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MORPHOGENETIC TREND OF LEPIDOCYCLINA AND ITS APPLICATION IN TIME STRATIGRAPHY

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ABSTRACT

The morphogenetic trend of *Lepidocyclina* in Miocene sediments from Sarawak, East Malaysia, has been studied. A correlation has been established between the degree of curvature of *Lepidocyclina* and the planktonic foraminiferal zonation in the area. The results prove that this evolutionary trend of *Lepidocyclina* is a practical tool for chronostratigraphy.

INTRODUCTION

The Central Luconia area, offshore Sarawak, East Malaysia, (fig. 1) is characterised by wide-spread reefal development in the Middle and Upper Miocene. During the Lower Miocene, a stable shelf developed which resulted in the deposition of a sequence of alternating carbonates and siliciclastics overlying a thick series of Oligocene to Lower Miocene siliciclastics. This was followed by a rather uniform carbonate unit of Lower Middle Miocene age which formed the floor on which the reefal buildups grew (fig. 2). Uplift of the northwest Borneo geosyncline (L i e c h t i, 1960) led to increased deposition of siliciclastics from Middle Miocene onwards, resulting in a northward prograding siliciclastic wedge that filled in and covered the carbonate platform topography (fig. 3).

The lack of detailed chrono-stratigraphical control in carbonate sections of Miocene age in Central Luconia area has always made it difficult to correlate between the different carbonate buildups and from carbonate buildups into the surrounding siliciclastic deposits (fig. 3).

Rich foraminiferal faunas have only been found in carbonate rocks belonging to offreef environments. However, even in these rocks, age-diagnostic planktonic Foraminifera are generally absent or cannot be isolated from the rocks for specific determination. Consequently, age determinations are not only restricted to these few open marine intervals but also are based on only the broad stratigraphical ranges of some large Foraminifera. These data can only provide subdivisions according to the Far East Letter Classification (v a n d e r V l e r k and U m b g r o v e, 1927) which are too broad for any useful tie-in with the planktonic foraminiferal zonation established for the siliciclastics in northwest Borneo.

In an attempt to improve the dating of the carbonates, a study was initiated to investigate whether the morphogenetic trend of *Lepidocyclina* could be used as a time-stratigraphical tool in the Miocene carbonate sequences. The "degree of curvature" parameter as defined by v a n d e r V l e r k (1968A and 1968B) was used for this investigation. The preliminary results revealed that the degree of curvature of *Lepidocyclina* from well samples increased persistently upwards in a borehole section and hence with decreasing age of the sediments.

A m b r o i s e and B e r e t t i (1974) investigated Lepidocyclinas from Madagascar, reviewed the various methods used so far in literature and added their own index of evolutionary degree. They agreed that in using the measurements on the embryonic chambers a biostratigraphical scale can be established without having to rely on specific determinations of *Lepidocyclina*.

In order to evaluate the significance of this morphogenetic trend in relation to the planktonic foraminiferal zonation in use in northwest Borneo, a follow-up detailed study was undertaken to determine the degree of curvature of *Lepidocyclina* from samples belonging to well defined planktonic foraminiferal zones.

The degree of curvature method was applied by P a l m i e r i (1973) on Lepidocyclinas from two wells drilled in the Capricorn Basin, offshore Queensland, Australia. His results (p. 317, fig. 4) for the Lower Miocene interval are in close agreement with our data from Sarawak. Above the "Orbulina datum" Palmieri reported degree of curvature values of 60% to approximately 75%. The highest values were derived from a higher stratigraphical level than that investigated in Sarawak.

METHOD OF STUDY

Only megalospheric specimens of *Lepidocyclina*, characterised by nucleoconchs of the isolepidine, nephrolepidine

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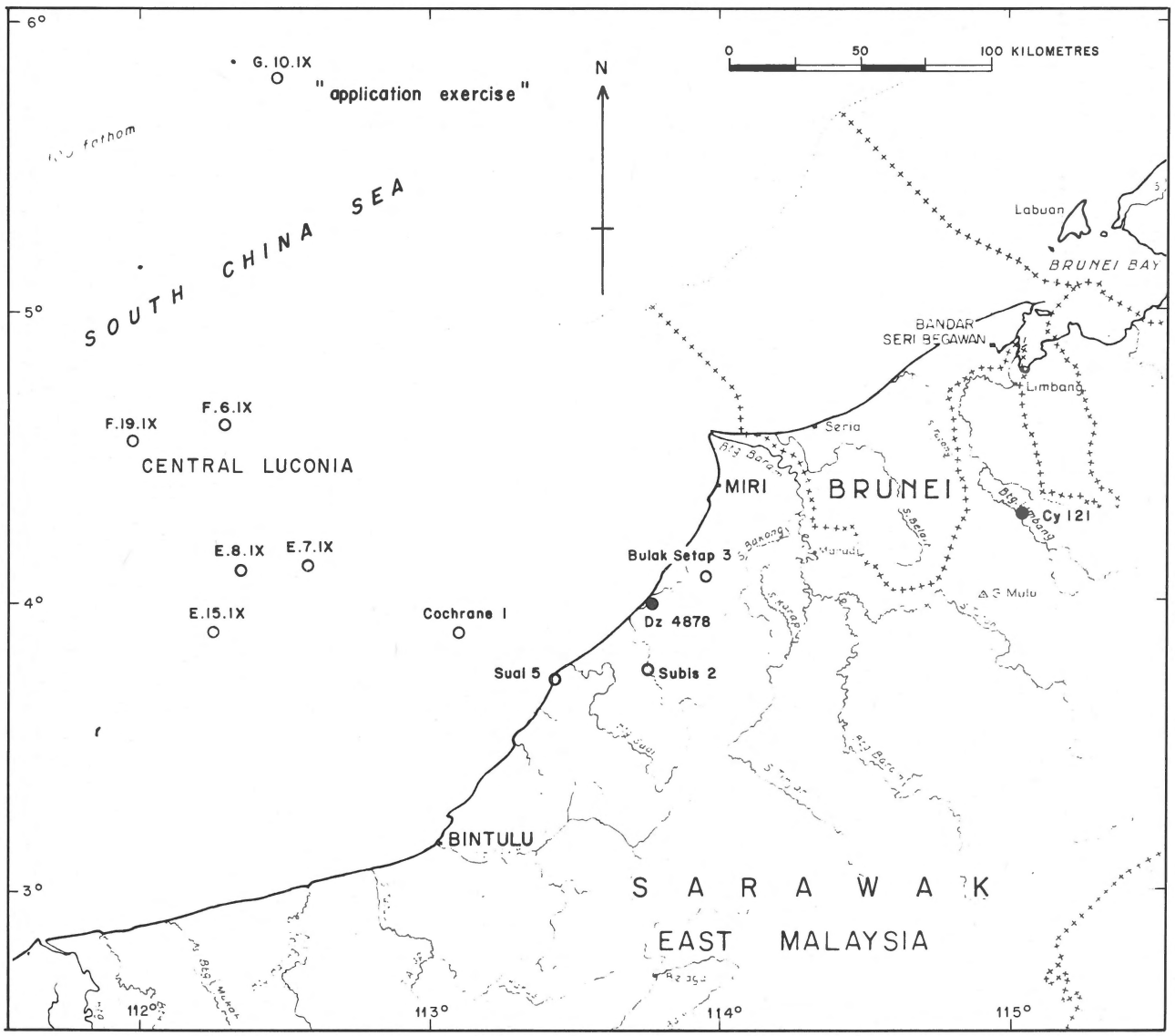


