Artikel: The Kimmeridgian marker foraminifer Prinvolutina aquitanica : Pelissié & Peybernès, 1982 is a junior synonym of Mironovella granulosa (Bielecka & Poaryski, 1954), Epistominidae

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DOI: https://doi.org/10.5169/seals-738484

The Kimmeridgian marker foraminifer *Parinvolutina aquitanica* Pelissié & Peybernès, 1982 is a junior synonym of *Mironovella granulosa* (Bielecka & Pożaryski, 1954), Epistominidae

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Ms. submitted the 15th April 2013, accepted 15th June 2013

Abstract

The Kimmeridgian foraminifer Parinvolutina aquitanica *Pelissié & Peybernès, 1982 – so far known only in thin sections – has been obtained in isolated forms by acetolysis extraction from hard rocks sampled at Les Bouchoux, in the Jura Mts. (SE France). This foraminifer belongs to the epistominid* Mironovella granulosa *(Bielecka & Pożaryski, 1954). Genus* Parinvolutina *and the type species* P. aquitanica *are junior synonyms of the former, so they are invalid. Emended specific diagnosis, ecophenotypic variability and evolutionary aspects are given and discussed. This characteristic species has a wide palaeogeographic distribution and it is a good marker of the latest Late Oxfordian-Early Tithonian epicontinental areas of the Tethys.*

Keywords: *Epistominidae, Late Jurassic, Jura Mts, thin section, isolated forms, biostratigraphy*

Introduction

The small benthic foraminifer with aragonitic wall *Parinvolutina aquitanica* Pelissié & Peybernès, 1982 was originally described in rock thin sections from the Late Kimmeridgian (Mutabilis Zone) of the Quercy (South France). These authors classified this new taxon into the family Involutinidae Bütschli, despite of the test is pluriloculine. This strange form, with characteristic axial sections resembling an insect, has been regarded as a stratigraphic marker of the Kimmeridgian in open sea carbonate platforms (e.g., Hardenbol et al. 1998), where good index foraminifer are rare. Bernier (1967, 1984) cited this form from the Early Kimmeridgian of the Cévennes and Southern Jura Mts. (France), and classified it into the subfamily Epistomininae Wedekind. Loeblich and Tappan (1988) put the genus *Parinvolutina*, albeit with uncertainty and misinterpretation, into the family Robuloididae Reiss, superfamily Robuloidacea Reiss, suborder Lagenina Delage and Hérouard. Blau (1993) discovered similar sections in the Barremian-Albian of Colombia; this widely extended the stratigraphical range of *P. aquitanica*. Strangely this author classified this foraminifer into the order Tournayellida Hohenegger and Piller,? sub-

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order Lagenina Delage and Hérouard. Hardenbol et al. (1998) considered *Parinvolutina aquitanica* to be a good short range marker of the basal Late Kimmeridgian (Acanthicum Zone). More recently, several Master's theses focusing on the Kimmeridgian of the Central and Northern Jura Mts. have illustrated sections of this species (Gretz 2008; Sandoz 2009; Fischer 2012). In order to elucidate the nature of this foraminifer we have re-sampled the limestones of the Calcaires d'Aranc and the Couches à céphalopodes formations (Kimmeridgian) near Les Bouchoux village in the Jura Mts., where Bernier (1984) found this foraminifer in sections. By means of acetolysis extraction it was possible to obtain isolated tests and it could be established that *P. aquitanica* is a junior synonym of *Mironovella granulosa* (Bielecka & Pozaryski, 1954). The description and systematic position of this foraminifer, as well as its stratigraphical and palaeoecological interests are the aims of the present paper.

Geological settings, material and methods

Although the Late Jurassic of the southern Jura Mts. displays very variable facies in space and time, their evolution takes place in a general shallowing up succession from the Oxfordian to the Tithonian. The Oxfordian is essentially represented by basinal marly facies which become progressively calcareous and shallow at the top of the stage. Then the succession passes to a moderately deep carbonate platform in the basal Early Kimmeridgian represented by the Calcaires d'Aranc. This formation is overlain by the Couches à céphalopodes of Early-Late Kimmeridgian short basinal episode, and this is followed by the various peri-reef and reef facies of the Late Kimmeridgian–Tithonian. The material analysed in this study comes from the Kimmeridgian formations Les Calcaires d'Aranc and Les Couches à céphlopodes which outcrop near the village Les Bouchoux, 10 km south of St. Claude in the southern Jura Mts. (Fig. 1, coord. x869.20, y2150.75, z1060 m). This field section was studied in detail for ammonite content by Hantzpergue (1975). Bernier (1984) analysed the same outcrop, focusing on the sedimentology and the micropalaeontology. More recently, we sampled it for the protoglobigerinids (Görög and Wernli 2013). Only the top of the Calcaires d'Aranc and the first 30 m of the Couches à céphalopodes where Bernier (1984) recorded *Parinvolutina aquitanica* in sections were re-sampled in detail (Fig. 1, 2). Twenty three rock thin sections of hard rocks were made.

