55	1.58
B 3	1.59	1.71	17.55	20.85	0.00	1.42	67.28	0.03	0.93	1.59	0.00	0.00	0.00	0.00	0.00	7.83	0.07
B 11	0.13	1.07	7.14	8.34	0.00	18.59	33.14	0.04	2.49	7.71	0.00	28.95	0.00	0.00	0.00	0.75	0.00
B 19	0.22	0.11	2.19	2.52	0.00	4.31	69.65	0.08	0.74	2.64	0.00	2.82	0.00	0.00	0.00	6.47	0.77
B 26	0.06	1.41	0.00	1.47	0.00	21.89	31.41	0.00	1.69	1.01	0.00	24.48	0.00	0.00	0.00	17.57	0.48
B 28	0.97	0.29	10.44	11.70	0.00	1.95	56.30	0.00	0.30	0.23	0.00	0.35	0.00	0.01	0.13	28.31	0.71
B 41	3.37	1.87	8.17	13.41	0.00	0.48	64.80	0.03	3.27	2.33	0.00	1.29	0.00	0.00	0.38	11.07	2.89
B 57	0.34	0.09	1.09	1.52	0.00	0.82	70.20	0.00	0.05	0.11	0.00	14.31	0.00	0.00	0.03	11.97	0.99
B 67	0.61	0.52	0.15	1.28	0.00	32.82	56.23	0.56	0.84	1.78	0.00	0.22	0.38	0.00	0.00	5.85	0.05
B 74	0.04	2.97	0.02	3.03	0.00	19.62	60.97	0.00	0.28	0.64	0.00	7.82	0.00	0.00	0.00	3.01	4.61
C 5	1.04	0.62	2.26	3.92	0.00	9.99	44.85	0.42	0.12	4.88	0.00	0.15	0.00	0.00	0.00	31.51	4.15
C 8	1.59	3.44	2.27	7.30	0.03	23.29	46.48	0.23	1.43	2.59	0.00	7.98	0.00	0.00	0.00	10.25	0.42
C 9	0.13	0.60	0.22	0.95	0.00	1.31	1.43	0.00	0.06	0.32	0.00	0.85	0.00	0.00	0.00	0.57	94.52
C 10	0.13	0.89	0.39	1.41	0.00	11.16	57.29	0.06	0.02	0.04	0.00	0.00	0.00	0.00	0.00	29.88	0.15
C 13	0.00	1.69	0.03	1.72	0.00	0.14	41.26	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.11	21.87	33.95
C 16	0.54	33.92	0.77	35.22	0.00	7.06	35.93	0.97	6.95	0.84	0.00	2.12	0.03	0.77	0.00	8.04	2.06
C 17	0.20	1.60	0.51	2.31	0.00	4.15	74.27	0.07	0.03	0.08	0.00	0.00	0.00	0.03	0.00	18.01	1.04
C 19	0.43	41.55	0.77	42.75	0.00	5.83	35.14	1.25	3.02	0.27	0.00	0.00	0.00	0.00	0.00	11.23	0.51
C 21	0.07	2.02	0.06	2.15	0.01	34.68	23.70	0.02	0.34	0.00	0.00	0.00	0.00	0.00	0.08	15.81	23.20
C 24	0.10	0.76	0.51	1.37	0.00	10.08	27.19	0.03	0.43	2.65	0.00	2.69	0.00	0.00	0.00	55.56	0.00
D 1	0.84	8.27	0.84	9.95	0.00	8.35	46.69	0.17	3.50	0.00	0.00	9.54	0.34	0.00	0.59	1.86	19.00
D 2	0.84	5.37	0.78	6.99	0.00	23.45	29.27	0.16	1.42	0.78	0.00	27.87	0.00	0.29	0.00	8.32	1.11
D 7	0.37	0.97	1.03	2.37	0.00	18.10	63.32	1.58	0.51	0.10	0.00	12.78	0.00	0.00	0.00	1.13	0.12
m	0.66	5.66	3.12	9.45	0.00	10.82	42.58	0.22	1.51	1.31	0.00	5.91	0.03	0.04	0.05	12.43	15.25
s	0.86	11.47	4.94	13.24	0.01	9.83	21.17	0.40	1.96	1.79	0.01	8.77	0.10	0.15	0.13	12.39	28.48
min.	0.00	0.09	0.00	0.86	0.00	0.14	1.43	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00
max.	3.37	41.55	17.55	52.02	0.03	34.68	74.27	1.58	7.47	7.71	0.03	28.95	0.38	0.77	0.59	55.56	94.52

Seagrass (12 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 5	0.38	23.69	3.78	27.85	0.00	0.16	51.42	0.27	4.76	0.09	0.00	0.00	0.06	0.02	0.00	13.75	1.63
A 6	0.36	13.02	1.73	15.11	0.00	0.92	42.24	0.17	1.96	0.50	0.00	0.96	0.00	0.10	0.00	3.44	34.60
A 19	1.51	42.11	2.95	46.57	0.00	0.91	29.65	1.18	3.61	1.17	0.00	0.00	0.00	1.85	0.00	5.21	9.84
A 25	1.85	35.22	2.27	39.34	0.00	0.21	43.74	0.19	6.08	0.62	0.00	0.00	0.00	0.00	0.00	8.64	1.18
A 30	0.56	43.03	1.50	45.18	0.00	0.21	40.79	0.49	4.19	0.12	0.00	0.00	0.00	0.00	0.00	6.89	2.23
B 12	0.62	1.18	5.94	7.74	0.00	20.95	34.99	0.37	3.42	4.14	0.00	22.50	0.02	0.00	0.00	5.87	0.00
B 17	0.58	31.86	5.59	38.03	0.00	1.57	44.84	0.84	3.59	1.06	0.18	0.13	1.41	1.75	0.00	5.63	0.99
B 48	3.06	0.46	1.71	5.23	0.00	6.70	65.95	0.09	3.04	2.78	0.00	0.32	1.11	0.00	0.26	13.08	1.45
C 6	0.74	21.90	1.24	23.88	0.00	16.63	29.14	1.24	4.10	0.16	0.00	0.77	0.00	8.09	0.00	12.52	3.46
C 7	1.39	20.45	1.74	23.58	0.25	3.38	47.64	1.89	5.11	0.65	0.00	0.00	0.10	0.94	0.00	15.68	0.79
C 20	0.73	28.07	2.41	31.21	0.00	0.07	32.62	0.73	14.38	0.98	0.00	0.00	0.00	2.01	0.00	17.83	0.17
C 23	0.69	5.58	0.44	6.71	0.00	0.20	63.65	0.07	3.58	9.31	0.00	0.00	0.00	2.17	0.00	14.13	0.18
m	1.04	22.21	2.61	25.87	0.02	4.33	43.89	0.63	4.82	1.80	0.02	2.06	0.23	1.41	0.02	10.22	4.71
s	0.76	14.17	1.63	14.17	0.07	6.78	11.50	0.54	3.05	2.54	0.05	6.17	0.47	2.19	0.07	4.60	9.37
min.	0.36	0.46	0.44	5.23	0.00	0.07	29.14	0.07	1.96	0.09	0.00	0.00	0.00	0.00	0.00	3.44	0.00
max.	3.06	43.03	5.94	46.57	0.25	20.95	65.95	1.89	14.38	9.31	0.18	22.50	1.41	8.09	0.26	17.83	34.60

Mud (14 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
B 13	0.14	0.20	5.38	5.72	0.05	27.04	47.35	0.27	1.94	2.58	0.00	12.71	0.00	0.00	0.02	2.31	0.02
B 14	6.48	7.07	9.06	22.61	0.07	0.07	51.14	0.00	3.54	6.93	0.00	0.00	0.00	0.00	4.72	10.83	0.07
B 16	0.40	2.06	2.40	4.86	0.00	0.68	86.97	0.04	1.66	2.60	0.00	0.18	0.00	0.00	0.04	2.95	0.00
B 20	1.00	0.52	18.19	19.71	0.00	1.61	69.74	0.02	2.90	3.21	0.00	0.00	0.22	0.00	0.00	2.19	0.42
B 21	3.46	3.97	16.35	23.78	0.00	7.36	23.20	0.42	2.04	5.50	0.00	0.00	0.00	0.00	0.74	4.29	32.67
B 22	2.31	3.99	8.01	14.31	0.00	2.91	74.58	0.13	2.44	3.20	0.00	0.00	0.00	0.28	0.09	1.04	1.01
B 23	0.04	0.50	2.96	3.50	0.01	23.62	51.32	0.36	1.29	5.95	0.00	11.70	0.03	0.00	0.00	2.27	0.04
B 43	4.51	7.75	10.86	23.12	0.00	0.00	56.50	0.00	3.47	9.31	0.00	0.00	0.00	0.00	0.74	6.87	0.00
B 44	0.92	1.41	3.92	6.25	0.00	0.24	82.01	0.00	2.25	7.01	0.00	0.00	0.00	0.00	0.00	2.25	0.00
B 46	0.63	1.15	6.00	7.78	0.00	0.00	82.23	0.00	1.42	4.50	0.00	0.00	0.00	0.00	0.00	4.03	0.03
B 58	1.51	3.62	24.75	29.88	0.00	0.00	62.06	0.00	2.16	3.73	0.00	0.00	0.00	0.00	0.00	2.02	0.15
B 70	7.02	8.80	14.17	29.99	0.00	0.00	47.25	0.00	6.33	8.28	0.00	0.00	0.00	0.00	0.00	8.15	0.00
D 5	0.47	1.15	2.96	4.58	0.00	4.66	66.81	0.40	2.61	5.06	0.00	10.79	0.00	0.00	0.00	4.90	0.20
D 6	1.94	2.14	8.06	12.14	0.00	0.00	61.33	0.00	5.71	11.84	0.00	0.71	0.00	0.00	0.00	8.16	0.10
m	2.20	3.17	9.51	14.87	0.01	4.87	61.61	0.12	2.84	5.69	0.00	2.58	0.02	0.02	0.45	4.45	2.48
s	2.23	2.75	6.43	9.40	0.02	8.64	16.63	0.16	1.45	2.65	0.00	4.80	0.06	0.07	1.21	2.85	8.38
min.	0.04	0.20	2.40	3.50	0.00	0.00	23.20	0.00	1.29	2.58	0.00	0.00	0.00	0.00	0.00	1.04	0.00
max.	7.02	8.80	24.75	29.99	0.07	27.04	86.97	0.42	6.33	11.84	0.00	12.71	0.22	0.28	4.72	10.83	32.67

Tab. 9. continued

Muddy sand (33 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 3	1.33	19.82	9.54	30.69	0.00	0.26	44.16	0.34	5.82	0.09	0.00	0.00	0.00	0.00	0.00	18.12	0.51
A 4	1.04	12.94	31.55	45.53	0.00	0.09	38.56	0.12	4.80	0.41	0.00	0.00	0.00	0.00	0.00	9.21	1.37
A 12	1.12	3.39	15.15	19.66	0.00	3.14	62.40	0.01	6.50	0.73	0.00	0.03	0.04	0.00	0.00	7.32	0.19
A 14	1.80	3.72	35.35	40.87	0.00	0.18	50.50	0.01	5.33	0.44	0.00	0.00	0.07	0.00	0.00	2.45	0.15
A 16	0.20	0.06	0.52	0.78	0.00	13.46	58.33	0.02	0.34	0.25	0.00	0.56	0.00	0.00	0.00	6.32	19.94
A 22	0.64	19.31	2.58	22.53	0.00	0.30	64.31	0.19	5.65	1.82	0.00	0.26	0.00	0.00	0.00	5.00	0.12
A 24	0.40	1.13	18.02	19.55	0.00	6.30	65.27	0.00	5.92	0.57	0.00	0.91	0.00	0.00	0.00	0.84	0.63
A 26	0.18	0.15	14.25	14.58	0.00	2.19	74.47	0.00	3.16	1.86	0.00	0.00	0.11	0.00	0.00	3.39	0.25
A 27	2.65	1.28	7.81	11.74	0.00	0.17	49.27	0.20	2.26	1.31	0.00	0.00	0.00	0.00	0.00	2.91	32.14
B 6	7.95	1.92	26.75	36.62	0.00	0.62	49.68	0.05	2.23	1.80	0.00	0.00	0.00	0.00	0.00	5.70	3.29
B 8	7.82	0.94	5.76	14.52	0.00	10.04	44.99	0.01	2.98	1.36	0.00	14.71	0.00	0.00	0.00	8.43	2.95
B 9	4.59	2.53	4.01	11.13	0.02	2.16	48.40	0.13	5.05	1.78	0.00	3.98	2.14	0.00	0.00	24.30	0.91
B 15	0.43	0.36	3.55	4.34	0.00	17.08	64.53	0.06	1.84	4.40	0.00	5.05	0.00	0.00	0.00	2.70	0.00
B 30	1.46	2.15	5.02	8.63	0.33	31.03	34.86	2.64	2.34	2.85	0.00	16.06	0.14	0.00	0.29	0.82	0.00
B 32	5.56	1.35	10.61	17.52	0.00	5.94	52.62	0.40	1.59	2.38	0.00	0.00	0.36	0.00	0.03	17.74	1.43
B 33	3.57	5.74	45.32	54.81	0.00	0.67	9.32	1.20	1.59	2.90	0.00	2.03	0.26	0.00	0.23	27.17	0.00
B 34	2.20	1.02	59.95	63.17	0.00	1.74	22.17	0.10	1.23	1.35	0.00	0.03	0.03	0.01	0.00	10.09	0.07
B 35	0.95	1.49	16.81	19.25	0.00	0.26	62.35	0.03	6.13	3.20	0.00	0.63	0.24	0.02	0.09	7.34	0.45
B 36	1.40	0.67	27.73	29.80	0.02	0.47	60.32	0.09	1.60	1.84	0.00	0.07	0.00	0.16	0.00	5.75	0.07
B 37	4.85	1.20	58.72	64.77	0.00	2.35	16.22	0.03	1.23	0.51	0.00	0.00	0.02	0.00	0.00	6.62	8.25
B 38	0.82	0.30	39.96	41.08	0.00	9.82	42.93	0.00	3.46	1.20	0.00	0.00	0.00	0.00	0.00	1.25	0.28
B 42	2.37	0.47	5.09	7.93	0.00	1.02	66.25	0.02	5.58	3.23	0.00	2.58	0.00	0.00	0.06	10.57	2.76
B 45	0.28	0.11	0.84	1.23	0.01	10.71	53.83	0.86	1.14	2.30	0.00	29.58	0.00	0.00	0.00	0.34	0.00
B 51	1.57	0.80	0.25	2.62	0.00	0.00	7.65	0.14	1.26	0.36	0.00	0.00	87.31	0.00	0.03	0.19	0.42
B 52	0.97	0.98	24.92	26.87	0.01	26.46	34.50	0.56	0.82	1.34	0.00	1.92	0.02	0.00	0.00	7.50	0.00
B 53	1.86	1.94	26.88	30.68	0.00	0.13	55.87	0.00	1.96	5.80	0.00	0.00	0.27	0.00	0.00	5.30	0.00
B 54	3.30	1.01	10.72	15.03	0.00	0.73	63.92	0.26	3.49	2.37	0.00	0.94	0.63	0.00	0.64	10.39	1.60
B 69	1.83	0.72	3.51	6.06	0.00	0.41	84.93	0.18	3.41	1.97	0.00	0.00	0.00	0.00	0.00	2.56	0.46
C 2	3.98	19.89	31.22	55.09	0.00	0.00	26.79	0.22	1.14	1.47	0.00	0.00	1.81	0.00	0.00	13.48	0.00
C 4	9.30	2.74	3.12	15.16	0.00	2.91	69.40	0.90	3.83	0.76	0.00	0.00	0.00	0.00	0.00	6.19	0.86
C 12	0.25	23.30	1.52	25.07	0.00	3.92	53.27	0.22	1.65	1.45	0.00	6.43	0.00	0.00	0.00	7.99	0.00
C 14	1.01	1.05	6.59	8.65	0.04	14.92	34.58	0.53	1.54	1.26	0.00	30.70	1.19	0.00	0.00	7.62	0.00
D 9	1.25	2.10	7.62	10.97	0.06	0.81	68.06	0.13	2.63	5.42	0.00	5.45	0.00	0.00	0.00	6.46	0.00
m	2.39	6.54	17.01	23.54	0.01	5.16	49.54	0.29	3.02	1.84	0.00	3.69	2.87	0.01	0.04	7.64	2.40
s	2.34	6.54	16.39	17.68	0.06	7.63	18.28	0.50	1.81	1.36	0.00	7.73	14.94	0.03	0.12	6.32	6.39
min.	0.18	0.06	0.25	0.78	0.00	0.00	7.65	0.00	0.34	0.09	0.00	0.00	0.00	0.00	0.00	0.19	0.00
max.	9.30	23.30	59.95	64.77	0.33	31.03	84.93	2.64	6.50	5.80	0.00	30.70	87.31	0.16	0.64	27.17	32.14

Tab. 9. continued

coral patches, 'Coral carpet' or reefs (e.g., B 11, D 7) or from intertidal to shallow subtidal areas, where sands with branched rhodoliths occur (e.g., A 1, D 2).

'Sand with seagrass' is not very clearly delimited from the former bottom facies types. Except for molluscs, all the more abundant constitutents are very variable in frequency. Corals may exceed 50 %, but such high values can be directly related to coral heads or colonies in the immediate vicinity of the sampling locality. The occurrence of compound grains is more continuous. All foraminifers together make up more than 10 %, with miliolids dominating. Generally, miliolids remain < 10 %; only sample A 11 contains more than 20 %; this sample was taken directly from a dense *Halophila* patch. The higher percentage of hyaline foraminifers occurs in those samples where the sediment represents in fact muddy sand which is sparsely settled by *Halophila*. Here the sediment surface is settled by *Operculina*. Remarkable is the relatively high content of agglutinated foraminifers reaching the highest mean of all bottom facies. The samples with higher mud (silt) contents are responsible for this relatively high mean value. Red algae are abundant in two samples: A 28, characterized by the frequent occurrence of corals, and C 15, from the intertidal ridge north of Al-Dahira; the latter reflects the presence of rhodoliths between the seagrass plants.

The 'Seagrass' bottom facies is very strictly differentiated from others by its high percentage of miliolid foraminifers. This reflects the seagrass leaf habitat of the living organisms. Only two samples have a content < 5 %: B 12 originates from a *Cymodocea* meadow with relatively abundant coral colonies and which therefore exhibit a higher coral content; B 48 comes from a larger bare sand area inside a *Halophila* meadow. Except molluscs, only compound grains exceed 10 % (relatively small standard deviation). Crustaceans are relatively frequent, in accordance with field observations where dense crab populations were observed between the seagrass plants. The relatively high mean value of terrigenous material stems from a single sample (A 6) from near the west coast of the 'Southwest channel'

The 'Muddy sand' bottom facies is clearly determined by one foraminiferal group — the hyaline one, represented mainly by the genus *Operculina*. These forms are living on the muddy sand bottom in such densities that divers observed nearly total cover on the sediment surface. This high standing crop is reflected in the sediment samples by percentages approaching 60 %. The paucity of hyaline foraminifers in some samples has several causes: A 16 and B 15 are adjacent to 'Coral carpet' areas, as is reflected by a higher coral content; a similar situation is present in B 45, which comes from the base of a submarine high near the eastern margin of the 'West area' basin. This submarine elevation is characterized by coral settlement representing a transitional structure between a Patch reef and a 'Coral carpet' (PILLER & PERVESLER, 1989, p. 112). A 22 originates near a *Halophila* strip and therefore contains many soritids, the same holds true for C 12. B 51 is the "*Halimeda* sample" Molluscs often are characterized by higher amounts of scaphopods.

The 'Mud' bottom facies is the domain of molluscs. Foraminifers, dominated by hyaline forms, are the second most abundant. Two groups of samples with higher hyaline foraminiferal contents can be differentiated. The first comprises samples taken from near the margin of the mud area; they have a higher sand content and contain *Operculina*. The second group, originating from central basin areas, is characterized by smaller hyaline foraminifers such as *Ammonia* and *Elphidium*. The two samples with a higher coral content (B 13, B 23) were taken directly at the base of the steep wall bordering the eastern margin of the mud basin (settled by corals and classified with 'Coral carpet' in bottom facies map). The higher red algal content of some samples has the same explanation. The relatively high amount of echinoderms is based on sediment inhabiting irregular echinoids and on ophiurids living on the sediment surface.

The comparison of the distribution of the component clusters (Fig. 27) with the bottom facies map (Enclosure 1 in PILLER & PERVESLER, 1989; Fig. 54) shows that the coral-red algal clusters (4, 5, 6, 9, 10) cover the area occupied by Coral reefs, 'Coral carpet', 'Sand with coral patches', as well as 'Rock bottom' and Sand with macroids. Macroids were omitted from samples of the latter, which are therefore similar to those of the adjoining 'Rock bottom'. As expected, the sediments of these bottom facies types are characterized by corals and red algae. A further distinction on the base of the investigated component categories is not possible. The best coincidence between both distributions (component clusters and bottom facies) is developed between the miliolid (=soritid) cluster (3) and 'Seagrass' and 'Sand with seagrass' respectively. Therefore, although seagrass is not or very rarely preserved in sediments, its presence can be reconstructed on the basis of the amount of soritid foraminifers. The distribution of the quartz clusters (12, 14) agrees well with the occurrence of pure sands along the main coast and with the sediments of intertidal flats on the main coast and west of Gazirat Safaga, including the Mangrove samples. The mollusc cluster (1), the *Operculina* clusters (2, 13) and the echinoderm cluster (8) mainly represent the area covered by 'Mud' and 'Muddy sand' A remarkable deviation exists in the 'North area', where a large area is occupied by the mollusc cluster which in the bottom facies map is classified as 'Sand with coral patches' or 'Sand with coral patches and seagrass' *Operculina* clusters and 'Muddy sand' coincide relatively well; the echinoderm cluster mainly covers the center of the 'Mud' area. The other clusters, represented only by a few samples, are not related to the bottom facies differentiated here. The *Halimeda* cluster, however, containing only sample B 51, could also be separated as a *Halimeda* bottom facies type because the sample is from an area densely settled by this alga. However, *Halimeda* is relatively rare in the Northern Bay of Safaga and this cluster is represented by an area of only a few decameters in diameter; it was therefore not separated as a bottom facies type (compare chapter 3).

6 Mineralogical analysis

6.1 Methods

X-ray powder diffraction analysis was carried out in order to determine the mineral composition of the sediments; atomic absorption spectrophotometry was employed to detect the abundance of the elements. For these analyses a sub-sample of approx. 5 g was selected. For the mineral composition analysis, powder slide mounts were prepared not only for the total samples but also for the mud fraction (< 63 μm) alone; of the total samples, 147 subsamples were studied, for the mud fraction only 139 due to the lower content (< 5 %) of mud in some samples.

Initially, samples with high mud content were analysed between 3° and 36° 2Θ. This procedure detected only carbonate minerals (aragonite, Mg-calcite, calcite), quartz, plagioclase, and alkalifeldspar. To insure that clay minerals are completely absent, for those samples with > 20 % mud content, the analysis was repeated for this 2Θ interval with the mud fraction alone. While no clay minerals were detected, all samples were analysed only between 18° and 36° 2Θ. The method for quantitative determination of carbonate minerals from X-ray analysis is a matter of debate (e.g., HARDY & TUCKER, 1988). Therefore, in some selected samples, the calculation of carbonate mineral frequency was done by using peak height as well as peak area. The results of both methods were identical or very close and therefore, following GAVISH & FRIEDMAN (1973), peak height analyses were carried out for all samples.

Carbonate content, for the total as well as for the mud fraction alone, was additionally detected using CO_2-gasometry. A comparison of the three values (X-ray diffractometry, atomic absorption spec-

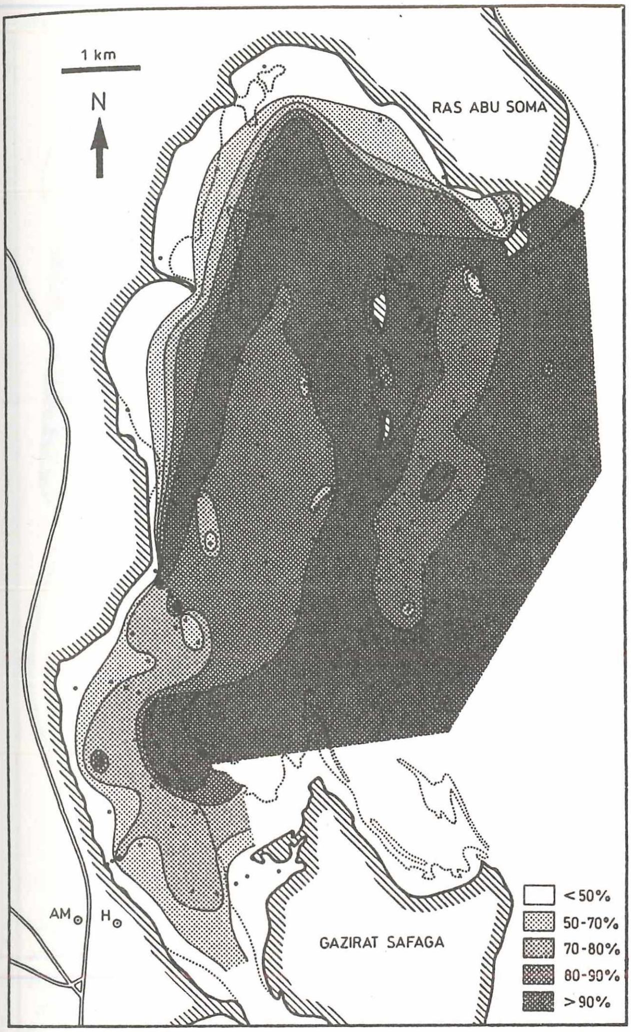


Fig. 31. Distribution of carbonate in the total samples.

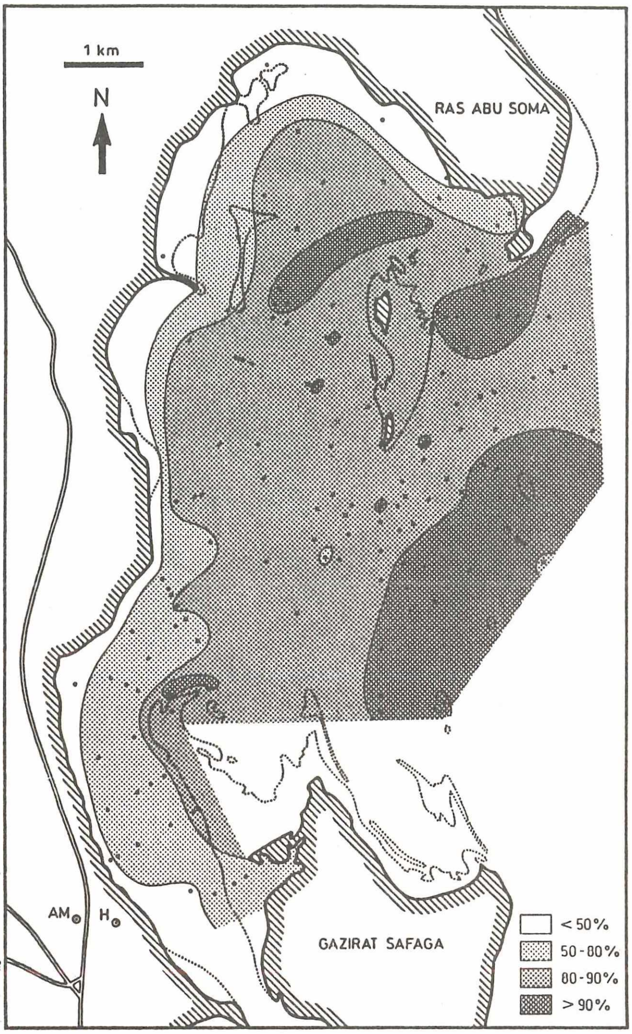


Fig. 32. Distribution of carbonate in the mud fraction.

trography, gasometry) revealed essential differences in some cases. The CO_2-gasometry method gave the most constant results, being in full agreement with the different standards used. Therefore these values were used in calculating the percentages of the carbonate minerals using the carbonate mineral ratio obtained from X-ray diffraction. The analogous procedure was used to calculate the non-carbonate minerals (Appendix 4).

6.2 Carbonate minerals

The opportunity to study a carbonate environment was one of the main reasons for investigating Northern Safaga Bay. Carbonate minerals, their content and distribution, as well as their origin are therefore of primary importance. Three carbonate minerals — aragonite, Mg-calcite and calcite — were detected by X-ray analysis; no dolomite was traced.

6.2.1 Distribution of carbonate content

In the **total samples**, the carbonate content makes up more than 90 % in a very extended area of the bay (Fig. 31). The lowest percentages are found along the main coast (down to a value of 11 %: A 7, C 9; Appendix 4) and in the southern part of the intertidal area west of Gazirat Safaga. The 'West area' and 'North area' are characterized by a general increase in a seaward direction. In the 'Southwest channel' the content is generally lower. Values between 80 and 90 % were typical for the basins. The reduced values of the 'West area' basin represent a continuation of the lower 'Southwest channel' percentage. In the 'East area' the reduced amount is not restricted to the basins alone but also includes an area south of Tubya Arba.

The distributional pattern of carbonate in the **mud fraction** (Fig. 32, Appendix 4) is quite different from that of the total sample. In most samples the content ranges between 80 and 90 %. As in the total samples the smallest percentages (down to

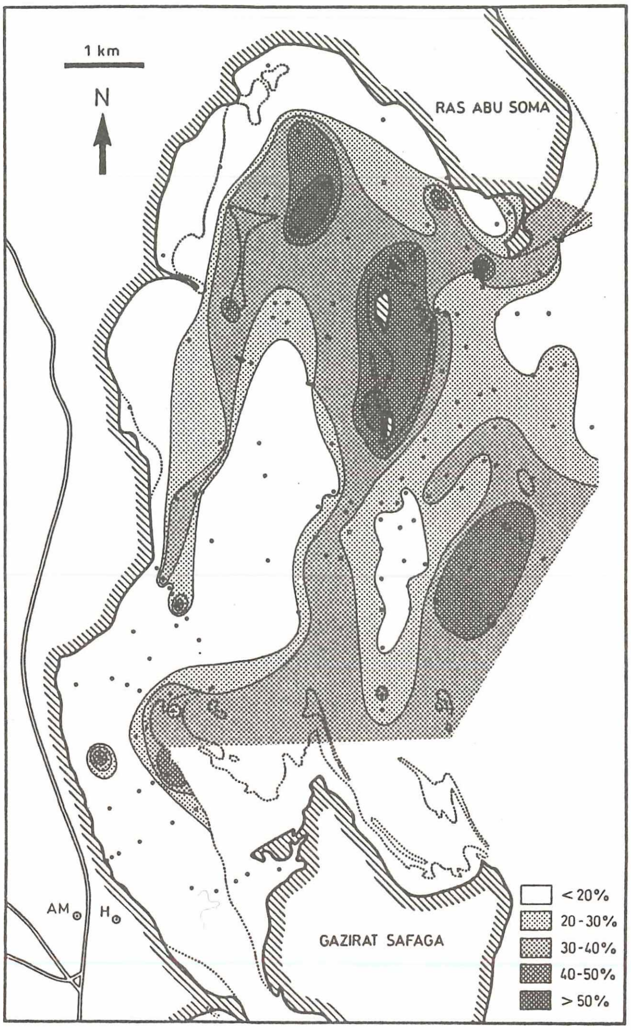


Fig. 33. Distribution of aragonite in the total samples (related to the total mineral content).

Fig. 34. Distribution of Mg-calcite in the total samples (related to the total mineral content).

21 % in A 6) are present along the main coast and in the southern part of the intertidal flat west of Gazirat Safaga. The 'Southwest channel' also exhibits reduced values, mainly between 60 and 80 %. With the exception of a few isolated samples, three larger areas with a content exceeding 90 % are recognizable. The first is in the southeast of the 'East area', including not only the shallower area west of the patch reefs of Tubya al-Kabir, Tubya al-Saghira, Gamul al-Saghira, and Gamul al-Kabir, but also the southernmost parts of the southern basin. The second is located between the southern margin of Ras Abu Soma and the western margin of Tubya al-Hamra, including the slope between the 'North area' and the 'East area' as well as the northernmost part of the northern basin of the 'East area'. The third is represented by a narrow, curved strip north to northwest of Tubya al-Hamra, extending from the deeper part of the western 'North area' to the northern end of the 'West area' basin (Fig. 32).

6.2.2 Distribution of carbonate minerals

Based on the frequencies of carbonate minerals related to total mineral content, the distributional pattern of the particular carbonate minerals is strongly influenced by the concentration of non-carbonate minerals along the main coast (Figs. 31, 32). Therefore the distributional pattern shows — as does carbonate content in general — an increase away from the main coast. In the **total samples**, however, aragonite is least frequent not only along the coast, but also in the 'West area' basin and its southern continuation into the 'Southwest channel', in the southern basin of the 'East area' and in that part of the 'East area' directly exposed to the open sea (Fig. 33). In all these areas, the aragonite content does not exceed 20 %. A content > 40 % is present around the Tubya islands and Tubya Arba, west of Tubya al-Saghira and Gamul al-Saghira, in the center of the 'North area', and in a few isolated samples. More than 50 % aragonite occur in 5 samples distributed in three areas: two in the 'North area' (C 11, C 18),

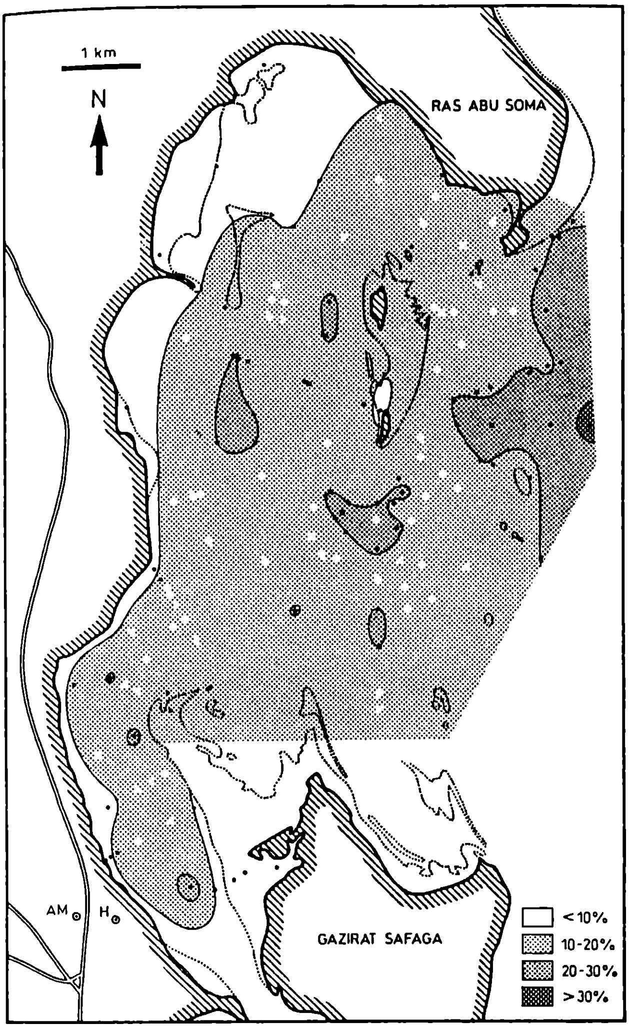


Fig. 35. Distribution of calcite in the total samples (related to the total mineral content).

two west of Tubya al-Bayda (B 25, B 26) and one at Tubya Arba (C 30).

The most frequent carbonate mineral is Mg-calcite (Fig. 34, Appendix 4). A percentage < 30 % is present only in a narrow strip along the main coast, in the southern part of the intertidal flat west of Gazirat Safaga off the mangrove, west of Tubya al-Bayda, and around Tubya Arba. Between 30 and 40 % are also observable parallel to the main coast, including the central part of the 'Southwest channel' and Tubya Arba. The shallow area around the Tubya islands and certain isolated samples also range in this percentage. The main part of the bay is characterized by a Mg-calcite content between 40 and 50 %. Larger areas with more than 50 % are developed in the southern basin of the 'East area' and on and west of the submarine ridge south of Ras Abu Soma (Fig. 34).

Calcite, the least abundant carbonate mineral in the bay, reaches 30 % only in sample B 39 (Fig. 35). Larger areas with more than 20 % are developed on the submarine ridge south of Ras Abu Soma, with a tongue-like extension to the west, and on the ridge south of Tubya al-Bayda, with little extensions to the basins in its west and east. A strip paralleling the main coast and the intertidal flat west of Gazirat Safaga, and a small area west of Tubya al-Bayda contain less than 10 % calcite in the total samples.

In the **mud fraction**, the distributional pattern is simpler than in the total fraction and the values are generally lower (Appendix 4).

Aragonite exceeds 40 % in only two samples (B 27, C 28) and more than 30 % are present around the Tubya islands and in a few isolated samples. Along the main coast, in the 'West area' basin, except its northernmost part, in the 'Southwest channel', except off the northern part of the intertidal flat northwest of Gazirat Safaga, and in two samples from the eastern margin of the bay, aragonite remains below 20 % (Fig. 36).

Mg-calcite is also the most abundant carbonate mineral in the mud fraction, but reaches 50 % in only 3 samples (B 12, B 23, B 30). The fine fraction of the entire bay is composed of 40 to 50 % Mg-calcite; exceptions are a strip along the main coast, the 'Southwest channel', with the exclusion of its eastern coast, two samples at the eastern margin of the 'West area' basin and one sample in the southern basin of the 'East area' (Fig. 37).

Although calcite does not reach 30 %, not a single sample contains less than 10 %. Noteworthy is the fact that the highest values, between 20 and 30 %, are reached not only in the 'East area', the 'West area' basin and the ridge in between, but also along the main coast of the 'North area' and the 'West area' and in some isolated 'Southwest channel' samples (Fig. 38).

The percentages of the carbonate minerals relative to total carbonate content provides additional information; the best representation for the distribution of aragonite and Mg-calcite is the ratio between both minerals.

In the **total samples** (Fig. 39), aragonite dominates in a few very distinct areas, all restricted to shallow water: around the Tubya islands and Tubya Arba, on the submarine platform representing the base for the patch reefs in the east (Tubya al-Kabir — Gamul al-Saghira), in the protected shallow water pan in the 'North area', at the southern cusp of Al-Dahira, and in some samples along the main coast (A 7, C 13, D 1) as well as west of Gazirat Safaga (A 13). The highest amounts of Mg-calcite (ratio aragonite/Mg-calcite < 0.4) are present in 4 clearly separated areas. One is located at the deep submarine ridge between Ras Abu Soma and Tubya al-Kabir, separating the bay from the open sea (lowest relative values). The second area covers the center of the southern basin of the 'East area', the third includes the 'West area' basin and the fourth

Fig. 36. Distribution of aragonite in the mud fraction (related to the total mineral content).

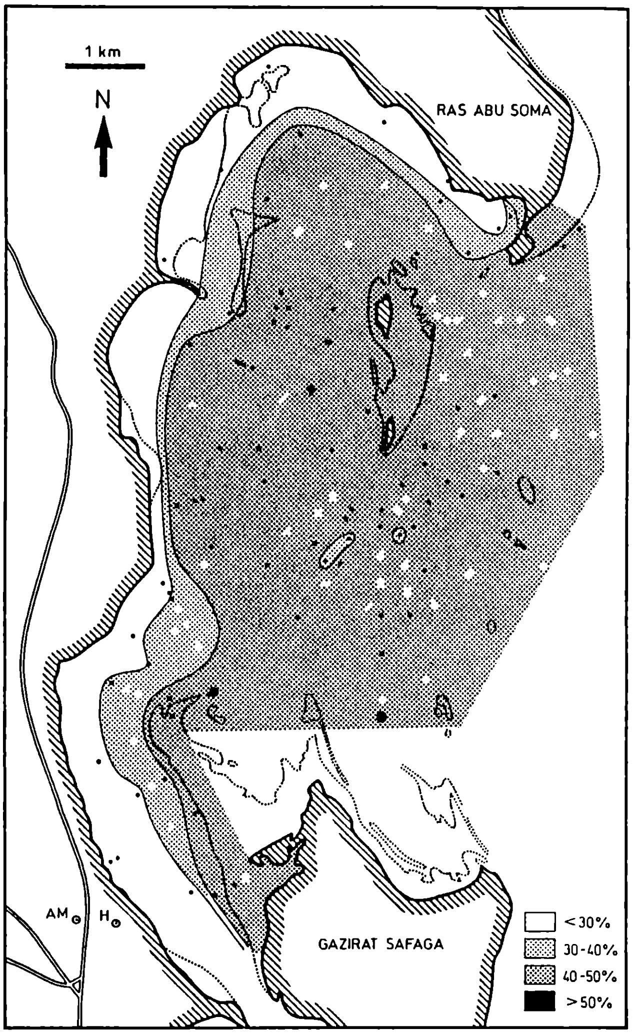


Fig. 37. Distribution of Mg-calcite in the mud fraction (related to the total mineral content).

is found in the southern part of the 'Southwest channel' The general distribution pattern of the ratio-values clearly follows the boundaries of the basins with high Mg-calcite content (Fig. 39).

The ratios of the **mud fraction** are more balanced than those of the total samples (Fig. 40). An aragonite/Mg-calcite–ratio > 1 is present only in 2 samples (C 27, C 13); values < 0.30 are completely absent and only 2 samples exhibit values < 0.40 (A 16, B 43). Nevertheless, the distributional pattern is similar to that of the total sample. The highest Mg-calcite contents are present in deeper waters, aragonite in shallow waters. The latter includes the Tubya islands and the complete 'North area', except three samples in the protected northwestern part (C 11, C 17, C 20), the submarine platform with the patch reefs between Tubya al-Kabir and Gamul al-Saghira, the west coast of the 'Southwest channel' and one isolated sample (A 28) at the transition between the 'West area' and the 'Southwest channel'.