Fig.1 : Situation Map

o well

● surface sample

and trybliolepidine type (Plate I) were investigated. Forms belonging to the subgenus *Eulepidina* and all the transitions from trybliolepidine to multilepidine types (Plate II) were excluded.

For each sample a maximum of 20 horizontal sections of *Lepidocyclina* were measured to established the degree to which the wall between the protoconch and the deuteroconch in the embryo was curved (Plate I A). All measurements were carried out under a 100x magnification using a micrometer.

The above procedure was adopted since it was considered essential that any method to be used should be practical and suitable for routine operational investigation. Therefore, the time taken for the preparation and study of one sample is kept to a minimum. The analysis, although simplified, still allows for relatively accurate results.

The samples used for this study were either from exploration wells or outcrops, the location of which are shown on fig. 1. These samples were selected because their age had already established by means of the planktonic Foraminifera.

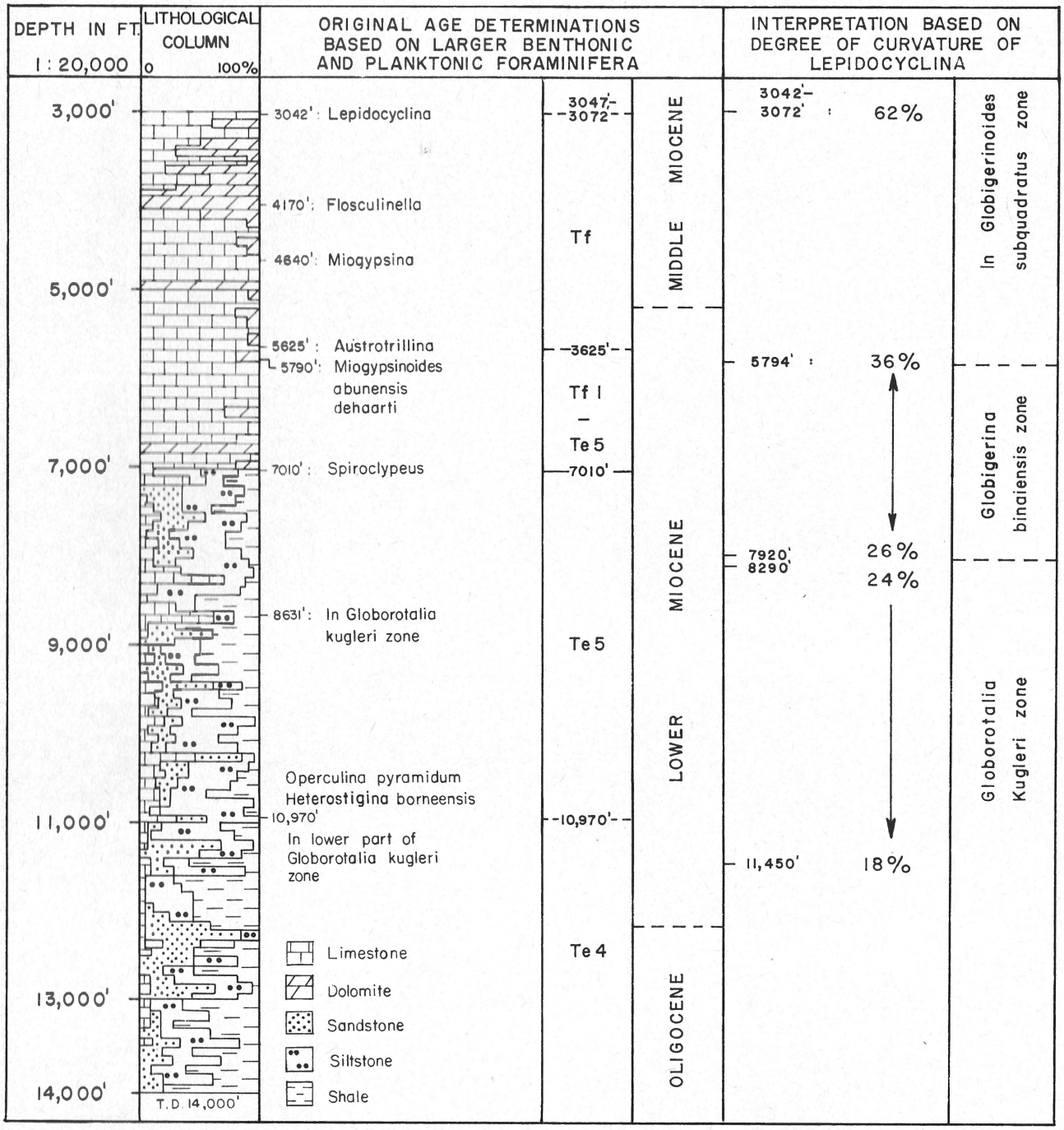


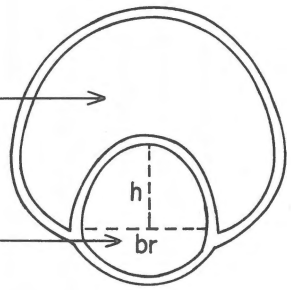
Fig. 2 : Stratigraphy of the Well G 10·1X

After the correlation was made between the degree of curvature of *Lepidocyclina* and the planktonic foraminiferal zonation, sample material from another offshore well, G.10.1X was investigated for the application exercise discussed in Chapter IV.

