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THE ALBIAN-CENOMANIAN BOUNDARY IN SOUTHERN INDIA

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ABSTRACT

The present study reviews the Albian - Cenomanian boundary in Southern India. The first appearance of *Rotalipora evoluta* Sigal is considered as indicative of the base of the Cenomanian Stage and the Albian - Cenomanian boundary in Southern India can be marked at the base of the *Rotalipora evoluta* Total Range Zone. In this paper, the distribution of foraminifera across Albian - Cenomanian boundary and a discussion on Global Stratotype Section and Point (GSSP) have also been given.

INTRODUCTION

The Uttattur Group of sediments constitutes, a critical source rock sequence in the Cauvery Basin. The sediments are extensively developed both in the surface and subsurface - where the hydrocarbons are also discovered from this sequence. In the outcrop, this sequence is characterized by a well diversified foraminiferal assemblage, whereas the diversified faunal suite are either rare or not well represented in the subsurface. During the past few decades, many biostratigraphical works have been carried out on the mid-Cretaceous sediments of the Cauvery Basin, Southern India. The purpose of this paper is to review the Albian - Cenomanian boundary in Southern India and to discuss about the boundary stratotypes.

The Subcommission on Cretaceous Stratigraphy (SCS) at "Second International Symposium on Cretaceous Stage Boundaries", in Brussels, 1995 agreed that the Stages are "packages of zones" and the most sensible way to define a Stage is by the base of the earliest biozone at a boundary stratotype. The base of the zone should preferably be defined on the first appearance of a new taxon. Ideally, the taxon to be chosen should be widespread, reasonably common, and identifiable by a non-specialist. Taxa belonging to well known phylogenitic series are preferable (Hancock, 1995).

As a result of provincialism, long distance correlation usually depends on indirect fossil evidence : definition on the basis of one index taxon needs to be supported by other palaeontological correlation.

A number of participants especially micropaleontologists stressed the importance of extinction events of certain planktic foraminifera for long distance correlation. Some of these events can be related to sea level changes. However, it was generally agreed, that appearance of new taxa must be the prime tool for definition, while extinction events are extremely important in actual practice. In order to achive a modern vision of the Stages an extensive Working Group meetings were held in Brussels (1995). Their proposals will be published soon. In this paper, the distribution of foraminifera across Albian-Cenomanian boundary is discussed. The Albian-Cenomanian sequence of Uttattur Group can be regarded as typical Indian and its correlation with ammonite reports has also been attempted. Apart from that, the author has also made an attempt to discuss the best possible stratotype for Albian-Cenomanian boundary and some recent developments on the subject.

GENERAL GEOLOGY

The Uttattur Group consists of silts, calcareous shales and sandy clays containing ferruginous, phosphatic and calcareous nodules. The clays are often streaked with yellow and ferruginous stains. At the base in a few places, there is a dark grey, somewhat arenaceous limestone which is usually weathered to a yellow colour. The major portion of the Uttattur Group were covered by a thick mantle of "Black cotton soil". However, the stream sections, pits, dug wells are serving as good locations for sample collection (fig.1).

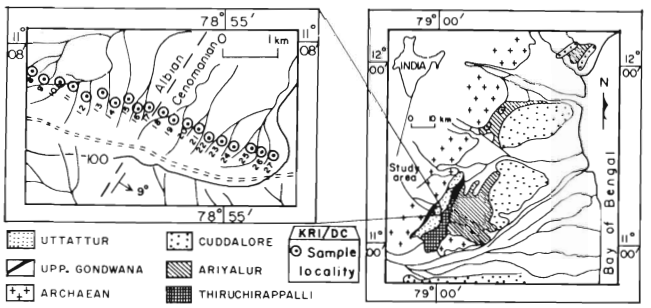

Fig. 1. Location map of the study area.

REVIEW OF ALBIAN - CENOMANIAN BOUNDARY

Before the Brussels Symposium 1995, there was not internationally agreed-upon stratotype for the Albian-Cenomanian boundary. A review of Albian - Cenomanian boundary literature on a global scale leads to conclude that there is no ideal section for an ammonite-based, boundary stratotype because few places retain a record of the Albian - Cenomanian boundary interval in superposition that is complete (e.g., Sadler, 1981), Murphy and Rodda (1996). The boundary stratotype sections in North Africa and Texas were dis-

cussed in Copenhagen at the 1983 Third International Symposium on the Cretaceous System (Birkelund *et al.*, 1984) are inadequately documented, facies restricted or both. The widespread occurrence of the ammonite *Stoliczkaia* and *Mortoniceras* in the Upper Albian and *Mantelliceras* in the Cenomanian classically bracket the boundary and must be used until the boundary is formally defined (Murphy and Rodda, 1996).

Traditionally, the Albian - Cenomanian boundary has been based on the occurrence of the ammonite *Stoliczkaia* and *Mortoniceras* in the Upper Albian and of *Mantelliceras* in the Cenomanian. In recent years, a number of workers have described the foraminifera, dinoflagellates and calcareous nannofossils (S.I.). The Second International Symposium on Cretaceous Stage Boundaries held in Brussels (1995), discussed various outstanding problems on the Cretaceous Stage and Substage boundaries. In the Working Group meetings on Albian (Malcolm B. Hart - Chairman), and Cenomanian (Karl-Amin Tröger - Chairman) discussed the Albian - Cenomanian boundary and stratotypes. It was proposed to study a potential Albian - Cenomanian stratotype in the "Marnes Bleues" Fm. (Upper Albian/Lower Cenomanian) at Mont Risou near Rosans (Drome), S.E. France. The reasons for this proposal are : 1. The sequence (Marnes Bleues Fm.) is highly expanded; 2. The base of the Lower Cenomanian is to be defined by the first occurrence of *Mantelliceras mantelli*; 3. The sequence allows a detailed study of ammonites, inoceramid bivalves, nannofossils and planktic foraminifera; 4. δ13C PDB curves are described and compared with curves of sections at Speeton (England) and Gubbio (Italy); 5. The sequence represents a continuous sedimentation without gaps and remarkable vertical facies changes (Tröger, 1995).