The calcite values relative to the total carbonate content show two coastal samples with more than 40 % calcite in the total fraction (C 9, C 21) (Fig. 41). The lowest amount (< 10 %) is present in the center of the 'North area' and in one sample west of Tubya al-Bayda. In the mud fraction (Fig. 42), the relative calcite content is higher, exhibiting a strip with more than 40 % along the main coast in the 'North area' and along the west coast of the 'Southwest channel' Parallel to this strip, values lie between 30 and 40 %. A large part of the bay (most of the 'West area' and the deeper areas in the 'East area') contains between 20 and 30 % calcite in the mud fraction. A content below 20 % is developed between Ras Abu Soma and Al-Dahira, including the Tubya islands and their surroundings, as well as the shallow water area north of Gazirat Safaga and its northern continuation to Tubya al-Kabir.

6.3 Non-carbonate minerals

The non-carbonate mineral content and its distribution is complementary to that of the carbonate content (Figs. 31, 32). Thus, it is < 10 % for a very large

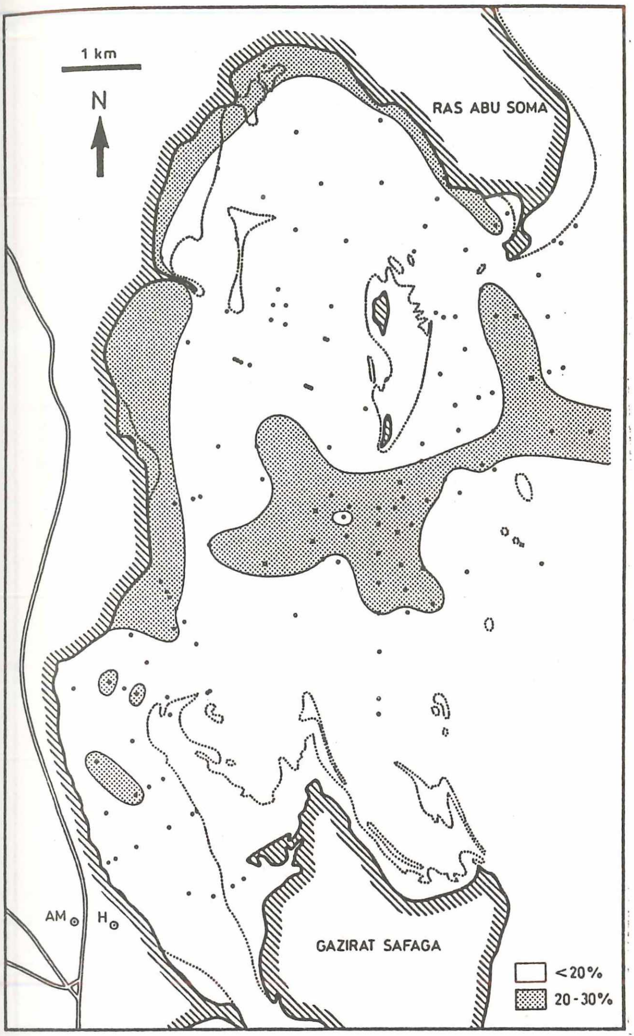


Fig. 38. Distribution of calcite in the mud fraction (related to the total mineral content).

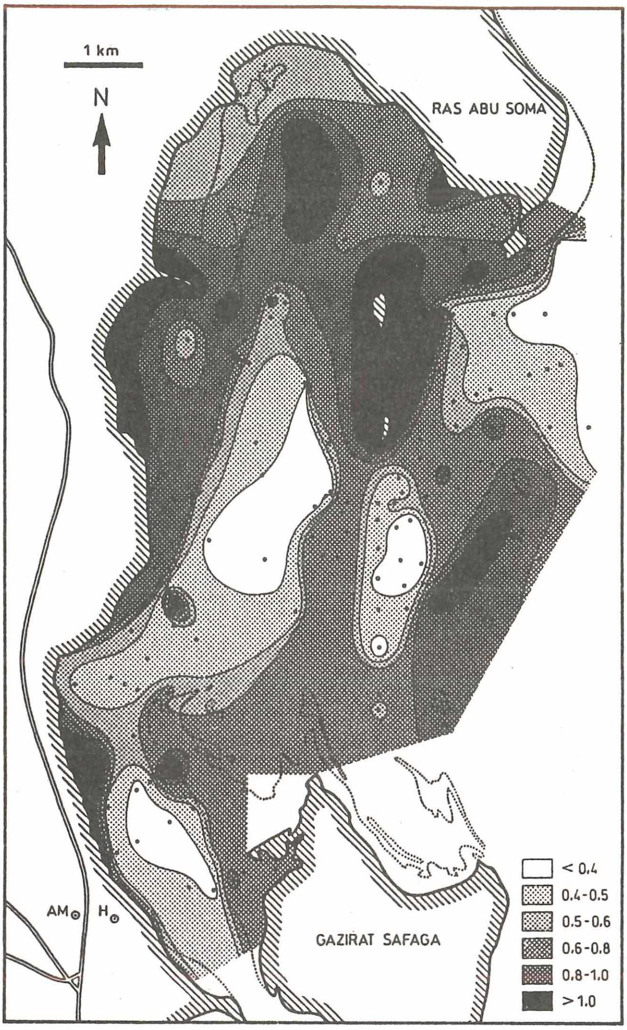


Fig. 39. Distribution of the aragonite/Mg-calcite ratio in the total samples.

area in the **total samples** and reaches between 10 and 20 % in the 'West area' and 'East area' basins. More than 20 % are present along the main coast and in the 'Southwest channel'. In some coastal samples it can reach nearly 90 % (89 %: A 7, C 9; 88 %: A 6; 87 %: D 1). In the **mud fraction** non-carbonate minerals are more abundant: the main part of the bay is covered by sediments with contents between 10 and 20 %. Less than 10 % were detected on and in the surroundings of the submarine platform exceeding from Tubya al-Kabir to Gamul al-Kabir, between the southeastern side of Ras Abu Soma and the western margin of Tubya al-Hamra, north and northwest of Tubya al-Hamra, and in a few isolated samples. Along the main coast and in the main part of the 'Southwest channel' the content surpasses 20 %. The maximum values are generally lower than those of the total samples; only one sample exceeds 70 % (A 6: 79 %).

Quartz clearly dominates among the three detected non-carbonate minerals (quartz, plagioclase and alkali-feldspars). In the **total samples** a narrow strip along the coast exhibits values between 40 and 50 % (Fig. 43). The 20 % isoline nearly parallels this strip, increasing in width only in the 'Southwest channel'. A few isolated samples also contain more than 20 %. The basin of the 'West area', both basins of the 'East area', a part of the 'Southwest channel', and a strip parallel to the main coast contain 10 to 20 % quartz. Most shallow water areas (except along the main coast) and the submarine ridges have values < 10 %. Although the quartz content in the **mud fraction** (Fig. 44) is generally higher, the maximum values are lower than those of the total samples. Less than 10 % are present on and around the submarine platform between Tubya al-Kabir and Gamul al-Kabir, between Ras Abu Soma and Tubya al-Hamra, in a curved area west and north of Tubya al-Hamra, and in a few isolated samples. Most values range between 10 and 20 %; values exceeding 30 % are present along the main coast, reaching a maximum in the 'North area' (C 21: 50 %; C 13: 48 %).

In the total samples, plagioclase remains below

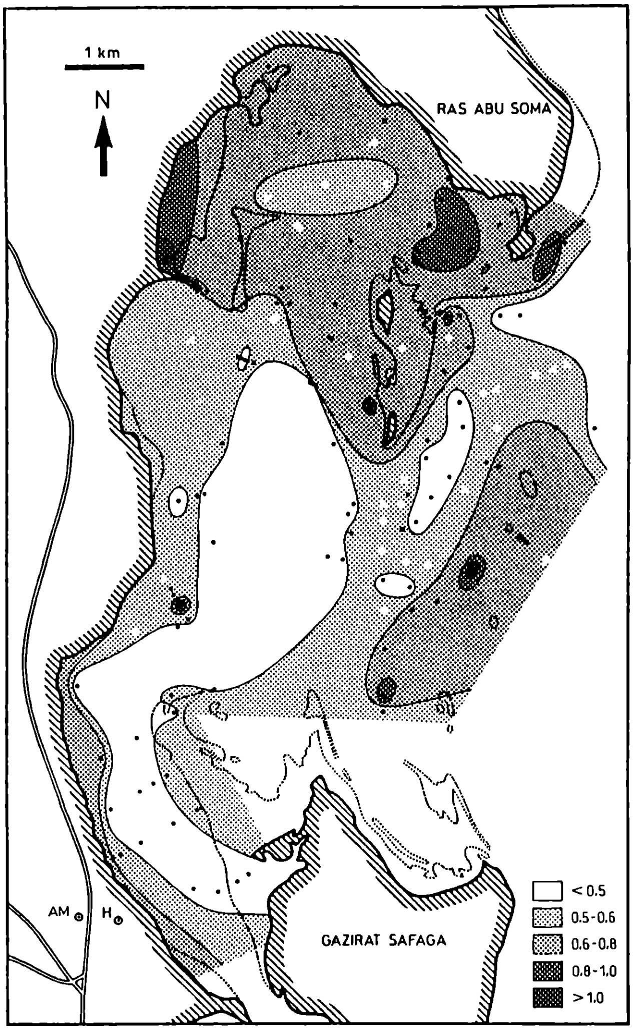


Fig. 40. Distribution of the aragonite/Mg-calcite ratio in the mud fraction.

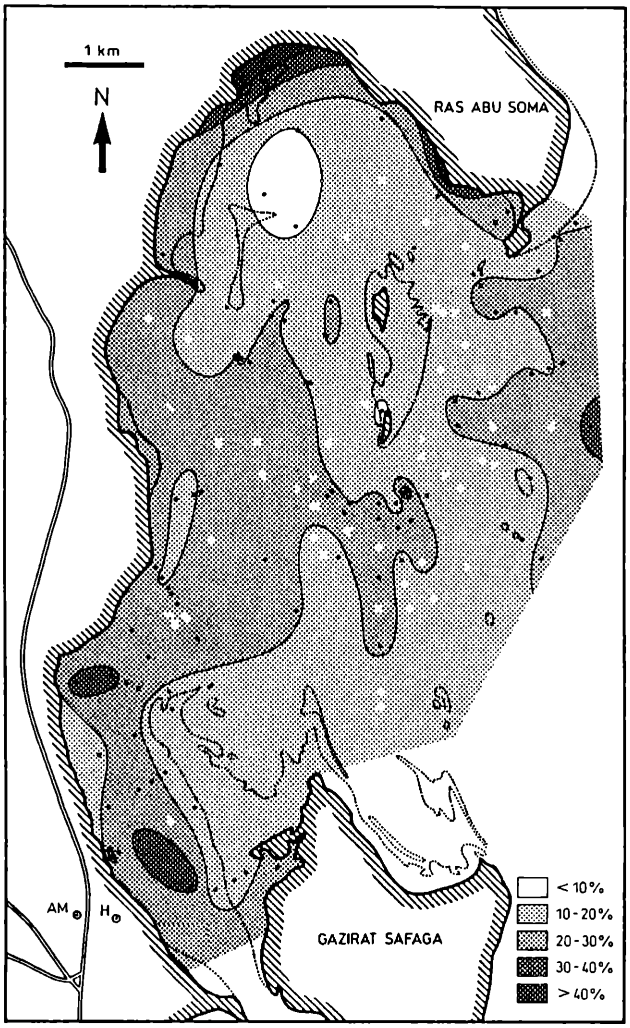


Fig. 41. Distribution of calcite in the total samples related to the carbonate content.

5 % in the main part of the bay (Fig. 45). More than 10 % are developed only in a very narrow strip along the main coast, in parts of the 'Southwest channel' and in isolated samples. One sample (A 6) is remarkable in being dominated by plagioclase (53 %); 8 samples contain between 20 and 30 % (A 7, A 10, A 15, A 19, A 32, C 9, C 21, D 1). The plagioclase content of the mud fraction is distinctly smaller than in the total sample. Values above 10 % are present in only two samples: 19 % in C 9 and 50 % in A 7, while those between 5 and 10 % are more frequent along the main coast and in most 'Southwest channel' samples.

Alkali-feldspars are the least abundant minerals in the sediments (comp. Appendix 4). In the total samples, only 1 sample exceeds 20 % (A 6: 26 %) and 5 samples range between 10 and 20 % (A 7, A 15, C 9, C 13, D 1). Values > 5 % occur mainly along the main coast. The content exceeds 10 % in only two samples (A 6: 15 %; A 14: 13 %) in the mud fraction, and exceeds 5 % in 12 samples, most from coastal areas.

6.4 Relations between minerals, grain size and components

All carbonate minerals are significantly negatively correlated with non-carbonate minerals (Tab. 10). Whereas all three non-carbonate minerals show high positive correlations to the other non-carbonate minerals ($r>0.6$), the correlations between the carbonate minerals are more differentiated: aragonite is significantly, but slightly ($r=0.348$) positively correlated to Mg-calcite and is nearly uncorrelated ($r=0.074$) to calcite. The relation between Mg-calcite and calcite is, in contrast, strong ($r=0.642$).

Aragonite is significantly positively correlated with medium sand and all coarser grain fractions (Tab. 11). Highest correlation coefficients are present with respect to coarse and very coarse sand and gravel. Negative correlations exist to very fine sand fractions and mud.

Mg-calcite is significantly positively correlated only to mud and negatively to fine sand and the coarser fraction of very fine sand, whereas nearly no

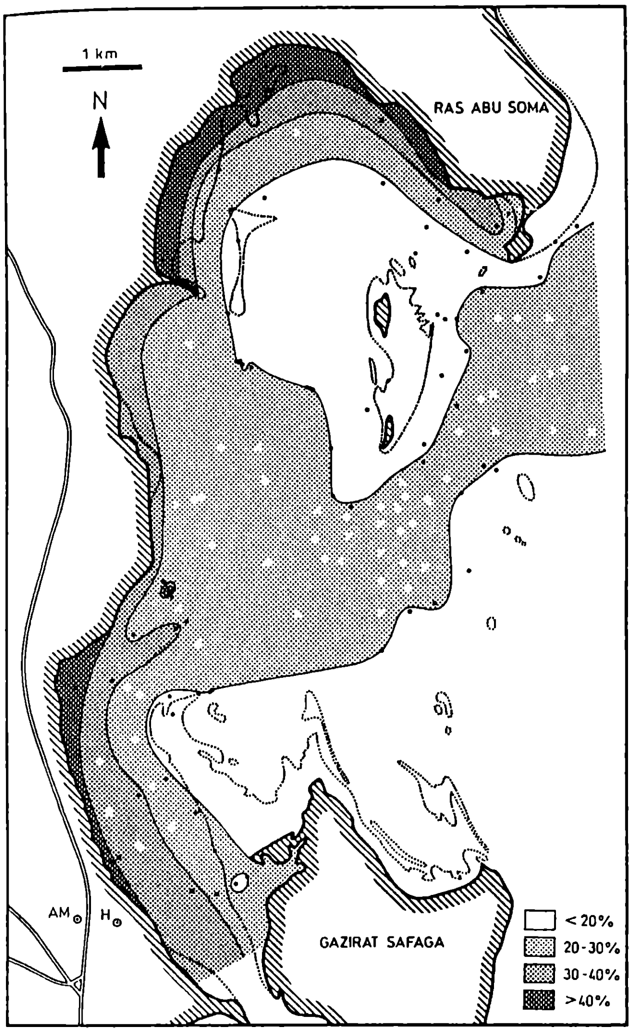


Fig. 42. Distribution of calcite in the mud fraction related to the carbonate content.

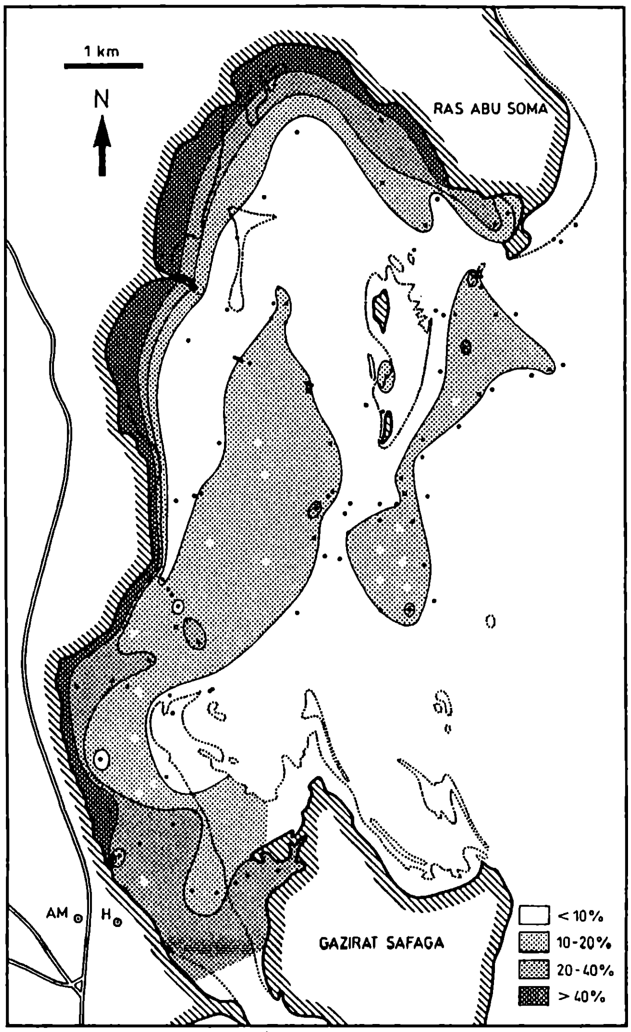


Fig. 43. Distribution of quartz in the total samples.

correlation exists (r=0.047) to the finer fraction of very fine sand.

The correlations of calcite are similar to those of Mg-calcite in being significantly positive only to mud and negatively to fine sand. Additionally, slightly negative correlations exist to the finer fractions of medium and coarse sand.

Quartz is significantly positively correlated to sand fractions between 0.18 and 0.09 mm and significantly negatively to very coarse sand and gravel. Plagioclase only shows significant positive correlations to fine sand and the coarser fraction of very fine sand. Alkali-feldspars are similar, but are also slightly negatively correlated to gravel.

Aragonite is significantly positively correlated to corals, red algae and compound grains, and negatively to miliolid and hyaline foraminifers, to crustaceans and to quartz (Tab. 12).

Mg-calcite is significantly positively correlated to molluscs, echinoderms and hyaline foraminifera, and very highly negatively to quartz. Calcite exhibits significant positive relations to molluscs as well as to hyaline and agglutinated foraminifers. As in the two other carbonate minerals, a high negative correlation was detected to quartz.

All three non-carbonate minerals show very similar correlations: a highly positive one to quartz (as component category) and a weak one, as far as quartz and alkali-feldspars are concerned, to miliolid foraminifers. Significant negative coefficients exist to molluscs and red algae and, only for quartz, to corals.

6.5 Minerals versus bottom facies

In the **total samples** (Tab. 13), the highest carbonate content (more than 95 %) and lowest standard deviation (2.87 %) occur in 'Rock bottom' facies. Around 90 % carbonate content are present in 'Sand with coral patches' and 'Coral carpet' The lowest mean values were detected in 'Seagrass' (70.5 %), 'Sand' (72.16 %) and 'Sand with seagrass' (79.29 %), together with relatively high standard de-

Fig. 44. Distribution of quartz in the mud fraction.

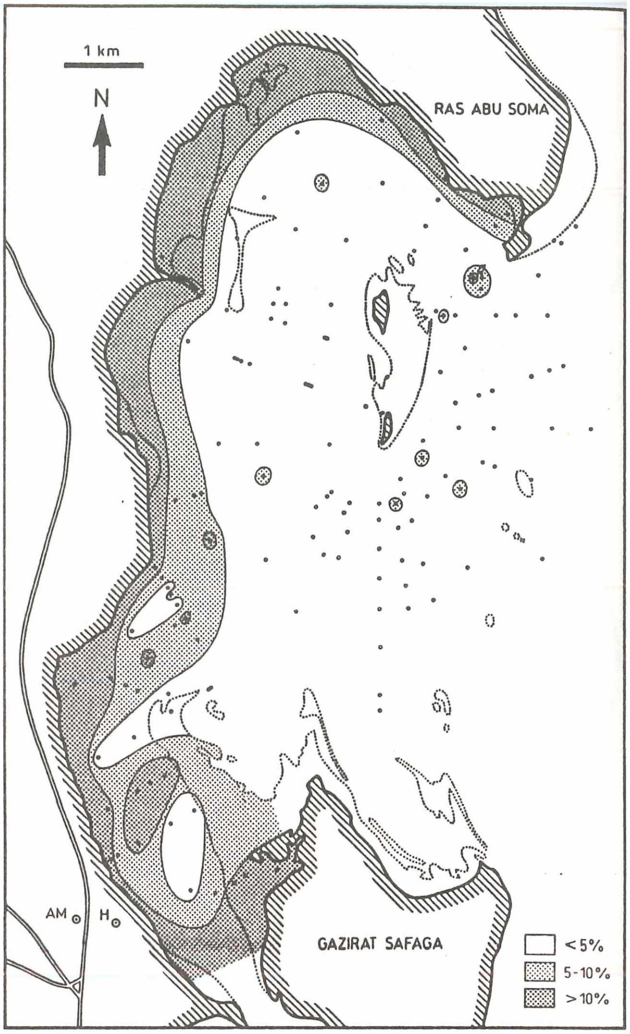


Fig. 45. Distribution of plagioclase in the total samples.

viations (22.18 %, 30.19 %, 17.69 %). The content in 'Muddy sand' and 'Mud' is nearly equal (approx. 83 %), with a low standard deviation (3.62 %) in 'Mud'. In the **mud fraction** (Tab. 13), the lowest carbonate content is also present in 'Seagrass' (68.83 %) and in 'Sand' (75.76 %), but, in contrast to the total samples, 'Sand with coral patches' exhibits a relatively low mean value (76.11 %). 'Sand with seagrass' contains 83.90 % (low standard deviation of 7.27 %); this percentage is higher than in the total samples. In 'Rock bottom' (85.30 %) and 'Coral carpet' (86.75 %) the amount is smaller, whereas in 'Muddy sand' (83.11 %) and 'Mud' (85.93 %) the contents are very close to those of the total samples.

The distribution of the carbonate minerals in the total samples as related to the total mineral content (Tab. 13) shows that aragonite is most abundant in 'Sand with coral patches'; the remaining bottom facies are dominated by Mg-calcite. In the mud fraction, Mg-calcite prevails throughout and the aragonite content is generally smaller than in the total sample; in 'Muddy sand', 'Mud' and 'Rock bottom' it is nearly equal. In 'Rock bottom', 'Coral carpet', 'Seagrass', and 'Muddy sand', Mg-calcite is more frequent in the total samples; in 'Sand with coral patches' the values are equal, and in 'Sand', 'Sand with seagrass' and 'Mud' those of the mud fraction are higher. The highest mean value of Mg-calcite was detected in 'Rock bottom' (49.70 %), the lowest in 'Sand' (31.52 %). In the total samples, calcite reaches its greatest abundance in 'Rock bottom' (21.70 %), its lowest in 'Sand' (12.84 %). In every bottom facies except 'Rock bottom', the calcite content is higher in the mud fraction; the greatest difference exists in 'Sand' bottom facies (12.84 versus 18.11 %).

Quartz occurs in the total samples most frequently in 'Sand' (17.16 %), followed by 'Seagrass', 'Sand with seagrass', 'Mud', and 'Muddy sand' (12.26 %). It is distinctly less abundant in 'Coral carpet' (7.94 %), 'Sand with coral patches' (7.27 %) and 'Rock bottom' (4.70 %). In the mud fraction the mean quartz percentages are more uniform between the bottom facies, ranging from 11.63 % ('Coral car-

	aragonite	Mg calcite	calcite	quartz	plagioclase	alkali feldspar
aragonite	1.000					
Mg calcite	.348	1.000				
calcite	.074	.642	1.000			
quartz	-.706	-.767	-.517	1.000		
plagioclase	-.638	-.817	-.616	.721	1.000	
alkali feldspar	-.607	-.800	-.583	.696	.899	1.000

Tab. 10. Correlation coefficients between minerals (123 samples). Underlined type = 1 % significance level.

(mm)	V2 > 2.0	V3 > 1.41	V4 > 1.0	V5 > 0.71	V6 > 0.50	V7 > 0.35	V8 > 0.25	V9 > 0.18	V10 > 0.125	V11 > 0.09	V12 > 0.063	V13 < 0.063
V26	.488	.493	.480	.437	.293	.381	.310	.011	-.121	-.276	-.360	-.281
V27	.059	.030	.034	-.061	-.167	-.116	-.165	-.416	-.481	-.314	.047	.342
V28	.076	-.037	-.045	-.178	-.276	-.225	-.251	-.410	-.420	-.225	.112	.387
V29	-.344	-.314	-.306	-.219	-.064	-.154	-.123	.198	.345	.369	.215	-.027
V30	-.223	-.176	-.176	-.089	.023	-.042	.043	.326	.396	.325	.074	-.167
V31	-.237	-.215	-.210	-.079	.089	.003	.098	.405	.437	.264	-.006	-.188

V26 aragonite V27 Mg calcite V28 calcite
V29 quartz V30 plagioclase V31 alkali feldspar

Tab. 11. Correlation coefficients between grain size fractions and minerals (123 samples). Underlined type = 1 % significance level.

	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25
aragonite	-.166	-.281	-.304	.449	.133	-.350	-.018	.051	.385	.272	-.438	-.070
Mg calcite	.181	.286	-.158	.070	.367	.034	.304	.094	.207	-.024	-.680	.029
calcite	.279	.364	-.182	-.080	.442	.072	.175	.053	.074	-.117	-.559	.109
quartz	-.028	-.054	.303	-.291	-.281	.208	-.190	-.082	-.368	-.090	.630	.026
plagioclase	-.102	-.103	.226	-.208	-.365	.077	-.206	-.093	-.291	-.093	.710	.057
alkali feldspar	-.024	-.126	.231	-.204	-.345	.052	-.186	-.097	-.241	-.101	.669	.069

V14 agglutinated foraminifera V15 hyaline foraminifera V16 miliolid foraminifera
V17 corals V18 molluscs V19 crustaceans
V20 echinoderms V21 worm tubes V22 red algae
V23 compound grains V24 quartz V25 pellets

Tab. 12. Correlation coefficients between minerals and components (123 samples). Underlined type = 1 % significance level.

pet') to 19.83 % ('Seagrass'). In 'Sand with seagrass' and 'Mud' the values of the mud fraction are insignificantly smaller than in the total samples, whereas in the other bottom facies those of mud fractions are higher, with the greatest difference found in 'Rock bottom' (4.70 versus 13.80 %). Plagioclase exceeds 5 % in the total samples only in 'Seagrass' (10.08 %) and 'Sand' (6.74 %), in the mud fraction exclusively in 'Seagrass' (7.33 %); all 3 cases are characterized by a very high standard deviation. Alkali-feldspars occur most frequently in 'Seagrass' (total sample: 4.25 %, mud fraction: 4.00 %).

The carbonate mineral frequency related to carbonate content clearly differs between some bottom facies and also between total samples and mud fractions as documented in triangular diagrams (Figs. 46, 47). In **'Rock bottom'**, all samples range on the order of more than 50 % Mg-calcite and less than 40 % aragonite or calcite. In the mud fraction (Fig. 47) the samples are less scattered. The samples of **'Sand with coral patches'** show a wider distribution along the aragonite – Mg-calcite line, with less than 20 % calcite except for one sample (A 8). The distribution of the samples in the mud fractions is different in having around 50 % Mg-calcite and less than 40 % aragonite or calcite. This pattern reflects the higher calcite content in the mud fraction. **'Sand'** samples are widely dispersed: for the total samples mainly along the aragonite – Mg-calcite line, except for samples A 15, B 26, C 13, C 21, which exhibit a high calcite content. In the mud fraction the samples are mostly grouped around 50 % Mg-calcite, but the distribution is located between Mg-calcite and calcite. In **'Coral carpet'**, the samples are positioned in a zone parallel to the aragonite – Mg-calcite line, between less than 50 % aragonite and 30 % calcite. In the mud fraction the distribution shows an elongation along the Mg-calcite – calcite line around 50 % Mg-calcite. The **'Sand with seagrass'** samples are arranged in a zone parallel to the aragonite

Rock bottom (10 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
B 1	23.00	52.00	23.00	98.00	2.00	0.00	0.00	4134	543	1.56
	21.00	42.00	19.00	82.00	18.00	0.00	0.00			
B 2	26.00	49.00	13.00	88.00	12.00	0.00	0.00	4402	385	0.66
	24.00	45.00	18.00	87.00	13.00	0.00	0.00			
B 4	22.00	53.00	18.00	93.00	7.00	0.00	0.00	3848	530	0.81
	22.00	44.00	18.00	84.00	16.00	0.00	0.00			
B 39	15.00	52.00	30.00	97.00	3.00	0.00	0.00	2969	242	0.81
	21.00	46.00	22.00	89.00	11.00	0.00	0.00			
B 40	22.00	47.00	26.00	95.00	5.00	0.00	0.00	3615	169	0.77
	26.00	43.00	21.00	90.00	10.00	0.00	0.00			
B 56	33.00	46.00	18.00	97.00	1.00	1.00	1.00	3848	539	0.66
	18.00	45.00	19.00	82.00	18.00	0.00	0.00			
B 60	33.00	43.00	21.00	97.00	3.00	0.00	0.00	4051	781	0.20
	19.00	44.00	17.00	80.00	12.00	5.00	3.00			
C 1	16.00	51.00	26.00	93.00	7.00	0.00	0.00	3391	462	0.77
	19.00	43.00	18.00	80.00	20.00	0.00	0.00			
C 27	30.00	47.00	18.00	96.00	4.00	0.00	0.00	4816	33	1.32
	28.00	47.00	19.00	94.00	6.00	0.00	0.00			
C 29	16.00	57.00	24.00	97.00	3.00	0.00	0.00	3364	207	0.88
	23.00	44.00	18.00	85.00	14.00	1.00	0.00			
m	23.60	49.70	21.70	95.10	4.70	0.00	0.00	3844	389	0.84
	22.10	44.30	18.90	85.30	13.80	0.60	0.30			
s	6.46	3.87	4.79	2.87	3.06	0.30	0.00	513	213	0.35
	3.04	1.41	1.44	4.40	4.06	1.49	0.90			
min.	15.00	43.00	13.00	88.00	1.00	0.00	0.00	2969	33	0.20
	18.00	42.00	17.00	80.00	6.00	0.00	0.00			
max.	33.00	57.00	30.00	98.00	12.00	0.00	0.00	4810	781	1.56
	28.00	47.00	22.00	94.00	20.00	5.00	3.00			

Sand with coral patches (11 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 2	22.00	44.00	10.00	76.00	20.00	4.00	0.00	4354	286	0.18
	22.00	42.00	18.00	82.00	16.00	2.00	0.00			
A 8	17.00	35.00	23.00	75.00	18.00	3.00	4.00	3369	1078	41.78
	10.00	20.00	18.00	48.00	41.00	6.00	5.00			
A 17	44.00	34.00	17.00	95.00	4.00	1.00	0.00	6192	330	0.66
	18.00	24.00	22.00	64.00	26.00	7.00	3.00			
A 23	33.00	42.00	15.00	90.00	7.00	2.00	1.00	5493	462	0.66
	32.00	41.00	17.00	90.00	8.00	1.00	1.00			
A 31	38.00	39.00	16.00	93.00	6.00	1.00	0.00	5304	240	0.22
	13.00	26.00	16.00	55.00	33.00	7.00	5.00			
B 10	39.00	41.00	16.00	97.00	3.00	0.00	0.00	5322	0	0.20
B 25	51.00	25.00	15.00	91.00	9.00	0.00	0.00	6659	0	0.44
	33.00	42.00	14.00	89.00	11.00	0.00	0.00			
B 73	29.00	49.00	13.00	91.00	3.00	3.00	3.00	4833	0	0.08
	27.00	47.00	16.00	90.00	10.00	0.00	0.00			
C 11	51.00	31.00	10.00	92.00	1.00	7.00	0.00	7314	132	0.08
	26.00	45.00	13.00	84.00	14.00	1.00	1.00			
C 18	51.00	34.00	10.00	94.00	6.00	0.00	0.00	6360	66	0.02
	26.00	42.00	15.00	83.00	9.00	4.00	4.00			
C 30	55.00	28.00	14.00	97.00	3.00	0.00	0.00	7176	22	0.05
m	39.09	36.55	14.45	90.09	7.27	1.91	0.73	5671	238	4.03
	23.00	36.56	16.56	76.11	18.67	3.11	2.11			
s	12.15	6.87	3.65	7.23	5.94	2.11	1.35	1156	305	11.94
	7.53	9.62	2.50	15.20	11.20	2.77	2.02			
min.	17.00	25.00	10.00	75.00	1.00	0.00	0.00	3369	0	0.02
	10.00	20.00	13.00	48.00	8.00	0.00	0.00			
max.	55.00	49.00	23.00	97.00	20.00	7.00	4.00	7314	1078	41.78
	33.00	47.00	22.00	90.00	41.00	7.00	5.00			

Tab. 13. Mineral composition (%) and contents of trace elements (ppm) of the samples related to bottom facies. (First line represents values of total sample, second those of mud fraction).

– Mg-calcite line in both the total samples, which are more widely scattered, and in the mud fractions. **'Seagrass'** samples are closely distributed between less than 40 % aragonite and less than 30 % calcite. The mud fraction distribution is wider between Mg-calcite and calcite, with less than 30 % aragonite. In **'Muddy sand'**, the samples are very closely scattered, with more than 50 % Mg-calcite. In the mud fraction the samples are grouped still closer around 50 % Mg-calcite. The **'Mud'** bottom facies samples are also closely arranged, but more elongated in the total samples along the aragonite – Mg-calcite line.

6.6 Summary of results

The investigation of the carbonate and non-carbonate content separately for the total samples and the mud fraction alone revealed that the non-

Sand facies (31 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 7	5.00	4.00	2.00	11.00	44.00	26.00	19.00	1539	286	43.98
A 10	13.00	14.00	4.00	31.00	31.00	30.00	8.00	4827	418	0.22
	13.00	41.00	12.00	66.00	24.00	7.00	3.00			
A 15	5.00	10.00	6.00	21.00	44.00	22.00	13.00	1869	1113	87.96
	10.00	23.00	19.00	52.00	35.00	9.00	4.00			
A 20	17.00	38.00	17.00	72.00	17.00	7.00	4.00	2436	1143	43.98
	15.00	32.00	20.00	67.00	24.00	5.00	4.00			
B 3	20.00	48.00	24.00	92.00	8.00	0.00	0.00	3963	904	1.61
	22.00	40.00	26.00	88.00	12.00	0.00	0.00			
B 11	27.00	48.00	15.00	90.00	4.00	3.00	3.00	4706	1	0.53
	24.00	47.00	18.00	89.00	11.00	0.00	0.00			
B 19	32.00	39.00	21.00	92.00	8.00	0.00	0.00	3778	449	1.54
	21.00	43.00	20.00	84.00	16.00	0.00	0.00			
B 26	53.00	29.00	9.00	91.00	9.00	0.00	0.00	7886	68	0.06
B 28	32.00	43.00	16.00	91.00	8.00	1.00	0.00	4820	979	23.09
	19.00	45.00	21.00	85.00	11.00	3.00	1.00			
B 41	34.00	38.00	24.00	96.00	4.00	0.00	0.00	4328	275	0.44
	24.00	44.00	20.00	88.00	12.00	0.00	0.00			
B 57	28.00	42.00	20.00	90.00	10.00	0.00	0.00	4222	959	1.65
	21.00	38.00	21.00	80.00	13.00	4.00	3.00			
B 67	35.00	43.00	15.00	93.00	7.00	0.00	0.00	4789	341	0.22
	18.00	44.00	25.00	87.00	10.00	2.00	1.00			
B 71	22.00	40.00	14.00	76.00	20.00	2.00	2.00	3958	625	1.61
	30.00	44.00	18.00	92.00	8.00	0.00	0.00			
B 72	34.00	44.00	16.00	94.00	6.00	0.00	0.00	5484	110	0.22
	28.00	45.00	15.00	88.00	12.00	0.00	0.00			
B 74	48.00	30.00	10.00	88.00	12.00	0.00	0.00	6817	88	0.22
	25.00	49.00	14.00	87.00	13.00	0.00	0.00			
C 5	34.00	34.00	16.00	84.00	8.00	5.00	3.00	4789	145	0.55
	35.00	41.00	14.00	90.00	8.00	2.00	1.00			
C 8	36.00	44.00	12.00	92.00	8.00	0.00	0.00	4596	198	0.18
	35.00	38.00	14.00	87.00	10.00	2.00	1.00			
C 9	2.00	3.00	6.00	11.00	44.00	27.00	18.00	396	592	1.65
	7.00	10.00	23.00	40.00	36.00	19.00	5.00			
C 10	44.00	40.00	10.00	94.00	6.00	0.00	0.00	6395	147	0.44
	27.00	42.00	18.00	87.00	9.00	2.00	2.00			
C 13	16.00	3.00	8.00	27.00	44.00	16.00	13.00	4957	990	1.06
	12.00	6.00	20.00	38.00	48.00	9.00	5.00			
C 16	14.00	31.00	10.00	55.00	25.00	11.00	9.00	3215	312	0.18
	18.00	29.00	16.00	63.00	30.00	4.00	3.00			
C 17	38.00	46.00	7.00	91.00	9.00	0.00	0.00	5106	205	0.04
	25.00	44.00	17.00	85.00	15.00	0.00	0.00			
C 19	19.00	27.00	11.00	57.00	30.00	8.00	5.00	3554	462	1.54
	12.00	18.00	18.00	48.00	40.00	7.00	5.00			
C 21	7.00	6.00	11.00	24.00	46.00	22.00	8.00	2846	873	65.97
	6.00	9.00	20.00	35.00	50.00	9.00	6.00			
C 22	40.00	32.00	13.00	85.00	9.00	4.00	2.00	5977	328	0.22
	28.00	31.00	17.00	76.00	19.00	4.00	1.00			
C 24	47.00	37.00	10.00	94.00	6.00	0.00	0.00	7010	77	0.44
	34.00	40.00	12.00	86.00	14.00	0.00	0.00			
C 31	43.00	39.00	14.00	96.00	4.00	0.00	0.00	6091	33	0.05
D 1	5.00	4.00	4.00	13.00	47.00	25.00	15.00	1924	875	120.95
D 2	46.00	36.00	12.00	94.00	6.00	0.00	0.00	6417	506	0.05
	23.00	39.00	17.00	79.00	17.00	3.00	1.00			
D 4	33.00	46.00	16.00	95.00	5.00	0.00	0.00	4433	319	0.06
	29.00	42.00	17.00	87.00	13.00	0.00	0.00			
D 7	33.00	39.00	25.00	97.00	3.00	0.00	0.00	4517	198	0.07
	28.00	44.00	17.00	89.00	11.00	0.00	0.00			
m	27.81	31.52	12.84	72.16	17.16	6.74	3.94	4440	452	12.93
	21.81	35.85	18.11	75.67	19.30	3.37	1.70			
s	14.27	14.69	5.86	30.19	15.24	9.89	5.80	1674	349	28.94
	8.06	11.99	3.41	17.54	12.11	4.31	1.94			
min.	2.00	3.00	2.00	11.00	3.00	0.00	0.00	396	1	0.04
	6.00	6.00	12.00	35.00	8.00	0.00	0.00			
max.	53.00	48.00	25.00	97.00	47.00	30.00	19.00	7886	1143	120.95
	35.00	49.00	26.00	92.00	50.00	19.00	6.00			

Tab. 13. continued

carbonate content is distinctly higher in the mud fraction of most samples. In the total fractions, the non-carbonate content is highest along the main coast and on the intertidal flat west of Gazirat Safaga (Fig. 31). The reduced non-carbonate content in the basins is also worthy of note, whereas that of the mud fractions is not conspicuous (Fig. 32); because also the separating areas in between exhibit a higher non-carbonate content. These distributional patterns, with highest values along the coast, clearly indicate that the non-carbonate material comes from outside the bay, either by fluviatile or eolian transport, or by erosion from Safaga island. Distribution inside the bay is regulated by water currents: they disperse the suspended mud fractions more continuously, whereas sand fractions are deposited over deeper water areas where the current velocity is reduced.

