PALEOBATHYMETRY IN SEGARA ANAKAN LAGOON, SOUTHERN JAVA, DERIVED FROM BENTHIC FORAMINIFERAL DISTRIBUTION

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ABSTRACT

The Segara Anakan Lagoon at the south coast of Java is a unique lagoon that is separated from the Indian Ocean by a barrier island, Nusakambangan Island. Sixty-two subsamples of marine sediments from a borehole (BH-5) have been used for studying the paleobathymetry of this lagoon. In this study, the paleobathymetry is derived from the distribution of benthic foraminifera. The results of the quantitative and cluster analyses of benthic foraminifera show that the lagoon underwent three different stages with different water depths during the Quaternary. This is shown by three sediment sequences that are characterized by different microfossil indices or the absence of microfossil indices, respectively. The sediments from depth interval I (0 - 704 cm) are typical of a marsh habitat zone and reflect a fluvial sedimentary system with no microfossil indices. All microfossils in this horizon are reworked fossils and therefore cannot be used as fossil indices. Sediment from depth interval II (704 - 1825 cm) are representative of a marsh habitat to inner neritic zone and indicate the existence of a lagoonal sedimentary system, with *Ammonia beccarii* (Linne) being the dominant benthic foraminifera. Sediments from depth interval III (1825 - 3000 cm) reflect an inner neritic to middle neritic zone in a shallow-water sedimentary system, which is dominated by *Uvigerina bassensis* Parr. Overall, the distribution of benthic foraminifera suggests significant paleobathymetrical changes in this area during the Quaternary, ranging from shallow-water to marsh habitat environments.

SARI

Laguna Segara Anakan yang terletak di pantai selatan Jawa merupakan laguna yang unik, dipisahkan dari Samudera Indonesia oleh pulau penghalang yaitu Pulau Nusakambangan. Enam puluh dua subsampel endapan marin dari sebuah sumur bor (BH-5) telah digunakan untuk studi paleobatimetri di laguna ini yang berdasarkan pada analisis distribusi foraminifera bentik. Hasil dari analisis kuantitatif dan "cluster" forminifera bentik menunjukkan bahwa laguna ini mengalami tiga tahap suksesi dengan batimetri yang berbeda selama Kuarter. Hal ini diperlihatkan dengan adanya tiga sekuen sedimen yang dicirikan oleh perbedaan mikrofosil indeks. Sedimen pada interval I (0 – 704 cm) merupakan endapan rawa dan menunjukkan sistem pengendapan sungai tanpa fosil indeks. Semua fosil pada horizon ini merupakan "reworked fossil", sehingga tidak dapat digunakan sebagai fosil penciri. Sedimen pada interval II (704 – 1825 cm) mewakili lingkungan rawa sampai neritik dalam, dan mengindikasikan sistem pengendapan laguna dengan foraminifera bentik yang dominan adalah *Ammonia beccarii* (Linne). Sedangkan sedimen pada interval III (1825 – 3000 cm) menunjukkan zona neritik dalam hingga neritik tengah, dengan sistem sedimentasi laut dangkal. Interval ini didominasi oleh *Uvigerina basensis* Parr. Dari uraian tersebut maka disimpulkan bahwa distribusi foraminifera bentik ini memperlihatkan adanya perubahan paleobatimetri selama Kuarter dari laut dangkal hingga lingkungan rawa.

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INTRODUCTION

The study area of the region of the Segara Anakan Lagoon belongs physiographically to the system of the Southern Java Mountains, which reach from the Gulf of Ciletuh in the region of Banten to Nusakambangan Island (Van Bemmelen, 1949). The morphology of the research area surrounding the lagoon is characterized by hills and alluvial planes which belong to the Citanduy Valley. Nusakambangan Island is a hilly area with steep slopes, with the elevation ranging from 50 to100 meter above mean sea level. This island is the southern border of Segara Anakan Lagoon, separating the latter from the Indian Ocean. The lagoon is connected to the ocean by two inlet channels, the main channel at the southwest (Nusakambangan Inlet Channel) and the second one at the southeast of the lagoon (Kroya Coast). To the north of the lagoon there is an alluvial plane which is formed by material from the tributaries surrounding the lagoon. This material has been reworked several times, especially the small particles (Simandjuntak and Surono, 1992).

Morphologically, the Segara Anakan Lagoon and the surrounding area are linked to the following sequence of sedimentary rocks: clastic sediment, volcanic sediments, and carbonates. Stratigraphically, the area is defined by the so called Jampang, Nusakambangan, Pamutuan, Kalipucang and Halang Formations, and the alluvial plane. The age of these formation ranges from the Early Miocene to the Quaternary. The formations reflect a range of sedimentary systems, covering deep sea to marsh habitat sedimentary systems. It is important to note, however, that this lagoonal area is part of the Citanduy Normal Fault System reaching from the northwest to the southeast of the Island of Java. Consequently, tectonic factors have also influenced the development of this lagoonal area.

