Geol. Soc. Malaysia, Bulletin 26, April 1990; pp. 35 - 46

Stratigraphy of the Mantanani Islands, Sabah

M.B. IDRIS [1] & K.H. KOK [2]

[1]Dept. of Geology, Universiti Malaya, 59100, Kuala Lumpur.
[2]Geoservices Eastern Inc., Singapore.

Abstract: The Mantanani Islands are esssentially underlain by sedimentary rocks. These are mainly bioclastic limestones and calcarenites. Lithostratigraphically, they may be divided into two units — a well-bedded unit conformably overlain by a relatively thicker massive conglomeratic unit. Their sedimentological features and faunal content suggest a warm shallow marine paleoenvironment. Deposition took place on a gentle slope of the shelf area, and was interupted by frequent influx of sediment that prevented full biohermal development. These rocks are mostly of at least Mid-Miocene age. Similar rocks known as the Balambangan Limestone Member are exposed on the southern tips of Banggi and Balambangan Islands, north of Kudat Peninsula.

Abstrak: Hanya batuan sedimen sahaja terdapat di kepulauan Mantanani. Ianya terdiri dari batu kapur bioklastik dan kalkarenit. Batuan ini terbahagi kepada dua unit lithostratigrafi. Unit bawah di wakili oleh batuan terlapis baik dan unit atas yang lebih tebal, konglomerat massif. Ciri-ciri sedimen dan kandungan faunanya mencadangkan paleoenvironmen laut tohor yang suam. Pengenapan berlaku diatas cerun landai dan sering diganggu oleh pembekalan sedimen yang menghalang perkembangan terumbu sepenuhnya. Fosil-fosil menunjukkan batuan ini berumur Miosen Tengah. Batuan berciri serupa yang dikenali sebagai Balambangan Limestone Member, terdedah di Pulau Banggi dan Pulau Balambangan yang terletak di utara Semenanjung Kudat.

INTRODUCTION

The Mantanani Islands are a group of three islands, namely, Pulau Mantanani Besar (PMB), Pulau Mantanani Kecil (PMK) and Pulau Lungisan (PL), located offshore Sabah, in the South China Sea, west of Kudat Peninsula (Fig. 1). Only sedimentary rocks are exposed. Their stratigraphy is discussed below.

GENERAL GEOLOGY

The lithologic variety of the Mantanani Islands is limited to sedimentary rocks. These may be categorised generally into an older succession of bioclastic limestone with minor intercalation of calcareous siliciclastic and a younger carbonate sand deposit (Fig. 2). The strata of the older sequence dip steeply, of which two trends are observed. Those on PMB and PL strike NNW and dip 65° – 75° northerly, while those on PMK strike SSW and dip 60° – 70° southerly. With respect to the lithologic correlation and the nature of the highly tilted strata on these islands, a major submarine dislocation (most probably a right lateral strike-slip fault) is envisaged to exist in between the two larger islands.

Presented at GSM Annual Geological Conference '89

A comparative study of aerial photographs taken in 1969 and 1981, indicates that PMB has increased in size areally. Recent deposits are accumulated along its southern coast and a prominent spit is developed on the eastern tip of the island. These are brought about by a drift from the southwest direction.

LITHOSTRATIGRAPHY

A generalised stratigraphic column of the sedimentary rocks on the Mantanani Islands is illustrated in Fig. 3. The column which extends slightly over 100 m, may be divided into two units. These are:-

a) Well-bedded unit (lower unit)

b) Massive conglomeratic unit (upper unit)

a) Well-bedded unit

It is approximately 10 m thick, consisting of beds ranging from 0.3 – 0.6 m thick. These beds exhibit sharp bedding-plane contact. Calcareous quartzarenite and calcilutite are more prevalent in the lower half of this unit, whereas very calcareous siltstone occurs towards the top.

The calcareous quartzarenite is composed of medium to coarse sand in calcitic cement. Minor quartz and lithic granules may occur in certain beds. Cobbles of well lithified calcareous siltstone, commonly of elongate subrounded shape in cross-section, are distributed as a single clast horizon within the calcareous quartzarenite beds.