When non-carbonate minerals are present, they

Coral carpet (17 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 13	41.00	39.00	11.00	91.00	9.00	0.00	0.00	5784	565	98.96
	22.00	39.00	18.00	79.00	16.00	3.00	2.00			
A 18	18.00	37.00	19.00	74.00	16.00	5.00	5.00	3782	1429	43.98
	17.00	35.00	25.00	78.00	16.00	4.00	2.00			
A 29	27.00	40.00	17.00	84.00	12.00	3.00	1.00	4763	1231	26.39
	20.00	37.00	20.00	77.00	21.00	1.00	1.00			
B 5	25.00	52.00	11.00	88.00	12.00	0.00	0.00	4248	732	0.62
	23.00	44.00	19.00	86.00	14.00	0.00	0.00			
B 7	31.00	50.00	12.00	93.00	7.00	0.00	0.00	5058	484	1.14
	33.00	47.00	12.00	92.00	8.00	0.00	0.00			
B 24	30.00	46.00	16.00	92.00	8.00	0.00	0.00	4970	614	1.54
	28.00	46.00	17.00	91.00	9.00	0.00	0.00			
B 27	46.00	39.00	11.00	96.00	4.00	0.00	0.00	6439	33	0.18
	42.00	41.00	12.00	95.00	5.00	0.00	0.00			
B 31	36.00	48.00	13.00	97.00	3.00	0.00	0.00	5436	145	0.48
	37.00	43.00	15.00	95.00	5.00	0.00	0.00			
B 47	33.00	42.00	20.00	96.00	4.00	0.00	0.00	5110	33	0.99
	28.00	43.00	18.00	89.00	11.00	0.00	0.00			
B 59	33.00	45.00	19.00	96.00	4.00	0.00	0.00	4565	752	0.44
	18.00	37.00	20.00	75.00	25.00	0.00	0.00			
B 61	34.00	43.00	20.00	97.00	1.00	1.00	1.00	3598	783	32.99
	20.00	40.00	22.00	82.00	18.00	0.00	0.00			
B 68	37.00	44.00	13.00	95.00	5.00	0.00	0.00	4561	297	0.22
	22.00	40.00	19.00	81.00	11.00	5.00	3.00			
C 25	35.00	44.00	19.00	98.00	3.00	0.00	0.00	5379	51	0.20
	39.00	40.00	11.00	90.00	5.00	0.00	5.00			
C 28	33.00	46.00	18.00	97.00	3.00	0.00	0.00	5036	22	1.14
	41.00	44.00	12.00	97.00	3.00	0.00	0.00			
C 32	28.00	23.00	12.00	63.00	25.00	11.00	1.00	4086	165	1.54
D 3	34.00	39.00	21.00	94.00	6.00	0.00	0.00	4592	286	0.77
	31.00	41.00	18.00	90.00	10.00	0.00	0.00			
D 8	24.00	45.00	18.00	87.00	13.00	0.00	0.00	4556	719	1.10
	30.00	43.00	18.00	91.00	9.00	0.00	0.00			
m	32.06	42.47	15.88	90.47	7.94	1.18	0.47	4821	491	12.51
	28.19	41.25	17.25	86.75	11.63	0.81	0.81			
s	6.38	6.29	3.58	9.09	5.93	2.79	1.19	692	410	25.28
	8.10	3.21	3.82	6.88	6.06	1.59	1.42			
min.	18.00	23.00	11.00	63.00	1.00	0.00	0.00	3598	22	0.18
	17.00	35.00	11.00	75.00	3.00	0.00	0.00			
max.	46.00	52.00	21.00	98.00	25.00	11.00	5.00	6439	1429	98.96
	42.00	47.00	25.00	97.00	25.00	5.00	5.00			

Sand with seagrass (11 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 11	16.00	46.00	10.00	72.00	16.00	8.00	4.00	3285	462	1.10
	17.00	44.00	17.00	78.00	11.00	9.00	2.00			
A 21	20.00	40.00	18.00	78.00	14.00	6.00	2.00	3325	941	41.78
	17.00	36.00	18.00	71.00	23.00	4.00	2.00			
A 28	47.00	32.00	17.00	96.00	4.00	0.00	0.00	6865	264	0.33
	34.00	34.00	18.00	86.00	10.00	3.00	1.00			
A 32	10.00	13.00	7.00	30.00	40.00	22.00	8.00	3598	1231	109.95
B 18	33.00	42.00	17.00	92.00	8.00	0.00	0.00	4745	352	0.64
	23.00	45.00	18.00	86.00	14.00	0.00	0.00			
B 49	36.00	40.00	17.00	93.00	4.00	2.00	1.00	4974	1231	1.54
	20.00	46.00	20.00	86.00	14.00	0.00	0.00			
B 62	20.00	44.00	15.00	79.00	21.00	0.00	0.00	4130	537	1.52
	29.00	46.00	17.00	92.00	5.00	2.00	1.00			
B 75	26.00	52.00	12.00	90.00	10.00	0.00	0.00	4671	22	0.59
	24.00	48.00	14.00	86.00	14.00	0.00	0.00			
C 3	20.00	45.00	20.00	85.00	15.00	0.00	0.00	4200	567	0.70
	22.00	47.00	23.00	92.00	8.00	0.00	0.00			
C 15	34.00	43.00	11.00	88.00	6.00	3.00	3.00	5678	141	1.06
	23.00	37.00	12.00	72.00	24.00	3.00	1.00			
C 26	23.00	31.00	15.00	69.00	18.00	7.00	6.00	3857	396	21.99
	29.00	41.00	20.00	90.00	10.00	0.00	0.00			
m	25.91	38.91	14.45	79.27	14.18	4.36	2.18	4484	559	16.47
	23.80	42.40	17.70	83.90	13.30	2.10	0.70			
s	10.12	9.98	3.77	17.69	9.82	6.30	2.66	1027	391	32.11
	5.19	4.80	2.93	7.27	5.78	2.74	0.78			
min.	10.00	13.00	7.00	30.00	4.00	0.00	0.00	3285	22	0.33
	17.00	34.00	12.00	71.00	5.00	0.00	0.00			
max.	47.00	52.00	20.00	96.00	40.00	22.00	8.00	6865	1231	109.95
	34.00	48.00	23.00	92.00	24.00	9.00	2.00			

Tab. 13. continued

Seagrass (12 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 5	18.00	37.00	17.00	72.00	18.00	9.00	1.00	2876	1058	37.38
	14.00	26.00	18.00	58.00	31.00	7.00	4.00			
A 6	3.00	5.00	4.00	12.00	9.00	53.00	26.00	649	1880	131.94
	4.00	6.00	11.00	21.00	14.00	50.00	15.00			
A 19	9.00	18.00	12.00	39.00	31.00	21.00	9.00	3219	1924	153.93
	7.00	15.00	19.00	41.00	45.00	9.00	5.00			
A 25	21.00	40.00	17.00	78.00	17.00	3.00	2.00	3598	1207	37.38
	16.00	29.00	19.00	65.00	27.00	4.00	4.00			
A 30	19.00	39.00	16.00	74.00	18.00	5.00	3.00	3589	627	1.65
	13.00	25.00	26.00	64.00	26.00	6.00	4.00			
B 12	27.00	50.00	14.00	91.00	9.00	0.00	0.00	4631	88	0.59
	23.00	50.00	19.00	92.00	5.00	2.00	1.00			
B 17	23.00	48.00	15.00	86.00	8.00	4.00	2.00	4512	508	0.66
	21.00	42.00	18.00	81.00	14.00	3.00	2.00			
B 48	28.00	44.00	17.00	89.00	6.00	5.00	0.00	4420	567	1.32
	25.00	45.00	18.00	88.00	12.00	0.00	0.00			
C 6	23.00	34.00	16.00	73.00	12.00	11.00	4.00	4794	862	37.38
	23.00	31.00	18.00	72.00	19.00	2.00	7.00			
C 7	19.00	31.00	14.00	64.00	22.00	10.00	4.00	3879	785	28.59
	22.00	27.00	21.00	70.00	24.00	3.00	3.00			
C 20	24.00	44.00	15.00	83.00	17.00	0.00	0.00	4745	290	0.04
	24.00	43.00	17.00	84.00	11.00	2.00	3.00			
C 23	28.00	42.00	15.00	85.00	15.00	0.00	0.00	5058	618	0.77
	28.00	46.00	16.00	90.00	10.00	0.00	0.00			
m	20.17	36.00	14.33	70.50	15.17	10.08	4.25	3831	868	35.97
	18.33	32.08	18.33	68.83	19.83	7.33	4.00			
s	7.23	12.40	3.42	22.18	6.72	14.16	7.01	1164	546	50.49
	7.19	12.89	3.27	20.33	10.76	13.12	3.85			
min.	3.00	5.00	4.00	12.00	6.00	0.00	0.00	649	88	0.04
	4.00	6.00	11.00	21.00	5.00	0.00	0.00			
max.	28.00	50.00	17.00	91.00	31.00	53.00	26.00	5058	1924	153.93
	28.00	50.00	26.00	92.00	45.00	50.00	15.00			

Mud (14 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
B 13	30.00	39.00	17.00	86.00	14.00	0.00	0.00	4970	1121	34.08
	19.00	43.00	22.00	84.00	13.00	3.00	0.00			
B 14	19.00	44.00	20.00	83.00	12.00	4.00	1.00	3606	1352	27.49
	19.00	45.00	20.00	84.00	16.00	0.00	0.00			
B 16	25.00	46.00	15.00	86.00	14.00	0.00	0.00	3452	1045	1.63
	22.00	48.00	18.00	88.00	12.00	0.00	0.00			
B 20	22.00	47.00	15.00	84.00	15.00	1.00	0.00	3831	693	26.39
	23.00	49.00	16.00	88.00	12.00	0.00	0.00			
B 21	22.00	40.00	19.00	81.00	16.00	2.00	1.00	3857	836	1.65
	23.00	46.00	19.00	88.00	5.00	6.00	1.00			
B 22	20.00	47.00	18.00	85.00	15.00	0.00	0.00	4081	1482	32.99
	21.00	49.00	17.00	87.00	13.00	0.00	0.00			
B 23	16.00	47.00	16.00	79.00	21.00	0.00	0.00			
	21.00	50.00	18.00	89.00	11.00	0.00	0.00			
B 43	16.00	45.00	19.00	80.00	14.00	4.00	2.00	3171	1623	65.97
	17.00	44.00	22.00	83.00	11.00	4.00	2.00			
B 44	16.00	44.00	19.00	79.00	21.00	0.00	0.00	3430	1570	39.58
	15.00	48.00	21.00	84.00	7.00	5.00	4.00			
B 46	16.00	43.00	20.00	79.00	15.00	4.00	2.00	3624	1469	37.38
	19.00	44.00	20.00	84.00	11.00	4.00	1.00			
B 58	20.00	48.00	20.00	88.00	7.00	3.00	2.00	3716	1388	48.38
	20.00	46.00	17.00	83.00	17.00	0.00	0.00			
B 70	18.00	44.00	19.00	81.00	11.00	7.00	1.00	3413	1253	46.18
	19.00	47.00	17.00	83.00	17.00	0.00	0.00			
D 5	27.00	45.00	18.00	90.00	10.00	0.00	0.00	4323	871	2.09
	27.00	45.00	16.00	89.00	11.00	0.00	0.00			
D 6	25.00	45.00	18.00	88.00	10.00	1.00	1.00	4389	858	0.97
	25.00	47.00	17.00	89.00	8.00	1.00	2.00			
m	20.86	44.57	18.07	83.50	13.93	1.86	0.71	3836	1197	28.06
	20.71	46.50	18.57	85.93	11.71	1.64	0.71			
s	4.36	2.50	1.67	3.62	3.77	2.13	0.80	475	300	20.13
	3.03	2.06	2.03	2.43	3.39	2.16	1.16			
min.	16.00	39.00	15.00	79.00	7.00	0.00	0.00	3171	693	0.97
	15.00	43.00	16.00	83.00	5.00	0.00	0.00			
max.	30.00	48.00	20.00	90.00	21.00	7.00	2.00	4970	1623	65.97
	27.00	50.00	22.00	89.00	17.00	6.00	4.00			

Tab. 13. continued

Muddy sand (39 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 3	16.00	43.00	19.00	78.00	21.00	1.00	0.00	3290	814	21.99
	18.00	39.00	18.00	75.00	24.00	1.00	0.00			
A 4	12.00	33.00	19.00	64.00	21.00	10.00	5.00	2419	1423	48.38
	10.00	22.00	19.00	51.00	39.00	5.00	5.00			
A 12	16.00	36.00	16.00	68.00	14.00	16.00	2.00	2542	1100	35.18
	15.00	34.00	18.00	67.00	25.00	6.00	2.00			
A 14	12.00	39.00	19.00	70.00	15.00	10.00	5.00	2199	1132	46.18
	13.00	29.00	21.00	63.00	19.00	5.00	13.00			
A 16	21.00	37.00	21.00	79.00	16.00	2.00	3.00	3831	871	26.39
	13.00	35.00	19.00	67.00	23.00	6.00	4.00			
A 22	14.00	28.00	20.00	62.00	25.00	10.00	3.00	2947	1198	48.38
	14.00	31.00	20.00	65.00	26.00	4.00	5.00			
A 24	15.00	36.00	16.00	67.00	21.00	11.00	1.00	2027	1341	63.77
	14.00	30.00	19.00	63.00	28.00	6.00	3.00			
A 26	15.00	35.00	17.00	67.00	25.00	6.00	2.00	2604	1465	39.58
	15.00	35.00	19.00	69.00	21.00	5.00	5.00			
A 27	18.00	29.00	18.00	65.00	20.00	11.00	4.00	4178	880	24.19
	19.00	32.00	18.00	69.00	22.00	6.00	3.00			
B 6	25.00	44.00	20.00	89.00	11.00	0.00	0.00	4130	721	21.99
	22.00	45.00	20.00	87.00	13.00	0.00	0.00			
B 8	26.00	38.00	20.00	84.00	9.00	0.00	7.00	4235	506	0.88
	25.00	44.00	24.00	93.00	7.00	0.00	0.00			
B 9	27.00	44.00	15.00	86.00	14.00	0.00	0.00	4904	563	1.10
	26.00	48.00	16.00	90.00	10.00	0.00	0.00			
B 15	28.00	46.00	20.00	94.00	6.00	0.00	0.00	3963	690	1.01
	25.00	44.00	18.00	87.00	10.00	1.00	2.00			
B 30	28.00	53.00	14.00	96.00	4.00	0.00	0.00	4565	279	1.14
	29.00	50.00	16.00	95.00	5.00	0.00	0.00			
B 32	18.00	52.00	22.00	92.00	8.00	0.00	0.00	4367	484	0.88
	28.00	45.00	19.00	92.00	8.00	0.00	0.00			
B 33	21.00	49.00	20.00	90.00	10.00	0.00	0.00	4077	693	1.54
	25.00	45.00	20.00	90.00	10.00	0.00	0.00			
B 34	18.00	49.00	19.00	86.00	14.00	0.00	0.00	3378	963	23.09
	21.00	44.00	23.00	88.00	12.00	0.00	0.00			
B 35	20.00	49.00	21.00	90.00	10.00	0.00	0.00	3848	873	24.19
	23.00	42.00	23.00	88.00	10.00	1.00	1.00			
B 36	19.00	44.00	22.00	85.00	15.00	0.00	0.00	3646	783	1.61
	23.00	45.00	21.00	89.00	11.00	0.00	0.00			
B 37	23.00	48.00	20.00	91.00	9.00	0.00	0.00	3976	631	1.54
	23.00	44.00	23.00	90.00	10.00	0.00	0.00			
B 38	13.00	33.00	16.00	62.00	19.00	14.00	5.00	2388	1001	24.19
	17.00	41.00	20.00	78.00	16.00	3.00	3.00			
B 42	24.00	47.00	20.00	91.00	9.00	0.00	0.00	4288	849	1.10
	21.00	44.00	18.00	83.00	11.00	3.00	3.00			
B 45	22.00	44.00	20.00	86.00	14.00	0.00	0.00	4178	1132	1.76
B 50	29.00	45.00	15.00	89.00	2.00	8.00	1.00	4882	1058	25.29
	22.00	46.00	20.00	88.00	12.00	0.00	0.00			
B 51	40.00	39.00	15.00	94.00	6.00	0.00	0.00	6324	510	1.67
	27.00	44.00	21.00	92.00	8.00	0.00	0.00			
B 52	19.00	51.00	19.00	89.00	11.00	0.00	0.00	3835	704	26.39
	25.00	47.00	20.00	92.00	5.00	1.00	2.00			
B 53	18.00	51.00	19.00	88.00	12.00	0.00	0.00	3479	814	1.63
	20.00	41.00	21.00	82.00	10.00	4.00	4.00			
B 54	19.00	41.00	28.00	88.00	12.00	0.00	0.00	4266	785	34.08
	22.00	44.00	22.00	88.00	12.00	0.00	0.00			
B 55	23.00	49.00	18.00	90.00	10.00	0.00	0.00	4139	532	1.65
	25.00	43.00	21.00	89.00	11.00	0.00	0.00			
B 63	20.00	53.00	15.00	88.00	8.00	3.00	1.00	3844	620	1.98
	24.00	48.00	20.00	92.00	8.00	0.00	0.00			
B 64	19.00	53.00	16.00	88.00	12.00	0.00	0.00	3558	818	32.99
	25.00	46.00	20.00	91.00	8.00	1.00	0.00			
B 65	17.00	45.00	23.00	85.00	10.00	3.00	2.00	3598	816	21.99
	22.00	39.00	23.00	85.00	15.00	0.00	0.00			
B 66	26.00	49.00	13.00	88.00	4.00	6.00	2.00	4117	792	0.92
	23.00	42.00	20.00	85.00	12.00	2.00	1.00			
B 69	20.00	38.00	18.00	76.00	16.00	6.00	2.00	4781	605	0.18
	20.00	44.00	19.00	83.00	12.00	2.00	3.00			
C 2	17.00	56.00	18.00	91.00	9.00	0.00	0.00	3646	583	1.10
	20.00	49.00	21.00	90.00	10.00	0.00	0.00			
C 4	23.00	49.00	15.00	87.00	13.00	0.00	0.00	4424	308	0.88
	27.00	45.00	18.00	90.00	10.00	0.00	0.00			
C 12	34.00	47.00	12.00	93.00	7.00	0.00	0.00	5766	264	0.07
	33.00	43.00	16.00	92.00	6.00	1.00	1.00			
C 14	30.00	44.00	16.00	90.00	10.00	0.00	0.00	5278	431	0.84
	30.00	42.00	18.00	90.00	10.00	0.00	0.00			
D 9	24.00	50.00	16.00	90.00	6.00	4.00	0.00	4240	946	0.99
	25.00	48.00	17.00	90.00	10.00	0.00	0.00			
m	21.26	44.00	18.21	83.49	12.26	3.10	1.15	3901	794	15.71
	21.82	41.55	19.71	83.11	13.66	1.66	1.58			
s	5.96	6.96	3.03	9.96	5.57	4.61	1.82	910	290	17.62
	5.13	6.21	1.99	10.77	7.31	2.17	2.52			
min.	12.00	28.00	12.00	62.00	2.00	0.00	0.00	2027	264	0.07
	10.00	22.00	16.00	51.00	5.00	0.00	0.00			
max.	40.00	56.00	28.00	96.00	25.00	16.00	7.00	6324	1465	63.77
	33.00	50.00	24.00	95.00	39.00	6.00	13.00			

Tab. 13. continued

reach relatively high amounts and obscure the distribution of the different carbonate minerals. This is clearly documented by the decreasing percentage towards the coast (Figs. 33 – 38) and, in the case of aragonite, in the basins. Only the calcite distribution in the mud fraction (Fig. 38) exhibits a higher percentage along the main coast of the 'North area' and 'West area' and, additionally, in a large area including parts of the 'East area' and the 'West area'. This distribution seems to reflect a terrigenous origin of the calcite, with a higher amount along the coast and subsequent transportation by water currents inside the bay (elevated values in the 'East area' and 'West area'). The terrigenous — or erosional — origin of calcite and its further distribution by water currents is supported by its frequency distribution relative to carbonate (Figs. 41, 42). Although calcite is generally the least abundant carbonate mineral, it can reach percentages exceeding 50 % along the main coast, in the total samples as well as in the mud fraction. This amount generally decreases away from the coast. Values above 20 % are very widespread in the mud fraction; their distributional pattern, however, supports a dispersion by water currents (Fig. 42). Calcite in the total samples is elevated not only along the main coast and the 'West area' basin, but also at the submarine ridge south of Tubya al-Bayda and at the eastern submarine ridge separating the bay from the open sea (Fig. 41). The occurrence at the last two localities can probably be related to submarine erosion as well as the tongues of higher calcite values west of these ridges (Fig. 41) points to the distribution of these eroded material by water currents.

The distribution of aragonite can be explained by its correlation with components and grain size. Its positive correlation to coarse sediment fractions explains its greater occurrence in shallow water areas as well as its positive correlation to corals and compound grains. The unusually high positive correlation coefficient between aragonite and red algae (composed of Mg-calcite) can be attributed to the co-occurrence of red algae and corals. When computing a partial correlation coefficient by excluding all other variables, no significant correlation between aragonite and red algae exists (r=–0.052). The positive correlation between aragonite, corals, and coarse grain fractions as well as the low aragonite content in the mud fraction, especially in the muddy basins, suggests that corals mainly supply coarse sand and gravel to the sediments; this is in accordance with previous studies (compare FLÜGEL, 1982; SCOFFIN, 1987).

The most abundant carbonate mineral is Mg-calcite, comprising between 40 and 50 % of the total mineral content in the main part of the bay (in the total samples as well as in the mud fraction). The aragonite/Mg-calcite ratio (total samples) clearly documents that in the basins as well as on and eastward of the submarine ridge south of Ras Abu Soma, the Mg-calcite frequency is twice as high as that of aragonite. The positive correlation to mud, very fine sand (partly) and fine sand corroborates this distributional pattern. The correlation analysis with components revealed positive correlations to molluscs, hyaline foraminifers and echinoderms, although only the latter two are composed of Mg-calcite. Therefore the sediment fractions containing most of the Mg-calcite are not encompassed by component analysis.

The mineral distribution in the bottom facies types partly reflects the distribution of the latter. The relatively high amount of non-carbonate minerals in 'Sand' and 'Sand with seagrass' (total samples and mud fractions) and in 'Seagrass' (total samples) can be explained by the predominantly coastal occurrence of these bottom facies. The high non-carbonate content in the mud fraction of 'Sand with coral patches' is also attributed to coastal samples. The high carbonate content in the total samples reflects the high percentage of corals combined with the highest aragonite percentage (39.09 %) of all bottom facies; this is also documented in the triangular diagrams (Figs. 46, 47).

The general high mollusc content detected by component analysis implies a generally high aragonite amount; in fact, aragonite is less abundant, especially in those sample groups ('Mud' and 'Muddy sand' bottom) where molluscs clearly dominate. Therefore, as also demonstrated by the mollusc distribution in the grain size categories, this skeletal group decreases drastically with decreasing grain size and represents only an insignificant percentage of the total sample in fine-grained sediments. Generally, the mineral distribution only coincides well with the investigated component fractions (> 250 μm) in shallow water areas (higher aragonite content and — near the coast — higher quartz content) with a distinctly low percentage of mud fraction.

7 Trace elements

7.1 Methods

In order to detect the abundance of selected trace elements, atomic absorption spectrophotometry was carried out on 146 samples previously analysed by X-ray diffractometry. For samples with more than 50 % carbonate content, only 0.5 gram pulverized material was selected, 1.0 gram was used for those with less than 50 %. Before analysis the samples were dissolved in 2 ml distilled water and 20 ml of 2 N HCL. From the clear solution 10 ml were extracted, transferred to a 50 ml flask and diluted with 40 ml

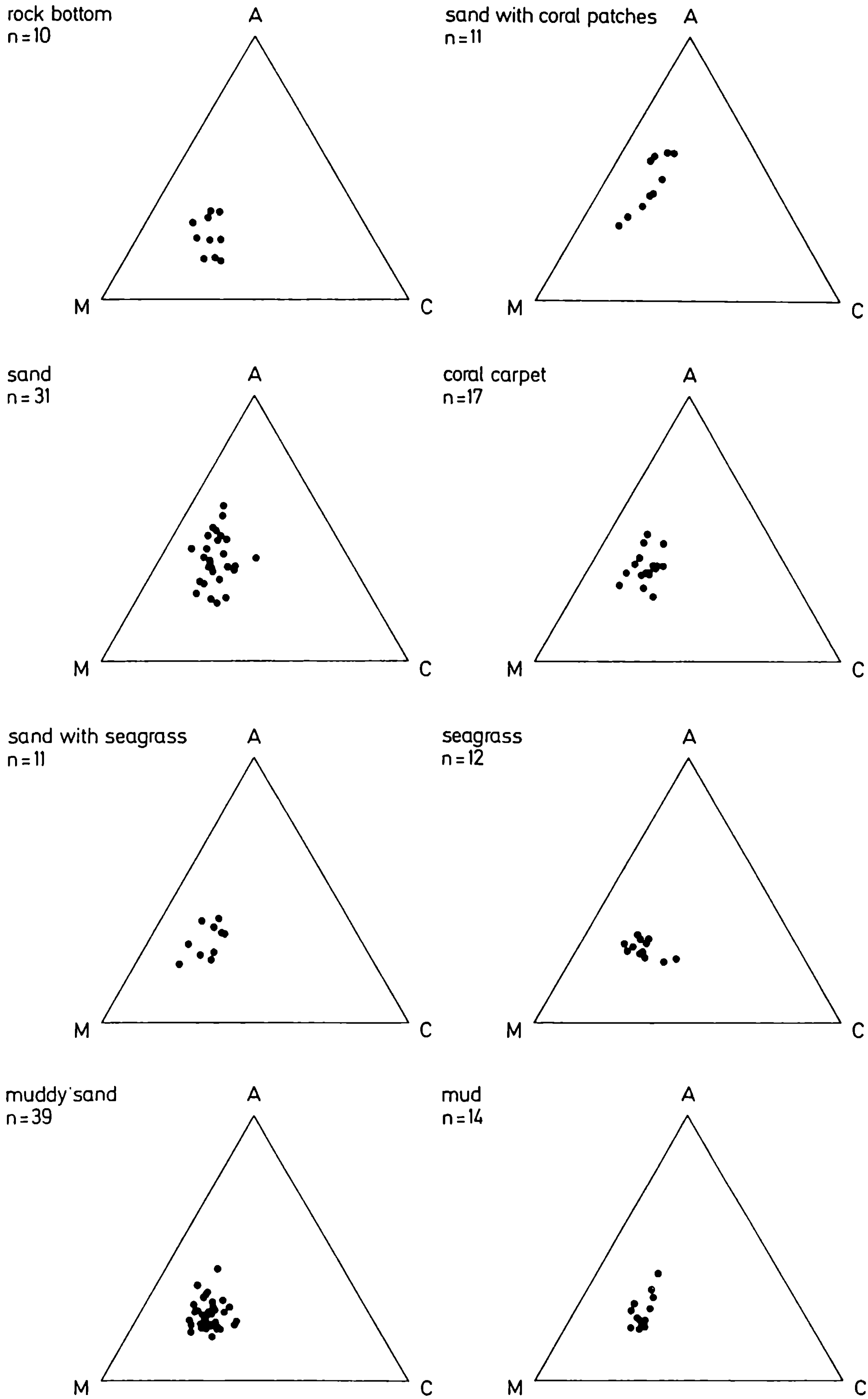


Fig. 46. Triangular diagrams of aragonite (A) – Mg-calcite (M) – calcite (C) of the total samples related to bottom facies.

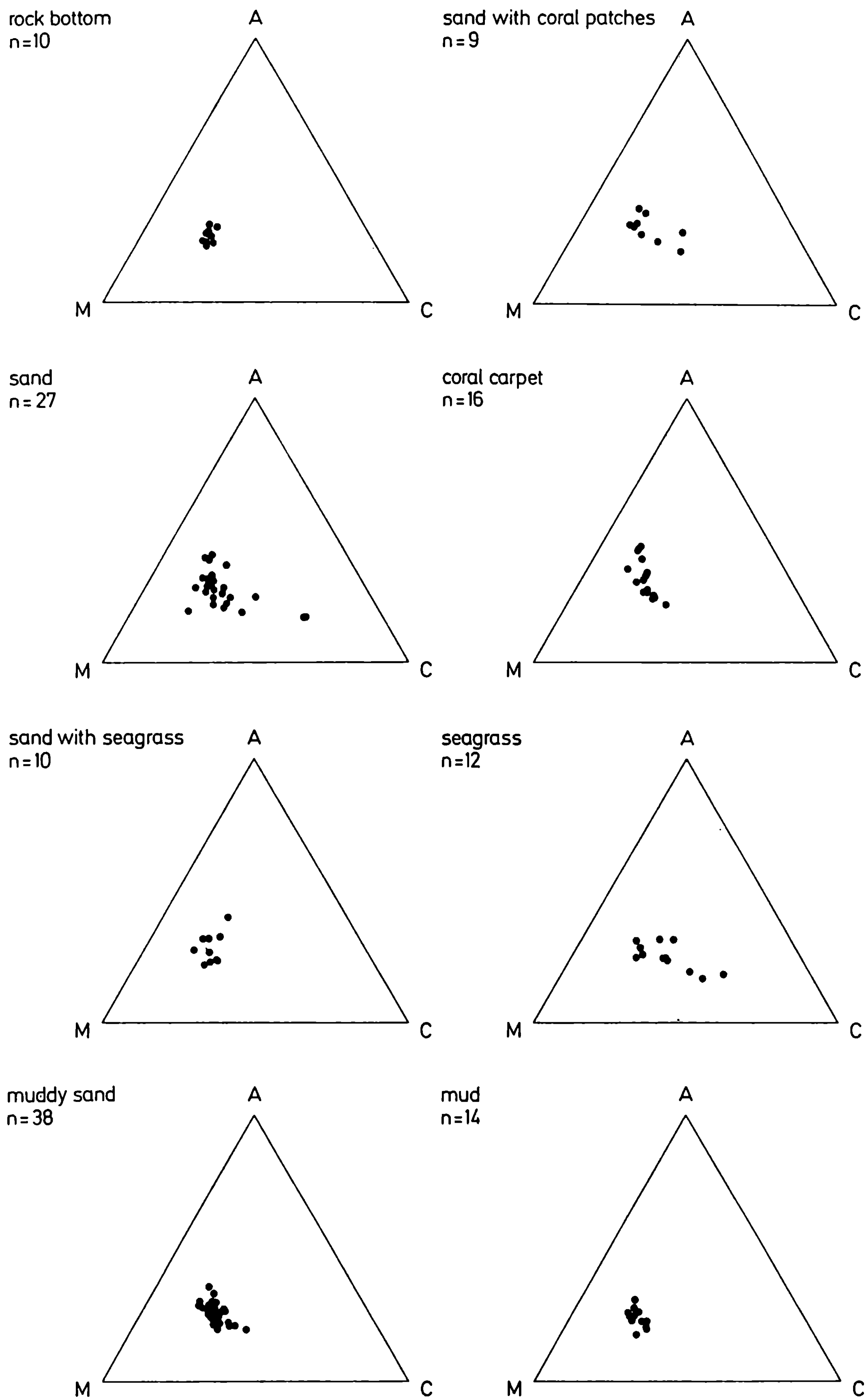


Fig. 47. Triangular diagrams of aragonite (A) – Mg-calcite (M) – calcite (C) of the mud fraction related to bottom facies.

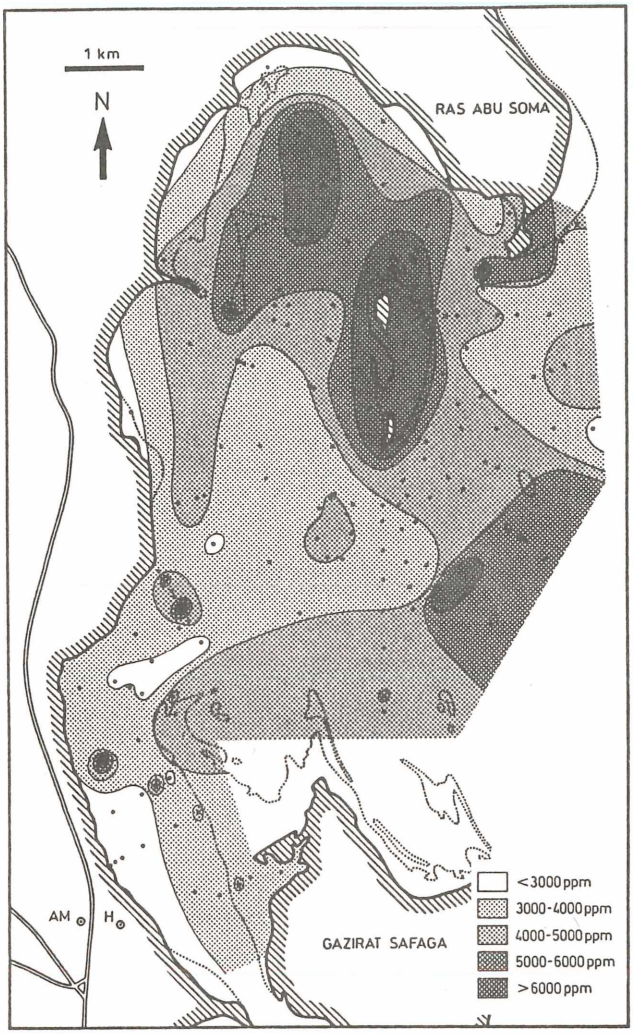


Fig. 48. Distribution of strontium (Sr^{++}).

Fig. 49. Distribution of iron (Fe^{++}).

distilled water. This 50 ml solution of each sample was analysed for Sr^{++}, Fe^{++} and Mn^{++}. Iron and manganese were selected to test whether dark staining of particles occurring frequently in some samples is due to the presence of minerals containing these elements.

7.2 Distribution of strontium

Sr reaches more than 7000 ppm in only 4 samples of the bay (B 26, C 11, C 24, C 30; Appendix 4). These are located in areas where the Sr content generally exceeds 6000 ppm: around the Tubya islands, in the central northwest area of the 'North area' and around Tubya Arba (Fig. 48). Values > 6000 ppm were also detected west of Gamul al-Saghira and in three isolated samples (A 17, A 28, D 2). The lowest values (< 3000 ppm) are found along the main coast of the 'North area' and the 'West area', in two isolated samples — one at the eastern slope against the open sea (B 39) and one at the western margin of the 'West area' basin (B 38) — and in large areas in the 'Southwest channel'.

7.3 Distribution of iron

Fe contents above 1000 ppm are restricted to the 'Southwest channel' (except its eastern coast), the 'West area' basin (except its northernmost part) and to two 'East area' samples (B 49, B 50) (Fig. 49). More than 1500 ppm are present only in 4 samples (A 6, A 19, B 43, B 44); none exceed 2000 ppm. The lowest values (< 100 ppm) are found around the Tubya islands, south of Ras Abu Soma including Tubya Arba, around the submarine plane with the patch reefs between Tubya al-Kabir and Gamul al-Saghira, around the northwestern cusp of the intertidal area of Gazirat Safaga, and in one 'North area' sample (C 18).

7.4 Distribution of manganese

Mn is the least abundant of the investigated trace elements, exceeding 100 ppm in only 4 samples (A 6, A 19, A 32, D 1) along or adjacent to the main coast (Fig. 50). Samples ranging between 50 and 100 ppm are also rare (Appendix 4). More than 30 ppm man-

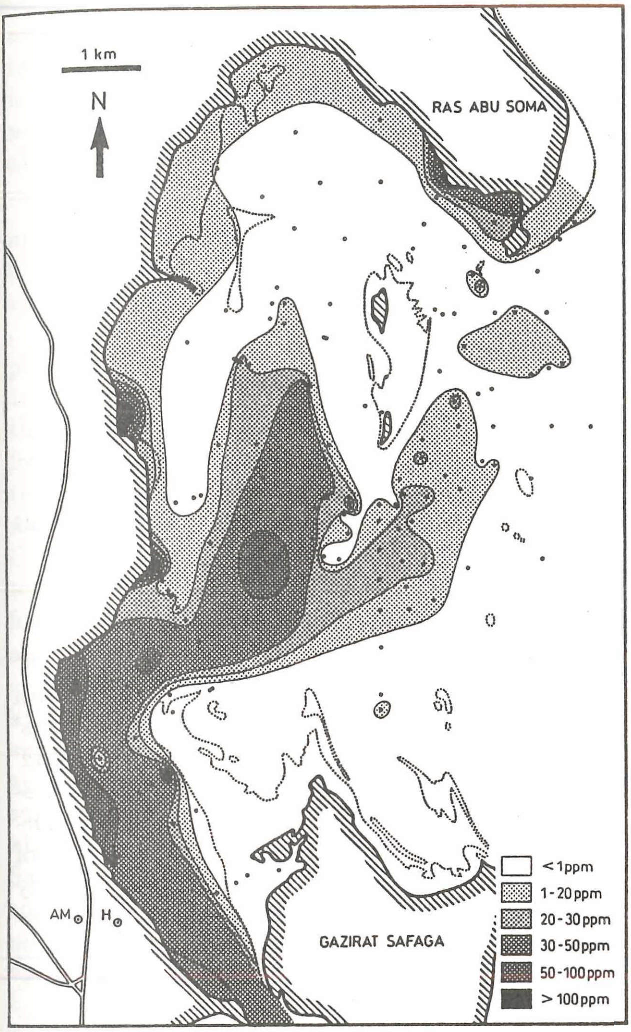


Fig. 50. Distribution of manganese (Mn^{++}).

ganese were detected in the 'Southwest channel' (except its eastern coast) and in the 'West area' basin (except its northern and northwestern part). A large area, including most shallow water areas except the main coast, but also parts of the submarine ridge south of Ras Abu Soma, contains less than 1 ppm Mn.

7.5 Relations between trace elements, grain size, components, and minerals

Strontium is significantly positively correlated to gravel, very coarse sand and the coarser fraction of medium sand (Tab. 14). Iron is significantly negatively correlated to all grain size fractions > 0.25 mm and shows a significant high positive relation to mud and a weak one to the finer fraction of very fine sand. The correlations of manganese to grain size are all relatively weak; a significantly negative one exists to very coarse sand, the coarser fraction of coarse sand and coarser medium sand.

Among components, Sr is significantly positively correlated to corals, red algae and compound grains, negatively to quartz, hyaline foraminifers and crustaceans. Iron shows a relatively strong negative correlation to corals and a weak to red algae; significant positive correlations exist to hyaline foraminifers, molluscs and crustaceans. No significant correlations with any component category could be detected for manganese.

Strontium shows a highly positive correlation to aragonite and a weaker one to Mg-calcite, whereas significant negative correlations exist to quartz, plagioclase and alkali-feldspar. In contrast, iron and manganese are significantly positively correlated to non-carbonate minerals and negatively to aragonite. These correlations are also documented in the relations between the trace elements, with negative correlations of Sr to Fe and Mn and a positive one between Fe and Mn.

7.6 Trace elements versus bottom facies

The highest mean Sr value (5671 ppm), together with a relatively high standard deviation (1156 ppm), is developed in **'Sand with coral patches'** (Tab. 13). The lowest mean values were detected in **'Seagrass'** (3831 ppm), **'Mud'** (3836 ppm) and **'Rock bottom'** (3844 ppm) with a relatively high standard deviation in **'Seagrass'** (1164 ppm) and the lowest in **'Mud'** (475 ppm), where all samples range between 3000 and 5000 ppm. The mean value in **'Sand'** (4440 ppm) is relatively high, but the standard deviation is the highest (1674 ppm) of all bottom facies. **'Sand'** includes the sample with not only the highest (B 26: 7886 ppm) but also the lowest (C 9: 396 ppm) strontium value.

The highest mean Fe·value (1197 ppm, relatively small variance: s=300 ppm) is present in **'Mud'**, followed by **'Seagrass'** (868 ppm, s=546 ppm) and **'Muddy sand'** (794 ppm, s=290 ppm). The least mean value (238 ppm, s=305 ppm) was found in **'Sand with coral patches'**, containing only three samples with less than 1 ppm Fe (B 10, B 25, B 73). The two highest values (A 19: 1924 ppm, A 6: 1880 ppm) occur in **'Seagrass'**.

Mn is most abundant in 'Seagrass' ($\bar{x}$= 35.97 ppm) although the samples are highly variable (s=50.49 ppm); this is followed by **'Mud'** (28.06 ppm), with relatively uniform values (s=20.13 ppm). The lowest mean values occur in **'Rock bottom'** (0.84 ppm) and **'Sand with coral patches'** (4.03 ppm). In the former, all values are lower than 2 ppm (s=0.35 ppm), in the latter all values except one (A 8: 41.78 ppm), lie below 1 ppm (s=11.94).

	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13
Sr	.322	.313	.306	.286	.180	.267	.185	-.063	-.127	-.175	-.219	-.161
Fe	-.318	-.411	-.462	-.549	-.526	-.574	-.504	-.230	-.097	.106	.254	.544
Mn	-.223	-.267	-.291	-.277	-.229	-.307	-.258	.025	.108	.123	.058	.224

	V14	V15	V16	V17	V18	V19	V20	V21	V22	V23	V24	V25
Sr	-.099	-.276	-.218	.408	.039	-.269	.051	.073	.339	.331	-.414	-.057
Fe	.164	.283	.151	-.469	.286	.274	.117	-.022	-.298	-.181	-.012	.182
Mn	.017	.024	.154	-.142	.141	.146	.098	-.056	-.203	-.146	.028	.036

	V26	V27	V28	V29	V30	V31	V32	V33	V34
Sr	.892	.344	.047	-.593	-.621	-.603	1.000	-.564	-.342
Fe	-.581	-.149	.205	.332	.334	.273	-.564	1.000	.555
Mn	-.368	-.260	-.075	.334	.322	.293	-.342	.555	1.000

Tab. 14. Correlation between trace elements (Sr, Fe, Mn) and grain size fractions (V2 to V13), component categories (V14 to V25), minerals (V26 to V31), and trace elements (V32 to V34). Underlined type = 1 % significance level. List of variables see Tables 11 and 12.

7.7 Summary of results

Distribution and the correlation analyses clearly document a distinct relation of trace elements to grain size. The higher Sr values in shallow waters are clearly linked with the coarser sediments there, and both are related to a higher coral content and compound grains. Partial correlation coefficients show the absence of significant relations of corals to aragonite (r=0.044), compound grains to aragonite (r=–0.035), as well as of corals to Sr (r=–0.019) and compound grains to Sr (r=0.107). However, a significant positive partial correlation (excluding all other variables) exists between aragonite and strontium (r=0.498). These correlations suggests that strontium is fixed in aragonite and that the main aragonite-bearing sediment constituents are corals and compound grains (as is also expressed in their correlation coefficients; Tab. 14). For (scleractinian) corals these relations are clear because their skeletons are composed of aragonite. For compound grains this is not obvious a *priori*, as coral fragments do not appear to be a main constituent; a possible explanation may be that aragonite (and Sr) are fixed in the cements producing the compound grains.

The more frequent occurrence of Fe (and to a less extent also of Mn) in deeper waters coincides well with the positive correlation to the mud fraction. The general higher content of terrigenous minerals in mud and the positive correlations of iron and manganese to non-carbonate minerals as well as the negative (but not significant) correlation to Mg-calcite point to a terrigenous origin of these trace elements. Due to the absence of clay minerals and lack of a significant correlation to calcite, their fixation remains unclear. In conclusion, Sr is fixed to autochthonous carbonate, whereas iron and manganese seem to be imported from external sources and distributed inside the bay by water currents.

The distribution of Sr in the bottom facies, with the highest mean values in 'Sand with coral patches' and 'Coral carpet' and the lowest in 'Seagrass', 'Mud' and 'Rock bottom', reflects the dependence of its distribution on the occurrence of aragonite. The occurrence of Fe and Mn is controlled by the content of mud fraction, with highest values in 'Mud', 'Muddy sand', 'Seagrass', and 'Sand with seagrass' The distribution of Mn and its high positive correlation with Fe coincides well with the investigations of UJIIE et al. (1983) from Okinawa, but contradicts the results of MONTAGGIONI et al. (1986) on the east coast of the Red Sea; they also do not coincide with results for ancient examples (compare summary in FLÜGEL, 1982).