DISCUSSION OF RESULTS

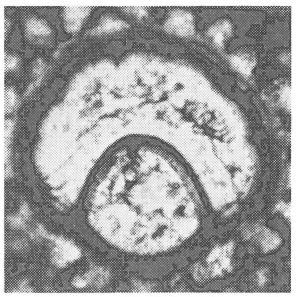
The average degree of curvature of *Lepidocyclina* increases gradually and persistently from 19% in the *Globorotalia kugleri* zone to 62% in the *Globigerinoides sub-*

Degree of curvature = $\frac{h}{br}$ x 100 = %



MIDDLE MIOCENE

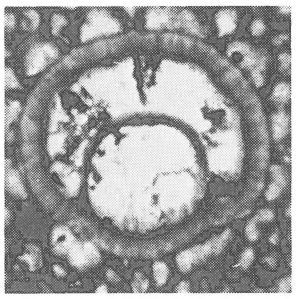
Globigerinoides subquadratus zone



110 X

DOC = 62 %

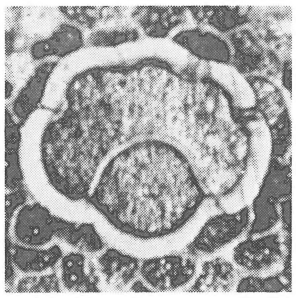
Globorotalia lobata / robusta zone



110 X

DOC = 56 %

Globorotalia barisanensis – fohsi zone

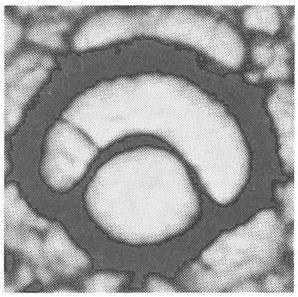


90 X

DOC = 53 %

LOWER MIOCENE

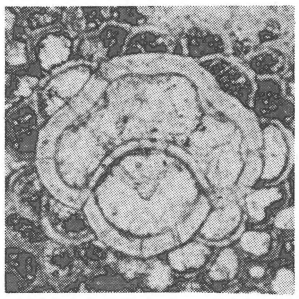
Globigerinatella insueta / Globigerinoides bisphericus zone



170 X

DOC = 47 %

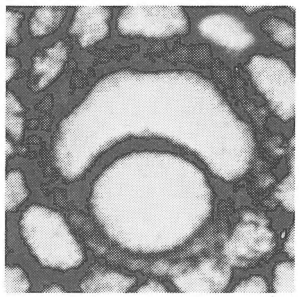
Catapsydrax dissimilis / stainforthi zone



