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Biostratigraphy and Paleoecology of Fusulininids from Bukit Panching, Pahang

M.B. IDRIS[1] & M.S. AZLAN[2]

[1] Department of Geology, University of Malaya, Kuala Lumpur.

[2] Personnel Section, Universiti Pertanian Malaysia, Serdang.

Abstract : Bukit Panching, part of the previously described massively bedded Upper Carboniferous Panching Limestone, exhibits well-bedded limestones of thickness 1-4 metres that offer excellent stratigraphic control. From the distribution of the fusulininids recovered, five local assemblage zones are established. These fusulininids and the lithological character of the limestone indicates that the limestone of Bukit Panching was deposited in a warm shallow marine sheltered environment. Although fusulinaceans seemed to dominate the fauna, endothyraceans were the most diverse.

INTRODUCTION

Originally Scrivenor (1931), Muir-Wood (1948), Sakagami (1972) and Ozawa (1975) suggested that the Panching Limestone was of Lower Carboniferous age based on brachiopods, bryozoa, corals and foraminifera recovered from Bukit Charas. However, Igo & Koike (1968) and Mamet and Saurin (1970) who worked on conodonts and foraminifera from similar samples indicated an Upper Carboniferous age. More recent attempts which include detailed samplings of the four limestone hills that constitute the Panching Limestone by Metcalfe *et al.* (1980) and Metcalfe (1980a, 1980b) revealed conodonts, corals and foraminifera of Upper Carboniferous age.

Bukit Panching represents the southernmost hill of the Panching Limestone. More recent quarrying activities in the hill revealed excellent well-bedded exposures that offer complete stratigraphical control that are not available before. Thin sections were made from 44 samples taken at regular intervals. The biostratigraphy and paleoecology of its foraminiferal content are discussed below.

LOCATION AND STRATIGRAPHY

Bukit Panching is a small limestone hill that rises steeply from the sorrounding relatively flat land to a height of 148 m. It is located close to Panching town, along the Kuantan - Sungai Lembing road (Fig. 1).

This hill has been designated to be part of the massively bedded Upper Carboniferous Panching Limestone which has been estimated to be about 600 m thick (Metcalfe *et al.*, 1980). However, exposures on the quarry face indicate that the limestone here is well-bedded, consisting of beds ranging in thickness from