8 Sedimentary facies

A major aim of this study was a classification of samples into sedimentary facies based on the data presented in chapters 4 – 7. Due to the large sample number, UPGMA-cluster analyses were computed using different combinations of variables. The most useful results were obtained using 35 variables: 12 represent grain size fractions (1 gravel, 10 sand, 1 mud), 16 are component categories (not separated into size fractions), 6 represent the minerals, and 1 variable is strontium. This analysis incorporated 122 samples (Figs. 51, 52).

Two main clusters are separated based on the amount of carbonate and non-carbonate minerals. The carbonate mineral cluster includes 110 samples, whereas that of non-carbonate minerals comprises only 12. The carbonate cluster is clearly subdivided into two further clusters by grain size. One is characterized by a greater amount of mud (including clusters 1 – 6 in Fig. 52), the other by the extreme dominance of sand (clusters 7 – 9). Further subdivision is due to the different amount of components. The non-carbonate cluster is also subdivided by the variable component contents.

15 clusters (Tab. 15, 16) were clearly differentiated at the correlation coefficient level of 0.85 (Fig. 52). Cluster 1 (28 samples) is characterized by a very high mud content ($\bar{x}$=68.76 %) and a high percentage of molluscs ($\bar{x}$=56.47 %). Cluster 2 comprises only sample B 21; it is very similar to cluster 1 in its high mud content, but is separated by a distinctly lower mollusc content ($\bar{x}$=23.20 %) and more frequent hyaline foraminifers and quartz. The latter occurs only in the coarse fraction (> 250 μm) and is barely detectable in the mineral composition. Cluster 3 (7 samples) is clearly separated from clusters 1 and 2 by the relatively high amount of hyaline foraminifers ($\bar{x}$=43.15 %). The mud content is relatively high and the samples are composed mainly of fine sand and silt. Cluster 4 (24 samples) has the highest mean mollusc value (62.03 %) and is very similar to cluster 1, yet is distinctly separated by grain size, which is dominated by fine sand. The 12 samples of cluster 5 are separated by the relatively high amount of miliolid foraminifers ($\bar{x}$=28.17 %). Sample B 51 represents cluster 6; the high *Halimeda* content (87.31 %) distinguishes it from all other samples (and clusters). Cluster 7 (2 samples), together with 8 and 9, belongs to the sandy group of the "carbonate cluster" and is characterized by a compound grain mean of 57.36 % together with the highest Sr amount ($\bar{x}$=7162 ppm). Clusters 8 and 9 are very closely related by the cluster analysis: both contain samples with relatively high amounts of corals and red algae, the distinguishing character to cluster 7. The distinction between cluster 8 (28 samples) and 9 (8 samples) is mainly due to the clearly higher coral ($\bar{x}$=41.59 %) and red algae content ($\bar{x}$=17.62 %) in cluster 9 (cluster 8: corals: $\bar{x}$=15.49 %, red algae: 11.69 %). Aragonite (40.88 % vs. 33.86 %) and strontium values (5998 ppm vs. 4800 ppm) are also distinctly higher in cluster 9.

Clusters 10 – 15 belong to the second main cluster, the "non-carbonate" cluster: mean carbonate content here does not exceed 30 %. The largest cluster (10) contains 5 samples and is separated from the other non-carbonate clusters by the high amount of quartz and feldspar in the coarse fraction (> 250 μm) ($\bar{x}$=87.41 %). The two samples in cluster 11 are characterized by a high miliolid foraminifer ($\bar{x}$=39.73 %) and silt content ($\bar{x}$=18.06 %). Cluster 12 also contains only two samples and is characterized by a relatively high coral content ($\bar{x}$=32.86 %). Clusters 13, 14 and 15 are each represented by only one sample. Cluster 13 (C 13) is isolated by the mixture of relatively high percentages of molluscs, quartz and compound grains, cluster 14 (A 6) by the highest feldspar content (plagioclase: 53 %, alkali-feldspars: 26 %) and cluster 15 (D 1) by the mixture of abundant molluscs together with miliolid foraminifers, corals, red algae, and quartz.

A critical review of the cluster analysis with regard to the possible correspondence of clusters to sedimentary facies led to certain changes as to the fusion of clusters. A principal weighing of the variables is possible with regard to the amount of the samples they represent. In this respect, grain size, minerals and strontium are more important in reflecting the whole samples, whereas components were only analysed for grain sizes > 250 μm. If for example, the components are used as most important variables, clusters 5 and 11 as well as clusters 8, 9, 12, and 15 would be very closely related. Because of the restricted amount of the analysed components, however, the separation of the two main clusters (carbonate – non-carbonate) reflects a very distinct boundary. Among the carbonate clusters, cluster 1 and 2 are, in fact, very similar because of their high mud content. As explained above, this characteristic is considered to outweigh the differing mollusc – quartz relation. Clusters 8 and 9 are very closely related by the cluster analysis and differ mainly in the amount of corals and red algae. The higher coral content entails a higher percentage of strontium, and the three elevated values combined lead to a separation in the cluster analysis. These two clusters can be fused with respect to sedimentary facies. The clusters of the non-carbonate group are mainly separated on the basis of variable amounts of component categories. The largest cluster (10) contains 5 samples and is, as expected, also characterized by a high quartz content (as a component category). Among the other five clusters two (11, 12) contain 2 samples, while three clusters only 1. In these samples the investigated components (> 250 μm) represent only a small percentage of the whole samples (i.e., dominance of fractions < 250 μm) and can be considered as of minor importance. The result is the fusion of all non-carbonate clusters into one sedimentary facies.

Eight sedimentary facies can therefore be distinguished based on the cluster analysis and taking into account the above-mentioned modifications (Figs. 53, 55; Tab. 17, 18, 19).

8.1 Coralgal facies

This facies (36 samples) is characterized by a relatively high percentage of corals ($\bar{x}$=20.89 %) and/or coralline red algae ($\bar{x}$=12.75 %). Molluscs, dominating in the main part of the bay, attain a remarkably high percentage ($\bar{x}$=48.62 %). Compound grains are the fourth component category reaching more than 5 % ($\bar{x}$=8.43 %), having a relatively high

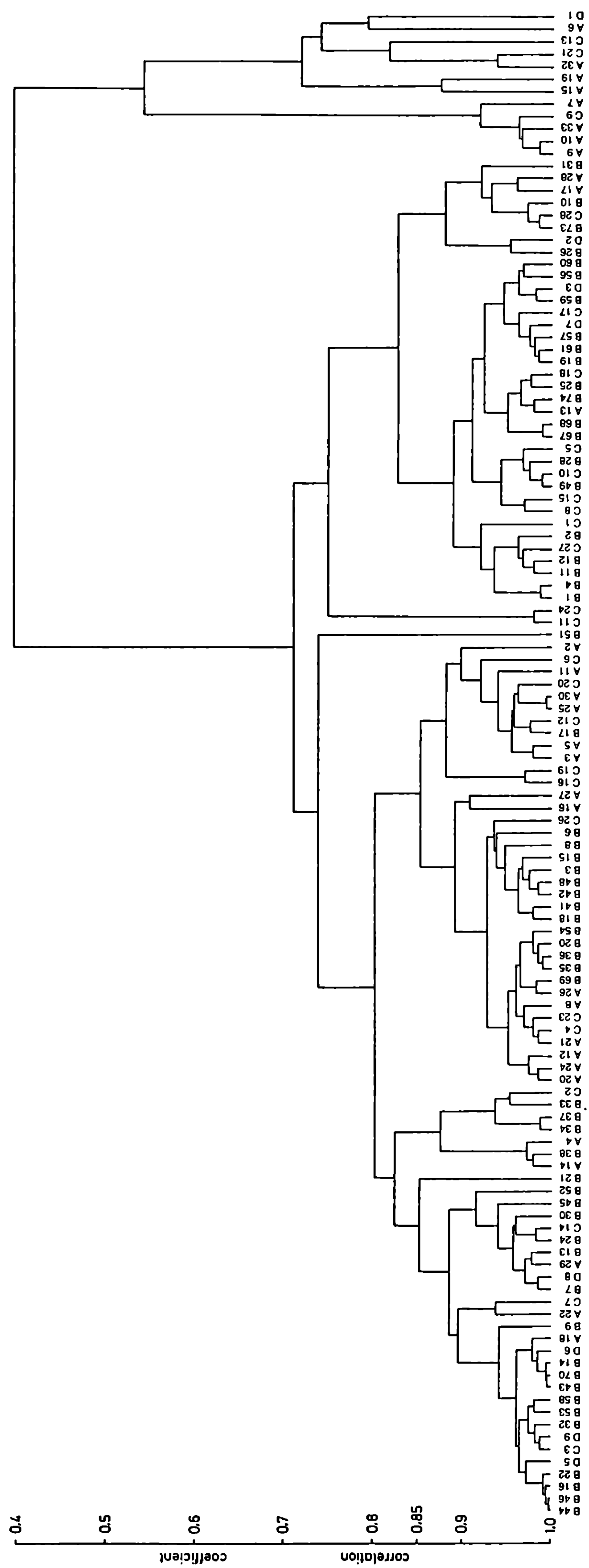


Fig. 51. Dendrogram of a hierarchical UPGMA cluster analysis of grain size, components, minerals, and strontium.

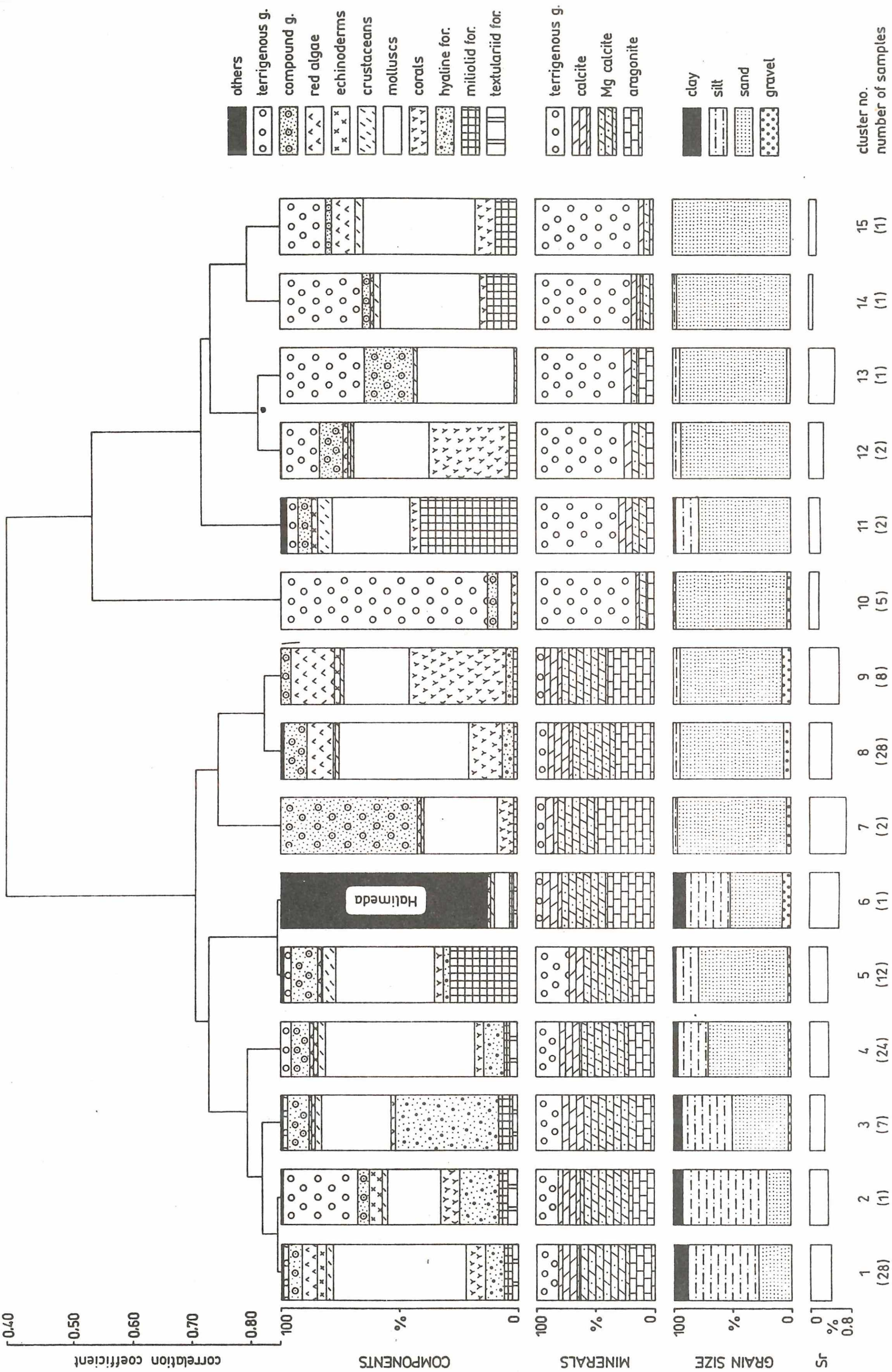


Fig. 52. Frequency distribution of the mean values of the 35 variables (grain size, components, minerals, strontium) in the 15 clusters distinguished at a correlation coefficient of 0.85 of the dendrogram in Fig. 51.

cluster: 1 (28 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	1.29	29.96	59.02	9.74	22.21	43.79	17.57	83.61	12.89	1.96	0.79	4084.86
s	1.43	19.23	17.50	4.08	5.45	6.20	2.34	7.82	4.89	2.98	1.32	630.50
min.	0.00	3.69	26.23	2.53	14.00	28.00	12.00	62.00	4.00	0.00	0.00	2947.00
max.	5.78	61.89	82.86	17.88	34.00	53.00	22.00	96.00	25.00	10.00	5.00	5278.00

cluster: 2

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
B 21	0.00	20.24	70.94	8.81	22.00	40.00	19.00	81.00	16.00	2.00	1.00	3857.00

cluster: 3 (7 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	1.23	51.65	42.20	4.92	16.57	43.86	18.71	79.14	13.86	4.86	2.14	3154.00
s	0.53	9.18	7.16	2.92	4.10	8.25	1.28	12.26	4.49	5.74	2.47	742.47
min.	0.64	35.79	32.93	2.12	12.00	33.00	16.00	62.00	9.00	0.00	0.00	2199.00
max.	2.11	62.98	52.02	11.54	23.00	56.00	20.00	91.00	21.00	14.00	5.00	4077.00

cluster: 4 (24 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	2.19	69.52	25.17	3.12	22.13	40.58	19.04	81.75	13.33	3.38	1.88	3837.29
s	2.38	10.97	10.01	1.64	5.16	5.47	3.35	9.54	5.11	4.42	2.40	760.10
min.	0.37	50.82	5.82	1.01	15.00	15.00	15.00	65.00	4.00	0.00	0.00	2027.00
max.	11.36	92.06	42.61	6.42	34.00	49.00	28.00	96.00	25.00	16.00	8.00	5058.00

cluster: 5 (12 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	1.89	79.03	17.84	1.24	20.75	40.00	14.00	74.75	17.42	5.33	2.50	3964.83
s	1.46	9.94	8.97	0.72	5.02	6.36	3.08	10.30	6.22	3.84	2.60	821.64
min.	0.21	68.20	0.62	0.00	14.00	27.00	10.00	55.00	7.00	0.00	0.00	2876.00
max.	5.66	98.53	27.32	2.42	34.00	48.00	19.00	93.00	30.00	11.00	9.00	5766.00

cluster: 6

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
B 51	7.33	44.85	37.71	10.11	40.00	39.00	15.00	94.00	6.00	0.00	0.00	6224.00

cluster: 7 (2 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	3.85	94.09	2.07	0.00	49.00	34.00	10.00	93.00	3.50	3.50	0.00	7162.00
s	2.35	2.37	0.02	0.00	2.00	3.00	0.00	1.00	2.50	3.50	0.00	152.00
min.	6.19	91.72	2.09	0.00	47.00	31.00	10.00	92.00	1.00	7.00	0.00	7010.00
max.	1.50	96.46	2.05	0.00	51.00	37.00	10.00	94.00	6.00	0.00	0.00	7314.00

cluster: 8 (28 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	7.49	88.54	3.61	0.36	33.86	42.54	16.25	92.64	6.36	0.57	0.43	4800.86
s	5.28	5.85	2.64	0.55	7.95	6.34	4.77	3.31	2.93	1.21	0.94	895.62
min.	0.64	72.84	0.91	0.00	16.00	25.00	7.00	84.00	1.00	0.00	0.00	3391.00
max.	23.08	96.30	10.76	1.84	51.00	53.00	26.00	98.00	12.00	5.00	3.00	7886.00

cluster: 9 (8 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	6.24	88.88	4.66	0.22	40.88	39.38	14.38	94.75	4.38	0.50	0.38	5998.38
s	4.90	6.87	5.72	0.48	7.51	7.21	2.91	2.38	2.00	1.00	0.99	973.71
min.	1.78	77.08	0.10	0.00	29.00	29.00	9.00	91.00	3.00	0.00	0.00	4833.00
max.	15.71	97.50	19.21	1.46	53.00	49.00	18.00	97.00	9.00	3.00	3.00	6817.00

Tab. 15. Some statistical parameters of grain size, minerals and Sr of the clusters computed by an UPGMA cluster analysis comprising 35 variables (grain size, components, minerals, strontium).

cluster: 10 (5 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	3.03	95.53	0.99	0.45	5.80	7.20	3.40	16.40	41.40	29.00	13.20	1942.60
s	2.67	3.11	0.62	0.40	4.35	5.19	1.74	9.99	5.54	4.34	4.53	1770.00
min.	0.03	91.35	0.06	0.00	1.00	2.00	1.00	4.00	31.00	25.00	8.00	0.00
max.	7.28	99.49	1.87	0.93	13.00	14.00	6.00	31.00	47.00	37.00	19.00	3219.00

cluster: 11 (2 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	0.91	79.80	18.06	1.24	7.00	14.00	9.00	30.00	37.50	21.50	11.00	2544.00
s	0.52	9.76	9.01	0.22	2.00	4.00	3.00	9.00	6.50	0.50	2.00	675.00
min.	0.39	89.56	9.05	1.01	5.00	10.00	6.00	21.00	44.00	22.00	13.00	1869.00
max.	1.43	70.04	27.07	1.46	9.00	18.00	12.00	39.00	31.00	21.00	9.00	4827.00

cluster: 12 (2 samples)

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
m	0.55	93.61	5.64	0.22	8.50	9.50	9.00	27.00	43.00	22.00	8.00	3221.50
s	0.27	0.64	0.26	0.11	1.50	3.50	2.00	3.00	3.00	0.00	0.00	376.50
min.	0.27	94.25	5.38	0.11	10.00	13.00	7.00	30.00	40.00	22.00	8.00	2845.00
max.	0.82	92.96	5.90	0.32	7.00	6.00	11.00	24.00	46.00	22.00	8.00	3598.00

cluster: 13

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
C 13	3.57	93.30	3.13	0.00	16.00	3.00	8.00	27.00	44.00	16.00	13.00	4956.00

cluster: 14

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
A 6	0.63	96.44	2.93	0.00	3.00	5.00	4.00	12.00	9.00	53.00	26.00	649.00

cluster: 15

	gravel	sand	silt	clay	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr
D 1	0.12	99.59	0.29	0.00	5.00	4.00	4.00	13.00	47.00	25.00	15.00	1924.00

Tab. 15. continued

variance (s=8.59 %); these grains compose up to around 30 % of the components > 250 μm in a few samples. The hyaline group dominates ($\bar{x}$=3.52 %, s=4.33 %) among foraminifers, reaching more than 10 % in some samples.

The grain size ranges mainly in the sand category ($\bar{x}$=88.61 %), although the samples contain the highest percentage of gravel ($\bar{x}$=7.21 %) of all sedimentary facies (except *Halimeda* facies); this is also expressed by the lowest mean grain size (M_Z=1.23 Φ). The mud content is generally below 5 % and sorting ranges mainly between moderate and poor.

The carbonate content in the total samples is the highest of all sedimentary facies ($\bar{x}$=93.11 %); aragonite abundance (relative to carbonate minerals) is relatively high ($\bar{x}$=38 %), in a few samples exceeding 50 % (related to the total mineral content). The carbonate content of the mud fraction is distinctly lower ($\bar{x}$=84.68 %) than in the total samples.

Strontium is present with a relatively high mean value of 5067 ppm; iron and manganese are relatively rare.

8.2 Mud facies

A high mud content and relatively abundant molluscs are typical for this facies (29 samples). The mud content is generally higher than 50 %, except for 5 samples; the mean silt value is 59.43 %, that of clay 9.70 %. Sorting is mainly between very poor and extremely poor, as is also expressed by a mean value of 2.72 Φ for the 2nd moment.

Molluscs ($\bar{x}$=55.32 %) are by far the dominating component group; no additional category reaches an average of 10 %. Hyaline foraminifers (8.75 %), corals (7.62 %), red algae (6.25 %), and compound grains (6.23 %) reach mean values > 5 %; all have relatively high variances.

The mean carbonate content is 84.20 % in the total samples, but non-carbonate minerals are nearly absent in the fractions > 250 μm (except one sample). The carbonate content in the mud fraction is higher (85.79 %) than in the total samples. Strontium content reaches a mean of 4077 ppm; the manganese value (961 ppm) is the highest of all sedimentary facies.

cluster 1 (28 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	2.16	3.70	8.47	14.33	0.04	7.63	56.47	0.72	2.79	4.15	0.00	6.48	0.65	0.05	0.21	6.30	0.23
s	2.34	4.99	7.62	10.18	0.07	9.63	13.40	1.66	1.50	2.82	0.00	9.13	2.46	0.18	0.88	5.54	0.42
min.	0.04	0.11	0.84	1.23	0.00	0.00	34.50	0.00	0.82	0.65	0.00	0.00	0.00	0.00	0.00	0.34	0.00
max.	9.06	20.45	26.88	38.39	0.33	31.03	86.97	8.69	6.33	11.84	0.00	30.70	13.25	0.94	4.72	24.30	1.43

cluster 2

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
B 21	3.46	3.97	16.35	23.78	0.00	7.36	23.20	0.42	2.04	5.50	0.00	0.00	0.00	0.00	0.74	4.29	32.67

cluster 3 (7 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	2.61	6.40	43.15	52.19	0.00	2.12	29.50	0.24	2.68	1.18	0.00	0.29	0.31	0.0	0.03	10.04	1.45
s	1.43	6.82	11.54	9.18	0.00	3.25	13.88	0.40	1.69	0.82	0.00	0.71	0.62	0.00	0.08	8.04	2.81
min.	0.82	0.30	31.55	40.87	0.00	0.00	9.32	0.00	1.14	0.41	0.00	0.00	0.00	0.00	0.00	1.25	0.00
max.	4.85	19.89	59.95	64.77	0.00	9.82	50.50	1.20	5.33	2.90	0.00	2.03	1.81	0.01	0.23	27.17	8.25

cluster 4 (24 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	2.81	2.09	9.54	14.43	0.00	4.53	62.03	0.10	3.15	2.08	0.00	1.28	0.10	0.10	0.06	7.55	3.58
s	2.79	2.34	8.11	7.85	0.00	5.07	8.04	0.18	1.58	1.83	0.00	3.02	0.25	0.43	0.15	4.81	7.18
min.	0.18	0.06	0.44	0.78	0.00	0.17	44.99	0.00	0.34	0.03	0.00	0.00	0.00	0.00	0.00	0.55	0.00
max.	9.30	9.03	27.73	36.62	0.02	17.08	84.93	0.90	6.50	9.31	0.00	14.71	1.11	2.17	0.64	19.34	32.14

cluster 5 (12 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.75	28.17	2.69	31.61	0.00	3.83	41.51	0.62	5.19	0.79	0.02	1.33	0.14	1.10	0.00	11.21	2.67
s	0.42	8.57	2.45	8.30	0.00	4.61	7.79	0.40	3.09	0.74	0.05	2.32	0.38	2.22	0.00	4.17	4.09
min.	0.25	14.71	0.77	16.85	0.00	0.07	29.14	0.08	1.65	0.09	0.00	0.00	0.00	0.00	0.00	5.63	0.00
max.	1.85	43.03	9.54	45.18	0.02	16.63	53.27	1.25	14.38	2.74	0.18	6.43	1.41	8.09	0.00	18.12	15.68

cluster 6

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
B 51	1.57	0.80	0.25	2.62	0.00	0.00	7.65	0.14	1.26	0.36	0.00	0.00	87.31	0.00	0.03	0.19	0.42

cluster 7 (2 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.06	0.71	0.28	1.04	0.00	7.67	30.98	0.02	0.28	1.34	0.00	1.35	0.00	0.00	0.00	57.36	0.00
s	0.05	0.05	0.23	0.33	0.00	2.42	3.78	0.02	0.15	1.32	0.00	1.35	0.00	0.00	0.00	1.79	0.00
min.	0.01	0.65	0.04	0.70	0.00	5.25	27.19	0.00	0.13	0.02	0.00	0.00	0.00	0.00	0.00	55.56	0.00
max.	0.10	0.76	0.51	1.37	0.00	10.08	34.76	0.03	0.43	2.65	0.00	2.69	0.00	0.00	0.00	59.15	0.00

cluster 8 (28 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.41	1.09	3.31	4.82	0.00	15.49	54.74	0.57	0.54	1.34	0.00	11.69	0.03	0.25	0.02	9.35	0.80
s	0.36	1.77	4.18	4.49	0.01	10.59	10.92	0.80	0.77	1.75	0.00	10.53	0.08	1.30	0.09	9.09	1.71
min.	0.04	0.03	0.02	0.44	0.00	0.82	33.14	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.53	0.00
max.	1.59	9.33	14.86	16.61	0.07	41.60	74.27	3.24	3.42	7.71	0.00	32.00	0.38	7.01	0.49	31.51	7.56

cluster 9 (8 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.27	1.32	2.41	4.00	0.00	41.59	26.97	0.30	1.38	2.90	0.00	17.62	0.14	0.04	0.00	4.77	0.20
s	0.34	1.66	2.46	2.59	0.00	12.61	4.42	0.38	1.00	2.10	0.00	10.27	0.34	0.10	0.00	5.40	0.38
min.	0.00	0.09	0.00	0.59	0.00	21.89	20.66	0.00	0.29	0.78	0.00	1.28	0.00	0.00	0.00	0.25	0.00
max.	0.85	5.37	8.06	8.24	0.00	56.16	34.76	1.16	3.68	6.97	0.01	34.99	1.03	0.29	0.00	17.57	1.11

Tab. 16. Some statistical parameters of the components of the clusters computed by an UPGMA cluster analysis comprising 35 variables (grain size, components, minerals, strontium).

cluster 10 (5 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.08	0.63	0.61	1.31	0.00	1.41	5.34	0.03	0.20	0.23	0.00	0.22	0.00	0.07	0.00	3.78	87.41
s	0.04	0.63	0.89	0.83	0.00	1.67	3.31	0.05	0.11	0.23	0.00	0.33	0.00	0.10	0.00	2.90	3.89
min.	0.00	0.00	0.04	0.24	0.00	0.08	1.43	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.57	83.25
max.	0.13	1.74	2.38	2.53	0.00	4.65	9.80	0.13	0.35	0.61	0.00	0.85	0.00	0.24	0.00	8.72	94.52

cluster 11 (2 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	2.34	39.73	7.23	49.30	0.00	2.04	28.27	0.76	5.54	2.47	0.02	0.25	0.08	0.97	0.00	4.74	5.59
s	0.83	2.38	4.28	2.72	0.00	1.13	1.38	0.42	1.93	1.30	0.02	0.25	0.08	0.89	0.00	0.47	4.26
min.	3.16	37.35	11.51	52.02	0.00	3.16	26.89	0.34	7.47	3.76	0.03	0.50	0.15	0.08	0.00	4.27	1.33
max.	1.51	42.11	2.95	46.57	0.00	0.91	29.65	1.18	3.61	1.17	0.00	0.00	0.00	1.85	0.00	5.21	9.84

cluster 12 (2 samples)

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
m	0.55	3.55	0.74	4.84	0.00	32.86	31.92	0.21	1.15	1.04	0.00	1.73	0.00	0.00	0.04	10.28	15.94
s	0.48	1.53	0.67	2.69	0.00	1.82	8.21	0.19	0.81	1.04	0.00	1.73	0.00	0.00	0.04	5.53	7.27
min.	1.03	5.08	1.41	7.52	0.00	31.03	40.13	0.40	1.96	2.08	0.00	3.45	0.00	0.00	0.00	4.75	8.67
max.	0.07	2.02	0.06	2.15	0.01	34.68	23.70	0.02	0.34	0.00	0.00	0.00	0.00	0.00	0.08	15.81	23.20

cluster 13

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
C 13	0.00	1.69	0.03	1.72	0.00	0.14	41.26	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.11	21.87	33.95

cluster 14

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
A 6	0.36	13.02	1.73	15.11	0.00	0.92	42.24	0.17	1.96	0.50	0.00	0.96	0.00	0.10	0.00	3.44	34.60

cluster 15

	aggl	mil	hyal	for	spon	cor	moll	worm	crus	echi	vert	red	gre	pla	pel	comp	qua
D 1	0.84	8.27	0.84	9.95	0.00	8.35	46.69	0.17	3.50	0.00	0.00	9.54	0.34	0.00	0.59	1.86	19.00

Tab. 16. continued

8.3 Molluscan facies

The 24 samples classified here are clearly dominated by molluscs ($\bar{x}$=63.03 %, relatively low variance: s=8.04 %). Only two additional categories, hyaline foraminifers ($\bar{x}$=9.54 %) and compound grains ($\bar{x}$=7.55 %), exceed 5 %.

The grain size distribution is dominated by sand (mainly fine to very fine sand) ($\bar{x}$=69.52 %), with each sample containing > 50 %. Six samples exhibit > 40 % mud. The consistently present mud content is documented in the sediment terminology, being mainly silty sand or siltsand.

The carbonate content reaches a mean value of 81.75 % in the total samples and 80.29 % in the mud fraction. Except for two samples, the non-carbonate minerals are concentrated in the fractions < 250 μm. Strontium values are relatively low (3837 ppm).

8.4 Operculina facies

Hyaline foraminifers, mainly represented by the genus *Operculina*, are the dominating components in this facies (7 samples). The mean value of these larger foraminifers is 43.15 % (s=11.54 %), and they occur more frequently than molluscs ($\bar{x}$=29.50 %, s=13.88 %). One additional component group, compound grains ($\bar{x}$=10.04 %, s=8.04 %), exceeds 10 %. Miliolid foraminifers are the only group between 5 and 10 % ($\bar{x}$=6.40 %, s=6.82 %), reaching nearly 20 % in one sample.

In grain size distribution the relation between sand/gravel and mud is nearly equal (52.88 % vs. 47.12 %). Sorting is very poor to extremely poor, with a mean value of 2.61 Φ for the 2nd moment.

The carbonate content may reach nearly 80 %. Aragonite content (related to carbonate minerals) is the lowest (21 %) of all sedimentary facies, while calcite is relatively abundant (24 %); strontium is rare ($\bar{x}$=3155 ppm) and iron relatively abundant ($\bar{x}$=918 ppm).

8.5 Soritid facies

This sedimentary facies (12 samples) is characterized by abundant larger porcellaneous foraminifers ($\bar{x}$=28.17 %) of the genera *Sorites* and *Amphisorus*. The most abundant components are mol-

Coralgal facies (36 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_Z	2.mom.	Sk_I	4.mom.
A 13	6.47	91.91	1.62	0.00	sand	poor	1.19	1.44	-0.07	3.08
A 17	12.61	85.02	2.37	0.00	gravelly sand	poor	0.89	1.48	-0.05	2.71
A 28	15.71	80.17	4.11	0.00	gravelly sand	poor	0.69	1.72	0.14	3.31
B 1	1.45	94.94	3.62	0.00	sand	moderate	1.52	1.23	0.02	7.04
B 2	1.98	95.77	1.72	0.53	sand	moderate	1.08	1.20	0.01	7.28
B 4	3.10	95.68	1.22	0.00	sand	moderate	1.25	1.13	-0.13	3.57
B 10	6.76	93.14	0.10	0.00	sand	moderate	0.68	1.09	0.03	2.75
B 11	3.85	94.69	1.46	0.00	sand	moderate	1.32	1.24	0.00	3.02
B 12	1.79	87.95	9.23	1.04	sand	poor	1.60	1.91	0.33	8.78
B 19	12.56	80.45	5.72	1.27	gravelly sand	v. poor	0.92	2.14	0.19	8.35
B 25	5.49	93.60	0.91	0.00	sand	moderate	0.95	1.14	-0.17	4.22
B 26	1.78	97.50	0.72	0.00	sand	moderate	1.49	1.03	0.02	3.61
B 28	2.47	87.51	8.18	1.84	sand	poor	2.02	1.94	0.14	10.18
B 31	2.24	77.08	19.21	1.46	silty sand	v. poor	2.40	2.21	0.05	8.19
B 49	6.12	86.01	6.12	1.75	sand	v. poor	1.78	2.13	-0.13	9.08
B 56	23.08	75.55	1.37	0.00	gravelly sand	moderate	0.10	1.34	0.20	6.31
B 57	9.93	86.43	3.64	0.00	sand	poor	1.14	1.59	-0.15	3.24
B 59	18.25	80.25	1.51	0.00	gravelly sand	poor	0.57	1.56	0.06	2.88
B 60	7.87	90.05	2.09	0.00	sand	moderate	0.84	1.39	-0.11	5.10
B 61	7.01	91.49	1.50	0.00	sand	moderate	0.92	1.28	-0.01	4.00
B 67	8.35	89.28	2.37	0.00	sand	poor	0.96	1.48	0.12	2.69
B 68	8.30	88.89	2.82	0.00	sand	poor	1.11	1.47	-0.03	2.73
B 73	5.25	91.44	3.32	0.00	sand	poor	1.17	1.41	0.00	4.02
B 74	7.56	90.13	2.31	0.00	sand	poor	1.51	1.52	-0.36	2.54
C 1	3.88	94.24	1.56	0.32	sand	moderate	1.20	1.26	-0.04	4.22
C 5	2.48	96.30	1.22	0.00	sand	moderate	1.34	1.20	-0.01	2.93
C 8	0.64	92.84	6.32	0.20	sand	moderate	2.03	1.38	0.11	6.12
C 10	8.03	86.24	5.53	0.20	sand	poor	1.59	1.70	0.12	4.33
C 15	1.84	91.87	5.47	0.83	sand	poor	1.96	1.67	-0.07	10.97
C 17	8.30	86.34	5.20	0.16	sand	poor	1.37	1.71	-0.03	4.12
C 18	12.75	85.68	1.37	0.20	gravelly sand	poor	0.63	1.46	0.10	2.94
C 27	9.71	88.31	1.98	0.00	sand	poor	1.05	1.43	-0.06	2.93
C 28	3.27	91.20	5.22	0.31	sand	poor	1.30	1.53	0.21	7.34
D 2	2.28	95.47	2.25	0.00	sand	moderate	1.22	1.37	0.14	2.71
D 3	15.19	72.84	10.76	1.21	silty gravelly sand	v. poor	1.24	2.43	0.08	5.88
D 7	11.37	83.85	4.24	0.53	gravelly sand	poor	1.09	1.70	-0.06	3.10
m	7.21	88.61	3.84	0.33			1.23	1.53	0.02	4.90
s	5.22	6.09	3.59	0.54			0.45	0.33	0.13	2.40
min.	0.64	72.84	0.10	0.00			0.10	1.03	-0.36	2.54
max.	23.08	97.50	19.21	1.84			2.40	2.43	0.33	10.97

Mud facies (29 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_Z	2.mom.	Sk_I	4.mom.
A 18	0.01	11.29	79.77	8.93	sandy silt	v. poor	5.44	2.33	0.37	6.12
A 22	1.05	37.06	56.89	5.00	sandsilt	v. poor	4.44	2.33	0.08	5.71
A 29	2.75	44.39	41.17	11.69	sandy silt sand	extr. poor	4.05	3.70	0.07	3.00
B 7	3.64	54.74	39.09	2.53	siltsand	v. poor	3.37	2.36	-0.14	4.21
B 9	0.13	38.23	56.05	5.60	sandsilt	v. poor	4.53	2.14	0.29	7.56
B 13	1.37	44.70	44.12	9.81	siltsand	extr. poor	4.27	3.30	0.08	3.26
B 14	0.03	4.91	21.32	2.12	clayey silt	v. poor	6.12	2.17	0.41	4.94
B 16	0.10	9.78	79.17	10.95	clayey silt	v. poor	5.86	2.55	0.41	5.63
B 21	0.00	20.24	70.94	8.81	sandy silt	v. poor	5.22	2.44	0.43	6.89
B 22	0.13	4.78	82.63	12.47	clayey silt	v. poor	6.19	2.16	0.46	4.72
B 24	0.96	47.89	44.43	6.73	siltsand	extr. poor	3.99	2.73	0.08	3.95
B 23	2.27	24.03	55.82	17.88	clayey sandsilt	extr. poor	5.81	3.42	0.06	2.67
B 30	2.60	49.80	39.97	7.64	siltsand	extr. poor	3.53	3.13	0.02	3.64
B 32	1.18	28.49	63.24	7.09	sandsilt	extr. poor	4.62	2.81	-0.03	5.38
B 43	0.00	5.30	81.39	13.31	clayey silt	v. poor	6.20	2.35	0.45	4.91
B 44	0.30	3.69	80.52	15.49	clayey silt	v. poor	6.54	2.33	0.50	4.25
B 45	5.78	61.81	26.23	6.18	siltsand	extr. poor	2.64	3.24	0.40	3.59
B 46	0.32	4.35	80.90	14.43	clayey silt	v. poor	6.43	2.44	0.48	4.76
B 52	2.42	47.47	44.08	6.03	siltsand	extr. poor	3.43	3.09	-0.11	3.88
B 53	0.95	38.78	46.33	13.93	clayey sandsilt	extr. poor	4.94	3.42	0.18	3.19
B 58	0.02	10.15	76.23	13.60	clayey sandy silt	v. poor	6.07	2.55	0.43	4.51
B 70	0.00	8.37	75.06	16.57	clayey silt	extr. poor	6.49	2.67	0.44	3.75
C 3	1.19	36.25	53.11	9.45	sandsilt	extr. poor	4.66	2.92	0.12	4.26
C 7	0.42	61.89	33.90	3.80	siltsand	poor	3.91	1.95	0.35	9.57
C 14	3.97	43.14	49.16	3.73	sandsilt	extr. poor	3.59	2.66	-0.22	4.41
D 5	0.54	27.18	64.27	8.01	sandsilt	extr. poor	4.85	2.69	0.15	5.87
D 6	0.10	11.21	76.20	12.50	clayey sandy silt	extr. poor	5.80	2.79	0.41	5.53
D 8	2.43	54.33	36.74	6.50	siltsand	extr. poor	3.72	3.00	0.19	5.91
D 9	1.59	24.91	63.18	10.33	clayey sandsilt	extr. poor	5.15	3.29	0.20	5.12
m	1.25	29.63	59.43	9.70			4.89	2.72	0.23	4.87
s	1.43	18.98	17.33	4.01			1.10	0.45	0.21	1.45
min.	0.00	3.69	26.43	2.53			2.64	1.95	-0.22	2.67
max.	5.78	61.89	82.86	17.88			6.54	3.70	0.50	9.57

Tab. 17. Frequency of main grain size categories (%), terminology and sorting, as well as mean (M_Z), sorting (2nd moment), skewness (SK_I), and kurtosis (4th moment) related to sedimentary facies.