Though the Cretaceous of Southern India contains continuous well exposed sections, it has not attracted or gained its place in the international scene. This may be due to lack of multidisciplinary work on the same sample from a particular stratum among the researchers and good number of publications on the Stage boundaries. The purpose of this paper is to review the Albian - Cenomanian boundary, to collate the foraminiferal biostratigraphy with ammonite biostratigraphy, to discuss the implications and potential of Indian sequence to contribute to the understanding of this boundary on a global scale, and to describe some key foraminiferal taxa and their use in biostratigraphy.

Nevertheless, the widespread occurrences of *Stoliczkaia* and *Mortoniceras* in the Upper Albian and of *Mantelliceras* in the Lower Cenomanian classically bracket the boundary, and the selection of criteria within this interval would be appropriate. A recommendation for establishing the stratotype of Albian - Cenomanian boundary at the Mont Risou section was generally agreed by the Cenomanian Working Group headed by Prof. K-A Tröger as its Chairman in the Second International Symposium on Cretaceous Stage Boundaries at Brussels in Sept. 1995. The traditional approach has been to search for a criterion among ammonites, but the vagaries of distribution and preservation of ammonite taxa have frustrated the selection of an ammonite-based boundary that is widely applicable in the interval between the last *Mortoniceras* / *Stoliczkaia* and the first *Mantelliceras* (Murphy and Rodda, 1996). Changes in the planktic microfossils do not occur close enough to the change in the ammonite faunas to preserve the traditional meanings of the Stages (Robaszynski and Amédro, 1986).

The difficulty in finding a suitable stratotype for Albian-Cenomanian boundary is that the beds in the Albian-Cenomanian transition yield more or less provincial or facies restricted faunas that are difficult to correlate. Moreover, peculiarities of preservation in different areas inhibit proper identification (Murphy and Rodda, 1996). The work in Central Tunisia by Robaszynski, Amédro and their colleagues (Robaszynski *et al.* 1993, 1994) holds the greatest promise as a stratotype, as it is complete and characterized by phosphatic preservation of the ammonites that may permit comparison with other areas. Bellier (1985) have used the section near the Pont du Fahs Village in Tunisia, a potential stratotype for the Tethyan region, as a standard reference for correlations based on foraminifera. They supported their correlations with ammonite data from the areas cited in Solignac (1927). The section at Pont du Fahs can be observed in a single traverse, but the reported fossiliferous localities from the numbered stratigraphic units are up to 0.5 km. from one another (Solignac, 1927). Salaj (1980) and Wonders (1980) described the foraminiferal biostratigraphy of this area but without mentioning ammonites. Robaszynski *et al.* (1993) provided integrated biostratigraphic and sequence stratigraphic interpretations for a section in the Kalaat Senan region in Central Tunisia. They have also proposed the section near Kef El Azreg which... "would be an excellent choice for an Albian - Cenomanian boundary stratotype within the Tethyan region". In terms of the described ammonite sequence, the northern Tunisian section still does not qualify as a site for the GSSP. The data have not yet been collected (and the work is in progress by Robaszynski and his colleagues), that show the position of a biological event in the interval between definitely Cenomanian and definitely Albian strata (Robaszynski, Pers. comm.)

According to Murphy and Rodda (1996), the boundary sequence in California is best exposed along Dry Creek in northern Tehama County, where an angular relationship within the Buddeen Canyon Formation, resulting from channel cutting on deep-sea fans, separates Upper Albian ammonite bearing rocks from the the ammonite rocks of Lower Cenomanian. The Dry Creek section across the Albian - Cenomanian boundary contains ammonites on both side; however the microfossils were absent on the Lower Cenomanian part.

Southern India

The two studies deal with the foraminiferal biostatigraphy of the Uttattur Group in the Albian - Cenomanian boundary interval (Narayanan, 1977 and Venkatachalapathy and Ragothaman, 1995) with generally similar results. Their studies indicate that the *Rotalipora* and *Praeglobotruncana* appear in the upper part of the Late Albian, and *Planomalina buxtorfi* is also present in this interval. *Hedbergella planispira* and *H.delrioensis* are considered true representatives of their biostratigraphic ranges in the Cauvery Basin, because these taxa are reported as abundant at most sample sites throughout their observed taxon range zones in the Uttattur Group (fig.2).

There is some unanimity among those who worked on ammonites in the Uttattur Group. Sastry *et al.*, (1968) proposed three biostratigraphic zones. They are i, *Schloenbachia inflata* Zone - (Upper Albian); ii, *Calycoceras newboldi* Zone - (Cenomanian); iii, *Mammites conciliatum* Zone - (Lower Turonian). Chiplonkar and Phansalkar (1976) proposed five zones as follows : i, *Mortoniceras (M.) inflatum* / belemnite Range Zone - (Lower to Upper Albian); ii, *Mantelliceras tuberculatum* Assemblage Zone - (Lower Cenomanian); iii, *Acanthoceras rhotomagense* Assemblage Zone (Middle Cenomanian); iv, *Calycoceras choffati* Acme Zone (Upper Cenomanian); v, *Mammites conciliatum* Assemblage Zone (Lower Turonian). Ayyasami and Banerji (1984) proposed five zones for the Uttattur sediments of Upper Albian to Lower Turonian age. They are : i, *Mortoniceras inflatum* Zone - (Upper Albian); ii, *Mantelliceras vicinale* Zone - (Lower Cenomanian); iii, *Calycoceras newboldi* Zone - (Middle Cenomanian); iv, *Eucalycoceras pentagonum* zone - (Upper Cenomanian); v, *Mammites conciliatum* Zone - (Lower Turonian).

