CHAPTER - 4

BIOSTRATIGRAPHY

In chapters 2 and 3, on the basis of field and sedimentological characteristics, details regarding various litho facies present within Maniyara Fort Formation are described. In this chapter, the paleontalogical studies i.e. faunal contents of the formation have been examined in relation to specific facies types and their regional as well as vertical distribution. Microfossil groups studied include larger foraminifera, smaller foraminifera, planktonic foraminifera and ostracoda. Besides, an attempt has also been made to describe the nannoplankton fauna. Selected megafossils such as coral, bryozoa, echinoids, gastropods, pelecypods etc. are described briefly.

4.1 METHODOLOGY

In order to disintegrate the fossils embedded in rocks, consolidated sediments were granulated by agate mortar and crusher, 50 gms. of the material was soaked in water and then put into equal volume of hydrogen peroxide and concentrated Ammonia solution, and boiled. This was followed by QUAT-O (mildly acidic regent) solution treatment for 12 hours. After washing, the same was boiled in water for 2 hrs, with 20 gms of washing soda and subjected to ultrasonic sound for 2 minutes. After washing over 200 mesh, residue was dried in a oven at 100° C. Each residue was subseqently sieved after coning

and quartering method. Microfauna occuring in the 30, 60, 100 and 150 mesh fractions were hand picked, identified and counted, using binocular microscope.

This method was found inadiquate to obtain the fauna from hard and massive limestone samples. For their study thin sections were prepared by grinding the rockchips successively over 100, FFF and 600 carborundum powder.

Additionally, smear-slides were prepared for nannoplankton studies.

4.2 VERTICAL FAUNAL DISTRIBUTION

As stated earlier, total faunal content of larger foraminifera, smaller foraminifera, and planktonic foraminifera, ostracoda and megafossils were studied. Nannoplankton investigations are described seperately. The state of preservation, size, colour and nature of test, relation of test with the matrix and with other specimens were taken into account. For the interpretation of paleobathymetry and paleoecology, principles adopted by Butt, (1981), for similar investigations to decipher the bathymetry of Cretaceous of W. Morocco, were followed. Foraminiferal number, species diversity and gross percentage ratio of major faunal groups were calculated and were plotted in pie diagram. Foraminiferal number is the number of foraminifera in one gram of dry sediment (Bandy and Arnal, 1960).

For the identification of the recovered fauna classic work of Adams (1984,86); Adams et. al. (1986); Sirotti (1982); Drooger (1986) van der Vlerk (1963, 68); Bolli and Saunders (1985) and Berggern et. al. (1985) is consulted.

4.2.1 Ratipal Section

The base of the Ratipal section (Figure 4.1) is characterised by olive green coloured, oval shaped glauconite pellets, few miliolids, dwarf boliviniids and small, smooth shelled ostracods. Rich larger foraminiferal assemblage is recovered from the overlying silty and argillaceous dolomite sequence. It mainly comprises of reticulate Nummulites such as N. fichteli Michelotti, N. intermedius, N. clipeus Nuttall, Heterostegina kohili and few Operculina. Both macrospheric and microspheric tests of Nummulites are present. Pararotalia mexicana and gastropoda occur commonly. The faunal diversity is moderate and bulk of faunal number is represented by larger foraminifera as shown in the gross foraminiferal assembalge. Many genera of benthic foraminifera replace the nummulitidae in the overlying shaly sediments. Austrotrillina howchini, Cibicides lobatus, Acostina and many species of nodosaridae and miliolids are present frequently.

Sharp reduction in foraminiferal appearance is noted in the overlying sediments. The fauna is not matrix free and of worn out type. Occurrence of bryozoa and ostracoda Cytheretta is noteworthy.

Nummulites once again dominate the fossil content in the overlying sequence. Nummulites fichteli, N. intermedius occur together with Lepidocyclina Eulepidina dilatala and Operculina. Larger foraminiferal shells are pinkish white coloured and very fragile. Many genera of benthic foraminifera are present further

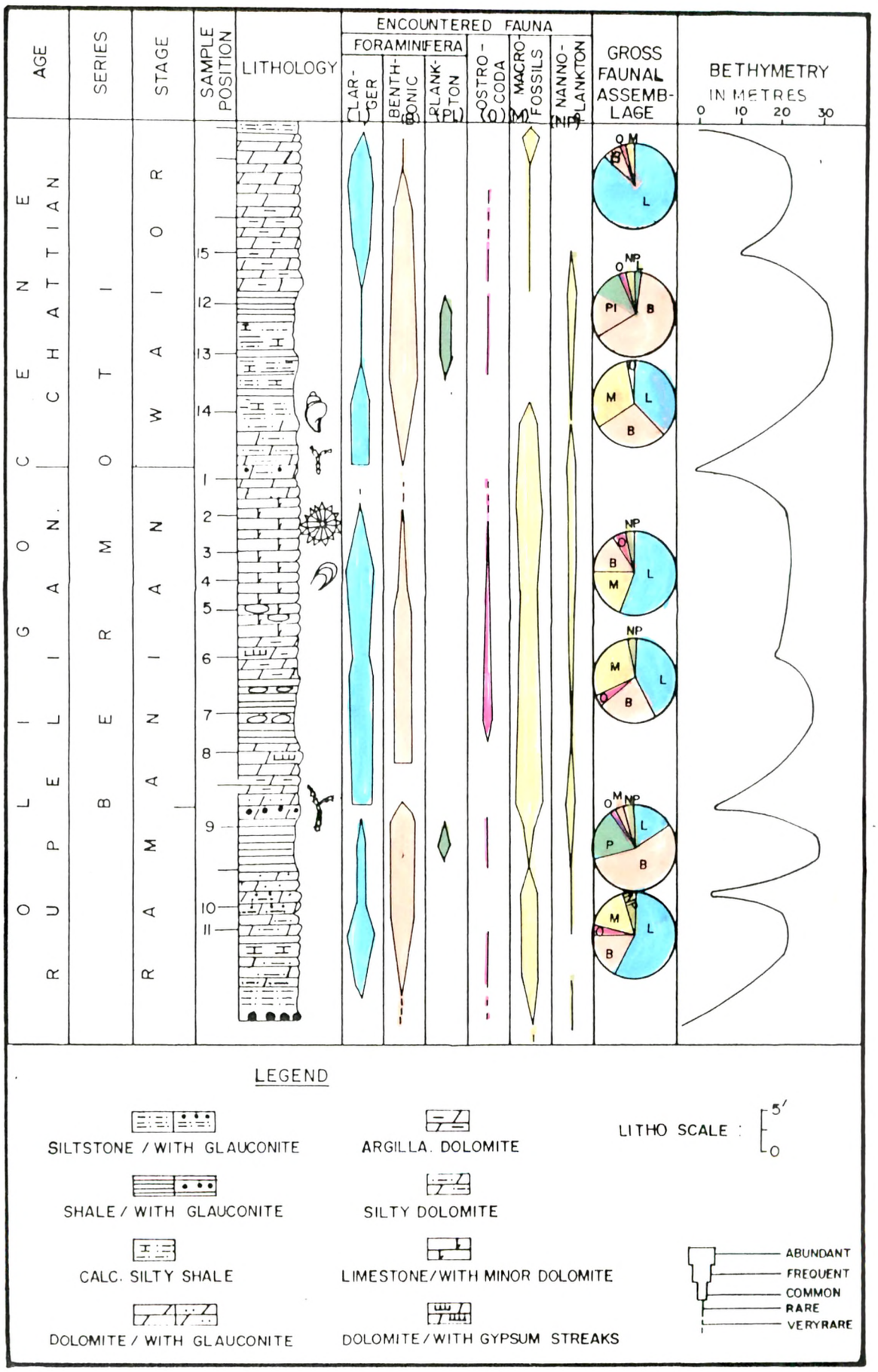


FIG. 4·1, BIOSTRATIGRAPHY OF RATIPAL SECTION.

upwards alongwith delicate oyster shells. Both faunal number and diversity is high. In the overlying thick, massive coralline limestone, fauna adheres to the carbonate mud matrix. Thin section study reveals, besides corals, presence of Sphaerogypsina globulus Ruess and Pyrgo bulloides. The faunal number is high but diversity is low.

Only few smooth shelled ostracoda belonging to genera Haplocytheredea and bryozoa are recovered from the overlying red siltstone band. Flattened large sized echinoids and gastropoda are present. This marks the top of Ramania stage.

The total absence of reticulate Nummulites from the samples overlying siltstone sequence is striking. Larger foraminiferal assemblage comprises of Operculina spp. Lepidocyclina Eulepidina dilatata, L.E premarginata, L. Nephrolepidina nipponica and Miogypsina (Miogypsinoides). Besides, miliolids and Planolinderina freudenthali are common. High benthic foraminiferal number and diversity is noted from the overlying shales, Anomallinella rostata, Cibicides pseudoungeriana, Acostina piramidale, Bolivina marginata, Rectobolivina, Nodosaria regularis, Globoratalia opima, Globigerina sp, Rotalia are recovered (Tewari et. al. 1968).

Very high number and very low diversity characterise the Spiroclypeus rich silty dolomite, towards the top of Ratipal section. Only few juvenile benthics together with gastropods and bryozoa occur in the red siltstone band which mark the top of Waior stage.