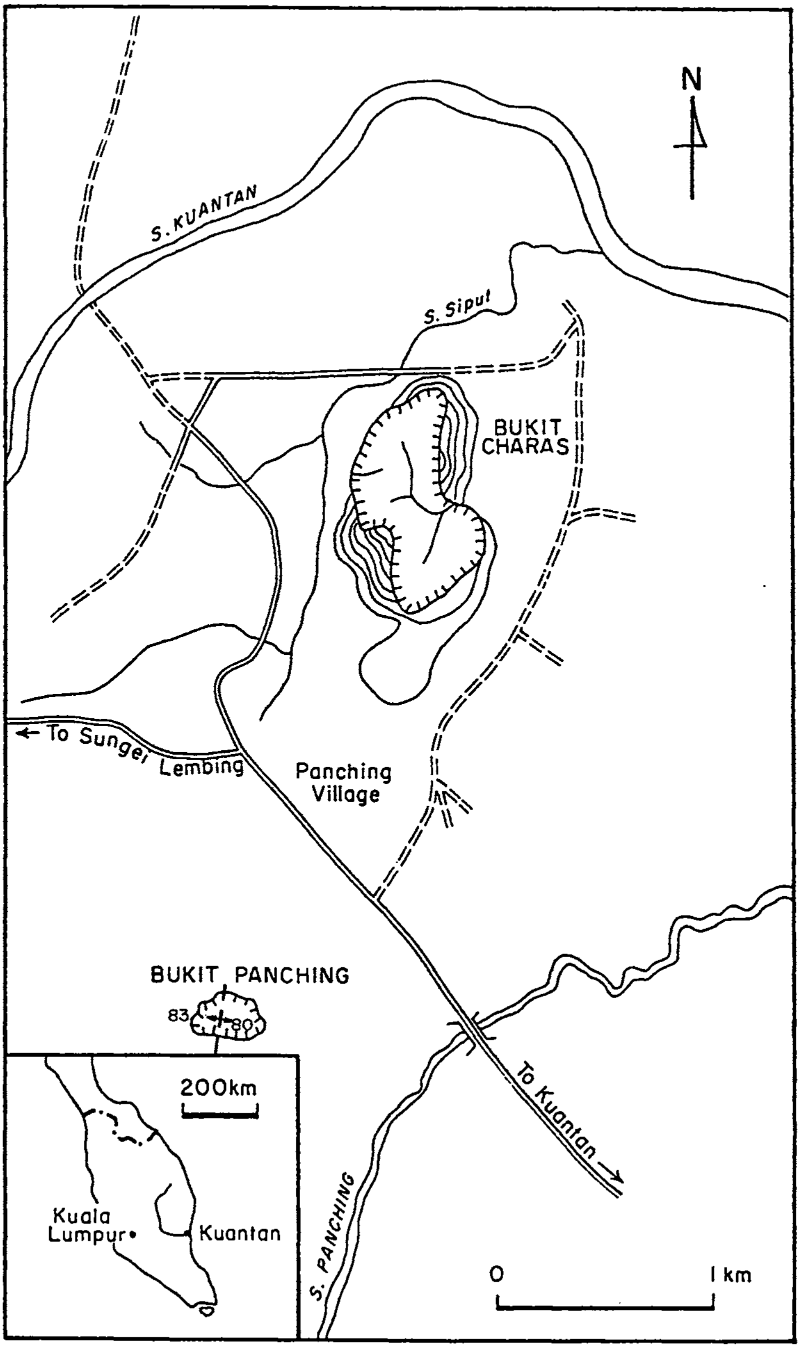

Figure 1: Location map of Bukit Panching.

1 - 4 m. Generally these beds strike in a NS direction and dip steeply (75° - 83°) to the east. The whole hill represents a tightly folded sequence as can be observed from the southern face. The beds on the eastern limb can be confidently logged from the base upwards of which samples at 2 m intervals are taken (Fig. 2). This sequence consists mainly of dark to light grey limestones that can petrographically be described as biomicrite and biosparudite. Beds of the western limb of the fold are obscured by fallen debris and vegetation.

BIOSTRATIGRAPHY

Prior to this, the Panching Limestone is thought to be massively bedded and unfolded. Thus the establishment of foraminiferal biozones is considered necessary to elucidate the local stratigraphy of the formation.

The foraminiferal species found in the Bukit Panching limestone are:-

Archaediscus baschkirius Krestonikov & Teodorovitch
Archaediscus krestonikovi Rauser
Climacammina antiqua Brady
Climacammina textulariforme Moeller
Endothyta bowmani Bowman
Endothyranella armstrongi Cushman & Waters
Endothyranopsis pseudoglobulus Reytilinger
Eostafella mosquensis Vissarionova
Eostafella toriyamai Ozawa
Howchinia bradyana Howchin
Monotaxinoides transitorius Brazhinikova & Yartseva
Paleotextularia grahamensis Cushman & Waters
Quasiendothyra aljutovica Reytilinger
Tetrataxis conica Ehrenberg
Tuberitina collosa Reytilinger
Yanischewskina typica Mikhaylov

Their numerical abundance is given in Table 1 and their illustrations are provided in Plate 1. From the summary of the stratigraphical distribution of the foraminifera in the Bukit Panching limestone, five biozones can be differentiated (Fig. 2). These are informally referred to as (from oldest to youngest):-

p1 Assemblage Zone
p2 Assemblage Zone
p3 Assemblage Zone
p4 Assemblage Zone
p5 Assemblage Zone

Table 1: Numerical distribution and abundance (%) of the fusulininid species samples of Bukit Panching.