Molluscan facies (24 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_Z	2.mom.	Sk_I	4.mom.
A 8	4.50	68.80	25.35	1.35	siltsand	v. poor	2.62	2.28	-0.10	4.70
A 12	2.17	67.87	27.84	2.12	siltsand	v. poor	2.99	2.23	-0.09	5.53
A 16	11.36	71.76	14.33	2.56	silty gravelly sand	extr. poor	1.54	2.64	0.29	6.05
A 20	1.61	75.78	21.01	1.60	silty sand	poor	2.82	1.97	0.02	7.12
A 21	3.45	64.61	28.69	3.25	siltsand	v. poor	3.02	2.52	0.01	5.78
A 24	0.48	78.39	19.42	1.71	silty sand	poor	3.02	1.86	0.02	10.13
A 26	0.61	55.64	37.89	5.85	siltsand	extr. poor	3.97	2.61	0.28	6.89
A 27	0.37	73.27	23.72	2.65	silty sand	v. poor	3.14	2.19	0.11	9.44
B 3	1.68	78.32	17.58	2.42	silty sand	v. poor	2.57	2.33	0.01	7.63
B 6	0.80	78.62	18.50	2.09	silty sand	poor	2.95	1.91	0.08	8.76
B 8	1.22	75.76	20.23	2.79	silty sand	v. poor	2.96	2.10	0.17	6.75
B 15	6.84	69.72	82.66	12.41	silty sand	v. poor	2.37	2.54	0.11	5.56
B 18	1.82	85.73	11.44	1.01	silty sand	poor	2.38	1.79	-0.07	8.06
B 20	2.10	55.50	35.98	6.42	siltsand	extr. poor	3.94	2.69	0.48	4.90
B 35	0.72	55.35	38.20	5.73	siltsand	extr. poor	3.82	2.71	0.17	7.26
B 36	1.12	56.57	38.02	4.29	siltsand	v. poor	3.70	2.39	0.07	5.29
B 41	1.00	92.06	5.82	1.13	sand	poor	2.16	1.64	-0.02	13.04
B 42	1.91	75.31	18.65	4.13	silty sand	v. poor	2.91	2.44	0.15	6.85
B 48	2.53	74.52	19.02	3.93	silty sand	v. poor	2.77	2.51	0.22	6.40
B 54	0.72	50.82	42.61	5.84	siltsand	v. poor	3.91	2.53	0.13	5.27
B 69	2.06	59.04	33.59	5.32	siltsand	extr. poor	3.70	2.60	0.14	6.25
C 4	1.44	62.96	32.38	3.23	siltsand	v. poor	3.51	2.17	0.07	6.18
C 23	1.58	56.38	40.13	1.90	siltsand	v. poor	3.66	2.02	-0.03	7.35
C 26	0.57	85.64	12.27	1.52	silty sand	poor	2.66	1.75	0.09	11.19
m	2.19	69.52	25.17	3.12			3.05	2.27	0.10	7.19
s	2.38	10.97	10.01	1.64			0.62	0.32	0.13	2.02
min.	0.37	50.82	5.82	1.01			1.54	1.64	-0.10	4.70
max.	11.36	92.06	42.61	6.42			3.97	2.71	0.48	13.04

Operculina facies (7 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_Z	2.mom.	Sk_I	4.mom.
A 4	1.98	62.98	32.93	2.12	siltsand	v. poor	2.98	2.40	-0.11	6.52
A 14	0.91	54.84	41.57	2.69	siltsand	v. poor	3.47	2.26	-0.15	4.42
B 33	1.04	57.35	36.18	5.43	siltsand	extr. poor	3.75	2.66	0.22	5.56
B 34	2.11	41.99	50.79	5.11	sandsilt	extr. poor	3.64	2.91	-0.18	4.16
B 37	1.06	48.82	46.59	3.53	siltsand	v. poor	3.67	2.42	-0.14	4.86
B 38	0.89	59.78	35.34	3.99	siltsand	v. poor	3.62	2.44	0.14	5.94
C 2	0.64	35.79	52.02	11.54	clayey sandsilt	extr. poor	4.71	3.18	0.08	3.28
m	1.23	51.65	42.20	4.92			3.69	2.61	-0.02	4.96
s	0.53	9.18	7.16	2.92			0.48	0.30	0.15	1.04
min.	0.64	35.79	32.93	2.12			2.98	2.26	-0.18	3.28
max.	2.11	62.98	52.02	11.54			4.71	3.18	0.22	6.52

Soritid facies (12 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_Z	2.mom.	Sk_I	4.mom.
A 2	0.85	98.53	0.62	0.00	sand	moderate	2.47	1.16	-0.38	3.26
A 3	3.23	68.20	26.85	1.72	siltsand	v. poor	2.76	2.31	-0.08	7.92
A 5	5.66	72.24	20.98	1.12	silty sand	v. poor	2.57	2.21	-0.10	4.10
A 11	2.88	78.56	17.62	0.93	silty sand	poor	2.39	2.00	-0.02	6.78
A 25	2.08	72.30	23.56	2.07	silty sand	v. poor	2.90	2.13	-0.13	7.00
A 30	2.33	70.98	24.28	2.42	silty sand	v. poor	3.01	2.19	-0.12	7.92
B 17	0.85	75.03	22.66	1.47	silty sand	poor	2.99	1.86	0.11	7.00
C 6	0.21	81.56	16.02	2.22	silty sand	poor	3.05	1.80	0.06	11.46
C 12	1.53	73.19	24.39	0.89	silty sand	poor	2.94	1.80	-0.08	6.37
C 16	0.80	95.93	2.98	0.29	sand	moderate	2.25	1.08	-0.19	3.82
C 19	1.88	90.49	6.77	0.86	sand	poor	2.30	1.47	-0.18	3.28
C 20	0.43	71.40	27.32	0.86	siltsand	poor	3.21	1.58	0.03	6.97
m	1.89	79.03	17.84	1.24			2.74	1.80	-0.09	6.32
s	1.46	9.94	8.97	0.72			0.31	0.39	0.12	2.29
min.	0.21	68.20	0.62	0.00			2.25	1.08	-0.38	3.26
max.	5.66	98.53	27.32	2.42			3.21	2.31	0.11	11.46

Tab. 17. continued

luscs ($\bar{x}$=41.51 %); compound grains are consistently present ($\bar{x}$=11.21 %, s=4.17 %). The fourth component category, exceeding 5 %, are crustaceans ($\bar{x}$=5.19 %).

The grain size is clearly dominated by sand fractions ($\bar{x}$=79.03 %), but, except for 3 samples, a considerable amount of silt ($\bar{x}$=17.84 %) is always present. The mean carbonate content is 74.75 % in the total samples, with a clear dominance of Mg-calcite (54 % related to carbonate minerals). In the mud fractions the Mg-calcite content is distinctly lower. Except in one sample the non-carbonate content is restricted to grain sizes < 250 μm. Little strontium is present ($\bar{x}$=3965 ppm).

Terrigenous facies (12 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
A 6	0.63	96.44	2.93	0.00	sand	moderate	2.61	0.93	-0.11	5.77
A 7	0.28	99.49	0.06	0.17	sand	mod.well	0.76	0.54	0.05	16.56
A 9	3.87	94.60	1.53	0.00	sand	moderate	1.11	1.24	0.02	3.61
A 10	7.28	91.35	1.36	0.00	sand	poor	1.05	1.42	-0.08	3.11
A 15	0.39	89.56	9.05	1.01	sand	poor	2.68	1.40	0.25	18.39
A 19	1.43	70.04	27.07	1.46	siltsand	poor	3.19	1.94	-0.13	9.40
A 32	0.27	94.25	5.38	0.11	sand	moderate	3.15	0.84	-0.14	16.86
A 33	3.69	93.51	2.80	0.00	sand	poor	1.36	1.49	-0.08	2.34
C 9	0.03	98.72	1.06	0.20	sand	moderate	1.90	0.88	0.01	3.99
C 13	3.57	93.30	3.13	0.00	sand	poor	1.93	1.47	0.28	2.67
C 21	0.82	92.96	5.90	0.32	sand	moderate	2.67	1.30	-0.45	10.48
D 1	0.12	99.59	0.29	0.00	sand	well	2.41	0.47	-0.17	12.48
m	1.87	92.82	4.89	0.43			2.07	1.16	-0.05	8.81
s	2.16	7.50	7.17	0.49			0.81	0.41	0.19	5.81
min.	0.03	70.04	0.06	0.00			0.76	0.47	-0.45	2.34
max.	7.28	99.59	27.07	1.46			3.19	1.94	0.28	18.39

Compound grains facies (2 samples)

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
C 11	6.19	91.72	2.09	0.00	sand	moderate	1.25	1.36	0.06	2.96
C 24	1.50	96.46	2.05	0.00	sand	moderate	1.72	1.25	-0.07	2.95
m	3.85	94.09	2.07	0.00			1.49	1.31	-0.01	2.955
s	2.35	2.37	0.02	0.00			0.23	0.05	0.07	0.01

Halimeda facies (1 sample)

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
B 51	7.33	44.85	37.71	10.11	clayey siltsand	extr. poor	3.64	3.82	0.08	3.24

Tab. 17. continued

8.6 Terrigenous facies

The 12 samples representing this facies are characterized by a high non-carbonate mineral content (mean of total samples: nearly 80 %) as well as a high content of quartz as component category ($\bar{x}$=47.30 %). The latter, along with the other more frequently occurring components, is highly variable (s=35.18 %). Molluscs attain a mean of 23.11 % (s=16.41 %), miliolid foraminifers 9.39 % (s=14.10 %), corals 7.19 % (s=11.73 %), and compound grains 6.34 % (s=6.07 %). The carbonate content of the mud fraction (41.86 %) is more than double that of the total samples. This is mainly due to distinctly higher calcite and Mg-calcite values, whereas that of aragonite is similar. Calcite reaches the highest mean value of all sedimentary facies (28 % related to carbonate), although aragonite is also relatively abundant (34 % vs. 38 % Mg-calcite).

Strontium values are low ($\bar{x}$=2398 ppm), iron relatively high (936 ppm), and manganese the highest in all sedimentary facies (59.86 ppm).

The grain size is very sand-dominated, with only two samples containing more than 10 % mud. Sorting is between well and poor, with the lowest mean value (1.16 Φ) of all sedimentary facies for the 2nd moment.

8.7 Compound grain facies

This facies is represented by only 2 samples in which compound grains exceed 50 %. Mollusc values are 34.76 % and 27.19 %, corals 5.25 % and 10.08 %. No additional component category exceeds 5 %.

The grain size is distinctly dominated by sand (91.72 %, 96.46 %) and the samples are moderately sorted.

The carbonate content in the total samples is very high (92 % and 94 %) and the aragonite content (relative to carbonate minerals) is the highest (53 %) of all sedimentary facies. In the mud fractions not only is the carbonate content distinctly lower, but especially the aragonite content (49 vs. 30 % related to the total mineral content). Strontium is very abundant (7314 ppm and 7010 ppm), whereas Fe and Mn are least frequent of all sedimentary facies.

8.8 Halimeda facies

This facies is represented by a unique sample (B 51) containing more than 87 % *Halimeda*. Molluscs (7.65 %) are the only other component category present in conspicuous amounts. The relation of sand/gravel to silt/clay is nearly equal, but the amount of gravel (7.33 %) and clay (10.11 %) is remarkably high, resulting in extremely poor sorting and the highest value (3.82 Φ) for the 2nd moment of all samples. The carbonate content is high (94 %),

Coralgal facies (36 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 13	0.14	0.25	0.39	0.78	0.00	17.72	60.64	0.00	0.10	0.29	0.00	9.07	0.00	0.00	0.00	3.84	7.56
A 17	0.11	0.17	0.31	0.59	0.00	38.79	22.34	0.03	0.32	1.09	0.00	34.99	0.00	0.00	0.00	1.85	0.00
A 28	0.18	0.42	2.05	2.65	0.01	52.95	25.02	0.66	0.96	1.40	0.00	16.11	0.00	0.00	0.00	0.25	0.00
B 1	0.56	0.71	13.00	14.27	0.01	4.57	51.35	0.47	0.26	0.48	0.00	25.08	0.00	0.01	0.00	3.10	0.40
B 2	0.95	0.89	5.24	7.08	0.00	23.32	44.65	3.24	1.08	1.18	0.00	12.69	0.00	0.00	0.00	6.80	0.00
B 4	0.33	0.66	11.42	12.41	0.00	4.93	44.10	1.13	0.22	0.30	0.00	32.00	0.21	0.00	0.00	4.51	0.19
B 10	0.09	0.09	8.06	8.24	0.00	53.90	27.58	0.23	0.29	3.51	0.00	1.28	0.00	0.00	0.00	4.44	0.00
B 11	0.13	1.07	7.14	8.34	0.00	18.59	33.14	0.04	2.49	7.71	0.00	28.95	0.00	0.00	0.00	0.75	0.00
B 12	0.62	1.18	5.94	7.74	0.00	20.95	34.99	0.37	3.42	4.14	0.00	22.50	0.02	0.00	0.00	5.87	0.00
B 19	0.22	0.11	2.19	2.52	0.00	4.31	69.65	0.08	0.74	2.64	0.00	2.82	0.00	0.00	0.00	6.47	0.77
B 25	0.09	0.29	0.81	1.19	0.00	27.00	62.14	0.76	0.05	0.29	0.00	3.32	0.00	0.00	0.00	5.08	0.18
B 26	0.06	1.41	0.00	1.47	0.00	21.89	31.41	0.00	1.69	1.01	0.00	24.48	0.00	0.00	0.00	17.57	0.48
B 28	0.97	0.29	10.44	11.70	0.00	1.95	56.30	0.00	0.30	0.23	0.00	0.35	0.00	0.01	0.13	28.31	0.71
B 31	0.85	0.98	1.62	3.45	0.01	37.72	34.76	1.16	3.68	3.39	0.01	12.76	0.07	0.00	0.00	3.00	0.00
B 49	0.44	0.27	4.36	5.07	0.00	11.16	51.41	0.04	0.22	1.16	0.00	1.98	0.00	0.00	0.49	28.02	0.45
B 56	0.15	0.48	0.74	1.37	0.00	4.85	63.70	0.56	0.03	0.70	0.00	21.35	0.00	0.00	0.00	7.35	0.00
B 57	0.34	0.09	1.09	1.52	0.00	0.82	70.20	0.00	0.05	0.11	0.00	14.31	0.00	0.00	0.03	11.97	0.99
B 59	0.18	0.12	0.42	0.72	0.00	19.67	52.92	0.63	0.18	1.81	0.00	20.13	0.02	0.00	0.00	3.92	0.00
B 60	0.27	0.06	0.74	1.07	0.00	2.16	62.59	1.13	0.22	0.03	0.00	30.57	0.00	0.00	0.00	2.22	0.00
B 61	0.07	0.03	1.56	1.66	0.01	9.09	70.03	0.94	0.04	0.55	0.00	10.88	0.00	0.00	0.00	6.52	0.29
B 67	0.61	0.52	0.15	1.28	0.00	32.82	56.23	0.56	0.84	1.78	0.00	0.22	0.38	0.00	0.00	5.85	0.05
B 68	0.36	0.71	0.80	1.87	0.00	41.60	51.85	0.22	0.45	0.28	0.00	3.12	0.00	0.00	0.00	0.53	0.07
B 73	0.03	1.96	4.08	6.07	0.00	47.82	20.66	0.10	1.50	6.97	0.00	15.42	1.03	0.00	0.00	0.44	0.00
B 74	0.04	2.97	0.02	3.03	0.00	19.62	60.97	0.00	0.28	0.64	0.00	7.82	0.00	0.00	0.00	3.01	4.61
C 1	0.48	1.27	14.86	16.61	0.00	24.04	52.56	0.22	0.60	0.93	0.00	0.00	0.00	0.00	0.00	5.01	0.00
C 5	1.04	0.62	2.26	3.92	0.00	9.99	44.85	0.42	0.12	4.88	0.00	0.15	0.00	0.00	0.00	31.51	4.15
C 8	1.59	3.44	2.27	7.30	0.03	23.29	46.48	0.23	1.43	2.59	0.00	7.98	0.00	0.00	0.00	10.25	0.42
C 10	0.13	0.89	0.39	1.41	0.00	11.16	57.29	0.06	0.02	0.04	0.00	0.00	0.00	0.00	0.00	29.88	0.15
C 15	0.11	9.83	0.11	10.05	0.00	6.75	48.27	0.06	0.46	0.35	0.00	13.66	0.00	7.01	0.00	13.37	0.01
C 17	0.20	1.60	0.51	2.31	0.00	4.15	74.27	0.07	0.03	0.08	0.00	0.00	0.00	0.03	0.00	18.01	1.04
C 18	0.07	0.31	0.06	0.44	0.00	21.19	66.83	0.00	0.01	0.08	0.00	0.06	0.00	0.00	0.00	11.38	0.00
C 27	0.41	0.09	2.89	3.39	0.00	34.36	35.24	0.20	0.11	2.73	0.00	19.04	0.00	0.00	0.00	4.93	0.01
C 28	0.00	0.12	2.40	2.52	0.00	56.16	24.73	0.02	1.17	5.02	0.00	8.06	0.00	0.00	0.00	2.31	0.00
D 2	0.84	5.37	0.78	6.99	0.00	23.45	29.27	0.16	1.42	0.78	0.00	27.87	0.00	0.29	0.00	8.32	1.11
D 3	0.53	1.19	1.82	3.54	0.07	15.63	46.84	2.84	0.95	1.34	0.00	26.39	0.07	0.00	0.00	2.21	0.12
D 7	0.37	0.97	1.03	2.37	0.00	18.10	63.32	1.58	0.51	0.10	0.00	12.78	0.00	0.00	0.00	1.13	0.12
m	0.40	1.22	3.52	5.16	0.00	20.89	48.62	0.51	0.91	1.70	0.00	12.75	0.05	0.20	0.02	8.43	0.46
s	0.37	1.78	4.33	4.78	0.01	15.78	15.22	0.74	1.30	1.93	0.00	10.95	0.18	1.15	0.08	8.59	1.00
min.	0.00	0.03	0.00	0.44	0.00	0.82	20.66	0.00	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.25	0.00
max.	1.59	9.33	15.15	19.66	0.07	56.16	74.27	3.24	6.50	7.71	0.01	34.99	1.03	7.01	0.49	31.51	4.61

Mud facies (29 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 18	9.06	3.93	25.40	38.39	0.00	0.51	43.13	0.30	4.32	1.33	0.00	0.00	0.00	0.00	0.00	10.63	1.38
A 22	0.64	19.31	2.58	22.53	0.00	0.30	64.31	0.19	5.65	1.82	0.00	0.26	0.00	0.00	0.00	5.00	0.12
A 29	0.17	0.13	1.23	1.53	0.01	16.34	59.37	8.69	2.36	1.67	0.00	8.68	0.00	0.00	0.00	1.15	0.00
B 7	0.98	1.30	7.84	10.12	0.02	15.82	52.60	0.36	2.10	8.03	0.00	9.12	0.16	0.00	0.00	1.66	0.00
B 9	4.59	2.53	4.01	11.13	0.02	2.16	48.40	0.13	5.05	1.78	0.00	3.98	2.14	0.00	0.00	24.30	0.91
B 13	0.14	0.20	5.38	5.72	0.05	27.04	47.35	0.27	1.94	2.58	0.00	12.71	0.00	0.00	0.02	2.31	0.02
B 14	6.48	7.07	9.06	22.61	0.07	0.07	51.14	0.00	3.54	6.93	0.00	0.00	0.00	0.00	4.72	10.83	0.07
B 16	0.40	2.06	2.40	4.86	0.00	0.68	86.97	0.04	1.66	2.60	0.00	0.18	0.00	0.00	0.04	2.95	0.00
B 21	3.46	3.97	16.35	23.78	0.00	7.36	23.20	0.42	2.04	5.50	0.00	0.00	0.00	0.00	0.74	4.29	32.67
B 22	2.31	3.99	8.01	14.31	0.00	2.91	74.58	0.13	2.44	3.20	0.00	0.00	0.00	0.28	0.09	1.04	1.01
B 23	0.04	0.50	2.96	3.50	0.01	23.62	51.32	0.36	1.29	5.95	0.00	11.70	0.03	0.00	0.00	2.27	0.04
B 24	0.99	1.69	4.00	6.68	0.08	11.55	47.74	0.38	2.35	2.64	0.00	23.44	0.40	0.00	0.00	4.70	0.04
B 30	1.46	2.15	5.02	8.63	0.33	31.03	34.86	2.64	2.34	2.85	0.00	16.06	0.14	0.00	0.29	0.82	0.00
B 32	5.56	1.35	10.61	17.52	0.00	5.94	52.62	0.40	1.59	2.38	0.00	0.00	0.36	0.00	0.03	17.74	1.43
B 43	4.51	7.75	10.86	23.12	0.00	0.00	56.50	0.00	3.47	9.31	0.00	0.00	0.00	0.00	0.74	6.87	0.00
B 44	0.92	1.41	3.92	6.25	0.00	0.24	82.01	0.00	2.25	7.01	0.00	0.00	0.00	0.00	0.00	2.25	0.00
B 45	0.28	0.11	0.84	1.23	0.01	10.71	53.83	0.86	1.14	2.30	0.00	29.58	0.00	0.00	0.00	0.34	0.00
B 46	0.63	1.15	6.00	7.78	0.00	0.00	82.23	0.00	1.42	4.50	0.00	0.00	0.00	0.00	0.00	4.03	0.03
B 52	0.97	0.98	24.92	26.87	0.01	26.46	34.50	0.56	0.82	1.34	0.00	1.92	0.02	0.00	0.00	7.50	0.00
B 53	1.86	1.94	26.88	30.68	0.00	0.13	55.87	0.00	1.96	5.80	0.00	0.00	0.27	0.00	0.00	5.30	0.00
B 58	1.51	3.62	24.75	29.88	0.00	0.00	62.06	0.00	2.16	3.73	0.00	0.00	0.00	0.00	0.00	2.02	0.15
B 70	7.02	8.80	14.17	29.99	0.00	0.00	47.25	0.00	6.33	8.28	0.00	0.00	0.00	0.00	0.00	8.15	0.00
C 3	3.26	3.96	7.28	14.50	0.00	0.00	58.10	0.20	2.82	1.02	0.00	0.00	13.25	0.22	0.00	9.91	0.00
C 7	1.39	20.45	1.74	23.58	0.25	3.38	47.64	1.89	5.11	0.65	0.00	0.00	0.10	0.94	0.00	15.68	0.79
C 14	1.01	1.05	6.59	8.65	0.04	14.92	34.58	0.53	1.54	1.26	0.00	30.70	1.19	0.00	0.00	7.62	0.00
D 5	0.47	1.15	2.96	4.58	0.00	4.66	66.81	0.40	2.61	5.06	0.00	10.79	0.00	0.00	0.00	4.90	0.20
D 6	1.94	2.14	8.06	12.14	0.00	0.00	61.33	0.00	5.71	11.84	0.00	0.71	0.00	0.00	0.00	8.16	0.10
D 8	0.51	0.79	2.18	3.48	0.03	14.28	55.86	1.80	1.54	4.84	0.00	16.08	0.25	0.00	0.00	1.67	0.18
D 9	1.25	2.10	7.62	10.97	0.06	0.81	68.06	0.13	2.63	5.42	0.00	5.45	0.00	0.00	0.00	6.46	0.00
m	2.20	3.71	8.75	14.66	0.03	7.62	55.32	0.71	2.76	4.19	0.00	6.25	0.63	0.05	0.23	6.23	1.35
s	2.31	4.90	7.63	10.15	0.07	9.47	14.50	1.63	1.48	2.78	0.00	9.04	2.42	0.18	0.87	5.45	5.93
min.	0.04	0.11	0.84	1.23	0.00	0.00	23.20	0.00	0.82	0.65	0.00	0.00	0.00	0.00	0.00	0.34	0.00
max.	9.06	20.45	26.88	38.39	0.33	31.03	86.97	8.69	6.33	11.84	0.00	30.70	13.25	0.94	4.72	24.30	32.67

Tab. 18. Frequency of components (%) of samples and some statistical parameters related to sedimentary facies.

Molluscan facies (24 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 8	0.36	9.03	1.40	10.79	0.00	6.01	61.52	0.13	1.15	0.45	0.00	2.32	0.00	0.00	0.00	17.16	0.45
A 12	1.12	3.39	15.15	19.66	0.00	3.14	62.40	0.01	6.50	0.73	0.00	0.03	0.04	0.00	0.00	7.32	0.19
A 16	0.20	0.06	0.52	0.78	0.00	13.46	58.33	0.02	0.34	0.25	0.00	0.56	0.00	0.00	0.00	6.32	19.94
A 21	2.61	7.94	1.53	12.08	0.00	5.00	64.81	0.02	2.40	1.76	0.00	0.12	0.00	0.00	0.00	7.30	6.50
A 20	0.87	0.52	15.34	16.73	0.00	14.65	62.40	0.00	3.45	0.03	0.00	0.60	0.00	0.00	0.00	0.55	1.58
A 24	0.40	1.13	18.02	19.55	0.00	6.30	65.27	0.00	5.92	0.57	0.00	0.91	0.00	0.00	0.00	0.84	0.63
A 26	0.18	0.15	14.25	14.58	0.00	2.19	74.47	0.00	3.16	1.86	0.00	0.00	0.11	0.00	0.00	3.39	0.25
A 27	2.65	1.28	7.81	11.74	0.00	0.17	49.27	0.20	2.26	1.31	0.00	0.00	0.00	0.00	0.00	2.91	32.14
B 3	1.59	1.71	17.55	20.85	0.00	1.42	67.28	0.03	0.93	1.59	0.00	0.00	0.00	0.00	0.00	7.83	0.07
B 6	7.95	1.92	26.75	36.62	0.00	0.62	49.68	0.05	2.23	1.80	0.00	0.00	0.00	0.00	0.00	5.70	3.29
B 8	7.82	0.94	5.76	14.52	0.00	10.04	44.99	0.01	2.98	1.36	0.00	14.71	0.00	0.00	0.00	8.43	2.95
B 15	0.43	0.36	3.55	4.34	0.00	17.08	64.53	0.06	1.84	4.40	0.00	5.05	0.00	0.00	0.00	2.70	0.00
B 18	5.49	1.78	2.36	9.63	0.00	11.83	62.35	0.05	3.63	1.42	0.00	0.68	0.01	0.11	0.00	8.21	2.08
B 20	1.00	0.52	18.19	19.71	0.00	1.61	69.74	0.02	2.90	3.21	0.00	0.00	0.22	0.00	0.00	2.19	0.42
B 35	0.95	1.49	16.81	19.25	0.00	0.26	62.35	0.03	6.13	3.20	0.00	0.63	0.24	0.02	0.09	7.34	0.45
B 36	1.40	0.67	27.73	29.80	0.02	0.47	60.32	0.09	1.60	1.84	0.00	0.07	0.00	0.16	0.00	5.75	0.07
B 41	3.37	1.87	8.17	13.41	0.00	0.48	64.80	0.03	3.27	2.33	0.00	1.29	0.00	0.00	0.38	11.07	2.89
B 42	2.37	0.47	5.09	7.93	0.00	1.02	66.25	0.02	5.58	3.23	0.00	2.58	0.00	0.00	0.06	10.57	2.76
B 48	3.06	0.46	1.71	5.23	0.00	6.70	65.95	0.09	3.04	2.78	0.00	0.32	1.11	0.00	0.26	13.08	1.45
B 54	3.30	1.01	10.72	15.03	0.00	0.73	63.92	0.26	3.49	2.37	0.00	0.94	0.63	0.00	0.64	10.39	1.60
B 69	1.83	0.72	3.51	6.06	0.00	0.41	84.93	0.18	3.41	1.97	0.00	0.00	0.00	0.00	0.00	2.56	0.46
C 4	9.30	2.74	3.12	15.16	0.00	2.91	69.40	0.90	3.83	0.76	0.00	0.00	0.00	0.00	0.00	6.19	0.86
C 23	0.69	5.58	0.44	6.71	0.00	0.20	63.65	0.07	3.58	9.31	0.00	0.00	0.00	2.17	0.00	14.13	0.18
C 26	8.44	4.37	3.43	16.24	0.00	1.98	54.16	0.21	1.93	1.36	0.00	0.00	0.00	0.00	0.00	19.34	4.77
m	2.81	2.09	9.54	14.43	0.00	4.53	63.03	0.10	3.15	2.08	0.00	1.28	0.10	0.10	0.06	7.55	3.58
s	2.79	2.34	8.11	7.85	0.01	5.07	8.04	0.18	1.58	1.83	0.00	3.02	0.25	0.43	0.15	4.81	7.18
min.	0.18	0.06	0.44	0.78	0.00	0.17	44.99	0.00	0.34	0.03	0.00	0.00	0.00	0.00	0.00	0.55	0.00
max.	9.30	9.03	27.73	36.62	0.02	17.08	84.93	0.90	6.50	9.31	0.00	14.71	1.11	2.17	0.64	19.34	32.14

Operculina facies (7 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 4	1.04	12.94	31.55	45.53	0.00	0.09	38.56	0.12	4.80	0.41	0.00	0.00	0.00	0.00	0.00	9.21	1.37
A 14	1.80	3.72	35.35	40.87	0.00	0.18	50.50	0.01	5.33	0.44	0.00	0.00	0.07	0.00	0.00	2.45	0.15
B 33	3.57	5.74	45.32	54.81	0.00	0.67	9.32	1.20	1.59	2.90	0.00	2.03	0.26	0.00	0.23	27.17	0.00
B 34	2.20	1.02	59.95	63.17	0.00	1.74	22.17	0.10	1.23	1.35	0.00	0.03	0.03	0.01	0.00	10.09	0.07
B 37	4.85	1.20	58.72	64.77	0.00	2.35	16.22	0.03	1.23	0.51	0.00	0.00	0.02	0.00	0.00	6.62	8.25
B 38	0.82	0.30	39.96	41.08	0.00	9.82	42.93	0.00	3.46	1.20	0.00	0.00	0.00	0.00	0.00	1.25	0.28
C 2	3.98	19.89	31.22	55.09	0.00	0.00	26.79	0.22	1.14	1.47	0.00	0.00	1.81	0.00	0.00	13.48	0.00
m	2.61	6.40	43.15	52.19	0.00	2.12	29.50	0.24	2.68	1.18	0.00	0.29	0.31	0.0	0.03	10.04	1.45
s	1.43	6.82	11.54	9.18	0.00	3.25	13.88	0.40	1.69	0.82	0.00	0.71	0.62	0.00	0.08	8.04	2.81
min.	0.82	0.30	31.55	40.87	0.00	0.00	9.32	0.00	1.14	0.41	0.00	0.00	0.00	0.00	0.00	1.25	0.00
max.	4.85	19.89	59.95	64.77	0.00	9.82	50.50	1.20	5.33	2.90	0.00	2.03	1.81	0.01	0.23	27.17	8.25

Soritid facies (12 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 2	0.69	14.71	1.45	16.85	0.02	6.19	52.36	0.08	3.75	2.74	0.00	6.29	0.09	0.00	0.00	7.97	3.66
A 3	1.33	19.82	9.54	30.69	0.00	0.26	44.16	0.34	5.82	0.09	0.00	0.00	0.00	0.00	0.00	18.12	0.51
A 5	0.38	23.69	3.78	27.85	0.00	0.16	51.42	0.27	4.76	0.09	0.00	0.00	0.06	0.02	0.00	13.75	1.63
A 11	0.86	21.00	1.40	23.26	0.00	3.83	34.67	0.87	3.93	1.03	0.00	0.23	0.07	0.50	0.00	15.90	15.68
A 25	1.85	35.22	2.27	39.34	0.00	0.21	43.74	0.19	6.08	0.62	0.00	0.00	0.00	0.00	0.00	8.64	1.18
A 30	0.56	43.03	1.50	45.18	0.00	0.21	40.79	0.49	4.19	0.12	0.00	0.00	0.00	0.00	0.00	6.89	2.23
B 17	0.58	31.86	5.59	38.03	0.00	1.57	44.84	0.84	3.59	1.06	0.18	0.13	1.41	1.75	0.00	5.63	0.99
C 6	0.74	21.90	1.24	23.88	0.00	16.63	29.14	1.24	4.10	0.16	0.00	0.77	0.00	8.09	0.00	12.52	3.46
C 12	0.25	23.30	1.52	25.07	0.00	3.92	53.27	0.22	1.65	1.45	0.00	6.43	0.00	0.00	0.00	7.99	0.00
C 16	0.54	33.92	0.77	35.22	0.00	7.06	35.93	0.97	6.95	0.84	0.00	2.12	0.03	0.77	0.00	8.04	2.06
C 19	0.43	41.55	0.77	42.75	0.00	5.83	35.14	1.25	3.02	0.27	0.00	0.00	0.00	0.00	0.00	11.23	0.51
C 20	0.73	28.07	2.41	31.21	0.00	0.07	32.62	0.73	14.38	0.98	0.00	0.00	0.00	2.01	0.00	17.83	0.17
m	0.75	28.17	2.69	31.61	0.00	3.83	41.51	0.62	5.19	0.79	0.02	1.33	0.14	1.10	0.00	11.21	2.67
s	0.42	8.57	2.45	8.30	0.00	4.61	7.79	0.40	3.09	0.74	0.05	2.32	0.38	2.22	0.00	4.17	4.09
min.	0.25	14.71	0.77	16.85	0.00	0.07	29.14	0.08	1.65	0.09	0.00	0.00	0.00	0.00	0.00	5.63	0.00
max.	1.85	43.03	9.54	45.18	0.02	16.63	53.27	1.25	14.38	2.74	0.18	6.43	1.41	8.09	0.00	18.12	15.68

Tab. 18. continued

and in the total sample, aragonite dominates relative to carbonate minerals (43 %) and to total mineral content (40 %). The mean value of strontium (6324 ppm) is relatively high.

8.9 Distribution of sedimentary facies

Fig. 53 is a composite distributional map, based on the analysed samples and the coordination of these data to field observations. The **Coralgal facies** covers a very wide area of the bay framing the 'East area' and the 'West area' basins. It prevails in

Terrigenous facies (12 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
A 6	0.36	13.02	1.73	15.11	0.00	0.92	42.24	0.17	1.96	0.50	0.00	0.96	0.00	0.10	0.00	3.44	34.60
A 7	0.06	0.76	0.04	0.86	0.00	0.74	8.52	0.00	0.18	0.61	0.00	0.24	0.00	0.00	0.00	1.20	87.65
A 9	0.10	0.05	2.38	2.53	0.00	0.28	4.62	0.13	0.35	0.00	0.00	0.00	0.00	0.13	0.00	8.72	83.25
A 10	0.09	1.74	0.15	1.98	0.00	4.65	2.34	0.02	0.11	0.22	0.00	0.00	0.00	0.00	0.00	3.72	86.96
A 15	3.16	37.35	11.51	52.02	0.00	3.16	26.89	0.34	7.47	3.76	0.03	0.50	0.15	0.08	0.00	4.27	1.33
A 19	1.51	42.11	2.95	46.57	0.00	0.91	29.65	1.18	3.61	1.17	0.00	0.00	0.00	1.85	0.00	5.21	9.84
A 32	1.03	5.08	1.41	7.52	0.00	31.03	40.13	0.40	1.96	2.08	0.00	3.45	0.00	0.00	0.00	4.75	8.67
A 33	0.00	0.00	0.24	0.24	0.00	0.08	9.80	0.00	0.31	0.00	0.00	0.00	0.00	0.24	0.00	4.67	84.66
C 9	0.13	0.60	0.22	0.95	0.00	1.31	1.43	0.00	0.06	0.32	0.00	0.85	0.00	0.00	0.00	0.57	94.52
C 13	0.00	1.69	0.03	1.72	0.00	0.14	41.26	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.11	21.87	33.95
C 21	0.07	2.02	0.06	2.15	0.01	34.68	23.70	0.02	0.34	0.00	0.00	0.00	0.00	0.00	0.08	15.81	23.20
D 1	0.84	8.27	0.84	9.95	0.00	8.35	46.69	0.17	3.50	0.00	0.00	9.54	0.34	0.00	0.59	1.86	19.00
m	0.61	9.39	1.80	11.80	0.00	7.19	23.11	0.20	1.73	0.72	0.00	1.30	0.04	0.20	0.07	6.34	47.30
s	0.90	14.10	3.08	17.34	0.00	11.73	16.41	0.32	2.12	1.09	0.01	2.66	0.10	0.50	0.04	6.07	35.18
min.	0.00	0.00	0.03	0.24	0.00	0.08	1.43	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.57	1.33
max.	3.16	42.11	11.51	52.02	0.01	34.68	46.69	1.18	7.47	3.76	0.03	9.54	0.34	1.85	0.59	21.87	94.52

Compound grains facies (2 samples)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
C 11	0.01	0.65	0.04	0.70	0.00	5.25	34.76	0.00	0.13	0.02	0.00	0.00	0.00	0.00	0.00	59.15	0.00
C 24	0.10	0.76	0.51	1.37	0.00	10.08	27.19	0.03	0.43	2.65	0.00	2.69	0.00	0.00	0.00	55.56	0.00
m	0.06	0.71	0.28	1.04	0.00	7.67	30.98	0.02	0.28	1.34	0.00	1.35	0.00	0.00	0.00	57.36	0.00
s	0.05	0.05	0.23	0.33	0.00	2.42	3.78	0.02	0.15	1.32	0.00	1.35	0.00	0.00	0.00	1.79	0.00

Halimeda facies (1 sample)

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	gre	plan	pel	comp	qua
B 51	1.57	0.80	0.25	2.62	0.00	0.00	7.65	0.14	1.26	0.36	0.00	0.00	87.31	0.00	0.03	0.19	0.42

Tab. 18. continued

the shallow water north of Gazirat Safaga, reaching northward not only along the eastern margin of the bay to Ras Abu Soma, including the relatively shallow water platform with Gamul al-Kabir, Gamul al-Saghira, Tubya al-Saghira, and Tubya al-Kabir, and the submarine ridge in their north, but also along the submarine ridge extending to the Tubya islands. The Tubya islands are surrounded by Coralgal facies, which is connected by a wide strip with Ras Abu Soma in the northeast; the whole area between the Tubya islands and the 'West area' basin is covered by this facies, extending to the northwest and including a large area of the west part of the 'North area' West of the 'West area' basin a narrow strip of Coralgal facies is developed; only isolated occurrences are found in the 'Southwest channel'

The **Mud facies** covers nearly the entire 'West area' basin, with a slight extension into the 'Southwest channel' This large continuous area is supplemented by isolated patches, represented mainly by single samples: one larger occurrence is near the eastern margin of the southern basin of the 'East area', one sample is located in the northern basin of the 'East area', and one lies in the connection of these two basins east of Tubya al-Bayda. Three additional isolated samples, embedded into Coralgal facies, occur in the 'East area' In the 'North area' only a single shallow water sample west of Ras Abu Soma and one sample in the center of the northern part of the 'Southwest channel' are classified as mud facies.

The **Molluscan facies** covers two larger areas. One is in the 'East area' including the main part of the northern basin and the two connecting strips to the southern basin as well as a small part of the southern basin. The second is located in the 'Southwest channel' along the channel axis. A narrow strip is developed also along the western margin of the basin of the 'West area', one sample is located at the eastern margin of the shallow water area at the western coast of the 'West area', another in the 'North area' north of Tubya al-Hamra.

The **Operculina facies** exhibits a relatively dispersed distribution. A more continuous area is located in the southern basin of the 'East area', only one sample in its northern basin. A small area occurs in the southern part of the western margin of the 'West area' basin, a larger one in the central part of the southern 'Southwest channel'

The **Soritid facies** covers a large, continuous area in the 'North area' and 'West area' parallel to the coast, covering the shallow waters west of the 'West area' basin, the strip between the intertidal area north of Al-Dahira and the tidal flat along the coast, and a large area in the center of the 'North area' running eastward to Ras Abu Soma. Additionally, three separated areas are developed as small strips paralleling the coasts in the 'Southwest channel': two along the west coast, one of them in the north near the

Coralgal facies (36 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 13	41.00	39.00	11.00	91.00	9.00	0.00	0.00	5784	565	98.96
	22.00	39.00	18.00	79.00	16.00	3.00	2.00			
A 17	44.00	34.00	17.00	95.00	4.00	1.00	0.00	6192	330	0.66
	18.00	24.00	22.00	64.00	26.00	7.00	3.00			
A 28	47.00	32.00	17.00	96.00	4.00	0.00	0.00	6865	264	0.33
	34.00	34.00	18.00	86.00	10.00	3.00	1.00			
B 1	23.00	52.00	23.00	98.00	2.00	0.00	0.00	4134	543	1.56
	21.00	42.00	19.00	82.00	18.00	0.00	0.00			
B 2	26.00	49.00	13.00	88.00	12.00	0.00	0.00	4402	385	0.66
	24.00	45.00	18.00	87.00	13.00	0.00	0.00			
B 4	22.00	53.00	18.00	93.00	7.00	0.00	0.00	3848	530	0.81
	22.00	44.00	18.00	84.00	16.00	0.00	0.00			
B 10	39.00	41.00	16.00	97.00	3.00	0.00	0.00	5322	0	0.20
B 11	27.00	48.00	15.00	90.00	4.00	3.00	3.00	4706	1	0.53
	24.00	47.00	18.00	89.00	11.00	0.00	0.00			
B 12	27.00	50.00	14.00	91.00	9.00	0.00	0.00	4631	88	0.59
	23.00	50.00	19.00	92.00	5.00	2.00	1.00			
B 19	32.00	39.00	21.00	92.00	8.00	0.00	0.00	3778	449	1.54
	21.00	43.00	20.00	84.00	16.00	0.00	0.00			
B 25	51.00	25.00	15.00	91.00	9.00	0.00	0.00	6659	0	0.44
	33.00	42.00	14.00	89.00	11.00	0.00	0.00			
B 26	53.00	29.00	9.00	91.00	9.00	0.00	0.00	7886	68	0.06
B 28	32.00	43.00	16.00	91.00	8.00	1.00	0.00	4820	979	23.09
	19.00	45.00	21.00	85.00	11.00	3.00	1.00			
B 31	36.00	48.00	13.00	97.00	3.00	0.00	0.00	5436	145	0.48
	37.00	43.00	15.00	95.00	5.00	0.00	0.00			
B 49	36.00	40.00	17.00	93.00	4.00	2.00	1.00	4974	1231	1.54
	20.00	46.00	20.00	86.00	14.00	0.00	0.00			
B 56	33.00	46.00	18.00	97.00	1.00	1.00	1.00	3848	539	0.66
	18.00	45.00	19.00	82.00	18.00	0.00	0.00			
B 57	28.00	42.00	20.00	90.00	10.00	0.00	0.00	4222	959	1.65
	21.00	38.00	21.00	80.00	13.00	4.00	3.00			
B 59	33.00	45.00	19.00	96.00	4.00	0.00	0.00	4565	752	0.44
	18.00	37.00	20.00	75.00	25.00	0.00	0.00			
B 60	33.00	43.00	21.00	97.00	3.00	0.00	0.00	4051	781	0.20
	19.00	44.00	17.00	80.00	12.00	5.00	3.00			
B 61	34.00	43.00	20.00	97.00	1.00	1.00	1.00	3598	783	32.99
	20.00	40.00	22.00	82.00	18.00	0.00	0.00			
B 67	35.00	43.00	15.00	93.00	7.00	0.00	0.00	4789	341	0.22
	18.00	44.00	25.00	87.00	10.00	2.00	1.00			
B 68	37.00	44.00	13.00	95.00	5.00	0.00	0.00	4561	297	0.22
	22.00	40.00	19.00	81.00	11.00	5.00	3.00			
B 73	29.00	49.00	13.00	91.00	3.00	3.00	3.00	4833	0	0.08
	27.00	47.00	16.00	90.00	10.00	0.00	0.00			
B 74	48.00	30.00	10.00	88.00	12.00	0.00	0.00	6817	88	0.22
	25.00	49.00	14.00	87.00	13.00	0.00	0.00			
C 1	16.00	51.00	26.00	93.00	7.00	0.00	0.00	3391	462	0.77
	19.00	43.00	18.00	80.00	20.00	0.00	0.00			
C 5	34.00	34.00	16.00	84.00	8.00	5.00	3.00	4789	145	0.55
	35.00	41.00	14.00	90.00	8.00	2.00	1.00			
C 8	36.00	44.00	12.00	92.00	8.00	0.00	0.00	4596	198	0.18
	35.00	38.00	14.00	87.00	10.00	2.00	1.00			
C 10	44.00	40.00	10.00	94.00	6.00	0.00	0.00	6395	147	0.44
	27.00	42.00	18.00	87.00	9.00	2.00	2.00			
C 15	34.00	43.00	11.00	88.00	6.00	3.00	3.00	5678	141	1.06
	23.00	37.00	12.00	72.00	24.00	3.00	1.00			
C 17	38.00	46.00	7.00	91.00	9.00	0.00	0.00	5106	205	0.04
	25.00	44.00	17.00	85.00	15.00	0.00	0.00			
C 18	51.00	34.00	10.00	94.00	6.00	0.00	0.00	6360	66	0.02
	26.00	42.00	15.00	83.00	9.00	4.00	4.00			
C 27	30.00	47.00	18.00	96.00	4.00	0.00	0.00	4816	33	1.32
	28.00	47.00	19.00	94.00	6.00	0.00	0.00			
C 28	33.00	46.00	18.00	97.00	3.00	0.00	0.00	5036	22	1.14
	41.00	44.00	12.00	97.00	3.00	0.00	0.00			
D 2	46.00	36.00	12.00	94.00	6.00	0.00	0.00	6417	506	0.05
	23.00	39.00	17.00	79.00	17.00	3.00	1.00			
D 3	34.00	39.00	21.00	94.00	6.00	0.00	0.00	4592	286	0.77
	31.00	41.00	18.00	90.00	10.00	0.00	0.00			
D 7	33.00	39.00	25.00	97.00	3.00	0.00	0.00	4517	198	0.07
	28.00	44.00	17.00	89.00	11.00	0.00	0.00			
m	35.42	41.83	15.83	93.11	5.92	0.56	0.42	5067	348	4.85
	24.91	42.06	17.76	84.68	13.06	1.47	0.82			
s	8.38	6.68	4.49	3.25	2.87	1.17	0.95	1040	313	17.15
	6.07	4.72	2.85	6.47	5.44	1.90	1.15			
min.	16.00	25.00	7.00	84.00	1.00	0.00	0.00	3391	0	0.02
	18.00	24.00	12.00	64.00	3.00	0.00	0.00			
max.	53.00	53.00	26.00	98.00	12.00	5.00	3.00	7886	1231	98.96
	41.00	50.00	25.00	97.00	26.00	7.00	4.00			

Tab. 19. Frequency of minerals (%) and trace elements (ppm) related to sedimentary facies.