Sastry *et al.* (1968) divide Albian - Cenomanian using *Schloenbachia inflata* Zone and Calycoceras newboldi Zone. Chiplonkar and Phansalkar (1976) have taken into consideration, *Mortoniceras (M.) inflatum*/ belemnite Range Zone - Lower to Upper Albian and *Mantelliceras tuberculatum* Assemblage Zone to mark the Lower Cenomanian. *M.tuberculatum* Assemblage consists of *M. inflatum* Subzone on the lower side and *Calycoceras newboldi* on the upper side. However, Ayyasami and Banerji (1984) used the *Mortoniceras inflatum and Mantelliceras vicinale* to divide the Albian - Cenomanian boundary. Robaszynski (pers. comm.) opined that the *Schloenbachia* is nearly a *Mortoniceras*.

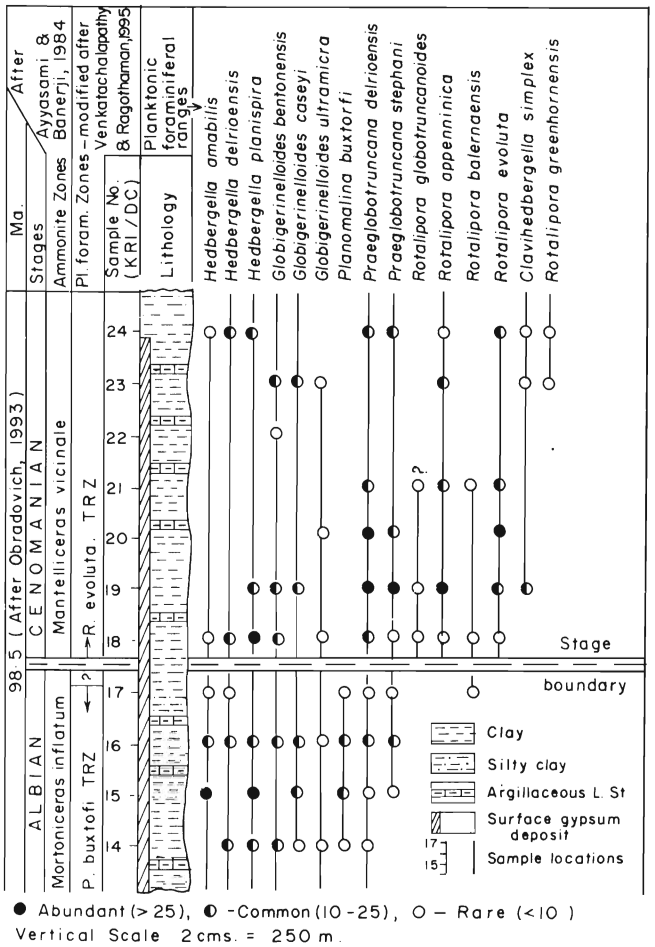

Fig. 2. Ranges of planktic foraminifera across Albian-Cenomanian boundary.

All the three publications on ammonites, referred as above, kept *Mammites conciliatum* Zone for Lower Turonian. Sastry *et al.* (1968) and Ayyasami and Banerji (1984) used *Calycoceras newboldi* Zone for Lower Cenomanian and Middle Cenomanian respectively. But they are using different zones in determining other Stage and Substage boundaries in the Uttattur Group. The ammonite study of Ayyasami and Banerji (1984) looks reasonable in terms of some uniformity in maintaining the internationally well-known ammonite genus.

DISCUSSION

Even if the Cenomanian Working Group has chosen the planktic foraminifera to put the Albian - Cenomanian boundary, "the traditional ammonite studies" give generally very good information for the

Albian - Cenomanian boundary in the field. In general, the changes in the planktic foraminifera do not occur close enough as is observed in the ammonite fauna.

Foraminifera in the Uttattur Group

Though the earliest work on fossil studies was started by Blanford (1862), the biostratigraphical works began in the early 1970's with the impetus from the studies in search for hydrocarbons in the Cretaceous - Tertiary rocks of the Cauvery Basin. Among the published foraminiferal biostratigraphical works from this area, mention is to be made about Narayanan (1977) and Venkatachalapathy and Ragothaman (1995). Narayanan (1972, 1977) attempted, for the first time, a detailed foraminiferal biozonation for the Uttattur Group based on the occurrence of planktic foraminifera. The detailed study on the mid-Cretaceous sediments of the Cauvery Basin by Venkatachalapathy (1993) and Venkatachalapathy and Ragothaman (1995) allowed them to establish 9 internationally recognized biozones. They have also made an attempt to determine the Substage and Stage boundaries based on the occurrence of key taxa and correlated them with equivalents in other regions of the world.

Albian - Cenomanian boundary

In the Uttattur Group, the Upper Albian *Planomalina buxtorfi* Total Range Zone is overlain by the Lower Cenomanian *Rotalipora evoluta* Total Range Zone (fig.2) - Venkatachalapathy and Ragothaman (1995). The assemblage of *Planomalina buxtorfi* (Gandolfi) includes the concurrent occurrence of this zonal marker and *Hedbergella planispira* (Tappan), *H. delrioensis* (Plummer) and *Rotalipora balernaensis* (Gandolfi).