	ARCHAEDISCACEANS								ENDOTHYRACEANS																FUSULINACEANS						TETRATAXACEANS			
	Archaediscus baschkirius		*Archaediscus krestovnikovi*		*Howchinia bradyana*		*Monotaxinoides transitorius*		*Climacammina antiqua*		*Climacammina textulariforme*		*Endothyra bowmani*		*Endothyranella armstrongi*		*Endothyranopsis pseudoglobulus*		*Paleotextularia grahamensis*		*Quasiendothyra aljutovica*		*Tuberitina collosa*		*Eostafella mosquensis*		*Eostafella toriyamai*		*Yanischewskina typica*		*Tetrataxis conica*		Overall fauna	
Sample	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	Total	%
P1	–	–	–	–	1	100.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0.2
P2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	1	0.2
P3	–	–	–	–	–	–	–	–	–	–	–	–	3	23.1	–	–	–	–	2	15.4	1	7.7	–	–	7	53.8	–	–	–	–	–	–	13	2.3
P4	–	–	–	–	1	50.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	50.0	–	–	–	–	–	–	2	0.4
P5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0.0
P6	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0.2
P7	–	–	–	–	1	50.0	–	–	–	–	–	–	1	50.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0.4
P8	–	–	–	–	1	100.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0.2
P9	–	–	–	–	2	100.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0.4
P10	–	–	–	–	2	66.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	33.3	3	0.5
P11	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	–	–	–	–	–	–	–	–	1	0.2
P12	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0.0
P13	–	–	–	–	1	33.3	–	–	–	–	–	–	–	–	–	–	–	–	2	66.6	–	–	–	–	–	–	–	–	–	–	–	–	3	0.5
P14	–	–	–	–	6	85.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	14.3	7	1.2
P15	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0.0
P16	–	–	–	–	8	15.5	1	2..0	–	–	–	–	26	51.0	1	2.0	–	–	–	–	1	2.0	–	–	1	2.0	13	25.5	–	–	–	–	51	9.1
P17	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	8.3	–	–	2	16.6	9	75.0	–	–	–	–	12	2.1
P18	–	–	1	2.7	11	29.7	–	–	–	–	–	–	1	2.7	–	–	–	–	–	–	16	43.2	–	–	5	13.5	2	5.4	–	–	1	2.7	37	6.6
P19	–	–	–	–	–	–	1	2.5	–	–	1	2.5	2	5.0	–	–	1	2.5	1	2.5	–	–	–	–	16	41.0	12	30.7	5	12.8	–	–	39	6.9
P20	–	–	–	–	–	–	–	–	–	–	1	9.0	3	27.0	–	–	–	–	–	–	–	–	–	–	4	36.4	3	27.3	–	–	–	–	11	2.0
P21	–	–	–	–	3	17.6	–	–	–	–	–	–	1	5.9	–	–	–	–	–	–	–	–	–	–	7	41.1	6	35.3	–	–	–	–	17	3.0
P22	4	15.4	2	7.7	9	34.6	1	3.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	11.5	2	7.7	5	19.2	–	–	26	4.6
P23	–	–	–	–	2	40.0	–	–	–	–	–	–	1	20.0	–	–	2	40.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	0.9
P24	–	–	–	–	4	18.2	–	–	–	–	–	–	6	27.2	–	–	–	–	–	–	–	–	–	–	6	27.2	5	22.7	–	–	1	4.5	22	3.9
P25	–	–	–	–	–	–	–	–	–	–	–	–	4	66.6	–	–	–	–	–	–	–	–	–	–	2	33.3	–	–	–	–	–	–	6	1.1

Continue....

Table 1: Numerical distribution and abundance (%) of the fusulininid species samples of Bukit Panching.

	ARCHAEDISCACEANS								ENDOTHYRACEANS																FUSULINACEANS						TETRATAXACEANS			
	Archaediscus baschkirius		*Archaediscus krestovnikovi*		*Howchinia bradyana*		*Monotaxinoides transitorius*		*Climacammina antiqua*		*Climacammina textulariforme*		*Endothyra bowmani*		*Endothyranella armstrongi*		*Endothyranopsis pseudoglobulus*		*Paleotextularia grahamensis*		*Quasiendothyra aljutovica*		*Tuberitina collosa*		*Eostafella mosquensis*		*Eostafella toriyamai*		*Yanischewskina typica*		*Tetrataxis conica*		Overall fauna	
Sample	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	popn	%	Total	%
P26	1	5.9	–	–	–	–	–	–	–	–	–	–	2	11.7	–	–	–	–	1	5.9	–	–	–	–	13	76.5	–	–	–	–	–	–	17	3.0
P27	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	100.0	–	–	–	–	–	–	5	0.9
P28	–	–	1	4.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	16	69.6	3	13.0	3	13.0	–	–	23	4.1
P29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7	43.7	–	–	9	56.3	–	–	–	–	–	–	16	2.8
P30	–	–	–	–	–	–	–	–	–	–	1	7.7	–	–	–	–	–	–	–	–	–	–	–	–	12	92.3	–	–	–	–	–	–	13	2.3
P31	1	09.1	1	9.1	–	–	–	–	–	–	2	18.2	–	–	–	–	2	18.2	–	–	–	–	–	–	1	9.1	4	36.3	–	–	–	–	11	2.0
P32	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8	100.0	–	–	8	1.4
P33	–	–	–	–	–	–	1	5.2	–	–	–	–	–	–	–	–	1	5.2	4	21.1	–	–	–	–	3	15.8	6	31.5	4	21.1	–	–	19	3.4
P34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	28.5	2	28.5	–	–	2	28.5	–	–	1	14.3	–	–	7	1.2
P35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	50.0	2	50.0	–	–	–	–	4	0.7
P36	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	75.0	–	–	–	–	–	–	1	25.0	–	–	–	–	4	0.7
P37	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	0.0
P38	7	16.2	–	–	–	–	–	–	–	–	6	14.0	–	–	–	–	–	–	–	–	4	9.3	–	–	12	27.9	9	20.9	5	11.6	–	–	43	7.7
P39	3	50.0	–	–	–	–	–	–	–	–	1	16.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	33.4	–	–	–	–	6	1.1
P40	6	13.0	–	–	5	10.9	–	–	–	–	14	30.4	–	–	–	–	2	4.3	–	–	–	–	–	–	6	13.0	8	17.4	5	10.9	–	–	46	8.2
P41	4	16.6	–	–	–	–	–	–	1	4.1	–	–	–	–	–	–	–	–	1	4.1	6	25.0	–	–	8	33.3	4	16.6	–	–	–	–	24	4.3
P42	–	–	–	–	–	–	–	–	–	–	2	22.2	–	–	–	–	–	–	–	–	–	–	–	–	7	77.7	–	–	–	–	–	–	9	1.6
P43	–	–	–	–	–	–	–	–	–	–	5	20.0	–	–	–	–	–	–	–	–	–	–	–	–	9	36.0	11	44.0	–	–	–	–	25	4.4
P44	–	–	–	–	–	–	–	–	–	–	3	15.8	–	–	4	21.0	2	10.5	–	–	–	–	–	–	6	31.5	–	–	4	21.0	–	–	19	3.4
Total	26		5		57		4		1		36		51		5		10		16		38		1		165		102		40		5		562	100.0
	Archaediscacean popn: 92 16.38%								Endothyracean popn: 158 28.11%																Fusulinacean: 307 54.62%						5 0.89%		Tetrataxacean	