The Calcaires d'Aranc Formation consists of fine grained-limestones brown beige when freshly cut, with a light beige weathering colour, oncoidal and fossiliferous, with dispersed corals, rhynchonellids, rare aptychii and ammonites. They were dated from the Platynota Zone by Hantzpergue (1975). The microfacies of the Calcaires d'Aranc is a micropelletoidal, microintraclastic mudstone-wackestone with rare, dispersed but various microfossils. These are identical to that of the Couches à céphalopodes (described below) apart from the presence of the larger foraminifer *Everticyclammina virguliana* (Koechlin, 1942), *Pfenderina* cf. *salernitana* Sartoni & Crescenti, 1962, and *Amijiella arabica* (Redmond, 1964). These complex foraminifer indicate a relatively shallow episode compared to that of the overlying Couches à céphalopodes Formation which starts in the Hypselocyclum Zone (Hanzpergue 1975). It is a monotonous succession of well stratified, grey or grey beige mudstone beds (30-50 cm thick), often amalgamated in 1.5 m to 5 m thick layers. Some horizons are rich in brown, small oncoids reaching a size of up to 6 mm. Here, only two thin marly interbeds are noted, at 8 and 10 m from the base of the formation. The ammonites are frequent, occurring beside bivalves and gastropods (e.g., *Apporhais*). The microfacies of this formation is a micritic mudstone with a few dispersed bioclasts and various but rare microfossils. In thin sections *Spirillina* and *Miliospirella*, *Lenticulina* spp. (biconvex smooth forms probably belong to *L. muensteri*, flat forms with sutural costae that could represent *L. tricarinella*), other Nodosariidae (*Nodosaria*, *Dentalina*, *Planularia*), Textulariidae and Verneuilinidae (*Verneuilinoides*, *Textularia*, *Spiroplectammina* and *Marssonella*?), *Ammobaculites*, *Mohlerina basiliensis* (Mohler, 1938), *Hungarillina*, *Paalzowella*, miliolids (*Ophthalmidium*, *Labalina*, *Cyclogyra*), *Glomospira*, smooth and ornate epistominids and protoglobigerinids were found. The last have recently been described by Görög and Wernli (2013). The other microfossils are serpulids, calcisphaerulids (*Cadosina fusca*, *C. radiata* and *Colomisphaera* sp.) and *Globochaetes*. The microbialites represented by oncoids and sometimes, laminated crusts often include small sessile foraminifers like nubeculariids, placopsilinids and ?to lypamminids. Geodids spicules (rhaxes) are omnipresent, but no hexactinellids were found.

"*Parinvolutina aquitanica*" has been found in one sample (W2941) of the Calcaires d'Aranc and in two others, respectively at 20 m and 22 m (W2956, W2958) from the base of the Couches à céphalopodes (some metres below the "*Ataxioceras* horizon"). These reveal relatively rich associations of "*P. aquitanica*" in thin sections. In these last two levels about 50 specimens were counted in a rock-thin section (2.5 x 3.5 cm). They are moderately to fairly well-preserved. These rocks were treated by means of acetol-

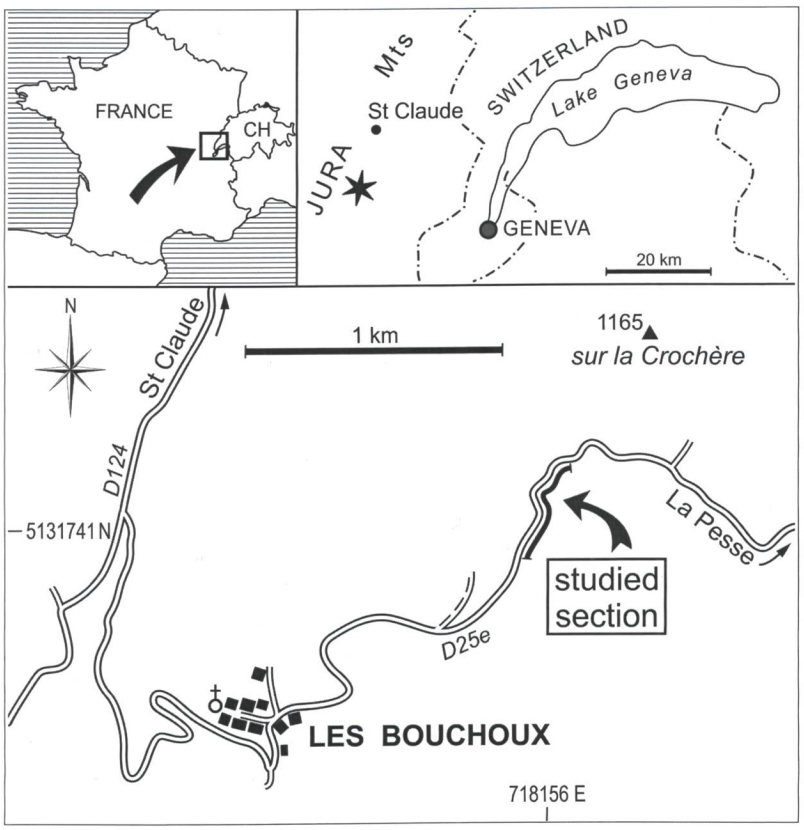

Fig. 1. Location of Les Bouchoux studied section.

ysis to extract isolated tests. More than 200 isolated tests were examined of which 71 were analysed with the SEM. The only two thin marly interbeds of this series (Fig. 2, samples W2949 and W2995) – that have been washed by standard method (gasoline) – reveal well-preserved isolated foraminifer fauna but without "Parinvolutina aquitanica".

Systematic palaeontology

The classification follows that of Loeblich and Tappan (1988). In the synonym list descriptions based on isolated specimens are indicated by "I" while sections of specimens are indicated by "S".

Order Foraminiferida d'Orbigny, 1826
Suborder Robertinina Loeblich and Tappan 1984
Superfamily Ceratobuliminacea Cushman, 1927
Family Epistominidae Wedekind, 1937
Subfamily Epistomininae Wedekind, 1937

Genus *Mironovella* Dain, 1970

Type species. *Mironovella mjatliukae* Dain, 1970

Diagnosis. Test very low trochospiral, nearly planispiral; almost entirely evolute on both sides; quasi-symmetric test bicarinate with parallel truncate profile; oval protoforamen in equatorial position, surrounded by elevated lip between the two keels.