The Lower Cenomanian *Rotalipora evoluta* Total Range Zone consists of *Globigerinelloides bentonensis* (Morrow), *G. caseyi* (Bolli, Loeblich and Tappan), *Hedbergella amabilis* Loeblich & Tappan, *H. planispira* Tappan, *H. delrioensis* (Carsey), *Rotalipora appenninica* (Renz), *R. balernaensis* (Gandolfi), *R. evoluta* Sigal, *R. greenhornensis* (Morrow), *Praeglobotruncana delrioensis* (Plummer) and *P. stephani* (Gandolfi). The occurrence of *R.brotzeni* (Sigal) has been noticed by Govindan *et al.*, (1996) in the subsurface of the Cauvery Basin (i.e., Karai-4), Southern India. According to Raju and Mishra (1996, p.5), the *Rotalipora brotzeni* Zone is yet to be established in the Indian basins.

In the study area, the foraminifers are common, well preserved, and occur with a variety. The sections exposed near Karai, Terani, Uttattur villages are of particular significance because of their excellent, easily accessible exposures with good preservation of ammonites and foraminifera (Sastry *et al.*, 1968; Chiplonkar and Phansalkar, 1976; Narayanan, 1977; Ayyasami and Banerji, 1984; Venkatachalapathy and Ragothaman, 1995). The lithology is more or less uniform throughout the Uttattur Group.

In the Uttattur Group, the characteristic extinction event of the *Planomalina buxtorfi* (Gandolfi) happens approximatelya a few metres below the Albian - Cenomanian boundary. The appearance of *Rotalipora evoluta* Sigal is considered as indicative of the begining of the Cenomanian as reported by Pessagno (1967), Pflaumann and Cepak (1982), and Venkatachalapathy and Ragothaman (1995). Raju and Mishra (1996, p.5) stated that "the Albian - Cenomanian boundary can be marked in the Cauvery, K.G. and Rajasthan basins at the top of *P. buxtorfi* Zone. However, the author is using the recommandations of the Brussels Symposium (1995) in defining Stage boundaries; and in the present work, the Albian - Cenomanian boundary is marked at the base of the *Rotalipora evoluta* Total Range Zone.

Correlation

Narayanan (1977) recognized the *Planomalina buxtorfi Zone* in the Uttattur Group for the interval from the first appearance of *P. buxtorfi* to the first appearance of *Rotalipora evoluta*. The interval between the top of the *Hedbergella planispira* Partial Range Zone and the base of the *Rotalipora evoluta* Total Range Zone is represented by the *Planomalina buxtorfi* Total Range Zone (Venkatachalapathy and Ragothaman, 1995). The *Planomalina buxtorfi* Zone has been recognized in many localities of the world. Most workers including van Hinte (1976), Caron (1978), Wonders (1980) and Leckie (1984), placed it within the Albian, ranging from early Late Albian to latest Albian in age. However, Postuma (1971) extended its range into early Cenomanian (fig.3).

Planktonic foraminiferal zones across Albian – Cenomanian boundary

Stages	Venkatachalapathy & Ragothaman 1995	Sliter 1989	Caron 1985	Leckie 1984	Pflaumann & Cepek 1982	Wonders 1980	Narayanan 1977
Cenomanian	*Rotalipora evoluta*	*R brotzeni*	*brotzeni = globotruncanoides*	*gandolfi*	*evoluta*	*appenninica*	*evoluta*
Albian	*Planomalina buxtorfi*	*R appenninica*	*appenninica*	*praebuxtorfi – buxtorfi*	*appenninica*	*appenninica + buxtorfi*	*buxtorfi*

Ammonite zones across Albian – Cenomanian boundary

Stages	Murphy & Rodda 1996	Robaszynski et al 1993, 1994	Hancock et al 1993	Birkelund et al 1990	Ayyasami & Banerji, 1984	Chiplonkar & Phansalkar, 1976
Cenomanian	*Mantelliceras (G.) wooldridgei*	*Mantelliceras cf mantelli*	*Mantelliceras mantelli*	*Mantelliceras mantelli*	*Mantelliceras vicinale*	*Mantelliceras tuberculatum*
Albian	*Mortoniceras (D.) perinflatum*	*Stoliczkaia dispar*	*Stoliczkaia dispar*	*Stoliczkaia dispar*	*Mortoniceras inflatum*	*Mortoniceras (M.) inflatum/ Pervinquieria*

Fig. 3. Global correlation of foraminiferal and Ammonite Zones across Albian-Cenomanian boundary.

According to Murphy and Rodda (1996), *Rotalipora evoluta* and *R. brotzeni* were considered distinct species by Salaj and Samuel (1966), Bellier (1978) and Caron (1985). On the other hand, Loeblich and Tappan (1961), Pessagno (1967), Postuma (1971) and Wonders (1978) synonimized *R. brotzeni* with *R.greenhornensis* and either

treated *R.evoluta* as a distinct species or synonymized it with *R. appenninica* (Masters, 1977). Robaszynski *et al.* (1993) treated *R. evoluta* and *R. appenninica* as valid species and recognized four separate morphotypes of R. *appenninica*. Three of them range from the Upper Albian through part or all of the Lower Cenomanian. Robaszynski *et al.* (1993, fig. 6) gave the range of *R.greenhornensis* in terms of two morphs, which are Lower Cenomanian and Lower Cenomanian - Middle Cenomanian. They also changed the identification of Robaszynski *et al.* (1979) of *R.brotzeni* to *R. globotruncanoides* (Robaszynski *et al.*, 1993, p. 401).

Narayanan (1977), proposed the *Planomalina buxtorfi* Zone to indicate strata of Upper Albian age. The published works of Robaszynski (1984), Caron (1985) and Sliter (1989) indicates that *P. buxtorfi* is restricted to the Upper Albian period.

