CHAPTER - 5

ENVIRONMENTAL DISTRIBUTION OF FOSSILS

The vertical distribution of benthic foraminifera (Figures 4.1 to 4.12) described in Chapter-4, shows that certain species are present only in some parts of the sequences. It seems that faunal composition is related to lithofacies. For example in the present study, corals are always present in massive limestones. Morever, there is a clear preference for the association of taxa. This forms the basis of recognising the biofacies (Morris 1982). However, characteristic faunal constituents of biofacies may or may not comprise total faunal assemblage and associated taxa may also include other genera/species. It simply emphasizes that the co-occurrence of the faunal constituents is striking.

5.1 BIOFACIES

Figures 5.1 to 5.5 show quantitative percentage distribution of characteristic fauna representing nine biofacies in "key' section. The figurative presentation have highlighted the animal's preference of substratum to thrive on, preference for association with other species and also preference of environmental setting (Butt, 1981).

Quantitative percentage of, apparently preferred, association of taxa are plotted against the lithocolumns of key sections. Total 9 biofacies are recognised.

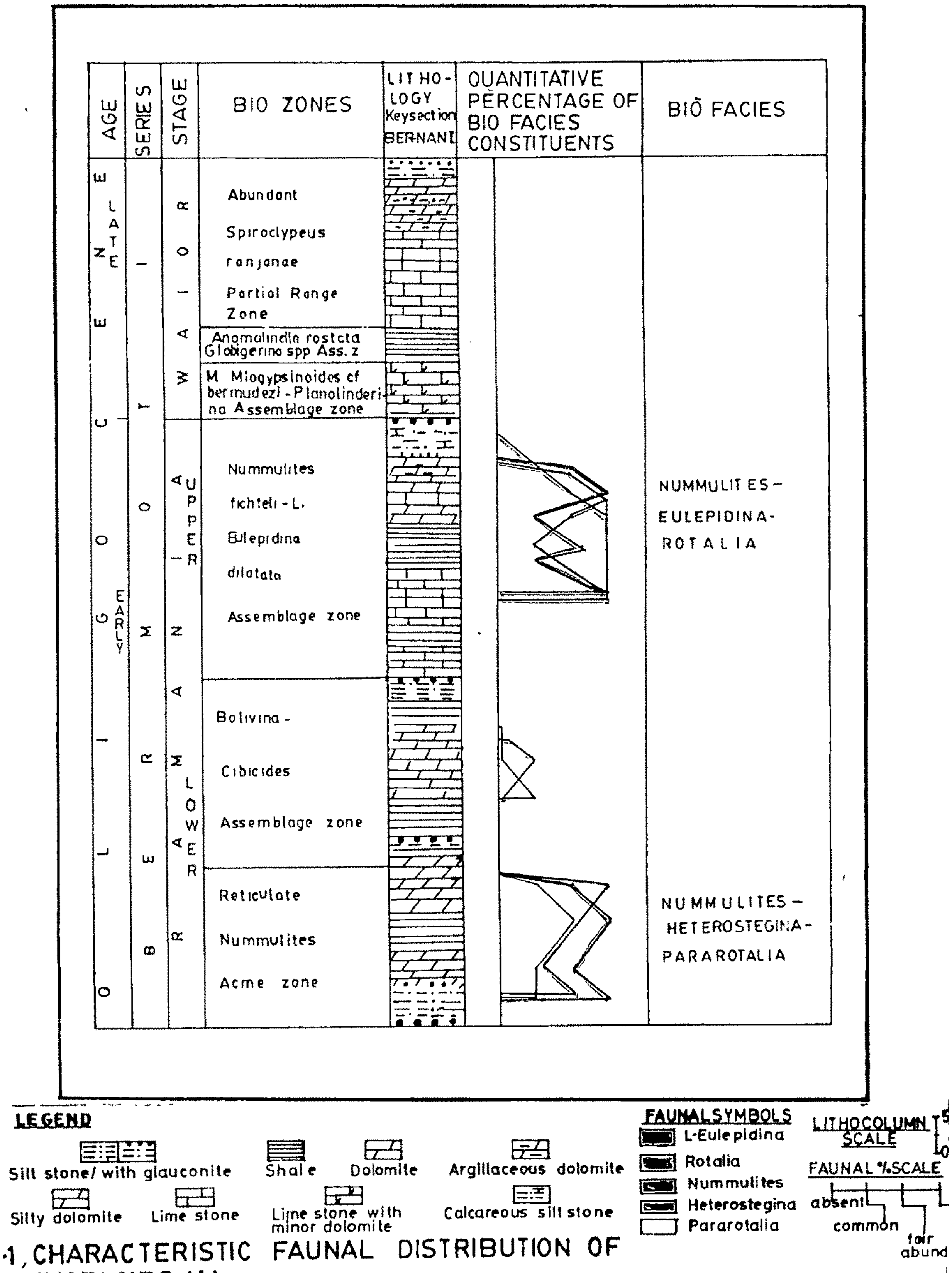

FIG. 5·1, CHARACTERISTIC FAUNAL DISTRIBUTION OF BIOFACIES (I)