Mironovella granulosa (Bielecka & Pozaryski, 1954) emend.
(Fig. 3A-U, Fig. 4A-T)

- 1954 *Epistomina stellicostata* var. *granulosa* n. sp., n. var. Bielecka and Poźaryski: p. 72 (in English p. 200), pl. XII, figs 61 a-c. (I)
- 1962 *Brotzenia ornata* (Roemer); Lloyd: p. 378, pl. 2, figs 12a-c, text-fig. 7A. (I)
- ?1970 *Mironovella mjatliukae* Dain, sp. nov. Dain: p. 73, pl. XIX, figs 1a, б, B, 2, 3. (I)
- ?1970 *Mironovella lloydi* Dain, sp. nov. Dain: p. 75, pl. XIX, figs 5a, б, B. (I)
- pars 1976 *Mironovella gemina* Dain, sp. nov. Dain and Kuznetsova: p. 134, pl. XXX, figs 5a, б, B;? figs 6a , б, B. (I)
- 1981 *Epistomina ornata* (Roemer); Shipp and Murray: p. 136, pl. 6.3.2, figs 13-15 same in 1989 *Epistomina ornata* (Roemer); Shipp: p. 260, pl. 6.4.3, figs 9-11. (I)
- 1982 *Parinvolutina aquitanica* n. gen., n. sp. Pelissié and Peybernès: p. 118, pl. 1, figs 1-7, text-figs 7A-C, pl. 1 figs 1-2 refigured in 1984. *Parinvolutina aquitanica* Pelissié and Peybernès 1982; Pelissié *et al.*: p. 486, pl. 2, figs 1-2. (S)
- 1984 *Parinvolutina aquitanica* Pelissié & Peybernès 1982, emend. Bernier: p. 528, pl. 21, figs 8-10. cum syn. (S)
- ?1985 *Mironovella gemina* Dain in Dain et Kuznetsova; Grigelis: p. 169, pl. XXXVIII, figs 4a, б, B, the fig. 4 a is the same figure as 1978 *Mironovella mayungaensis* (sic!) (Espitalie and Sigal); Grigelis: pl. I, fig. 7. (I)
- 1985 *Mironovella foveata* K. Kuznetsova et Umanskaja in Dain; Grigelis: p. 169, pl. VIII, figs 3a, 6, B, pl. XXXVIII, figs 3a, 6, B. (I)
- ?1985 *Mironovella mjatliukae* Dain; Grigelis: p. 169, pl. XXXVIII, figs 5a, б, B, 6a, б, B. (I)
- non 1993 *Parinvolutina aquitanica* Pelissié & Peybernès 1982; Blau: p. 300, figs 4a-i. (S)
- non 2004 *Epistomina aquitanica* (Pelissié & Peybernès); Piuz: p. 52, pl. 17, figs 13, 16-18. (S)
- ?2005 *Parinvolutina aquitanica* Pelissie & Peybernes, 1983 (? = *Epistomina* sp.); Gawlik et al.: pl. 3, fig. 9/3. (S)
- 2012 "*Parinvolutina aquitanica*" Pelissié and Peybernès; Fischer: p. 53, pl. 20, figs 7-8. (S)