The barrier island blocks the sediment transport from the tributaries in the north of the lagoon into the open ocean. This makes the lagoon a unique environment with small islands inside it. There are a lot of tributaries which influence the lagoon. The biggest tributary is the Citanduy River in the northwest of the lagoon. As pointed out by Setyawan (2002), the Segara Anakan Lagoon is currently part of the Citanduy River Basin, and any changes in the Citanduy River morphology will influence the Segara Anakan area. This is further supported by evidence that, at the peak of the Last Glaciation 18,000 years B.P., the present Segara Anakan Lagoon area was part of the Citanduy River drainage system and was located in a subaerial environment (Setyawan, 2002).

Sedimentation rates are very high in the lagoon, as shown by grain size analysis from core BH-2 and BH-5, and from palynological analysis in core BH-5 (0.1 cm/year, Sarmili, et al, 2000). This finding is confirmed by the results of more detailed pollen analysis which show that the depth interval 670 – 720 cm in borehole BH-5 covers approximately 8000 years (Desiana, personal communication, 2003). At present, the capacity of the Segara Anakan Lagoon to take up sediments is rapidly decreasing due to significant sediment supply from the Citanduy River and other tributaries to the lagoon. The lagoon is becoming shallower to the point of being transformed into land. As a consequence, mangrove swamps expand and tidal channels develop. The sediments of the lagoon are more and more characterized by increasing fractions of alluvial and swamp sediments, which consist of a mix of clay, silt and organic materials (Rahardjo, 1982).

The high rates of sedimentation have influenced the distribution of the biota, including the microfauna such as foraminifera. Consequently, the foraminiferal distribution in sediment cores taken from the lagoon and it´s surrounding areas may be used to interpret ancient marine environments, particularly the paleobathymetry of the lagoon.

Foraminiferal distribution is a function of a number of enviromental variables. Although water depth is not the main environmental variable influencing foraminiferal distribution, it does, however, reflect the three dimensional space in which numerous environmental variables interact, for example temperature, light and nutrients. All these factors may be limiting factors for the growth of foraminifera (Gibson, 1968). Characteristics of benthic foraminiferal assemblages, including species diversity, and species dominance, are the subject of this paper because they give information about the set of environmental variables mentioned above, from the combination of which paleo-water depths can be inferred. The study of species diversity in benthic foraminifera showed diversity changes with depth in modern assemblages. Consequently, the analysis of foraminiferal remains associated with the Quaternary deposits is one of the most useful methods to interpret the paleoebathymetric changes which may have occurred in the lagoon.

METHODS

A 30-meters borehole (BH-5) was drilled at four meters water depth in the eastern part of the Segara Anakan Lagoon by the Marine Geological Institute of Indonesia in 1999. The unconsolidated samples are dominated by mud, silt and clay (Fig. 1).

The 62 subsamples were selected at 50 cm intervals from this borehole for a foraminiferal study. Additional samples were collected where lithological changes occurred. The samples were sieved using three different sizes of sieves: 250 μm, 100 μm, and 60μm. About 200 specimens of foraminifera were picked from the fraction larger than 100μm. The autochthonous and allochthonous specimen were separated. This study only focuses on the autochthonous specimens of benthic foraminifera. By identifying benthic foraminiferal species, we can determine the depth interval of each sediment sequence. This identification was done by referring to the previous studies of Barker (1960), Matsunaga (1963), Saito (1963), Loeblich Jr. and Tappan (1988), Van Marle (1991), Albani and Yassini (1993), Yassini and Jones (1995). These depth intervals will be correlated with the modeling of bathymetrical zones from Van Marle (1991).

Quantitative and semi-quantitative analysis was used to explain the benthic foraminiferal distribution. The numbers of benthic foraminifera per 1 gram dry weight were calculated and the results were given in percent. From this analysis, the distribution pattern of benthic foraminifera along the core was determined. These data were then used to calculate the diversity index by using the q-basic computer program (Bakus, 1990). The variety of species composition in each subsample is being explained by the diversity index. Based on the similarity of species from each subsamples, the percentages of benthic foraminiferal contents per 1 gram dry weight are also used in the cluster analysis for grouping benthic foraminifera (Fig. 2).

Based on the diversity indices and the results of the cluster analysis, which reflect the water depth in which the benthic foraminifera live, it is possible to group the benthic foraminiferal assemblages. The environmental conditions inferred from the correlation between these assemblages and the sediment characteristics of the core and from the surrounding area were then transferred to data on paleo-water depths.

RESULTS

The vertical distribution of foraminifera throughout core BH-5 shows 52 genera and 117 species of benthic foraminifera. According to the results from the semi-quantitative analysis, the distribution of benthic foraminifera at the top of the core is different from that at the base. This finding is also supported by the diversity index analysis and quantitative analysis. (Table 1).

