CHAPTER : III

BIOSTRATIGRAPHY

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A. INTRODUCTION

The Palaeogene succession of Kutch is rich in mega- and micro-fossils. Among the different groups represented Foraminifera are the most abundant and occur through the greater part of the succession. They are represented by a large number of stratigraphically significant genera such as, Alveolina, Assilina, Asterocyclus, Austrotrillina, Borelis, Dictyoconoides, Discocyclus, Bulepidina, Heterostegina, Linderina, Lokhartia, Mvogypsinoidea, Nephrolepidina and Nummulites. Many of these genera are well-known for their potentiality in the classification and correlation of the Lower Tertiary marine succession.

The stratigraphic ranges of twenty-four genera and sixty-six species are shown in Figs. 9-14. An analysis of the ranges permits recognition of the following eight Zones in the sequence examined (in stratigraphic order) :-

8. Spiroclupeus ranjanae Zone
7. Bulepidina dilatata Zone
6. Nummulites fichteli Zone
5. Alveolina elliptica Zone
4. Discocyclus sowerbyi Zone
3. Nummulites obtusus Zone
2. Barren Zone
1. Assilina laxispira Zone

B. DESCRIPTION OF ZONES

1. Assilina laxispira Zone, Zone Nov.
   a. Name : The zone is named after Assilina laxispira de la Harpe, the taxon restricted to this zone.
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**Species**

- *Lockhartia tipperi* (Davies)
- *L. sp. aff. L. conditi* (Nuttall)
- *Nummulites crasseornata* Henrici
- *Assilina daviesi* Cizancourt
- *A. laxispira de la Harpe*
- *A. spinosa* Davies

Fig. 10 Stratigraphic distribution of larger foraminifera in Kokdi Nadi Section, Near Naroda, North-Western Kutch.
b. **Kind**: It is a local range zone.

c. **Definition**: *Assilina laxispira* Zone, is defined by the stratigraphic range of *Assilina laxispira* de la Harpe in the present area (Fig. 14).

d. **Boundary and relationship to adjacent biozone**: The lower and upper boundaries of this zone are marked by the first and last occurrences respectively of *A. laxispira* de la Harpe. This zone is overlain by Barren Zone (Figs. 13-14).

e. **Diagnostic fossils**: In addition to *A. laxispira* de la Harpe, the following six species of larger foraminifera are characteristic of this zone: *Assilina daviesi* Cizancourt, *A. spinosa* Davies, *Nummulites crasseornata* Henrici, *Lockhartia pustulosa* Smout, *L. tipperi* (Davies) and *L. sp. aff. L. conditi* (Nuttall). All the larger foraminiferal species identified are restricted to this zone (see Fig. 14).

f. **Description and illustration of taxa diagnostic of the unit**: The larger foraminifera listed above as diagnostic of *A. laxispira* Zone are described, discussed and illustrated in the systematic part of the thesis.

g. **Associated biota**: In *A. laxispira* Zone both larger and planktonic foraminifera are represented. Larger foraminifera constitutes the most dominant group of fossils. Out of the seven species of larger foraminifera identified, only three species range throughout the zone and another three species are confined to its lower part (Fig. 14). Megainvertebrates and ostracodes also occur.

h. **Relation to associated lithostratigraphic unit**: This
zone corresponds to the Assilina Limestone Member of the Naredi Formation of the present area.

i. **Associated lithology**: Limestone as well as calcareous claystone rich in Assilina and shales.

j. **Thickness and lateral extent**: In the present area this zone is well-developed in Nareda, Guvar and Harudi areas. It attains a maximum thickness of 6.7 m.

k. **Correlation and Age**: Detailed discussion on correlation and age of the A. laxispira Zone has been presented in Chapter 4. This zone is Early Eocene in age.

l. **Remarks**: Assilina laxispira de la Harpe constitutes a dominant larger foraminiferal element in the Assilina Limestone Member of the Naredi Formation in the present area. It is a morphologically distinctive and readily recognisable foraminifera. It ranges throughout the zone and occurs as a rock-forming element at certain levels. Thus this well-known and widely distributed taxon is used here as the zonal species.

This zone is correlatable with the Assilina granulosa Zone of Raju (1971) (See Fig. 15).