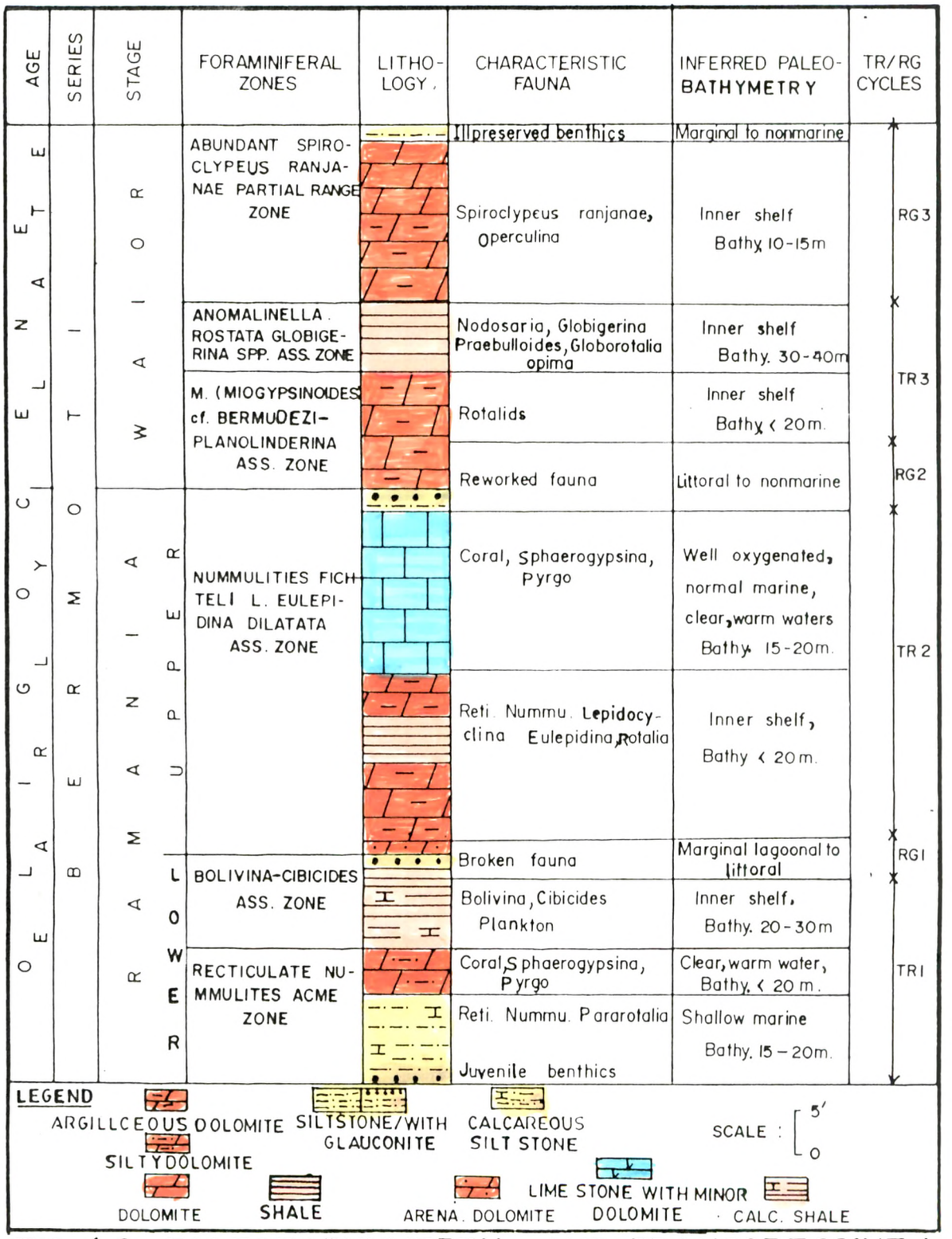


FIG. 4·3, PALEOBATHYMETRY AND TRANSGRESSIVE/REGRESSIVE CYCLES BASED ON FAUNAL PARAMETERS, RATIPAL SECTION.

Detailed vertical faunal distribution of the Ratipal section is displayed in Figure 4.2 .

Paleobathymetry and transgressive cycles

Figure 4.3 shows the bathymetry of depositing medium at the time of Bermoti series of Ratipal section. At the time of deposition of Anomalinella rostata-Globigerina spp. assemblage zone, basin attained maximum bathymetry of 30 to 40 metres. Total three sedimentry cycles are noticed, during the deposition of Bermoti series of this section. Lower Ramania, upper Ramania and Waior sediments were deposited in one cycle each. Microfacies data, however, indicates two sea level fluctuations during both lower and upper Ramania times.

4.2.2 Bermoti Section

A good number of miliolids, ill-developed boliviniids together with Elphidium, Florilus, Pararoralia, ostracoda Cytheretta and bryozoa occur in the siltstone sequence at the base of Ramania stage of Bermoti section (Figure 4.4). Patchy corals found above this are associated with Sphaerogypsina globulus and Pyrgo bulloides. The intervening limestone sequence is studded with Nummulites. N. fichteli, N intermedius, N. clipeus, and Pararotalia mexicana make up the faunal assemblage. Overlying thin sequence of greyish green coloured shale is poorly fossiliferous. Reticulate Nummulites assemblage occurs above the shale, which in turn is followed by calcareous sandstone band with very sparse fauna, constitutting few gastropods and echinoids.

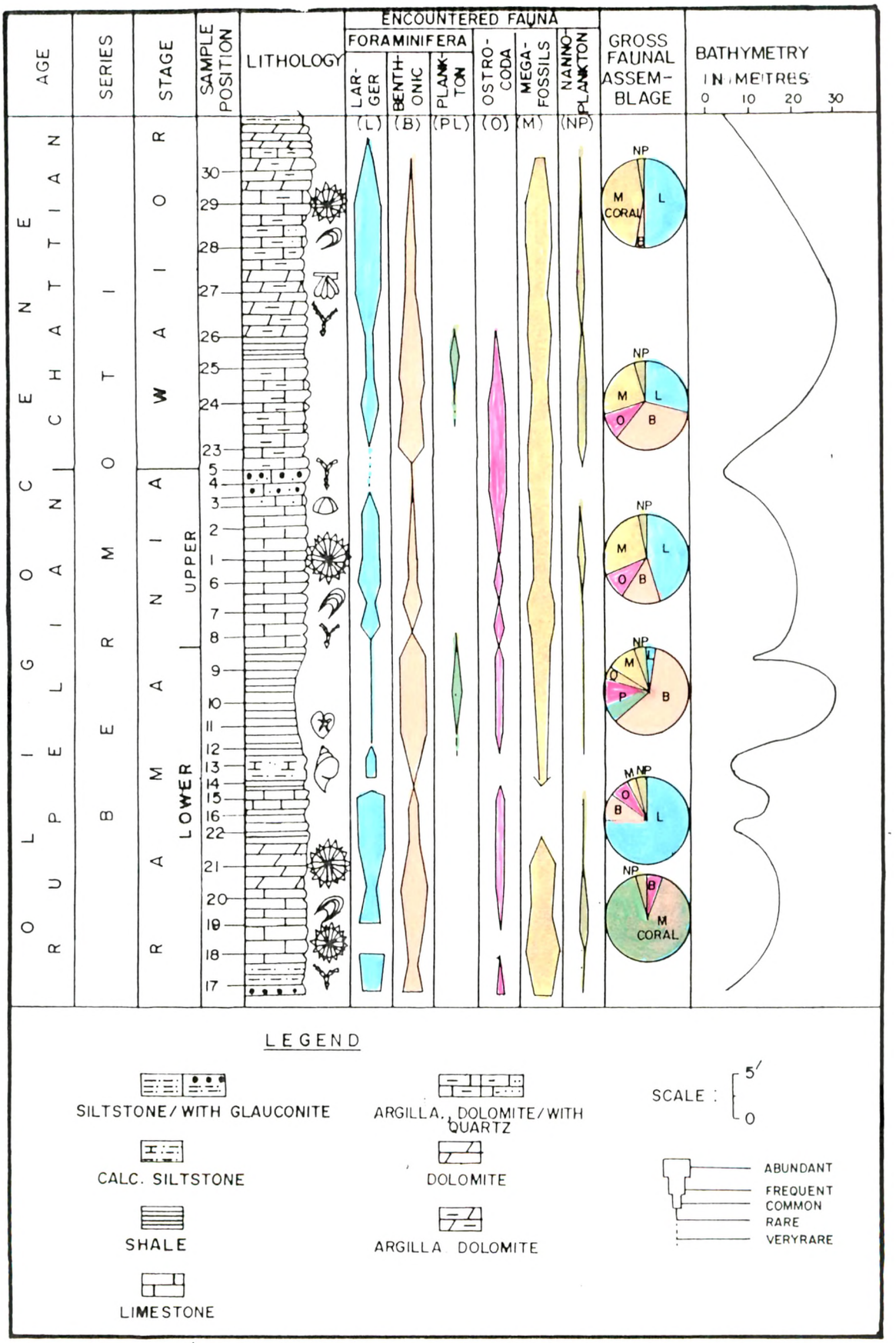


FIG. 4·4, BIOSTRATIGRAPHY OF BER-MOTI SECTION.