The distribution of benthic foraminifers from the top to bottom of the core varies and indicates the presence of a range of different benthic foraminiferal assemblages.

Depth interval 0 – 704 cm contains very few benthic foraminfera. The benthic foraminifera dominating this layer are *Spiroloculina* sp.3 and *Elphidium depressulum*. These species occur in the form of reworked fossils, i.e. they are allochthonous in origin. The percentages of benthic foraminifera per 1 gram dry weight range from 0.79 to 2.11 %. The diversity indices in this layer vary between 0.69 and 1.10 (average).

The benthic foraminifera of depth interval 704 – 1825 cm are highly abundant. The foraminifera are dominated by *Ammonia beccarii*, Elphidiidae and Miliolid. The Elphidiidae are dominated by *Elphidium advenum*, *Elphidium depressulum*, *Elphidium discoidale multiloculum*, *Elphidium* sp.1, *Elphidium* sp.2, *Elphidium* sp.3 and *Cribrononion* cf. *C. argenteum*. The genera of *Spiroloculina*, *Quinqueloculina* and *Miliolina* dominate the group of Miliolid. The percentages of benthic foraminifera per 1 gram dry weight range from 0.17 to 94.30. The diversity indices for this depth interval are between 1.10 and 3.30 (average to high abundance). The distribution pattern of benthic foraminifera in this layer is unique because *Ammonia beccarii* is highly abundant and appears in every sub-interval. The percentages of these foraminifera are very high, between 61.13 and 94.30 %. The preservation of the fossils are good, indicating that the *Ammonia beccarii* represent *in situ* fossil.

In depth interval 1825 – 3000 cm, the most common genera of benthic foraminifera are *Bolivina*, *Bulimina*, *Hyalinea* and *Uvigerina*. The genus *Bolivina* is dominated by *Bolivina albatrossi*, *Bolivina robusta* and *Bolivina* cf. *B.* robusta. The genus *Bulimina* is dominated by *Bulimina marginata* and *Bulimina pupoides*. The species dominating the genus *Hyalinea* is *Hyalinea balthica*. The genus *Uvigerina* is highly abundant in this interval and dominated by *Uvigerina bassensis*, *Uvigerina peregrina* var. *dirupta*, and *Uvigerina proboscidea*. *Ammonia beccarii* still appears in this interval but the percentage is low. The percentages of benthic foraminifera per 1 gram dry weight range from 0.01 to 0.96. The diversity indices in this interval range from 2.71 to 3.66 (high).

Based on cluster analysis of the benthic foraminiferal percentage per 1 gram of dry weight, two biofacies can be recognized: Firstly, biofacies I dominated by *Ammonia beccarii* (Linne). Biofacies I dominates depth interval II. Secondly biofacies II dominated by *Uvigerina bassensis* Parr. Biofacies II dominates depth interval III (Fig. 2). The assemblage dominated by *Ammonia beccarii* is found in 44 subsamples, from depth interval II to depth interval III. However, the percentage of this species decreases in depth interval III. The percentage per 1 gram of dry weight in depth interval II is between 1.77 and 6.69, but in depth interval III it is 0.005 – 0.04 %. In contrast, the *Uvigerina bassensis* dominated assemblage is only found in depth interval III. The percentage of this assemblage in 25 subsamples is between 0.06 and 0.34.

DISCUSSION

Based on the distribution patterns of benthic foraminifera, the core can be divided into three depth intervals. Interval I covers the depth of 0 to 704 cm. Interval II covers 704 to 1825 cm, and interval III covers 1825 to 3000 cm. According to the previous studies of Barker (1960), Matsunaga (1963), Saito (1963), Loeblich Jr. and Tappan (1988), Van Marle (1991), Albani and Yassini (1993), and Yassini and Jones (1995), it is possible to infer the water depth in which the benthic foraminifera lived.

The benthic foraminifera in depth interval I are all reworked fossil. Consequently, it is not possible to infer the water depth in which they lived before. The assemblages indicate, that the influence of high-energy environments from rivers must have been significant. This is shown by the bad preservation of the fossils. Also, only a small amount of these fossils is found in this layer. The fossils must have been transported by the river and by tidal currents with high energy. This is in agreement with recent findings of Gustiantini et al (2003) who showed that the distribution patterns of benthic foraminifera in the surface sediments in the Segara Anakan Lagoon are controlled by both tidal currents and high sediment input from the river. The surface sediments discussed by these authors represent the top of the depth interval discussed in this current paper.

Ammonia beccarii which is dominating interval II indicates environmental conditions typical of marsh habitat to inner neritic zones (0 –30 m). The occurrences of *Elphidium advenum* and *Elphidium depressulum* reflect an inner neritic to middle neritic environment (0 – 100 m). *Elphidium discoidale multiloculum and Cribrononion* cf. *C. Argenteum* lived in an inner neritic zone (0 – 30 m).

