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The Gargasian (Middle Aptian) strata from Cassis-La Bédoule (Lower Aptian historical stratotype, SE France): planktonic and benthic foraminiferal assemblages and biostratigraphy

Michel MOULLADE[1]

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Abstract: This paper presents a thorough analysis of foraminiferal assemblages ranging in age from the Bedoulian-Gargasian transition to the middle Gargasian in the Cassis-La Bédoule area (SE France), the historical stratotype of the Lower Aptian substage. This region is particularly suitable for detailed studies of Aptian foraminifera owing to rapid and continuous sediment depositional rates and well-diversified microfaunas. The ranges of benthic forms appear to be fairly stable but some species (*Praedorothia praeoxycona*, *Lenticulina* cf. *nodosa*, *Astacolus crepidularis*, *Globorotalites bartensteini*) become extinct at the end of the Bedoulian and thus can be used to separate this substage from the Gargasian. The stratotypic area also offers an opportunity to follow the evolution of planktonic forms step by step at a crucial period of their history, when modalities of speciation and phylogenetic relationships appear to be particularly complex. The important morphologic variability of Aptian planktonic foraminifera does not help finding stable stratigraphic markers; nevertheless, we are able to propose a biozonation comprising five zones (Cabri, Luterbacheri, Ferreolensis, Barri, Algerianus) for the interval under consideration, usually subdivided into three zones. Our study of foraminiferal assemblages and species took into account the range of variability among populations and not just the characteristics of a single specimen, such as the holotype. As a result this paper provides new taxonomic precisions on certain planktonic species hitherto controversial or possibly of doubtful validity.

Key Words: Early Cretaceous; Aptian; historical stratotype; Foraminifera; biostratigraphy; taxonomy; evolution

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Résumé : *Le Gargasien (Aptien moyen) de Cassis-La Bédoule (stratotype historique de l'Aptien inférieur, SE France) : associations et biostratigraphie des Foraminifères benthiques et planctoniques*.- L'analyse approfondie des associations de Foraminifères depuis les termes du passage Bédoulien-Gargasien jusqu'au Gargasien moyen a été réalisée dans le secteur de Cassis-La Bédoule (SE France), stratotype historique du Bédoulien (Aptien inférieur), particulièrement favorable à ce niveau en raison de la continuité et de la dilatation de la série ainsi que de la diversification de la microfaune. L'éventail des formes benthiques se révèle assez stable mais quelques espèces (*Praedorothia praeoxycona*, *Lenticulina* cf. *nodosa*, *Astacolus crepidularis*, *Globorotalites bartensteini*) s'éteignent à la fin du Bédoulien et peuvent être utilisées pour différencier ce sous-étage par rapport au Gargasien. L'aire stratotypique offre aussi la possibilité de suivre pas à pas l'évolution des formes planctoniques à un moment crucial de leur histoire, lorsque les processus de spéciation et les liens phylogénétiques s'avèrent particulièrement complexes. La grande variabilité morphologique des formes planctoniques durant l'Aptien ne facilite pas le choix de marqueurs stratigraphiques stables; il est cependant possible de proposer une biozonation comportant cinq zones (à Cabri, Luterbacheri, Ferreolensis, Barri, Algerianus) pour l'intervalle considéré, habituellement subdivisé en trois zones. L'étude populationnelle, et non pas seulement typologique, des associations nous a enfin permis d'apporter quelques précisions taxinomiques nouvelles, en particulier sur certaines formes planctoniques d'acception controversée ou même de validité douteuse.

Mots-Clefs : Crétacé inférieur ; Aptien ; stratotype historique ; Foraminifères ; biostratigraphie ; taxinomie ; évolution

Introduction

The geographical location and the stratigraphic relationships of the three sections (La Bédoule-Les Tocchis; Cassis-carrière Comte; Cassis-carrière de La Marcouline) included in this micropaleontological study have already been presented in the two introductory chapters (MOULLADE & TRONCHETTI, 2004; MOULLADE *et alii*, 2004) of the Memoir in *Carnets de Géologie* devoted to the type-Gargasian. In these two papers the reader will also find information on the lithology and relative positions of samples in the La Marcouline section as well as on the circumstances that justify the re-study of what remains of the Aptian type-sections, employing a pluridisciplinary approach that uses the

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methods of integrated stratigraphy.

The main purpose of this note is to perfect our knowledge of the distribution of benthic and planktonic foraminifera during the Bedoulian-Gargasian transition, based on a detailed analysis of selected sections in the stratotypic area of Cassis-La Bédoule. In comparison with the Vocontian domain and Italy this region is regarded as particularly favorable for a study of these levels, because it:

- has high sedimentation rates and lacks hiatuses, both of which permit increased precision in any investigation regarding the evolution of taxa,
- is rich in macrofossils (particularly in ammonites, cf. CONTE, 1994; ROPOLO *et alii*, 1998), making biostratigraphic correlations easier.

Previous works concerning Aptian Foraminifera from the western part of Basse-Provence, and in particular from that of the Bedoulian stratotypic area, are few and most are already somewhat out-of-date. In 1961, CHEVALIER described several new species of which the type-material, for some at least, came from this area. FABRE-TAXY *et alii* (1965) provided the first extensive analysis of the distribution of the Bedoulian stratotype microfauna (foraminifers, ostracods), and correlated it with the distribution of ammonites. In a comparative study of Aptian planktonic foraminifera from Mexico and SE France, LONGORIA (1974) included three samples taken from the upper Bedoulian of the Cassis section. In her thesis devoted to the upper Aptian stratigraphy and sedimentology of Provence, GIROUD D'ARGOUD (1975) included, for the purpose of biostratigraphic correlation, data on the micropaleontological content of samples taken from some sections in the Cassis area studied herein. In his memoir on the Cretaceous foraminifera of Provence, TRONCHETTI (1981) referred frequently to individuals of species collected from the Cassis-La Bédoule stratotype giving precisions on their paleontological acceptance and their stratigraphic distribution. FRIÈS (1987) visited the Bedoulian stratotype using its well-defined terms to locate more precisely the Bedoulian-Gargasian boundary in the Subalpine Basin. Then using the ranges of ammonites and foraminifera the author proposed broader correlations between Basse-Provence and the Vocontian (Subalpine) basin.

The most recent study (MOULLADE *et alii*, 1998) on Aptian foraminifera from this region deals mainly with Bedoulian forms. Here, we shall use this work as a starting point for our paleontological and biostratigraphic study of Gargasian levels. In addition we shall use the data provided by the latest compilations on foraminifera (mostly planktonic) of the Tethyan Aptian (MOULLADE *et alii*, 2002; VERGA & PREMOLI SILVA, 2002, 2003a, 2003b).

Material and methods

The samples upon which the present study is based come from several localities. Because of the progressive degradation of the outcrops in recent years, in 1997-2002 we could sample only the uppermost Bedoulian beds of the Comte Quarry section and the lower (but not lowermost) and middle Gargasian beds of the La Marcouline Quarry section; the latter, as is the case everywhere in the area, lacks the higher terms of the Gargasian owing to pre-Cenomanian erosion. Both quarries are very near each other and located within the limits of the town of Cassis.

In addition, we had access to washed residues from and fractional samples of material collected from 1962 to 1966 by one of us (MM) in the Les Tocchis section, located in the village of La Bédoule (today Roquefort-La Bédoule), 2 km ENE of the La Marcouline section. This section has now disappeared because of urbanization but as late as the latter sixties exposed in a quasi-continuous way the uppermost Bedoulian to lowermost Gargasian transitional beds, thereby spanning the gap in the continuity of observation of the sequence between the two almost contiguous quarries at Cassis. Unfortunately, nowadays this dominantly marly transitional level cannot be seen anywhere in Basse-Provence.

The Bedoulian and Gargasian marly limestones of Provence are relatively indurated and must be washed with chemicals added. These products not only eliminate the major part of the biogenic components, thus concentrating the microfauna, but also clean the microfossils better than water alone, for without the chemicals the specimens often remain more or less encrusted by an argillocalcareous matrix that makes their identification difficult.

The samples collected in the sixties were prepared for examination using the AVERBURG (1962), method. This involves a soaking in sodium thiosulphate followed by the addition of hydrogen peroxide. The washed residue is then processed in Bradosol (cationic moistening; see details *in* CARBONNEL *et alii*, 1965; MOULLADE, 1966). Unfortunately, these samples were sieved through an 80 µm mesh screen, thought to be sufficient at that time. Our current knowledge about the size of the smallest planktonic foraminifera requires that sediments be sieved through a finer mesh of at least 63 µm, or even of 45 µm.

After having been crushed and oven-dried, the samples collected at the turn of the century were soaked for a minimum of several days in Rewoquat W 3690 (cationic tenside), then sieved at 45 µm using warm water and rinsed with hydrogen peroxide. This procedure is time consuming but gives excellent results, for both concentrating and cleaning microfaunas.

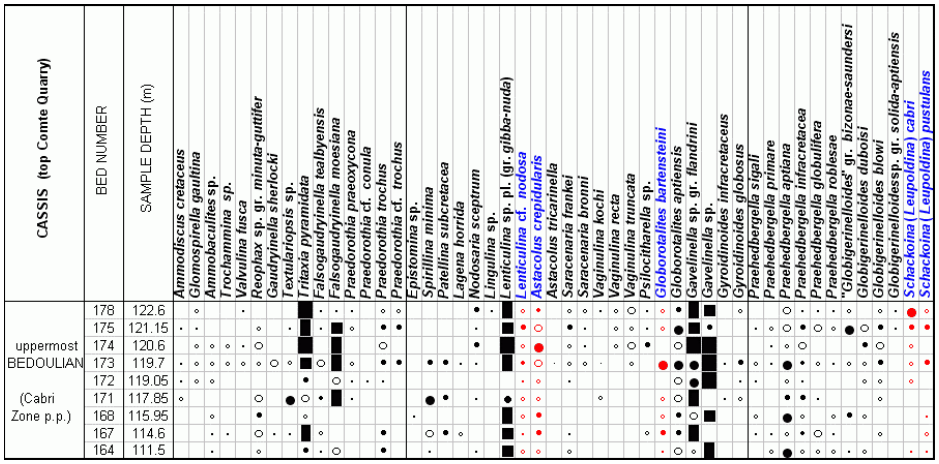

Figure 1: Distribution of Foraminifera in the upper part of the Comte Quarry section (Cassis, SE France).