Deep-dwelling benthics such as nodasariids, boliviniids, buliminids, cibicides are associated with Austrotrillina and other miliolids. Few Globorotalia and Globigerina specimens are also present in the cement coloured shale. Both benthic faunal number and diversity is high. Towards the top, but for ostracoda Cytheretta and bryozoa, drastic reduction of faunal content is noticed. This is followed by massive limestone sequence comprising coral, algae and molluscan shell. Sphaerogypsina globulus and Pyrgo bulloides are the only foraminifera present. Lepidocyclina Eulepidina dilatata, L.(E.) formosa, Nummulites fichteli, N. intermedius constitute the bulk of larger foraminiferal assemblage of limestone in upper Ramania stage of the Bermoti section. Above this, calcareous siltstone band contains broken faunal tests with boring holes, Ostracoda Hyplocytheridea, Cytheretta and bryozoa mark top of Ramania strata.

Miogypsina Miogypsinoides cf. bermudezi, Lepidocyclina Eulepidina formosa, L. Nephrolepidina, Operculina and Planolinderina frudenthali occur in basal part of Waior stage. Anomalinella rostata, Nodosaria, Bolivina, Bulimina, Brizalina, Acostina, Globorotalia opima nana, Globigerina, ornamented ostracoda Actinocythereis kutchensis are the associated taxa, (Khosla et. al. (1981).

Faunal assemblage constituting coral, Sphaerogypsina, Pyrgo and algae occur above and is followed by Spiroclypeus ranjanae in the argillaceous dolomite sequence. Towards the top of Waior stage, red coloured marl band contains only few broken, ill preserved fauna and clay pellets. Figure 4.5 illustrates detailed vertical faunal destribution in Bermoti sequence.

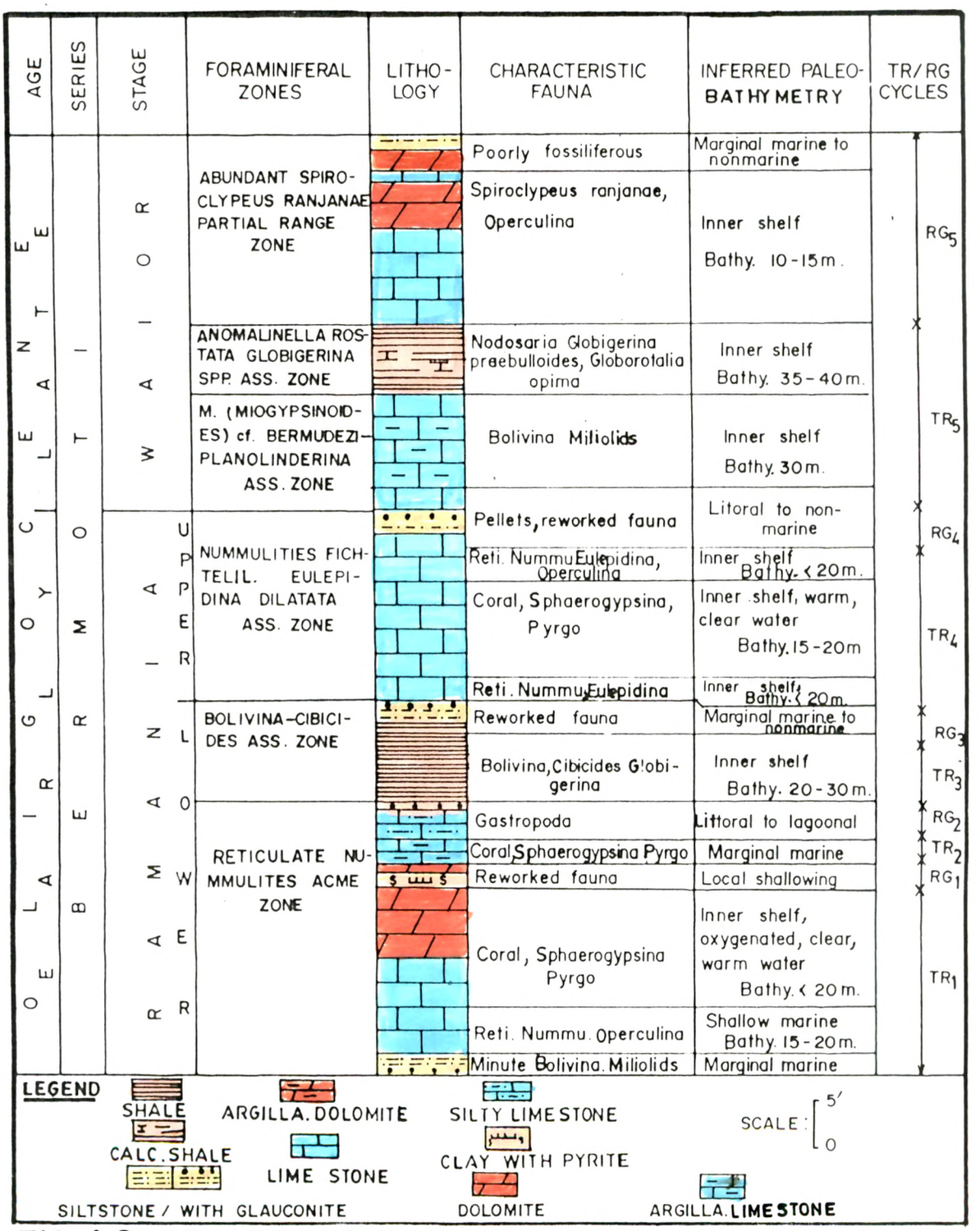


FIG. 4·6, PALEOBATHYMETRY AND TRANSGRESSIVE / REGRESSIVE CYCLES BASED ON FAUNAL PARAMETERS, BER-MOTI SECTION.

Paleobathymetry and transgressive regressive cycles.

Lower Ramania sequence is marked by oscillating sea as indicated by three short lived transgressions and regressions. The bathymetry ranged between 5 to 30 metres (Figure 4.6). Upper Ramania and Waior depositions are the outcome of one transgressive-regressive cycle each, suggesting stable basinal conditions. Maximum bathymetry of 35-40 metres was attained during transgression TR5, resulting in deposition of shale in middle part of Waior stage. Inference drawn on sedimentary cycles are similar for lower and upper Ramaina stage, on the basis of both, faunal and microfacies. However, latter shows presence of two sedimentary cycles during Waior stage deposition.

4.2.3. Bernani Section

As in other sections, presence of minute boliviniids and miliolids, together with brown/olive green pellets, mark the base of Ramania stage of this section, (Figure 4.7).

A good number of reticulate Nummulites, Heterostegina, Operculina and Rotalia occur in underlying sequence, which in turn is overlain by poorly fossiliferous calcareous marl.

Abundant reticulate Nummulites reappear together with, Heterostegina kohili, Operculina vinotti, Pararotolia, Florilus and ostracoda Actinocythereis ramaniaensis and Leguminocythereis.