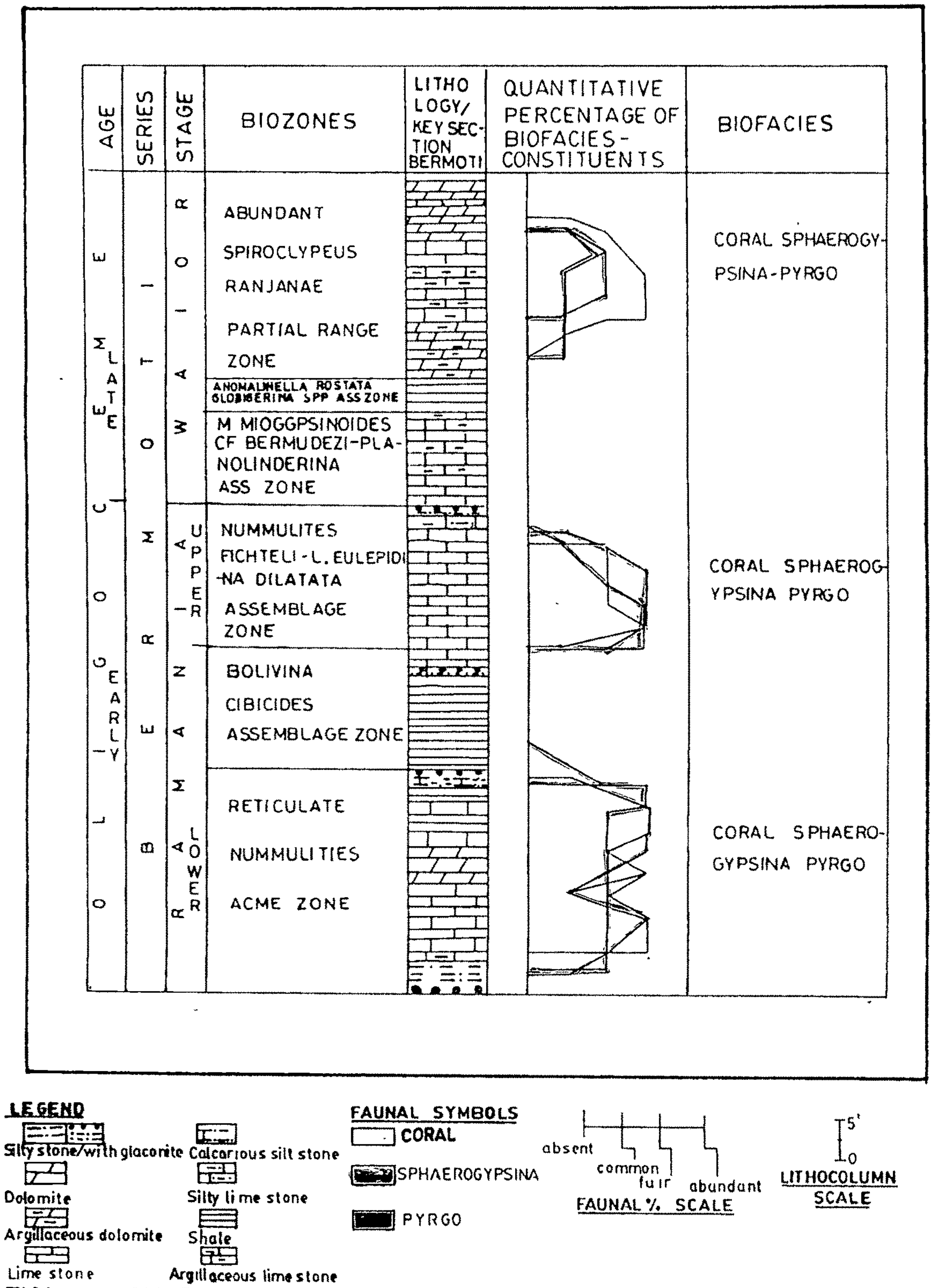

FIG: 5·2 CHARACTERISTIC FAUNAL DISTRIBUTION OF BIOFACIES (II)