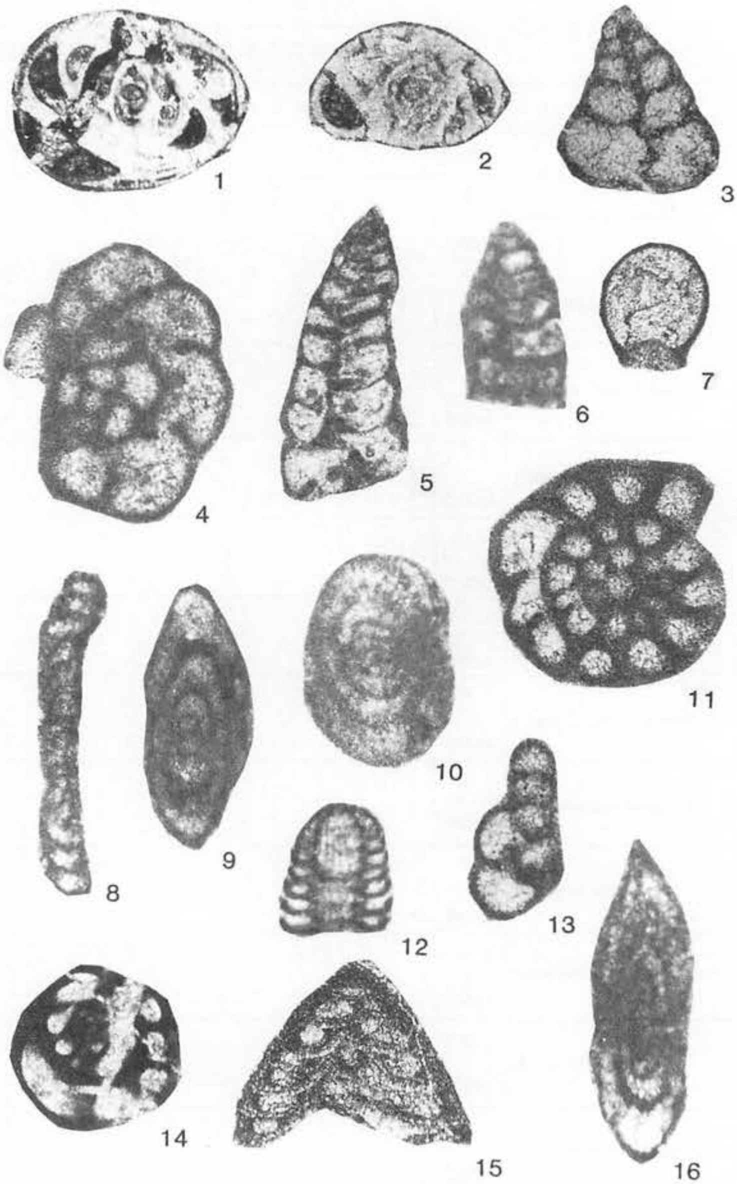

Plate 1. The figures are all axial sections unless stated otherwise. All specimens are reposited in the Paleontology Collection, University of Malaya, Kuala Lumpur.