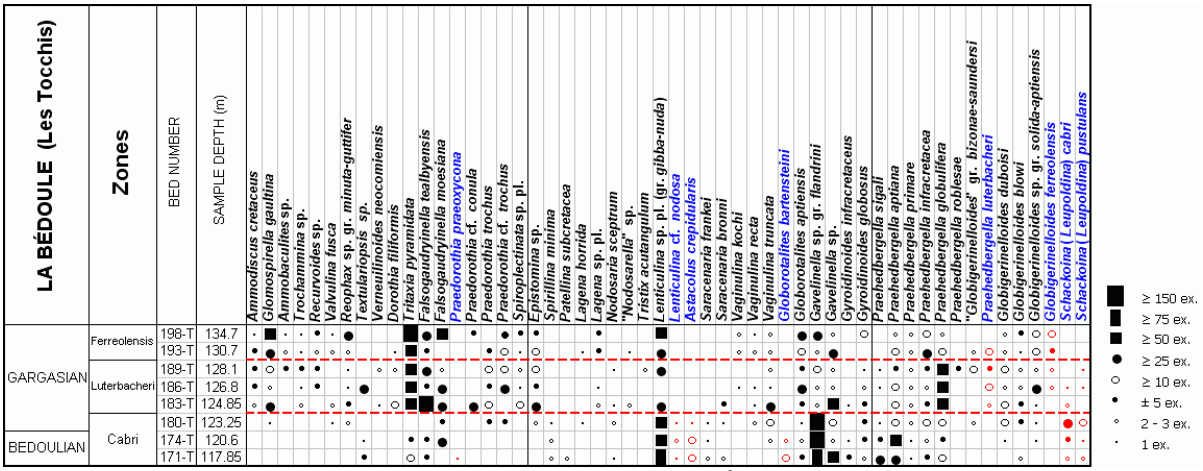

Figure 2: Distribution of Foraminifera in the Les Tocchis section (La Bédoule, SE France).

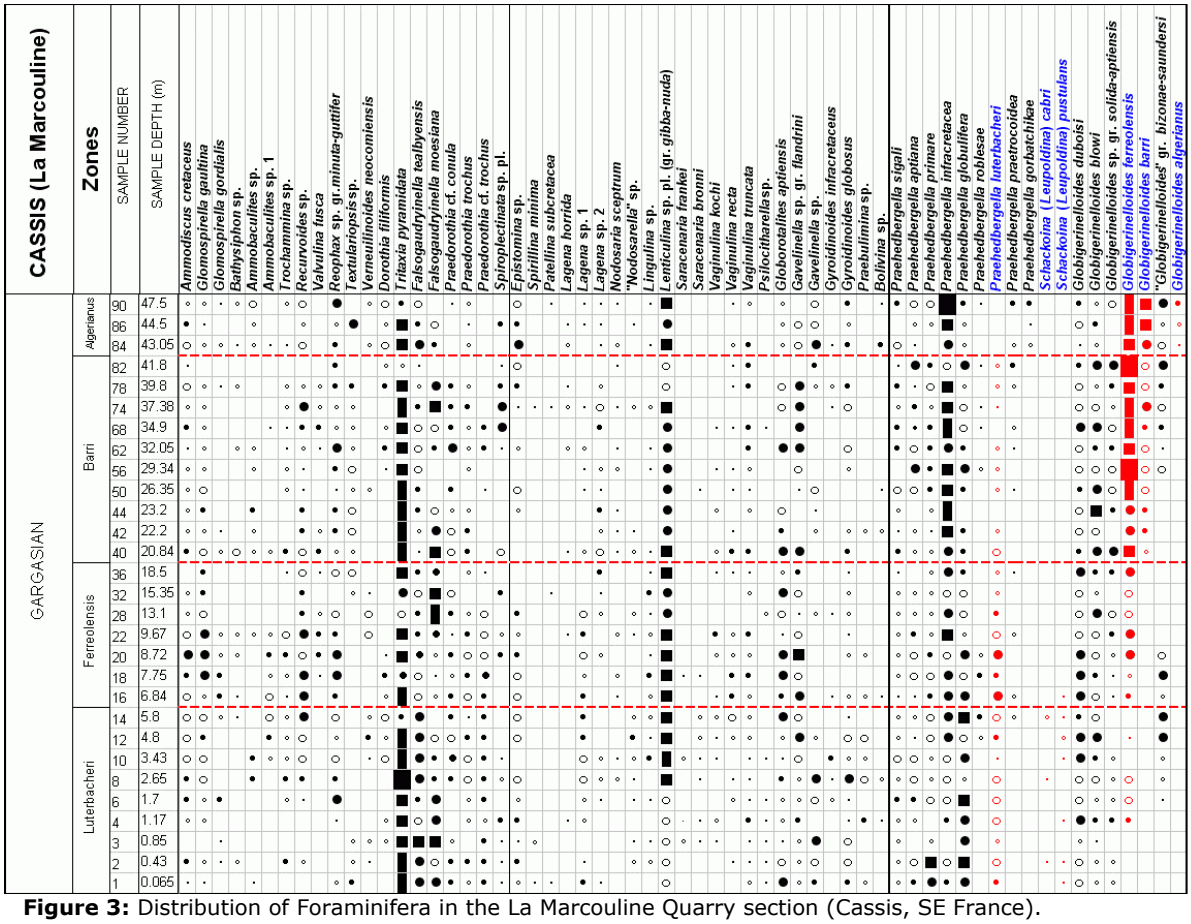

Figure 3: Distribution of Foraminifera in the La Marcouline Quarry section (Cassis, SE France).

The state of preservation of the microfossils varies with its location in the sequence: from moderately well to rather good (*e.g.* the more marly middle Gargasian levels) to mediocre or even poor in the more indurated uppermost levels of the Bedoulian. These levels are not necessarily more calcareous but are certainly more siliceous, as shown by the increased occurrence of sponge spicules, radiolarians and diatoms in the corresponding washed residues. We also noted the rather constant presence in the residues of a significant fraction of more or less distorted tests, particularly among the thin walled planktonic foraminifera (*e.g.* small few-chambered *Globigerinelloides* [ex-*Blowiella*], small *Praehedbergella*) but also some agglutinated benthics among them representatives of the Trochamminidae, *Reophax* and *Recurvoides*. These deformations are probably the result of rather strong compaction.

The foraminiferal content of all the samples (9 from the uppermost levels of the Comte Quarry section, 8 from the Les Tocchis section and 24 from the La Marcouline Quarry section) was examined quantitatively; that is, the number of specimens of each species of foraminifera was counted. This led to the establishment of frequency classes as follows:

Category	RR	R	R-F	F	F-C	C	AB	V.AB
Specimens numb.	1	2-3	±5	≥10	≥20	≥50	≥75	≥150

Abundances are indicated by symbols for each species and each sample in the distribution tables of Figs. 1-3.

The material (remaining fractional sample, washed residues, slides) upon which this study is based are in the collections of the Paleontology Museum of the University of Provence in Marseilles.

Results

Dominant forms

Upper Bedoulian: *Tritaxia pyramidata*, Falsogaudryinellas, "smooth" (*i.e.* not ornamented: *L.* gr. *gibba-nuda*) Lenticulinas, Gavelinellas.

Gargasian: *Tritaxia pyramidata* remains (more or less consistently) a dominant species, Falsogaudryinellas and Lenticulinas are slightly less numerous and Gavelinellas much less common than in the Bedoulian; on the other hand planktonic forms are more abundant.

Species diversity

The number of species increases upwards in the series. Taken as a whole the type-Bedoulian includes 31 benthic species (14 agglutinated and 17 calcareous) and 11 planktonic species, *i.e.* a total of 42 species of foraminifera. The (lower-middle) Gargasian from the same area provided 45 benthic species (20 agglutinated and 25 calcareous), plus 21 planktonic species, *i.e.* 66 species; these data are summarized in the table below:

Species number	Agglut.	Calc.	Plankt.	Total
GARGASIAN	20	25	21	66
BEDOULIAN	14	17	11	42

The longevity of the great majority of species, both benthics and curiously enough, planktonics, is rather lengthy. Numerous species have ranges that include a major part of the Aptian stage. The increasing diversity in the foraminiferal fauna of the upper Aptian was caused by both a rather low rate of extinction and by a progressive enrichment in new species.

Biostratigraphic markers

Our data show that in the Aptian strata of Cassis-La Bédoule the number of potential markers of both benthic and planktonic forms is rather low (Fig. 4).

Benthic Foraminifera

In this category are a few species that are commonly encountered in the Tethys well before Aptian times, but become extinct at the end of the Bedoulian or range only slightly past the Bedoulian-Gargasian boundary:

- *Praedorothia praeoxycona*
- *Lenticulina* cf. *nodosa*
- *Astacolus crepidularis*
- *Globorotalites bartensteini*

Benthic forms that first appear during the Gargasian appear to have little stratigraphical significance. They are representatives of agglutinated genera like *Bathysiphon*, *Ammobaculites*, *Trochammina*, *Recurvoides*, and the agglutinated species *Praedorothia* cf. *conula*. Their presence at this level may well be related to a change in environment from that of underlying strata.

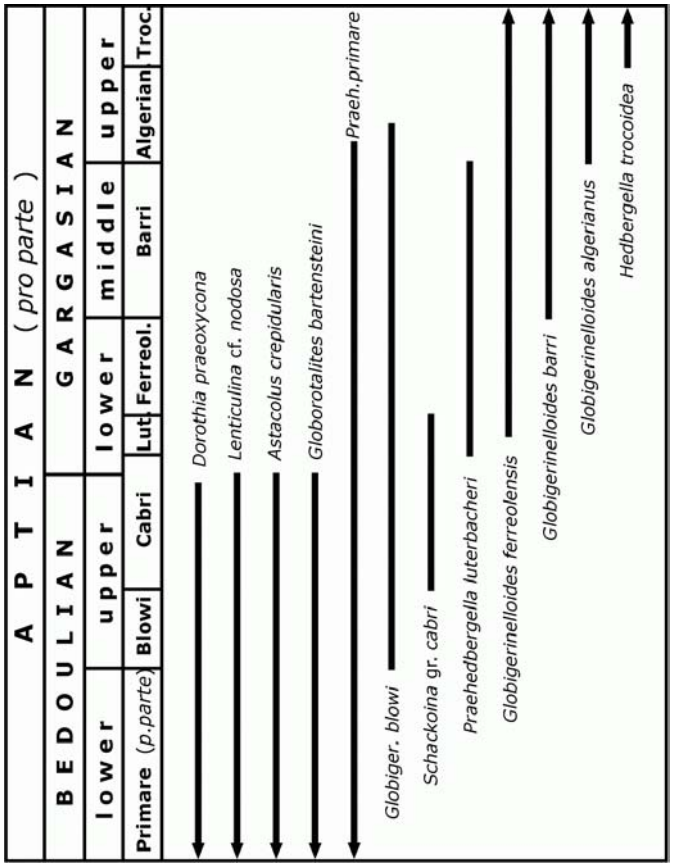

Figure 4: Stratigraphic range of the principal Aptian markers (benthic and planktonic Foraminifera).