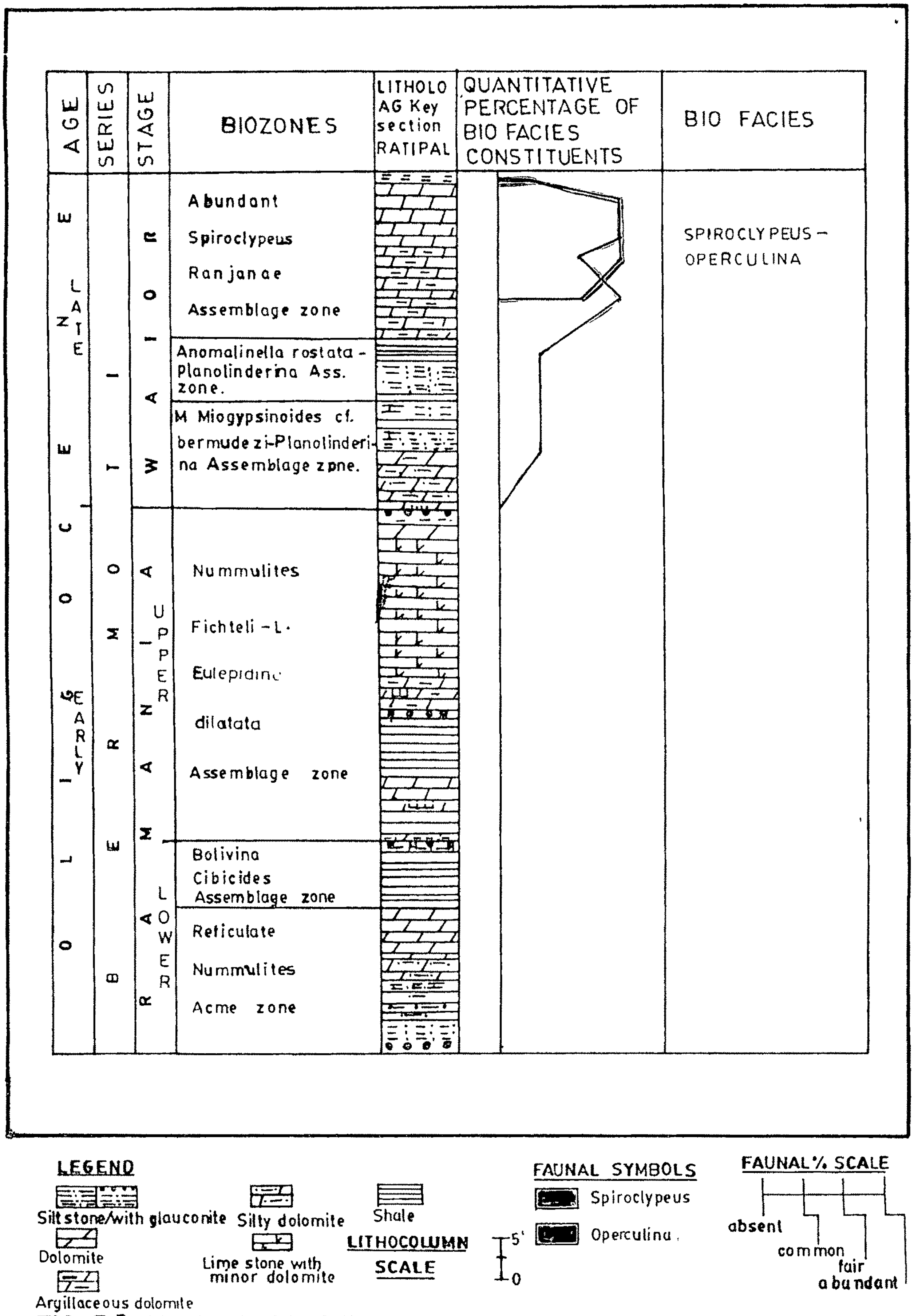

FIG. 5·3, CHARACTERISTIC FAUNAL DISTRIBUTION OF BIOFACIES. III

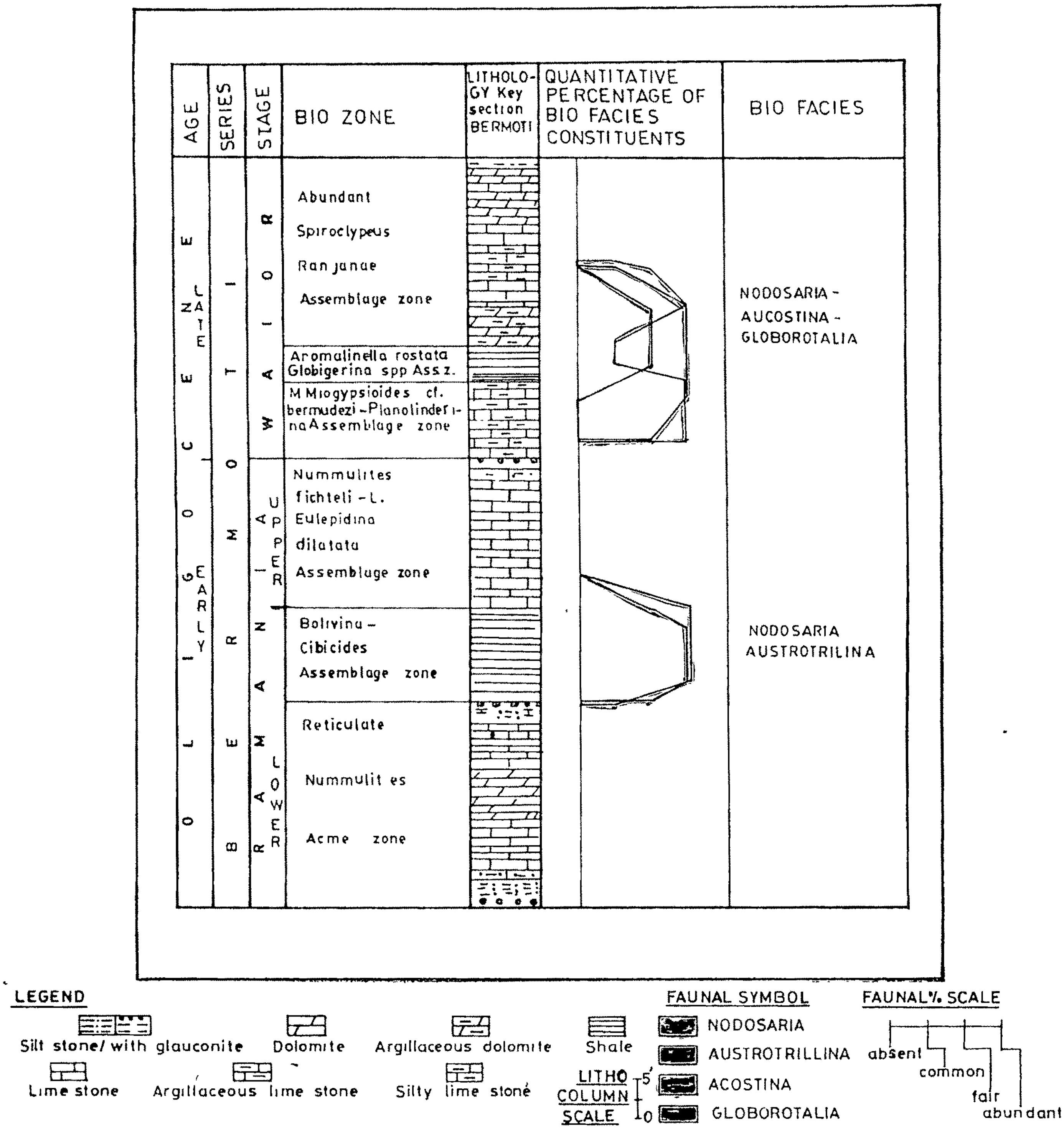

FIG. 5·4, CHARACTERISTIC FAUNAL DISTRIBUTION OF BIOFACIES (IV)

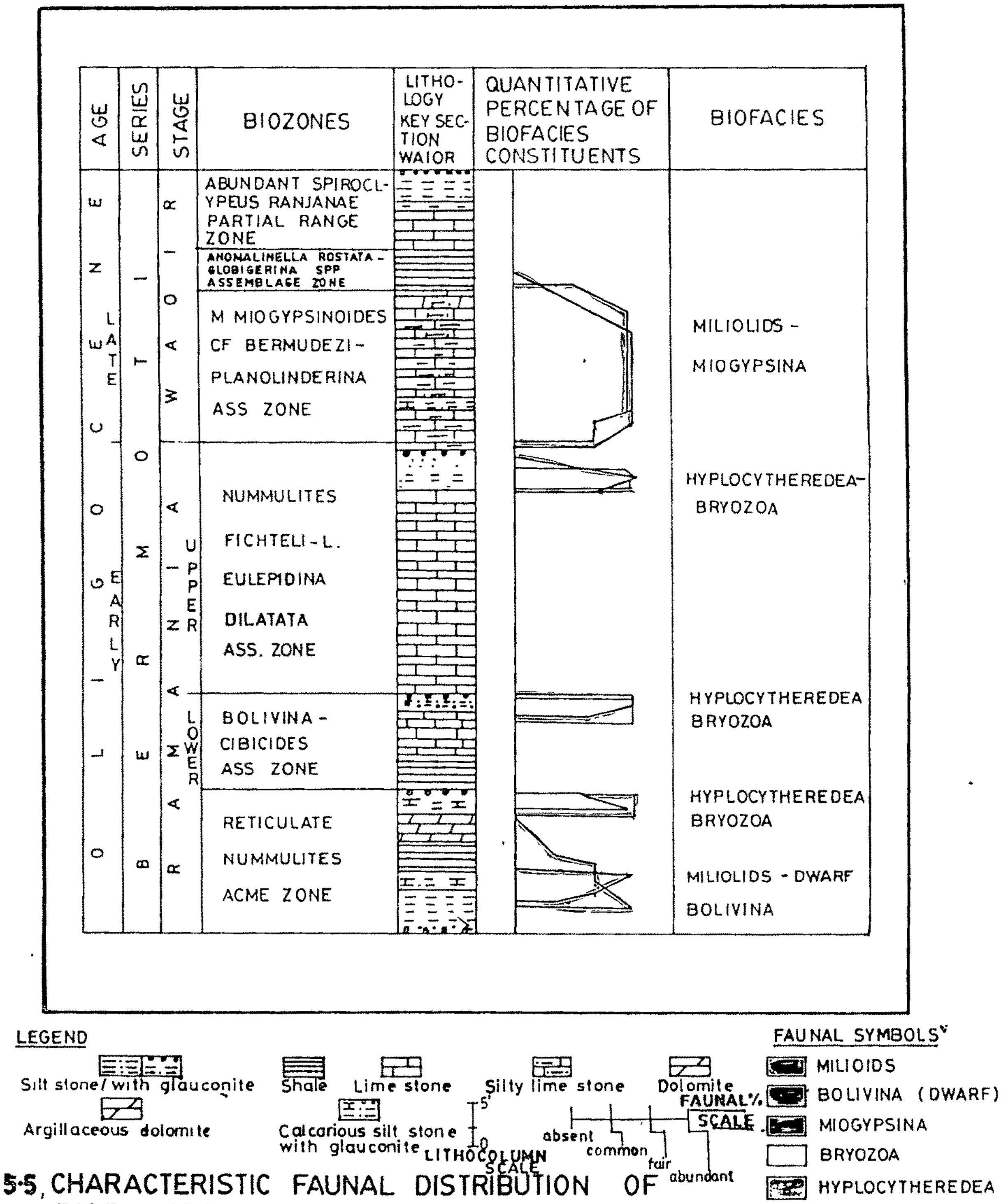

FIG. 5·5, CHARACTERISTIC FAUNAL DISTRIBUTION OF BIOFACIES (V)

They are,

Spiroclypeus - *Operculina* biofacies

Nodosaria - *Acostina* biofacies

Miliolids - *Miogypsina* biofacies

Coral - *Sphaerogypsina* - *Pyrgo* biofacies

Nummulites - *Eulepidina* - *Rotalia* biofacies

Nodosaria - *Austrotrillina* biofacies

Nummulites - *Heterostegina* - *Pararotalia* biofacies

Miliolids - dwarf Boliviniids biofacies

Haplocytheridea - Bryozoa biofacies,

Figure 5.6 illustrates the correlation and gross distribution of biofacies occurring in Ratipal, Bermoti, Bernani and Waior sections.