1.*Archaediscus krestovnikovi* (X40), F.5443, P22.
2.*Archaediscus baschkirius* (X110), F.5436, P28.
3.*Paleotextularia grahamensis* (X35), F.5457, P33.
4.*Endothyra bowmani* (X90), sagittal section, F.5436, P26.
5.*Climmacammina textulariforme* (X30), F.5459, P2.
6.*Climmacammina antiqua* (X35), F.5446, P41.
7.*Tuberitina collosa* (X75), F.5461, P11.
8.*Monotaxinoides transitorius* (X150), F.5456, P19.
9.*Eostafella toriyamai* (X130), F.5450, P18.
10.*Endothyranopsis pseudoglobulus* (X45), F.5435, P19.
11.*Quasiendothyra aljutovica* (X90), sagittal section, F.5446,P18.
12.*Howchinia bradyana* (X90), F.5455, P18.
13.*Endothryanella armstrongi* (X100), F.5449, P44.
14.*Yanischewskina typica* (X60), sagittal sction, F.5463, P28.
15.*Textrataxis conica* (X60), F.5459, P2.
16.*Eostafella mosquensis* (X80), F.5451, P2b.

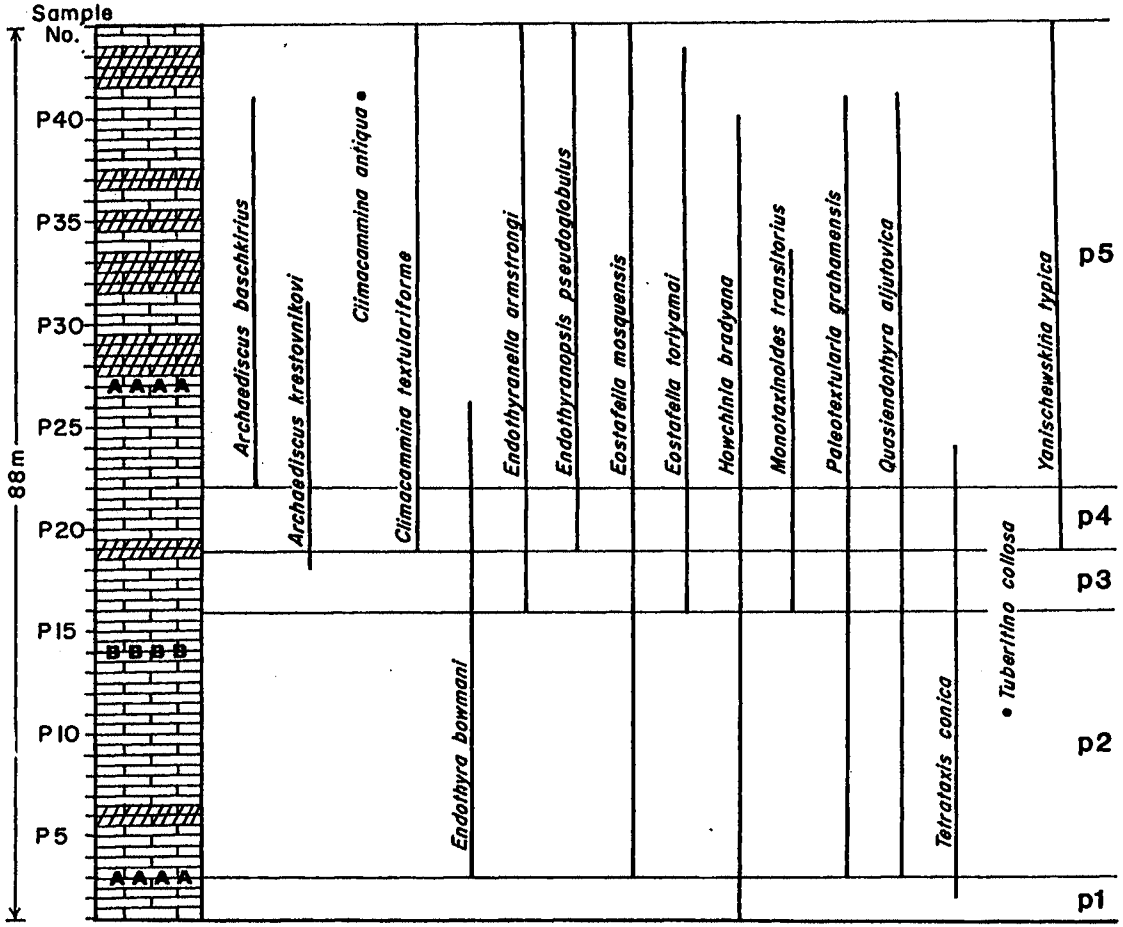

Figure 2 : The local fusulininid assemblage zones of Bukit Panching limestone. Stippled lithology represents biosparudite, unstippled - biomicrite, AAAA - algal rich beds and BBBB - bryozoan rich beds

p1 Assemblage Zone

This zone represents the oldest biozone in the Bukit Panching limestone. It is a relatively narrow zone, extending from the exposed base of the Panching Limestone to a height of about 6 m at Bukit Panching.