Planktonic Foraminifera

No planktonic species present in the Bedoulian became extinct during that substage. *Schackoina* gr. *cabri* (= *S. cabri s.s.* + *S. pustulans*), which first appeared in the late Bedoulian, is the only species with a very short range, for it disappeared in the earliest Gargasian. A short distance above the Bedoulian-Gargasian boundary two new forms appear almost simultaneously: first *Praehedbergella luterbacheri*, then *Globigerinelloides ferreolensis*. Both taxa are sporadically represented in the lowermost portion of their range where they coexist with the last Schackoinas, which are also irregular in occurrence in this level of overlap. From the lower limit of its acme upward *G. ferreolensis* becomes an important component of the middle / upper Gargasian planktonic microfauna

Two other planktonic species, *G. barri* and *G. algerianus*, mark the remainder of the Gargasian section at La Marcouline where they appear successively, their first occurrences being separated by about 20 meters in a 50 meter section. These species are very useful markers for both have a broad geographic distribution and their first occurrences have been found to be consistently reliable in the Tethyan realm. Some other planktonic species also appear in these levels: *Praehedbergella praetrocoidea* and then *Praehedbergella gorbatchikae*, but they are more sporadic and therefore of lesser value as markers.

Interpretation

Correlation

The detailed inventory of the micropaleontological content of the three sections mentioned above led first to a refinement in their correlation, which was initially based on geometrical considerations (Fig. 5).

The very short distance (2 km) between the two areas (Les Tocchis and Comte-La Marcouline) allows us to eliminate the possibility of any diachronism between the first occurrences of planktonic forms, such as that recently observed (DESMARES *et alii*, 2004) in the Cenomanian-Turonian of the Western Interior where the separation was much greater (600 km). For example the homology between the "Triplet" of beds 22-24-26 at La Marcouline (Cassis) and beds 196-T, 197-T, 198-T at Les Tocchis (La Bédoule), suggested by MOULLADE *et alii* (2004), is strongly substantiated. On the basis of the last occurrence of the Schackoinas and the first occurrence of *Globigerinelloides ferreolensis* it is also possible to suggest a correlation between level 14 (Marcouline) and level 193-T (Tocchis) and between level 6 (Marcouline) and 188-T (Tocchis). These correlations show that the units of the La Marcouline sequence are constantly thicker than those of Les Tocchis. As regards the underlying levels, with the exception of the unquestionable geometric homology between bed 170 (Cassis-Comte Quarry) and bed 170-T (La Bédoule-Les Tocchis), a detailed correlation is more ticklish; in particular because of the gap mentioned above in the Cassis section that is not measurable directly and was represented at La Bédoule by a marly sequence between beds 178-T and 186-T. Thus several datums (the last occurrences of *Astacolus crepidularis* and *Lenticulina* cf. *nodosa*, and the first occurrence of *Praehedbergella luterbacheri*), which are well-determined at Les Tocchis cannot be precisely located at Cassis for they are very likely in the zone of no outcrop. However, using the Les Tocchis section as a guide, the order of magnitude of the Cassis gap can be estimated as at least 5 meters, even somewhat more if the greater thickness of the series mentioned above is taken into account. As a result one cannot assume a positive bed to bed homology between the two sections above level 170; this necessitates that the numbering of the beds at Les Tocchis be differentiated by the addition of the suffix "-T".

Proposal for updating Aptian foraminiferal zonation

The more detailed data obtained through our analysis of the stratigraphic distribution of the principal planktonic markers in the Gargasian portion of the Bedoulian stratotypic area allow us to refine to a somewhat greater degree the zonation published in MOULLADE *et alii* (1998)

and, in a more general way that of the lower-middle Gargasian of the Tethyan region (ROBAZYNSKI & CARON, 1995; MOULLADE *et alii*, 2002). We propose a subdivision of the studied interval into five rather than three zones:

ROBAZYNSKI & CARON, 1995 MOULLADE *et alii*, 2002	This work
Algerianus	Algerianus
Ferreolensis	Barri
	Ferreolensis
Cabri	Luterbacheri
	Cabri

In the previously proposed zonation it was difficult to define with precision the boundary between the Cabri and Ferreolensis zones. Our findings which confirm those obtained by LONGORIA (1974) in Mexico and BANNER & DESAI (1988) in England, show that instead of being mutually exclusive, as has often been claimed, over a short interval both index species occur together. Such a concomitance exists over at least 5 meters at La Marcouline, slightly less at Les Tocchis. In this same interval *Schackoina* gr. *cabri* becomes very rare, and the first *Globigerinelloides ferreolensis* are still sparse. In addition, it is not always easy to delimit precisely the first occurrence of *G. ferreolensis*. As BANNER & DESAI (1988) foresaw, our observations show that this species arose from an initially trochospiral form through flattening and progressive symmetrization of the trochospire. Thus, the ancestor of *G. ferreolensis* is represented by *Praehedbergella luterbacheri*; the process of symmetrization, gradual but transient, can be detected only on well-preserved material with well-cleaned ombilici, and involves only a small number of specimens in a population. Often the degree of symmetrization remains undetected for its recognition depends on the conditions of fossilization and the methods of extraction. *Globigerinelloides ferreolensis* becomes typical and thus more readily identifiable and more abundant only at the level where *Schackoina* gr. *cabri* becomes extinct. For this reason we choose to use the beginning of the acme rather than the FAD (First appearance datum) of *Globigerinelloides ferreolensis* as the lower limit of the eponymous zone.

We propose to use the FAD of the ancestor of *G. ferreolensis* to mark the base of a new Luterbacheri zone, which thus includes the interval representing the highest portion of the old Cabri zone i.e the interval of time between the FAD of the species index and the beginning of the acme in the occurrence of *G. ferreolensis*.

In the same way the upper part of the old Ferreolensis zone can be set up as a Barri zone, its lower boundary defined par the FAD of *G. barri*, the phylogenetic successor of *G. ferreolensis*. The concept of a Barri zone, although it was based upon a slightly different definition of the index species, has already been proposed by BOLLI (1959).

The first representatives of the phylogenetic successor of *G. barri*, *i.e. G. algerianus*, appear in the last few meters of the La Marcouline section. Its FAD defines the lower limit of the zone it names, a zone that for many years has been widely used in the Tethyan domain.

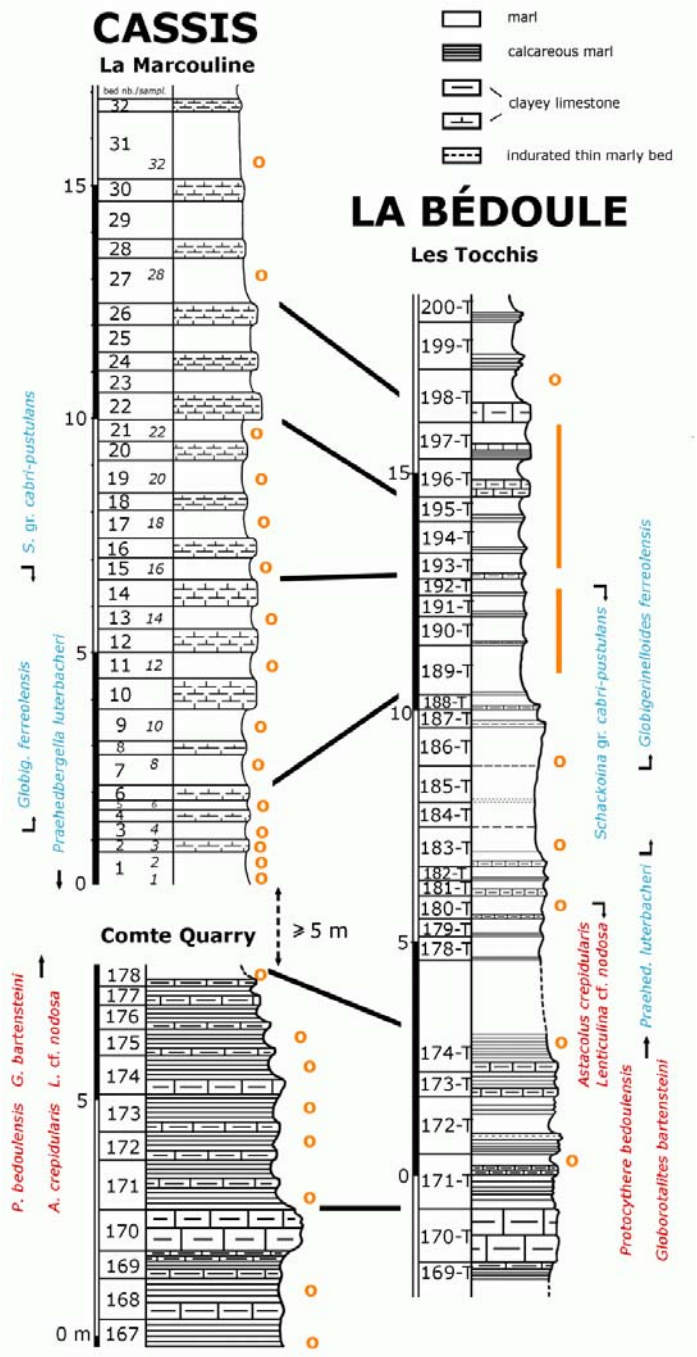

Figure 5: Correlation of the three sections (Comte, Tocchis, Marcouline) that permits a reconstitution of the sequence from uppermost Bedoulian to lowermost Gargasian. The boundary between the two substages is fixed at bed 178 (cf. CONTE, 1994).

The zones proposed above in some detail are summarized in Fig. 4 which also indicates the stratigraphic range of the main markers.

Discussion

Speciation

Taken as a whole the Aptian appears as the first significant period of radiation among planktonic foraminifera (CARON & HOMEWOOD, 1983; MAGNIEZ-JANNIN *et alii*, 1984; MOULLADE *et alii*, 2002). Combined with the published data on the type-Bedoulian (MOULLADE *et alii*, 1998), the results presented here concerning the Gargasian permit an addition to the particulars involved in the modalities of this process. Owing to the great detail obtainable because of the rapid rate of sedimentation in the stratotypic sections, it is possible to see that speciation during the Aptian, which actually had begun during the late Bedoulian, just before the anoxic event AOE1a (cf. MOULLADE *et alii*, 1998) was not a sudden explosion of new forms but a rather gradual increase in the number of species. The Bedoulian-Gargasian transitional beds correspond to a brief period of inactivity in planktonic speciation. This makes it difficult to subdivide them and to delimit the boundary between the two substages by means of planktonic foraminifera. It appears easier to approximate this boundary through the use of benthic foraminifera (Fig. 4) and ostracods (cf. BABINOT & MOULLADE, this volume).