Mud facies (29 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 18	18.00	37.00	19.00	74.00	16.00	5.00	5.00	3782	1429	43.98
	17.00	35.00	25.00	78.00	16.00	4.00	2.00			
A 22	14.00	28.00	20.00	62.00	25.00	10.00	3.00	2947	1198	48.38
	14.00	31.00	20.00	65.00	26.00	4.00	5.00			
A 29	27.00	40.00	17.00	84.00	12.00	3.00	1.00	4763	1231	26.39
	20.00	37.00	20.00	77.00	21.00	1.00	1.00			
B 7	31.00	50.00	12.00	93.00	7.00	0.00	0.00	5058	484	1.14
	33.00	47.00	12.00	92.00	8.00	0.00	0.00			
B 9	27.00	44.00	15.00	86.00	14.00	0.00	0.00	4904	563	1.10
	26.00	48.00	16.00	90.00	10.00	0.00	0.00			
B 13	30.00	39.00	17.00	86.00	14.00	0.00	0.00	4970	1121	34.08
	19.00	43.00	22.00	84.00	13.00	3.00	0.00			
B 14	19.00	44.00	20.00	83.00	12.00	4.00	1.00	3606	1352	27.49
	19.00	45.00	20.00	84.00	16.00	0.00	0.00			
B 16	25.00	46.00	15.00	86.00	14.00	0.00	0.00	3452	1045	1.63
	22.00	48.00	18.00	88.00	12.00	0.00	0.00			
B 21	22.00	40.00	19.00	81.00	16.00	2.00	1.00	3857	836	1.65
	23.00	46.00	19.00	88.00	5.00	6.00	1.00			
B 22	20.00	47.00	18.00	85.00	15.00	0.00	0.00	4081	1482	32.99
	21.00	49.00	17.00	87.00	13.00	0.00	0.00			
B 23	16.00	47.00	16.00	79.00	21.00	0.00	0.00			
	21.00	50.00	18.00	89.00	11.00	0.00	0.00			
B 24	30.00	46.00	16.00	92.00	8.00	0.00	0.00	4970	614	1.54
	28.00	46.00	17.00	91.00	9.00	0.00	0.00			
B 30	28.00	53.00	14.00	96.00	4.00	0.00	0.00	4565	279	1.14
	29.00	50.00	16.00	95.00	5.00	0.00	0.00			
B 32	18.00	52.00	22.00	92.00	8.00	0.00	0.00	4367	484	0.88
	28.00	45.00	19.00	92.00	8.00	0.00	0.00			
B 43	16.00	45.00	19.00	80.00	14.00	4.00	2.00	3171	1623	65.97
	17.00	44.00	22.00	83.00	11.00	4.00	2.00			
B 44	16.00	44.00	19.00	79.00	21.00	0.00	0.00	3430	1570	39.58
	15.00	48.00	21.00	84.00	7.00	5.00	4.00			
B 45	22.00	44.00	20.00	86.00	14.00	0.00	0.00	4178	1132	1.76
B 46	16.00	43.00	20.00	79.00	15.00	4.00	2.00	3624	1469	37.38
	19.00	44.00	20.00	84.00	11.00	4.00	1.00			
B 52	19.00	51.00	19.00	89.00	11.00	0.00	0.00	3835	704	26.39
	25.00	47.00	20.00	92.00	5.00	1.00	2.00			
B 53	18.00	51.00	19.00	88.00	12.00	0.00	0.00	3479	814	1.63
	20.00	41.00	21.00	82.00	10.00	4.00	4.00			
B 58	20.00	48.00	20.00	88.00	7.00	3.00	2.00	3716	1388	48.38
	20.00	46.00	17.00	83.00	17.00	0.00	0.00			
B 70	18.00	44.00	19.00	81.00	11.00	7.00	1.00	3413	1253	46.18
	19.00	47.00	17.00	83.00	17.00	0.00	0.00			
C 3	20.00	45.00	20.00	85.00	15.00	0.00	0.00	4200	567	0.70
	22.00	47.00	23.00	92.00	8.00	0.00	0.00			
C 7	19.00	31.00	14.00	64.00	22.00	10.00	4.00	3879	785	28.59
	22.00	27.00	21.00	70.00	24.00	3.00	3.00			
C 14	30.00	44.00	16.00	90.00	10.00	0.00	0.00	5278	431	0.84
	30.00	42.00	18.00	90.00	10.00	0.00	0.00			
D 5	27.00	45.00	18.00	90.00	10.00	0.00	0.00	4323	871	2.09
	27.00	45.00	16.00	89.00	11.00	0.00	0.00			
D 6	25.00	45.00	18.00	88.00	10.00	1.00	1.00	4389	858	0.97
	25.00	47.00	17.00	89.00	8.00	1.00	2.00			
D 8	24.00	45.00	18.00	87.00	13.00	0.00	0.00	4556	719	1.10
	30.00	43.00	18.00	91.00	9.00	0.00	0.00			
D 9	24.00	50.00	16.00	90.00	6.00	4.00	0.00	4240	946	0.99
	25.00	48.00	17.00	90.00	10.00	0.00	0.00			
m	22.03	44.41	17.76	81.43	13.00	1.97	0.79	4077	961	18.73
	22.71	44.14	18.82	85.79	11.82	1.43	0.96			
s	4.99	5.54	2.27	7.55	5.30	2.93	1.30	621	399	20.25
	4.77	5.42	2.61	6.70	5.27	1.94	1.45			
min.	14.00	28.00	12.00	62.00	4.00	0.00	0.00	2947	145	0.48
	14.00	27.00	12.00	65.00	5.00	0.00	0.00			
max.	31.00	53.00	22.00	96.00	25.00	10.00	5.00	5278	1623	65.97
	33.00	50.00	25.00	95.00	26.00	6.00	5.00			

Tab. 19. continued

transition to the 'West area' and one in the south, the third along the intertidal flat west of Gazirat Safaga. **Terrigenous facies** is restricted exclusively to coastal areas. This facies frames the bay as narrow strip along the main coast, starting west of Ras Abu Soma and running around to the southern end of the investigated area. Additionally, certain sections of the tidal flat west of Gazirat Safaga also belong to this facies.

The two **Compound grain facies** samples are located in the 'North area', one in the center of the shallow water pan of its western part, one north of Tubya al-Hamra; both adjoin Coralgal facies. The **Halimeda facies** sample is embedded into Coralgal facies near the western margin of the submarine platform west of Gamul al-Saghira.

Molluscan facies (24 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 8	17.00	35.00	23.00	75.00	18.00	3.00	4.00	3369	1078	41.78
	10.00	20.00	18.00	48.00	41.00	6.00	5.00			
A 12	16.00	36.00	16.00	68.00	14.00	16.00	2.00	2542	1100	35.18
	15.00	34.00	18.00	67.00	25.00	6.00	2.00			
A 16	21.00	37.00	21.00	79.00	16.00	2.00	3.00	3831	871	26.39
	13.00	35.00	19.00	67.00	23.00	6.00	4.00			
A 20	17.00	38.00	17.00	72.00	17.00	7.00	4.00	2436	1143	43.98
	15.00	32.00	20.00	67.00	24.00	5.00	4.00			
A 21	20.00	40.00	18.00	78.00	14.00	6.00	2.00	3325	941	41.78
	17.00	36.00	18.00	71.00	23.00	4.00	2.00			
A 24	15.00	36.00	16.00	67.00	21.00	11.00	1.00	2027	1341	63.77
	14.00	30.00	19.00	63.00	28.00	6.00	3.00			
A 26	15.00	35.00	17.00	67.00	25.00	6.00	2.00	2604	1465	39.58
	15.00	35.00	19.00	69.00	21.00	5.00	5.00			
A 27	18.00	29.00	18.00	65.00	20.00	11.00	4.00	4178	880	24.19
	19.00	32.00	18.00	69.00	22.00	6.00	3.00			
B 3	20.00	48.00	24.00	92.00	8.00	0.00	0.00	3963	904	1.61
	22.00	40.00	26.00	88.00	12.00	0.00	0.00			
B 6	25.00	44.00	20.00	89.00	11.00	0.00	0.00	4130	721	21.99
	22.00	45.00	20.00	87.00	13.00	0.00	0.00			
B 8	26.00	38.00	20.00	84.00	9.00	0.00	7.00	4235	506	0.88
	25.00	44.00	24.00	93.00	7.00	0.00	0.00			
B 15	28.00	46.00	20.00	94.00	6.00	0.00	0.00	3963	690	1.01
	25.00	44.00	18.00	87.00	10.00	1.00	2.00			
B 18	33.00	42.00	17.00	92.00	8.00	0.00	0.00	4745	352	0.64
	23.00	45.00	18.00	86.00	14.00	0.00	0.00			
B 20	22.00	47.00	15.00	84.00	15.00	1.00	0.00	3831	693	26.39
	23.00	49.00	16.00	88.00	12.00	0.00	0.00			
B 35	20.00	49.00	21.00	90.00	10.00	0.00	0.00	3848	873	24.19
	23.00	42.00	23.00	88.00	10.00	1.00	1.00			
B 36	19.00	44.00	22.00	85.00	15.00	0.00	0.00	3646	783	1.61
	23.00	45.00	21.00	89.00	11.00	0.00	0.00			
B 41	34.00	38.00	24.00	96.00	4.00	0.00	0.00	4328	275	0.44
	24.00	44.00	20.00	88.00	12.00	0.00	0.00			
B 42	24.00	47.00	20.00	91.00	9.00	0.00	0.00	4288	849	1.10
	21.00	44.00	18.00	83.00	11.00	3.00	3.00			
B 48	28.00	44.00	17.00	89.00	6.00	5.00	0.00	4420	567	1.32
	25.00	45.00	18.00	88.00	12.00	0.00	0.00			
B 54	19.00	41.00	28.00	88.00	12.00	0.00	0.00	4266	785	34.08
	22.00	44.00	22.00	88.00	12.00	0.00	0.00			
B 69	20.00	38.00	18.00	76.00	16.00	6.00	2.00	4781	605	0.18
	20.00	44.00	19.00	83.00	12.00	2.00	3.00			
C 4	23.00	49.00	15.00	87.00	13.00	0.00	0.00	4424	308	0.88
	27.00	45.00	18.00	90.00	10.00	0.00	0.00			
C 23	28.00	42.00	15.00	85.00	15.00	0.00	0.00	5058	618	0.77
	28.00	46.00	16.00	90.00	10.00	0.00	0.00			
C 26	23.00	31.00	15.00	69.00	18.00	7.00	6.00	3857	396	21.99
	29.00	41.00	20.00	90.00	10.00	0.00	0.00			
m	22.13	40.58	19.04	81.75	13.33	3.38	1.88	3837	781	18.99
	20.83	40.04	19.42	80.29	16.04	2.13	1.54			
s	5.16	5.47	3.35	9.54	5.11	4.42	2.40	760	302	18.65
	4.95	6.69	2.33	11.60	7.89	2.52	1.76			
min.	15.00	15.00	15.00	65.00	4.00	0.00	0.00	2027	275	0.18
	10.00	20.00	16.00	48.00	7.00	0.00	0.00			
max.	34.00	49.00	28.00	96.00	25.00	16.00	8.00	5058	1465	63.77
	29.00	49.00	26.00	93.00	41.00	6.00	5.00			

Tab. 19. continued

8.10 Summary of results

In comparison of the distributional maps of bottom facies (enclosure 1 in PILLER & PERVESLER, 1989; Fig. 54) with those of sedimentary facies (Fig. 53) reveals both a general coincidence as well as obvious differences (for sediment composition see Fig. 55).

The **Coralgal facies** distribution is nearly congruent with the areas covered by coral reefs, 'Coral carpet', 'Rock bottom', 'Sand with coral patches', and Sand with macroids; this explains the large area occupied by this facies. Discussing the reason for this fusion, coral reefs must be excluded, because, except for one sample (C 28), they were not investigated. Basically, the fusion of 'Coral carpet' and 'Sand with coral patches' was not unexpected due to the methods used: the investigated loose sediments of both bottom facies can only be representative for 'Sand with coral patches', because 'Coral carpet' primarily represents a hard bottom. Of the 8 samples classified as 'Sand with coral patches', only 5 are grouped in the Coralgal facies. Of the three excluded, A 8 stems from a sandy bottom with coral patches (although the *Halophila* settlement reflects a transitional position), C 11 from a sandy area with rare patches, and the 'Sand with coral patches' of A 2 is neighboured by a seagrass meadow. The latter sample is now classified with the Soritid facies; it represents a very marginal sample (reflected also in the dendrogram of the cluster analysis, Fig. 51) with the fewest miliolid foraminifers of all Soritid facies samples. An interesting fact is that of 12 'Coral

Operculina facies (7 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 4	12.00	33.00	19.00	64.00	21.00	10.00	5.00	2419	1423	48.38
	10.00	22.00	19.00	51.00	39.00	5.00	5.00			
A 14	12.00	39.00	19.00	70.00	15.00	10.00	5.00	2199	1132	46.18
	13.00	29.00	21.00	63.00	19.00	5.00	13.00			
B 33	21.00	49.00	20.00	90.00	10.00	0.00	0.00	4077	693	1.54
	25.00	45.00	20.00	90.00	10.00	0.00	0.00			
B 34	18.00	49.00	19.00	86.00	14.00	0.00	0.00	3378	963	23.09
	21.00	44.00	23.00	88.00	12.00	0.00	0.00			
B 37	23.00	48.00	20.00	91.00	9.00	0.00	0.00	3976	631	1.54
	23.00	44.00	23.00	90.00	10.00	0.00	0.00			
B 38	13.00	33.00	16.00	62.00	19.00	14.00	5.00	2388	1001	24.19
	17.00	41.00	20.00	78.00	16.00	3.00	3.00			
C 2	17.00	56.00	18.00	91.00	9.00	0.00	0.00	3646	583	1.10
	20.00	49.00	21.00	90.00	10.00	0.00	0.00			
m	16.57	43.86	18.71	79.14	13.86	4.86	2.14	3155	918	20.86
	18.43	39.14	21.00	78.57	16.57	1.86	3.00			
s	4.10	8.25	1.28	12.26	4.49	5.74	2.47	742	282	19.09
	5.01	9.09	1.41	14.56	9.71	2.23	4.47			
min.	12.00	33.00	16.00	62.00	9.00	0.00	0.00	2199	538	1.10
	10.00	22.00	19.00	51.00	10.00	0.00	0.00			
max.	23.00	56.00	20.00	91.00	21.00	14.00	5.00	4077	1423	48.38
	25.00	49.00	23.00	90.00	39.00	5.00	13.00			

Soritid facies (12 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 2	22.00	44.00	10.00	76.00	20.00	4.00	0.00	4354	286	0.18
	22.00	42.00	18.00	82.00	16.00	2.00	0.00			
A 3	16.00	43.00	19.00	78.00	21.00	1.00	0.00	3290	814	21.99
	18.00	39.00	18.00	75.00	24.00	1.00	0.00			
A 5	18.00	37.00	17.00	72.00	18.00	9.00	1.00	2876	1058	37.38
	14.00	26.00	18.00	58.00	31.00	7.00	4.00			
A 11	16.00	46.00	10.00	72.00	16.00	8.00	4.00	3285	462	1.10
	17.00	44.00	17.00	78.00	11.00	9.00	2.00			
A 25	21.00	40.00	17.00	78.00	17.00	3.00	2.00	3598	1207	37.38
	16.00	29.00	19.00	65.00	27.00	4.00	4.00			
A 30	19.00	39.00	16.00	74.00	18.00	5.00	3.00	3589	627	1.65
	13.00	25.00	26.00	64.00	26.00	6.00	4.00			
B 17	23.00	48.00	15.00	86.00	8.00	4.00	2.00	4512	508	0.66
	21.00	42.00	18.00	81.00	14.00	3.00	2.00			
C 6	23.00	34.00	16.00	73.00	12.00	11.00	4.00	4794	862	37.38
	23.00	31.00	18.00	72.00	19.00	2.00	7.00			
C 12	34.00	47.00	12.00	93.00	7.00	0.00	0.00	5766	264	0.07
	33.00	43.00	16.00	92.00	6.00	1.00	1.00			
C 16	14.00	31.00	10.00	55.00	25.00	11.00	9.00	3215	312	0.18
	18.00	29.00	16.00	63.00	30.00	4.00	3.00			
C 19	19.00	27.00	11.00	57.00	30.00	8.00	5.00	3554	462	1.54
	12.00	18.00	18.00	48.00	40.00	7.00	5.00			
C 20	24.00	44.00	15.00	83.00	17.00	0.00	0.00	4745	290	0.04
	24.00	43.00	17.00	84.00	11.00	2.00	3.00			
m	20.75	40.00	14.00	74.75	17.42	5.33	2.50	3965	582	11.63
	19.25	34.25	18.25	71.83	21.25	4.00	2.92			
s	5.02	6.36	3.08	10.30	6.22	3.84	2.60	822	317	15.97
	5.58	8.54	2.49	12.03	9.64	2.55	1.98			
min.	14.00	27.00	10.00	55.00	7.00	0.00	0.00	2876	264	0.04
	12.00	18.00	16.00	48.00	6.00	1.00	0.00			
max.	34.00	48.00	19.00	93.00	30.00	11.00	9.00	5766	1207	37.38
	33.00	44.00	26.00	92.00	40.00	9.00	7.00			

Tab. 19. continued

carpet' samples, 7 are grouped into Coralgal facies and 5 are into Mud (sedimentary) facies. However, the latter 5 samples originate from areas designated in the field as muddy sand patches or sandy patches inside 'Coral carpet' often characterized by clusters of openings of the burrowing crustacean *Axiopsis* sp. (PILLER & PERVESLER, 1989, p.113, pl. 4, fig. 4; compare also Appendix 1).

The samples of Sand with macroids were primarily classified together with 'Rock bottom' samples because they were thought to be very similar (except for the presence of macroids in the former, which are not analysed in this study; compare chapter 3). This similarity was supported by the analyses; the fact that both sample groups are placed into Coralgal facies is due to the variable ratio of corals and red algae in 'Coral carpet' and 'Sand with coral patches' as well as in 'Rock bottom'.

Besides the above-discussed bottom facies samples, 13 'Sand' bottom facies samples are also grouped into the Coralgal facies. These originate from different areas (Appendix 1): sand with rare coral patches (B 67, C 10, C 17); the base of coral reefs (B 11, C 5); larger sand areas in 'Coral car-

Terrigenous facies (12 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 6	3.00	5.00	4.00	12.00	9.00	53.00	26.00	649	1880	131.94
	4.00	6.00	11.00	21.00	14.00	50.00	15.00			
A 7	5.00	4.00	2.00	11.00	44.00	26.00	19.00	1539	286	43.98
A 9	8.00	13.00	4.00	25.00	41.00	25.00	9.00	2951		
A 10	13.00	14.00	4.00	31.00	31.00	30.00	8.00	4827	418	0.22
	13.00	41.00	12.00	66.00	24.00	7.00	3.00			
A 15	5.00	10.00	6.00	21.00	44.00	22.00	13.00	1869	1113	87.96
	10.00	23.00	19.00	52.00	35.00	9.00	4.00			
A 19	9.00	18.00	12.00	39.00	31.00	21.00	9.00	3219	1924	153.93
	7.00	15.00	19.00	41.00	45.00	9.00	5.00			
A 32	10.00	13.00	7.00	30.00	40.00	22.00	8.00	3598	1231	109.95
A 33	1.00	2.00	1.00	4.00	47.00	37.00	12.00	0		
C 9	2.00	3.00	6.00	11.00	44.00	27.00	18.00	396	592	1.65
	7.00	10.00	23.00	40.00	36.00	19.00	5.00			
C 13	16.00	3.00	8.00	27.00	44.00	16.00	13.00	4957	990	1.06
	12.00	6.00	20.00	38.00	48.00	9.00	5.00			
C 21	7.00	6.00	11.00	24.00	46.00	22.00	8.00	2846	873	65.97
	6.00	9.00	20.00	35.00	50.00	9.00	6.00			
D 1	5.00	4.00	4.00	13.00	47.00	25.00	15.00	1924	875	120.95
m	7.00	7.92	5.75	20.67	39.00	27.17	13.17	2398	936	59.86
	8.43	15.71	17.71	41.86	36.00	16.00	6.14			
s	4.28	5.17	3.19	9.99	10.45	9.25	5.34	1558	512	56.90
	3.06	11.71	4.13	13.02	12.25	14.35	3.72			
min.	1.00	2.00	1.00	4.00	9.00	16.00	8.00	0	286	0.22
	4.00	6.00	11.00	21.00	14.00	7.00	3.00			
max.	16.00	18.00	12.00	39.00	47.00	53.00	26.00	4956	1924	153.93
	13.00	41.00	23.00	66.00	50.00	50.00	15.00			

Compound grains facies (2 samples)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
C 11	51.00	31.00	10.00	92.00	1.00	7.00	0.00	7314	132	0.08
	26.00	45.00	13.00	84.00	14.00	1.00	1.00			
C 24	47.00	37.00	10.00	94.00	6.00	0.00	0.00	7010	77	0.44
	34.00	40.00	12.00	86.00	14.00	0.00	0.00			
m	49.00	34.00	10.00	93.00	3.50	3.50	0.00	7162	105	0.26
	30.00	42.50	12.50	85.00	14.00	0.50	0.50			
s	2.00	3.00	0.00	1.00	2.50	3.50	0.00	152	27	0.18
	4.00	2.50	0.50	1.00	0.00	0.50	0.50			

Halimeda facies (1 sample)

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
B 51	40.00	39.00	15.00	94.00	6.00	0.00	0.00	6324	510	1.67
	27.00	44.00	21.00	92.00	8.00	0.00	0.00			

Tab. 19. continued

pet' (C 8, D 7); sand area adjacent to 'Coral carpet' or 'Rock bottom' (B 28); shallow water sand with branched rhodoliths (D 2); sand patches on tidal flats adjacent to 'Sand with coral patches' (B 74, B 26); the base of a steep wall settled with corals (B 19). These samples therefore reflect the immediate vicinity of coral and/or red algae settlement and are located on the bottom facies map immediately outside coral/red algae-dominated facies, on the sedimentary facies map just inside the Coralgal facies. Thus, the degree of influence on the facies boundary position is only small.

The 3 'Sand with seagrass' samples and that of 'Seagrass' originate either near a 'Coral carpet' area (B 49) or from a sparse seagrass stock in sand with rhodoliths (C 15); the higher amount of corals may also be based on the frequent occurrence of isolated coral colonies and small coral patches inside seagrass areas (A 28, B 12). The latter is typical for transitions between 'Sand with coral patches' and 'Sand with seagrass' or 'Seagrass'.

The main area covered by the **Mud facies** coincides well with the distribution of 'Mud' bottom facies, restricted to the 'West area' basin. Additionally, a small tongue reaching into the 'Southwest channel' and a few smaller areas are classified here. The remaining discrepancies are due to the wider grain size limits in the analysis versus the field observations and, moreover, due to the fact that exact separations on the basis of grain size limits can only be drawn by sample analysis. Of the 14 'Mud' bottom facies samples, 13 are also present in the sedimentary facies. The missing one (B 20) is placed in the Molluscan facies and originates from a very marginal location at the western border of the basin. The additional samples were mainly placed into 'Muddy sand' bottom facies, 5 come from sediment patches in 'Coral carpet' (see above), one was placed in 'Seagrass' (C 7), and another in 'Sand with seagrass' (C 3). C 7 has a relatively high percentage of miliolid foraminifers (20.45 %) and is therefore closely related to Soritid facies; it is separated by its relatively high mud content (37.70 %) which, however, is one of the lowest of the Mud (sedimentary) facies. In the Mud (sedimentary) facies, two larger sub-clusters and one isolated sample (B 21 = cluster 2; Fig. 52) are clearly separated by the cluster analysis (Figs. 51, 52). B 21 differs in having a high quartz content in fractions > 250 μm. The two sub-clusters differ mainly in their corals/red algae content and/or in the amount of mud. The samples with higher coral and lower mud content originate either from mud patches in 'Coral carpet' (A 29, B 7, B 24, D8) or from marginal positions between mud bottoms and steep-walled 'Coral carpet' (B 13, B 30, B 45, B 52, C 14).

The **Molluscan facies** corresponds with the main part of the 'Muddy sand' bottom facies in being distributed not only in the 'East area' basins and along the axis of the 'Southwest channel' but also in forming a small strip between the 'West area' basin and the slope at its western border. Main differences exist in the southern basin of the 'East area', which is mainly characterized by Mud and *Operculina* facies. The correspondence with 'Muddy sand' is also documented by the sample distribution: 14 (of 24) samples were grouped into 'Muddy sand' bottom facies. The samples originally classified as 'Sand with seagrass' (A 21, B 18, C 26) represent, in fact, muddy sand with a sparse seagrass cover. Those of the 'Sand' bottom facies (A 20, B 3, B 41) have a relatively low mud content but are strongly mollusc-dominated and therefore grouped into this facies.

The **Operculina facies** represents the third sedimentary facies occupying parts of 'Muddy sand' bottom facies; all seven samples were originally classified with 'Muddy sand' Cluster analysis (Fig. 52) places this facies in an intermediate position between the Mud and Molluscan facies. Therefore, certain samples with higher *Operculina* content, originally classified as 'Muddy sand', are now grouped into the Mud (sedimentary) facies or Molluscan facies depending on the mud or mollusc content, respectively.

The distribution of the **Soritid facies** coincides very well with that of 'Seagrass' and the shallow water occurrences of 'Sand with seagrass', as well as with some areas of 'Sand with seagrass and coral patches' This can be attributed to the seagrass leaf habitat of some soritid foraminifers. These forms indirectly document the seagrass stock in the sediments. Of the 12 samples, 6 were placed in the 'Seagrass' bottom facies and one in 'Sand with seagrass'. Of the two 'Sand' bottom facies samples, one adjoins a *Halophila* meadow (C 16), one bears a sparse seagrass cover (C 19); the sample of 'Sand with coral patches' is also adjacent to a seagrass meadow (A 2), the 'Muddy sand' of sample C 12 is sparsely settled by *Halophila*, A 3 is near a seagrass area. Thus, all the above samples originate from areas with sparse seagrass stock or adjoin seagrass areas. In addition, samples C 16 and C 19 (originally grouped in 'Sand' bottom facies) are very close to Terrigenous facies in having 45 % and 43 % non-carbonate minerals.

Terrigenous facies is restricted to coastal strips and coincides on the one hand with coastal pure sands described in bottom facies (PILLER & PERVESLER, 1989, p. 114) and on the other with intertidal flats along the main coast and west of Gazirat Safaga. The correspondence in the latter is only partial because the intertidal flats in fact mainly represent a rocky substrate covered by sand patches in variable dimensions, or sand occurs in fissures and pockets. Of the 12 samples, 9 were classified as 'Sand' bottom facies (A 9 and A 33 originating from the Mangrove channel west of Gazirat Safaga); two (A 6, A 19) were grouped with 'Seagrass' and one (A 32) with 'Sand with seagrass' — in all three samples the carbonate content is relatively low. Generally the samples of this facies can be subdivided into 2 groups: In the first (A 7, A 9, A 10, A 33, C 9), not only non-carbonate mineral content is high, but the quartz of the component analysis also reaches more than 80 % and thus dominates the samples. In the second, only non-carbonate minerals dominate, whereas components are generally dominated by molluscs and, additionally, by miliolid foraminifers (A 15, A 19) or corals (A 32, C 21).

One of two samples representing **Compound grain facies** was classified with the 'Sand' bottom facies (C 24), the second with 'Sand with coral patches' (C 11). In fact, both originate from very similar bottom types and represent a transitional position: coral patches are very widely spaced at the C 11 site, and C 24 also comes from a sandy area with coral patches.

Sample B 51, representing the **Halimeda facies**, was grouped into 'Muddy sand', although very dense *Halimeda* was observed in the field. Due to its general infrequent occurrence in the bay it was not separated as bottom facies type (compare chapters 3 and 5.8).

9 Discussion

1. Although the Northern Bay of Safaga basically represents a carbonate-dominated environment it must be classified as mixed carbonate/terrigenous environment, due to the amount of non-carbonate minerals (Figs. 31, 32). The in part high concentrations of non-carbonate minerals along the coast designate especially this part of the bay as a mixed ter-

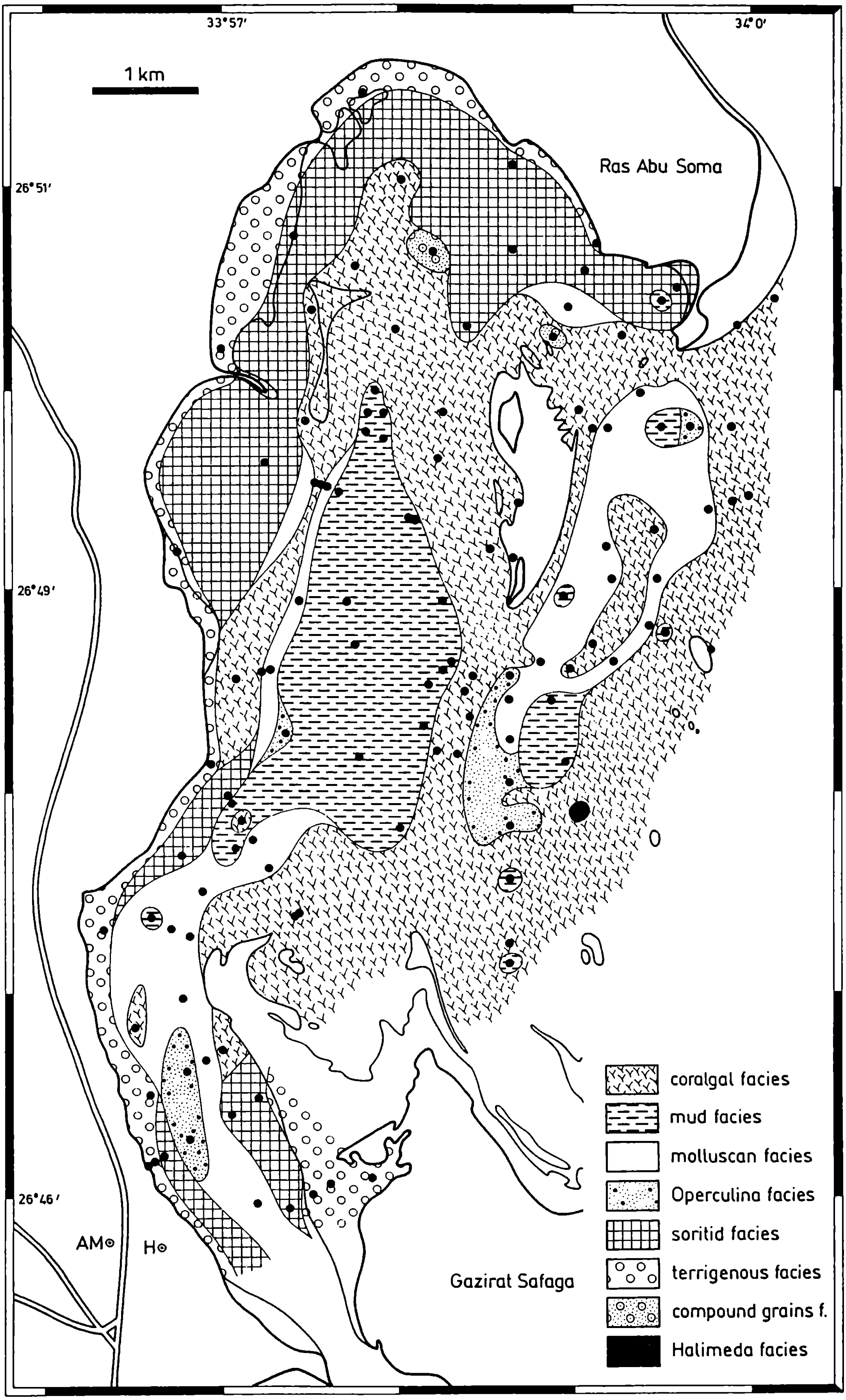


Fig. 53. Distribution of sedimentary facies.

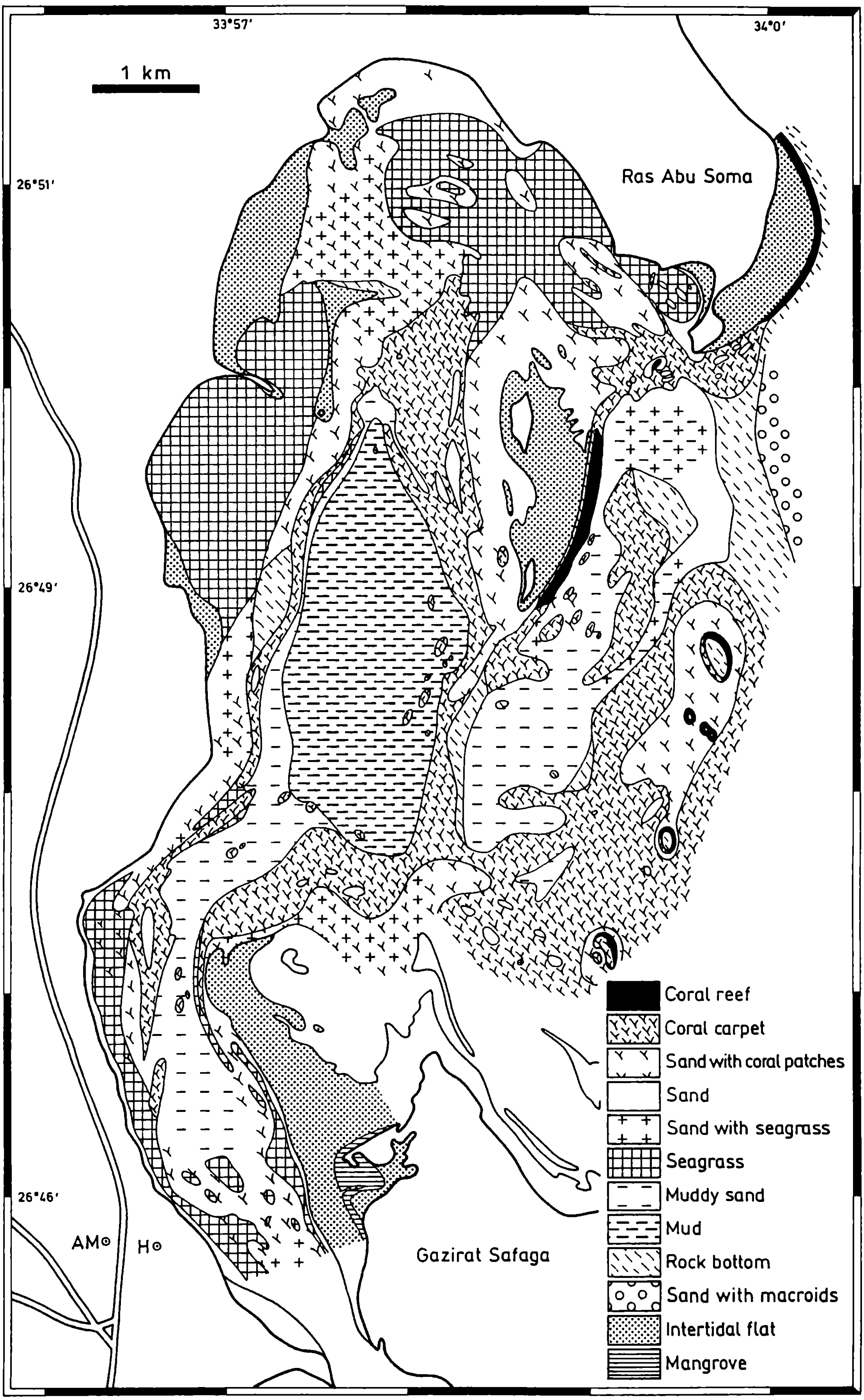


Fig. 54. Distribution of bottom facies (according to PILLER & PERVESLER, 1989).

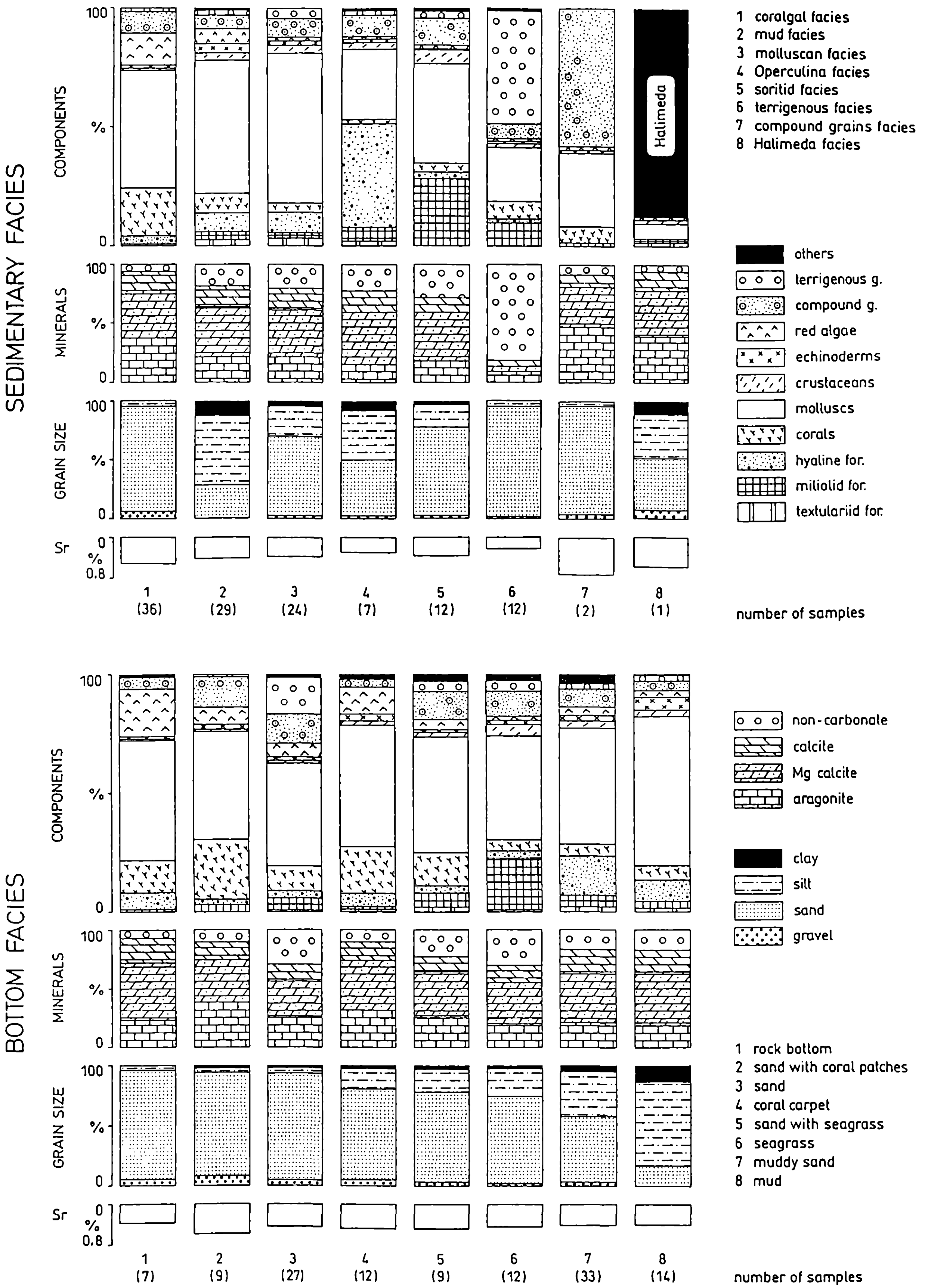


Fig. 55. Comparison of the frequencies of the mean values of the variables (grain size, components, minerals, strontium) of sedimentary facies versus bottom facies.

rigenous/carbonate shoreline (sensu SELLEY, 1985). Much of the subtidal area, especially the 'Southwest channel' and certain basin sectors, fit the definition of a mixed carbonate/terrigenous shelf. The origin of this intermediate environment can be attributed, at least partly, to all 4 categories distinguished by MOUNT (1984). FRIEDMAN (1968, 1988), in the Gulf of Aqaba, takes three of these categories ("punctuated mixing", in situ mixing, source mixing) into consideration. In the Northern Bay of Safaga "punctuated mixing" may dominate. Although direct observations are lacking, the presence of wadis (e.g., Wadi Barud, compare map in THIRIET, 1987) along the 'Southwest channel' and the elevated non-carbonate mineral content inside the channel point to a periodic input of this material by flashfloods and its subsequent distribution by water currents. The second possibility, probably a common mechanism, is by "facies mixing" (MOUNT's 4th category): one of the main processes causing this category is the eolian contribution of siliciclastic material (MOUNT, 1984, Fig. 1). Constant winds, predominantly from northern directions, apparently import a part of the siliciclastic material (especially in the 'North area'). The remaining two possibilities are thought to be of minor importance, although a form of "source mixing" may be responsible for the calcite supply, especially by erosion of fossil to subfossil coral limestones, predominantly present at the intertidal flats. This mode of contribution would be supported by the distribution of calcite (Figs. 35, 38, 41, 42).