The lower end of this zone coincides with the base of the logged section and its upper limit is demarcated by the appearance of *Endothyra bowmanni, Eostafella mosquensis, Paleotextularia grahamensis* and *Quasiendothyra aljutovica, Howchinia bradyana* and *Tetrataxis conica* may be found in this zone.

p2 Assemblage Zone

This is a broad zone of about 26 m thick. Its lower boundary coincides with the upper datum of the preceding p1 Assemblage Zone and its upper boundary is marked by the first appearance of *Endothyranella armstrongi, Eostafella toriyamai* and *Monotaxinoides transistorius.*

p3 Assemblage Zone

This zone extends for about 6 m. Its lower limit coincides with the upper limit of the p2 Assemblage Zone. The upper boundary of this zone is limited by the first appearance of *Climicammina textulariforme, Endothytamopsis pseudoglobulus* and *Yanischewskina typica.*

p4 Assemblage Zone

This zone succeeds the p3 Assemblage Zone and is about 6 m thick. Its lower limit coincides with the upper limit of the p3 Assemblage Zone and its upper limit is marked by the first appearance of *Archaediscus baschkirius.*

p5 Assemblage Zone

This is a thick zone that extends from the upper limit of the p4 Assemblage Zone, right to the top of the logged section. Its lower limit is demarcated by the appearance of *Archaediscus baschkirius.* Most of the foraminifera recovered from Bukit Panching are found in this zone, including *Climacammina antiqua.*

It should be stressed that the above biostratigraphical divisions are intended for local use only. However, on a broader spectrum, the Bukit Panching fauna is similar to the *Eostafella - Millerella* fusulinid zone but with a marked absence of *Millerella*. Instead, there is an abundance of *Howchinia*. Generally, the Bukit Panching fusulinid zone is characterised by an association of fusulinaceans (54.62%), endothyraceans (28.11%). archaediscineans (16.38%) and tetrataxaceans (0.89%. Table 1, Fig. 3). Although the fusulinaceans dominate the fauna, the endothyraceans are the most diverse, represented by eight out of the total 16 species encountered in the fauna. There is a distinct absence of tournayellid forams.

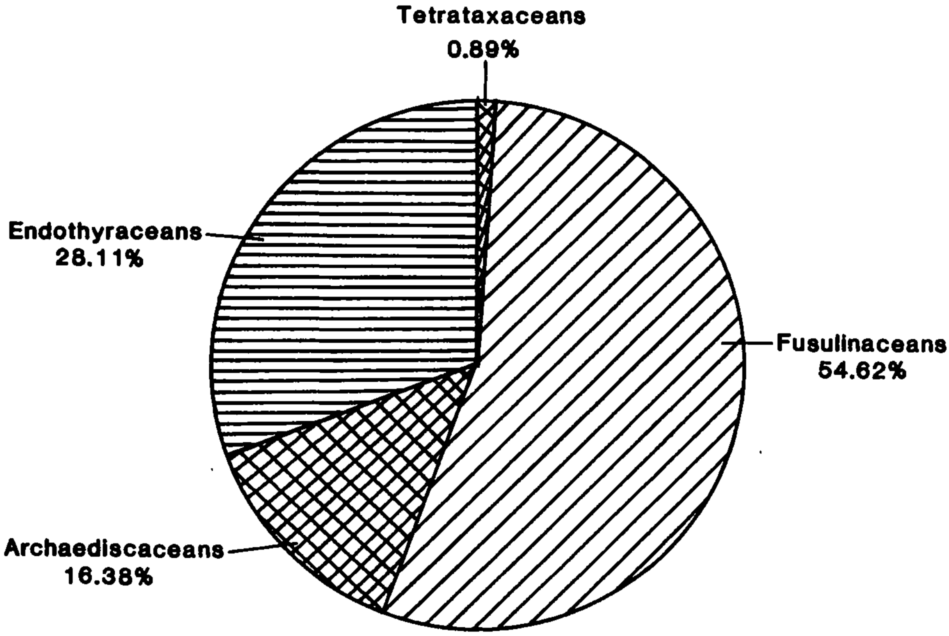

Figure 3: Distribution of the fusulininids superfamilies of Bukit Panching fauna

PALEOECOLOGY

An attempt is made here to elucidate the paleoecology of the foraminifera in Bukit Panching limestone. Morphological attributes,petrographical evidence and examination of the stratigraphical distributional patterns of the fauna are taken into consideration. The latter involves plotting the relative abundance (%) of each foraminifera species with the application of the similarity index of Murray & Wright, 1974. The similarity index is based on the comparison of percentage data of two succeeding samples and where a species is common to both, the smaller abundance is noted. The distribution pattern is plotted in Fig. 4.