5.1.1 *Haplocytheridea* - Bryozoa biofacies

It is present in all the sections at the base of Ramania and Waior stages. In Bernani and Waior sections it also occurs at the base of upper Ramania stage. It is developed in calcareous, usually glauconitic siltstone. Association of *Haplocytheridea* - a brackish water ostracoda with bryozoa signifies near shore clastics environment. In this biofacies presence of ichnofossils is noted in Waior stage of Waior section, which suggests tidal flat environment.

5.1.2 Miliolids - dwarf Boliviniids biofacies -

This biofacies occurs over *Haplocytheridea* - bryozoa biofacies of lower Ramania stage in all the four sections. It is associated with calcareous siltstone often with plenty of glauconitic pellets. Biofacies signifies shallow lagoon depositional setting (Plate VII. C.).

5.1.3 Nummulites - Heterostegina - Pararotalia biofacies

It is developed in argillaceous/silty limestone of lower Ramania stage and is observed in all the sections. Test of reticulate Nummulites are thin, discoidal and fragile. They are more or less arranged parallel to each other (Plate VIII. A). The dominant smaller benthic is Pararotalia mexicana. High faunal number and moderate diversity together with good state of tests preservation, suggests openshelf lagoon deposition (Luterbacher, 1984).

5.1.4 Nodosaria - Austrotrillina biofacies

This is present in all the sections in shale and silty shales of upper part of lower Ramania stage (Plate VIII. B). Besides characteristic faunal constituents, plenty of miliolids and deep dwelling benthics such as Bolivina, Cibicides, comprise associated taxa. High faunal number and diversity and laminated nature of shelly sediments suggest quieter deposition, (Wahi et. al. 1991).

5.1.5 Nummulites - Eulepidina - Rotalia biofacies

The facies occurs in lower part of upper Ramania stage in all the sections. Big, robust, microspheric forms of Nummulites out-number the large sized Lepidocyclina species (Plate VIII C and XII A). Rotalia is the prominant benthonic foraminifera present. Fanual number is very high whereas diversity is low. The biofacies is typically developed in limestone/argillaceous limestone. Luterbacher (1984), denoted a Nummulites bar environment to such a setting.

5.1.6 Coral - Sphaerogypsina - Pyrgo biofacies -

In the upper part of upper Ramania, this biofacies is developed in all the sections and is observed wherever corals are present, irrespective of their stratigraphic position. Big, ball shaped Sphaerogypsina globulus, Ruess, is associated with patchy and reefal corals. Another associate of coral is Pyrgo bulloides. Intimate association of these species with coralline limestone indicates that they may have lived in or around the coral patch-reefs. Similar observation is inferred by Morris, (1982), from middle Jurassic foraminifera of Cotswolds. Good to profuse presence of corals suggest very low detritus input and open platform conditions as environments of deposition (Plate IX. A).

5.1.7 Miliolids - Miogypsina biofacies -

This facies is present in lower Waior stage's argillaceous carbonate sediments and is better developed in eastern Bernani and Waior sections (Plate IX. B). Faunal number and diversity is moderate. Lagoonal depositional conditions can be inferred (Luterbacher, 1984).

5.1.8 Nodosaria - Acostina biofacies -

The shaly sequence occuring in the middle part of Waior stage is characterised by good assemblage of Nodosaria, Acostina and planktonic foraminifera. Many deep dwelling benthics such as Bolivina, Cibicides are the associated taxa. The high faunal number and diversity, is indicative of quieter deposition. The biofacies is better developed in Ratipal and Bermoti sections (Plate IX. C), whereas it is subdued in Bernani and Waior sections at the cost of miliolids - Miogypsina biofacies.

5.1.9 Spiroclyeus - Operculina biofacies -

Characterising the top of Waior stage, the biofacies is present in all the sections. Besides Spiroclypeus which forms nearly 90% of the faunal population, Operculina and few juvenile benthics are present, in the calcareous siltstone matrix. Big specimens of Spiroclypeus are arranged sub-paralled to each other (Plate X. A). Extremely high faunal number and very low diversity suggest the wave sorting action in shallow lagoonal set up.