The early / middle Gargasian was a time of moderate revival, in a progressive and regular rhythm, in the speciation of planktonic foraminifera. Their diversity continued to increase but only slowly because most species already in existence were still present at this level.

Therefore the intra-Aptian "radiation" is not a brutal or sudden phenomenon, but a progressive augmentation marked by two momentary episodes of acceleration in speciation (anagenetic phases): 1) the lower/middle portion of the late Bedoulian and 2) Gargasian (lowermost excluded), separated by a brief stasigenetic period straddling the Bedoulian-Gargasian boundary. During the period of time considered in this paper this radiation involves only microperforate (Schackoinas) and finely perforate (*Praehedbergella*, *Globigerinelloides*) planktonic foraminifera; macroperforate species (*e.g. Hedbergella trocoidea*) (cf. BOUDAGHER-FADEL *et alii*, 1998) do not appear until the late Gargasian.

In our current state of knowledge it does not appear possible to relate these biologic processes [a kind of "punctuated gradualism"] to variations in geochemical and sedimentological parameters. Consequently, a direct causal relationship between speciation in planktonic foraminifera and external factors is at best hypothetical.

Evolutionary trends and phylogenetic links (planktonic forms)

In certain portions of the latest Bedoulian/early-middle Gargasian period planktonic foraminifera show an increasing instability in the distinguishing characters of theirs tests. This variability is particularly manifest in some Praehedbergellas, and to a lesser extent in some "small few-chambered *Globigerinelloides*" (in VERGA & PREMOLI SILVA, 2003a), and the group of clavate species. Sequences of evolutive forms showing these fluctuating characters - which are quite apparent at Cassis-La Bédoule - are imperfectly or incompletely recorded everywhere else in the world, and the resulting lack of data has led many authors to phylogenetic and therefore to taxonomic misinterpretations.

The detailed study of a rather close sampling of the expanded composite section of Cassis-La Bédoule allowed us to follow step by step the evolution of planktonic foraminifera in the beds involving the Bedoulian-Gargasian transition. From a morphological point of view each lineage shows an evolution consisting of successive stages of apparent stability alternating with brief anagenetic sequences. In any case these forms cannot be defined taxonomically on the bases of stable criteria for they are subject to a constant, more or less rapid evolutionary slippage, which affects the mode of coiling, the number, shape and rugosity of chambers, *etc*. This variability leads to a relativization of the concept of species (and even more of genus) in a continuum that drifts continuously.

One particularly well-documented example (Fig. 6) in the Cassis-La Bédoule area involves forms that to begin with are distinctly trochospiral, with 6 chambers (in the last whorl) that increase in size moderately; the test shows a very slightly lobate outline. This is the taxon *Praehedbergella primare* (cf. taxonomic notes). This relatively long-ranging species appears in latest Barremian times (MOULLADE, 1966) and remains unchanged morphologically (stasigenetic phase) until the middle of the upper Bedoulian, where some specimens evolve by acquiring progressively a more distinctly lobate outline. These variants were considered as discrete entities taxonomically (in LONGORIA, 1974, under the name *Hedbergella similis*, a junior synonym of *Praehedbergella globulifera* (KRETCHMAR et GORBATCHIK), *in* GORBATCHIK, 1971). Both taxa (*P. primare* and *P. globulifera*), whose delimitation is not always clear during the interval in which speciation took place, coexist during the major part of the Gargasian. However, in the lowermost beds of the substage (more exactly in the brief period of coexistence of *Schackoina cabri* and *Globigerinelloides ferreolensis*) another process of rapid evolution is observed among populations of 6-chambered Praehedbergellas. The stable forms, regarded as typical of the two taxa mentioned above, are now a small

minority; most of the specimens, now strongly polymorphic, show a more and more marked tendency toward evolving from a trochospiral coiling to a planispiral one (the ombilical and spiral faces are less and less dissimilar, the aperture more and more peripheral); at about the same time, via numerous intermediate stages, the last whorl evolves from 6 to 7 chambers. During this short evolutionary phase the identification and characterization of "species" (and even of genera, based on the criterion - trochospiral vs. planispiral - mode of coiling) is made difficult if the usual rules of Linnean nomenclature are applied. The two terminal stabilized stages of this evolution are described in the literature respectively under the names *Praehedbergella luterbacheri*, a very low trochospiral typically 7-chambered form and *Globigerinelloides ferreolensis*, a planispiral 7- and very soon 8-chambered form. Unfortunately some authors, driven by a strictly typological approach that does not take these processes of evolutionary slippage into account, have erected species for numerous intermediate and transitory evolutionary stages selected at random in these changing and multiform populations. Our position has been to assign names only to the stabilized morphotypes.

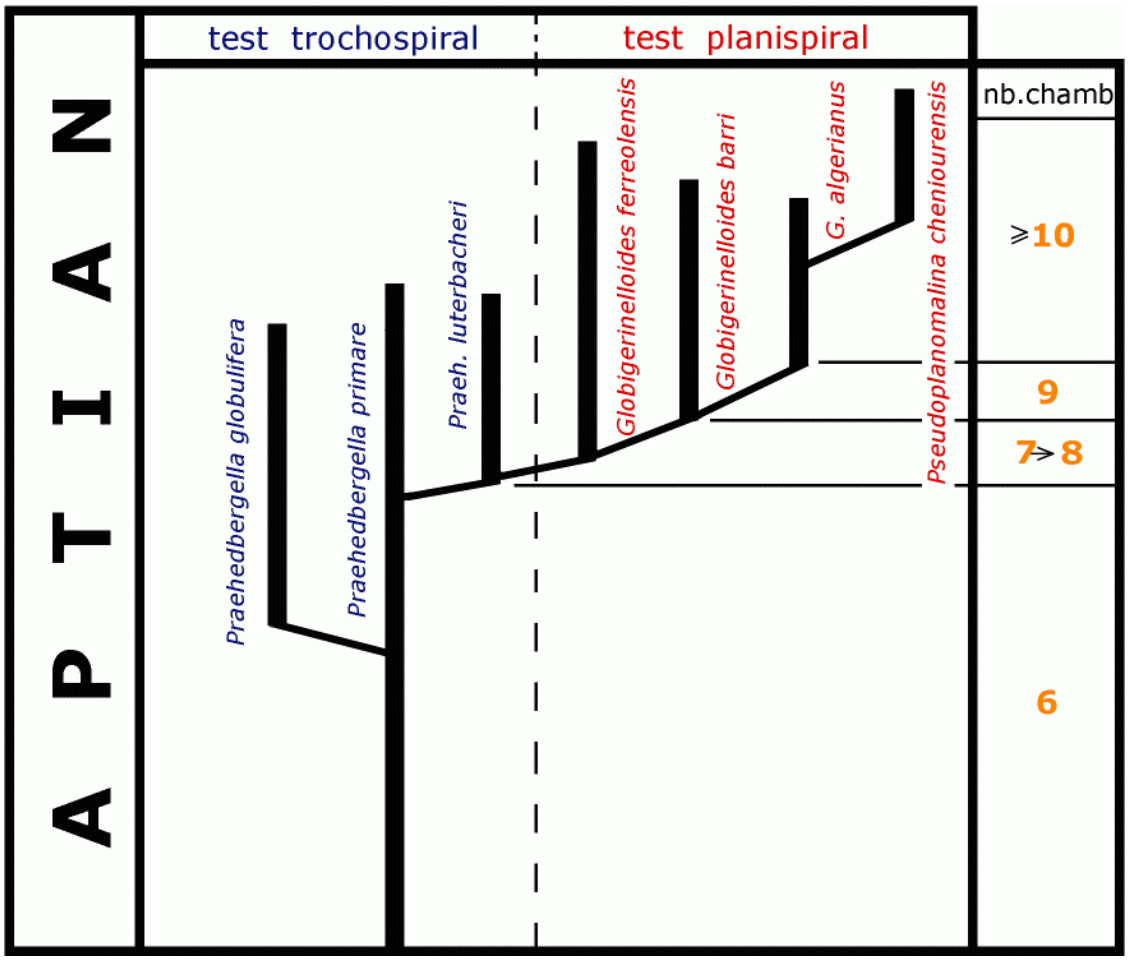

Figure 6: Evolution in Aptian times of the mode of coiling and number of chambers in the last whorl in a planktonic foraminiferal lineage with a test initially trochospiral and 6-chambered.

Higher in the sequence the only noticeable evolution affecting the planispiral forms in strata of early / middle Gargasian age involves the number and shape of chambers. Typical 7- or 8-chambered *G. ferreolensis* persist but fairly soon variants, always few in number, appear. They include all the stages intermediate to the 9-chambered (= *G. barri*) and higher in the succession to ten or more chambered forms (= *G. algerianus*). In some individuals of all three species (*ferreolensis*, *barri*, *algerianus*) there is also a more or less sporadic tendency toward a lateral widening of the last chambers (= "*Biglobigerinella*" trend). A trend toward uncoiling is also apparent in these three taxa but is most prevalent in *G. algerianus*. A great majority of authors are of opinion that neither of these variants is worthy of generic status. On the other hand, the progressive acquisition of a kind of peripheral keel by some specimens of *G. algerianus* has been named at both the specific and the generic level (*Pseudoplanomalina cheniourensis*, cf. MOULLADE *et alii*, 2002). The keeling process occurs near the upper Gargasian / Clansayesian boundary but was not seen in the Cassis-La Bédoule area owing to pre-Cenomanian erosion that removed the terms of the uppermost Aptian.

Environmental evolution

A detailed statistical analysis of the microfauna as well as its relationships with sedimentary data are beyond the scope of this essentially biostratigraphic paper. However, some general observations based on foraminiferal distribution suggest that during the Gargasian the sea was slightly deeper than it had been in late Bedoulian times (when the paleodepth was estimated to be between one and two hundred meters, MOULLADE *et alii*, 1998). The grounds for this presumption of a slight deepening are species diversity and the planktonic / benthic ratio: both tend to increase during the time in question. Furthermore, among benthic populations, the proportion of agglutinated forms, particularly those with an organic wall (*Bathysiphon*, *Reophax*, *Recurvoides*) tends to become greater during the Gargasian. Finally, shallow-water species like *Spirillina minima*, *Patellina subcretacea*, which occur more or less commonly in the Bedoulian are extremely rare or absent during the Gargasian.