Bolivina albatrossi lived from 20 to 100 meter water depth (inner neritic to middle neritic zone). *Bolivina robusta* and *Bolivina* cf. *B. robusta* reflect the same water depth, from 100 to > 2000 meter water depth (outer neritic to abyssal zone). *Bulimina marginata* lived in the inner neritic to outer neritic zone (0 – 200 m). *Bulimina pupoides* lived in a middle neritic to outer neritic environment (30 – 200 m). *Hyalinea balthica*, which dominates the genus *Hyalinea,* reflects an upper bathyal zone (200 – 500 m). *Uvigerina bassensis*, which is highly abundant in interval III, lived in an outer neritic to upper bathyal zone (100 – 500 m). In contrast, *Uvigerina peregrina* var. *dirupta* and *Uvigerina proboscidea* can lived in a deeper zone than *Uvigerina bassensis.* These species lived in an outer neritic to abyssal zone (100 - > 2000 m).

Based on the distribution patterns of benthic foraminifera derived from quantitative and semi-quantitative analysis, diversity index, cluster analysis, sediment characteristics of the sediment core and from the water depth determination derived, we can conclude that there are three different bathymetrycal zones and also three different sedimentary systems reflected throughout the core. These are from the base to the top of the core:

1. Middle neritic – inner neritic zone (100 – 30 meter water depth). Based on the appearances of *Uvigerina bassensis* and *Bolivina albatrossi*, this zone is reflected in depth interval III (3000 – 1825 cm). In addition, the sediments in this interval are characterized by silt that contains mollusc shells and organic matter from plant. These findings reflect a shallow water sedimentary system.
2. Inner neritic – marsh habitat zone (30 – 0 meter water depth). This zone is related to interval II (1825 – 704 cm). This is according to the abundance of *Ammonia beccarii* and *Elphidiidae* which reflect a lagoonal sedimentary system. Generally, *Ammonia beccarii* is a marker fossil for marginal marine environments, especially marsh and lagoon environments (Phleger, 1960, Yassini and Jones, 1993, Samir and El-Din, 2001, Gustiantini et al, 2003). The sediment in this interval also contains fossil molluscs and organic matter from plant, and is characterized by silt and sandy clay.
3. Marsh habitat zone (transition zone from marine to fluvial environment). This zone is reflected in interval I (704 – 0 cm). This interval is characterized by sediments of recent age. These sediments indicate a fluvial sedimentary system. This is supported by the macroscopic sediment description from BH-5, which shows that this interval is dominated by mud from fluvial sediments which are not lithified yet. The sediments contain mollusc shells and organic matter from plant. There are no marker fossils in this interval because all benthic foraminifera are allochthonous fossils.

From the discussion above, we conclude that significant changes in the bathymetry and the sedimentary environments have occurred in this lagoonal area during the Quaternary (Fig.3). The sedimentary environments typical of different water depths ranged from shallow water to marsh habitat zones.

The results of this study of benthic foraminifera confirm previous suggestions of significant bathymetrical changes reflecting a transition from a neritic zone to a marsh habitat in this lagoonal area (Sarmili et al, 2000, Oktaviani, 2001, Salinita, 2001). Firstly, Sarmili et al (2000), based on biostratigraphical analysis from four sediment cores, suggested bathymetrical changes reflecting the transition from a neritic zone to a marsh habitat zone. This was specifically inferred from the appearrences of *Amphistegina lessonii*, *Operculina ammonoides*, *Elphidium* spp. and *Ammonia beccarii*. In addition, the grain size analysis (Sarmili et al, 2000, Oktaviani, 2001) and a study of shoreline development (Salinita, 2001) reflect that the lagoon has become shallower every year.

This study has identified the paleobathymetrical changes which occurred in the Segara Anakan lagoon during the Quaternary period. The succession studied in this paper is the top part of a regional succession of sediment formations. This can be inferred from a comparison of the results of this study with those of studies of the regional geology (Simandjuntak and Surono, 1992). Clearly there is a relation between the paleobathymetrical changes in this lagoon and the regional paleobathymetry in this area. The regional paleobathymetrical changes reflect a range of sedimentary systems, covering deep-sea to marsh habitat sedimentary systems but have also been caused by the influence of sediments of the period from the Early Miocene to the Quaternary from the nearby land and the river beds in the catchment area of the lagoon (Simandjuntak and Surono, 1992).