5.2 ENVIRONMENTS OF DEPOSITION AND DISTRIBUTION OF FAUNA

The fore-gone discussion amply emphasizes the interrelationship of

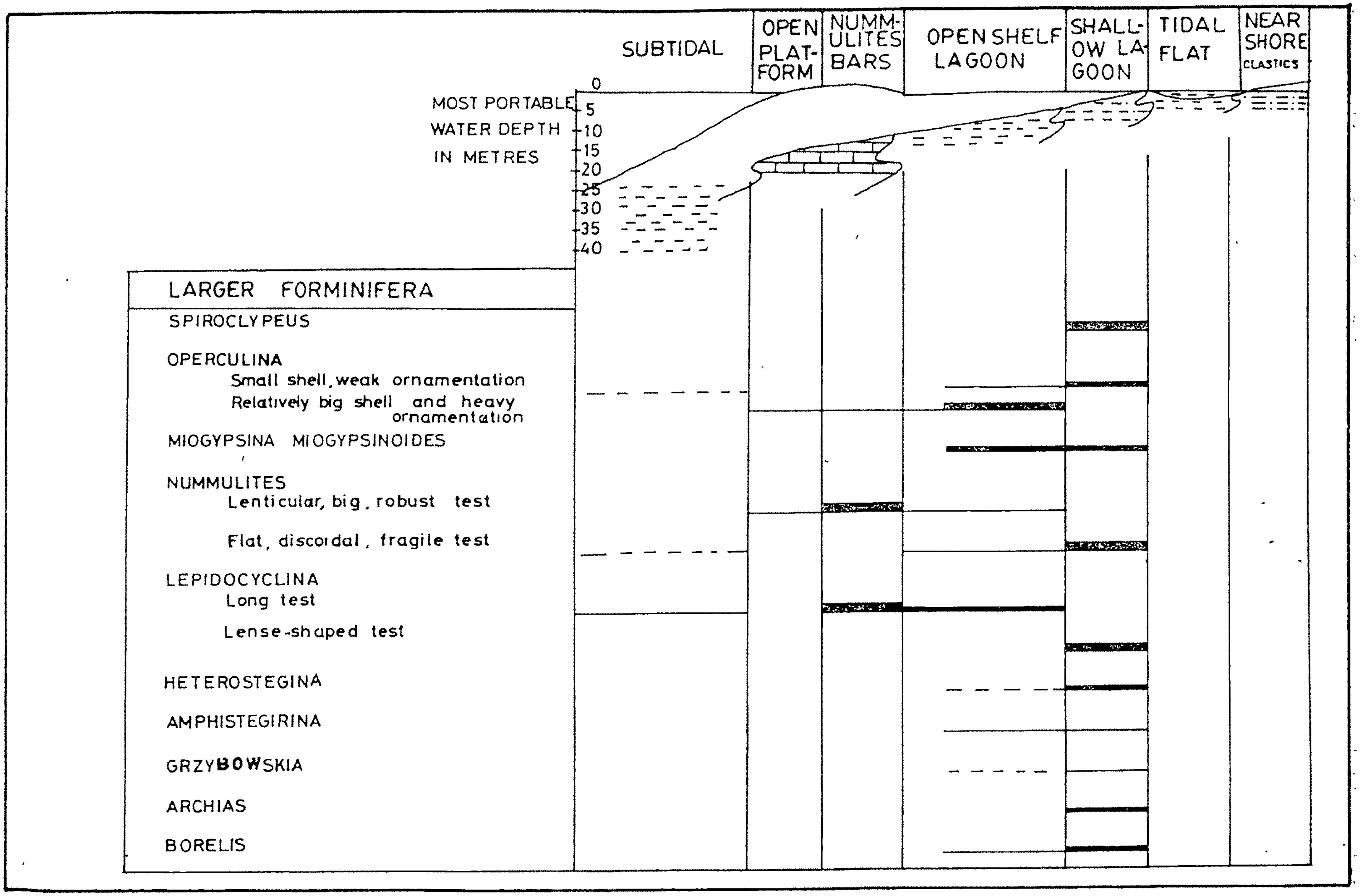

FIG. 5·7, ENVIRONMENTAL DISTRIBUTION OF LARGER FORAMINIFERA BERMOTI SERIES SECTION (highly schematized)

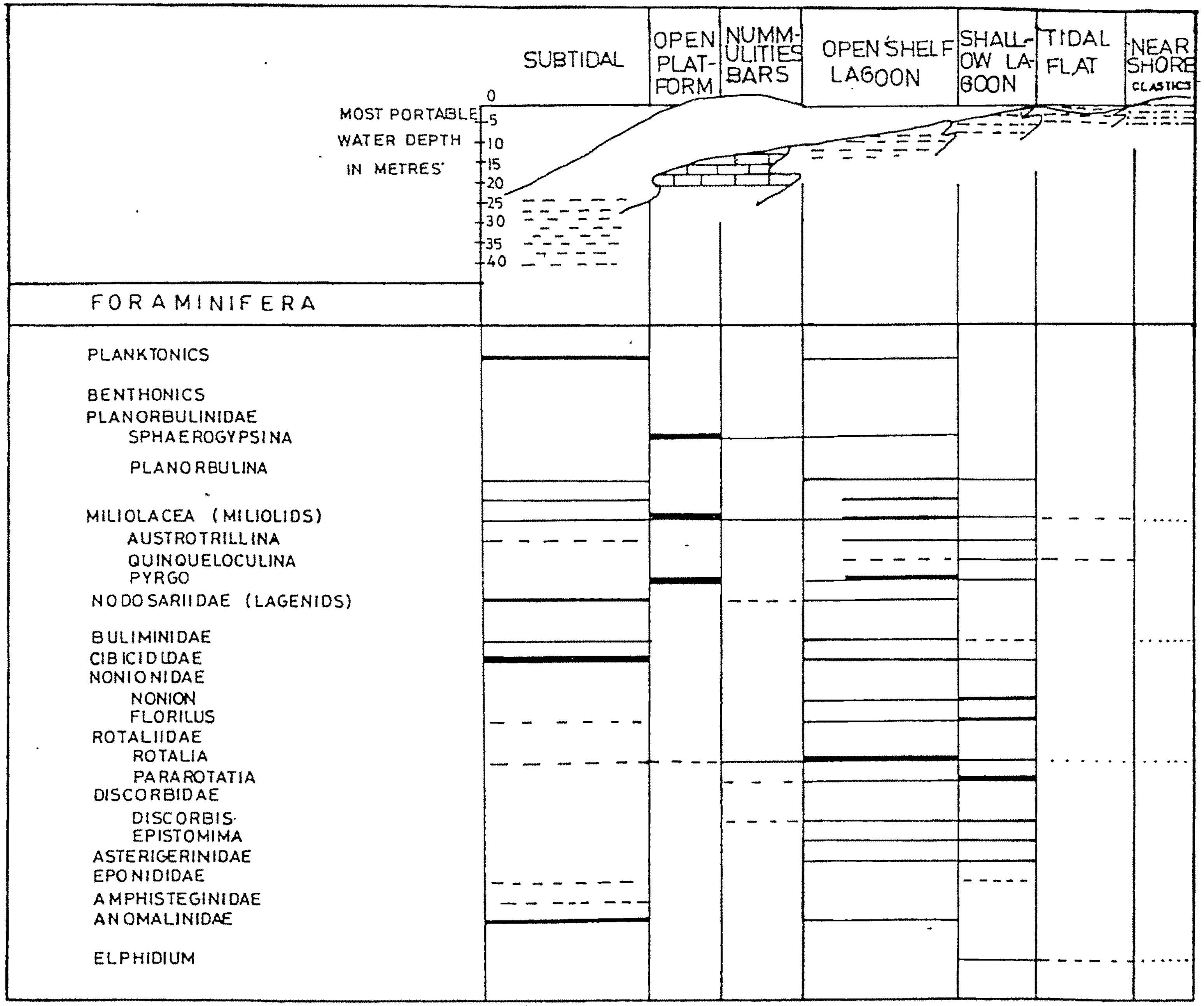

FIG. 5·8, ENVIRONMENTAL DISTRIBUTION OF BENTHONIC FORAMINIFERA
(highly schematized)