The upper part of *Schloenbachia inflata* Zone recognized by Sastry *et al.* (1968) and the upper part of the *Mortoniceras (M.) inflatum/Belemnite* Range Zone and *Mortoniceras inflatum* Zone of Ayyasami and Banerji (1984) are indicative of Upper Albian age. It is correlatable with the *P. buxtorfi* Zone recognized by Narayanan (1977) and Venkatachalapathy and Ragothaman (1995) in the Uttattur Group. The ranges of *P. buxtorfi* in the present study and in the American Gulf Coast (Pessagno, 1967), Western Mediterranean area (Wonders, 1980), Anglo-Paris Basin (Robaszynski, 1984), Global Correlation (Caron, 1985), and in Circum Pacific Terrain by (Sliter, 1989) are similar and restricted to the Albian period.

The position of the Albian - Cenomanian boundary in the Uttattur Group has been placed at the base of the *Rotalipora evoluta* Total Range Zone. The first appearance of *Rotalipora evoluta* Sigal is considered as indicative of the Cenomanian Stage in the Uttattur Group. The *Rotalipora evoluta* Zone was originally proposed by Pessagno (1967) for the deposits in American Gulf Coast. Subsequently, it has been recognized by many workers including Longoria and Gamper (1974) from the Sabinas Basin of Northern Mexico; Narayanan (1977); Ramanathan and Rao (1984); Venkatachalapathy and Ragothaman (1995) from the Cauvery Basin of Southern India; Pflaumann and Cepek (1982) from the West African Continental margin.

The early Cenomanian period is represented by the *Rotalipora evoluta* Total Range Zone in the present study (fig. 2). It is correlatable with the *Mantelliceras tuberculatum* Assemblage Zone of Chiplonkar and Phansalkar (1976) and *Mantelliceras vicinale* Zone of Ayyasami and Banerji (1984) (fig. 3). It is equivalent of *R.evoluta* Zone recorded by Pflaumann and Cepek (1982) and to the lower part of the *R. evoluta* Subzone recorded by Pessagno (1967). Others who consider the *Rotalipora brotzeni* Zone [which has been changed to *R. globotruncanoides* Zone by Robaszynski *et al.*, 1993, p. 401] to represent the Early Cenomanian stage, include Caron (1985), Sliter (1989), Robaszynski *et al.* (1993, 1994).

CONCLUSION

The third International Symposium on the Cretaceous System held in Copenhegan in 1983 (Birkelund *et al.*, 1984) and the subsequent NATO Advanced Research Workshop on Cretaceous Resources, Events and Rhythms held in Digne, France in 1988 (Ginsburg and Beaudoin, 1988), discussed various stratotypes for different Cretaceous Stages. It established many Working Groups for different Stages. Each Working Group was headed by a well-known senior scientist. It has generated or collected major amount of data and placed it before the Subcommission on Cretaceous Stratigraphy (SCS) for discussion to get the concrete proposal (Brussels, 1995). After a series of discussions, the Subcommission (SCS) proposed "Marnes Bleues" Formation at Mont Risou near Rosans (Drome), S.E. France as a potential stratotype for the base of the Cenomanian [where *R. globotruncanoides* is the marker species to start the Cenomanian Stage].

As a second choice, the Kalaat\Senan region, Central Tunisia may be considered because of its promising results both in ammonite and foraminfera in defining Albian - Cenomanian boundary (Robaszynski *et al.*, 1993 and 1994, Murphy and Rodda, 1996).

At the same time, the sections near Karai, Terani, Uttattur, Neykulam villages of Uttattur Group consist of continuous sequence of highly fossiliferous strata (containing ammonite, foraminifera, ostracoda, nannofossils and radiolaria) and can be covered in a single traverse from the oldest to the youngest. The difficulty or negative point for Uttattur sequences as stratotype is the lack of multidisciplinary work and publications on Stage boundaries. In terms of ammonite sequence, the South Indian section still does not qualify as a site for GSSP. However, the sections in the Uttattur Group appear to have the potential, if the collation of the ammonite, radiolarian and nannofossil biostratigraphy with the established foraminiferal biostratigraphy shows the position of a biological event in the interval between definitely Cenomanian and definitely Albian strata.

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EXPLANATION TO PLATES

Plate I

(bar = 100μm, unless otherwise indicated)

1-3 *Globigerinelloides bentonensis* (Morrow). 1- Spiral side (bar = 10μm); 2- Umbilical side; 3- Peripheral view. Stratigraphic position : *H. planispira* Zone (Middle Albian) - Sample No. KRI/DC 10.

4-6 *Globigerinelloides caseyi* (Bolli, Loeblich \& Tappan). 4-Spiral side (bar = 10μm); 5- Peripheral view (bar = 10μm); 6-Umbilical side (bar = 10μm). Stratigraphic position : *P. buxtorfi* Zone (Late Albian) - Sample No. KRI/DC 15.

7-8 *Globigerinelloides ultramicra* (Subbotina). 7- Spiral side (bar = 10μm); 8-Umbilical side (bar = 10μm) Stratigraphic position : *P. buxtorfi* Zone (Late Albian) - Sample No. KRI/DC 15.

Plate II

(bar = 100μm, unless otherwise indicated)

1-2 *Planomalina buxtorfi* (Gandolfi). 1- Side view; 2- Peripheral view. Stratigraphic position : *P. buxtorfi* Zone (Late Albian) - Sample No. KRI/DC 15.

3-4 *Hedbergella amabilis* Loeblich and Tappan. 3- Spiral side(bar = 10μm); 4-Umbilical side (bar = 10μm). Stratigraphic position : *P. buxtorfi* Zone (Late Albian) - Sample No. KRI/DC 16.

5-7 *Hedbergella delrioensis* (Carsey). 5- Spiral side; 6- Umbilical side (bar = 10μm); 7- Peripheral view. Stratigraphic position : *P. buxtorfi* Zone (Late Albian) - Sample No. KRI/DC 14.

8-9 *Hedbergella planispira* (Tappan). 8- Spiral side (bar = 10μm); 9- Umbilical side (bar = 10μm). Stratigraphic position : *H. planispira* Zone (Late Albian) - Sample No. KRI/DC 11.