CONCLUSIONS

The distinct bathymetrical changes which can be inferred from the distribution of benthic foraminifera in the Segara Anakan Lagoon point toward significant changes in water depth and sedimentation rates in the lagoon in the past. Given the extremely high sedimentation rates in the lagoon today, the findings of this present study of these past changes raise the question whether today′s sedimentation rates are truly caused by anthropogenic activities alone, as has been previously been suggested (Hindaryoen, 2003). From the results of this study is appears plausible that the presently high sedimentation rates may, at least partially, strongly be influenced by natural processes rather than anthropogenic activities. This is shown by gravely mud layers in the bottom of the core BH-5. This fact suggested that the high energy from the rivers has influence this area but this was not following by the present of bad environmental conditions such as low nutrients and pollution effects. This good environmental condition caused the high abundances of autochthonous and allochthonous specimens of foraminifera in this layer.

Consequently, the past bathymetrical changes found by this study need to be considered when analyzing the recent condition of this lagoon. The present trend is that high sedimentation rates result in parts of the lagoon being transformed into land. During the past decade, the lagoon has clearly become shallower every year, causing enormous damage to local industries such as fisheries Clearly, the relative proportions of the separate influences as well as the interaction of anthrophogenic and natural causes of changes in sedimentation rates need to be identified in future studies. Such studies are essential for a future sustainable management of this environment, including land, water and mangroves forests.

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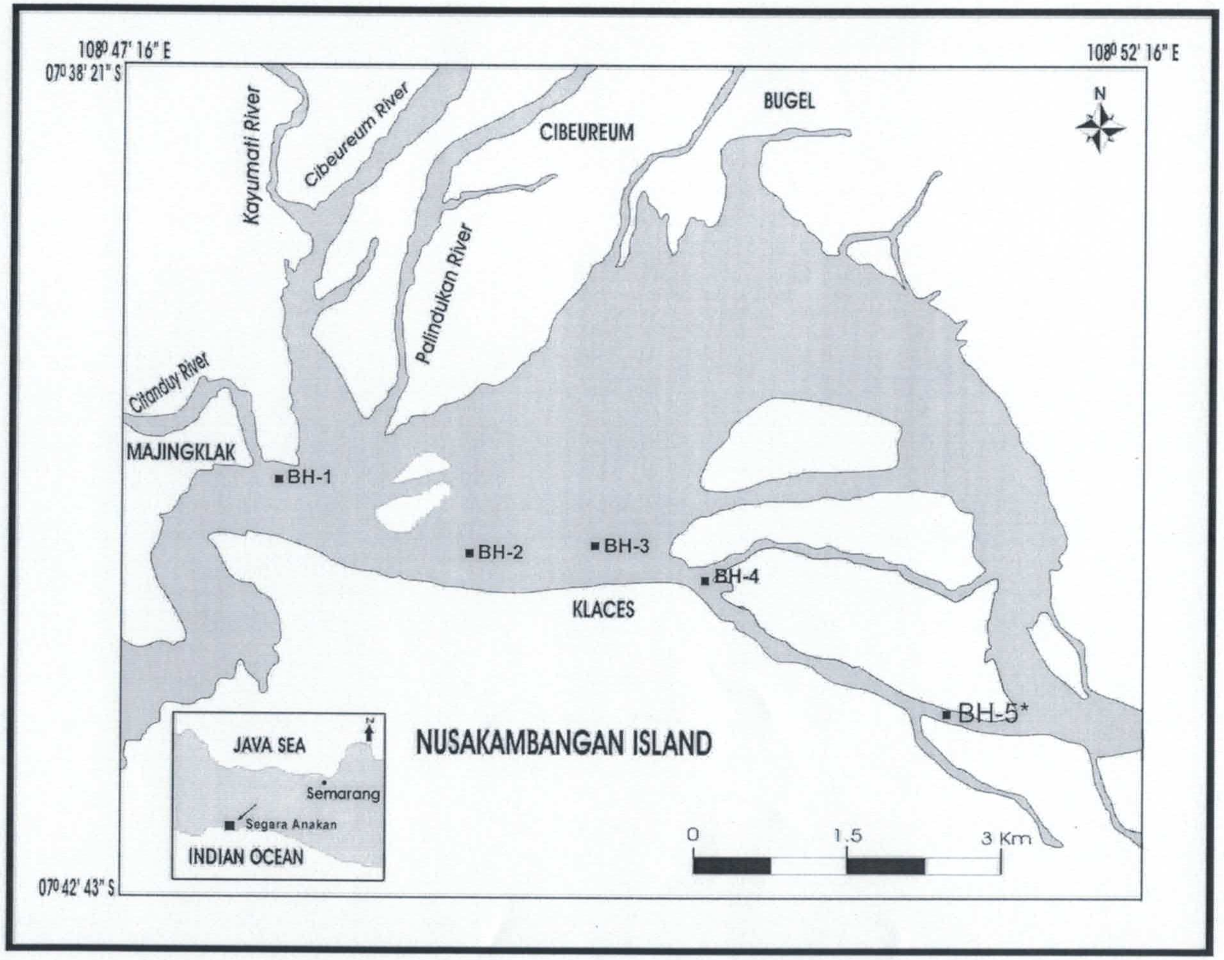

Fig. 1 Map of the research area and site of core sampling BH-5 (Modified after Sarmili, *et al.*; 2000).