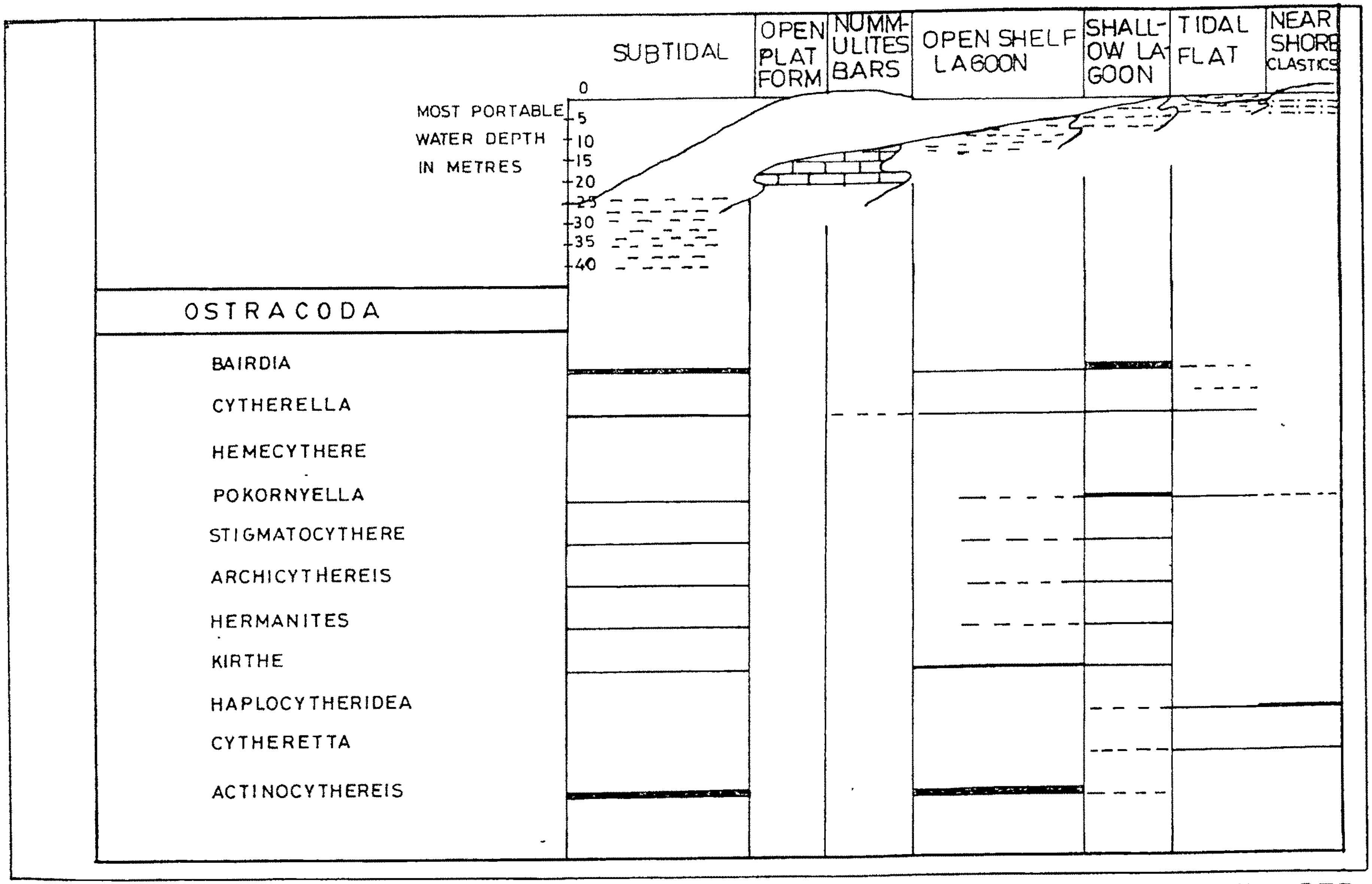

FIG. 5·9, ENVIRONMENTAL DISTRIBUTION OF OSTRACODA, BERMOTI SERIES
(highly schematized)

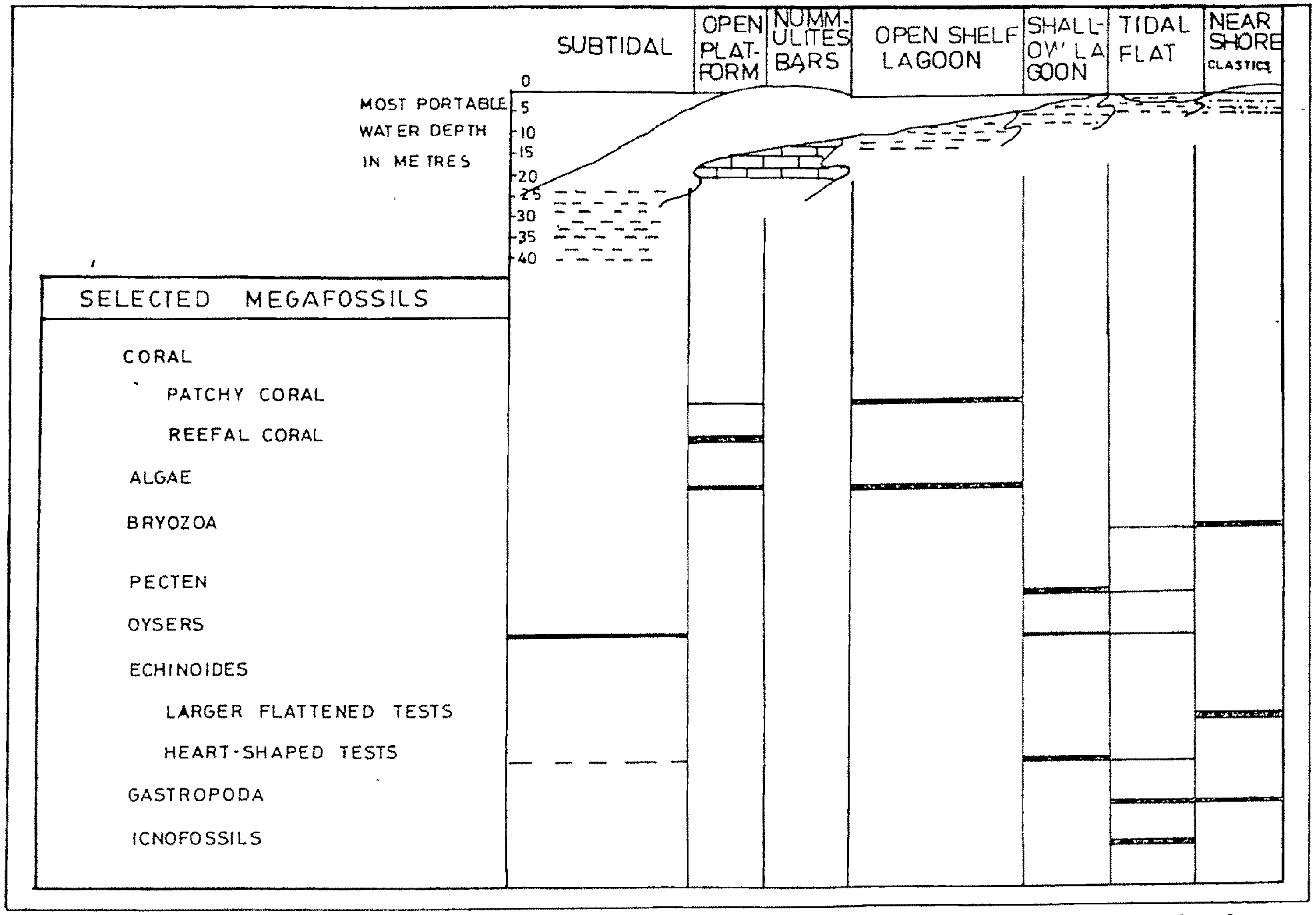

FIG. 5·10, ENVIRONMENTAL DISTRIBUTION OF SELECTED MEGAFOSSILS

(highly schematized)

fauna with the environment. An attempt now has also been made to assign the most likely environments of deposition to the identified fossil groups of Bermoti series. To decipher the paleo-ecological conditions, guidelines proposed by Murrary, (1973), are used.

Seven main environments are supposed to have played a role in the deposition of various sequences of Bermoti series of present area.

Figure 5.7, 5.8, 5.9 and 5.10 depict the most probable environmental arrangement of larger foraminifera, smaller foraminifera, ostracoda and selected megafossils respectively.

SHORT DESCRIPTION OF ENVIRONMENTS

1) **Nearshore Clastics -**

These deposits, typically, contain few brackish water ostracoda as Haplocytheridea, Cytherella and broyoza (plate X. B).

