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COMMENTS ON “NEW BIOSTRATIGRAPHY AND MICROFACIES ANALYSIS OF EOCENE JAHRUM FORMATION (SHAHREKORD REGION, HIGH ZAGROS, WEST IRAN). A CARBONATE PLATFORM WITHIN THE NEO-TETHYS OCEANIC REALM” BY BABAZADEH AND CLUZEL [BSGF (2023)]

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Abstract. Babazadeh & Cluzel (2023) studied two stratigraphic sections from the Eocene deposits of the southwest of Shahrekord region (Zagros region, Iran). According to the biostratigraphic ranges of larger benthic foraminifera, the authors suggested in total three assemblage zones assigned to the Ypresian-Bartonian and Bartonian. In a previous contribution, Babazadeh (2022) described three new species of agglutinated conical foraminifera from the Eocene biostratigraphic framework in the Mahallat region of central Iran. It is demonstrated herein that the identified larger benthic foraminifera in both publications need reassessment with respect to taxonomy and biostratigraphic outcomes.

Keywords: Eocene, Larger Benthic Foraminifera, *Nummulites, Alveolina,* Orbitolinidae, Coskinolinidae.

INTRODUCTION

Larger benthic foraminifera (LBF) are the predominant biogenic components characterizing Eocene shallow-water carbonate successions in different formations of the Zagros region (i.e., Jahrum, Taleh-Zang, Shahbazan; see Rahaghi, 1978, 1980; Hadi et al., 2019; Frouzandeh et al., 2023). Because LBF are characterized by complex internal architecture accurate identification requires a high level of experience and knowledge of their taxonomy, such as accurate thin-section production and correct measurements of different parameters of morphological traits (e.g., Consorti & Schlagintweit, 2020; Hadi, 2022). Nevertheless, many articles are still being published by some researchers obviously basing the determination upon simply matching of a specimen to an image from the literature without understanding the appearance and interpretation of the complex internal structures in various section planes. In recent times there have been many instances of wrongly identified LBF by non-specialists, and that even among LBF specialists (e.g., Consorti & Schlagintweit, 2020; Benedetti, 2021; Schlagintweit, 2022; Schlagintweit & Simmons, 2022; Consorti & Vicedo, 2022). The incorrect identifications of Eocene LBF taxa merely on the basis of speculation with superficial views and without attention to some fundamental necessaries such as the analysis of oriented thin-sections and the biometric methods for each group is apparent in these articles.

In a recent paper published by Babazadeh & Cluzel (2023) concentrated on the stratigraphic distribution of LBF from two Eocene successions (Jahrum Fm.) from the Zagros area. The authors listed numerous LBF, including 44 species of which they illustrated 22 in two plates. Unfortunately, many of these taxa are misidentified at generic and species rank and it appears that the authors did not consider any morphological or biometrical features. According to these considerations, the main objective of the present paper is the investigation of these LBF taxa to a correct specific or at least generic level.

2. DISCUSSION - LBF IDENTIFICATIONS

2.1 *Alveolina* and nummulitids

With respect to the alveolinid taxa and their identification, it is indispensable to provide at least an oriented axial section, and possibly more than one, instead of a single random section with poor preservation. The specimen illustrated in plate 2I of Babazadeh & Cluzel (2023) shows an unsuitable axial section, where only the nepionic and juvenile stages are clearly illustrated without considering the poles and outline of the test. Nevertheless, we tried to make an assessment based on the biometric parameters of this specimen estimating the axial and equatorial diameters at 5 mm and 1.7 mm in the 6th whorl, respectively. The spherical proloculus is large with a diameter of 520 µm and the elongation index is 2.94, whereas the thickness of the basal layer in the equatorial sector of this specimen is larger when compared with morphotypes of *A. fusiformis* (Fig. 1). In any case it cannot be assigned to the Bartonian forms that typically exhibit supplementary passages and chamberlets in the columellar region and commonly elongated proloculus (Fig. 1). Thus, the morphological and biometrical characters are not in accordance with the descriptions and illustrations of *A. fusiformis* provided by Hottinger (1960; 1974), Adams (1962), Dizer (1964) and Silva-Casal et al. (2021) (Fig. 1). Anyway, this species could correspond to one of the elongated forms from the late Ypresian-early Lutetian in which the internal structures are relatively regular with larger proloculus and elongation index, although the test is incomplete. They also obviously pointed out the