2. Barren Zone, Zone Nov.

a. **Name**: This zone is named the Barren Zone because it is devoid of larger foraminifera.

b. **Kind**: It is an interval zone.

c. **Definition**: Barren Zone, by definition, is the interval zone between the Assilina laxispira Zone below and Nummulites obtusus Zone above in the present area (see Fig. 14). The interval, is thus,
marked by the last occurrence of Assilina laxispira de la Harpe and the first occurrence of Nummulites obtusus (Sowerby) in Kutch.

**d. Boundary and relationship to adjacent biozone**: The lower boundary of the zone is marked by the extinction of Assilina laxispira de la Harpe, while the upper boundary is defined by the advent of Nummulites obtusus (Sowerby). Barren Zone is underlain by Assilina laxispira Zone and overlain by Nummulites obtusus Zone.

**e. Diagnostic fossils**: The zone is devoid of larger foraminifera.

**f. Associated biota**: Megainvertebrates represented by pelecypods and gastropods occurs abundantly at certain levels.

**g. Relation to associated lithostratigraphic unit**: This zone corresponds to the Ferruginous Claystone Member of Naredi Formation as well as to the lower part of the Harudi Formation in the present area of investigation.

**h. Associated lithology**: Ferruginous claystone, laterite, splintery shale and layers of argillaceous limestone as well as ferruginous limestone; rocks gypseous at places.

**i. Thickness and lateral extent**: The zone is well-developed in Harudi and Guvar areas. It is the second thickest zone in the present area and attains a maximum thickness of 12.5 mm. in the Guvar Stream section.

**j. Correlation and Age**: Discussion on the correlation and age of the Barren Zone has been presented in Chapter 4. This zone is considered to be late Early to early Middle Eocene in age.
k. **Remarks**: This zone is readily recognised by its mega-invertebrate assemblage and the complete absence of larger foraminifera.

Barren Zone corresponds to Raju's (1971) Lower Eocene Unfossiliferous Zone of Kutch.

3. **Nummulites obtusus** Zone, Zone Nov.
   a. **Name**: The zone is named after *Nummulites obtusus* (Sowerby), the taxon typical of the zone.
   b. **Kind**: It is an interval zone.
   c. **Definition**: *Nummulites obtusus* Zone, by definition, is the interval zone between the advent level of *Nummulites obtusus* (Sowerby) and the advent level of *Discocyclina sowerbyi* Nuttall in the present area of investigation (Fig. 14).
   d. **Boundary and relationship to adjacent biozone**: The lower boundary of the zone is defined by the advent of *Nummulites obtusus* (Sowerby), while the upper boundary is delineated by the first occurrence of *Discocyclina sowerbyi* Nuttall. *Nummulites obtusus* Zone is underlain by Barren Zone and conformably overlain by *Discocyclina sowerbyi* Zone.
   e. **Diagnostic fossils**: *Nummulites obtusus* (Sowerby) and *Nummulites vredenburgi* Prever are characteristic of the zone.
   f. **Description and illustration of taxa diagnostic of the unit**: The larger foraminifera listed above as diagnostic of the *N. obtusus* Zone are described, discussed and illustrated in the systematic part of the thesis.
g. Associated biota: Larger foraminifera is present only in the lower part of this zone. They are frequent in occurrence. A total of ten larger foraminiferal species identified in the zone (Fig. 14). All the ten species appear first in this zone. Of these, *N. pinfoldi* Davies, *N. stamineus* Nuttall, *N. varialarius* (Lamarck), *N. sp. aff. N. exilis* Douville, *Oncalinoides sainanensis* Cole, *O. vaughani* (Cushman), *O. sp. aff. O. aspenis* (Colom) and *Lockhartia garonensis* Samanta. Only two, *Nummulites obtusus* (Sowerby) and *N. vredenburgii* Prever are restricted here and the rest eight species range up into the overlying *Discocyclus sowerbyi* Zone. Planktonic foraminifera occurs in the upper part of *Nummulites obtusus* Zone. Mollusks and ostracodes are common in this zone. Algae occurs rarely at several samples.

h. Relation to associated lithostratigraphic unit: This zone corresponds the upper part of the Harudi Formation in the present area (Figs. 13-14).

i. Associated lithology: Generally calcareous claystone and shale; a gypseous argillaceous limestone marker bed with *Nummulites* as rock-forming element in the lower part.

j. Thickness and lateral extent: In the present area this zone is well-developed in Harudi and Guvar areas. It attains a maximum thickness of 5.5 m. in the Harudi area.

k. Correlation and Age: Discussion on the correlation and age of *Nummulites obtusus* Zone has been presented in Chapter 4. This zone is middle Middle Eocene in age.
1. Remarks: In the Nummulites obtusus Zone, the zonal species Nummulites obtusus (Sowerby) does not range throughout this zone. It is restricted in the lower part of the zone.