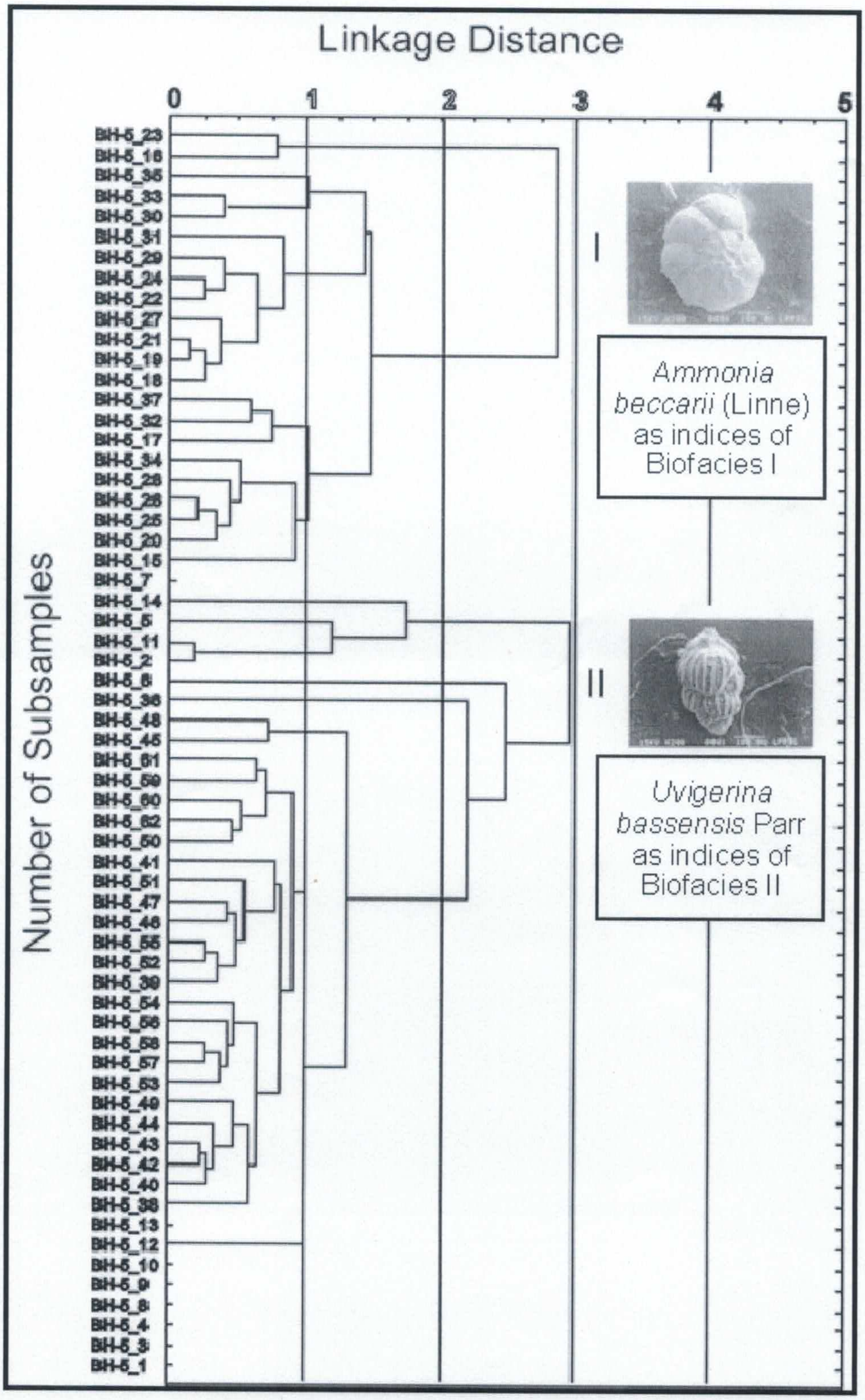

Fig. 2 Dendogram from Q-mode cluster analysis which points out two different biofacies: One dominated by *Ammonia beccarii* (Linne) and a second dominated by *Uvigerina bassensis* Parr respectively.