90 X

DOC = 40 %

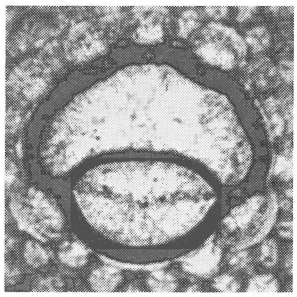
Globigerina binaiensis zone



180 X

DOC = 28 %

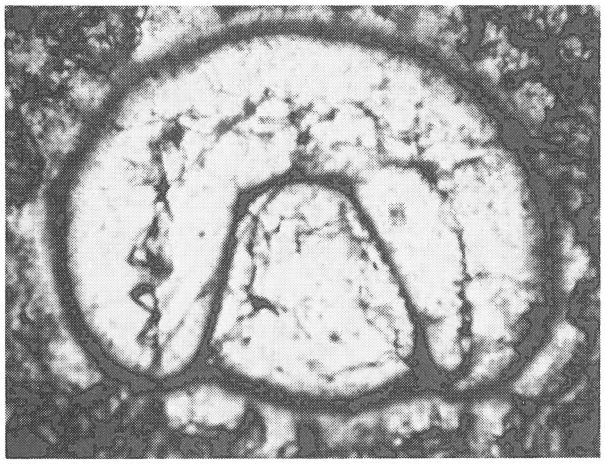
Globorotalia kugleri zone



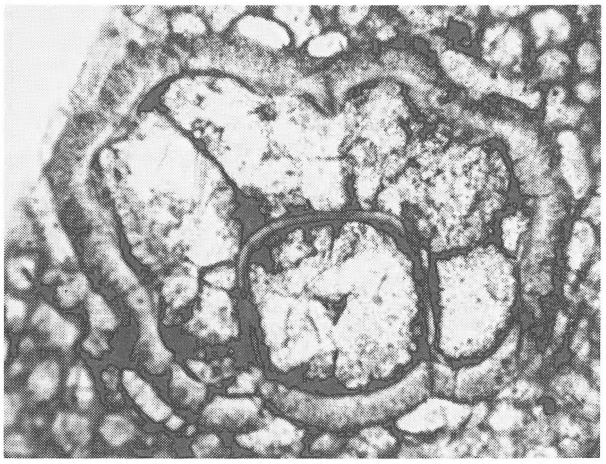
90 X

DOC = 20 %

Plate I : Evolutionary development in nucleoconchs of Lepidocyclina



100 X



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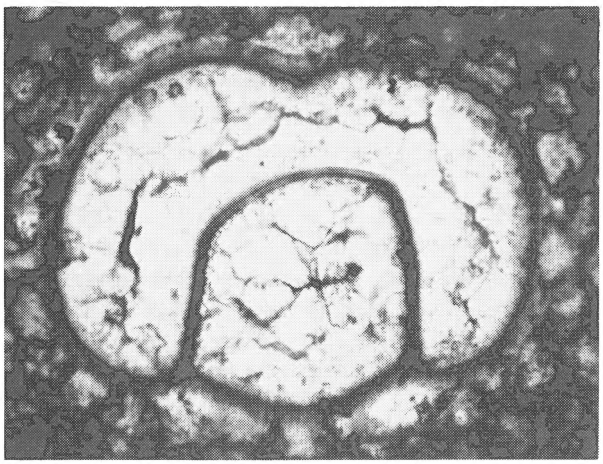
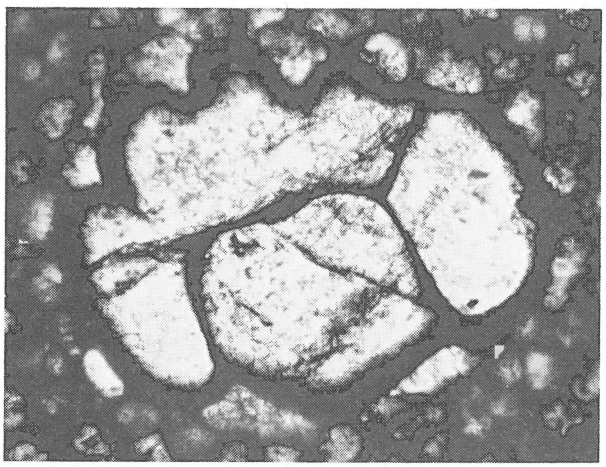
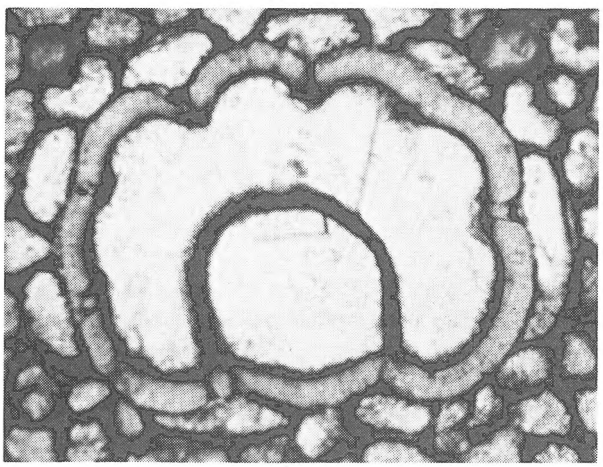


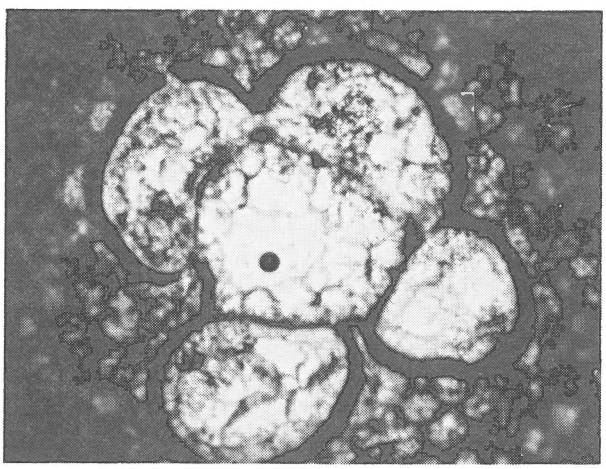
100 X



100 X



100 X



60 X

Plate II : Nucleoconchs of Lepidocyclina showing all the transitions from trybliolepidine to multilepidine type

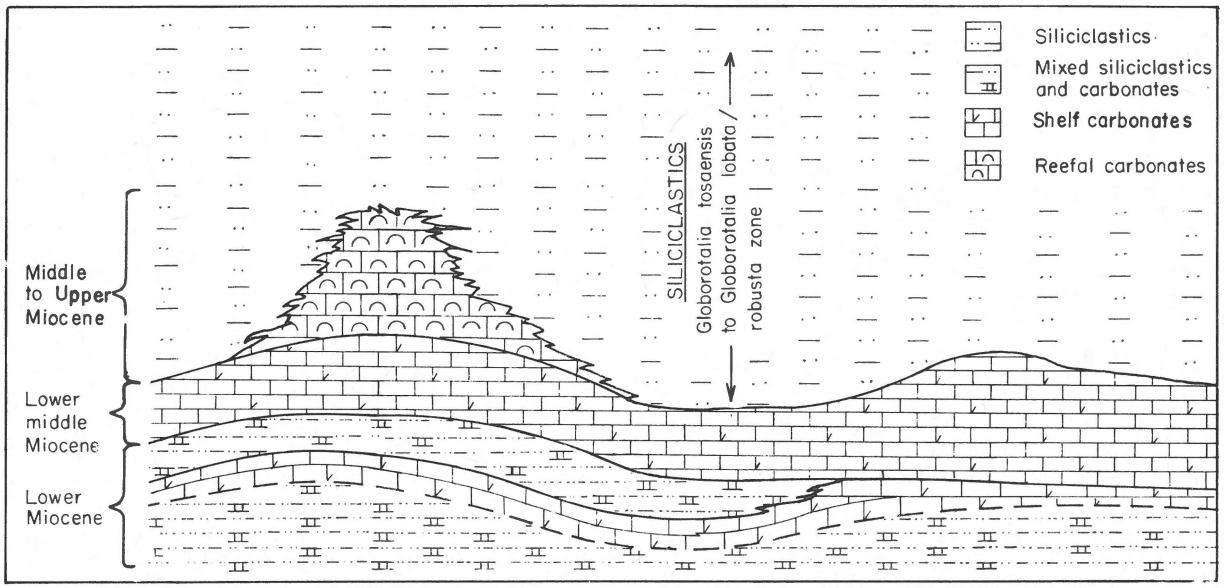


Fig. 3 A sketch showing the stratigraphical relationship between a carbonate buildup and the surrounding and overlying siliciclastics in the Central Luconia area.

quandratus zone (fig. 4). V a n d e r V l e r k (1968B) found values of 10.2 to 11.5% for samples from the *Globorotalia opima opima* zone (N 2) and *Globigerina ciperoensis* zone (N 3).