As the upper boundary of this interval is marked by the first appearance of a large number of Middle Eocene species characteristic of Discocyclina sowerbyi Zone, only one zone named after the stratigraphically significant taxon, Nummulites obtusus (Sowerby) is recognised in the investigation. N. obtusus (Sowerby) is a well-defined species and readily recognisable even in the field also.

This zone corresponds to Raju's (1971) Nummulites perforatus / Truncorotaloides topilensis Zone. It is tentatively correlatable with middle Middle Eocene Globoratalia lehneri Zone of Bolli (see Samanta, 1981, p. 817).

4. Discocyclina sowerbyi Zone, Samanta, 1978
   a. Name: This zone was named after Discocyclina sowerbyi Nuttall, the taxon typical of the zone (see Samanta, 1978).
   b. Kind: It is an interval zone.
   c. Definition: Discocyclina sowerbyi Zone, is the interval zone between the first appearance level of Discocyclina sowerbyi Nuttall and the last appearance level of Assilina exponens (Sowerby) in the present area of investigation (Fig. 14). The interval, thus corresponds to the lower part of the stratigraphic range of Discocyclina sowerbyi Nuttall between its first occurrence and the last occurrence of Assilina exponens (Sowerby).
d. Boundary and relationship to adjacent biozones: The lower and upper boundaries of the zone are defined by the first occurrence of *Discocyclina sowerbyi* Nuttall and the last occurrence of *Assilina exponens* (Sowerby) respectively. This zone is conformably underlain by *Nummulites obtusus* Zone and conformably overlain by *Alveolina elliptica* Zone.


f. Description and illustration of taxa diagnostic of the unit: The larger foraminifera listed above as diagnostic of this zone are described, discussed and illustrated later in the systematic part of the thesis.

g. Associated biota: Both larger and planktonic foraminifera occur abundantly in *Discocyclina sowerbyi* Zone. Of the thirty-six species of larger foraminifera identified (Fig. 14) *Assilina*
exponens (Sowerby) and Discocyclina sella (d'Archiac) are restricted in the upper part of the zone, while Nummulites scaber Lamarck, Linderina sp. cf. L. buranensis Nuttall & Brighton, Fabiania sp. and Discocyclina sp. aff. D. sowerbyi Nuttall are confined in the lower part. Eight species range up in this zone from the underlying Nummulites obtusus Zone. A total of twenty-nine species range up into the overlying Alveolina elliptica Zone. Megainvertebrates, ostracodes and benthonic and smaller foraminifera occur commonly at several horizons.

h. Relation to associated lithostratigraphic unit: Here, the zone corresponds to the lower part of the Fulra Limestone.

i. Associated lithology: Argillaceous foraminiferal limestone rich in Discocyclina; glauconitic in the lower part.

j. Thickness and lateral extent: This zone is very well-developed in Godhatad-Kapurasi as well as Guvar areas. It is the thickest of eight zones recognised here and attains a maximum thickness of 22.94 m.

k. Correlation and Age: Detailed discussion on the correlation and age of the Discocyclina sowerbyi Zone has been presented in Chapter 4. This zone is middle Middle Eocene in age.

l. Remarks: Discocyclina sowerbyi Nuttall forms a distinctive ready recognisable larger foraminiferal element in the Fulra Limestone exposed in the present area. It occurs as a rock-forming element at several levels. Assilina exponens is also distinctive and readily recognisable in the field which appears in the middle of the Fulra Limestone and becomes extinct before reaching its upper part.
Samanta (1978) used the advent and extinction levels of this two stratigraphically significant species in defining the limits of *Discocyclina sowerbyi* Zone.

It corresponds to the *Orbulinoides beckmanni* Zone of Bolli (see Samanta, 1970).