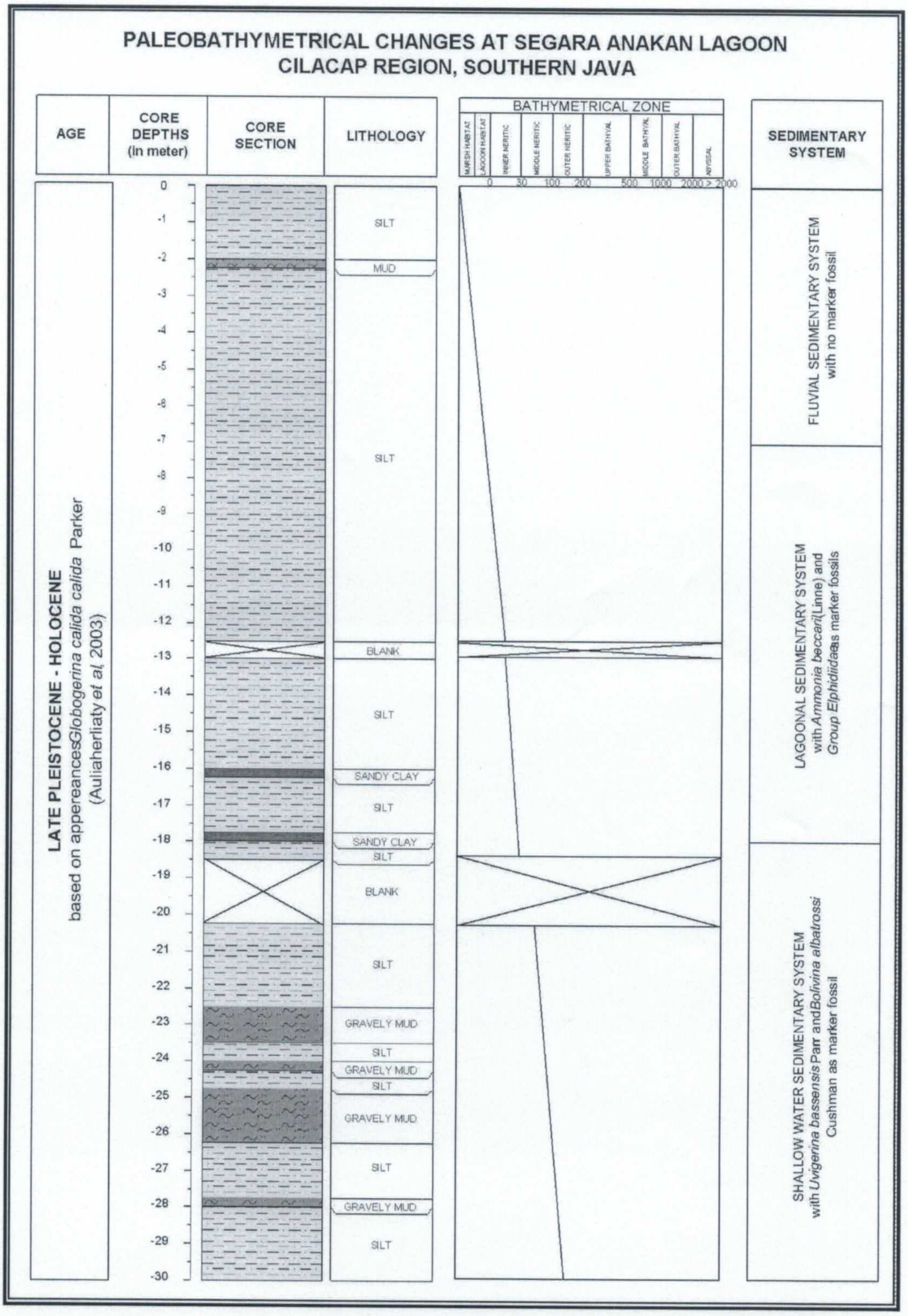

Fig. 3 Interpretation of paleobathymetrical changes in Segara Anakan Lagoon.

Table 1. Distribution of benthic foraminifera and diversity indices in core BH-5, Segara Anakan Lagoon