Synsedimentary structures within the beds consist of weakly developed lamination and ripple lamination. Other sedimentary features include load cast and convolute lamination. The softer calcilutite beds are interbedded with calcareous quartzarenite and does not exhibit any structure. In contrast, the sandy calcilutite forms beds ranging from 0.3 – 0.4 m thick with cross and ripple laminations. This grey limestone has disseminated siliciclastic detritus among the carbonate material which weathers to dark brown.

Rocks of this unit are moderately fossiliferous. The basal beds contain a lesser amount of fossils. The fauna includes smaller bivalves, gastropods, branched corals and foraminifers.

b) Massive conglomeratic unit

It extends to slightly more than 90 m thick and consists of predominantly limestone with intermittent layers of siliciclastic detritus, recognized as calcareous quartzarenite. The limestone is recognised as cobbly bioclastic packstone or cobbly-pebbly bioclastic packstone. The term packstone here implies clast-supported fabric, whereas the prefix indicates description of the clast size. Bioclastic suggests the nature of the clasts which are mainly of organic origin, commonly corals and bivalves.

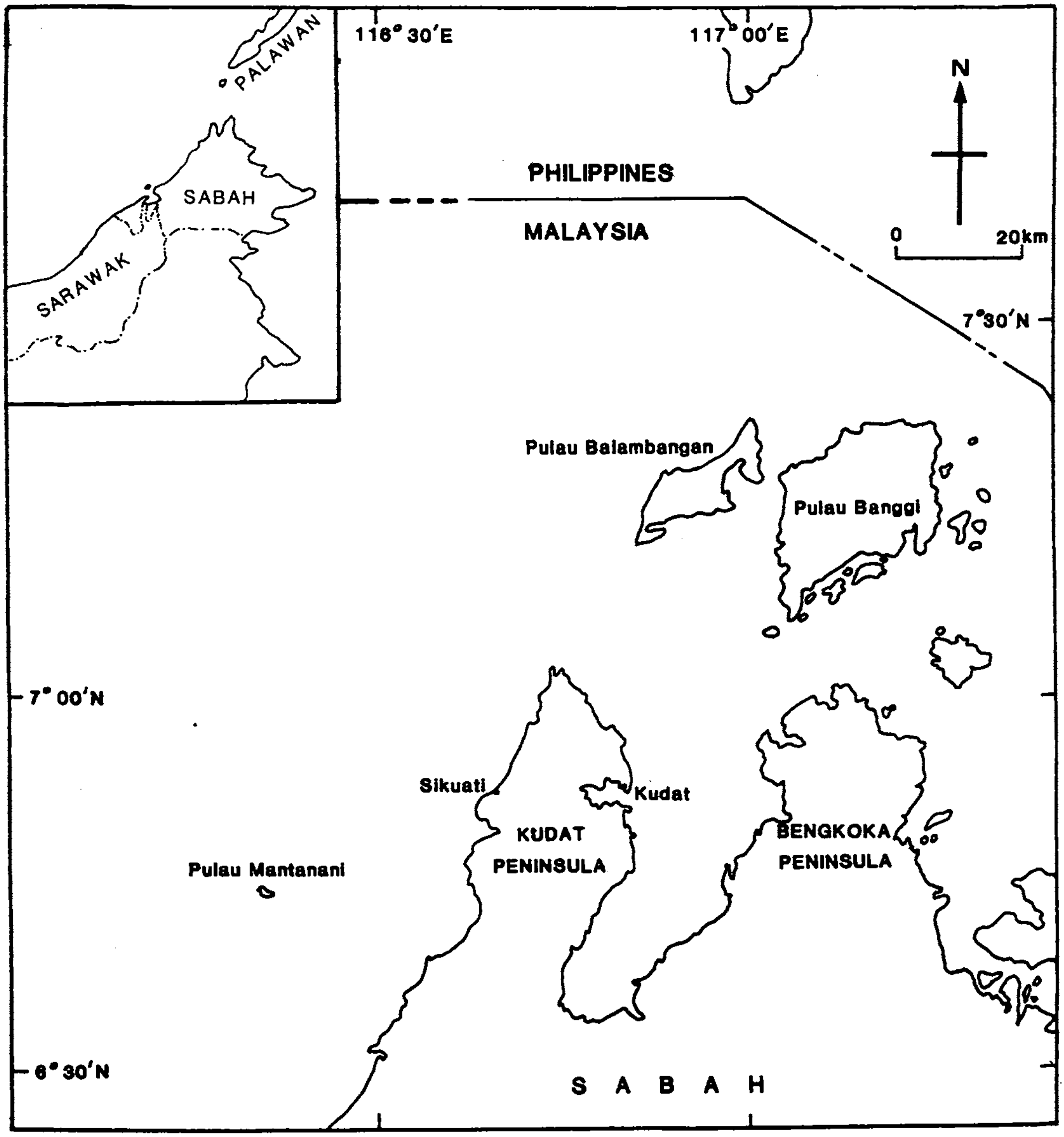

Figure 1 : Map of North Sabah

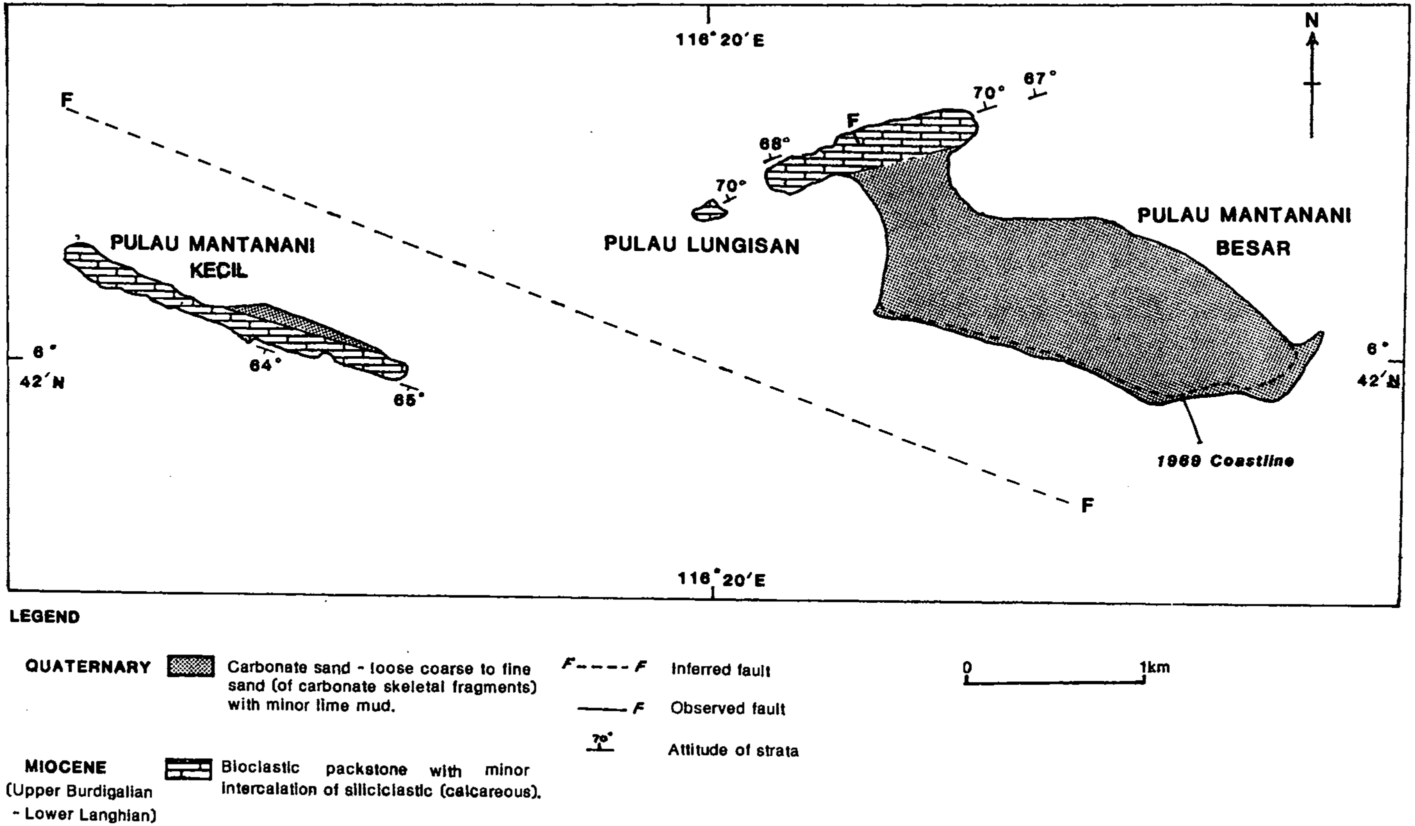

Figure 2 : Geologic map of the Mantanani Islands, Sabah

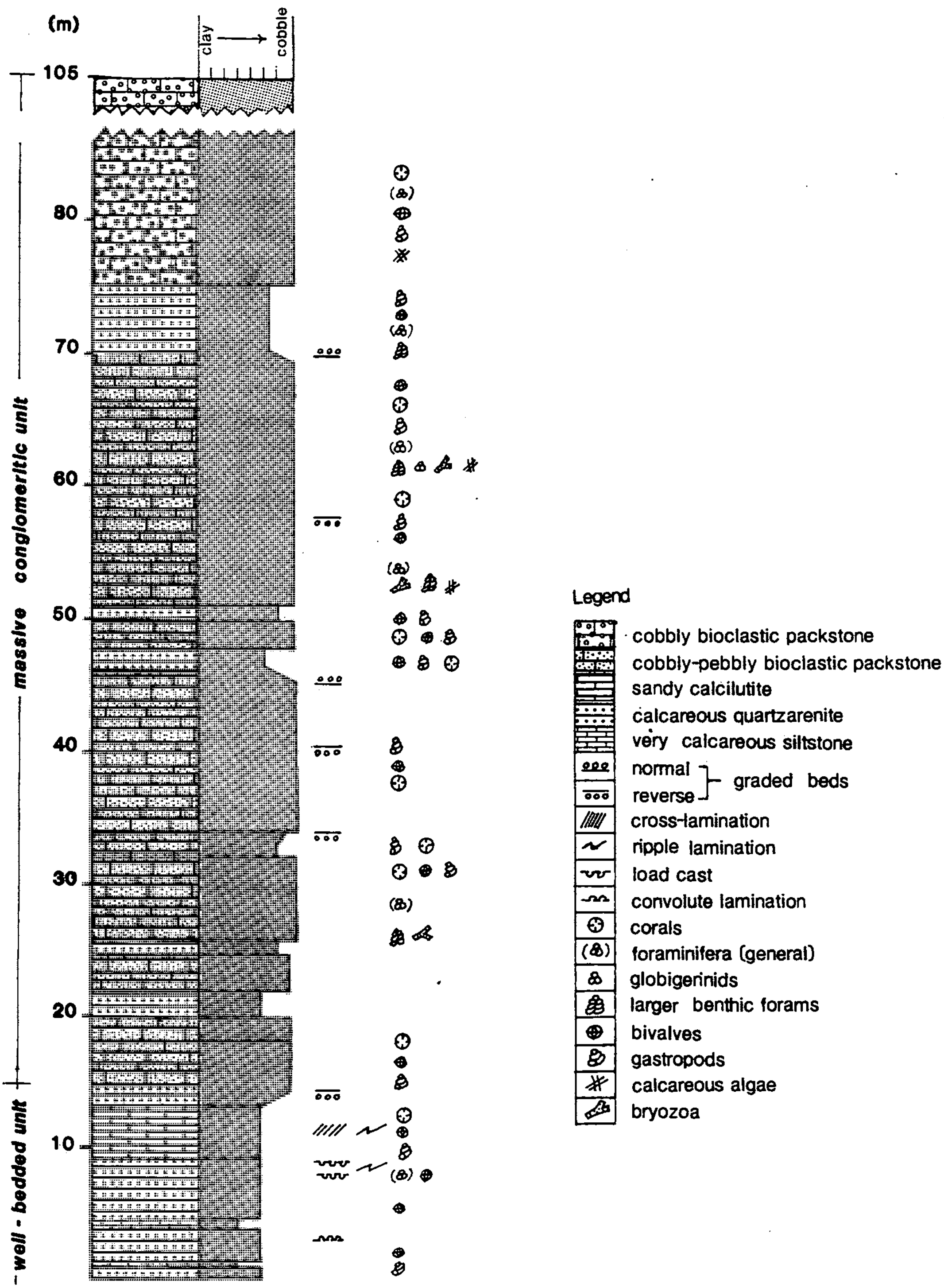

Figure 3 : Generalised stratigraphic section of the Miocene rocks of Mantanani Islands.

Individual beds range from 0.1 – 1.0 m thick, except for the topmost part of the column, where beds tend to be thicker, 1.0 – 1.4 m thick.

Both reverse and normal graded beds are present in the cobbly-pebbly bioclastic packstone. The parallel laminated calcareous quartzarenites are in gradational contact with the limestones. Generally, six distinct sedimentation cycles are observed, each demarcated by the presence of less coarse calcareous quartzarenite. Another apparent cycle is observed between the 32 – 34 m marks where the packstone tends to be less coarse. Each cycle is characterised by the deposition of