2) **Tidal Flat -**

It is a very low dipping intertidal zone with periodic subaerial exposure, and is characterised by bioturbation. Gastropoda and echinoderms are commonly occurring megafossils.

3) **Shallow Lagoon -**

The microfauna consists, mainly, of Elphidium, miliolids

Rotalia and rare Cibicides. Larger foraminifera, are either rare or absent (Plate X VII C and VIII C).

4) Open Shelf Lagoon -

The assemblages of larger foraminifera are characterized by the presence of small lenticular and thin - shelled nummulites (Plate IX A and X. C). The smaller foraminifera include Rotalia, Cibicides, Asterigerina etc. Paracypris, Echinocythereis and Actinocythereis are common ostracoda genera.

5) Nummulites Bars -

Relatively large, robust test of Nummulites with very high faunal number and low diversity characterises this environment (Plate XI. B).

6) Open Platfrom -

The main faunal components of the practically mud-free, open platforms are coralline algae, (Plate X.D) spherical forms of Sphaerogypsina and dominating miliolids - mainly Pyrgo. The ostraeoda assemblages of the carbonate detritus rich facies viz. Nummulites bar and open platform consist, mainly, of highly ornamented and robust specimens of ostracod, Actinocythereis being most common in Bermoti series.

7) Subtidal -

In the shales of subtidal deposits, relatively small

AGE	SERIES	STAGE	LITHOLOGY	DOMINANT SPECIES	MAJOR ASSESSARIES	SPECIMEN ABUNDANCE	FAUNAL DIVERSITY	INFERRED CAUSES
O	B	W A	DOLOMITE	SPIROCLYPEUS	OPERCULINA, ROTALIA	VERY HIGH	VERY LOW	WAVE ACTION, SIZE SORTING
L		I O	CALCAREOUS SHALE	NODOSARIDAE, PLANKTONS	BRIZALINA BOLIVINA CIBICIDES	HIGH	MODERATE	QUIETER MARINE DEPOSITION
I	E	R						
G	R	R	GLAUCONITIC SANDSTONE/ SILTSTONE	BRYOZOA, BRACKISH WATER OSTRACODA	GASTROPODA, FLATTENED ECHINOIDES	LOW	LOW	EPISODIC SUBAREAL EXPOSURE HIGH ENERGY WAVE ACTION
		A	ARGILLACEOUS LIMESTONE	NUMMULITES LEPIDOCYCLINA	OPERCULINA, ROTALIA	VERY HIGH	LOW	HIGH ENERGY, INTERTIDAL
O	M	M	MASSIVE LIMESTONE	CORAL	SPHAEROGYPSINA, PYRGO	HIGH	LOW	CLEAN , SHALLOW, OPEN MARINE, VERY LOW DETRITUS INPUT
C	O	A	ARGILLACEOUS LIMESTONE	THINSHELLED NUMMULITES	HETROSTEGINA, PARAROTALIA OPERCULINA	HIGH	MODERATE	SHELTERED LAGOON
E	T	N	SILTSTONE/ SANDSTONE	GASTROPODA, MOLLUSC	ELPHIDIUM, BROZOA, ECHINOIDS	LOW	LOW	VERY SHALLOW, MARINE TO NON-MARINE
N		I	CALCAREOUS SHALE	BOLIVINA, CIBICIDES	MILIOLIDS NODOSARIIDS FEW PLANKTONS	HIGH	MODERATE	QUIETER MARINE DEPOSITION
	I		SILTSTONE/ SANDSTONE					
E		A	GLAUCONITIC, CALCAREOUS SILTSTONE	RETICULATE NUMMULITES	FEW BENTHICS	HIGH	LOW	MODERATE ENERGY SHALLOW MARINE

TABLE – 5.1: DISTRIBUTION OF FAUNAL ASSEMBLAGES AND PROBABLE CAUSES RESPONSIBLE FOR THEIR DISTRIBUTION.

AGE	SERIES	STAGES		AFTER RAJU, 1974 BIOZONES	PRESENT WORK BIOZONES	PRESENT WORK BIOFACIES
OLIGOCENE	BERMOTI	WAIOR		M.(Miogypsinoides) complanata	Abundant Spiroclypeus ranjanea Partial Range Zone	Spiroclypeus-Operculina
				M.(Miogypsinoides) cf. bermudezi	Anomalinella rostata - Globigerina Spp. Ass. Zone	Nodosaria - Acostina
					M(Miogypsinoides) bermudezi - Planolinderina Ass. Zone	Miliolids - Miogypsina
		RAMANIA	UPPER	N. fichteli - intermedius/ Lepidocyclina	Nummulites fichteli - Lepidocyclina Eulepidina dilatata Ass. Zone	Coral-Sphaerogypsina -Pyrgo Nummulites-Eulepidina-Rotatia
			LOWER	N. fichteli-intermedius	Bolivina-Cibicides Ass. Zone	Nodosaria-Austrotrillina
					Reticulate Nummulites Acme Zone	Nummulites-Heterostegina - Pararotalia Miliolids - dwarf Boliviniids Hyplocytheredae-Bryozoa

TABLE: 5.2 BIOSTRATIGRAPHY OF BERMOTI SERIES.