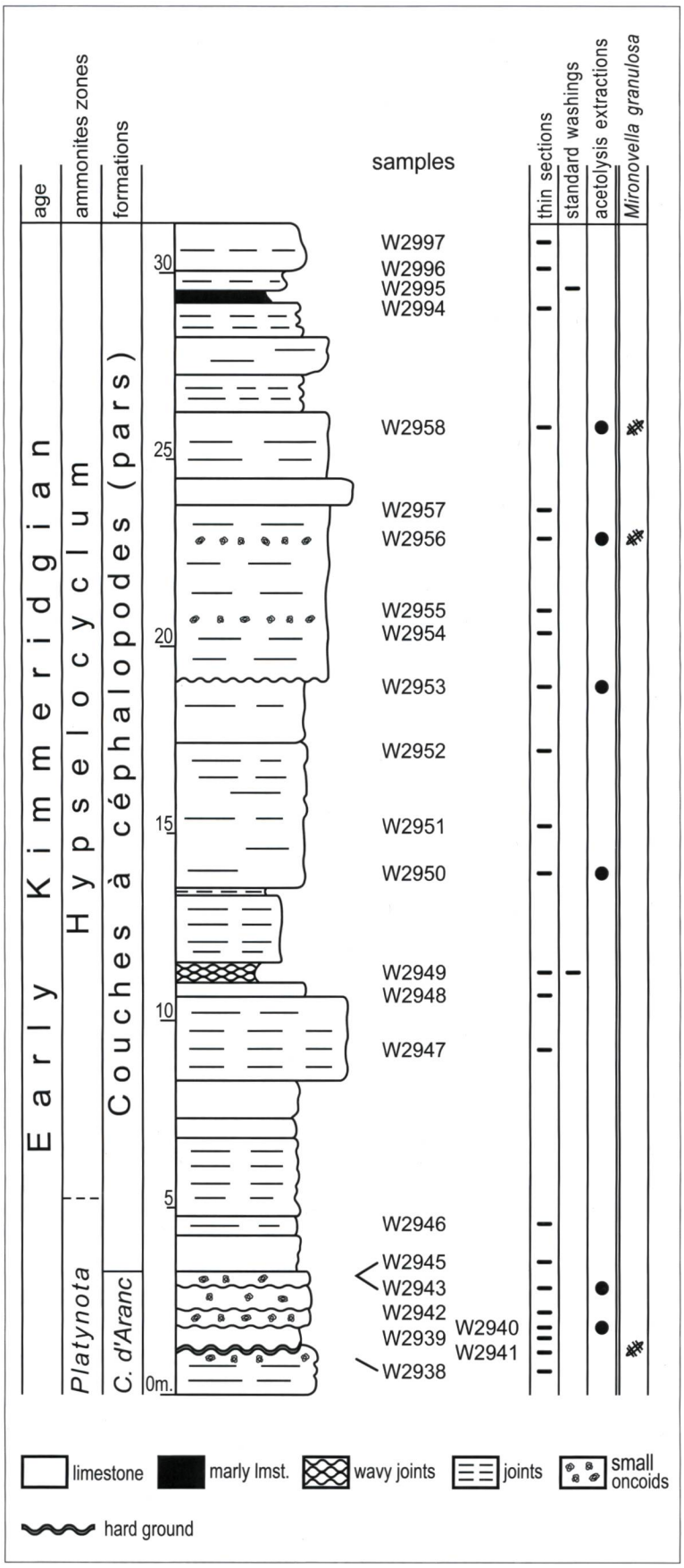

Fig. 2. Log of the Les Bouchoux section with stratigraphical distribution of Mironovella granulosa *(Bielecka & Pożaryski, 1954). Ammonites zonation following Hantzpergue (1975).*

Material

More than 200 isolated, and nearly 100 sections of specimens housed in the Micropalaeontological Collection of the University of Geneva.

Description

In isolated forms.

The test is very low trochospiral, nearly planispiral, usually entirely evolute, flat to slightly biconvex with a parallel bicarinate periphery. It is difficult to discriminate the umbilical side from the spiral one: generally, the umbilical side is slightly flatter than the spiral one. The tests are usually 300 µm in diameter, with a maximum of 400 µm. The 11-15 chambers display a gradual enlargement in size. The test is coiled in two whorls, mainly sinistral (Fig. 3(A-C, E-F)). The last whorl consists of 6-7 chambers (Fig. 3(A-F)). In this part of the test the interlocular sutures are strongly-elevated, forming continuous, sharp crests (Fig. 3(G, H, P, R, T)): on the spiral side the sutures are curved backward, especially at the last chambers (Fig. 3(A-D)); they cross the periphery parallel to the coiling axis, appearing as transversal crests (Fig. 3(G-M, P-T); on the umbilical side they are nearly straight and radial (Fig. 3(E-F)). On both sides of the test the sutural crests are connected with peripheral keels, giving a bicarinate periphery. On the umbilical side, near the periphery, the junction of the sutural crest and the keel presents a Y-shape (Fig. 3(E-F)). The left branch of this Y-shape is the continuation towards the transversal crests (Fig. 3(J-K)). In the central areas of the two sides, the sutural crests form a loose reticulum that follows approximately the outline of the first chambers.

Due to the preservation of the ornamentation – the height of the crests – the tests appear to be more or less biconvex.

The aperture (protoforamen) is elliptic, up to 2/3 of the peripheral length of the chamber, located between the transversal crests, and shifted forwards. It is in equatorial position, surrounded by a lip,