less coarse material followed by coarser material on top. Duration of the cycles varies, but the deposition of calcareous quartzarenite is relatively more brief, thickest being 5 m at the topmost episode.

The limestones are very fossiliferous, fossils are essentially the framework of these rocks. The fauna includes corals, molluscs, bryozoans, forams, calcareous algae and echonoids. A coquina, about 1 m thick is observed at the 16 m level. The bioclasts in the packstone are mainly scleractinian corals of mainly ovoid massive form and minor branched corals and robust bivalves. Fossils are sparse in the calcareous quartzarenite and these are limited to fragments of corals and molluscs and foraminiferas.

PALEONTOLOGY AND AGE

Macrofossils are more abundant in the upper unit. These are commonly corals and robust molluscs. The molluscs are mainly bivalves which are disseminated among the corals. There are also coral rich beds devoid of molluscs. Microfossils are also recovered from samples taken at regular intervals. The list of macrofossils and microfossils are provided in Table 1.

The macrofossils are poor age indices as most are long ranging. However, *Trochus sp., Fungia sp.* and *Galexea sp.* first appeared in early Miocene. Similarly, most foraminifers identified are not age diagnostic except for *G. transitoria* which was recovered from a limestone strata at the 30 m mark in the upper unit on Pulau Mantanani Kecil. However, the last occurrence of *Lepidocyclina* is in the Middle Miocene and *G. altiapertura* ranges from early to middle Miocene with a questionable occurrence till late Miocene. The presence of *G. transitora* defines a late Burdigalian to early Langhian age. This coincides with the N7 and N8 planktonic foraminiferal zones (Fig. 4) of Blow (1970). It should be noted that the *G. transitoria* occurred in a sample within the upper unit at the eastern end of Pulau Mantanani Kecil and is of good preservation showing no signs of a reworking. Although no diagnostic fossil was found on Pulau Mantanani Besar, the strata correlated well with the lithostratigraphic character of those on Pulau Mantanani Kecil.