5. *Alveolina elliptica* Zone, Samanta & Lahiri, 1985

a. **Name**: The zone was named after *Alveolina elliptica* (Sowerby), the taxon typical of the Zone.

b. **Kind**: It is an interval zone.

c. **Definition**: *Alveolina elliptica* Zone by definition is the interval zone between the disappearance level of *Assilina exponens* (Sowerby) and the extinction level of *Alveolina elliptica* (Sowerby) (Fig. 14). In the present area the interval, thus, corresponds to stratigraphic range of *Alveolina elliptica* (Sowerby) between the last occurrence of *Assilina exponens* (Sowerby) and the extinction level of *Alveolina elliptica* (Sowerby).

d. **Boundary and relationship to adjacent biozone**: The lower and upper boundaries of *Alveolina elliptica* Zone are defined by the extinction levels of *Assilina exponens* (Sowerby) and *Alveolina elliptica* (Sowerby) respectively. This zone is conformably underlain by *Discocyclina sowerbyi* Zone and paraconformably overlain by *Nummulites fichteli* Zone.

e. **Diagnostic fossils**: In addition to *Alveolina elliptica* (Sowerby) the following eleven larger foraminiferal species range throughout this zone: *Nummulites maculatus* Nuttall, *N. stamineus*

f. **Description and illustration of taxa diagnostic of the unit** : The larger foraminifera listed above as diagnostic of the *Alveolina elliptica* Zone are described, discussed and illustrated in the systematic part of the thesis.

g. **Associated biota** : Both larger and smaller foraminifera occur in this zone. Out of the thirty-three species of larger foraminifera recognised in this zone, twenty-nine range up to this zone from the underlying *Discocyclina sowerbyi* Zone. Only one species, *Gypsina globulus* (Reuss) range up into the overlying *Nummulites fichteli* Zone. Algae is frequent at several horizons.

h. **Relation to associated lithostratigraphic unit** : This zone corresponds to the upper part of the Fulra Limestone in the present area (Figs. 13-14).

i. **Associated lithology** : Massive foraminiferal limestone which is occasionally argillaceous.

j. **Thickness and lateral extent** : This zone is well-developed in Godhatad-Kapurasi and Guvar areas. It attains a maximum thickness of 12.06 m.
k. **Correlation and Age**: Discussion on the correlation and age of the Alveolina elliptica Zone has been given in Chapter 4. This zone is late Middle Eocene in age (Figs. 13-14).

l. **Remarks**: In the present area of investigation Alveolina elliptica (Sowerby) is confined to the upper part of the Fulra Limestone (Fig. 14). Here the first undoubted occurrence of Alveolina elliptica (Sowerby) coincides with the disappearance of Assilina exponens (Sowerby).

This zone corresponds to the Discocyclina omphalus Zone of Samanta (1978) recognised for the upper part of Fulra Limestone in Kutch. A. elliptica Zone is tentatively correlatable with the Truncorotaloides rohri Zone of Bolli (see Samanta, 1970).

6. **Nummulites fichteli Zone, Samanta & Lahiri, 1985**
   a. **Name**: The zone was named after *Nummulites fichteli* Michelotti, the taxon typical of the zone.
   b. **Kind**: It is an interval zone.
   c. **Definition**: *Nummulites fichteli* Zone, by definition, is the interval zone between the advent level of *Nummulites fichteli* Michelotti and the advent level of *Eulepidina dilatata* (Michelotti) in the present area (Fig. 14). The interval thus, corresponds to the lower part of the stratigraphic range of *Nummulites fichteli* Michelotti between its first occurrence and the first appearance of *Eulepidina dilatata* (Michelotti).
   d. **Boundary and relationship to adjacent biozones**: The lower as well as upper boundaries of this zone are defined by the first appearance levels of *Nummulites fichteli* Michelotti and
Eulepidina dilatata (Michelotti) respectively. N. fichteli Zone is paraconformably underlain by the Alveolina elliptica Zone and conformably overlain by Eulepidina dilatata Zone.

e. Diagnostic fossils: In addition to Nummulites fichteli Michelotti the following three species of larger foraminifera range throughout the zone: Heterostegina kohlii Tandon, Amphistegina mamilla (Fichtel & Moll) and Gypsina globulus (Reuss).

f. Description and illustration of taxa diagnostic of the unit: The larger foraminifera listed above as diagnostic of the Nummulites fichteli Zone are described, discussed and illustrated later in the systematic part of this thesis.