Conclusion

This micropaleontological study of a Gargasian composite section from the Bedoulian stratotypic area allowed us to follow in great detail the evolution of foraminiferal assemblages during the period of transition between the two Aptian substages.

In general, the changes observed among the benthic forms appear to be progressive and reflect in particular a slight deepening upward during that time; several species extinctions in the benthic microfauna are correlated with the Bedoulian / Gargasian boundary.

Many planktonic species have a relatively long range: some of them that make their appeareance in the Bedoulian or even in the late Barremian are still present in the Gargasian. However, some stable markers, their level of first appearance well-calibrated, permit the division of the interval studied into five zones instead of the three of the previous zonation. On either side of the Bedoulian-Gargasian boundary certain groups are affected by a rapid yet progressive morphologic instability. Such somewhat disordered phases of evolution have not always been analyzed correctly by authors some of whom merely multiplied new taxa in this ever-changing background. The greater thickness of the succession and the absence of hiatuses in the Cassis-La Bédoule stratotypic area allowed us to observe these processes in great detail and especially to make certain their stratigraphical continuity. These initial regional results need substantiation through a similar study of middle Aptian microfaunas from another privileged stratotypic region, *i.e.* that of the Apt-Gargas (work in progress) and, through the Vocontian Basin, to integrate the data provided by the study of stratotypes into the Tethyan framework.

Taxonomic notes

Presented below is the minimum of information needed for the identification of the principal species of planktonic foraminifera whose taxonomy is the most controversial and thus subject to continual revision. At the generic level we will use a classification which fundamentally results from the hierarchy of criteria proposed by MOULLADE *et alii* (2002) but as for small *Globigerinelloides* includes a few changes adapted from the recent work of VERGA & PREMOLI SILVA (2003a). Complete synonymies, descriptions, more detailed discussions and more numerous illustrations will be provided in a forthcoming, more paleontologically-oriented paper, that will combine the observations on benthic and planktonic forms from Basse Provence, the Aptian stratotypic area (Apt-Gargas basin) and the Vocontian domain.

Praehedbergella aptiana (BARTENSTEIN 1965*)*

Hedbergella aptiana BARTENSTEIN, 1965, p. 347-348, text-figs. 3-6.

Blefuscuiana aptiana (BARTENSTEIN), BANNER et DESAI, 1988, p. 158, pl. 5, figs. 1-3.

Blefuscuiana aptiana (BARTENSTEIN) *sensu stricto*, BOUDAGHER-FADEL, BANNER et WHITTAKER, 1997, p. 125, pl. 8.2, figs. 1-8.

Blefuscuiana aptiana (BARTENSTEIN) *orientalis* BOUDAGHER-FADEL, BANNER, GORBATCHIK, SIMMONS et WHITTAKER, 1996, p. 125-126, pl. 8.2, figs. 9-11.

Remarks. We share fully BANNER & DESAI's opinion (1988) that the holotype described and illustrated in text-fig. 3 by BARTENSTEIN (1965) is a distorted specimen and thus paratypes are more suitable for defining this species (particularly, in our opinion, those of text-figs. 4 and 6).

Occurrence. Middle Barremian to early Aptian according to BARTENSTEIN (1965). In the Cassis-La Bédoule area, this species is rare during the latest Barremian, but moderately abundant in the Bedoulian and early-middle Gargasian.

Praehedbergella globulifera (KRETCHMAR et GORBATCHIK, *in* GORBATCHIK 1971)

Clavihedbergella globulifera KRETCHMAR et GORBATCHIK (*in* GORBATCHIK), 1971, p. 136, pl. 10, figs. 1a-c.

Hedbergella maslakovae LONGORIA, 1974, p. 61-63, pl. 20, figs. 1-3, 14-16; pl. 24, figs. 11-14.

Hedbergella similis LONGORIA, 1974, p. 68-69, pl. 16, figs. 10-21; pl. 18, figs. 12-13; pl. 23, figs. 14-16.

Lilliputianella globulifera KRETCHMAR et GORBATCHIK, 1971, BOUDAGHER-FADEL, BANNER et WHITTAKER, 1997, p. 164-165, pl. 9.1, figs. 5-15.

Remarks. The holotype of *Praehedbergella globulifera* has 5 chambers in the last whorl, those of *P. maslakovae* and *P. similis* 6 chambers; these species may also be distinguished typologically by the shape of their last chambers, slightly more elongate radially in *globulifera* than in *similis* and *maslakovae* (but not so much as to form cylindriform chambers like those of *P. roblesae*). The analysis of populations shows that in fact all these forms constitute a single but highly variable plexus (as demonstrated in LONGORIA's numerous illustrations (1974) of *P. similis*) and that the holotypes of *P. globulifera*, *P. maslakovae* and *P. similis* represent only random morphotypes among many others. Taking anteriority into account, we are of the opinion that BOUDAGHER-FADEL *et alii* (1997) were right in considering *P. maslakovae* and *P. similis* as junior synonyms of the species described by KRETCHMAR & GORBATCHIK (1971).

Occurrence. This plexus first appears in the late Bedoulian, is rather well-represented in the early Gargasian and progressively decreases in frequency in the middle Gargasian.

Praehedbergella gorbachikae (LONGORIA 1974)

Pl. 5, figs. 7-12

Hedbergella gorbachikae LONGORIA, 1974, p. 56-58, pl. 15, figs. 1-16.

Remarks. This species belongs to the *Praehedbergella infracretacea* group, in which it is distinguished by a more protruding adombilical part of the last chamber.

Occurrence. LONGORIA (1974) proposed this taxon as the index of a new Gargasian zone, intercalated between the Algerianus and Trocoidea zones. Our observations led us to reject this proposal because 1) *P. gorbatchikae* constitutes a very marginal component of the *infracretacea* group, 2) the first appearance of this species coincides with that of *Globigerinelloides algerianus*, a more significant marker.

Praehedbergella infracretacea (GLAESSNER 1937)

Globigerina infracretacea GLAESSNER, 1937, p. 28, text-fig. 1.

Globigerina aptica AGALAROVA, 1951, p. 49, pl. 8, figs. 9-11.

Hedbergella delrioensis (CARSEY), LONGORIA, 1974, p. 54-55 (*pro parte* : pl. 10, figs. 10-12; pl. 13, figs. 3-5, 15-18).

Praehedbergella luterbacheri (LONGORIA 1974)

Pl. 3, figs. 5-10; Pl. 4, figs. 1-6

Hedbergella luterbacheri LONGORIA, 1974, p. 61, pl. 19, figs. 21-23; 24-26; pl. 26, figs. 15-17.

Praeglobotruncana modesta BOLLI, 1959, p. 267 (*pro parte* : at least mentioned but not illustrated forms from the *Biglobigerinella barri* zone, Maridale formation).

Hedbergella planispira (TAPPAN) 1940, LONGORIA, 1974, p. 64-65 (*pro parte* : Aptian 7-chambered forms, *i.e.*: pl. 11, fig. 4-6; pl. 23, figs. 17-18).

Blefuscuiana kuznetsovae BANNER et DESAI, 1988, p. 156-158, (*pro parte* : pl. 3, fig. 10; pl. 4, figs. 1-2, 4; non pl. 4, fig. 3).

Remarks. We follow the author of this species in limiting the definition of *Praehedbergella luterbacheri* to low trochospiral 7- (rarely 8-) chambered forms with a rather slowly opening spire and a moderately lobate outline. The 7-chambered specimens of *P. kuznetsovae*, including the holotype, have a spire that opens slightly less slowly. Taking into account the range of variability within populations we are led to regard *P. kuznetsovae* as a junior synonym of *P. luterbacheri*.

Our observations in the Cassis-La Bédoule area show that by a progressive evolution of the coiling of the initially low trochospiral test towards planispirality, *P. luterbacheri* is the immediate ancestor of *Globigerinelloides ferreolensis* (cf. Pl. 4, figs. figs. 7-9).

Occurrence. Because it first appears in the upper part of the Cabri zone (*sensu lato*), just a few meters above the Bedoulian-Gargasian boundary, this species constitutes an interesting marker which can be used to approximate the boundary between the two substages and to be the index of a new zone intercalated between the Cabri zone (*s.s.*) and the Ferreolensis zone (see the biostratigraphic section of this paper). *Praehedbergella luterbacheri*, most often represented by few specimens, becomes rare in the upper part of the Ferreolensis zone and disappears near the Ferreolensis-Algerianus zonal boundary.

Praehedbergella praetrocoidea (KRETCHMAR et GORBATCHIK 1986)

Pl. 4, figs. 10-12; Pl. 5, figs. 1-6

Hedbergella praetrocoidea KRETCHMAR et GORBATCHIK (*in* GORBATCHIK), 1986, p. 95, pl. 16, figs. 3-5.

Occurrence. Species sporadically present, always very few in number, in the early-middle Gargasian.

Praehedbergella primare (KRETCHMAR et GORBATCHIK 1986)

Clavihedbergella primare KRETCHMAR et GORBATCHIK (*in* GORBATCHIK), 1986, p. 120-121, pl. 25, figs. 2a-3a, 2b-3b.

Hedbergella sp., aff. *planispira* (TAPPAN),

MOULLADE, 1966, p. 94, pl. 8, figs. 1-3.

Hedbergella planispira (TAPPAN, 1940), LONGORIA, 1974, p. 64-65 (*pro parte* : Aptian 6-chambered forms): pl. 23, figs. 5-7.

Hedbergella aff. *planispira* auct., SIGAL, 1979, pl. 2, figs. 1-2.

Blefuscuiana kuznetsovae BANNER et DESAI, 1988, p. 156-158 (*pro parte* : pl. 4, fig. 3)

Hedbergella kuznetsovae (BANNER et DESAI), COCCIONI et PREMOLI SILVA, 1994, p. 676, fig. 12: 1-12.

Blefuscuiana primare (KRETCHMAR et GORBATCHIK, 1986), BOUDAGHER-FADEL, BANNER et WHITTAKER, 1997, p. 131, pl. 8.10, figs. 1-3.

Praehedbergella kuznetsovae (BANNER et DESAI, 1988), MOULLADE, TRONCHETTI, KUHNT et MASSE, 1998, p. 207-208, pl. 3, figs. 8-9.

Remarks. KRETCHMAR & GORBATCHIK (*in* GORBATCHIK, 1986) defined this species as having 5.5 to 6 chambers in the last whorl and illustrate a holotype with 6 chambers. Initially, the rather succinct description and mediocre illustrations provided by the authors did not give a precise idea of the determining characteristics of this species.