Calsaeous algae	*Foraminifera*
Halimeda sp.	*Ammonia* cf. *sandakanensis*
Lithophyllum sp.	*Amphiroa* sp.
Lithoporella sp.	*Amphistegina* sp.
Lithothamnium sp.	*Austrotrillina* cf. *howchini*
	?Coryphostoma sp.
Corals	*Discorbis* sp.
Acropora sp.	*Elphidium* sp.
Favia sp.	*Globerigerina* sp.
Fungia sp.	*Globerigerinoides altiapetura*
Galexea sp.	*Globerigerinoides transitoria*
?Goniastrea sp.	*Gypsina* cf. *globulus*
	Heterolepa sp.
	Lepidocyclina cf. sumatrensis
Molluscs	*Nummulites* sp.
Aequipecten sp.	*Operculina* cf. *venosa*
?Cerithium sp.	*Operculinoides* cf. *balcei*
Dentalium sp.	*Orbulina suturalis*
?Pitar sp.	*Quinqueloculina* sp.
Tridicana sp.	*Rotalia* sp.
Trochus sp.	*Spiroloculina* sp.
	?Textularia
	Triloculina sp.

Table 1. List of fossils from Mantanani Islands.

Thus, the strata on Mantanani Island is of late Burdigalian to early Langhian age, at least at the horizon where *G. transitoria* was recovered, though the age of the lower unit is still open to question.

SEDIMENTATION STYLE AND PALEOENVIRONMENT

In the field, the well-bedded unit passes conformably into the massive conglomeratic unit. Hence, during the deposition of the well-bedded unit within the Mantanani area, reefal development adjacent to it is most likely. A schematic relationship between the two units is represented by Fig. 5. This association compares favourably with the depositional margin of shallow water sedimentation on a slope as proposed by Wilson (1975). Thus the well-bedded unit is considered as a turbiditic unit generated due to downslope movement. Here it is necessary to stress that turbidities may be generated by most downslope and storm deposits irrespective of water depth, given the right conditions. Whereas the massive conglomeratic unit corresponds to associated reefal development (fore reef slope) that were distributed by storm reworkings.

SERIES & SUBSERIES		STAGE	PLANKTONIC FORAMINIFERAL ZONATIONS (BLOW, 1970).
MIOCENE	UPPER	MESSINIAN	N. 18
			N. 17
		TORTONIAN	N. 16
			N. 15
	MIDDLE	SERRAVALLIAN	N. 14
			N. 13
			N. 12
			N. 11
		LANGHIAN	N. 10
			N. 9
	LOWER		N. 8
		BURDIGALIAN	N. 7
			N. 6
		AQUITANIAN	N. 5
			N. 4

Figure 4: Miocene planktonic foraminiferal zonations.

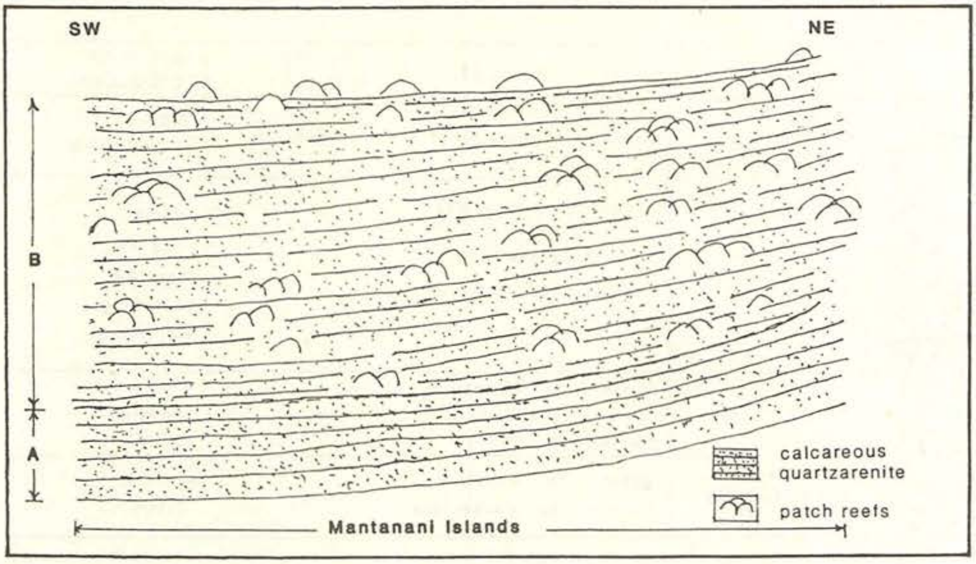

Figure 5 : Schematic representation of spatial distribution of the Mantanani rock-types based on individual logs (not drawn to scale). A – lower unit, B – upper unit.