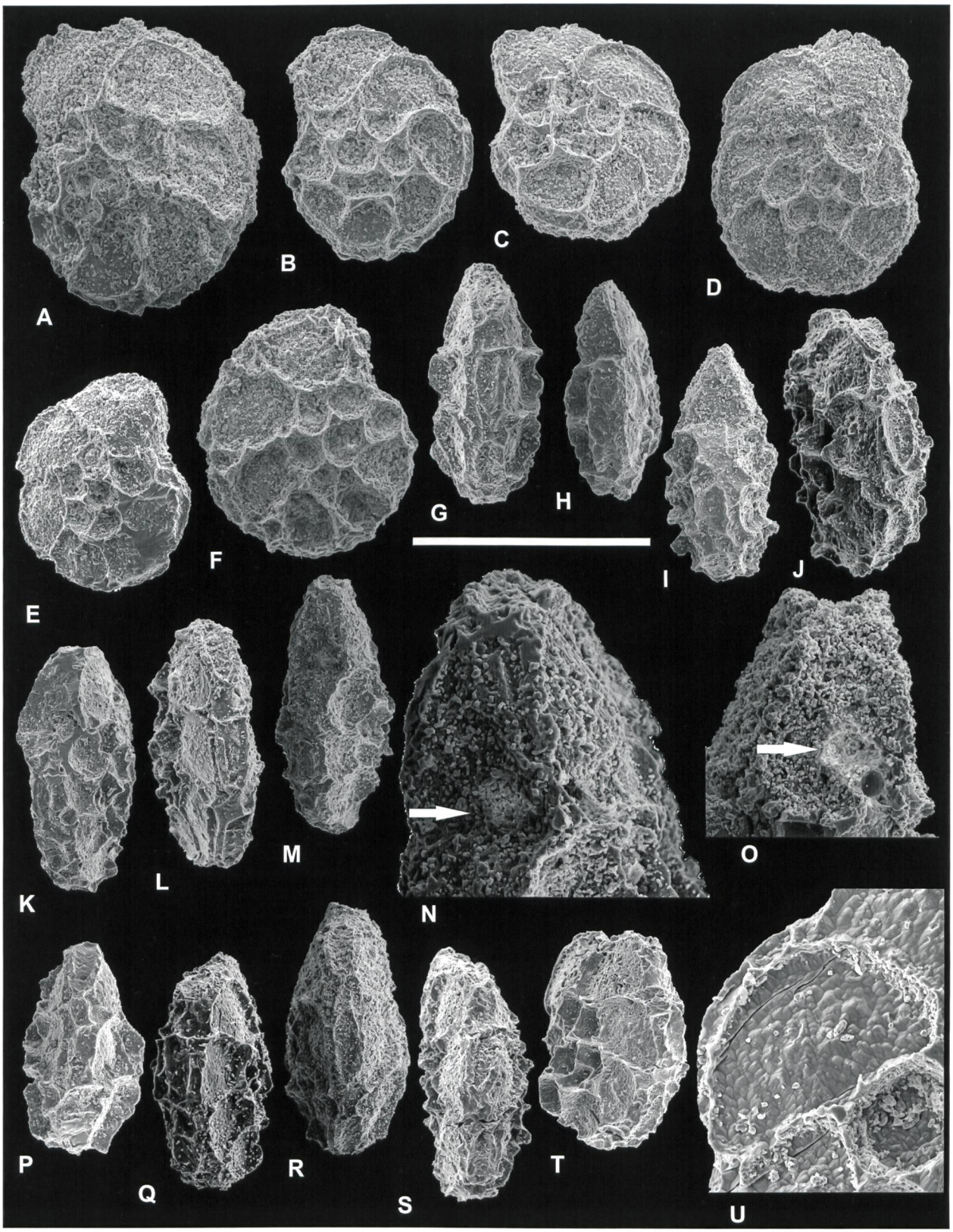

Fig. 3. Mironovella granulosa *(Bielecka & Pożaryski, 1954) in isolated forms, Early Kimmeridgian, Les Bouchoux. All specimens are in the Micropalaeontological Collection of the University of Geneva. Scale bar = 300 µm except N and P, where 150 µm. All individuals are from the sample W2958, excepted P and Q which are from the sample W2956. A-C spiral side, sinistral, D spiral side, dextral; E-F umbilical side, sinistral; G-S peripheral views: G, J, L, P, Q, R and S with well visible oval protoforamen (closed) surrounded by an elevated lip; H and I, areal face of last chamber (without deuteroforamen); M, N (enlargement of the individual M) and O, areal face of the n-1 chamber with the deuteroforamen (arrow). T oblique view of the umbilical side, U enlargement of the wall surface with papillate aspect.*