To illustrate the evolutionary trend, a selection of photographs of nucleoconchs of Lepidocyclina specimens from samples belonging to different planktonic foraminiferal zones are shown on Plate I. However, this selection does not show forms characteristic of particular planktonic foraminiferal zones since all transitions between the examples presented on Plate 1 exist. From the photographs, it can be seen that the curvature of the wall between the protoconch and deuteroconch increases in progressively younger forms. In other words when examining *Lepidocyclina* specimens from the *Globorotalia kugleri* to the *Globigerinoides subquadratus* zone, a change from forms characterised by an embryonic chamber arrangement of the predominantly nephrolepidine/ isolepidine type via that of the nephrolepidine/ trybliolepidine to trybliolepidine/nephrolepidine type can be observed. The average value of the degree of curvature for each sample has been plotted against the planktonic foraminiferal zone to which the sample belongs. The positions of these sample points within a planktonic foraminiferal zone (fig. 4) were plotted according to the average values, i.e. 24% plotted above 23%, etc. These results illustrate the evolutionary trend of *Lepidocyclina* in relation to the planktonic foraminiferal zonation in use in northwest Borneo.

The top of the histograms (fig. 5 & 6) denoting a 5% interval of the degree of curvature measurements, generally includes 50% or more of the total number of measurements per sample. From the *Globorotalia kugleri* zone upwards, both the positions of the histograms tops and the arithmetic mean shift towards the right, indicating an increase in the degree of curvature with decreasing age.

To check in the accuracy of the method applied, the standard deviation and the standard error of the mean have been computed for the degree of curvature measurements per sample and have been tabulated in Table 1. Since the standard error of the mean is found to be small (o.6-1.5), the conclusions arrived at during this study are considered reliable. Hence the method used is thought to be accurate enough for further chrono-stratigraphical application.

APPLICATION EXERCISE

The well G.10.1X was chosen because of its thick, continuous lepidocyclina-bearing interval. Parameters of the foregoing study were used for the examination of *Lepidocyclina* occuring in this well. The results (fig. 7), i.e. the mean values, histogram tops and to a certain extent also the range in variations of the degree of curvature can be compared with those derived from the study. Based on the comparison (Table 2), the interval at 3042'- 3072', in G.10.1X can be attributed to the *Globigerinoides subquadratus* zone. The original interpretation based on the ranges of larger foraminifera could only give a Tf age (fig. 2). The next lepidocyclina-bearing interval 5794'-7920', originally given a Te5-Tf1 age, for the interval 5794'-7010' and Te5 age for the

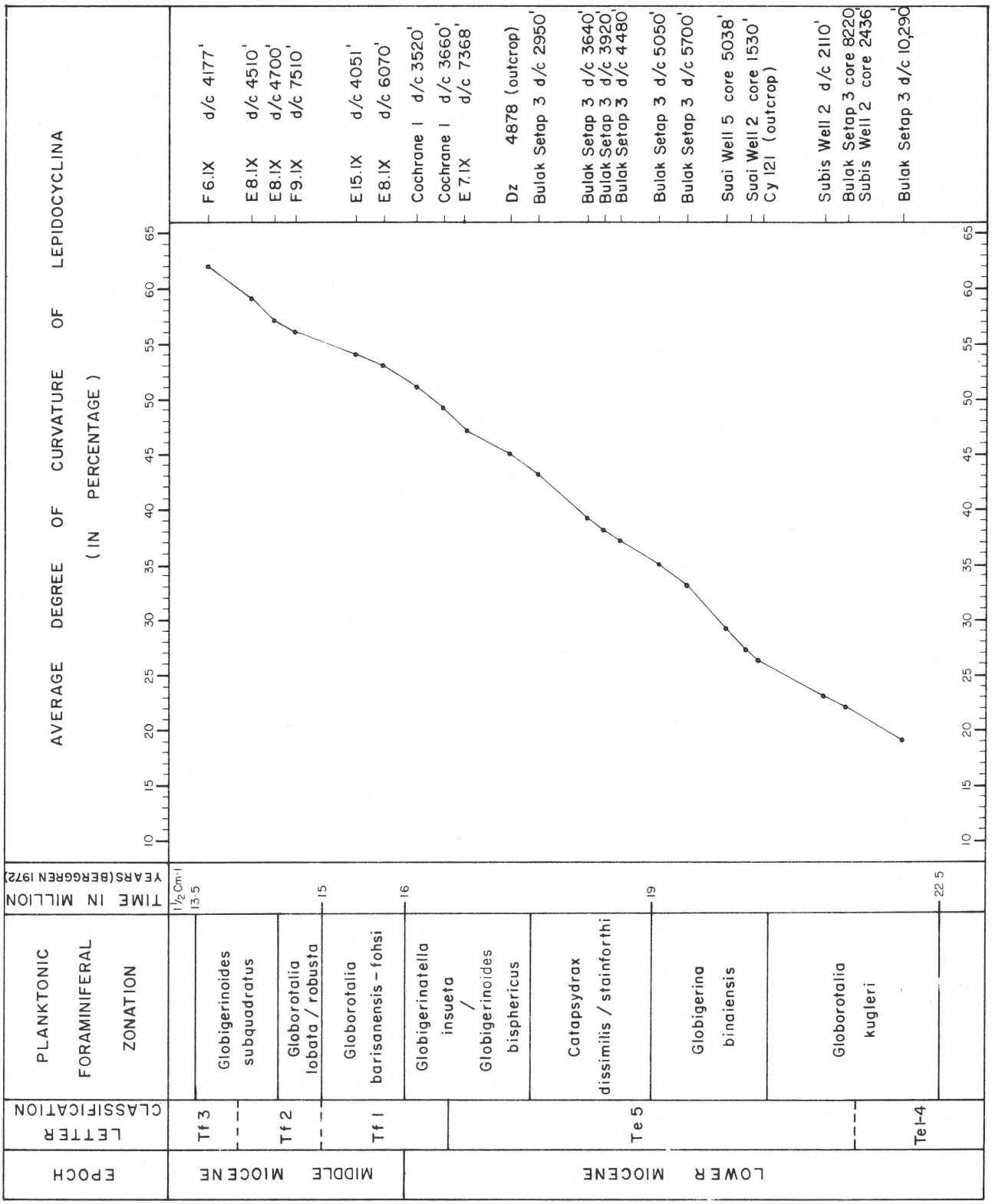


Fig.4 : Correlation between the average degree of curvature of Lepidocyclina and planktonic foraminiferal zonation of Northwest Borneo