As previously noted, there are minor coarsening upward cycles within the massive conglomeratic unit. In fact, the entire sequence is a large scale coarsening upward cycle (thickening to a lesser degree). These features suggest a major regressive phase which is brought about by accelerated sedimentation (deposition more rapid than subsidence) and/or a relative drop in sea level due to tectonic effect (uplift).

In addition to the sedimentological factors, biological consideration is important too as the massive conglomeratic unit is predominantly reefal and its sediment are governed by the biota. This unit apparently did not reach a state of biohermal reef. It exhibits repeated cycles, that is initial stabilization of substrate and later colonized by patch reefs which may even reach a diversification stage (Fig. 6). However the shallow shelf area was drastically affected by periodic storm that promoted reworking and redistribution of reef material. When the storm subsided, condition was again favourable for reefal development. Episodic influx of siliciclastic material has hindered reefal development momentarily, these being relatively infrequent to obstruct reefal development altogether. Obviously a subsidising basin is required to account for such a thick sequence of shallow water deposit.

Autochthonous calcareous algae are realiable depth indicators as they are light dependent for photosynthesis and thus restricted to the photic zone. They are useful as they are not commonly transported too far from source and still remain intact. The presence of both crustose and articulate coralline and

STAGE	TYPE OF LST.	SPECIES DIVERSITY	SHAPE OF REEFBUILDERS
DOMINATION	bindstone - framestone	low - moderate	laminate encrusting
DIVERSIFICATION	framestone (bindstone) mudstone to wackestone matrix	high	domal massive lamellar branching encrusting
COLONIZATION	baffle- to floatstone (bindstone) with a mud-wackestone matrix	low	branching lamellar encrusting
STABILIZATION	grain- to rudstone (pack- to wackestone	low	skeletal debris

Figure 6 : Division of reef core facies (After James, 1983).

cordacean algae suggest shallow water depth of less than 30 m. This is supported by the *in situ* growth of corals which usually thrive at shallow depths (10 m or less). Present day patch reefs profilerating on shallow water platforms around the islands occur at depths of less than 4.5 m. The corals are clearly indicative of warm shallow marine and turbulent waters of low sedimentation rate and active circulation to cleanse their polyps from being choked by sediments. The presence of bivalves and echinoderms also suggest shallow marine conditions.

The indigenous foram appears to be benthic forms associated with reefal biota, whereas the miliolids (*Quinqueloculina sp.* and *Triloculina sp.*) being reliable nearshore indices (Bandy and Arnal, 1960), are derived and deposited here. *Ammonia* cf. *sandakanensis* in the calcareous sandstone where it occurred together with *Operculinoides* cf. *balcei* are also derived with the occurrence of arenaceous foram with agglutinated quartzose test in the packstone. However, *Discorbis sp.* in the lime clay matrix of packstone is indicative of lagoonal conditions with hypersaline implication (Brasier, 1980). Minor occurrences of globogerinids usually occur in the outer shelf or bathyal deposits and may also be deposited in shelf areas (neritic). The reefal association of larger benthics (*Lepidocyclina sp.* and *Nummulites sp.*) are typical of shallow marine environments where Wagner (1964), has delineated a water depth of 50-60 m that is for *Lepidocyclina* association with crustose algae. In summary, the biotic assemblage present implies a warm carbonate shallow marine environment, generally of normal salinity though localised areas of hypersalinity may be present and a nearby brackish water environment. The lower unit was deposited in deeper water relative to the upper unit.

DISCUSSION

Onshore western Sabah is dominantly underlain by deeper marine Paleogene sediments of the Crocker Formation. Further offshore is deep to shallow marine Neogene sediments. Similar limestones to those found on Mantanani Islands are exposed on the southern tips of the Banggi and Balambangan Islands (Wilson, 1961). Thus in addition to the clastic sediments and the carbonates, possibly middle Miocene carbonate buildups may be detected in the subsurface in the stretch of area offshore between these islands and the Mantanani Islands.