Plate III

(bar = 100μm)

1-3 *Praeglobotruncana delrioensis* (Plummer). 1- Spiral side; 2- Umbilical side; 3- Peripheral view. Stratigraphic position : *R. evoluta* Zone (Early Cenomanian) - Sample No. KRI/DC 19.

4-6 *Praeglobotruncana stephani* (Gandolfi). 4- Spiral side; 5- Umbilical side; 6- Peripheral view. Stratigraphic position : *R. evoluta* Zone (Early Cenomanian) - Sample No. KRI/DC 19.

7-8 *Clavihedbergella simplex* (Moreman). 7- Spiral side; 8- Umbilical side. Stratigraphic position : *R. evoluta* Zone (Early Cenomanian) - Sample No. KRI/DC 19.

9 *Rotalipora balernaensis* (Gandolfi). 9- Spiral side. Stratigraphic position : *P .buxtorfi* Zone (Late Albian) - Sample No. KRI/DC 17.

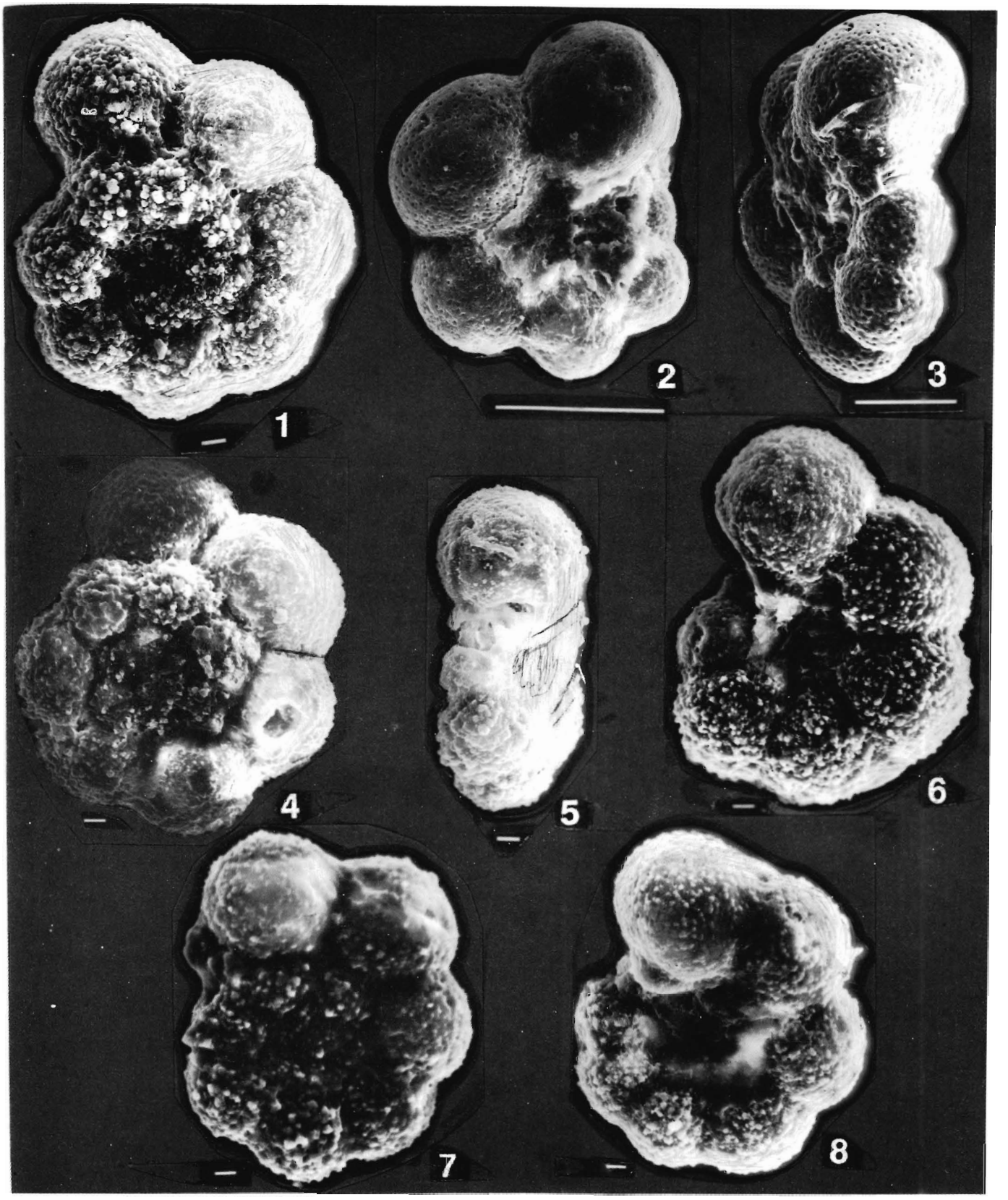
Plate IV

(bar = 100μm)

1-3 *Rotalipora appenninica* (Renz). 1- Spiral side; 2- Umbilical side; 3- Peripheral view. Stratigraphic position : *R. evoluta* Zone (Early Cenomanian) - Sample No. KRI/DC 19.

4-6 *Rotalipora evoluta* Sigal. 4- Spiral side; 5- Umbilical side; 6- Peripheral side. Stratigraphic position : *R. evoluta* Zone (Early Cenomanian) - Sample No. KRI/DC 21.

7-8 *Rotalipora greenhornensis* (Morrow). 7- Spiral side; 8- Umbilical side. Stratigraphic position : *R. greenhornensis* Zone (Early Cenomanian) - Sample No. 24.