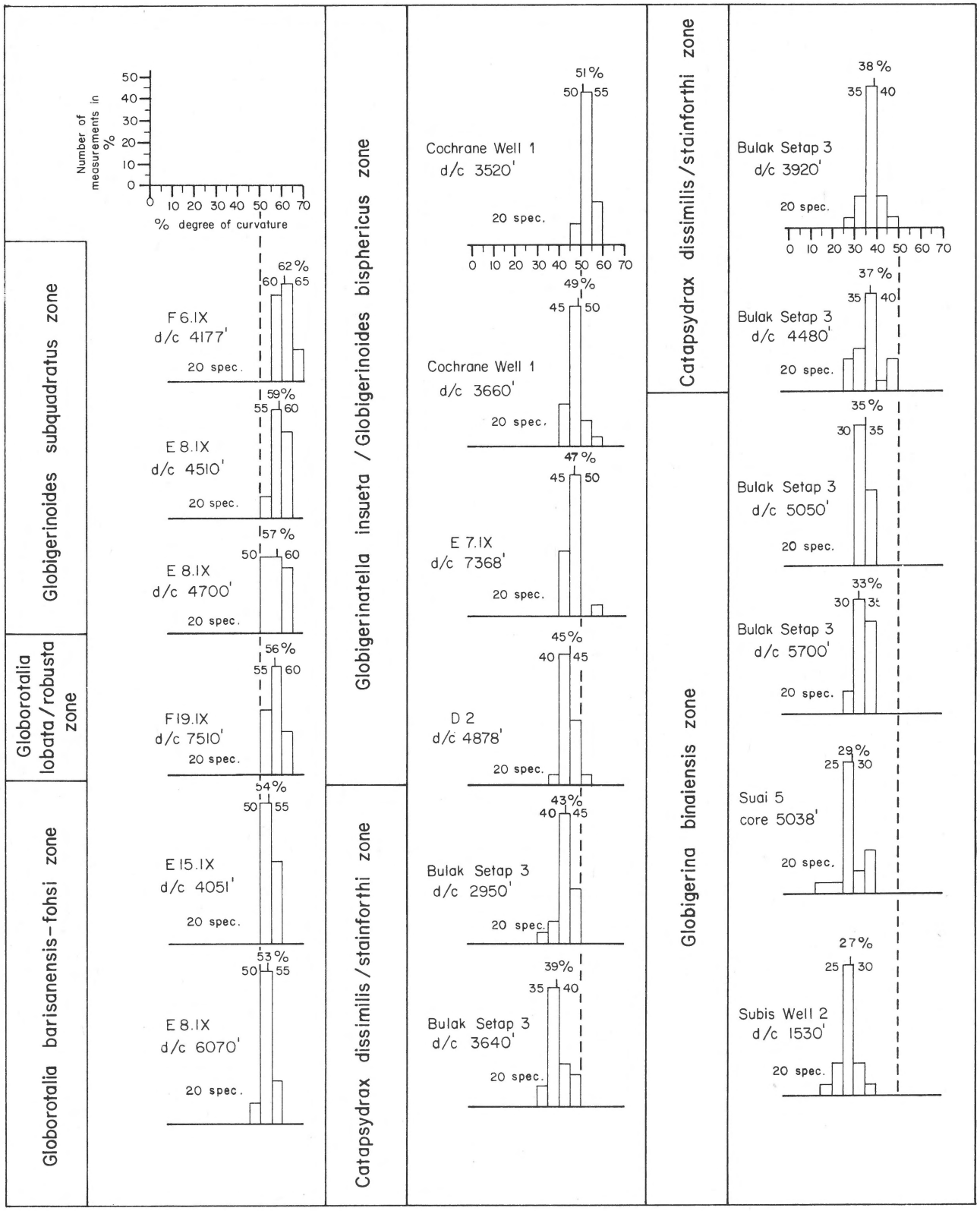


Fig. 5 : Histograms of degree of curvature of Lepidocyclina from selected sample material