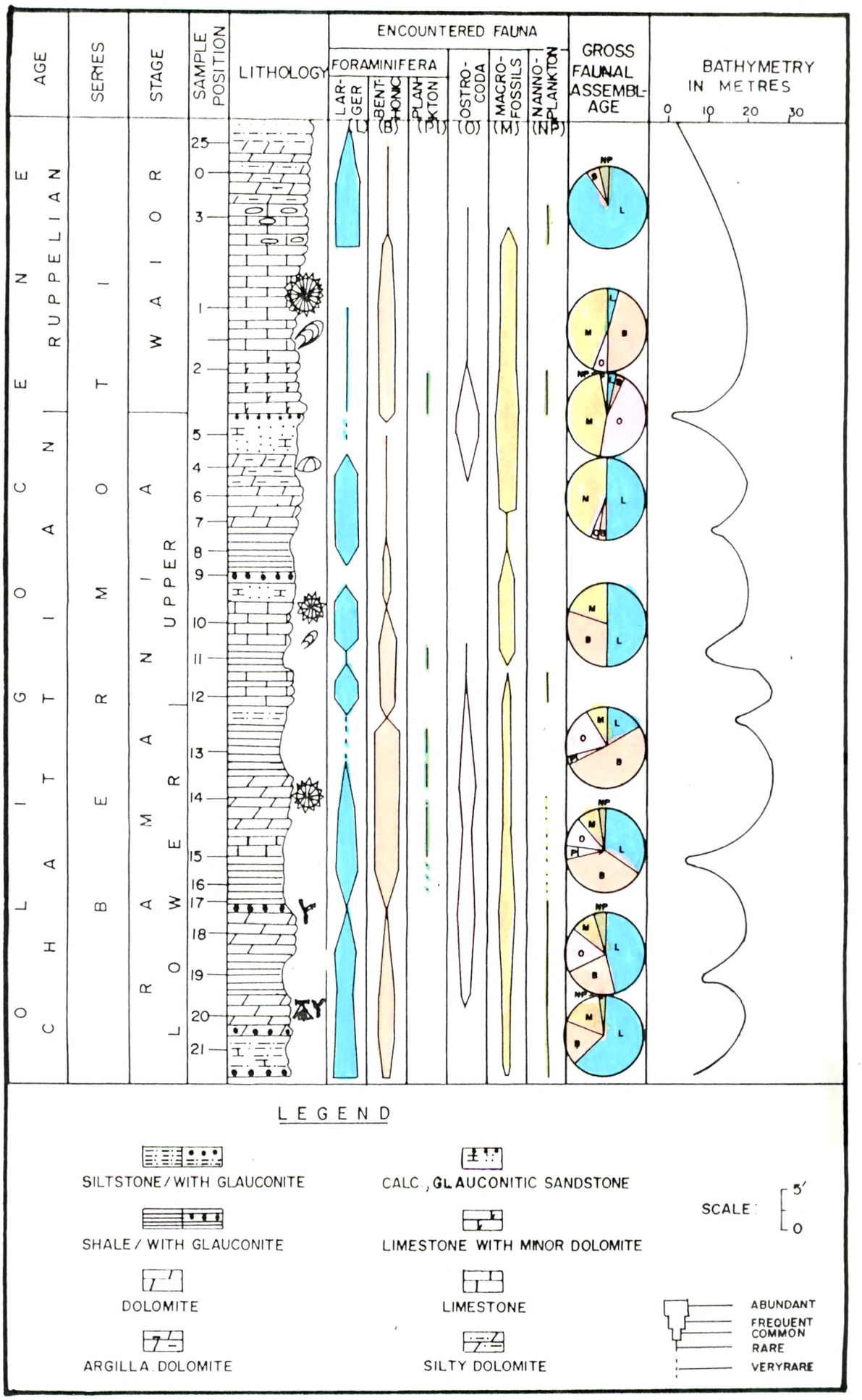


FIG. 4·7 BIOSTRATIGRAPHY OF BER-NANI SECTION.

A sudden and drastic reduction of foraminifera is observed at the top of lower Ramania stage. Haplocytheridae and few Cytheretta are the only ostracoda present. The size of ostracoda matches with that of oval shaped glauconitic pellets. In the overlying shaly sequence high faunal number and diversity is observed, Nodosaria, miliolids, Austrotrillina, Cibicides, Bolivina, Discorbis, Pararotalia, Planolinderina, Gypsina and Florilus are the main benthics present. The sequence is also noted for the diverse ostracoda content such as Actinocythereis ramaniensis, Stigmatocythere, Hemecythere and Dentokrithe.

In the intervening limestone sequence Nummulites are well developed. Generally, larger foram tests are thin, disc shaped, fragile and are arranged parallel-sub-parallel to each other. Overlying calcareous sandstone is poorly fossiliferous.

In the upper Ramania stage limestone, big, robust and microspheric forms of Nummulites are developed. Besides, occurrence of Lepidocyclina Eulepidina dilatata is noted. Among the associated taxa, specimens of Rotalia are frequent, followed by miliolids and Planorbulina. Coralline limestone occur above the Nummulites dominated sequence in which big, round species of Sphaerogypsina globulus and miliolids mainly Pyrgo are present. Occurrence of ostracoda Hyplocytheredae, bryozoa and reworked fauna mark the top of Ramania stage.

The thin section study of dolomitic limestone of Waior stage

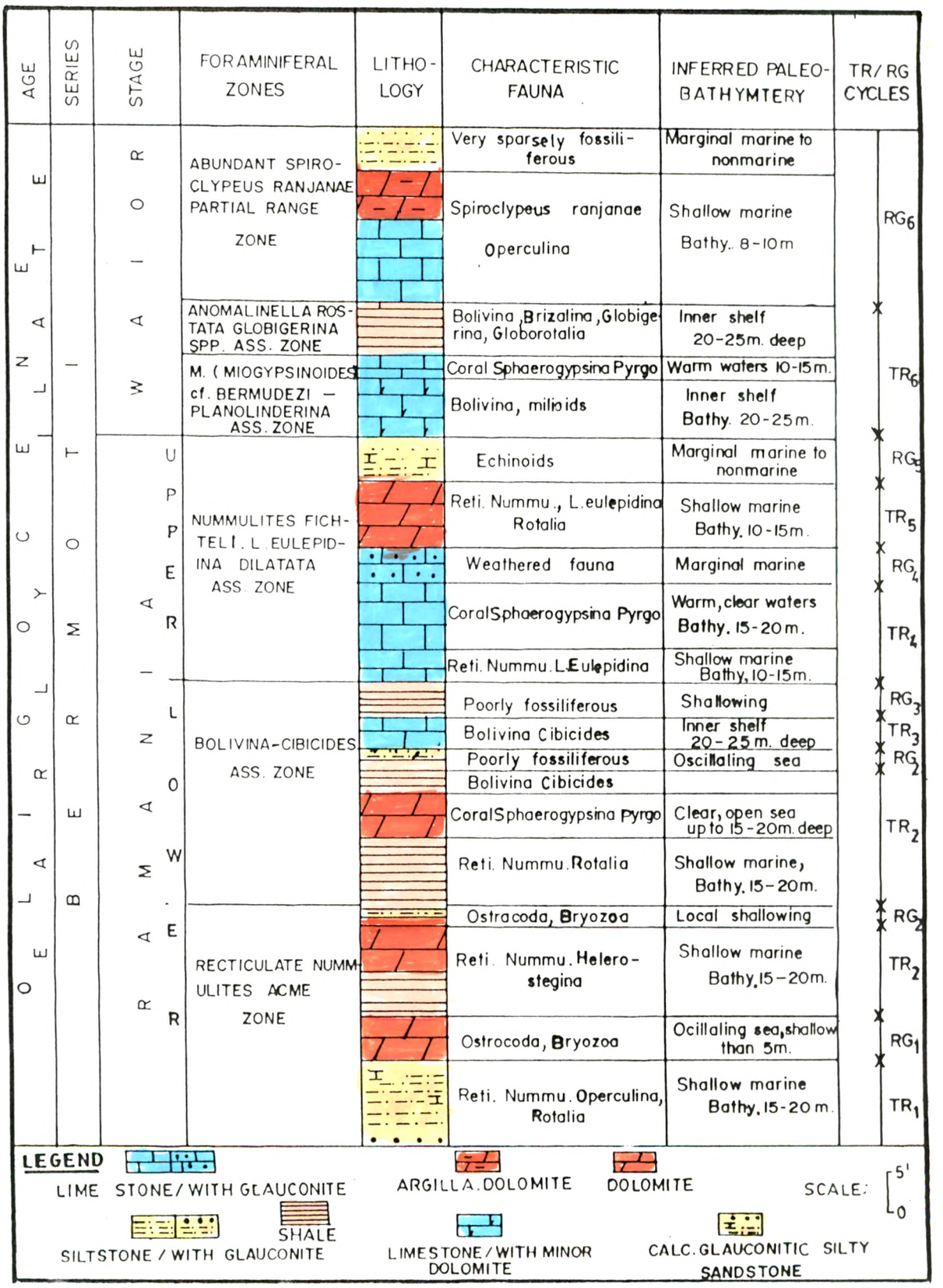


FIG. 4·9, PALEOBATHYMETRY AND TRANSGRESSIVE / REGRESSIVE CYCLES BASED ON FAUNAL PARAMETERS, BER-NANI SECTION.

shows good coralline growth and occurrence of Sphaerogypsina and Pyrgo. In the overlying carbonate sequence Miogypsina Miogysinoides and benthics particularly miliolids viz Quinqueloculina, Sigmoidina, Austrotrillina and Pyrgo are common. Among ostracoda Bairdia, Hermanites are noted. Lepidocyclina Nephrolepidina, Planolinderina occur commonly in the lower part, Anomalinella rostata, Cibicides, Nodosaria, Acostina are the faunal constituents occuring in the middle part of Waior stage. Towards the top, abundant big forms of Spiroclypeus ranjanae are arranged paralled to each other. Here the faunal diversity is low while number is very high. Overlying red siltstone band is very poorly fossiliferous. Figure 4.8 shows detailed vertical distribution of fauna occurring in Bernani section.

Paleobathymetry and transgressive regressive cycles.

Three transgressive-regressive cycles in lower Ramania and two cycles in upper Ramania are observed, suggesting unstable conditions during Ramania deposition of Bernani section (Figure 4.9). During Waior Sedimentation, maximum depth of sea was of the order of 25 to 30 metres and deposits were accumulated in one sedimentary cycle. This is in accordance with the conclusion drawn on microfacies study. However, latter shows one cycle for upper Ramania stage and two for lower Ramania stage deposits.