But figures of topotypes in BOUDAGHER-FADEL, BANNER & WHITTAKER (1997) lead us to believe that *Praehedbergella primare* is in agreement with the concept of finely perforate, low trochospiral Barremo-Aptian forms, with 6 chambers in the last whorl that increase slowly; forms of this description have been referred to *Hedbergella planispira* (as "aff. *planispira*") by several authors, but these homeomorphs of *H. planispira* cannot be attributed to this Albian species, which has a macroperforate test, nor to *Praehedbergella kuznetsovae* for that species is typically 7-chambered with a spire that opens slightly less slowly.

Occurrence. Crimea: late Barremian-early Aptian. In SE France, this species appears in the latest Barremian and continues (decreasing in frequency) up to the middle Gargasian (Algerianus zone).

Praehedbergella roblesae (OBREGÓN 1959)

Globigerina roblesae OBREGÓN, 1959, p. 149, pl. 4, fig. 4.

Schackoina gr. *cabri* (SIGAL 1952)

Schackoina cabri SIGAL, 1952, p. 20-21, figs. 1-8.

Schackoina pustulans BOLLI, 1957, p. 274-275, pl. 1, figs. 1-4, 6-7.

Leupoldina protuberans BOLLI, 1957, p. 277, pl. 2, figs. 1-13.

Globigerinelloides algerianus (CUSHMAN et TEN DAM 1948)

Globigerinelloides algeriana CUSHMAN et TEN DAM, 1948, p. 43, pl. 8, figs. 4-6.

Remarks. Test planispiral, with at least 10, typically 10-12 or even more chambers in the last whorl; some specimens show a trend toward uncoiling in the last or the last few chambers or to widening until final bilobation.

Occurrence. This Tethyan middle-late Gargasian marker was seen only in the last meters of the Cassis-La Marcouline section, where it is represented by rather rare 10-11-chambered specimens.

Globigerinelloides gr. *aptiensis* (LONGORIA 1974)

Globigerinelloides aptiense LONGORIA, 1974, p. 79-80, pl. 4, figs. 9-10; pl. 8, figs. 4-6, 17-18.

Blowiella solida KRETCHMAR et GORBATCHIK (*in* GORBATCHIK), 1986, p. 123, pl. 27, fig. 3.

Remarks. These two planispiral 6-chambered forms differ typologically only in the degree of opening of the spire, which is very moderate in the *solida* morphotype, but slightly more rapid in the *aptiensis* morphotype; Here, again, between these extremes many intermediate stages exist; in addition, the stratigraphic distribution of all these varied and rather sporadic morphotypes is identical. We are therefore led to follow VERGA & PREMOLI SILVA (2003b) in considering *Blowiella solida* as a junior synonym of *Globigerinelloides aptiensis*. We have observed within this plexus the occurrence of very rare *Biglobigerinella*-like specimens; such a trend to the bilobation of the last chamber is more common among the *solida* morphotype.

Occurrence. Rare specimens assignable to this plexus appear in the late Bedoulian, are sporadically present in the early-middle Gargasian and become even rarer higher in the series.

Globigerinelloides barri (BOLLI, LOEBICH et TAPPAN, 1957)

Globigerinelloides barri BOLLI, LOEBLICH et TAPPAN, 1957, p. 25 (*pro parte*: pl. 1, figs. 17, 18 a-b).

Remarks. Test planispiral with 9 chambers in the last whorl. Phylogenetic successor of *G. ferreolensis*.

"*Globigerinelloides*" gr. *bizonae* (CHEVALIER 1961) – *saundersi* (BOLLI, 1959)

Pl. 1, figs. 1-12; Pl. 2, figs. 1-12; Pl. 3, figs. 1-4

Planomalina saundersi BOLLI, 1959, p. 262, pl. 20, figs. 9-11.

Hastigerinella bizonae CHEVALIER, 1961, p. 34-36, pl. 1, figs. 24-28.

Clavihedbergella bizonae (CHEVALIER, 1961), KUHRY, 1971, p. 231-232, pl. 3, figs. 2 a-c.

Hedbergella kuhryi LONGORIA, 1974, p. 60, pl. 14, figs. 1-6.

non *Claviblowiella saundersi* (BOLLI, 1959), BOUDAGHER-FADEL, BANNER et WHITTAKER, 1997, p. 181, pl. 10.2, figs. 7-11.

Blowiella saundersi (BOLLI, 1959), MOULLADE, TRONCHETTI, KUHNT et MASSE, 1998, p. 205-206, pl. 4, fig. 6.

Claviblowiella saundersi (BOLLI, 1959), LIPSON-BENITAH et ALMOGI-LABIN, 2004, p. 42, pl. 3, figs. 3a-b.

Remarks. To make a better comparison of the species named *Clavihedbergella bizonae* by CHEVALIER (1961) with that described by BOLLI (1959) as *Planomalina saundersi*, we have examined the holotype of *bizonae* (deposited in the collections of the Museum of Natural History of Paris, N° F62120). It is re-illustrated herein as it appears under an optical microscope (Pl. 1, figs. 10-12). The shape of the last chambers - ogival and pointed with an apical tapering suggesting that it is the base of a spine, although almost always found broken at the base- is similar in the two taxa. CHEVALIER (1961) defined the mode of coiling of his species as "trochoïde" (= trochospiral), a construction that can be seen on the figured paratypes; however, the holotype appears to be weakly dissymmetrical and shows a tendency toward planispirality. The holotype of the species of BOLLI is described as planispiral by its author, but the profile shows a slight asymmetry. Therefore using a strict typologic approach it is hard to find any objective argument that supports a differentiation of the two species.

The stratigraphic information in CHEVALIER's thesis (1960) shows that the type-population (holotype plus 10 "paratypoïdes" (= paratypes), of which only 4 specimens - the most clearly trochospiral - were illustrated again in his paper of 1961) comes from only one sample (labelled MG 781). This sample was taken in the La Marcouline Quarry, precisely in the more marly uppermost unit that we have dated middle Gargasian (Algerianus Zone). Furthermore, CHEVALIER (1960) quoted the occurrence of *G. algerianus* in levels that include sample 781. The specimens of "*Globigerinelloides*" *bizonae-saundersi* that we illustrate Pl. 3, figs. 1-4 come from this unit.

A meticulous analysis of the populations that we have followed step by step in the sections of the historical stratotype of Cassis-La Bédoule shows that those from the latest Bedoulian-early Gargasian are composed predominantly of distinctly trochospiral specimens. However, a part of or even the complete internal whorl is often visible on the umbilical side, and in addition its surface is slightly more depressed than that of its dorsal homologue. As early as the lower Gargasian a trend toward a more symmetrical coiling appears and is developed in an increasing number of specimens upward in the series. In the middle Gargasian these subsymmetrical specimens predominate but they are always accompanied by few more distinctly dissymmetrical individuals.

Added to this fluctuation in the mode of coiling is some morphologic variability in the shape of the chambers, in particular a more or less radial elongation that can attain the "*cepedai*" stage, described as a true species by OBREGÓN (1959) but which seems to represent only an extreme variant (very rare in our populations) of the species of BOLLI.

Therefore, taking into account both the features of the holotypes and intra-populational variability, it appears that the species described by CHEVALIER (1961) cannot be distinguished from that of BOLLI (1959) and must be regarded as a junior synonym.

Within this plexus the fluctuation of characters (*e.g.* mode of coiling, and the spinose extension on last chambers), considered of generic significance by a majority of authors, causes a problem in generic assignment. As a provisional measure pending additional research we group these forms under the provisional appellation "*Globigerinelloides*".

Globigerinelloides gr. *blowi* (BOLLI 1959)

Planomalina blowi BOLLI, 1959, p. 260, pl. 20, figs. 2-3.

Planomalina maridalensis BOLLI, 1959, p. 261, pl. 20, figs. 4-6.

Globigerinella duboisi CHEVALIER, 1961, p. 33, pl. 1, figs. 14-18.

Globigerinella gottisi CHEVALIER, 1961, p. 32 (*pro parte* : pl. 1, figs. 9-11, 13).

Globigerinelloides paragottisi VERGA et PREMOLI SILVA, 2003, p. 332-333, figs. 6. 7-14, 7. 1-13.

Remarks. In this few-chambered planispiral plexus, *G. duboisi* (typically 4 chambers) et *G. blowi* (5 chambers) are dominant morphotypes, always present simultaneously among the populations. They are linked by a minority of individuals comprising many intermediate stages, both in the shape and in the number of chambers. The *G. maridalensis* and *G. paragottisi* morphotypes are seen only very sporadically so their recognition as species does not seem worthwhile.

Occurrence. All the forms cited above are more or less constantly present from late Bedoulian to late Gargasian times.

Globigerinelloides ferreolensis (MOULLADE 1961)

Biticinella ferreolensis MOULLADE, 1961, p. 214, pl. 1, figs. 1-5.

Biglobigerinella sigali CHEVALIER, 1961, p. 33, pl. 1, figs. 19-23.

Globigerinelloides macrocameratus LONGORIA, 1974, p. 85-86, pl. 5, figs. 1-6.

Remarks. Test planispiral, 7-8 chambers in the last whorl. In the lowermost Gargasian this species evolved from low trochospirally coiled specimens of *Praehedbergella luterbacheri* with an increasingly flattened trochospire and a spiral side differing hardly at all from the umbilical one; the spiral side shows only a slightly greater part of the chambers of the internal whorl. The aperture too tends to become more and more symmetrical. The evolution of all these characters takes place within a progressive but rapid evolution towards planispirality, and include various intermediate stages. These variants do not justify the erection of a new species (a kind of "*praeferreolensis*" stage), which in any event cannot be attributed to a precise genus since none can be considered as belonging to typical *Praehedbergella* nor to *Globigerinelloides*.

Even when the coiling mode is stabilized, the intra-populational morphologic variability of the species *ferreolensis* appears to be rather extensive. This may involve the widening rate of the chambers (until they become bilobate, a feature leading to a "*Biglobigerinella*" morphotype), the opening rhythm of the spire, and an increase in the height of the chambers, but there is no tendency to uncoiling (as in *G. algerianus*); a very low rate of increase of chamber height in some specimens does not justify the erection of the species "*macrocameratus*" (as described by LONGORIA, 1974).

Occurrence. Gargasian species (lowest terms at the base of the substage excluded).