Genera of Foraminifera

LEGEND:
X = < 0.1
O = 0.1 - 1
V = > 1

Core interval (cm)	*Ammomassilina*	*Ammonia*	*Amphistegina*	*Bolivina*	*Bolivinita*	*Brizalina*	*Bulimina*	*Calcarina*	*Cassidulina*	*Chrysallidinella*	*Cibicides*	*Cribrononion*	*Elphidium*	*Eponides*	*Fissurina*	*Guttulina*	*Gyroidina*	*Houglundina*	*Hyalinea*	*Laevidentalina*	*Lagena*	*Lagenodosaria*	*Lamarckina*	*Laticarinina*	*Lenticulina*	*Marginulina*	*Miliolina*	*Miliolinella*	*Nodosaria*	*Nonion*	*Nonionella*	*Oolina*	*Operculina*	*Osangularia*	*Parafrondicularia*	*Planularia*	*Planulina*	*Pleurostomella*	*Poroeponides*	*Procerolagena*	*Pseudoglandulina*	*Pyrulina*	*Quinqueloculina*	*Robulus*	*Rosalina*	*Siphouvigerina*	*Spirillina*	*Spiroloculina*	*Stilostomella*	*Streblus*	*Uvigerina*	*Valvulineria*	Diversity Index
Total Species	1	1	1	7	1	1	5	1	1	1	2	1	7	2	7	1	5	1	3	1	5	1	1	1	2	1	1	2	4	2	1	3	1	1	1	2	2	4	1	1	1	1	5	4	1	1	1	6	4	1	4	1	
15-19																																																					-
50-54																																																V					-
115-119																																																					-
150-154																																																					-
215-219													O																																		O	V					1.10
250-254				O									O																																								0.69
315-319													V																																								-
350-354																																																					-
415-419																																																					-
450-454																																																					-
515-519																																																V					-
553-557																																																					-
602-606																																																					-
650-654													O																																			O					0.69
704-708		V											O						O											O																							1.39
750-754		V		O									X	X					X											X							X																2.20
803-807		V					O																																													1.10
850-854		V		O		X					X		O						X		X							X		O								X		X	X		X					O					3.09
906-910		V		O				X					O				X		X									X	X	O	X		X										X				X	X		X			3.30
950-954		V		O																								O		X													O					O					2.48
1003-1007		V		O									X															X		X													X					X					2.56
1050-1054		V		O				X			X		X				X											X		O													X					X					2.56
1115-1119		V		O				O																		X		X		O																		X					2.30
1150-1154		V		O				X					O					X												X													X					X					2.30
1205-1209		V		X				X					X					X	X									X		X													X		X			X					2.71
1225-1229		V		X				X				X	O															X		X													X		X			O					2.71
1303-1307		V	X	X								X	O						X									X		O																		X					2.56
1350-1354		V		O				X					O														X			O																		O					2.56
1400-1404		V		X				X					O																	X													X	X	X			X					2.40
1450-1454		V		O				X					V										X							X																							2.20
1500-1504		V											V	O																																		X					1.61
1550-1554		V		O				X					O				X											X		X															X			X					2.40
1605-1609		V		O									V		X													X		O								O								X								2.40
1650-1654		X			X						X		O						X																								X										1.95
1706-1710		X									X		V																	X													O					O					2.08
1750-1754		X		X			X	X					O															X		X													X									2.56
1804-1808		X					X					X	O	X																X													X									X	2.48
1825-1829	X	X		O	X	X	O						X	X		X	X		O		X	X		X		X					X	X					X	X						X	X				X		O	X	3.66
2027-2031		X		O		X	X			X			X	X	X		X		X		X								X	X	X					X	X	X						X		X					O	X	3.58
2050-2054		X		O	X	X	O	X			X		X	X			X	X	O		X								X		X							X														O		3.30
2075-2079		X		O	X	X	X						X	X					O		X									X	X					X		O	X					X	X					X		O	X	3.43
2103-2107		X		O		X	O		X				X	X	X				O												X					X	X	X					X	X		X			X		O		3.37
2150-2154		X		O		X	O						X	X					O												X					X		X						X	X						O		3.14
2205-2209		X		O	X		O								X				O											X	X						X	O						X							O		3.18
2250-2254				O			O								X				X											X								X				X		X							O		2.83
2300-2304		X		O		X	X		X										O		X										X					X	X	X						X							O		3.04
2350-2354		X		O			X						X				X		O		X									X	X					X		X						X							O		3.30
2416-2420		X		O			O												O																			O						X				X	X		O		2.71
2450-2454		X		O			O				X		X	X					O																	X		X													O		2.71
2502-2506		X		O	X	X	X												O						X	X		X								X								X							O		2.83
2525-2529		X		O			X							X			X		O		X								X								X							X							O		2.83
2550-2554		X		O	X		X		X		X			X	X		X		O		X				X						X					X	X	X			X			X							O	X	3.37
2575-2579	X	X		O	X		X				X			X	X		X		X		X				X				X			X				X	X	X						X	X				X	X	O	X	3.58
2603-2607		X		O			O				X			X					O											X						X		X						X							O		3.04
2650-2654		X		O			X	X	X		X			X			X		O						X				X			X						X													O	X	3.26
2706-2710		X		O	X	X	X		X		X			X	X		X		O		X					X								X				O						X							O		3.53
2750-2754				O	X		X		X		X			O			X		O															X	X	X		X						X	X						O	X	3.26
2779-2783				O	X		X		X		X			O	X		X		O		X				X											X	X	X						X					X		O		3.37
2821-2825				V	X	X	X		O		O			X			X		O		X															X								X		X		X	X	X	O		3.43
2850-2854		X		O	X	X	X		X		X			X			X		O		X								X							X		X						X							O	X	3.37
2910-2914	X	X		O			X		X		X			O			X		O	X					X				X			X				X	X	X						X	X				X		O		3.61
2950-2954		X		O	X	X	X		X		X			X	X		X		O		X				X											X	X	X					X	X							O		3.43