4.2.4 Waior Section

Few bryozoa and mollusc shells are recovered from the glauconitic siltstone occurring at the base of Ramania stage (Figure 4.10). In the overlying sediments miliolids and dwarf

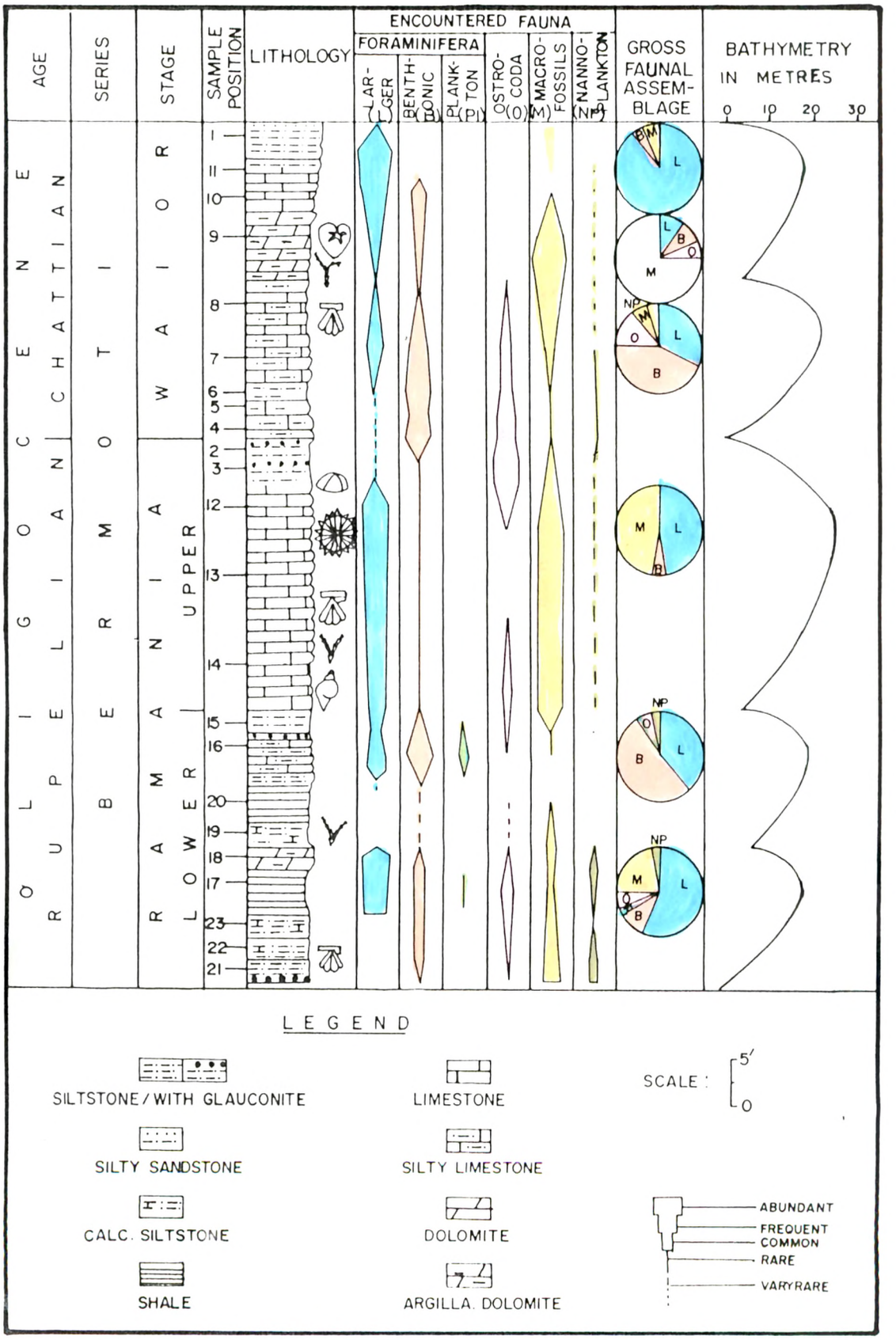


FIG. 4·10 BIOSTRATIGRAPHY OF WAIOR SECTION.

boliviniids make their presence. Abundant Nummulites fichteli, and N. intermedius characterise the overlying sequence. Heterostegina, Operculina, Planorbulina, Grzybowskia, Pararotalia and Nonion comprise associated taxa. However, no identifiable fauna other than bryozoa is observed in the overlying yellow ochreous shaly band.

Plenty of delicate tests of reticulate Nummulites are arranged parallel to each other in the overlying silty limestone. Besides Rotalia, Pararatalia, and few specimens of Hermanites ostracoda comprise faunal assemblage which is high in number but moderate to low in diversity. Benthic foraminifera viz. Cibicides, Austrotrillina, Nodosaria, Bolivina, miliolids, Rotalia and ostracoda belonging to the genera Leguminocythereis, Stigmatocythere, Pokornyella, and Actinocythereis ramaniaensis constitute the faunal assemblage of siltstone band. In the overlying sequence, heart shaped echinoids, bryozoa and ostracoda Cytheretta are present.

Lepidocyclina Eulepidina dilatala together with reticulate Nummulites appear in the overlying thick carbonate sequence. Miliolids and Rotalia are associated benthonic foraminifera.

Robust microspheric forms of larger foraminifera dominate the faunal assemblage. Nummulites limestone grades upwards into massive coral-algal limestone in which Sphaerogypsina globulus and Pyrgo bulloides are associated taxa. For both the limestones faunal number is very high while diversity is low. Grzybowskia, Archias and Heterostegina occur intermittantly. The top of Ramania stage is

characterised by glauconite pellets, ostracoda Cytheretta, Haplocytheridea, bryozoa, flattened echinoids and gastropods. Planolinderina frudenthali, Miogypsina Miogypsinoides, cf. bermudezi, miliolids, ornamented ostracoda Actinocythereis kutchensis form the rich faunal constitutent of lower part of Waior stage. Miliolids include Austrotrillina, Quinqueloculina and Pyrgo spp.

High foraminiferal number and diversity is observed in the overlying sediments which constitute Anomalinella, Rotalia, Cibicides, Eponids, Bolivina, Lepidocyclina Nephrolepidina, Borelis, Miogypsina (Miogypsinoides) complanata and ostracoda Actinocythereis kutchensis, A. spinellosa, Pokornyella, and Stigmatocythere. This rich and diverse fauna dwindles upwards, and is characterised by plenty of mollusc shells and ichnofossils. Reddish brown calcareous siltstone band is full of Spiroclypeus ranjanae and few Operculina Unfossiliferous sequence with clay pellets marks the top of Waior stage. Figure 4.11 displays vertical faunal distribution in detail.

Paleobathymetry and transgressive regressive cycles -

Compared with the regressive phases of lower Ramania times, as observed in other sections, regressions RG1 and RG2 (lower Ramania stage) of Waior section, are of longer duration (Figure 4.12). Total six sedimentary cycles are responsible for Bermoti series depostion; of which 2 cycles are responsible for lower Ramania

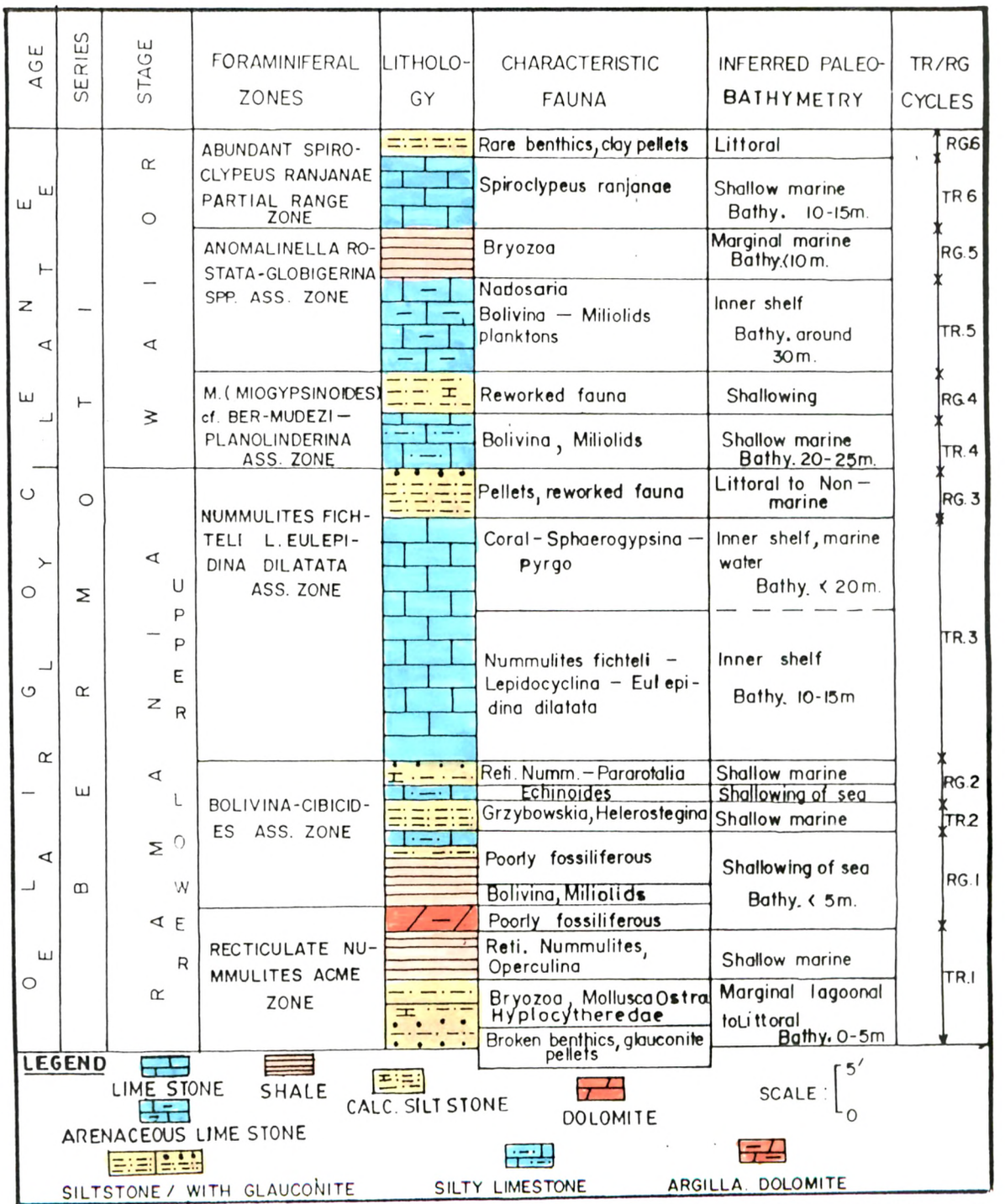


FIG. 4·12 PALEOBATHYMETRY AND TRANSGRESSIVE / REGRESSIVE CYCLES BASED ON FAUNAL PARAMETERS, WAIOR SECTION.

deposits, one cycle for the upper Ramania sediments and 3 cycle for the Waior sequence. However, microfacies data shows 2 cycles for upper Ramania stage thus making the total cycles as seven. Oscillatory marine conditions prevailed in lower Ramania and Waior deposition while upper Ramania deposition took place in comparatively stable environment. The maximum water depth of 25-30 metres is observed in the middle part of Waior stage.