All the forams observed are benthonic fusulininids displaying a variety of morphological shapes. They are uniserial, uniserial-biserial, viserial, trochiform, planispiral, discoidal, fusiform and planispiral-uniserial forms. Basically, most of them are flat-bottomed or possessed sides that are compatible for resting on the substrate. Lipps (1975) suggested that planispiral forams are active detrital feeders whereas elongate forms (uniserial, biserial) are passive deposit feeders that lived near the sediment-water interface. They are probably infaunal forms (Haynes, 1982). The trochiforms have been suggested by Henbest (1963), to lead an active or temporarily fixed life and may be attached to seaweed. The latter is not clear in Bukit Panching. Although *Howchinia* and *Tetrataxis* do not show significant increases in the algal and bryozoan-rich limestones, the abundance

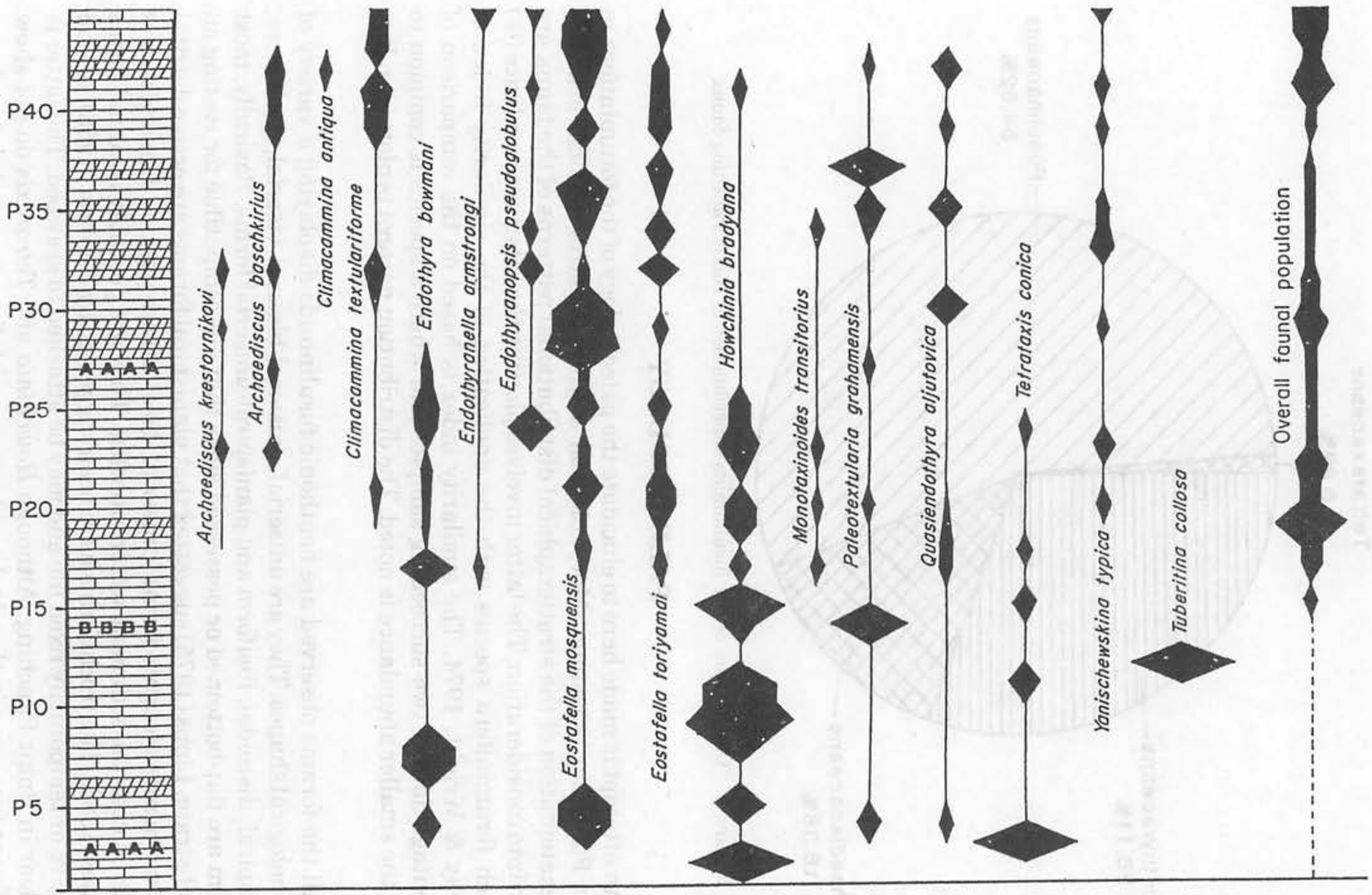

Figure 4 : Stratigraphical populational distribution of the individual species (lateral scale: 1mm = 10%) and the overall faunal population (lateral scale: 1mm = 1%) of Bukit Panching fusulininids. Legend for the stratigraphic column is similar to that of Fig. 2.

is not seen in the upper algal-rice bed. Generally, these trochiforms preferred the lower part (deeper?) of the Bukit Panching limestone where the energy level is lower as indicated by the lesser occurrence of biosparudite beds.

Lithologically, the succession consists mainly of biomicrite interspersed with biosparudite at certain intervals. Some of the biomicrite contain an abundance of algae and bryozoan debris. Physically, these limestones appear dark and are richer in carbonaceous content. These suggest a lower energy environment of deposition in calm waters or ineffective winnowing activities which took place probably at the deeper part of the shallow marine environment, or in a sheltered environment. In contrast, the biosparudite indicates higher energy environment, where water currents are more vigourous enabling the winnowing process to deposit the biosparudites. Generally, the limestones here are interpreted to be deposited in a warm shallow marine (low energy zone) lagoonal environment.

In the early stage of deposition, the carbonate supply enters the zone of calm waters where winnowing process was ineffective. Since warm and normal salinity water was present in the environment, ecologically it was suitable for foraminifera to live and thrive. However, they were lesser in abundance and of low diversity (Fig. 4) probably due to the instability of the environment as the quiet sea-floor experienced a more rapid rate of precipitation of calcium carbonate that formed the biomicritic layers. As can be seen from Fig. 4, only certain species prevailed in this environment, especially *Howchinia*.

On-going sedimentation coupled with normal salinity and optimum temperature activated the tendency for an abundance of fauna. Occasionally, vigorous current activities, winnow away the lime mud and created more space for precipitation of sparry calcite. This caused the deposition of biosparudite.