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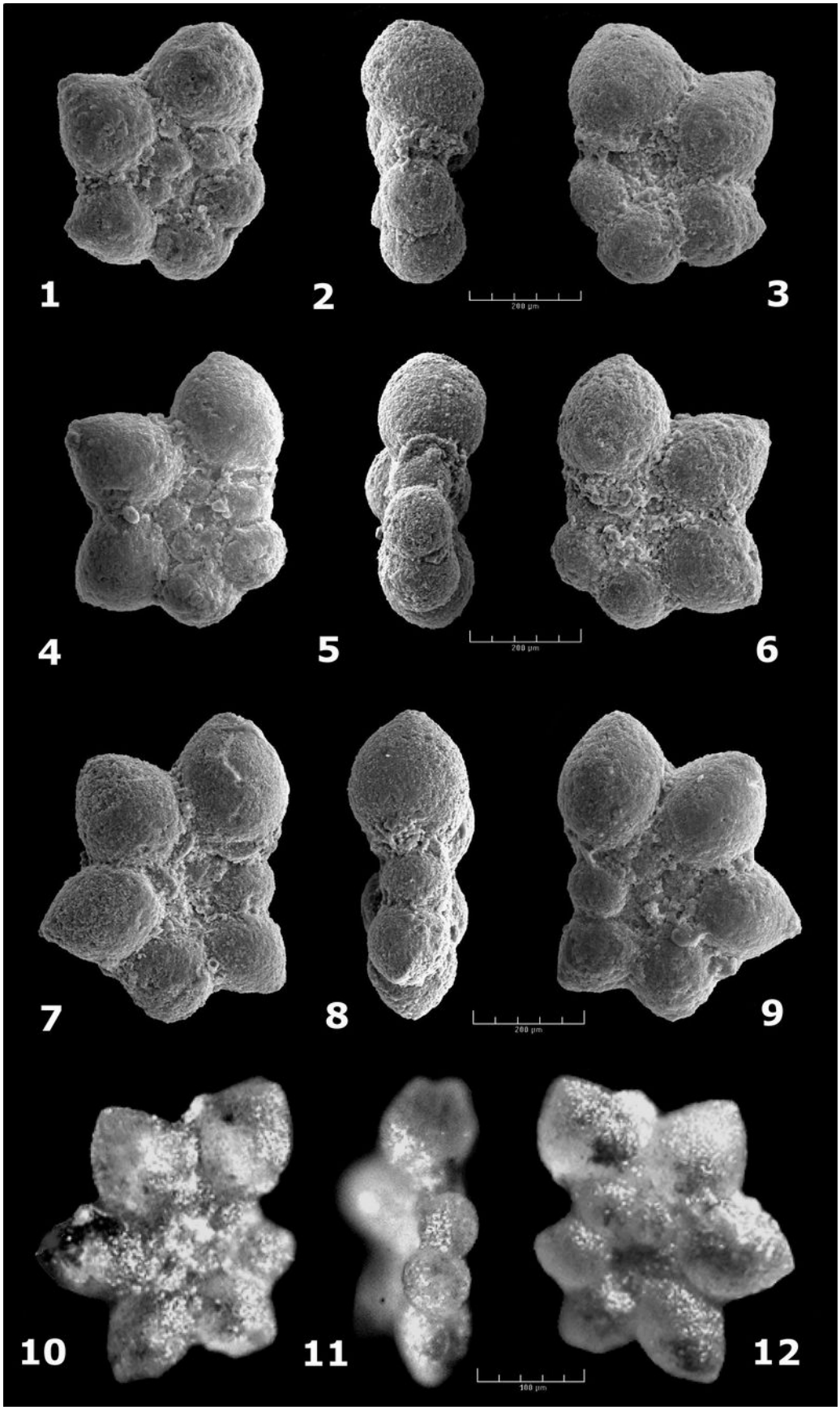
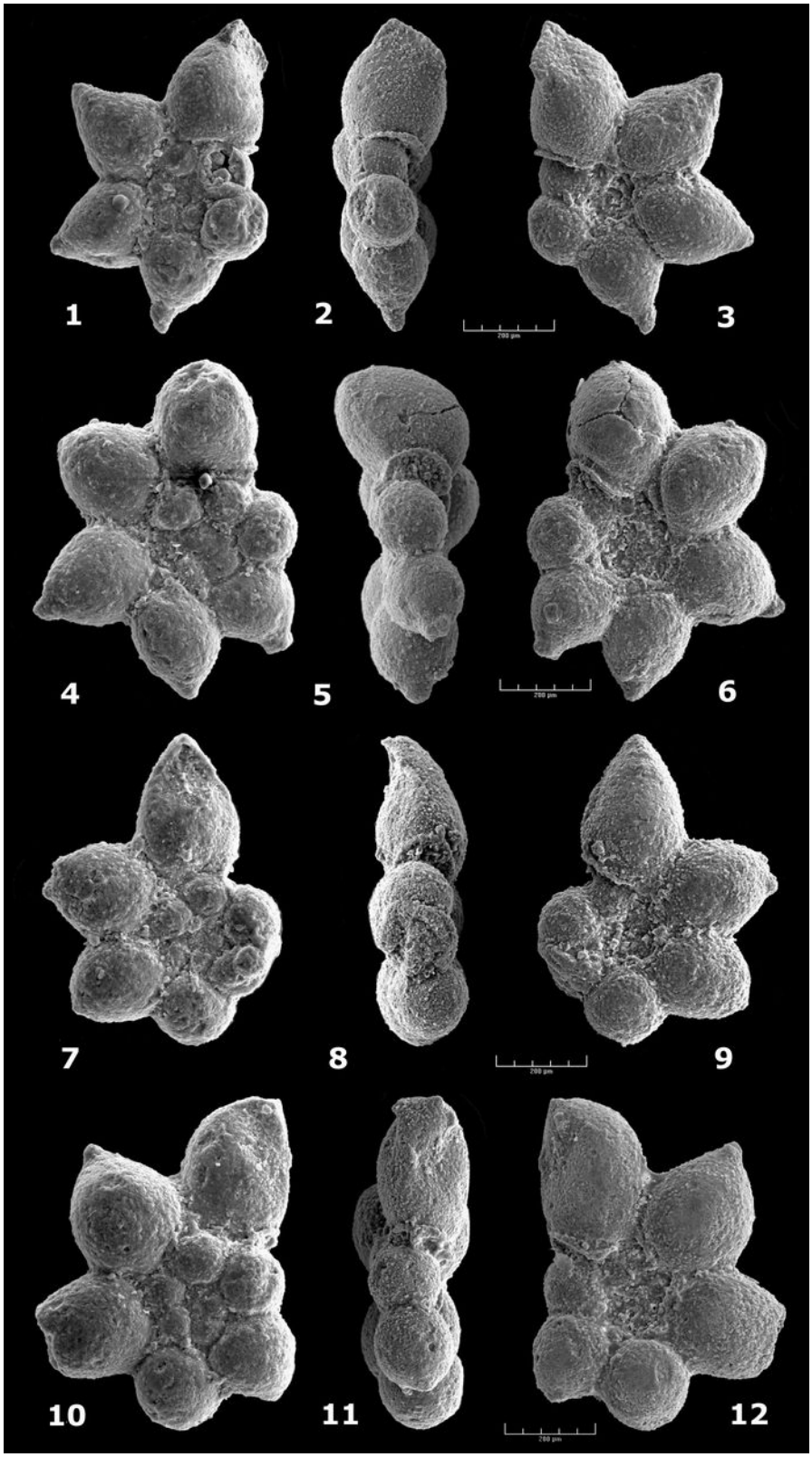
Plate 1:



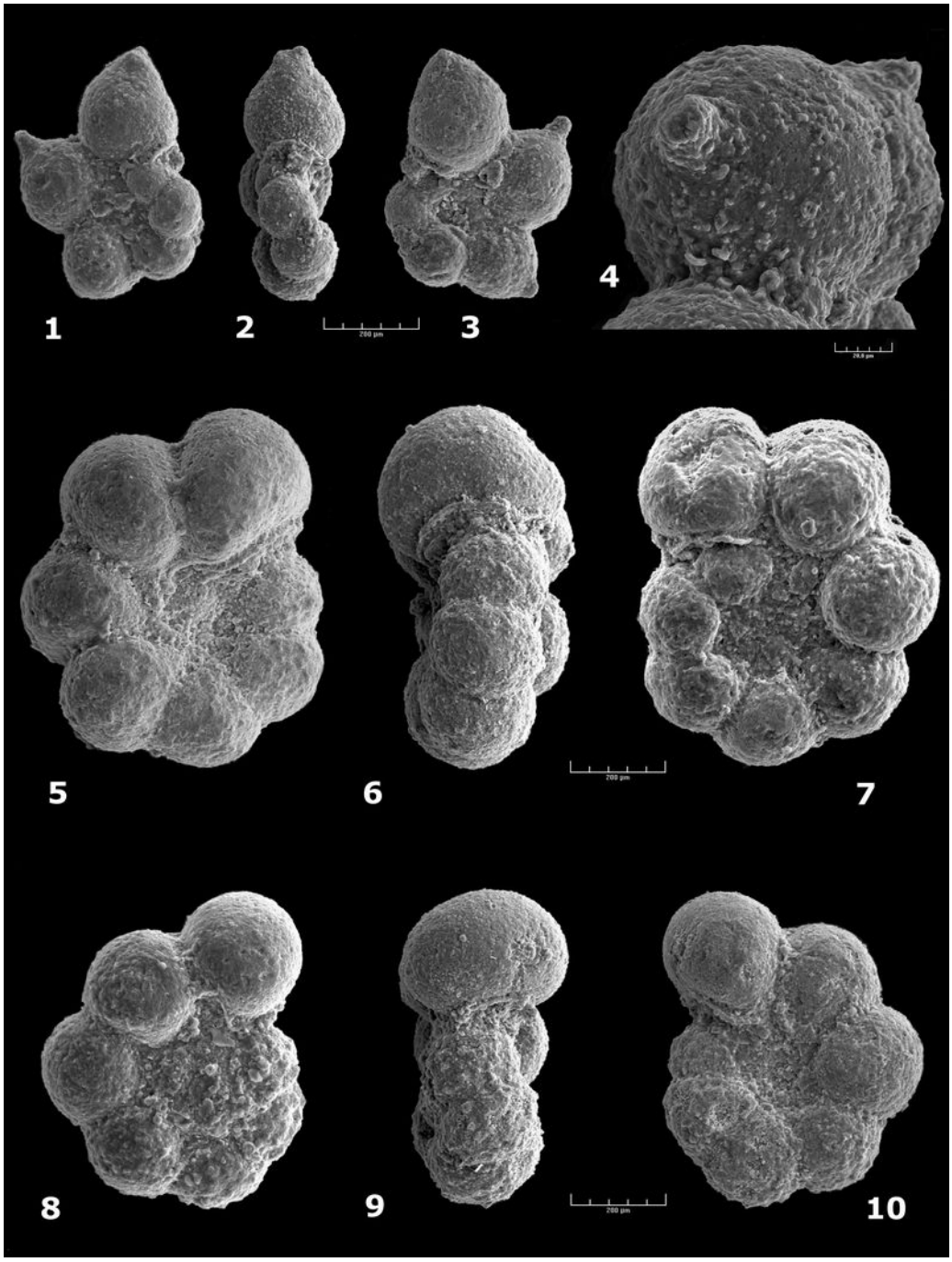
1-9. "*Globigerinelloides*" gr. *bizonae* (CHEVALIER) – *saundersi* (BOLLI). 3 specimens showing various modes of coiling (from trochospiral to subplanispiral). Lowermost Gargasian, Luterbacheri Zone, Les Tocchis section (La Bédoule), bed 189-T.
10-12. *Hastigerinella bizonae*, Holotype re-illustrated as it appears under an optical microscope (x 200), CHEVALIER's collection (Muséum National d'Histoire Naturelle, Paris). "lower Gargasian, region of Comte near Cassis", according to the author of the species (1961).