4.3 AGE AND BIOZONES

4.3.1 Foraminiferal Makers of Bermoti Series

Detailed biostratigraphic discussion of sections have led to identify age diagnostic micropaleontological markers of Bermoti series. Ray (1985), similarly has worked out age and taxonomical relationship for the Cretaceous deposits in the Algarve, Southern Portugal. Table 4.1 shows observed ranges of biostratigraphically significant taxa of Bermoti series. Reticulate Nummulites viz. N. fichteli and N. intermedius range from base to the top of Ramania stage, while Lepidocyclina Eulepidina dilatata appears in the upper Ramania stage and continues in Waior stage. Austrotrillina howchini is another marker of Ramania stage.

Foraminiferal markers of Waior stage include Miogypsina Miogypsinoides cf. bermudezi, Planolinderina frudenthali, Lepidocyclina Nephrolepidina, Spiroclypeus ranjanae, Anomalinella rostata and planktonic foraminifera Globorotalia opima.

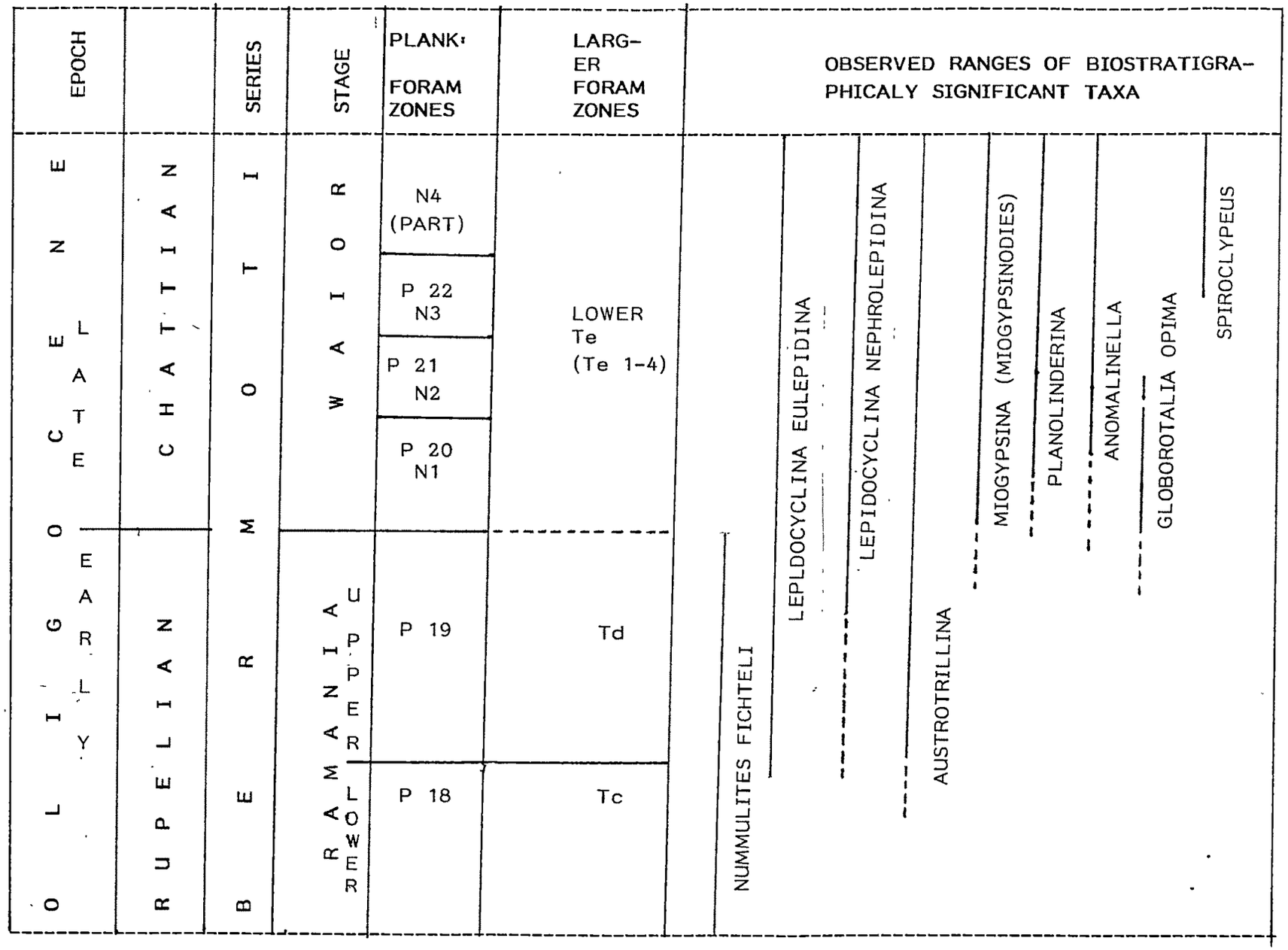


TABLE:4.1, CRITERIA USED FOR BIOZOZAL ASSIGNMENT OF BERMOTI SERIES

4.3.2 Age

Many workers have described the foraminiferal contents of Bermoti series (Raju 1973, Samanta 1970, Pandey 1982). According to them early Oligocene Ramania stage is taken as equivalent to planktonic foraminiferal zones P-18 and P 19 and late Oligocene age Waior stage includes plankton foram zones P 20 /N1, P 21/N2, P23/N3 and N4 (part).

Owing to their wide distribution and fast phylogenetic evolution, planktonic foraminifera is widely used for zonation. Table 4.2 shows standard planktonic foraminiferal zones proposed by Bollie and Saunders (1985). However, in shallow water deposits, especially carbonates, planktonic foraminifera occur only in small numbers or are absent (Luterbatuer 1984, Mcgrowan, 1985). van der Vlerk and Umbgrove (1927), have proposed a "Letter stage classification of Tertiary" based on larger foraminifera which occur abundantly in carbonates. It was revised and applied to the entire Indo - west-Pacific region by Adams (1970, 84 and 85). Table 4.3 summarises the history of Letter stage zone.

Adams, (1984) in the Oligocene Letter stage zones has recognised three successive assemblages of larger foraminifera (Table 4.4). The oldest defined as Tc is characterised by the presence of Nummulites without Lepidocyclina, second oldest, Td, includes Nummulites and Lepidocyclina while youngest Te 1-4 contains Lepidocyclina without Nummulites. Adams, (1984, op.cit), has equated Letter stage boundaries with those of planktonic foraminiferal