From structural points of view, the westward plunging tight megafold of Mantanani area corresponds to the east-west orientation of the Sulu Trend which is a province of complex structures extending westward into the Kudat Peninsula (Bol & Van Hoorn, 1980). This province, inclusive of the Mantanani Islands has a dominant Lower Pliocene deformation which caused the uplift of the strata to form the present setting and are related to the left-lateral strike-slip faulting within the basement. Seismic profiles depict the Mantanani Islands sitting on a structural high.

The associated middle Miocene reef buildups adjacent to Mantanani Islands on an elevated platform probably resemble those of Central Luconia in morphology (Epting, 1980). If the Mantanani area is envisaged as a topographic high reefal platform with deposition of bioclastic packstone intrabasinally, it would be difficult to account for the siliciclastic horizons that intervene the limestones periodically. Such clastic influx would not be able to move up gradient and be deposited on the platform. Hence, part of the basin margin should be located down slope of a continental source, most probably the Crocker Formation that had uplifted during Miocene and given rise to numerous Neogene deltaic facies adjacent to it.

The characteristic nature of the rocks in Mantanani Island is not seen elsewhere on the mainland. Coupled with its middle Miocene age, seem to suggests that a new stratigraphic unit should be erected. However, as mentioned earlier, similar limestone lithology are exposed on Banggi Island and Balambangan Island. Wilson (1961) dated the limestones on Banggi Island as Eocene and assigned it to the Banggi Formation, while those on Balambangan are thought to be middle — late Miocene and included it as the Balambangan Limestone Member of the Bongaya Formation. There is a possibility that these strata are coeval due to their proximity and similar lithology. The discrepancy in age may be due to reworked age diagnostic fossils from the clasts, especially for the limestones on Banggi Island. If so, the similar lithological characteristics, mode of occurrence, and age, suggest that the strata on Mantanani is correlatable to these rocks and may be identified as the Balambangan Limestone Member of the Bongaya Formation. This is consistent with the suggested presence of carbonate buildups along the western offshore of the Kudat Peninsula.

ACKNOWLEDGEMENT

This research was funded by a BP Carigali grant and Dept. of Geology, University Malaya, Kuala Lumpur. We would like to thank the Geological Survey Malaysia Sabah branch for their cooperation and Encik Abdullah Tatung, Ketua Kampong Mantanani Islands for assistance during fieldwork.

REFERENCES

BANDY, O.L. & ARNAL, R.E. 1960. Concepts of foraminifera paleoecology. *AAPG Bull.* 44: 1921 – 1923.

BLOW, W.H. 1970. Wilcoxon Group Paleontologic International Cenozoic Correlation Chart. 1981pp.

BOL, A.J. & VAN HOORN, B. 1980. Structural styles in Western Sabah offshore. *Geol. Soc. M'sia Bull.* 12: 1 – 16.

BRASIER, M.D. 1980. *Microfossils.* George Unwin Allen London. 193pp.

EPTING, M. 1980. Sedimentology of Miocene Carbonate Builtups, Central Luconia, offshore Sarawak. *Geol. Soc. Msia. Bull.* 12: 17 – 30.

JAMES, N.P. 1983. Reef. *In* Scholle, P.A.(Ed.) *Carbonate Depositional Environment. AAPG Mem* 33:345-462.

KOK, K.H. 1985. *The Geology of Mantanani Islands, Sabah, Malaysia.* Unpubl. BSc. thesis, Univ. Malaya, Kuala Lumpur.

WAGNER, C.W. 1964. Manual of larger foraminifera (Generic determination and stratigraphic value). *Bataafse Internationale Petroleum Maatschappiji N.V.*, The Hague, Shell Exploration and Production.

WILSON. J.L. 1975. *Carbonate Facies in Geologic History. Springer* — Verlag. New York. 471pp.

WILSON, R.A.M. 1961. The Geology and Mineral Resources of the Banggi Islands and Sugut River, North Borneo. Geol. Surv. Dept. British Borneo.

Manuscript received 18th April 1989