g. Associated biota: Larger foraminifera occur abundantly in this zone. A total of six larger foraminiferal species are identified (Fig. 14). Of these only one species Operculina roselli Hottinger is confined in this zone and another species Gypsina globulus (Reuss) ranges up into this zone from the underlying Alveolina elliptica Zone. The following four species, in addition to Nummulites fichteli Michelotti, namely, Operculina sp. aff. O. schwageri Silvestri, Heterostegina kohlii Tandon, Amphistegina mamilla (Fichtel & Moll) and Gypsina globulus (Reuss) range up into the overlying Eulepidina dilatata Zone. Megainvertebrates occur commonly at several horizons.

h. Relation to associated lithostratigraphic unit: This zone corresponds to the lower part of the Maniyara Fort Formation of the present area (Fig. 14).
i. Associated lithology: Calcareous siltstone, and calcareous claystone; rocks at places glauconitic.

j. Thickness and lateral extent: In the present area of study N. fichteli Zone is well-developed in Kapurasi area. It represents the thinnest zone of the present area and attains a maximum thickness of 4.50 m.

k. Correlation and Age: Detailed discussion on the correlation and age of the N. fichteli Zone has been presented in Chapter 4. This zone is Early Oligocene in age (Figs. 13-14).

l. Remarks: In the present areas Nummulites fichteli Michelotti occurs as a rock-forming element at several horizons within this zone. It is one of the most distinctive and readily recognisable larger foraminifera in the present area. Only four genera, Nummulites, Operculina, Amphistegina and Gypsina range above from the underlying horizon. Heterostegina kohlii Tandon occurs commonly in this zone. The frequency of the zonal species, N. fichteli Michelotti varies considerably. However, this is the only interval in Kutch containing reticulate Nummulites in appreciable number.

This zone corresponds to Raju's (1971) Nummulites intermedius-fichteli Zone.

7. Eulepidina dilatata Zone, Samanta & Lahiri, 1985
a. Name: The zone was named after Eulepidina dilatata (Michelotti), the taxon typical of the zone.

b. Kind: It is an interval zone.

c. Definition: Eulepidina dilatata Zone, by definition, is the interval zone between the advent level of Eulepidina dilatata
(Miehelotti) and the extinction level of Nummulites fichteli Michelotti in the present area of investigation (Fig. 14). The interval thus, corresponds to the upper part of the stratigraphic range of Nummulites fichteli Michelotti between the first appearance of Eulepidina dilatata (Miehelotti) and the last appearance of N. fichteli Michelotti.

d. Boundary and relationship to adjacent biozones: The lower boundary is defined by the advent level Eulepidina dilatata (Miehelotti). The upper boundary is marked by the extinction level of Nummulites fichteli Michelotti. E. dilatata Zone is conformably underlain by the Nummulites fichteli Zone and conformably overlain by the Spirogyrus ranjanae Zone.

e. Diagnostic fossils: In addition to Eulepidina dilatata (Miehelotti) the following five larger foraminiferal species range throughout the zone: Nummulites fichteli Michelotti, Operculinoides sp. aff. O. schwageri Silvestri, Heterostegina kohlii Tandon, Amphistegina mamilla (Fichtel & Moll) and Gypsina globulus (Reuss). Five species, namely, Eulepidina dilatata (Michelotti), Archas sp., Borelis philippineensis Hanzawa, B. pygmaeus Hanzawa and Gypsina discus Goes are restricted to this zone.

f. Description and illustration of taxa diagnostic of the unit: The larger foraminifera listed above as diagnostic of the Eulepidina dilatata Zone are described, discussed and illustrated later in the systematic part of this thesis.

g. Associated biota: In the present area, larger foraminifera range throughout the zone and occur commonly to rarely. A total
of thirteen species of larger foraminifera have been identified (Fig. 14). Of these, four range up from the underlying N. fichteli Zone. Of the six species ranging up into the overlying Spiroclupeus ranianae Zone, three appear first in Eulepidina dilatata Zone. Megainvertebrates are frequent in the Zone. Corals and algae occur as rock-forming element in the upper part. Mollusks also occur commonly.

h. Relation to associated lithostratigraphic unit: This zone corresponds to the middle part of the Maniyara Fort Formation (see Figs. 13-14).