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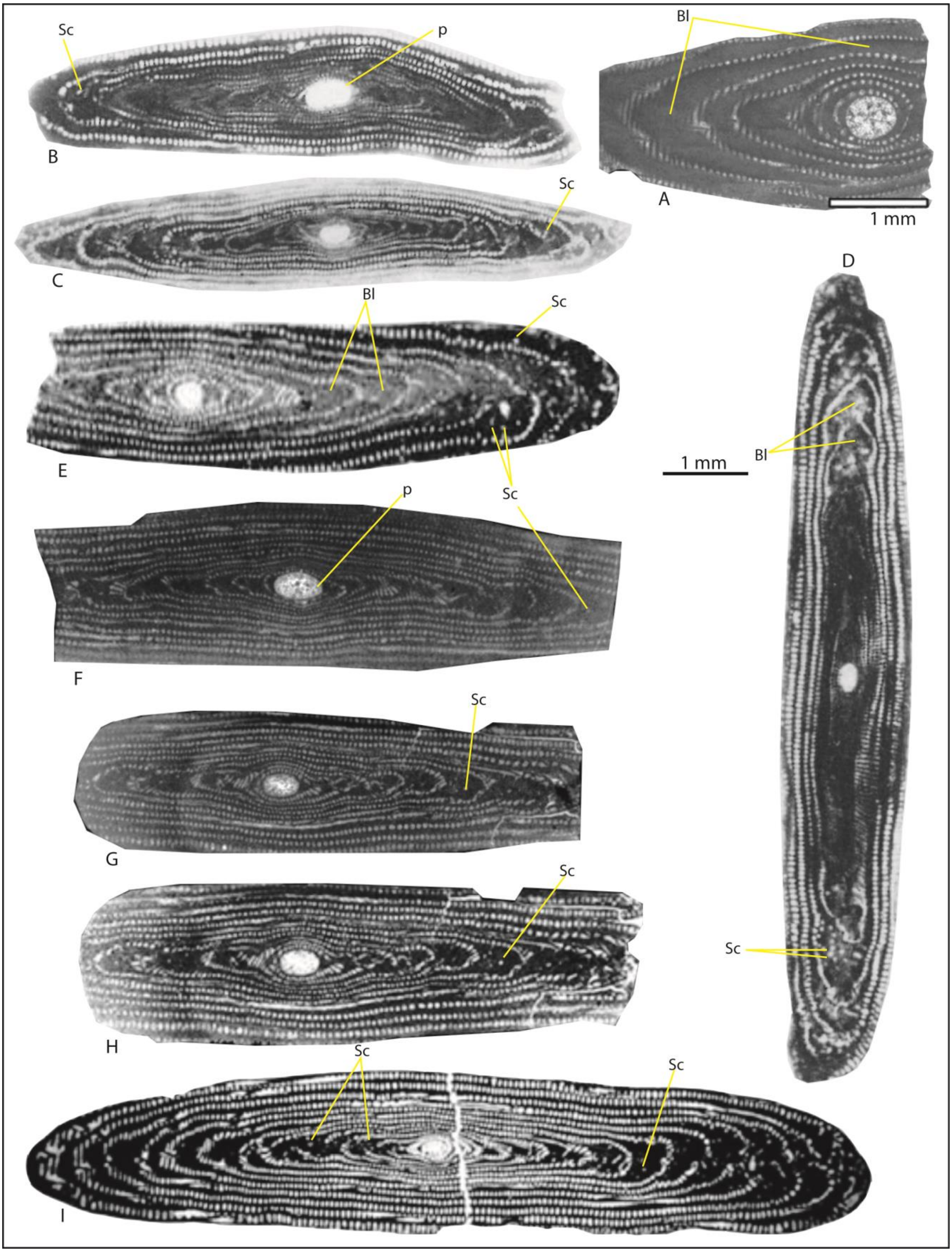

Fig. 1. *Alveolina fusiformis* illustrated from Babazadeh and Cluzel (2023) and comparison with other authors. **A.** From Babazadeh (2023, plate 2I); **B-D.** From Dizer (1965, plate 4, figs. 2, 6, 8); **E.** From Adams (1962, plate 3, fig. 6); **F-G.** From Hottinger (1974, plate 52, figs. 5-6); **H-I.** From Silva-Casal (2021, fig.20A, H). Abbreviations: P = proloculus; Sc = secondary chamber; Bl = basal layer.

occurrence of *A. elliptica* (Sowerby) with emphasis on the fusiform shape, whereas this cosmopolitan species (from the Mediterranean to Indo-Pacific regions) is an index for oval to subcylindrical forms (e.g. Drobne et al., 2011; Hadi et al., 2024). The authors illustrate incomplete figures of both axial and equatorial sections (A-forms) as *Nummulites ptukhiani* (plate 3A-B). On the other hand, the identification of reticulate *Nummulites* such as *N. ptukhiani* is more complex than in the case of other forms during the Bartonian (Cotton et al., 2016). This species is characterized by having a large proloculus up to 400 µm in many recent works throughout the Tethys (Cotton et al., 2016; Saraswati et al., 2017; Özcan et al., 2019). The size of the proloculus is a key parameter for discriminating other species such as *N. garganicus* and *N. hormoensis*, which belong to the *N. fabianii-lineage* with much smaller proloculus (Cotton et al., 2016; Saraswati et al., 2017). Herein, the diameter of the proloculus is measured as ~246 µm in plate 3A of Babazadeh & Cluzel (2023). Thus, the illustrated specimens cannot be assigned to the *N. ptukhiani*. For making a reliable identification, one has to follow either six biometric features of *Nummulites*, including four linear measurements (in µm) and two counts of chambers according to Less (1999) or apply the Windungsdiagramm (spiral diagram) of Schaub (1951).