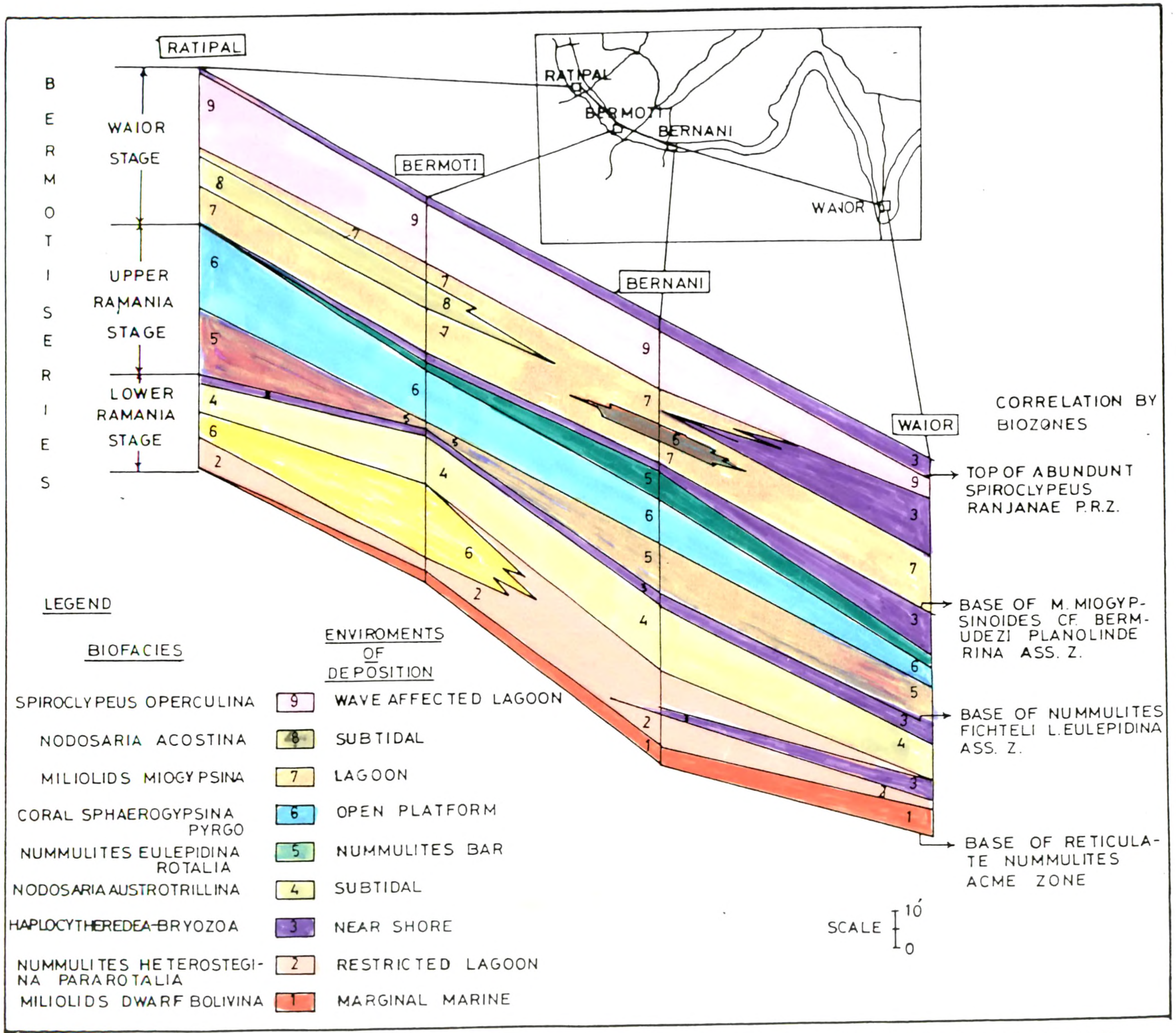

FIG. 5·11, CROSS SECTION SHOWING DISTRIBUTION OF BIOFACIE VIS-A-VIS ENVIRONMENTS BERIMOTI SERIES

Operculina is the only larger foraminifera present. Planktonic foraminifera are common. Lagenids, Cibicides, Asterigerina, Anomalina and Rotalia are the well represented genera. The ostracod assemblages are generally dominated by smooth and thin shelled Bairdia, Cytherella, Hermanites and Kirthe.

The genus Operculina is interpreted to be more widely adaptable as it occurs in both carbonate and shale deposits.

Table 5.1 summarises the distribution of faunal assemblages and factors governing the distribution. Morris, (1982) has also drawn similar inferrences on the distribution and paleoecology of middle Jurassic foraminifera of Costwolds.

Cross section (Figure 5.11) displays distribution of biofacies vis-a-vis environments of deposition; biostratigraphic frame is supported by correlation of larger foraminiferal zones.

With the help of generated faunal data a high resolution biostratography of Bermoti series is evolved (Table 5.2).

5.3 NANNOPLANKTON INVESTIGATIONS

A feasibility study of calcareous nannoplankton is carried out in order to determine their presence in study area.

5.3.1 METHODOLOGY

The samples were treated for concentration of the nanno-rich fraction, according to the method described by Gartner (1968).

Each sample was powdered and a suspension was prepared in distilled water. Initially, the suspension was kept undisturbed in a 100 ml. beaker, under a water column of 2 cm s, for five minutes to allow the settling of the coarser sediments. The decantant was then transferred to another beaker and was allowed to settle for 15 minutes in a water column of 2 cms. The residue obtained was smeared on a glass slide and then mounted. The smear slides were examined under a polarising Leitz Orthoplan microscope, with phase contrast.

5.3.2 DESCRIPTION OF NANNOFOSSILS

The nannofossils recovered are greatly affected by diagenesis. This is evident from the presence of only a couple of genera, known to be disolution/overgrowth resistant. Even as they are present in almost all the samples studied, the nannofossils are highly overgrown to partially recrystallised. This greatly prevents the generic identification of the individuals. However, grossly they can be described as follows.

Family : Coccolithaccae Poche (1913)
Genus : Coccolithus Schwarz (1894)

These are elliptical coccoliths with a distal shield of radiating petaloid elements which do not show birefrengence. The proximal shield is smaller than the distal and consists of two cycles, almost equal in size. The central area is filled with more or less radially oriented element.

In the present material, mostly proximal views are recorded. The specific identification is not possible due to overgrowth or etching. This genus is differentiated from Ericsonia, Black (1964), in which the two proximal shield cycles are of distinct sizes and can be easily distinguished (Perch - Nielsen, 1985). In the present study, this genus is differentiated from overgrown, Reticulofenestra Hay, Mohler and Wade (1966), on the basis of the difference in the proximal shield architecture.

Genus Ericsonia, Black (1964)

In the proximal view Ericsonia is easily distinguished from Coccolithus Schwarz (1894), by the difference in the size of the proximal cycles and open central area.

Family Discoasteraceae, Tan (1927)

Discoasteracea include star or rosette shaped calcareous nannofossils which remain dark in cross polarised light.

Genus - Discoaster, - Tan (1927)

This genus includes all forms with relatively flat star or rosette shaped bodies.

Family Prinsiaceae, Hay and Mohler (1976)

This family includes oval, subcircular or circular placoliths with dextragye interference figure in distal view. The proximal and distal shields show birefrengence. These are distinguished from members of coccolithaceae, whose shield does not show birefrengence in the distal view. Prinsiaceae are the more common coccoliths found in the Cenozoic as they are more dissolution/overgrowth resistant than other Cenozoic families.

f) Genus: Rerticulofenestra Hay, Mohler and Wade (1963)

Species are distinguished by an elliptical to subcircular outline, distal shield, slightly larger than proximal shield and one wall lining the central area. The central area is spanned by a net.

The central net is found only in well preserved assemblages and hence the different species may be distinguished by the overall size, relative size of the central opening and relative width of the wall lining the central area. In the present material, however, the sizes of the coccoliths have been significantly affected by overgrowth and hence no generic identification is possible.

5.3.3 INTERPRETATION

Vertical occurrences of nannoplankton fossils are plotted against the stratigraphic positions of the samples (Figure 5.12). Their distribution pattern reveals striking similarity in all the sections. Five peaks indicating increase in nannofossil number and diversity are observed. The oldest peak is found at the base of lower Ramania stage of the Ratipal and Bermoti sections. The second peak corresponds with the base of the upper Ramania and is observed in all the four sections. The third peak is associated with upper Ramania reefal limestone in the Ratipal and Bermoti sections.

The fourth peak is recognised in the lower part of Waior stage, while the fifth peak is present towards the top of Waior stage. Both, fourth and fifth peaks are tracable in all the sections.

Nannoplankton number and diversity is high in open, shallow marine carbonate sediments; conversely, high detritus input adversely affects their growth (Beckmann 89, Aubry 86). The stratigraphic position of the peaks, therefore, connotes with the transgressive phases observed in the present study. The inference is in accordance with the data generated on other parameters.

The study signifies that the carbonate sequences of Bermoti series, originally, were ideal site for profuse growth of nannoplanktons. However, later digenetic activities have greatly distorted/destroyed the coccolith population (Plate XIII).