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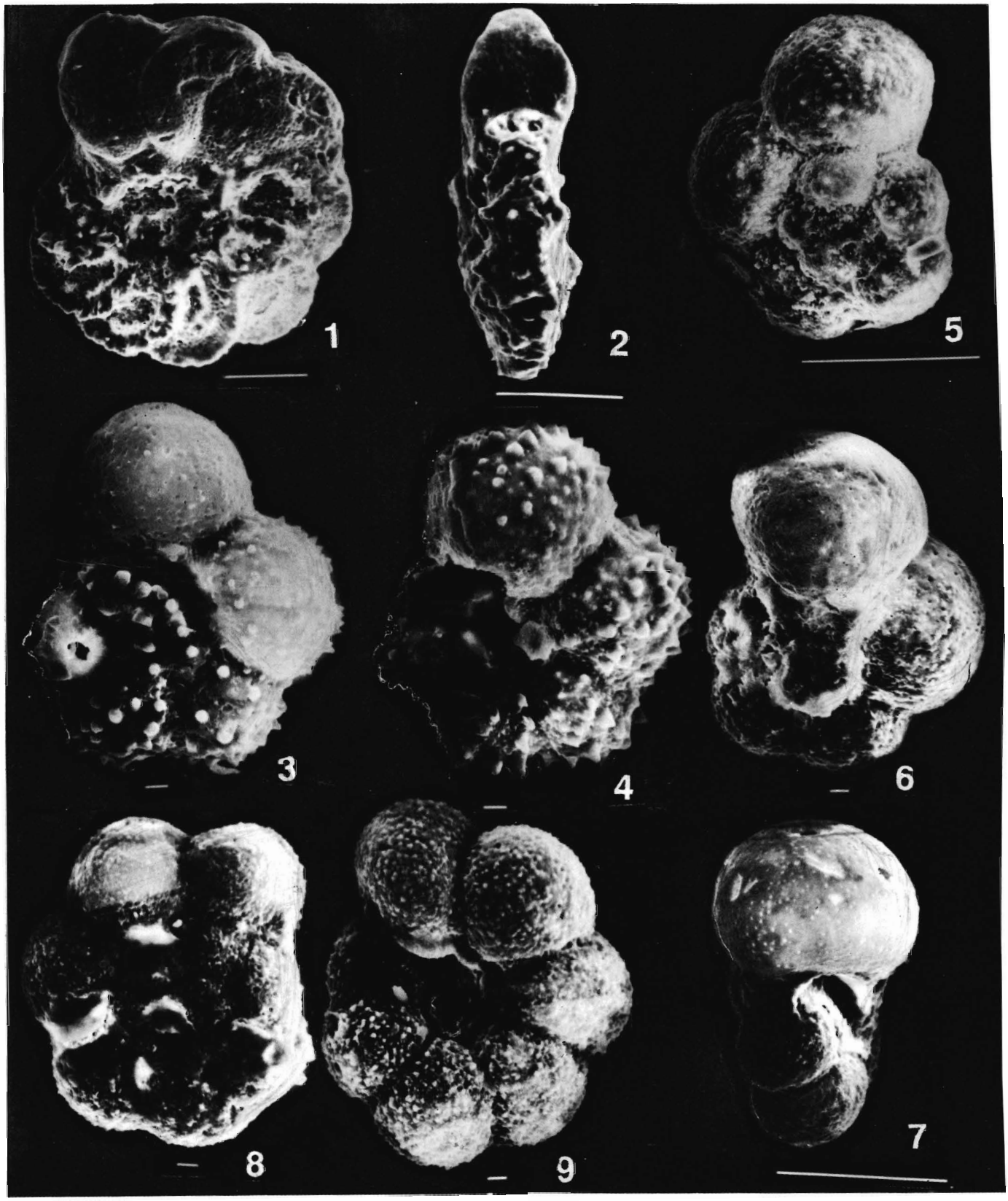