2. The study area partly represents a coral reef environment and thus contains certain environments influenced by these complex biological/geological structures. These coral reef-influenced areas are relatively widespread as demonstrated by the spatial distribution of the coralgal facies. However, it is remarkable and particularly important from a geological view point that the percentages of corals, coral fragments and coralline red algae are relatively low. Of 36 samples classified as coralgal facies, the mean value of corals is only 20.89 %; in only 3 samples does it exceed 50 %; for coralline algae the mean value is 12.75 %, with 30 % being attained only in 3 samples. Taking into account that only the fraction > 250 μm was investigated by component analysis and that the amount of corals decreases with decreasing grain size, the total coral amount in the sediments is actually distinctly smaller. Therefore, corals are only abundant in the immediate surroundings of coral heads or coral patches. The detected coral frequencies are distinctly lower than those of most other Red Sea (e.g., BRAITHWAITE, 1982: studying only components > 500 μm; GABRIE & MONTAGGIONI, 1982; MONTAGGIONI et al., 1986;) and Indo-Pacific reef environments (e.g., LEWIS, 1969; BOICHARD et al., 1985), except similar, low frequencies reported from the Ryukyu Islands (UJIIE & SHIOYA, 1980). It is unclear whether these differences reflect the different environments incorporated (all the other investigations are polarized on coral reefs s. str.) or whether they represent the effect of sampling technique. For the Northern Bay of Safaga, the distinct accumulation of corals and red algae immediately around their living place reflects relatively low energy conditions. The relatively low percentage of coral fragments in coralgal facies coincides well with frequencies detected in some fossil limestones; in fossil examples such relatively low frequencies are one argument leading to discussions about a reef vs. non-reef origin of bioclastic limestones (e.g., STANTON & FLÜGEL, 1989).

3. Another point worthy of note is the scarcity of codiacean algae, especially of *Halimeda*. This green alga is very abundant and important in producing and baffling large quantities of sediment in various tropical-subtropical, shallow water, carbonate environments all over the world (e.g., Great Barrier Reef: FLOOD & SCOFFIN, 1978; ORME et al., 1978; MARSHALL & DAVIES, 1988; Indo-Pacific: ROBERTS et al., 1988; Brazilian Shelf: CARANNANTE et al., 1988; Caribbean: MILLIMAN, 1977; JOHNS & MOORE, 1988). In the Bay of Safaga, its rarity was observed during field work and is clearly documented by component analysis: only two samples contain more than 10 % and in only 6 other samples (of 122) did its percentage exceed 1 %. *Halimeda* was observed in several localities, i.e., in some parts of coral reefs, in seagrass meadows, or on subtidal rock bottom; however, its sediment contribution is mostly very small. In the field, its presence was more obvious in sparse seagrass stocks on muddy sands and therefore in deeper water (mainly below 30 m). Similar low *Halimeda* frequencies were observed earlier by several authors in different areas of the Red Sea (e.g., Gulf of Aqaba: REISS, 1977, p. 12; GABRIE & MONTAGGIONI, 1982; Strait of Jubal at the southern end of the Gulf of Suez: ROBERTS & MURRAY, 1988; Jeddah area: MONTAGGIONI et al., 1986; Sudanese reefs: BRAITHWAITE, 1982). This is also mentioned by WALKER (1987), who concluded

(p. 157) that "the major contribution of calcareous algal breakdown to the sediments of the Red Sea should not be overlooked" This statement clearly contradicts the results of sediment analyses. Possible reasons for this low frequency were not discussed in detail. Elevated salinities may be one important factor for the local frequency variation (e.g., at the platform tops of Ashrafi Reef near the southern entrance of the Gulf of Suez ROBERTS & MURRAY (1988) suppose that high salinity (47 °/₀₀) may be responsible for the reduced content of green algae compared with higher percentages at the platform top). In general, however, high salinity does not seem to be a decisive factor explaining this scarcity.

4. A high percentage of recent shallow water carbonate muds is thought be a product of green algae skeleton decomposition (comp. FLÜGEL, 1982), although more recent investigations point to a reduction in the amount of skeletally derived mud particles in favour of a non-skeletal origin by whitings (SHINN et al., 1989). This discussion is polarized on aragonitic lime muds, whereas muds rich in Mg-calcite are more rarely (reported?). In the Northern Bay of Safaga the scarcity of calcareous green algae and the mineralogical composition of the carbonate muds exclude a production by submicroscopic green algal fragments. Mud produced by green algal decomposition should be aragonite-dominated; the studied mud, however, is largely composed of more than 50 % Mg-calcite and less than 30 % aragonite (related to the total carbonate content). Grain size analyses showed that the mud fraction is clearly dominated by (coarser) silt-sized particles. Compared with other investigations, the Mg-calcite content coincides well with those reported from the Southern Belize Shelf (18 - 64 m; MATTHEWS, 1966), Northern Belize Shelf (PUSEY, 1975), as well as with certain muddy facies types from the Persian Gulf (Gastropod muddy sand, Imperforate foraminiferal/gastropod mud; WAGNER & VAN DER TOGT, 1973) from very shallow water (< 10 m). In contrast to these shallow water occurrences, MILLIMAN et al. (1969) reported 50 % Mg-calcite contents from deep sea muds of the Red Sea. The origin of this deep sea mud was explained by direct precipitation of Mg-calcite from seawater; genesis of mud at the Belize Shelf (MATTHEWS, 1966; PUSEY, 1975) was attributed to skeletal debris produced either by disintegration or abrasion.

   A precipitary origin of the Northern Safaga Bay mud is not supported by grain size, as this mud is composed mainly of (coarser) silt size particles, whereas the deep water Mg-calcite muds of the Red Sea and Mediterranean Sea are composed of crystals mostly finer than 6 μm (MILLIMAN & MÜLLER, 1973).

   Additionally, a precipitary origin of the mud appears to be in contrast with the mineralogical composition of the cements, although these were not studied in detail. In the analyses of total samples, however, aragonite contents are highest in sediments with relatively abundant compound grains (in addition to areas with higher coral frequencies). Finally, the correlation analyses point to a positive relation between aragonite, corals and compound grains. However, the aragonite content in the mud fractions of these samples is low. These relations can be interpreted as follows: the cements binding the compound grains, being part of the grain and only analysed in the total samples, are made of aragonite, whereas the mud fraction in these shallow water samples are Mg-calcite dominated.

   Based on current information, the origin of the Mg-calcite mud is most likely related to skeletal debris, because of relative coarse grain size in the mud fraction. Due to the typically low energy conditions in the bay their production does not seem to stem from abrasion.

5. Another point of interest is the occurrence of relict sediments, often reported in similar investigations. Although this topic is the subject of further studies, some preliminary observations can be made. Certain samples in the 'East area' basins clearly contain dark-stained particles, which may point to relict sediments. Generally, non-skeletal carbonate grains are relatively rare, except for compound grains in some localities and peloids; ooids seem to be very rare and were only observed in the 'East area' basins, at depths mainly between 40 – 50 m. Both characters — stained particles and ooids, which do not occur in an environment favourable for ooid origin — may point to the occurrence of relict sediments. Their frequency and exclusive occurrence in the 'East area' remains to be explained. The staining of the particles seems unrelated to iron and manganese contents.

6. One of the geologically most important characters in the Northern Bay of Safaga is the immediate neighbourhood of 'Coral carpet' and mud sediments. In geological outcrops such features may lead to confusion. The sharpness of this boundary is documented both by visual observation and by sediment analyses, where the very marginal samples, e.g., in the 'West area' basin, are classified as Mud facies. Similar observations, but on a smaller scale, were made by SCHROEDER & NASR (1983), who described

mud-filled, isolated basins inside a fringing reef off Port Sudan. These basins can be considered as a kind of connecting link between the mud-filled depressions in 'Coral carpet' frequently observed in the present study. These depressions vary in frequency and size and, in the rugged area west of the Tubya islands (PILLER & PERVESLER, 1989, p. 110), nearly reach the dimensions as in the Sudanese reefs. Another similarity is the sediment composition, with a relatively high mud content as well as a considerable amount of quartz, concentrated in the fine fraction. In both areas its origin is interpreted as eolian and its deposition is due to reduced water current velocities in the bottom depressions.

7. Besides the larger mud-filled basins, another remarkable feature, especially from a geological view point, are the isolated steep-flanked elevations, up to 15 m in height, in the 'West area' basin and in the northern part of the 'Southwest channel' (PILLER & PERVESLER, 1989, p.110). These elevations, interpreted as being tectonic in origin, are built of fossil carbonate rocks and are settled by corals in variable densities. Their occurrence was classified as 'Coral carpet' by PILLER & PERVESLER (1989, p.112), but they represent transitional structures to Patch reefs. If the prevailing sedimentation conditions continue, these coral-settled risings will be covered by mud and, from the geologist's view, might be interpreted as coral reefs embedded in mud and probably killed by the muddy sedimentation. The muddy sediment, together with the scarcity or absence of green algae, may lead to a deeper water interpretation of these structures, although they were actually created in depths between 10 and 30 m.

10 Conclusion

Grain size distribution in the Northern Bay of Safaga is clearly dependent on the tectonically defined bottom morphology, with muddy sediment accumulations in depressions. The latter vary in size, ranging from meter-sized indentations in 'Coral carpet', over troughs of 100 and more meters in length, cut into underlying rocks up to more than 10 m depth, and finally to basins (30 to 50 m water depth) with dimensions of kilometers. These fine-grained sediments are dominated by silt fractions, with the highest mud content in the central parts of the 'West area' basin and lowest values in marginal positions and in the small depressions.

The distribution of the coarser grained sediments is determined to a lesser degree by bottom morphology, being more directly influenced by autochthonous skeletal grains. The clearly dominating components in fractions > 250 μm are molluscan shells and debris; these make up more than 40 % in the main part of the bay, occasionally exceeding 80 %. Besides this group, corals, red algae, miliolid and hyalin foraminifers, compound grains, and, with a limited distribution, quartz grains contribute high percentages to the sediments. Green algae are rare except for one small area where their fragments make up 87 % of the coarse fraction.

Mineralogically, the sediments are composed predominantly of carbonate. Quartz and feldspars are dominant only in a few localities in coastal areas. The quartz content is generally higher in the mud fraction due to an eolian origin; clay minerals are totally absent. Carbonate minerals are dominated by Mg-calcite, especially in the mud fractions. Aragonite is positively correlated to corals and compound grains, as well as to strontium. Because of its spatial distribution calcite can be interpreted as terrigenous. The origin of Mg-calcite may be bioclastic because of the silt-dominated mud fraction.

The bottom facies types distinguished by direct field observations are in part well documented in the sediments. For those bottom facies representing subtidal hard grounds (coral reefs, 'Coral carpet' and 'Rock bottom'), investigation methods involving the study of loose sediment samples alone are not adequate. These bottom facies were grouped together with 'Sand with coral patches' and Sand with macroids in the Coralgal facies. The other bottom facies were split off into several sedimentary facies types: 'Sand' bottom facies (except 'Sand with coral patches' and Sand with macroids) in Terrigenous facies and Compound grain facies, and the subfacies 'Muddy sand' mainly into Molluscan facies, *Operculina* facies and *Halimeda* facies. A good coincidence exists between the Soritid facies and the occurrence of seagrass, therefore corresponding widely with 'Seagrass' and 'Sand with seagrass' (bottom facies). The Mud (sedimentary) facies, has been expanded compared with the 'Mud' bottom facies, and also include some of the 'Muddy sand' samples. Altogether, the occurrence and distribution of the bottom facies, momentary present, would be clearly recognizable by sedimentological analyses, if the *status quo* became fossilized.

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Appendix 1: Position and short description of sample localities.
(no.: sample number; trans.: number of transect; dist.: distance (m) to land point; trans. and dist. according to Fig. 2 in PILLER & PERVESLER, 1989; depth: water depth)

no.	trans.	dist.	depth	description
A 1	A1	1375	0.5	Rocky tidal flat with rippled sand
A 2	A1	1304	6-7	Sand with coral patches
A 3	A1	980	17.5	Muddy sand
A 4	A1	520	18.5	Muddy sand with brown algae
A 5	A1	220	15.0	Halophila meadow
A 6	A1	114	1.5	Seagrass meadow with Halophila and Halodule
A 7	A1	beach		Sand
A 8	A4	650	10.0	Sand with Halophila between coral patches
A 9	A5	1320	0.0	Coarse sand between Mangrove roots
A 10	A5	1140	0.4	Rocky tidal flat with rippled fine gravel
A 11	A5	880	6.0	Sand with mixed seagrass
A 12	A8	900	22.0	Muddy sand with Operculina
A 13	A8	1100	7.0	Sand patches in coral carpet
A 14	A8	700	23.0	Muddy sand
A 15	A8	280	19.0	Sand strip between coral carpet and Halophila meadow
A 16	A9	900	24.0	Muddy sand
A 17	A9	380	6.0	Sand between coral patches
A 18	A10	1700	29.0	Muddy sand in coral carpet
A 19	A10	250	8.0	Halophila meadow
A 20	A11	1000	28.0	Sand with mounds
A 21	A11	825	25.0	Muddy sand with Halophila
A 22	A11	625	21.0	Muddy sand with mounds
A 23	A13	1250	9.0	Muddy sand with coral patches and Cymodocea patches
A 24	A13	750	31.0	Muddy sand with mounds
A 25	A13	370	17.0	Halophila meadow
A 26	A14	1150	29.0	Muddy sand with burrow openings
A 27	A14	850	35.0	Fine sand with mounds
A 28	A14	650	28.0	Sand with Halophila patches
A 29	A14	490	9.0	Sand in coral carpet
A 30	A14	400	13.0	Halophila meadow
A 31	A14	270	6.0	Sand with coral patches
A 32	A14	120	1.0	Fine sand with sparse Halodule
A 33	A6	1700	0.1	Pellet sand between Mangrove roots
B 1	B1	2335	62.0	Rock bottom with sand patches
B 2	B1	2150	50.0	Rock bottom with macroids, corals and sand patches
B 3	B1	1920	58.0	Sand with mounds covered by microbial mat
B 4	B1	1396	45.0	Rock bottom with sand patches
B 5	B1	1220	40.0	Coral carpet with sand patches
B 6	B1	905	40.0	Muddy sand with mounds
B 7	B2	1414	25.0	Coral carpet with sand patches
B 8	B2	1260	38.0	Muddy sand with Halophila patches and mounds
B 9	B2	460	35.0	Muddy sand with mounds
B 10	B2	115	16.5	Sand with coral patches
B 11	B3	3700	3.0	Sand strip between small fringing reef and seagrass
B 12	B3	3670	6.0	Cymodocea meadow
B 13	B3	1420	33.0	Mud with clusters of burrow openings
B 14	B4	1510	37.5	Mud with abundant mounds covered by microbial mat
B 15	B4	1990	32.0	Sand bottom, 3 m in front of steep wall of coral carpet
B 16	B4	600	34.0	Mud covered by microbial mat
B 17	B5	2630	6.0	Halophila meadow
B 18	B5	2005	28.0	Sand bottom with seagrass
B 19	B5	1945	31.0	Sand bottom with mounds
B 20	B5	1910	34.0	Mud bottom with many burrow openings
B 21	B5	1793	38.5	Mud covered by microbial mat
B 22	B5	1070	36.0	Mud with many mounds
B 23	B5	1020	33.0	Muddy sandy with burrow openings at the base of a steep wall of coral carpet
B 24	B5	995	25.0	Sand patch in coral carpet
B 25	B5	265	1.5	Sand between coral patches
B 26	B5	40	0.5	Sand with small mounds of Callianassa
B 27	B6	2000	17.0	Sand patch in coral carpet
B 28	B6	1000	41.0	Sand with mounds
B 29	B6	580	42.0	Muddy sand with Operculina and mounds
B 30	B7	3300	29.0	Muddy sand in coral carpet
B 31	B7	3100	17.0	Sand patch in coral carpet
B 32	B7	2520	42.0	Muddy sand in coral carpet
B 33	B7	2050	47.0	Muddy sand with Operculina
B 34	B7	1675	48.0	Muddy sand with Operculina
B 35	B7	1300	49.0	Muddy sand covered by microbial mat
B 36	B7	950	50.0	Muddy sand covered by microbial mat
B 37	B7	750	46.0	Muddy sand with Operculina
B 38	B8	2440	36.0	Sandy mud
B 39	B9	2530	72.0	Sand with macroids
B 40	B9	2060	49.0	Sand patch on rock bottom

Appendix 1: continued

no.	trans.	dist.	depth	description
B 41	B9	1325	48.0	Sand with Halophila and Operculina
B 42	B9	900	41.0	Muddy sand
B 43	B10	2010	35.0	Mud covered by microbial mat
B 44	B10	1100	35.0	Mud covered by microbial mat
B 45	B10	910	32.0	Muddy sand in front of coral carpet
B 46	B10	836	32.0	Mud with mounds
B 47	B11	2525	48.0	Sand patch in coral carpet
B 48	B11	1200	37.5	Halophila meadow with Halimeda
B 49	B11	950	41.0	Sand with sparse Halophila
B 50	B11	580	42.5	Muddy sand
B 51	B12	2210	34.0	Halimeda meadow
B 52	B12	1750	48.0	Muddy sand with Operculina
B 53	B12	1200	52.0	Mud with many burrow openings
B 54	B12	850	45.0	Muddy sand
B 55	B12	650	40.0	Muddy sand with Operculina
B 56	B14	1500	29.0	Sand patch on rock bottom
B 57	B14	1165	47.0	Fine sand
B 58	B15	2310	32.0	Mud with burrow openings
B 59	B15	1540	23.0	Sand patch in coral carpet
B 60	B15	960	33.0	Sand patch on rock bottom
B 61	B15	820	27.0	Sand patch in coral carpet
B 62	B17	2250	44.5	Muddy sand with Halophila
B 63	B17	1975	46.5	Muddy sand
B 64	B17	1650	49.5	Muddy sand with Operculina
B 65	B17	1250	51.5	Muddy sand with star-like trails
B 66	B17	940	50.0	Muddy sand with star-like trails
B 67	B18	2625	6.0	Sand with soritids
B 68	B18	2450	16.0	Sand patch in coral carpet
B 69	B18	2300	32.0	Muddy sand.
B 70	B18	1500	38.0	Mud with many mounds covered by microbial mat
B 71	B20	1400	48.0	Sand with Operculina
B 72	C11	970	33.0	Sand with mounds
B 73	C12	1775	9.5	Sand in coral carpet
B 74	--		0.5	Sand patch on rocky tidal flat
B 75	A13	1490	1.8	Sand with Halophila in coral carpet
C 1	C1	2050	57.0	Sand with macroids
C 2	C1	1650	50.0	Muddy sand with Operculina and Halimeda
C 3	C1	1400	47.5	Muddy sand with Halophila, soritids and Operculina
C 4	C1	900	40.0	Muddy sand with Halophila patches
C 5	C1	750	34.5	Sand strip at reef base
C 6	C2	2020	3.0	Halophila meadow
C 7	C2	1810	7.0	Halophila meadow
C 8	C2	1350	19.5	Sand groove in coral carpet
C 9	C3	3400	0.5	Fine sand covered by microbial mat
C 10	C3	2500	10.0	Sand with rare coral patches
C 11	C3	1800	7.0	Sand with rare coral patches
C 12	C3	1030	13.5	Muddy sand patch in Halophila meadow
C 13	C4	2850	0.2	Sand on rocky tidal flat
C 14	C4	1355	22.0	Muddy sand in coral carpet
C 15	C5	2100	0.5	Mixed seagrass meadow
C 16	C6	2720	0.5	Sand with soritids
C 17	C6	2088	8.0	Sand adjacent to Halophila meadow
C 18	C6	1520	7.0	Sand with Cymodocea patches
C 19	C7	2430	1.5	Sand with Halophila and mounds
C 20	C7	1650	14.0	Sand with Halophila
C 21	C8	beach	0.3	Sand with soritids
C 22	C8	1630	7.0	Sand
C 23	C8	1250	17.0	Halophila meadow
C 24	C8	900	6.0	Sand with coral patches
C 25	C10	2000	33.0	Sand patch in coral carpet
C 26	C10	1250	38.5	Sand with Halophila and large mounds
C 27	C12	2660	56.0	Sand grooves on steep rock bottom
C 28	C12	2340	15.0	Sand patch in coral reef
C 29	C12	2400	63.0	Sand with macroids
C 30	C12	1340	26.5	Sand with coral patches
C 31	C12	1320	15.0	Coarse sand
C 32	C12	1230	29.0	Sand groove in coral carpet
D 1	D2	1903	0.75	Sand with wave ripples
D 2	D2	100	0.75	Sand with rhodoliths
D 3	D4	1270	22.0	Sand patch in coral carpet with clusters of burrow openings
D 4	D4	1225	24.0	Sand groove in coral carpet
D 5	D4	700	32.0	Mud with star-like trails at the base of steep coral carpet
D 6	D4	525	33.5	Mud with many burrow openings
D 7	D5	1230	24.5	Sand patch in coral carpet
D 8	D5	670	30.0	Sand in coral carpet with clusters of burrow openings
D 9	D5	520	32.0	Sandy mud

Appendix 2: Frequency (%) of mean grain size categories, terminology and sorting, as well as mean (M_z), sorting (2.moment), skewness (Sk_I), and kurtosis (4. moment) of the sediments.

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
A 1	2.33	97.05	0.45	0.17	sand	moderate	1.29	1.02	-0.11	4.45
A 2	0.85	98.53	0.62	0.00	sand	moderate	2.47	1.16	-0.38	3.26
A 3	3.23	68.20	26.85	1.72	siltsand	v. poor	2.76	2.31	-0.08	7.92
A 4	1.98	62.98	32.93	2.12	siltsand	v. poor	2.98	2.40	-0.11	6.52
A 5	5.66	72.24	20.98	1.12	silty sand	v. poor	2.57	2.21	-0.10	4.10
A 6	0.63	96.44	2.93	0.00	sand	moderate	2.61	0.93	-0.11	5.77
A 7	0.28	99.49	0.06	0.17	sand	mod.well	0.76	0.54	0.05	16.56
A 8	4.50	68.80	25.35	1.35	siltsand	v. poor	2.62	2.28	-0.10	4.70
A 9	3.87	94.60	1.53	0.00	sand	moderate	1.11	1.24	0.02	3.61
A 10	7.28	91.35	1.36	0.00	sand	poor	1.05	1.42	-0.08	3.11
A 11	2.88	78.56	17.62	0.93	silty sand	poor	2.39	2.00	-0.02	6.78
A 12	2.17	67.87	27.84	2.12	siltsand	v. poor	2.99	2.23	-0.09	5.53
A 13	6.47	91.91	1.62	0.00	sand	poor	1.19	1.44	-0.07	3.08
A 14	0.91	54.84	41.57	2.69	siltsand	v. poor	3.47	2.26	-0.15	4.42
A 15	0.39	89.56	9.05	1.01	sand	poor	2.68	1.40	0.25	18.39
A 16	11.36	71.76	14.33	2.56	silty gravelly sand	extr. poor	1.54	2.64	0.29	6.05
A 17	12.61	85.02	2.37	0.00	gravelly sand	poor	0.89	1.48	-0.05	2.71
A 18	0.01	11.29	79.77	8.93	sandy silt	v. poor	5.44	2.33	0.37	6.12
A 19	1.43	70.04	27.07	1.46	siltsand	poor	3.19	1.94	-0.13	9.40
A 20	1.61	75.78	21.01	1.60	silty sand	poor	2.82	1.97	0.02	7.12
A 21	3.45	64.61	28.69	3.25	siltsand	v. poor	3.02	2.52	0.01	5.78
A 22	1.05	37.06	56.89	5.00	sandsilt	v. poor	4.44	2.33	0.08	5.71
A 23	7.26	77.20	14.76	0.79	silty sand	v. poor	2.21	2.09	-0.13	5.03
A 24	0.48	78.39	19.42	1.71	silty sand	poor	3.02	1.86	0.02	10.13
A 25	2.08	72.30	23.56	2.07	silty sand	v. poor	2.90	2.13	-0.13	7.00
A 26	0.61	55.64	37.89	5.85	siltsand	extr. poor	3.97	2.61	0.28	6.89
A 27	0.37	73.27	23.72	2.65	silty sand	v. poor	3.14	2.19	0.11	9.44
A 28	15.71	80.17	4.11	0.00	gravelly sand	poor	0.69	1.72	0.14	3.31
A 29	2.75	44.39	41.17	11.69	sandy silt sand	extr. poor	4.05	3.70	0.07	3.00
A 30	2.33	70.98	24.28	2.42	silty sand	v. poor	3.01	2.19	-0.12	7.92
A 31	11.77	86.74	1.49	0.00	gravelly sand	poor	0.71	1.42	0.09	2.76
A 32	0.27	94.25	5.38	0.11	sand	moderate	3.15	0.84	-0.14	16.86
A 33	3.69	93.51	2.80	0.00	sand	poor	1.36	1.49	-0.08	2.34
B 1	1.45	94.94	3.62	0.00	sand	moderate	1.52	1.23	0.02	7.04
B 2	1.98	95.77	1.72	0.53	sand	moderate	1.08	1.20	0.01	7.28
B 3	1.68	78.32	17.58	2.42	silty sand	v. poor	2.57	2.33	0.01	7.63
B 4	3.10	95.68	1.22	0.00	sand	moderate	1.25	1.13	-0.13	3.57
B 5	6.80	89.27	3.93	0.00	sand	poor	1.11	1.44	-0.07	4.20
B 6	0.80	78.62	18.50	2.09	silty sand	poor	2.95	1.91	0.08	8.76
B 7	3.64	54.74	39.09	2.53	siltsand	v. poor	3.37	2.36	-0.14	4.21
B 8	1.22	75.76	20.23	2.79	silty sand	v. poor	2.96	2.10	0.17	6.75
B 9	0.13	38.23	56.05	5.60	sandsilt	v. poor	4.53	2.14	0.29	7.56
B 10	6.76	93.14	0.10	0.00	sand	moderate	0.68	1.09	0.03	2.75
B 11	3.85	94.69	1.46	0.00	sand	moderate	1.32	1.24	0.00	3.02
B 12	1.79	87.95	9.23	1.04	sand	poor	1.60	1.91	0.33	8.78
B 13	1.37	44.70	44.12	9.81	siltsand	extr. poor	4.27	3.30	0.08	3.26
B 14	0.03	4.91	21.32	2.12	clayey silt	v. poor	6.12	2.17	0.41	4.94
B 15	6.84	69.72	21.32	2.12	silty sand	v. poor	2.37	2.54	0.11	5.56
B 16	0.10	9.78	79.17	10.95	clayey silt	v. poor	5.86	2.55	0.41	5.63
B 17	0,85	75.03	22.66	1.47	silty sand	poor	2.99	1.86	0.11	7.00
B 18	1.82	85.73	11.44	1.01	silty sand	poor	2.38	1.79	-0.07	8.06
B 19	12.56	80.45	5.72	1.27	gravelly sand	v. poor	0.92	2.14	0.19	8.35
B 20	2.10	55.50	35.98	6.42	siltsand	extr. poor	3.94	2.69	0.48	4.90
B 21	0.00	20.24	70.94	8.81	sandy silt	v. poor	5.22	2.44	0.43	6.89
B 22	0.13	4.78	82.63	12.47	clayey silt	v. poor	6.19	2.16	0.46	4.72
B 23	2.27	24.03	55.82	17.88	clayey sandsilt	extr. poor	5.81	3.42	0.06	2.67
B 24	0.96	47.89	44.43	6.73	siltsand	extr. poor	3.99	2.73	0.08	3.95
B 25	5.49	93.60	0.91	0.00	sand	moderate	0.95	1.14	-0.17	4.22
B 26	1.78	97.50	0.72	0.00	sand	moderate	1.49	1.03	0.02	3.61
B 27	2.76	95.42	1.82	0.00	sand	moderate	1.49	1.27	-0.07	2.92
B 28	2.47	87.51	8.18	1.84	sand	poor	2.02	1.94	0.14	10.18
B 30	2.60	49.80	39.97	7.64	siltsand	extr. poor	3.53	3.13	0.02	3.64
B 31	2.24	77.08	19.21	1.46	silty sand	v. poor	2.40	2.21	0.05	8.19
B 32	1.18	28.49	63.24	7.09	sandsilt	extr. poor	4.62	2.81	-0.03	5.38
B 33	1.04	57.35	36.18	5.43	siltsand	extr. poor	3.75	2.66	0.22	5.56
B 34	2.11	41.99	50.79	5.11	sandsilt	extr. poor	3.64	2.91	-0.18	4.16
B 35	0.72	55.35	38.20	5.73	siltsand	extr. poor	3.82	2.71	0.17	7.26
B 36	1.12	56.57	38.02	4.29	siltsand	v. poor	3.70	2.39	0.07	5.29
B 37	1.06	48.82	46.59	3.53	siltsand	v. poor	3.67	2.42	-0.14	4.86
B 38	0.89	59.78	35.34	3.99	siltsand	v. poor	3.62	2.44	0.14	5.94
B 39	3.94	94.47	1.59	0.00	sand	moderate	1.13	1.26	0.01	3.89
B 40	3.19	94.55	2.26	0.00	sand	moderate	1.11	1.31	0.14	3.25
B 41	1.00	92.06	5.82	1.13	sand	poor	2.16	1.64	-0.02	13.04
B 42	1.91	75.31	18.65	4.13	silty sand	v. poor	2.91	2.44	0.15	6.85

Appendix 2: continued.

number	gravel	sand	silt	clay	terminology	sorting	M_z	2.mom.	Sk_I	4.mom.
B 43	0.00	5.30	81.39	13.31	clayey silt	v. poor	6.20	2.35	0.45	4.91
B 44	0.30	3.69	80.52	15.49	clayey silt	v. poor	6.54	2.33	0.50	4.25
B 45	5.78	61.81	26.23	6.18	siltsand	extr. poor	2.64	3.24	0.40	3.59
B 46	0.32	4.35	80.90	14.43	clayey silt	v. poor	6.43	2.44	0.48	4.76
B 47	1.24	96.97	1.79	0.00	sand	moderate	1.40	1.16	0.05	3.46
B 48	2.53	74.52	19.02	3.93	silty sand	v. poor	2.77	2.51	0.22	6.40
B 49	6.12	86.01	6.12	1.75	sand	v. poor	1.78	2.13	-0.13	9.08
B 50	0.94	91.63	5.97	1.46	sand	poor	2.03	1.76	0.06	13.00
B 51	7.33	44.85	37.71	10.11	clayey siltsand	extr. poor	3.64	3.82	0.08	3.24
B 52	2.42	47.47	44.08	6.03	siltsand	extr. poor	3.43	3.09	-0.11	3.88
B 53	0.95	38.78	46.33	13.93	clayey sandsilt	extr. poor	4.94	3.42	0.18	3.19
B 54	0.72	50.82	42.61	5.84	siltsand	v. poor	3.91	2.53	0.13	5.27
B 55	1.66	42.51	49.04	6.80	sandsilt	extr. poor	4.26	2.77	0.14	5.93
B 56	23.08	75.55	1.37	0.00	gravelly sand	moderate	0.10	1.34	0.20	6.31
B 57	9.93	86.43	3.64	0.00	sand	poor	1.14	1.59	-0.15	3.24
B 58	0.02	10.15	76.23	13.60	clayey sandy silt	v. poor	6.07	2.55	0.43	4.51
B 59	18.25	80.25	1.51	0.00	gravelly sand	poor	0.57	1.56	0.06	2.88
B 60	7.87	90.05	2.09	0.00	sand	moderate	0.84	1.39	-0.11	5.10
B 61	7.01	91.49	1.50	0.00	sand	moderate	0.92	1.28	-0.01	4.00
B 62	1.78	35.39	55.57	7.26	sandsilt	extr. poor	3.84	3.15	-0.20	4.18
B 63	1.16	33.62	55.68	9.52	sandsilt	extr. poor	4.16	3.27	-0.14	3.03
B 64	1.83	52.91	38.65	6.61	siltsand	extr. poor	3.38	3.30	0.00	4.68
B 65	0.88	55.03	38.10	5.99	siltsand	extr. poor	3.64	2.78	0.20	5.00
B 66	2.91	67.23	25.23	4.66	siltsand	extr. poor	2.74	3.00	0.08	6.39
B 67	8.35	89.28	2.37	0.00	sand	poor	0.96	1.48	0.12	2.69
B 68	8.30	88.89	2.82	0.00	sand	poor	1.11	1.47	-0.03	2.73
B 69	2.06	59.04	33.59	5.32	siltsand	extr. poor	3.70	2.60	0.14	6.25
B 70	0.00	8.37	75.06	16.57	clayey silt	extr. poor	6.49	2.67	0.44	3.75
B 71	0.74	93.78	5.09	0.39	sand	poor	1.93	1.48	-0.03	8.66
B 72	0.01	89.48	9.97	0.53	sand	moderate	2.66	1.30	-0.11	9.87
B 73	5.25	91.44	3.32	0.00	sand	poor	1.17	1.41	0.00	4.02
B 74	7.56	90.13	2.31	0.00	sand	poor	1.51	1.52	-0.36	2.54
B 75	0.50	96.15	3.34	0.00	sand	moderate	2.26	1.13	-0.29	3.63
C 1	3.88	94.24	1.56	0.32	sand	moderate	1.20	1.26	-0.04	4.22
C 2	0.64	35.79	52.02	11.54	clayey sandsilt	extr. poor	4.71	3.18	0.08	3.28
C 3	1.19	36.25	53.11	9.45	sandsilt	extr. poor	4.66	2.92	0.12	4.26
C 4	1.44	62.96	32.38	3.23	siltsand	v. poor	3.51	2.17	0.07	6.18
C 5	2.48	96.30	1.22	0.00	sand	moderate	1.34	1.20	-0.01	2.93
C 6	0.21	81.56	16.02	2.22	silty sand	poor	3.05	1.80	0.06	11.46
C 7	0.42	61.89	33.90	3.80	siltsand	poor	3.91	1.95	0.35	9.57
C 8	0.64	92.84	6.32	0.20	sand	moderate	2.03	1.38	0.11	6.12
C 9	0.03	98.72	1.06	0.20	sand	moderate	1.90	0.88	0.01	3.99
C 10	8.03	86.24	5.53	0.20	sand	poor	1.59	1.70	0.12	4.33
C 11	6.19	91.72	2.09	0.00	sand	moderate	1.25	1.36	0.06	2.96
C 12	1.53	73.19	24.39	0.89	silty sand	poor	2.94	1.80	-0.08	6.37
C 13	3.57	93.30	3.13	0.00	sand	poor	1.93	1.47	0.28	2.67
C 14	3.97	43.14	49.16	3.73	sandsilt	extr. poor	3.59	2.66	-0.22	4.41
C 15	1.84	91.87	5.47	0.83	sand	poor	1.96	1.67	-0.07	10.97
C 16	0.80	95.93	2.98	0.29	sand	moderate	2.25	1.08	-0.19	3.82
C 17	8.30	86.34	5.20	0.16	sand	poor	1.37	1.71	-0.03	4.12
C 18	12.75	85.68	1.37	0.20	gravelly sand	poor	0.63	1.46	0.10	2.94
C 19	1.88	90.49	6.77	0.86	sand	poor	2.30	1.47	-0.18	3.28
C 20	0.43	71.40	27.32	0.86	siltsand	poor	3.21	1.58	0.03	6.97
C 21	0.82	92.96	5.90	0.32	sand	moderate	2.67	1.30	-0.45	10.48
C 22	3.13	92.93	3.95	0.00	sand	poor	1.88	1.48	-0.15	2.63
C 23	1.58	56.38	40.13	1.90	siltsand	v. poor	3.66	2.02	-0.03	7.35
C 24	1.50	96.46	2.05	0.00	sand	moderate	1.72	1.25	-0.07	2.95
C 25	2.22	95.41	2.37	0.00	sand	moderate	1.55	1.25	-0.05	3.33
C 26	0.57	85.64	12.27	1.52	silty sand	poor	2.66	1.75	0.09	11.19
C 27	9.71	88.31	1.98	0.00	sand	poor	1.05	1.43	-0.06	2.93
C 28	3.27	91.20	5.22	0.31	sand	poor	1.30	1.53	0.21	7.34
C 29	3.37	91.46	4.89	0.29	sand	poor	1.55	1.47	0.02	9.63
C 30	7.63	91.86	0.51	0.00	sand	moderate	0.70	1.22	0.08	2.81
C 31	10.23	89.00	0.77	0.00	gravelly sand	moderate	0.80	1.35	-0.04	2.63
C 32	1.05	98.15	0.80	0.00	sand	moderate	1.44	1.04	-0.11	3.48
D 1	0.12	99.59	0.29	0.00	sand	well	2.41	0.47	-0.17	12.48
D 2	2.28	95.47	2.25	0.00	sand	moderate	1.22	1.37	0.14	2.71
D 3	15.19	72.84	10.76	1.21	silty gravelly sand	v. poor	1.24	2.43	0.08	5.88
D 4	10.16	87.05	2.79	0.00	gravelly sand	poor	0.87	1.50	0.03	3.00
D 5	0.54	27.18	64.27	8.01	sandsilt	extr. poor	4.85	2.69	0.15	5.87
D 6	0.10	11.21	76.20	12.50	clayey sandy silt	extr. poor	5.80	2.79	0.41	5.53
D 7	11.37	83.85	4.24	0.53	gravelly sand	poor	1.09	1.70	-0.06	3.10
D 8	2.43	54.33	36.74	6.50	siltsand	extr. poor	3.72	3.00	0.19	5.91
D 9	1.59	24.91	63.18	10.33	clayey sandsilt	extr. poor	5.15	3.29	0.20	5.12

Appendix 3: Frequency (%) of components (> 250 µm) of the samples.