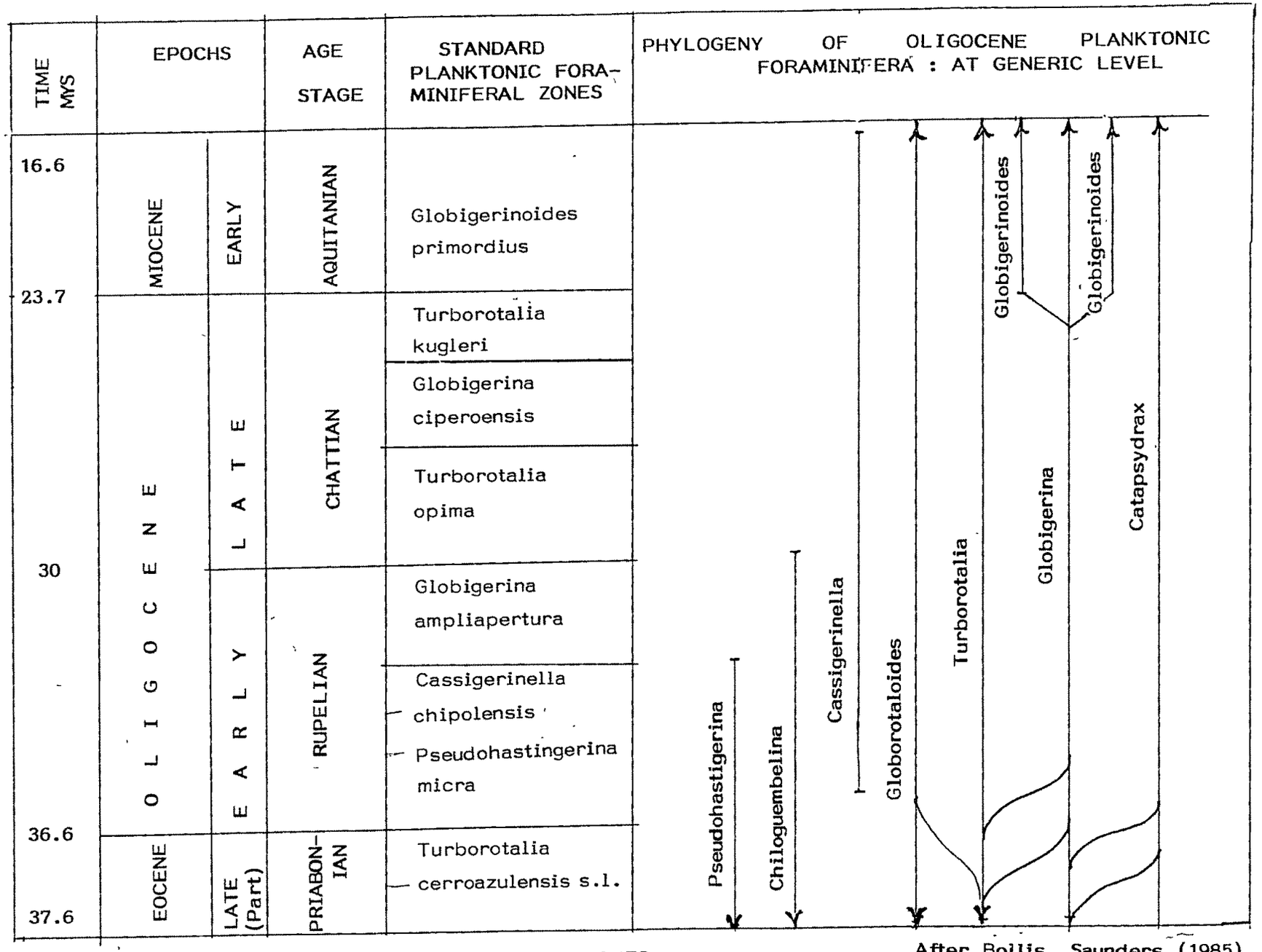
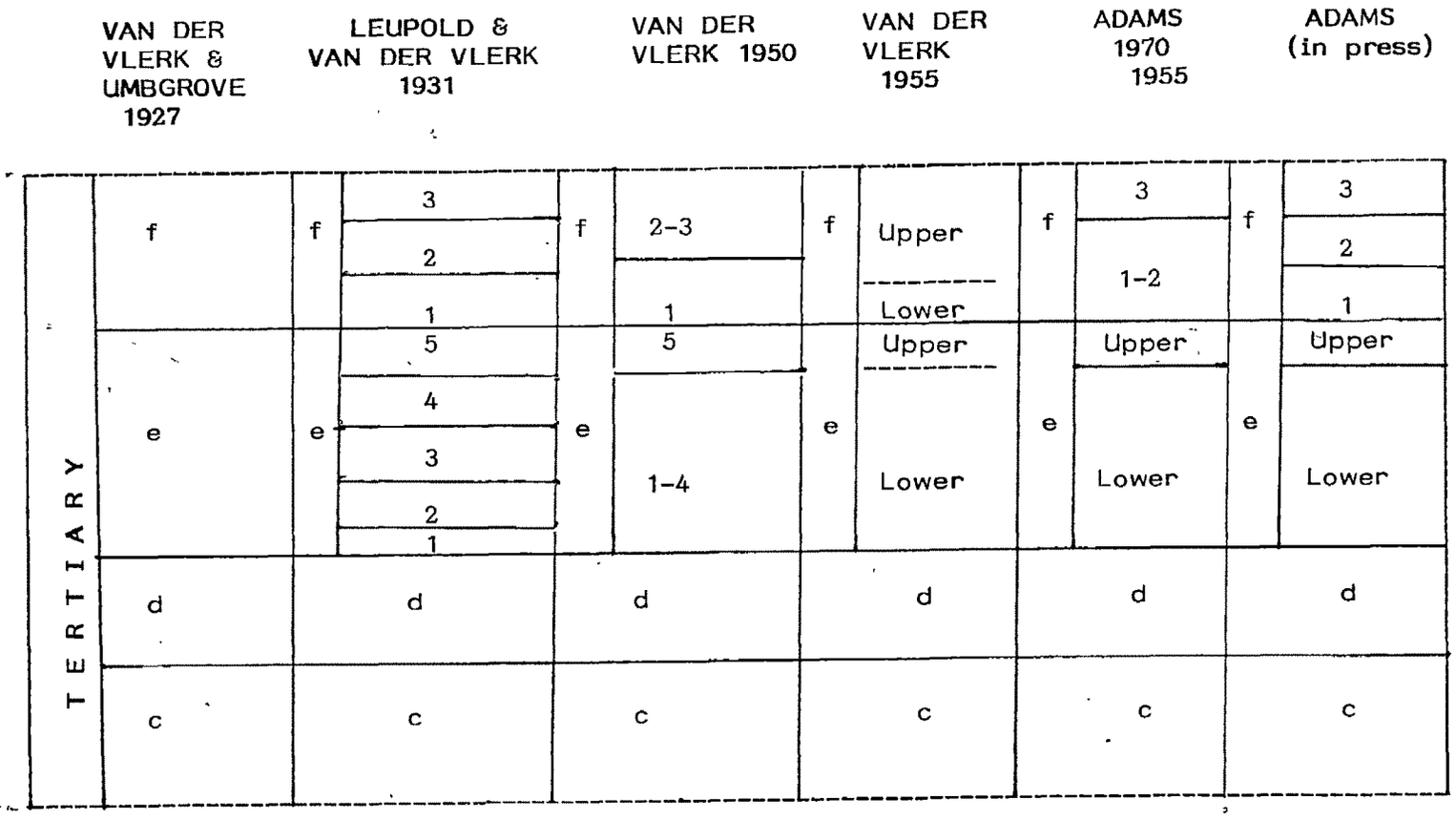


TABLE:4.2 STANDARD PLANKTONIC FORAMINIFERAL ZONES

After Bollis, Saunders (1985)



(AFTER ADAMS, 1984)

TABLE 4.3, HISTORY OF FAR EAST LETTER STAGE ZONES DEVELOPMENT.