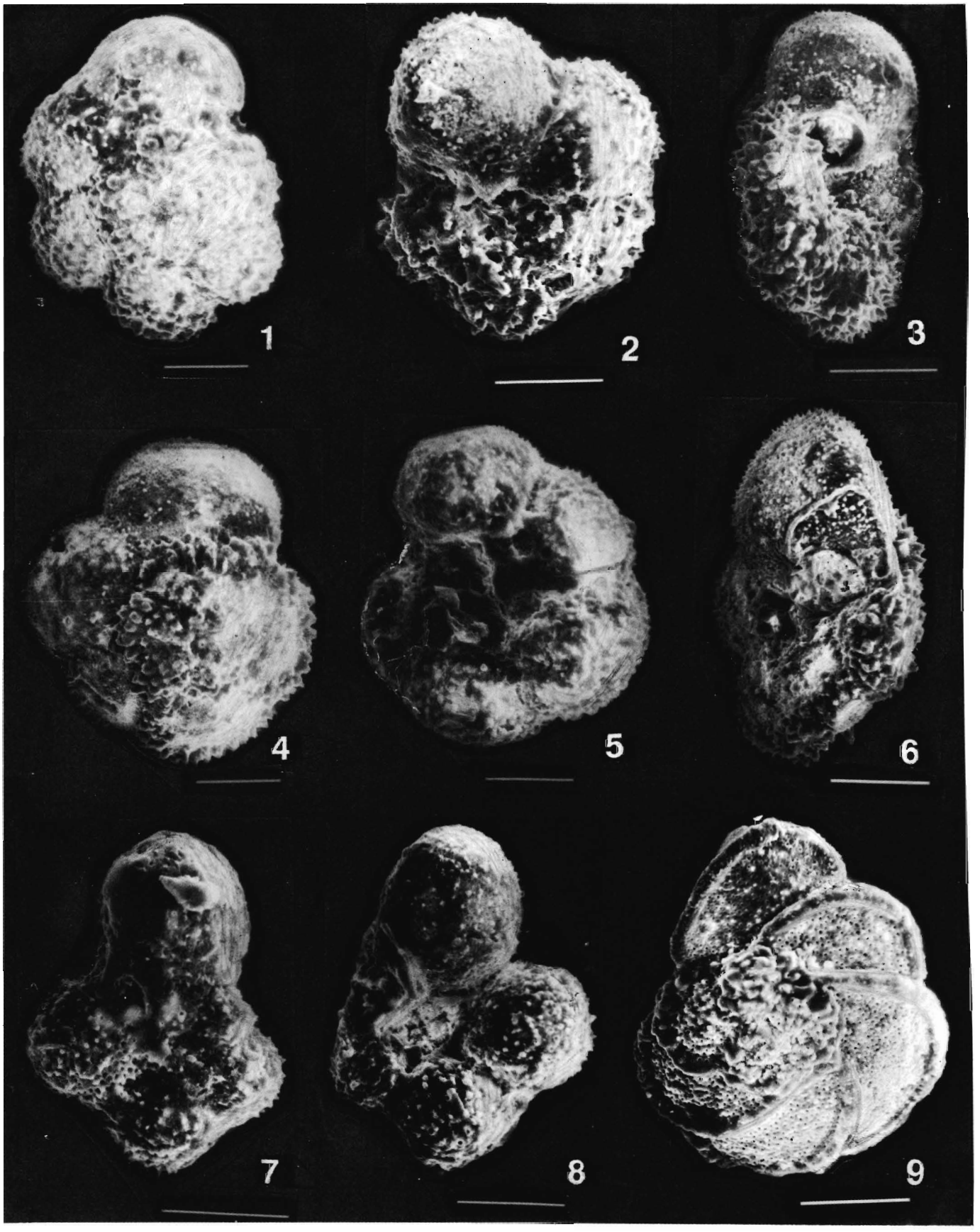
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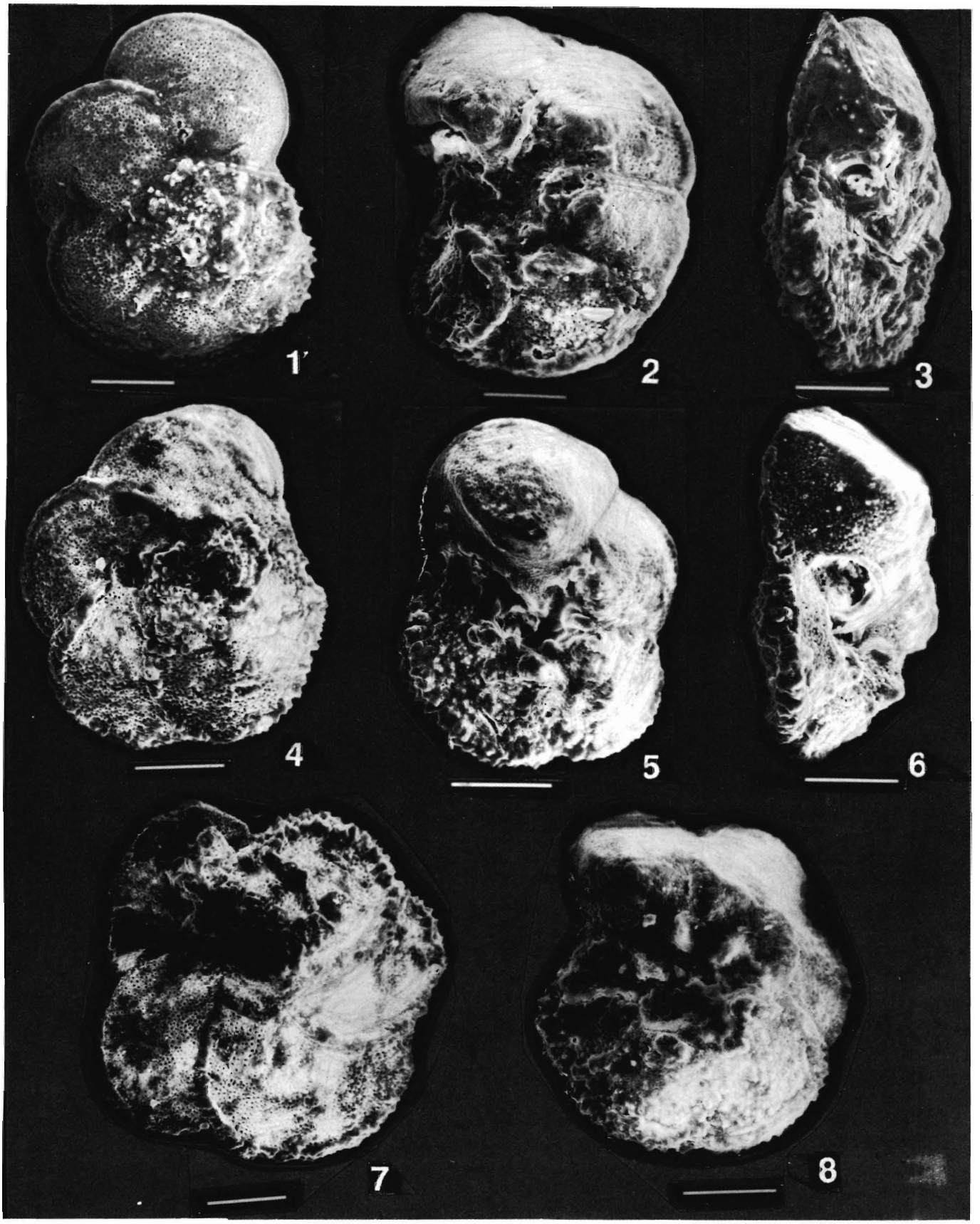
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