It is interesting to note that after a certain level of limestone deposition, the amount of foraminifera becomes consistent throughout the samples. This could probabaly be due to shallower and more favourable conditions. The slight fluctuations in the faunal abundance may be attributed to depth variations or other factors.

The inference of a warm shallow marine sheltered environment (lagoonal) is further supported by several evidences obtained from this biostratigraphic study. Abundance forams suggest that at the time of deposition the ecological factors must have been favourable. Brasier (1980) noted that most forams are adapted to normal salinity of sea water and cannot tolerate higher or lower salinity. The photic zone in tropical waters (which extends to approximately 200 m below surface) is a favourable region of accumulation of symbiotic algae. This in turn would promote the abundance of foraminifera. In addition, the optimum temperature of 28°C and well oxygenated zone will enhance the accumulation of the fauna. Such criteria are well defined in a sheltered environment. Ross, (1972) and Lagenheim *et al.* (1977) indicated that fusulinaceans are essentially shallow water forams and Ross (1973) recorded that endothyrids which are prominent in the Bukit Panching fauna, are abundant in nearshore and shelfal limestone. The lower abundance of endothyrids strongly indicates that the energy level is low as Skipp *et al.*, (1966) observed that this group of forams flourished in warm shallow moderately high energy environments. Instead fusulinaceans dominate the fauna here.

The fauna present are randomly oriented and vary in size ranging from a few microns to very coarse fragments (few cm). This suggest that the limestone is poorly sorted. It reflected that the animals have lived, died and been deposited in a zone free from active directional current or in a zone of weak current, incapable of winnowing, reworking, transporting or imbricating the organisms.

As such, the limestone at Bukit Panching was deposited in a sheltered basin-like environment (lagoonal) of moderate temperature and salinity in a tropical zone.

In general, the distribution patterns (Fig. 4) indicate that:-

i) there is an absence of energy control over any of the species present, i.e the species have no special preference for any energy level.

ii) there is an apparent effect on diversity in relation to water depth. Lower diversity and abundance are observed at the early stages of limestone deposition i.e. at relatively deeper water conditions and the dominant fauna here is *Howchinia bradyana*. The apparent increase in diversity at this level occurred in the association with algae, probably due to symbiotic process.

iii) fusulinaceans flourished the most in this environment, followed by endothyraceans, archaediscaceans and tetrataxaceans respectively. However, the endothyraceans are the most diverse.

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