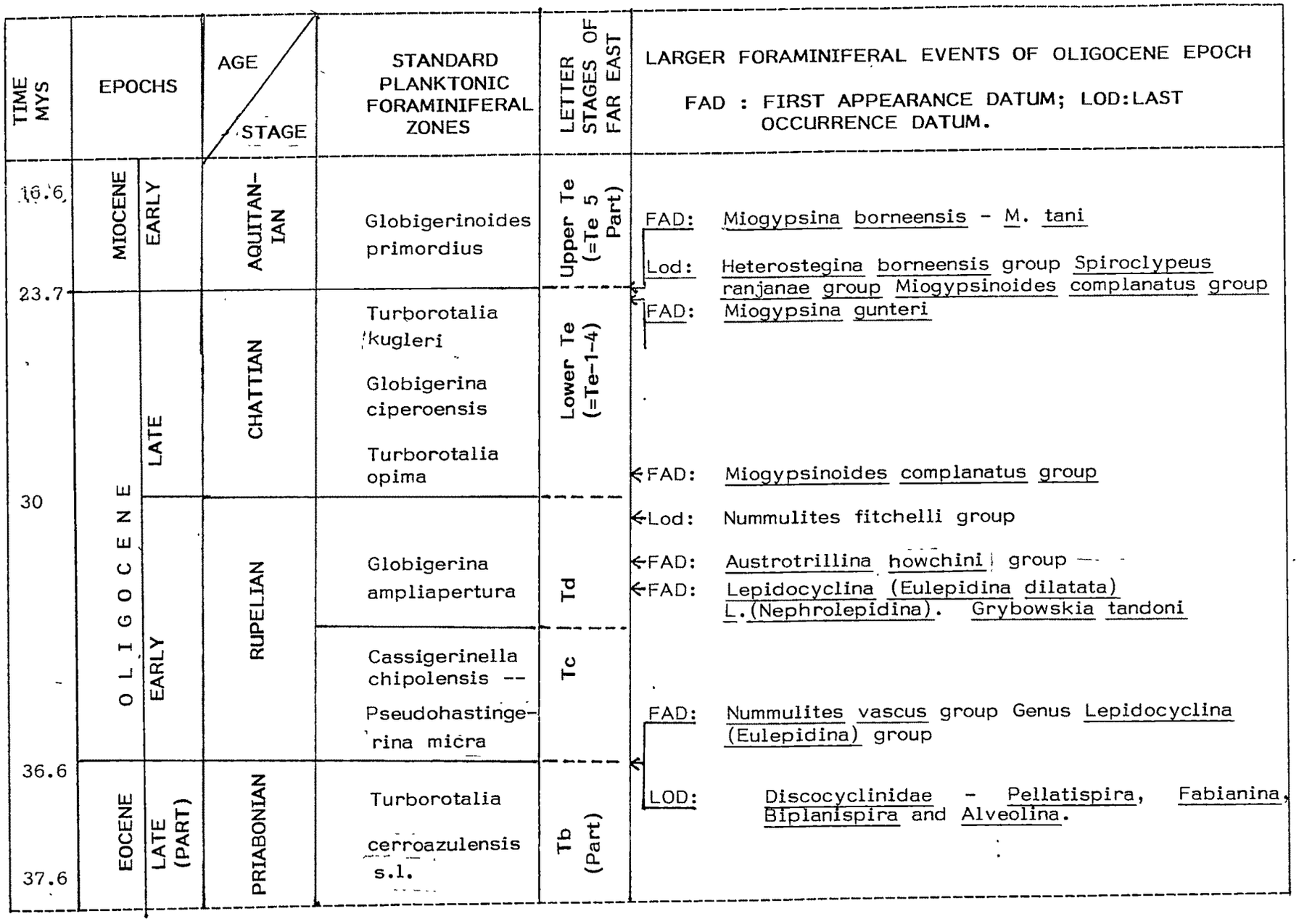
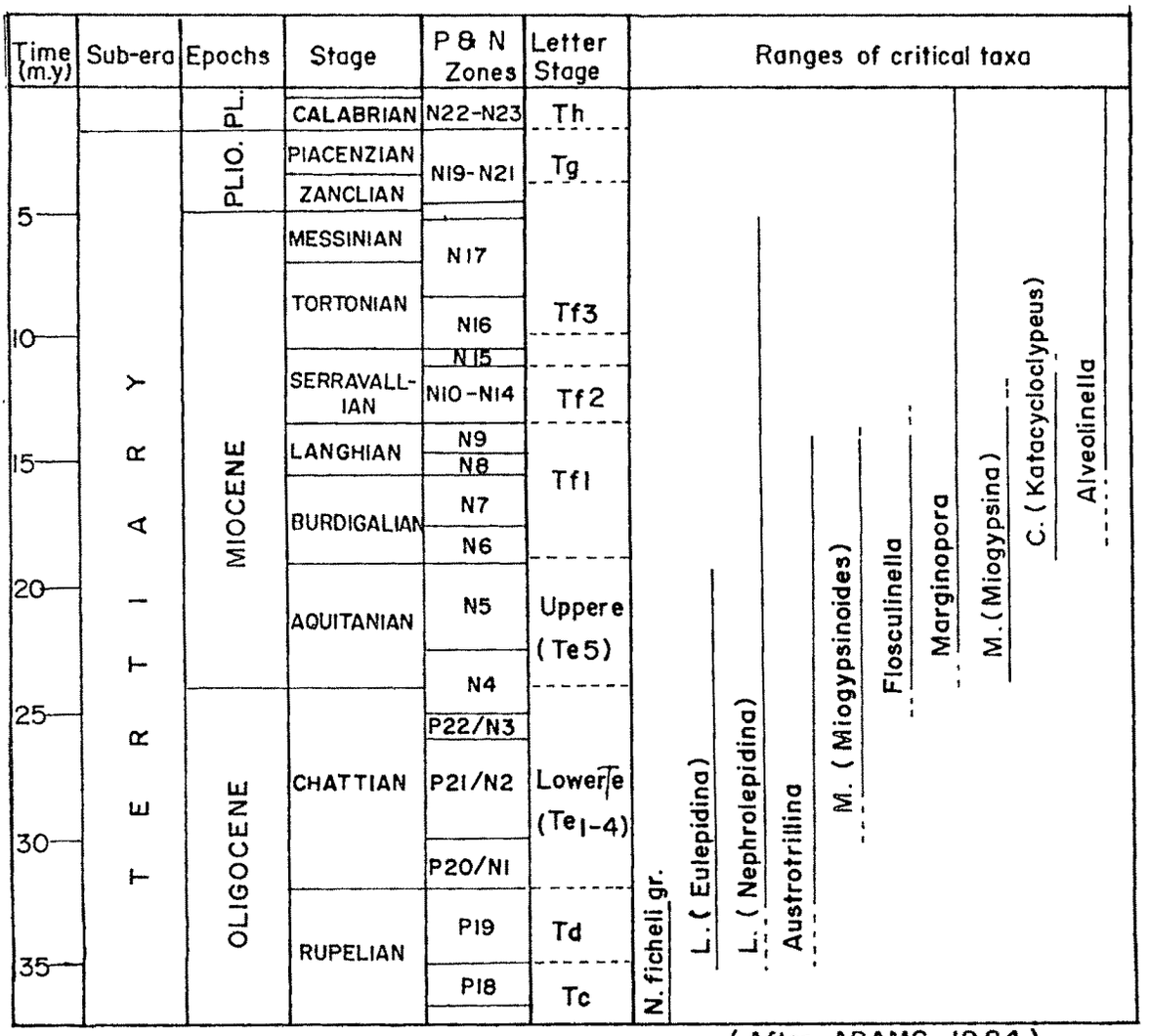


TABLE:4.4 LARGER FORAMINIFERAL EVENTS OF OLIGOCENE



(After ADAMS 1984).

TABLE: 4-5, LETTER STAGE BOUNDARIES AND RANGES OF TAXA.

zones (Table 4.5). He has also shown the ranges of critical taxa used for zonation.

The comparison of observed ranges of significant taxa of Bermoti series (Table 4.1) with the established ranges of larger foraminifera (Table 4.5) gives a good lead to tie the Ramania and Waior stages with standard Letter stage boundaries. Age disgnostic larger foraminiferal markers present in the present study are reticulate Nummulites, Lepidocyclina Eulepidina, L.Nephrolepidina, M. Miogypsinoides and Spiroclypeus. In lower Ramania stage, reticalate Nummulites dominate the faunal assemblage. Co-occurrence of Lepidocyclina Eulepidina and Nummulites is noted in upper Ramania stage. The generated data is compared with the works of Kepkemeti, (1981) and Cavelier et. al. 1981 regarding Eocene/Oligocene boundary events. Thus, the first appearance datum of L. Eulepidina divides the lower and upper Ramania as equivalent to Tc and Td respectively and last occurrence datum of Nummulites fichteli marks the boundary between Ramania and Waior stages. Larger foram markers, further enable to equate the Ramania stage with European chronostratigraphic stage Rupelian and the Waior with the Chattain. In terms of geological ages, the Ramania stage corresponds to 36.6 Ma to 30 Ma.

As mentioned above, first appearrance datum of Miogypsina in Waior felicitates to tie it with letter stage lower Te 1-4, (Raju 74). Additionally, presence of L. Nephrolepidina, Planolinderina frundenthali in the lower part, Anomallinella rostata in the shaly middle part and Spiroclypeus ranjanae in the upper part of Waior stage helps to equate it with Adam's (op. cit.) Letter stage, lower Te, ie Te 1-4. The occurrence of planktonic foraminiferal marker,

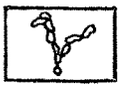
Globorotalia opima (P21/N2) afirms the age determination. (Keller, 1983). Waior stage is, thus, equivalent to Chattian stage ranging between 30 and 23.7 millions years.

4.3.3 Biozones

Biozones proposed by Raju (1974) for the Bermoti series has taken as initial base and the present work is further detailed and high resolution refinement.

In the lower Ramania, two distinct biozones occur, viz. Reliculate Nummulities Acme Zone in lower part and Bolivina-Cibicides Assemblage Zone in upper part. Upper Ramania comprises of Nummulites fichteli - Lepidocyclina Eulepidina dilatata Assemblage Zone.

Within Waior stage three biozones are recognised. They are Miogypsina (Miogypsinoides) cf. bermudezi - Planolinderina fraundenthali Assemblage zone, Anomalinella Rostata - Globigering spp. Assemblage Zone and Spiroclypeus ranjanae Partial Range Zone from base to top. Thus, the biostratigraphy of Bermoti series is evolved with six biozones of which three biozones are recognised in Ramania stage. Waior stage, similarly, is divisible into three biozones. All of them can be marked in Ratipal, Bermoti, Bernani and Waior sections and are fairly correlatable, (Figure 4.13).

FAUNAL SYMBOLS	
	BRYOZOA
	CORAL
	GASTROPODA
	ECHINOID
	PELECYPOD
	ALGAE
	ICNOFAUNA
	OSTRACODA
	ALGALMATS

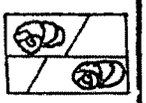
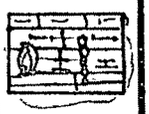
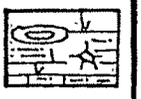
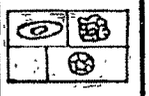
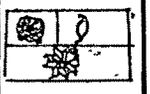
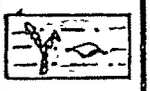
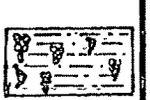
SYMBOLS OF BIOFACIES	
	SPIROCLYPEUS – OPERCULINA BIOFACIES
	NODOSARIA – ACOSTINA BIOFACIES
	NODOSARIA – AUSTROTRILLINA BIOFACIES
	NUMMULITES - HETEROSTEGINA -PARAROTALIA BIOFACIES
	NUMMULITES - EULEPIDINA - ROTALIA BIOFACIES
	CORAL – SPHAEROGYPSINA - PYRGO BIOFACIES
	HYPLOCYTHEREDEA - BRYOZOA BIOFACIES
	MILIOLIDS - DWARF BOLIVINIDS BIOFACIES
	MILIOLIDS – MIOGYPSINA BIOFACIES

FIG. 4·14 BIOSTRATIGRAPHIC LEGEND