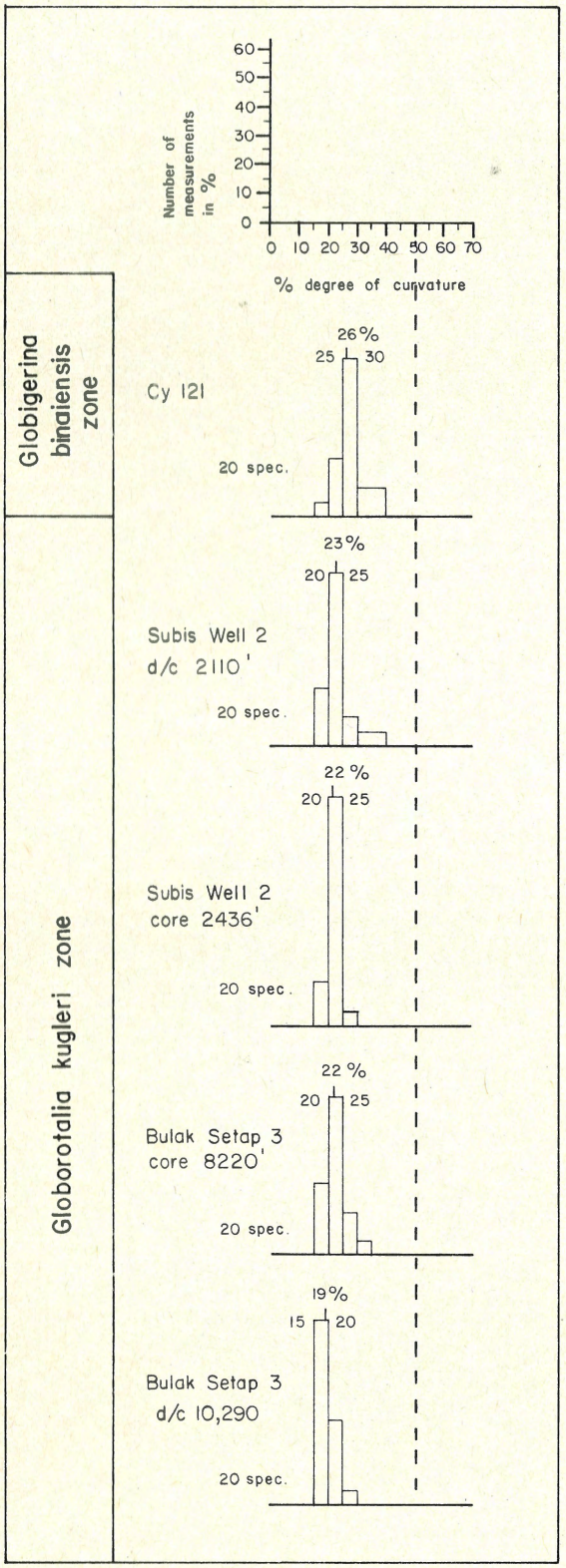


Fig.6 : Histogram of degree of curvature of Lepidocyclina from selected sample material.

interval 7010'-7920', is now attributed to the *Globigerina binaiensis* zone. From 8190' to 10,520', the degree of curvature of 19% to 24% assigns this interval to the *Globorotalia kugleri* zone which is in accordance with the planktonic foraminiferal zonation at 8631'. The 18%-19% degree of curvature found in the interval 10,520-11,450 indicates the older part of the *Globorotalia kugleri* zone which is confirmed by planktonic Foraminifera at 10,970'.

CONCLUSIONS

From the results so far obtained from this study, it can be concluded that the evolutionary trend of *Lepidoclina* based on the average degree of curvature parameter is a good chrono-stratigraphic indicator in the Miocene sediments of northwest Borneo.

In the absence of age-diagnostic planktonic Foraminifera, itcan be used to attribute sediments rich in Lepidocyclina specimens to the equivalent planktonic foraminiferal zones.

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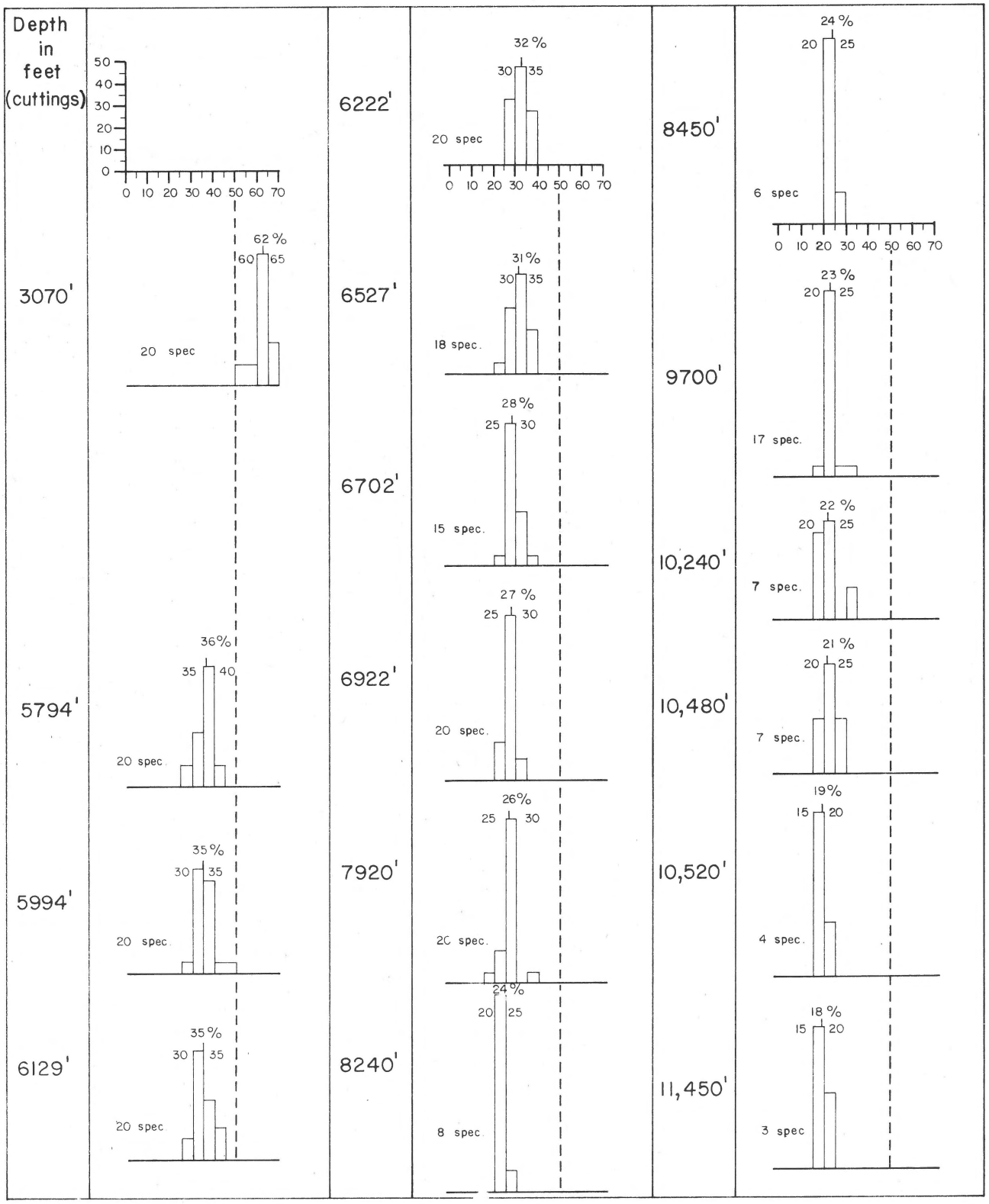