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	green	plan	pel	comp	qua
A 1	0.00	0.81	0.11	0.92	0.00	9.45	12.62	0.00	0.14	0.14	0.00	14.13	0.00	0.00	0.00	19.04	43.55
A 2	0.69	14.71	1.45	16.85	0.02	6.19	52.36	0.08	3.75	2.74	0.00	6.29	0.09	0.00	0.00	7.97	3.66
A 3	1.33	19.82	9.54	30.69	0.00	0.26	44.16	0.34	5.82	0.09	0.00	0.00	0.00	0.00	0.00	18.12	0.51
A 4	1.04	12.94	31.55	45.53	0.00	0.09	38.56	0.12	4.80	0.41	0.00	0.00	0.00	0.00	0.00	9.21	1.37
A 5	0.38	23.69	3.78	27.85	0.00	0.16	51.42	0.27	4.76	0.09	0.00	0.00	0.06	0.02	0.00	13.75	1.63
A 6	0.36	13.02	1.73	15.11	0.00	0.92	42.24	0.17	1.96	0.50	0.00	0.96	0.00	0.10	0.00	3.44	34.60
A 7	0.06	0.76	0.04	0.86	0.00	0.74	8.52	0.00	0.18	0.61	0.00	0.24	0.00	0.00	0.00	1.20	87.65
A 8	0.36	9.03	1.40	10.79	0.00	6.01	61.52	0.13	1.15	0.45	0.00	2.32	0.00	0.00	0.00	17.16	0.45
A 10	0.09	1.74	0.15	1.98	0.00	4.65	2.34	0.02	0.11	0.22	0.00	0.00	0.00	0.00	0.00	3.72	86.96
A 11	0.86	21.00	1.40	23.26	0.00	3.83	34.67	0.87	3.93	1.03	0.00	0.23	0.07	0.50	0.00	15.90	15.68
A 12	1.12	3.39	15.15	19.66	0.00	3.14	62.40	0.01	6.50	0.73	0.00	0.03	0.04	0.00	0.00	7.32	0.19
A 13	0.14	0.25	0.39	0.78	0.00	17.72	60.64	0.00	0.10	0.29	0.00	9.07	0.00	0.00	0.00	3.84	7.56
A 14	1.80	3.72	35.35	40.87	0.00	0.18	50.50	0.01	5.33	0.44	0.00	0.00	0.07	0.00	0.00	2.45	0.15
A 15	3.16	37.35	11.51	52.02	0.00	3.16	26.89	0.34	7.47	3.76	0.03	0.50	0.15	0.08	0.00	4.27	1.33
A 16	0.20	0.06	0.52	0.78	0.00	13.46	58.33	0.02	0.34	0.25	0.00	0.56	0.00	0.00	0.00	6.32	19.94
A 17	0.11	0.17	0.31	0.59	0.00	38.79	22.34	0.03	0.32	1.09	0.00	34.99	0.00	0.00	0.00	1.85	0.00
A 18	9.06	3.93	25.40	38.39	0.00	0.51	43.13	0.30	4.32	1.33	0.00	0.00	0.00	0.00	0.00	10.63	1.38
A 19	1.51	42.11	2.95	46.57	0.00	0.91	29.65	1.18	3.61	1.17	0.00	0.00	0.00	1.85	0.00	5.21	9.84
A 20	0.87	0.52	15.34	16.73	0.00	14.65	62.40	0.00	3.45	0.03	0.00	0.60	0.00	0.00	0.00	0.55	1.58
A 21	2.61	7.94	1.53	12.08	0.00	5.00	64.81	0.02	2.40	1.76	0.00	0.12	0.00	0.00	0.00	7.30	6.50
A 22	0.64	19.31	2.58	22.53	0.00	0.30	64.31	0.19	5.65	1.82	0.00	0.26	0.00	0.00	0.00	5.00	0.12
A 23	0.37	0.48	0.45	1.30	0.00	23.98	63.28	0.42	0.42	0.30	0.00	1.65	0.06	0.08	0.00	8.09	0.42
A 24	0.40	1.13	18.02	19.55	0.00	6.30	65.27	0.00	5.92	0.57	0.00	0.91	0.00	0.00	0.00	0.84	0.63
A 25	1.85	35.22	2.27	39.34	0.00	0.21	43.74	0.19	6.08	0.62	0.00	0.00	0.00	0.00	0.00	8.64	1.18
A 26	0.18	0.15	14.25	14.58	0.00	2.19	74.47	0.00	3.16	1.86	0.00	0.00	0.11	0.00	0.00	3.39	0.25
A 27	2.65	1.28	7.81	11.74	0.00	0.17	49.27	0.20	2.26	1.31	0.00	0.00	0.00	0.00	0.00	2.91	32.14
A 28	0.18	0.42	2.05	2.65	0.01	52.95	25.02	0.66	0.96	1.40	0.00	16.11	0.00	0.00	0.00	0.25	0.00
A 29	0.17	0.13	1.23	1.53	0.01	16.34	59.37	8.69	2.36	1.67	0.00	8.68	0.00	0.00	0.00	1.15	0.00
A 30	0.56	43.03	1.50	45.18	0.00	0.21	40.79	0.49	4.19	0.12	0.00	0.00	0.00	0.00	0.00	6.89	2.23
A 32	1.03	5.08	1.41	7.52	0.00	31.03	40.13	0.40	1.96	2.08	0.00	3.45	0.00	0.00	0.00	4.75	8.67
B 1	0.56	0.71	13.00	14.27	0.01	4.57	51.35	0.47	0.26	0.48	0.00	25.08	0.00	0.01	0.00	3.10	0.40
B 2	0.95	0.89	5.24	7.08	0.00	23.32	44.65	3.24	1.08	1.18	0.00	12.69	0.00	0.00	0.00	6.80	0.00
B 3	1.59	1.71	17.55	20.85	0.00	1.42	67.28	0.03	0.93	1.59	0.00	0.00	0.00	0.00	0.00	7.83	0.07
B 4	0.33	0.66	11.42	12.41	0.00	4.93	44.10	1.13	0.22	0.30	0.00	32.00	0.21	0.00	0.00	4.51	0.19
B 6	7.95	1.92	26.75	36.62	0.00	0.62	49.68	0.05	2.23	1.80	0.00	0.00	0.00	0.00	0.00	5.70	3.29
B 7	0.98	1.30	7.84	10.12	0.02	15.82	52.60	0.36	2.10	8.03	0.00	9.12	0.16	0.00	0.00	1.66	0.00
B 8	7.82	0.94	5.76	14.52	0.00	10.04	44.99	0.01	2.98	1.36	0.00	14.71	0.00	0.00	0.00	8.43	2.95
B 9	4.59	2.53	4.01	11.13	0.02	2.16	48.40	0.13	5.05	1.78	0.00	3.98	2.14	0.00	0.00	24.30	0.91
B 10	0.09	0.09	8.06	8.24	0.00	53.90	27.58	0.23	0.29	3.51	0.00	1.28	0.00	0.00	0.00	4.44	0.00
B 11	0.13	1.07	7.14	8.34	0.00	18.59	33.14	0.04	2.49	7.71	0.00	28.95	0.00	0.00	0.00	0.75	0.00
B 12	0.62	1.18	5.94	7.74	0.00	20.95	34.99	0.37	3.42	4.14	0.00	22.50	0.02	0.00	0.00	5.87	0.00
B 13	0.14	0.20	5.38	5.72	0.05	27.04	47.35	0.27	1.94	2.58	0.00	12.71	0.00	0.00	0.02	2.31	0.02
B 14	6.48	7.07	9.06	22.61	0.07	0.07	51.14	0.00	3.54	6.93	0.00	0.00	0.00	0.00	4.72	10.83	0.07
B 15	0.43	0.36	3.55	4.34	0.00	17.08	64.53	0.06	1.84	4.40	0.00	5.05	0.00	0.00	0.00	2.70	0.00
B 16	0.40	2.06	2.40	4.86	0.00	0.68	86.97	0.04	1.66	2.60	0.00	0.18	0.00	0.00	0.04	2.95	0.00
B 17	0.58	31.86	5.59	38.03	0.00	1.57	44.84	0.84	3.59	1.06	0.18	0.13	1.41	1.75	0.00	5.63	0.99
B 18	5.49	1.78	2.36	9.63	0.00	11.83	62.35	0.05	3.63	1.42	0.00	0.68	0.01	0.11	0.00	8.21	2.08
B 19	0.22	0.11	2.19	2.52	0.00	4.31	69.65	0.08	0.74	2.64	0.00	2.82	0.00	0.00	0.00	6.47	0.77
B 20	1.00	0.52	18.19	19.71	0.00	1.61	69.74	0.02	2.90	3.21	0.00	0.00	0.22	0.00	0.00	2.19	0.42
B 21	3.46	3.97	16.35	23.78	0.00	7.36	23.20	0.42	2.04	5.50	0.00	0.00	0.00	0.00	0.74	4.29	32.67
B 22	2.31	3.99	8.01	14.31	0.00	2.91	74.58	0.13	2.44	3.20	0.00	0.00	0.00	0.28	0.09	1.04	1.01
B 23	0.04	0.50	2.96	3.50	0.01	23.62	51.32	0.36	1.29	5.95	0.00	11.70	0.03	0.00	0.00	2.27	0.04
B 24	0.99	1.69	4.00	6.68	0.08	11.55	47.74	0.38	2.35	2.64	0.00	23.44	0.40	0.00	0.00	4.70	0.04
B 25	0.09	0.29	0.81	1.19	0.00	27.00	62.14	0.76	0.05	0.29	0.00	3.32	0.00	0.00	0.00	5.08	0.18
B 26	0.06	1.41	0.00	1.47	0.00	21.89	31.41	0.00	1.69	1.01	0.00	24.48	0.00	0.00	0.00	17.57	0.48
B 28	0.97	0.29	10.44	11.70	0.00	1.95	56.30	0.00	0.30	0.23	0.00	0.35	0.00	0.01	0.13	28.31	0.71
B 30	1.46	2.15	5.02	8.63	0.33	31.03	34.86	2.64	2.34	2.85	0.00	16.06	0.14	0.00	0.29	0.82	0.00
B 31	0.85	0.98	1.62	3.45	0.01	37.72	34.76	1.16	3.68	3.39	0.01	12.76	0.07	0.00	0.00	3.00	0.00
B 32	5.56	1.35	10.61	17.52	0.00	5.94	52.62	0.40	1.59	2.38	0.00	0.00	0.36	0.00	0.03	17.74	1.43
B 33	3.57	5.74	45.32	54.81	0.00	0.67	9.32	1.20	1.59	2.90	0.00	2.03	0.26	0.00	0.23	27.17	0.00
B 34	2.20	1.02	59.95	63.17	0.00	1.74	22.17	0.10	1.23	1.35	0.00	0.03	0.03	0.01	0.00	10.09	0.07
B 35	0.95	1.49	16.81	19.25	0.00	0.26	62.35	0.03	6.13	3.20	0.00	0.63	0.24	0.02	0.09	7.34	0.45
B 36	1.40	0.67	27.73	29.80	0.02	0.47	60.32	0.09	1.60	1.84	0.00	0.07	0.00	0.16	0.00	5.75	0.07
B 37	4.85	1.20	58.72	64.77	0.00	2.35	16.22	0.03	1.23	0.51	0.00	0.00	0.02	0.00	0.00	6.62	8.25
B 38	0.82	0.30	39.96	41.08	0.00	9.82	42.93	0.00	3.46	1.20	0.00	0.00	0.00	0.00	0.00	1.25	0.28
B 41	3.37	1.87	8.17	13.41	0.00	0.48	64.80	0.03	3.27	2.33	0.00	1.29	0.00	0.00	0.38	11.07	2.89
B 42	2.37	0.47	5.09	7.93	0.00	1.02	66.25	0.02	5.58	3.23	0.00	2.58	0.00	0.00	0.06	10.57	2.76
B 43	4.51	7.75	10.86	23.12	0.00	0.00	56.50	0.00	3.47	9.31	0.00	0.00	0.00	0.00	0.74	6.87	0.00
B 44	0.92	1.41	3.92	6.25	0.00	0.24	82.01	0.00	2.25	7.01	0.00	0.00	0.00	0.00	0.00	2.25	0.00
B 45	0.28	0.11	0.84	1.23	0.01	10.71	53.83	0.86	1.14	2.30	0.00	29.58	0.00	0.00	0.00	0.34	0.00
B 46	0.63	1.15	6.00	7.78	0.00	0.00	82.23	0.00	1.42	4.50	0.00	0.00	0.00	0.00	0.00	4.03	0.03
B 48	3.06	0.46	1.71	5.23	0.00	6.70	65.95	0.09	3.04	2.78	0.00	0.32	1.11	0.00	0.26	13.08	1.45
B 49	0.44	0.27	4.36	5.07	0.00	11.16	51.41	0.04	0.22	1.16	0.00	1.98	0.00	0.00	0.49	28.02	0.45

Appendix 3: continued

no.	aggl	mil	hyal	for	spon	coral	moll	worm	cru	ech	vert	red	green	plan	pel	comp	qua
B 51	1.57	0.80	0.25	2.62	0.00	0.00	7.65	0.14	1.26	0.36	0.00	0.00	87.31	0.00	0.03	0.19	0.42
B 52	0.97	0.98	24.92	26.87	0.01	26.46	34.50	0.56	0.82	1.34	0.00	1.92	0.02	0.00	0.00	7.50	0.00
B 53	1.86	1.94	26.88	30.68	0.00	0.13	55.87	0.00	1.96	5.80	0.00	0.00	0.27	0.00	0.00	5.30	0.00
B 54	3.30	1.01	10.72	15.03	0.00	0.73	63.92	0.26	3.49	2.37	0.00	0.94	0.63	0.00	0.64	10.39	1.60
B 56	0.15	0.48	0.74	1.37	0.00	4.85	63.70	0.56	0.03	0.70	0.00	21.35	0.00	0.00	0.00	7.35	0.00
B 57	0.34	0.09	1.09	1.52	0.00	0.82	70.20	0.00	0.05	0.11	0.00	14.31	0.00	0.00	0.03	11.97	0.99
B 58	1.51	3.62	24.75	29.88	0.00	0.00	62.06	0.00	2.16	3.73	0.00	0.00	0.00	0.00	0.00	2.02	0.15
B 59	0.18	0.12	0.42	0.72	0.00	19.67	52.92	0.63	0.18	1.81	0.00	20.13	0.02	0.00	0.00	3.92	0.00
B 60	0.27	0.06	0.74	1.07	0.00	2.16	62.59	1.13	0.22	0.03	0.00	30.57	0.00	0.00	0.00	2.22	0.00
B 61	0.07	0.03	1.56	1.66	0.01	9.09	70.03	0.94	0.04	0.55	0.00	10.88	0.00	0.00	0.00	6.52	0.29
B 67	0.61	0.52	0.15	1.28	0.00	32.82	56.23	0.56	0.84	1.78	0.00	0.22	0.38	0.00	0.00	5.85	0.05
B 68	0.36	0.71	0.80	1.87	0.00	41.60	51.85	0.22	0.45	0.28	0.00	3.12	0.00	0.00	0.00	0.53	0.07
B 69	1.83	0.72	3.51	6.06	0.00	0.41	84.93	0.18	3.41	1.97	0.00	0.00	0.00	0.00	0.00	2.56	0.46
B 70	7.02	8.80	14.17	29.99	0.00	0.00	47.25	0.00	6.33	8.28	0.00	0.00	0.00	0.00	0.00	8.15	0.00
B 73	0.03	1.96	4.08	6.07	0.00	47.82	20.66	0.10	1.50	6.97	0.00	15.42	1.03	0.00	0.00	0.44	0.00
B 74	0.04	2.97	0.02	3.03	0.00	19.62	60.97	0.00	0.28	0.64	0.00	7.82	0.00	0.00	0.00	3.01	4.61
C 1	0.48	1.27	14.86	16.61	0.00	24.04	52.56	0.22	0.60	0.93	0.00	0.00	0.00	0.00	0.00	5.01	0.00
C 2	3.98	19.89	31.22	55.09	0.00	0.00	26.79	0.22	1.14	1.47	0.00	0.00	1.81	0.00	0.00	13.48	0.00
C 3	3.26	3.96	7.28	14.50	0.00	0.00	58.10	0.20	2.82	1.02	0.00	0.00	13.25	0.22	0.00	9.91	0.00
C 4	9.30	2.74	3.12	15.16	0.00	2.91	69.40	0.90	3.83	0.76	0.00	0.00	0.00	0.00	0.00	6.19	0.86
C 5	1.04	0.62	2.26	3.92	0.00	9.99	44.85	0.42	0.12	4.88	0.00	0.15	0.00	0.00	0.00	31.51	4.15
C 6	0.74	21.90	1.24	23.88	0.00	16.63	29.14	1.24	4.10	0.16	0.00	0.77	0.00	8.09	0.00	12.52	3.46
C 7	1.39	20.45	1.74	23.58	0.25	3.38	47.64	1.89	5.11	0.65	0.00	0.00	0.10	0.94	0.00	15.68	0.79
C 8	1.59	3.44	2.27	7.30	0.03	23.29	46.48	0.23	1.43	2.59	0.00	7.98	0.00	0.00	0.00	10.25	0.42
C 9	0.13	0.60	0.22	0.95	0.00	1.31	1.43	0.00	0.06	0.32	0.00	0.85	0.00	0.00	0.00	0.57	94.52
C 10	0.13	0.89	0.39	1.41	0.00	11.16	57.29	0.06	0.02	0.04	0.00	0.00	0.00	0.00	0.00	29.88	0.15
C 11	0.01	0.65	0.04	0.70	0.00	5.25	34.76	0.00	0.13	0.02	0.00	0.00	0.00	0.00	0.00	59.15	0.00
C 12	0.25	23.30	1.52	25.07	0.00	3.92	53.27	0.22	1.65	1.45	0.00	6.43	0.00	0.00	0.00	7.99	0.00
C 13	0.00	1.69	0.03	1.72	0.00	0.14	41.26	0.00	0.95	0.00	0.00	0.00	0.00	0.00	0.11	21.87	33.95
C 14	1.01	1.05	6.59	8.65	0.04	14.92	34.58	0.53	1.54	1.26	0.00	30.70	1.19	0.00	0.00	7.62	0.00
C 15	0.11	9.83	0.11	10.05	0.00	6.75	48.27	0.06	0.46	0.35	0.00	13.66	0.00	7.01	0.00	13.37	0.01
C 16	0.54	33.92	0.77	35.22	0.00	7.06	35.93	0.97	6.95	0.84	0.00	2.12	0.03	0.77	0.00	8.04	2.06
C 17	0.20	1.60	0.51	2.31	0.00	4.15	74.27	0.07	0.03	0.08	0.00	0.00	0.00	0.03	0.00	18.01	1.04
C 18	0.07	0.31	0.06	0.44	0.00	21.19	66.83	0.00	0.01	0.08	0.00	0.06	0.00	0.00	0.00	11.38	0.00
C 19	0.43	41.55	0.77	42.75	0.00	5.83	35.14	1.25	3.02	0.27	0.00	0.00	0.00	0.00	0.00	11.23	0.51
C 20	0.73	28.07	2.41	31.21	0.00	0.07	32.62	0.73	14.38	0.98	0.00	0.00	0.00	2.01	0.00	17.83	0.17
C 21	0.07	2.02	0.06	2.15	0.01	34.68	23.70	0.02	0.34	0.00	0.00	0.00	0.00	0.00	0.08	15.81	23.20
C 23	0.69	5.58	0.44	6.71	0.00	0.20	63.65	0.07	3.58	9.31	0.00	0.00	0.00	2.17	0.00	14.13	0.18
C 24	0.10	0.76	0.51	1.37	0.00	10.08	27.19	0.03	0.43	2.65	0.00	2.69	0.00	0.00	0.00	55.56	0.00
C 26	8.44	4.37	3.43	16.24	0.00	1.98	54.16	0.21	1.93	1.36	0.00	0.00	0.00	0.00	0.00	19.34	4.77
C 27	0.41	0.09	2.89	3.39	0.00	34.36	35.24	0.20	0.11	2.73	0.00	19.04	0.00	0.00	0.00	4.93	0.01
C 28	0.00	0.12	2.40	2.52	0.00	56.16	24.73	0.02	1.17	5.02	0.00	8.06	0.00	0.00	0.00	2.31	0.00
D 1	0.84	8.27	0.84	9.95	0.00	8.35	46.69	0.17	3.50	0.00	0.00	9.54	0.34	0.00	0.59	1.86	19.00
D 2	0.84	5.37	0.78	6.99	0.00	23.45	29.27	0.16	1.42	0.78	0.00	27.87	0.00	0.29	0.00	8.32	1.11
D 3	0.53	1.19	1.82	3.54	0.07	15.63	46.84	2.84	0.95	1.34	0.00	26.39	0.07	0.00	0.00	2.21	0.12
D 5	0.47	1.15	2.96	4.58	0.00	4.66	66.81	0.40	2.61	5.06	0.00	10.79	0.00	0.00	0.00	4.90	0.20
D 6	1.94	2.14	8.06	12.14	0.00	0.00	61.33	0.00	5.71	11.84	0.00	0.71	0.00	0.00	0.00	8.16	0.10
D 7	0.37	0.97	1.03	2.37	0.00	18.10	63.32	1.58	0.51	0.10	0.00	12.78	0.00	0.00	0.00	1.13	0.12
D 8	0.51	0.79	2.18	3.48	0.03	14.28	55.86	1.80	1.54	4.84	0.00	16.08	0.25	0.00	0.00	1.67	0.18
D 9	1.25	2.10	7.62	10.97	0.06	0.81	68.06	0.13	2.63	5.42	0.00	5.45	0.00	0.00	0.00	6.46	0.00

Appendix 4: Mineral composition (%) and contents of trace elemtents (ppm) of the samples. (First line represents values of total sample, second those of mud fraction).

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
A 2	22.00	44.00	10.00	76.00	20.00	4.00	0.00	4354	286	0.18
	22.00	42.00	18.00	82.00	16.00	2.00	0.00			
A 3	16.00	43.00	19.00	78.00	21.00	1.00	0.00	3290	814	21.99
	18.00	39.00	18.00	75.00	24.00	1.00	0.00			
A 4	12.00	33.00	19.00	64.00	21.00	10.00	5.00	2419	1423	48.38
	10.00	22.00	19.00	51.00	39.00	5.00	5.00			
A 5	18.00	37.00	17.00	72.00	18.00	9.00	1.00	2876	1058	37.38
	14.00	26.00	18.00	58.00	31.00	7.00	4.00			
A 6	3.00	5.00	4.00	12.00	9.00	53.00	26.00	649	1880	131.94
	4.00	6.00	11.00	21.00	14.00	50.00	15.00			
A 7	5.00	4.00	2.00	11.00	44.00	26.00	19.00	1539	286	43.98
A 8	17.00	35.00	23.00	75.00	18.00	3.00	4.00	3369	1078	41.78
	10.00	20.00	18.00	48.00	41.00	6.00	5.00			
A 9	8.00	13.00	4.00	25.00	41.00	25.00	9.00	2951	503	0.40
A 10	13.00	14.00	4.00	31.00	31.00	30.00	8.00	4827	418	0.22
	13.00	41.00	12.00	66.00	24.00	7.00	3.00			
A 11	16.00	46.00	10.00	72.00	16.00	8.00	4.00	3285	462	1.10
	17.00	44.00	17.00	78.00	11.00	9.00	2.00			
A 12	16.00	36.00	16.00	68.00	14.00	16.00	2.00	2542	1100	35.18
	15.00	34.00	18.00	67.00	25.00	6.00	2.00			
A 13	41.00	39.00	11.00	91.00	9.00	0.00	0.00	5784	565	98.96
	22.00	39.00	18.00	79.00	16.00	3.00	2.00			
A 14	12.00	39.00	19.00	70.00	15.00	10.00	5.00	2199	1132	46.18
	13.00	29.00	21.00	63.00	19.00	5.00	13.00			
A 15	5.00	10.00	6.00	21.00	44.00	22.00	13.00	1869	1113	87.96
	10.00	23.00	19.00	52.00	35.00	9.00	4.00			
A 16	21.00	37.00	21.00	79.00	16.00	2.00	3.00	3831	871	26.39
	13.00	35.00	19.00	67.00	23.00	6.00	4.00			
A 17	44.00	34.00	17.00	95.00	4.00	1.00	0.00	6192	330	0.66
	18.00	24.00	22.00	64.00	26.00	7.00	3.00			
A 18	18.00	37.00	19.00	74.00	16.00	5.00	5.00	3782	1429	43.98
	17.00	35.00	25.00	78.00	16.00	4.00	2.00			
A 19	9.00	18.00	12.00	39.00	31.00	21.00	9.00	3219	1924	153.93
	7.00	15.00	19.00	41.00	45.00	9.00	5.00			
A 20	17.00	38.00	17.00	72.00	17.00	7.00	4.00	2436	1143	43.98
	15.00	32.00	20.00	67.00	24.00	5.00	4.00			
A 21	20.00	40.00	18.00	78.00	14.00	6.00	2.00	3325	941	41.78
	17.00	36.00	18.00	71.00	23.00	4.00	2.00			
A 22	14.00	28.00	20.00	62.00	25.00	10.00	3.00	2947	1198	48.38
	14.00	31.00	20.00	65.00	26.00	4.00	5.00			
A 23	33.00	42.00	15.00	90.00	7.00	2.00	1.00	5493	462	0.66
	32.00	41.00	17.00	90.00	8.00	1.00	1.00			
A 24	15.00	36.00	16.00	67.00	21.00	11.00	1.00	2027	1341	63.77
	14.00	30.00	19.00	63.00	28.00	6.00	3.00			
A 25	21.00	40.00	17.00	78.00	17.00	3.00	2.00	3598	1207	37.38
	16.00	29.00	19.00	65.00	27.00	4.00	4.00			
A 26	15.00	35.00	17.00	67.00	25.00	6.00	2.00	2604	1465	39.58
	15.00	35.00	19.00	69.00	21.00	5.00	5.00			
A 27	18.00	29.00	18.00	65.00	20.00	11.00	4.00	4178	880	24.19
	19.00	32.00	18.00	69.00	22.00	6.00	3.00			
A 28	47.00	32.00	17.00	96.00	4.00	0.00	0.00	6865	264	0.33
	34.00	34.00	18.00	86.00	10.00	3.00	1.00			
A 29	27.00	40.00	17.00	84.00	12.00	3.00	1.00	4763	1231	26.39
	20.00	37.00	20.00	77.00	21.00	1.00	1.00			
A 30	19.00	39.00	16.00	74.00	18.00	5.00	3.00	3589	627	1.65
	13.00	25.00	26.00	64.00	26.00	6.00	4.00			
A 31	38.00	39.00	16.00	93.00	6.00	1.00	0.00	5304	240	0.22
	13.00	26.00	16.00	55.00	33.00	7.00	5.00			
A 32	10.00	13.00	7.00	30.00	40.00	22.00	8.00	3598	1231	109.95
A 33	1.00	2.00	1.00	4.00	47.00	37.00	12.00	0	549	0.30
B 1	23.00	52.00	23.00	98.00	2.00	0.00	0.00	4134	543	1.56
	21.00	42.00	19.00	82.00	18.00	0.00	0.00			
B 2	26.00	49.00	13.00	88.00	12.00	0.00	0.00	4402	385	0.66
	24.00	45.00	18.00	87.00	13.00	0.00	0.00			
B 3	20.00	48.00	24.00	92.00	8.00	0.00	0.00	3963	904	1.61
	22.00	40.00	26.00	88.00	12.00	0.00	0.00			
B 4	22.00	53.00	18.00	93.00	7.00	0.00	0.00	3848	530	0.81
	22.00	44.00	18.00	84.00	16.00	0.00	0.00			
B 5	25.00	52.00	11.00	88.00	12.00	0.00	0.00	4248	732	0.62
	23.00	44.00	19.00	86.00	14.00	0.00	0.00			
B 6	25.00	44.00	20.00	89.00	11.00	0.00	0.00	4130	721	21.99
	22.00	45.00	20.00	87.00	13.00	0.00	0.00			
B 7	31.00	50.00	12.00	93.00	7.00	0.00	0.00	5058	484	1.14
	33.00	47.00	12.00	92.00	8.00	0.00	0.00			

Appendix 4: continued.

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
B 8	26.00	38.00	20.00	84.00	9.00	0.00	7.00	4235	506	0.88
	25.00	44.00	24.00	93.00	7.00	0.00	0.00			
B 9	27.00	44.00	15.00	86.00	14.00	0.00	0.00	4904	563	1.10
	26.00	48.00	16.00	90.00	10.00	0.00	0.00			
B 10	39.00	41.00	16.00	97.00	3.00	0.00	0.00	5322	0	0.20
B 11	27.00	48.00	15.00	90.00	4.00	3.00	3.00	4706	1	0.53
	24.00	47.00	18.00	89.00	11.00	0.00	0.00			
B 12	27.00	50.00	14.00	91.00	9.00	0.00	0.00	4631	88	0.59
	23.00	50.00	19.00	92.00	5.00	2.00	1.00			
B 13	30.00	39.00	17.00	86.00	14.00	0.00	0.00	4970	1121	34.08
	19.00	43.00	22.00	84.00	13.00	3.00	0.00			
B 14	19.00	44.00	20.00	83.00	12.00	4.00	1.00	3606	1352	27.49
	19.00	45.00	20.00	84.00	16.00	0.00	0.00			
B 15	28.00	46.00	20.00	94.00	6.00	0.00	0.00	3963	690	1.01
	25.00	44.00	18.00	87.00	10.00	1.00	2.00			
B 16	25.00	46.00	15.00	86.00	14.00	0.00	0.00	3452	1045	1.63
	22.00	48.00	18.00	88.00	12.00	0.00	0.00			
B 17	23.00	48.00	15.00	86.00	8.00	4.00	2.00	4512	508	0.66
	21.00	42.00	18.00	81.00	14.00	3.00	2.00			
B 18	33.00	42.00	17.00	92.00	8.00	0.00	0.00	4745	352	0.64
	23.00	45.00	18.00	86.00	14.00	0.00	0.00			
B 19	32.00	39.00	21.00	92.00	8.00	0.00	0.00	3778	449	1.54
	21.00	43.00	20.00	84.00	16.00	0.00	0.00			
B 20	22.00	47.00	15.00	84.00	15.00	1.00	0.00	3831	693	26.39
	23.00	49.00	16.00	88.00	12.00	0.00	0.00			
B 21	22.00	40.00	19.00	81.00	16.00	2.00	1.00	3857	836	1.65
	23.00	46.00	19.00	88.00	5.00	6.00	1.00			
B 22	20.00	47.00	18.00	85.00	15.00	0.00	0.00	4081	1482	32.99
	21.00	49.00	17.00	87.00	13.00	0.00	0.00			
B 23	16.00	47.00	16.00	79.00	21.00	0.00	0.00			
	21.00	50.00	18.00	89.00	11.00	0.00	0.00			
B 24	30.00	46.00	16.00	92.00	8.00	0.00	0.00	4970	614	1.54
	28.00	46.00	17.00	91.00	9.00	0.00	0.00			
B 25	51.00	25.00	15.00	91.00	9.00	0.00	0.00	6659	0	0.44
	33.00	42.00	14.00	89.00	11.00	0.00	0.00			
B 26	53.00	29.00	9.00	91.00	9.00	0.00	0.00	7886	68	0.06
B 27	46.00	39.00	11.00	96.00	4.00	0.00	0.00	6439	33	0.18
	42.00	41.00	12.00	95.00	5.00	0.00	0.00			
B 28	32.00	43.00	16.00	91.00	8.00	1.00	0.00	4820	979	23.09
	19.00	45.00	21.00	85.00	11.00	3.00	1.00			
B 30	28.00	53.00	14.00	96.00	4.00	0.00	0.00	4565	279	1.14
	29.00	50.00	16.00	95.00	5.00	0.00	0.00			
B 31	36.00	48.00	13.00	97.00	3.00	0.00	0.00	5436	145	0.48
	37.00	43.00	15.00	95.00	5.00	0.00	0.00			
B 32	18.00	52.00	22.00	92.00	8.00	0.00	0.00	4367	484	0.88
	28.00	45.00	19.00	92.00	8.00	0.00	0.00			
B 33	21.00	49.00	20.00	90.00	10.00	0.00	0.00	4077	693	1.54
	25.00	45.00	20.00	90.00	10.00	0.00	0.00			
B 34	18.00	49.00	19.00	86.00	14.00	0.00	0.00	3378	963	23.09
	21.00	44.00	23.00	88.00	12.00	0.00	0.00			
B 35	20.00	49.00	21.00	90.00	10.00	0.00	0.00	3848	873	24.19
	23.00	42.00	23.00	88.00	10.00	1.00	1.00			
B 36	19.00	44.00	22.00	85.00	15.00	0.00	0.00	3646	783	1.61
	23.00	45.00	21.00	89.00	11.00	0.00	0.00			
B 37	23.00	48.00	20.00	91.00	9.00	0.00	0.00	3976	631	1.54
	23.00	44.00	23.00	90.00	10.00	0.00	0.00			
B 38	13.00	33.00	16.00	62.00	19.00	14.00	5.00	2388	1001	24.19
	17.00	41.00	20.00	78.00	16.00	3.00	3.00			
B 39	15.00	52.00	30.00	97.00	3.00	0.00	0.00	2969	242	0.81
	21.00	46.00	22.00	89.00	11.00	0.00	0.00			
B 40	22.00	47.00	26.00	95.00	5.00	0.00	0.00	3615	169	0.77
	26.00	43.00	21.00	90.00	10.00	0.00	0.00			
B 41	34.00	38.00	24.00	96.00	4.00	0.00	0.00	4328	275	0.44
	24.00	44.00	20.00	88.00	12.00	0.00	0.00			
B 42	24.00	47.00	20.00	91.00	9.00	0.00	0.00	4288	849	1.10
	21.00	44.00	18.00	83.00	11.00	3.00	3.00			
B 43	16.00	45.00	19.00	80.00	14.00	4.00	2.00	3171	1623	65.97
	17.00	44.00	22.00	83.00	11.00	4.00	2.00			
B 44	16.00	44.00	19.00	79.00	21.00	0.00	0.00	3430	1570	39.58
	15.00	48.00	21.00	84.00	7.00	5.00	4.00			
B 45	22.00	44.00	20.00	86.00	14.00	0.00	0.00	4178	1132	1.76
B 46	16.00	43.00	20.00	79.00	15.00	4.00	2.00	3624	1469	37.38
	19.00	44.00	20.00	84.00	11.00	4.00	1.00			
B 47	33.00	42.00	20.00	96.00	4.00	0.00	0.00	5110	33	0.99
	28.00	43.00	18.00	89.00	11.00	0.00	0.00			
B 48	28.00	44.00	17.00	89.00	6.00	5.00	0.00	4420	567	1.32
	25.00	45.00	18.00	88.00	12.00	0.00	0.00			

Appendix 4: continued.

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
B 49	36.00	40.00	17.00	93.00	4.00	2.00	1.00	4974	1231	1.54
	20.00	46.00	20.00	86.00	14.00	0.00	0.00			
B 50	29.00	45.00	15.00	89.00	2.00	8.00	1.00	4882	1058	25.29
	22.00	46.00	20.00	88.00	12.00	0.00	0.00			
B 51	40.00	39.00	15.00	94.00	6.00	0.00	0.00	6324	510	1.67
	27.00	44.00	21.00	92.00	8.00	0.00	0.00			
B 52	19.00	51.00	19.00	89.00	11.00	0.00	0.00	3835	704	26.39
	25.00	47.00	20.00	92.00	5.00	1.00	2.00			
B 53	18.00	51.00	19.00	88.00	12.00	0.00	0.00	3479	814	1.63
	20.00	41.00	21.00	82.00	10.00	4.00	4.00			
B 54	19.00	41.00	28.00	88.00	12.00	0.00	0.00	4266	785	34.08
	22.00	44.00	22.00	88.00	12.00	0.00	0.00			
B 55	23.00	49.00	18.00	90.00	10.00	0.00	0.00	4139	532	1.65
	25.00	43.00	21.00	89.00	11.00	0.00	0.00			
B 56	33.00	46.00	18.00	97.00	1.00	1.00	1.00	3848	539	0.66
	18.00	45.00	19.00	82.00	18.00	0.00	0.00			
B 57	28.00	42.00	20.00	90.00	10.00	0.00	0.00	4222	959	1.65
	21.00	38.00	21.00	80.00	13.00	4.00	3.00			
B 58	20.00	48.00	20.00	88.00	7.00	3.00	2.00	3716	1388	48.38
	20.00	46.00	17.00	83.00	17.00	0.00	0.00			
B 59	33.00	45.00	19.00	96.00	4.00	0.00	0.00	4565	752	0.44
	18.00	37.00	20.00	75.00	25.00	0.00	0.00			
B 60	33.00	43.00	21.00	97.00	3.00	0.00	0.00	4051	781	0.20
	19.00	44.00	17.00	80.00	12.00	5.00	3.00			
B 61	34.00	43.00	20.00	97.00	1.00	1.00	1.00	3598	783	32.99
	20.00	40.00	22.00	82.00	18.00	0.00	0.00			
B 62	20.00	44.00	15.00	79.00	21.00	0.00	0.00	4130	537	1.52
	29.00	46.00	17.00	92.00	5.00	2.00	1.00			
B 63	20.00	53.00	15.00	88.00	8.00	3.00	1.00	3844	620	1.98
	24.00	48.00	20.00	92.00	8.00	0.00	0.00			
B 64	19.00	53.00	16.00	88.00	12.00	0.00	0.00	3558	818	32.99
	25.00	46.00	20.00	91.00	8.00	1.00	0.00			
B 65	17.00	45.00	23.00	85.00	10.00	3.00	2.00	3598	816	21.99
	22.00	39.00	23.00	85.00	15.00	0.00	0.00			
B 66	26.00	49.00	13.00	88.00	4.00	6.00	2.00	4117	792	0.92
	23.00	42.00	20.00	85.00	12.00	2.00	1.00			
B 67	35.00	43.00	15.00	93.00	7.00	0.00	0.00	4789	341	0.22
	18.00	44.00	25.00	87.00	10.00	2.00	1.00			
B 68	37.00	44.00	13.00	95.00	5.00	0.00	0.00	4561	297	0.22
	22.00	40.00	19.00	81.00	11.00	5.00	3.00			
B 69	20.00	38.00	18.00	76.00	16.00	6.00	2.00	4781	605	0.18
	20.00	44.00	19.00	83.00	12.00	2.00	3.00			
B 70	18.00	44.00	19.00	81.00	11.00	7.00	1.00	3413	1253	46.18
	19.00	47.00	17.00	83.00	17.00	0.00	0.00			
B 71	22.00	40.00	14.00	76.00	20.00	2.00	2.00	3958	625	1.61
	30.00	44.00	18.00	92.00	8.00	0.00	0.00			
B 72	34.00	44.00	16.00	94.00	6.00	0.00	0.00	5484	110	0.22
	28.00	45.00	15.00	88.00	12.00	0.00	0.00			
B 73	29.00	49.00	13.00	91.00	3.00	3.00	3.00	4833	0	0.08
	27.00	47.00	16.00	90.00	10.00	0.00	0.00			
B 74	48.00	30.00	10.00	88.00	12.00	0.00	0.00	6817	88	0.22
	25.00	49.00	14.00	87.00	13.00	0.00	0.00			
B 75	26.00	52.00	12.00	90.00	10.00	0.00	0.00	4671	22	0.59
	24.00	48.00	14.00	86.00	14.00	0.00	0.00			
C 1	16.00	51.00	26.00	93.00	7.00	0.00	0.00	3391	462	0.77
	19.00	43.00	18.00	80.00	20.00	0.00	0.00			
C 2	17.00	56.00	18.00	91.00	9.00	0.00	0.00	3646	583	1.10
	20.00	49.00	21.00	90.00	10.00	0.00	0.00			
C 3	20.00	45.00	20.00	85.00	15.00	0.00	0.00	4200	567	0.70
	22.00	47.00	23.00	92.00	8.00	0.00	0.00			
C 4	23.00	49.00	15.00	87.00	13.00	0.00	0.00	4424	308	0.88
	27.00	45.00	18.00	90.00	10.00	0.00	0.00			
C 5	34.00	34.00	16.00	84.00	8.00	5.00	3.00	4789	145	0.55
	35.00	41.00	14.00	90.00	8.00	2.00	1.00			
C 6	23.00	34.00	16.00	73.00	12.00	11.00	4.00	4794	862	37.38
	23.00	31.00	18.00	72.00	19.00	2.00	7.00			
C 7	19.00	31.00	14.00	64.00	22.00	10.00	4.00	3879	785	28.59
	22.00	27.00	21.00	70.00	24.00	3.00	3.00			
C 8	36.00	44.00	12.00	92.00	8.00	0.00	0.00	4596	198	0.18
	35.00	38.00	14.00	87.00	10.00	2.00	1.00			
C 9	2.00	3.00	6.00	11.00	44.00	27.00	18.00	396	592	1.65
	7.00	10.00	23.00	40.00	36.00	19.00	5.00			
C 10	44.00	40.00	10.00	94.00	6.00	0.00	0.00	6395	147	0.44
	27.00	42.00	18.00	87.00	9.00	2.00	2.00			
C 11	51.00	31.00	10.00	92.00	1.00	7.00	0.00	7314	132	0.08
	26.00	45.00	13.00	84.00	14.00	1.00	1.00			

Appendix 4: continued.

no.	arag	Mg-cal	cal	carb	qua	plag	alkal	Sr	Fe	Mn
C 12	34.00	47.00	12.00	93.00	7.00	0.00	0.00	5766	264	0.07
	33.00	43.00	16.00	92.00	6.00	1.00	1.00			
C 13	16.00	3.00	8.00	27.00	44.00	16.00	13.00	4957	990	1.06
	12.00	6.00	20.00	38.00	48.00	9.00	5.00			
C 14	30.00	44.00	16.00	90.00	10.00	0.00	0.00	5278	431	0.84
	30.00	42.00	18.00	90.00	10.00	0.00	0.00			
C 15	34.00	43.00	11.00	88.00	6.00	3.00	3.00	5678	141	1.06
	23.00	37.00	12.00	72.00	24.00	3.00	1.00			
C 16	14.00	31.00	10.00	55.00	25.00	11.00	9.00	3215	312	0.18
	18.00	29.00	16.00	63.00	30.00	4.00	3.00			
C 17	38.00	46.00	7.00	91.00	9.00	0.00	0.00	5106	205	0.04
	25.00	44.00	17.00	85.00	15.00	0.00	0.00			
C 18	51.00	34.00	10.00	94.00	6.00	0.00	0.00	6360	66	0.02
	26.00	42.00	15.00	83.00	9.00	4.00	4.00			
C 19	19.00	27.00	11.00	57.00	30.00	8.00	5.00	3554	462	1.54
	12.00	18.00	18.00	48.00	40.00	7.00	5.00			
C 20	24.00	44.00	15.00	83.00	17.00	0.00	0.00	4745	290	0.04
	24.00	43.00	17.00	84.00	11.00	2.00	3.00			
C 21	7.00	6.00	11.00	24.00	46.00	22.00	8.00	2846	873	65.97
	6.00	9.00	20.00	35.00	50.00	9.00	6.00			
C 22	40.00	32.00	13.00	85.00	9.00	4.00	2.00	5977	328	0.22
	28.00	31.00	17.00	76.00	19.00	4.00	1.00			
C 23	28.00	42.00	15.00	85.00	15.00	0.00	0.00	5058	618	0.77
	28.00	46.00	16.00	90.00	10.00	0.00	0.00			
C 24	47.00	37.00	10.00	94.00	6.00	0.00	0.00	7010	77	0.44
	34.00	40.00	12.00	86.00	14.00	0.00	0.00			
C 25	35.00	44.00	19.00	98.00	3.00	0.00	0.00	5379	51	0.20
	39.00	40.00	11.00	90.00	5.00	0.00	5.00			
C 26	23.00	31.00	15.00	69.00	18.00	7.00	6.00	3857	396	21.99
	29.00	41.00	20.00	90.00	10.00	0.00	0.00			
C 27	30.00	47.00	18.00	96.00	4.00	0.00	0.00	4816	33	1.32
	28.00	47.00	19.00	94.00	6.00	0.00	0.00			
C 28	33.00	46.00	18.00	97.00	3.00	0.00	0.00	5036	22	1.14
	41.00	44.00	12.00	97.00	3.00	0.00	0.00			
C 29	16.00	57.00	24.00	97.00	3.00	0.00	0.00	3364	207	0.88
	23.00	44.00	18.00	85.00	14.00	1.00	0.00			
C 30	55.00	28.00	14.00	97.00	3.00	0.00	0.00	7176	22	0.05
C 31	43.00	39.00	14.00	96.00	4.00	0.00	0.00	6091	33	0.05
C 32	28.00	23.00	12.00	63.00	25.00	11.00	1.00	4086	165	1.54
D 1	5.00	4.00	4.00	13.00	47.00	25.00	15.00	1924	875	120.95
D 2	46.00	36.00	12.00	94.00	6.00	0.00	0.00	6417	506	0.05
	23.00	39.00	17.00	79.00	17.00	3.00	1.00			
D 3	34.00	39.00	21.00	94.00	6.00	0.00	0.00	4592	286	0.77
	31.00	41.00	18.00	90.00	10.00	0.00	0.00			
D 4	33.00	46.00	16.00	95.00	5.00	0.00	0.00	4433	319	0.06
	29.00	42.00	17.00	87.00	13.00	0.00	0.00			
D 5	27.00	45.00	18.00	90.00	10.00	0.00	0.00	4323	871	2.09
	27.00	45.00	16.00	89.00	11.00	0.00	0.00			
D 6	25.00	45.00	18.00	88.00	10.00	1.00	1.00	4389	858	0.97
	25.00	47.00	17.00	89.00	8.00	1.00	2.00			
D 7	33.00	39.00	25.00	97.00	3.00	0.00	0.00	4517	198	0.07
	28.00	44.00	17.00	89.00	11.00	0.00	0.00			
D 8	24.00	45.00	18.00	87.00	13.00	0.00	0.00	4556	719	1.10
	30.00	43.00	18.00	91.00	9.00	0.00	0.00			
D 9	24.00	50.00	16.00	90.00	6.00	4.00	0.00	4240	946	0.99
	25.00	48.00	17.00	90.00	10.00	0.00	0.00			