Plate 2:



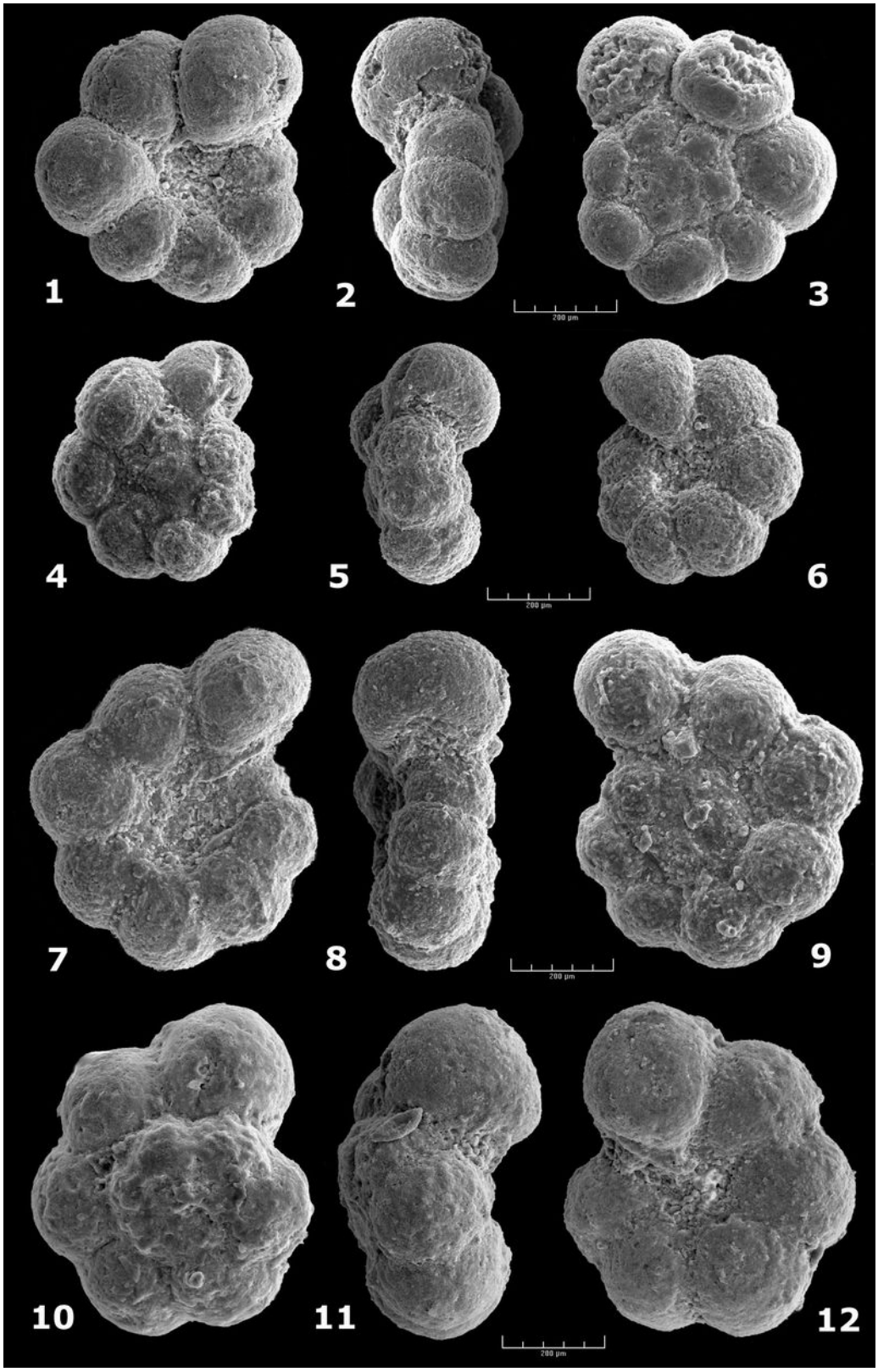
1-12. "*Globigerinelloides*" *bizonae* (CHEVALIER) – *saundersi* (BOLLI). 4 specimens from the middle Gargasian, Barri Zone, Cassis-La Marcouline section, showing various stages of dissymmetry in coiling. **1-3.** Sample 68. **4-12.** Sample 78.

Plate 3:



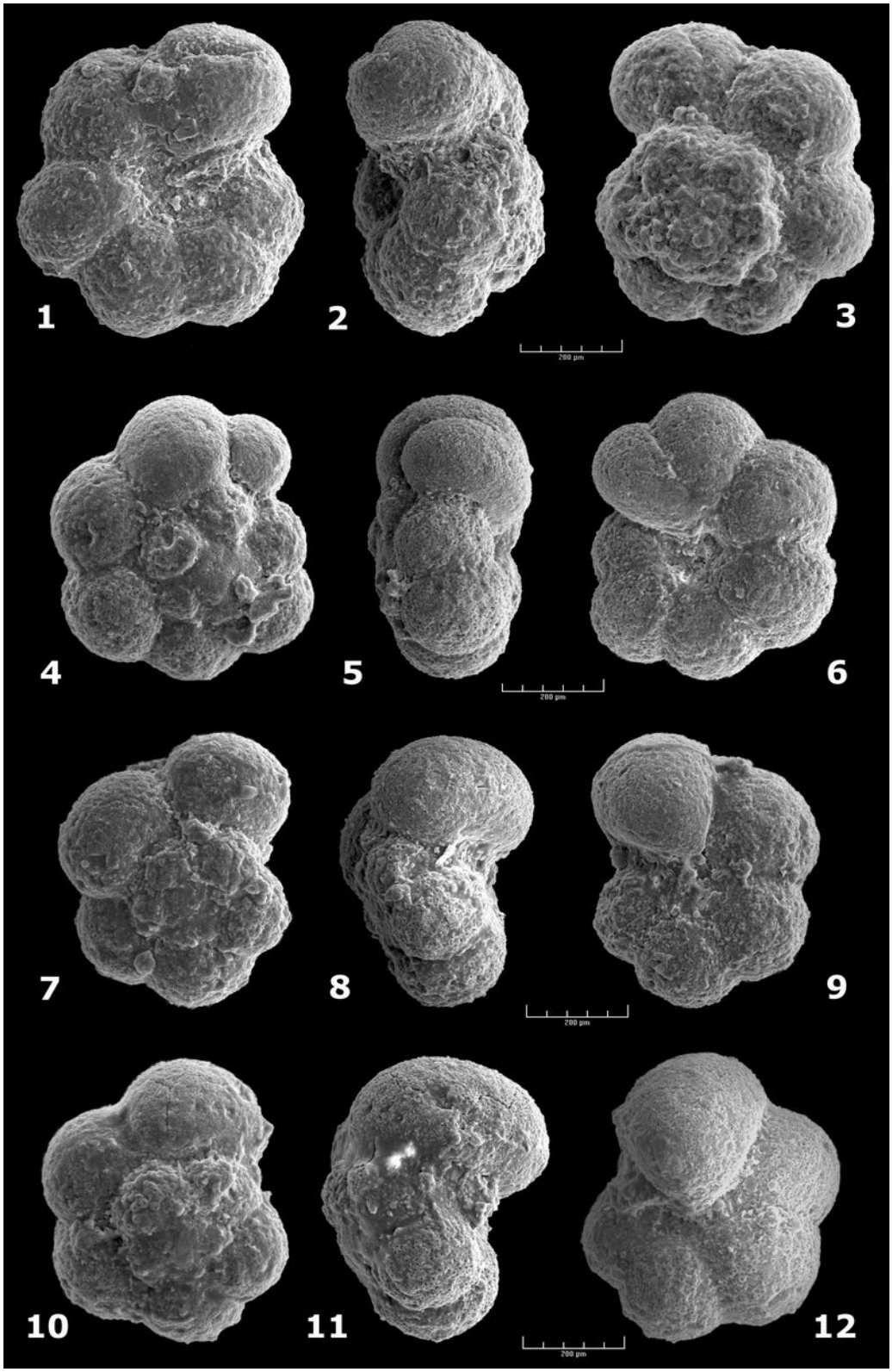
1-4. "*Globigerinelloides*" *bizonae* (CHEVALIER) – *saundersi* (BOLLI). Specimen from the base of the upper Gargasian, Algerianus Zone, Cassis-La Marcouline section, Sample 90. **4.** Enlargement of the penultimate chamber showing the beginning of the chamber extension (broken a little above its base).
5-10. *Praehedbergella luterbacheri* (LONGORIA). Specimens from the lowermost Gargasian, Luterbacheri Zone, Cassis-La Marcouline section, Sample 8.

Plate 4:



1-6. *Praehedbergella luterbacheri* (LONGORIA). **1-3.** lowermost Gargasian, Luterbacheri Zone, Les Tocchis section, bed 183-T. **4-6.** Middle Gargasian, Barri Zone, Cassis-La Marcouline section, Sample 78.
7-9. Transitional specimen between *Praehedbergella luterbacheri* (LONGORIA) and *Globigerinelloides ferreolensis* (MOULLADE). Lower Gargasian, base of the Ferreolensis Zone, Cassis-La Marcouline section, Sample 16.
10-12. *Praehedbergella praetrocoidea* (KRETCHMAR et GORBATCHIK), lower Gargasian, top of the Luterbacheri Zone, Cassis-La Marcouline section, Sample 14.

Plate 5:



1-6. *Praehedbergella praetrocoidea* (KRETCHMAR et GORBATCHIK). **1-3.** Lower Gargasian, Ferreolensis Zone, Cassis-La Marcouline section, Sample 22. **4-6.** Middle Gargasian, Barri Zone, Cassis-La Marcouline section, Sample 78.
7-12. *Praehedbergella gorbachikae* (LONGORIA), base of the upper Gargasian, Algerianus Zone, Cassis-La Marcouline section, Sample 90.