Fig. 7 : Histograms of degree of curvature of Lepidocyclina from sample material of Well G10.IX

PLANKTONIC FORAMINIFERAL ZONE	SAMPLES BELONGING TO WELL DEFINED PLANKTONIC FORAMINIFERAL ZONES				WELL G 10.IX			
	SAMPLE NUMBER/DEPTH	DEGREE OF CURVATURE OF LEPIDOCYCLINA IN %			SAMPLE DEPTH IN FT.	DEGREE OF CURVATURE OF LEPIDOCYCLINA IN %		
		EXTENT OF VARIATION	AVERAGE	HISTOGRAM TOP		EXTENT OF VARIATION	AVERAGE	HISTOGRAM TOP
Globigerinoides subquadratus	F 6.IX d/c 4177'	55 – 70	62	60 – 65	3072'	54 – 67	62	60 – 65
	E 8.IX d/c 4510'	55 – 64	59	55 – 60				
	E 8.IX d/c 4700'	50 – 64	57	50 – 60				
Globorotalia lobata / robusta	F 19.IX d/c 7510'	50 – 61	56	50 – 60				
Globorotalia barisanensis – fohsi	E 15.IX d/c 4051'	50 – 60	54	50 – 55				
	E 8.IX d/c 6070'	46 – 61	53	50 – 55				
Globigerinatella insueta / Globigerinoides bisphericus	Cochrane 1 d/c 3520'	45 – 57	51	50 – 55				
	Cochrane 1 d/c 3660'	41 – 58	49	45 – 50				
	E 7.IX d/c 7368'	40 – 56	47	45 – 50				
	Dz 4878	43 – 50	45	40 – 45				
Catapsydrax dissimilis/stainforthi	Bulak Setap 3 d/c 2950'	33 – 50	43	40 – 45				
	Bulak Setap 3 d/c 3640'	33 – 50	39	35 – 40				
	Bulak Setap 3 d/c 3920'	33 – 50	38	35 – 40				
	Bulak Setap 3 d/c 4480'	25 – 50	37	35 – 40				
					5794'	28 – 45	36	35 – 40
					5994'	29 – 50	35	30 – 35
	Bulak Setap 3 d/c 5050'	33 – 39	35	30 – 35	6129'	25 – 44	35	30 – 35
Globigerina binaiensis	Bulak Setap 3 d/c 5700'	25 – 37	34	30 – 35				
					6222'	25 – 37	32	30 – 35
	Suai Well 5 core 5038'	19 – 37	29	25 – 30	6576'	21 – 36	31	30 – 35
					6702'	21 – 36	28	25 – 30
	Subis Well 2 d/c 1530'	19 – 35	27	25 – 30	6922'	20 – 33	27	25 – 30
	Cy 121	15 – 36	26	25 – 30	7920'	19 – 37	26	25 – 30
					8240'	20 – 27	24	20 – 25
	Subis Well 2 d/c 2110'	15 – 36	23	20 – 25	8450'	22 – 28	24	20 – 25
					9700'	17 – 33	23	20 – 25
Globorotalia kugleri	Bulak Setap 3 core 8220'	15 – 31	22	20 – 25				
					10,240'	16 – 25	22	15 – 25
	Subis Well 2 core 2436'	15 – 29	22	20 – 25				
					10,480'	15 – 27	21	20 – 25
	Bulak Setap 3 d/c 10,290'	14 – 28	19	15 – 20	10,520'	17 – 22	19	15 – 20
					11,450'	15 – 21	18	15 – 20

Table 1 : Comparison of degree curvature of Lepidocyclina from sample material belonging to well defined planktonic foraminiferal zones with those from samples of the Well G 10.IX.

SAMPLE	NUMBER OF MEASURE — MENTS	DEGREE OF CURVATURE		STANDARD DEVIATION (σ)	STANDARD ERROR OF THE MEAN (σ_M)
		MEASURED EXTENT OF VARIATIONS	MEAN		
F 6.IX d/c 4177'	20	55 — 70	62	3·8	0·8
E 8.IX d/c 4510'	20	55 — 64	59	4·1	0·9
E 8.IX d/c 4700'	20	50 — 64	57	4·8	1·1
F19.IX d/c 7510'	20	50 — 61	56	4·7	1·0
E15.IX d/c 4051'	20	50 — 60	54	3·3	0·7
E 8.IX d/c 6070'	20	46 — 61	53	4·2	0·9
Cochrane 1 d/c 3520'	20	45 — 57	51	2·8	0·6
Cochrane 1 d/c 3660'	20	41 — 58	49	5·0	1·1
E 7.IX d/c 7368'	20	40 — 56	47	4·6	1·0
Dz 4878 (outcrop)	20	43 — 50	45	4·1	0·9
Bulak Setap 3 d/c 2950'	20	33 — 50	43	4·1	0·9
Bulak Setap 3 d/c 3640'	20	33 — 50	39	5·4	1·2
Bulak Setap 3 d/c 3920'	20	33 — 50	38	4·2	0·9
Bulak Setap 3 d/c 4480'	20	25 — 50	37	6·6	1·5
Bulak Setap 3 d/c 5050'	20	33 — 39	35	2·4	0·5
Bulak Setap 3 d/c 5700'	20	25 — 37	33	3·5	0·8
Suai Well 5 core 5038'	20	19 — 37	29	5·9	1·3
Subis Well 2 d/c 1530'	20	19 — 35	27	4·4	1·0
Cy 121 (outcrop)	20	16 — 36	26	5·3	1·2
Subis Well 2 d/c 2110'	20	15 — 36	23	4·9	1·1
Bulak Setap 3 core 8220'	20	15 — 31	22	4·2	0·9
Subis Well 2 core 2436'	20	15 — 29	22	3·2	0·7
Bulak Setap 3 d/c 10,290'	20	14 — 28	19	4·2	0·9

Table 2 : Standard deviation and standard error of the mean of the degree of curvature measurements. (σ_M = Standard deviation divided by the square root of the number of measurements)