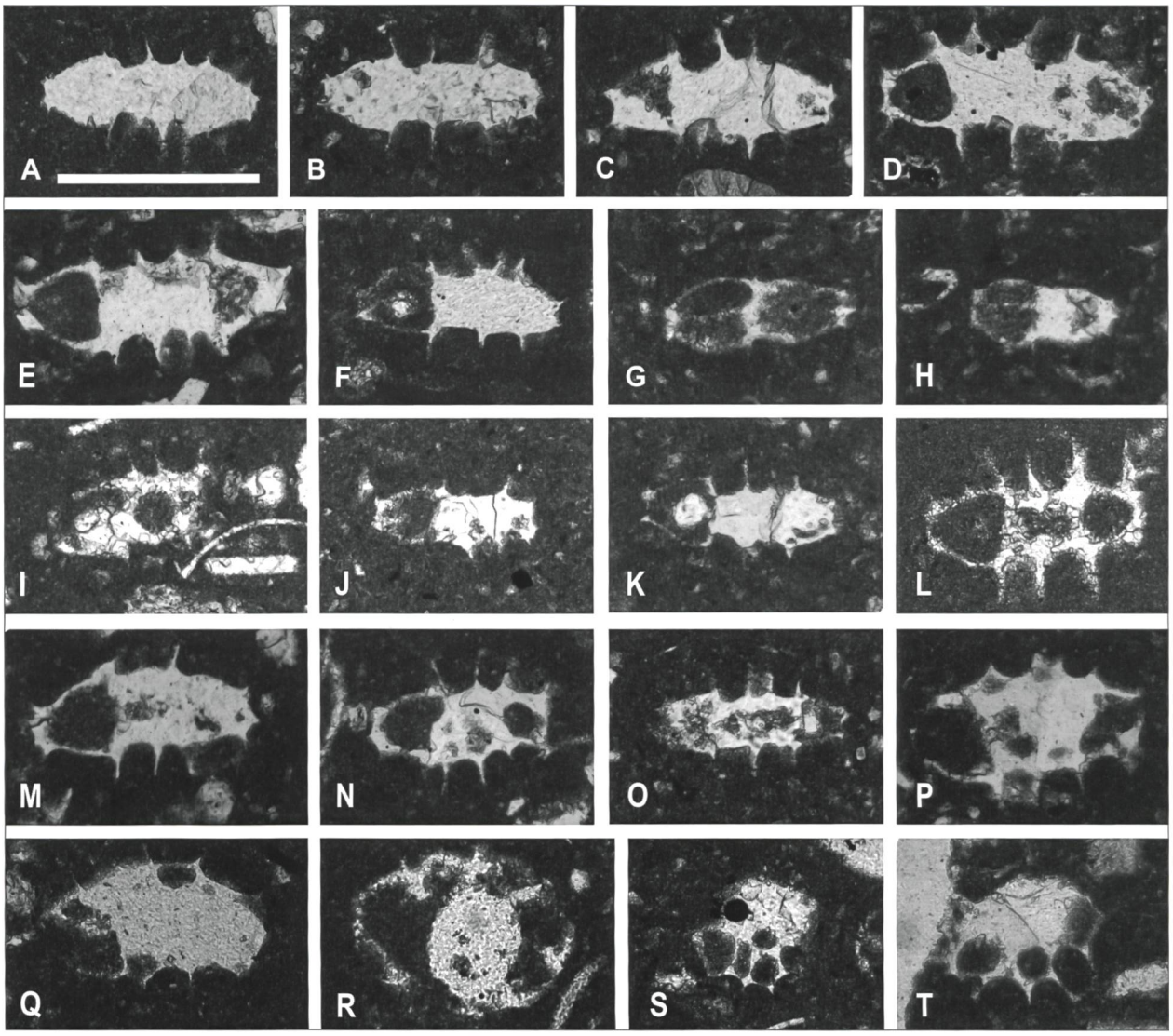

Fig. 4. Mironovella granulosa *(Bielecka & Pożaryski, 1954) in thin sections, Early Kimmeridgian, Les Bouchoux. All specimens are in the Micropalaeontological Collection of the University of Geneva . Scale bar = 300 µm except G-H and L where 200 µm. All individuals are from the sample W2958. A – D axial centred sections; E idem. with opened protoforamen (left); F idem. with folded internal partition; G–H, J subaxial sections with internal partition; I axial section with macrospherical proloculus; K axial section with folded internal partition; L-O subaxial sections; P–Q oblique sections; R equatorial section; S-T tangential sections.*

which somewhat protrudes above the keels and in some cases touches them (Fig. 3(G, JM, P-T). The protoforamina of all our specimens were closed – during the life of the animal – with shell-material. Frequently, the last chamber of the shells is not preserved because of its thin walls, so the opened protoforamen has been lost. There is a round to slightly oval, small opening, up to the ¼ of the height of the septa – the intercameral foramen (deuteroforamen) – in the basal part of the n-1 septa, shifted towards the spiral side (Fig. 3(M-O)). The septal face of the last chamber is high trapezoid in shape and rarely approaches a triangular-shape (Fig. 3(H, I). The lack of the intercameral aperture indicates the last-formed chamber (Fig. 3(I, K)).

The wall is fully recrystallised, probably originally aragonite with a papillated surface, except the crests (Fig. 3(U)).

In rock-thin sections.

The test is slightly trochospiral – nearly planispiral, and bicarinate. The spiral and the umbilical sides are nearly parallel, the spiral one being somewhat convex (Fig. 4(A-O)). The height of the test is about 80-100 µm. The tests are recrystallised and a large part of them are entirely filled with sparry calcite. Some of them are partly filled, generally in the early whorls, leaving the chambers of the last whorl empty. Thus the proloculus could be studied only in one specimen: this is a small-sized test (140 µm in diameter) with a

spherical, large (50 µm) proloculus, most probably a macrospheric form (Fig. 4(I)).

In the axial sections, the sutural crests appear on the both sides of the test like 3-5 "spines"; their length could reach the height of the test (Fig. 4(D, K-L, N)). The chambers are nearly trapezoidal in shape (Fig. 4(A-F, K-O)). On the periphery, the keels appear as two peaks. When an axial section passes through the aperture (protoforamen) it cuts the two keels and the lip of the aperture, thus producing a four-keeled appearance (Fig. 4(A-D, M-N)). Depending on the orientation of the section three "keels" are also obtained (Fig. 4(G-H, M)). The last one or two chambers are subdivided by a transverse, curve and delicate internal partition (sensu Loeblich and Tappan 1988; "Zahnplatten" sensu Hofker 1954 and Ohm 1967; toothplate sensu Lloyd 1962) that is positioned roughly in the equatorial plane of the test (Fig. 4(F-K)). The different sections (spots, line) of this thin internal partition indicate that its morphology is very complicated. It could be similar to the internal partition ("Zahnplatte") of *Brotzenia spinulifera* figured by Hofker (1954: p. 183, fig. 12) starting from the aperture and extending to the opposite wall. Most probably it was resorbed in the earlier chambers and remained only in the last ones.

In the equatorial sections the 6-7 chambers of the last whorl with the transversal crests give a "spiny" effect (Fig. 4(R)). In the tangential sections perpendicular to the coiling axis the reticulated surface ornamentation can be observed (Fig. 4(S-T)).

Remarks and comparisons

Based on the isolated specimens and different sections in rock thin sections from the same samples of Les Bouchoux, it can be stated that these forms are identical both with *Epistomina stellicostata* var. *granulosa* Bielecka & Pożaryski, 1954 described only from isolated specimen and with *Parinvolutina aquitanica* n. gen. n. sp. of Pelissié & Peybernès (1982) established only from sections. As indicated by the bicarinate periphery and other diagnostic characters, this species belongs to the genus *Mironovella* Dain, 1970. As *Epistomina stellicostata* Bielecka & Pożaryski, 1954 (sensu stricto) strongly differs from var. *granulosa* due to the lack of two keels, having a wide intercarinal periferal band, an ovate protoforamen surrounded by an elevated lip, and surface ornamentation, we promote *granulosa* to the rank of species. Thus the valid name of this species is *Mironovella granulosa* (Bielecka & Pożaryski, 1954). Following the Principle of Priority, *Parinvolutina* is thus a junior synonym of *Mironovella*, while *P. aquitanica* is junior synonym of *M. granulosa*. The isolated specimens of Les Bouchoux correspond well to the forms of Lloyd (1962), Shipp and Murray (1981) and Shipp (1989), who identified them as *Epistomina ornata* (=*Planulina ornata* Roemer 1841: p. 98, tab. XV, fig. 25, Early Cretaceous). However, this species has a monocarinate periphery, as pointed out by Hofker (1954: p. 181, text-fig. 7-8) and Ohm (1967: p. 135, pl. 18, fig. 1-2, pl. 20, fig. 7 – reference here corrected). In 1970 Dain established the genus *Mironovella* and published three new species: *M. mjatliukae* Dain, *M. lloydi* Dain and *M. foveata* K. Kuznetsova Umanskaja. This last species a possible junior synonym of *Epistomina mosquensis* var. *majungaensis* Espitalié Sigal, 1963 differs from *M. granulosa* in its inflated biconvex test, more numerous chambers (8-9) in the last whorl, and the smaller-sized dense alveolate ornamentation without connection with the sutures. Dain (1970) distinguished *Mironovella lloydi* from *M. granulosa* (=*Epistomina stellicostata* var. granulosa) by its larger size (600 µm), but did not specify the size-variation. However, he included *Brotzenia ornata* (= *Epistomina ornata* in Lloyd, 1962) in the synonymy, which has the same size as our specimens. *Mironovella mjatliukae* differs from *M. granulosa* only in the umbilical side, where the intercameral sutures of the last two or three chambers are depressed and the central reticulation appears independently from the sutures also.