i. Associated lithology: Calcareous massive claystone with intercalations of limestone bed in the lower part; massive coralline limestone with calcareous claystone and calcareous siltstone in the upper part.

j. Thickness and lateral extent: In the present area of investigation E. dilatata Zone is well-developed in two areas: Kapurasi and Guvar. It attains a maximum thickness of 12.02 m.

k. Correlation and Age: The correlation and age of the E. dilatata Zone have been discussed in detail in Chapter 4. This zone is Middle Oligocene in age.

l. Remarks: Eulepidina dilatata (Michelotti) the zonal species, occurs commonly to rarely in the present sample. It does not occur in all samples. The larger foraminiferal assemblage in the upper part of this zone is somewhat different from that of the lower part. Several morphologically and stratigraphically significant
genera, namely, Austrotrillina, Archaias and Borelis make their first appearance in the upper part. The extinction level of N. fichteli is considered here as stratigraphically significant enough to define the upper limit of this zone in Kutch.

This zone corresponds Nummulites intermedius / Eulepidina Zone of Raju's (1971).

8. Spiroclineus ranjanae Zone, Zone Nov.
   a. Name: This zone is named after Spiroclineus ranjanae Tewari, the taxon typical of the zone.
   b. Kind: It is an interval zone.
   c. Definition: By definition, Spiroclineus ranjanae Zone, is the interval zone between the extinction level of Nummulites fichteli Michelotti and the extinction level of Spiroclineus ranjanae Tewari in the present area (Fig. 14).
   d. Boundary and relationship to adjacent biozone: The lower and upper boundaries of S. ranjanae Zone are defined by the extinction levels of Nummulites fichteli Michelotti and Spiroclineus ranjanae Tewari respectively. This zone is conformably underlain by Nummulites fichteli Zone.
   e. Diagnostic fossils: In addition to Spiroclineus ranjanae Tewari the following nine species of larger foraminifera are characteristic of this zone: Austrotrillina sp., Pararotalia mecateneensis (Nuttall), Operculina sp. aff. O. schwageri Silvestri, Heterostegina borneensis Van der Vlerk, Miogypsinoides bermudezi (Drooger), Amphistegina mamilla (Fichtel & Moll), Gypsina globulus...
(Reuss), Nephrolepidina morgani (Lemoine & Douville) and N. sp.
Only four species namely, Spiroclupeus ranjanae Tewari, Miogypsinoides bermudezi (Drooger), Nephrolepidina morgani (Lemoine & Douville) and N. sp. are restricted to this zone.

f. Description and illustration of taxa diagnostic of the unit: The larger foraminifera listed above as diagnostic of the Spiroclupeus ranjanae Zone are described, discussed and illustrated in the systematic part of this thesis.

g. Associated biota: Foraminifera occurs as a dominant element in this zone. Larger foraminifera are well represented. The lower part is poor in larger foraminifera. Out of the ten species of larger foraminifera recognised in this zone, six range up from the underlying Eulepidina dilatata Zone. Algae occurs rarely to commonly.

h. Relation to associated lithostratigraphic unit: This zone corresponds to part of the Ber Moti Member of the Maniyara Fort Formation in the present area.

i. Associated lithology: Siltstone, hard foraminiferal limestone and shales.

j. Thickness and lateral extent: This zone has been examined only in Guvar area where it attains a thickness of 7.50 m.

k. Correlation and Age: Detailed discussion on the correlation and age of the Spiroclupeus ranjanae Zone has been given in Chapter 4. This zone is Late Oligocene in age.

l. Remarks: Spiroclupeus ranjanae Tewari occurs as rock-forming element at certain levels in this Zone. But this zonal species
does not range throughout the interval. In the present area the assemblage of genera typical of *Spiroclypeus ranjanae* Zone, namely, *Spiroclypeus, Miogypsinoides* and *Nephrolepidina* make their first appearance in the upper part of this zone. As the lower boundary of this zone is well-defined by the disappearance of *Nummulites fichteli* Michelotti only one zone, named after the morphologically distinct and stratigraphically significant taxon, *Spiroclypeus ranjanae* Tewari is recognised in this investigation.

This zone corresponds to the *Miogypsinoides complanata* / *Miogypsinoides cf. bermudezi* Zone of Raju (1971) (see Fig. 15).