The paratype of *M. gemina* Dain (Dain and Kuznetsova 1976: pl. XXX, fig. 6a, б, B) corresponds well to *M. granulosa*, while the holotype specimen differs slightly with respect to the ornamentation, namely pits (alveoli) appear on some sutures. These small variations of the ornamentation could be due to the preservation factors of the wall or, more probably, to its ecophenotypic origin (Williamson and Stam 1988). It has to be noted that all our specimens have the same ornamentation without pits or alveoli inside the crests. The *Mironovella* association of Les Bouchoux shows very few morphological variations.

Mironovella foveata in Grigelis (1985) is identical with *M. granulosa* but differs from the original description of Kuznetsova and Umanskaja (in Dain 1970). The morphology of *Mironovella mjatliukae* figured by Grigelis (1985) is very similar to that of *M. granulosa*. However, due to the lack of detailed description, poor preservation and the low resolution images, the interpretation of the surface ornamentation is not possible. This is also true for *Mironovella gemina* in Grigelis (1985).

The sections of *M. granulosa* of Les Bouchoux correspond very well to the sections of *P. aquitanica* figured by Pelissié and Peybernès (1982). However,

their description and the interpretation of the morphology is not exactly correct: the test is not planispiral and involute, but low trochospiral and evolute, as emended by Bernier (1984: p. 529); in the axial sections the "2-3 spines on the periphery" are in fact the sections of the keels and/or the elevated rim of the protoforamen; in the equatorial section sensu Pelissié and Peybernès (1982: p. 118) "the septa...are prolonged externally by a short spine", but they actually are sections of the transversal peripheral crests. Similarly, these "spines" cannot be "remnants of septa of an eroded or otherwise destroyed outer whorl", as interpreted by Loeblich and Tappan (1988: p. 393) and Blau (1993: p. 300-301).

Parinvolutina aquitanica described by Blau (1993) from the Barremian-Albian, differs from *M. granulosa* in its more massive, not so flat and somewhat larger (dominantly larger than 500 µm) test with 8-10 chambers. The differences in the wall texture and in the height of the trochospire indicate that these individuals are related to more than one species. Only the specimen figured by Blau (1993) on figure 4/c has a close resemblance to *Parinvolutina aquitanica*. However, it has to be noted that the Early Cretaceous forms of the *Epistomina* gr. *cretosa* also have a low trochospiral test with a bicarinate or quasi-bicarinate periphery, and sutural crests. A similar section, determined as "Epistominid foraminifera", is illustrated by Altiner (1991: pl. 13, fig. 35) in the Hauterivian of Anatolia (Turkey). Thus the determination of bicarinate flat specimens from thin sections of the Early Cretaceous rocks is inconclusive.

Specimens illustrated by Piuz (2004) from the Bajocian limestones of Jura Mts. display a triangular and not trapezoidal outline of the chambers in axial sections with more, 6-9 "spines" – the sections of the crests – on both sides of the test. The periphery is mono- or pseudo-bicarinate. The latter was formed by the peripheral keel and the lip of the protoforamen. According to us these forms belong to *Epistomina mosquensis* Uhlig, following the original description (Uhlig 1883: p. 766) and the detailed studies of Hofker (1954: p. 178) and Ohm (1967: p. 125).

Finally, the specimen figured by Gawlik et al. (2005: table 3, fig.9/3) does not have parallel sides and narrow crests like that of *M. granulosa*.

Stratigraphic range and palaeogeographic distribution

On the basis of the literature mentioned in the synonym list the occurrences of *M. granulosa* are the follows:

- Poland: Borehole Zagloba (Kujawy), Late Kimmeridgian (Bielecka and Pozaryski 1954).
- England: Black Head, near Osmington Mills and Shortlake, Dorset, Late Oxfordian – Early Kimmeridgian (Decipiens and Baylei-Euxodus zones (Lloyd 1962; Shipp and Murray 1981; Shipp 1989).
- France: Cras, near Limogne (Quercy), NE Aquitaine, Late Kimmeridgian (early Mutabilis Subzone) (Pelissié and Peybernès 1982; Pelissié et al. 1984). Causses orientaux, Massif Central, (Late Oxfordian?) Early Kimmeridgian (Fleury 1966; Bernier 1967). Col de la Rochette, Hauteville, Les Bouchoux and Champfromier (Southern Jura Mts.), Early Kimmeridgian (from Platynota to Acanthicum Zone) (Bernier 1984). Central Jura Mts., Late Kimmeridgian (Fischer 2011).
- Switzerland: Northern Jura Mts., Late Kimmeridgian (Eudoxus Zone, Caletanum Subzone), (Gretz 2008; Sandoz 2009).
- ?Austria: Grosser Barmstein, Hallein, Bad Dürrnberg, Early Tithonian – Early Berriasian (Gawlik et al. 2005).
- Russia: Ulyanovsk, Early Kimmeridgian (Rasenia stephanoides – Amoeboceras kitchini zone); ?Ulyanovsk, Kuibyschewski, Saratov and Kostroma regions, Republic of Tatarstan, Kimmeridgian (Virgatoxioceras fallax Zone) – Early Volgian (Dain 1970; Dain and Kuznetsova 1976). Borehole Zheleznodorozhnij, Kaliningrad district, Late Kimmeridgian – Early Volgian (Grigelis 1978; 1985).
- Kazakhstan: Eastern Karabek, Volgian (Dain and Kuznetsova 1976).

Summarising, *M. granulosa* ranges from the Late Oxfordian to the Early Tithonian, with a wide palaeogeographic distribution, but only in the northern epicontinental areas of the Tethys.

Palaeoecology

In the succession of Les Bouchoux the micropalaeontological content with ammonites and microplankton indicates a relatively open sea upper circalittoral depositional milieu. Following O. MacSotay in Bernier (1984), the gastropod *Apporhais* marks the water depth at about 250-400 m; however, this depth is probably overestimated, as shown by the frequent occurrence of oncoids. These kind of grains, with laminated concentric layers, form in a periodically agitated environment, probably due to violent storms and suggest rather shallower depths, about 50-100 m (Gygi 1992). In limestone facies Pelissié and Peybernès (1982) indicated an infralittoral milieu and Pelissié et al. (1984: fig. 3) assumed a circa- and infralittoral occurrence on a ramp.

In the original description of *M. granulosa* Bielecka & Pożaryski (1954) mentioned it as coming from cal-

careous shales of "shallow water" facies. In marly facies this species was found in the Sandsfoot Clay (Shipp and Murray 1981) and in the Kimmeridge Clay (Lloyd 1962; Shipp 1989). These have been deposited in hemipelagic environment with an average water depth of 50-100 metres (Hart and FitzPatrick 1995; Wright 2001; Pearce et al. 2010). Ascoli (1984) indicated that the ornamented forms are abundant in mid-outer shelf environments. In their review paper Williamson and Stam (1989) confirmed that the ornamented types of epistominids are predominantly found in relatively deep-water facies in the Jurassic.

Discussion and conclusions

So far "*Parinvolutina aquitanica*" Pelissié & Peybernès was known only in rock thin sections and considered a good marker of the Kimmeridgian. However, its morphology and taxonomic position have been misinterpreted. By means of acetolysis extractions it was possible to obtain numerous isolated tests allowing to clarify these points. This aragonitic foraminifer is a flat, evolute, very low trochospiral, truly bicarinate and strongly ornamented Epistominid. It must be attributed to the genus *Mironovella* Dain, 1970 and to the species *M. granulosa* (Bielecka & Pozaryski, 1954), here emended. So the binome *Parinvolutina aquitanica* is no longer retained and falls in synonymy with the previous taxa. The strong sutural and peripheral crests produce a "spiny" aspect in axial sections and in equatorial sections as well. All these "spines" were misinterpreted in the original description of Pelissié and Peybernès (1982) and, subsequently also by Loeblich and Tappan (1988). The quadrate periphery, which displays a "parallel truncate profile" sensu Williamson and Stam (1988), is bounded by two keels separated by a wide intercarinal band, in which the ovate protoforamina (primary apertures) bordered by a rim, are situated. This may result in a bi-, tri- or quadricarinate aspect in axial sections. All the other Jurassic epistominid species are monocarinate but can show a "pseudo-bicarinate" aspect in an axial section due to the rim surrounding the protoforamen. Their profile is "stepped back ventrally" sensu Williamson and Stam (1988). Other species very close to *Mironovella granulosa* –, namely *M. mjiatliukae* Dain, *M. lloydi* Dain and *M. gemina* Dain –, only differ in minor details of the ornamentation and can be considered as ecophenotypic variants. *Mironovella granulosa* was the first true bicarinate species in the evolution of the epistominids. In the Early Cretaceous other bicarinate species appeared, for example the *Epistomina cretosa* Ten Dam group, but their determination in thin sections is inconclusive.

Based on the results discussed in the present paper *M. granulosa* seems to be a good marker of the latest Late Oxfordian-Early Tithonian in epicontinental areas of the northern Tethys. Due to its characteristic axial sections, this unique epistominid can be easily recognized in thin sections of the Jurassic limestones. Based on the experience of the present authors and literature record, *Mironovella granulosa* is most frequently found in facies denoting an outer, open sea platforms and infralittoral milieu, where marker foraminifer are rare. It occurs more rarely in internal peri-reefal facies.

Acknowledgements

Sincere thanks are due to P. Hantzpergue (Lyon) who furnished us with precious unpublished documents about the ammonite datations of the successions. We are grateful to M. Conrad for his quick and conscientious reviewing. We thank Prof. P. Kindler who offered the facilities of the Dept. de Géologie et Paléontologie, Université de Genève. We benefited from the assistance of F. Gischig (Labo processing), R. Martini, A. Weber, A. Lefort (SEM photography) and J. Metzger (infography), who are warmly thanked. Thanks also to P. Rawlinson, who greatly improved the English. This work has been supported by the Hungarian OTKA Foundation (K68791), and this is greatly appreciated.

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