In addition, *N.* cf. *fossulatus* is shown by a single sub-axial section in plate 3C of Babazadeh & Cluzel (2023). This species is identifiable based on the deeply biumbilicate lenticular test resulting in a distinctive central cavity in axial sections so that the last two whorls show a “dumb-bell” shape (e.g., Cizancourt, 1946, fig. 1; Racey, 1995, pl. 1, fig. 26), (Fig. 2). Furthermore, the authors stress that there are close similarities between the measured biometric data (axial and equatorial measurements in the axial section) and some findings of Racey (1995) on the megalospheric forms of *N. fossulatus*, as there is a significance difference in diameter/thickness (D/T) ratio of test. Moreover, the thickening septum and septa in equatorial sections are noteworthy, they can be considered as a morphological key parameter in differentiation of some other species such as *N. postfossulatus* Sirel & Deveciler, 2018, whereas plate 2 C of Babazadeh & Cluzel (2023) shows just a sub-axial section. Insisting on the occurrence of *N.* cf. *fossulatus*, the authors should consequently have included comparison and discussion with *N. pinfoldi* Davies (1940), *N. postfossulatus* Sirel & Deveciler, 2018 and *N. cuvillieri* Sander, 1962 (Fig. 2).

Specimens of *N. malatyaensis* are figured in plate 3 D-F of Babazadeh & Cluzel (2023) based upon megalospheric forms showing poor preservation. This species was described for the first time by Sirel (2003) and thereafter recorded in the works of Deveciler (2014) and Sirel and Deveciler (2018) from Turkey, with a characteristic small proloculus (0.100 mm-0.275 mm in diameter) that is followed by numerous subrectangular chambers; their height is greater than width. In Babazadeh & Cluzel (2023), the measured size of the proloculus ranges from 315 to 420 µm (plate 3D-E) with relatively isometric chambers (see plate 3E), occasionally higher than longer and with a moderate marginal cord. In plate 3 D, the shown incomplete sub-axial section of *N. malatyaensis* can be deceptive under the influence of environmental conditions (for more detail see Racey, 1992; Beavington-Penny & Racey, 2004). Thus, the identification of *N. malatyaensis* without considering the external view and accurate biometric data (see Schaub, 1981; Less, 1999) and just relying on an incomplete sub-axial section is unacceptable from a taxonomic viewpoint. Instead, it would have been more reasonable to refer to this species with some nomenclature prefixes such as cf., aff. in plate 3D.

N. cf. *perforatus* is documented by sub-axial and sub-equatorial sections with figures that show an incomplete view of the test (Babazadeh & Cluzel 2023, plate 3 G-H). The unsuitable sections only allow an estimation of the biometric data, thus leading to inaccurate data rather than reliable facts. In fact, a correct identification is practically impossible only based on A-forms with poor preservation and random sections. This species belongs to giant and lenticular *Nummulites* within *N. burdigalensis* group (= *N. perforatus-biedai* group with distance lineages) that show many similarities with other large taxa with meandriform septal filaments (e.g., *N. deshayesi*, *N. aturicus*, *N. crassus* and *N. obesus*). Even in suitable sections, the identification of *N. perforatus* is often tricky.

The specimen shown in plate 3L in Babazadeh & Cluzel (2023) represents a sub-axial section illustrated with incomplete image. This specimen cannot reliably be referred to any *Nummulites* species. Babazadeh & Cluzel (2023) just assigned the megalospheric specimens in plate 3I-J to *N. globulus*.

The authors discriminated *N. globulus* and *N. atacicus* based upon some common features such as test size, surface ornamentations and arrangement of internal structures but neither figure I nor K shows the spiral intervals somewhat equal according to the number of septa and whorls per radius.

However, for making a reliable identification of *Nummulites*, we believe that these data are still unsuitable and inadequate.

Babazadeh & Cluzel (2023) also commented about three *Assilina* species, identified as *A.* cf. *laminosa*, *A.* cf. *granulosa* and *A.* cf. *khorrassanica* and illustrated them as incomplete sub-axial sections in plate 2P-R. Undoubtedly, these determinations are unacceptable in the light of the presented and available data. It would have been more purposeful making additional thin-sections in order to investigate the morphological parameters through axial and equatorial sections. In the absence of adequate diagnostic sections, exact specific determinations of *Assilina* specimens are simply not possible. Instead, an open nomenclatural approach should be preferred however often avoided by many researchers.

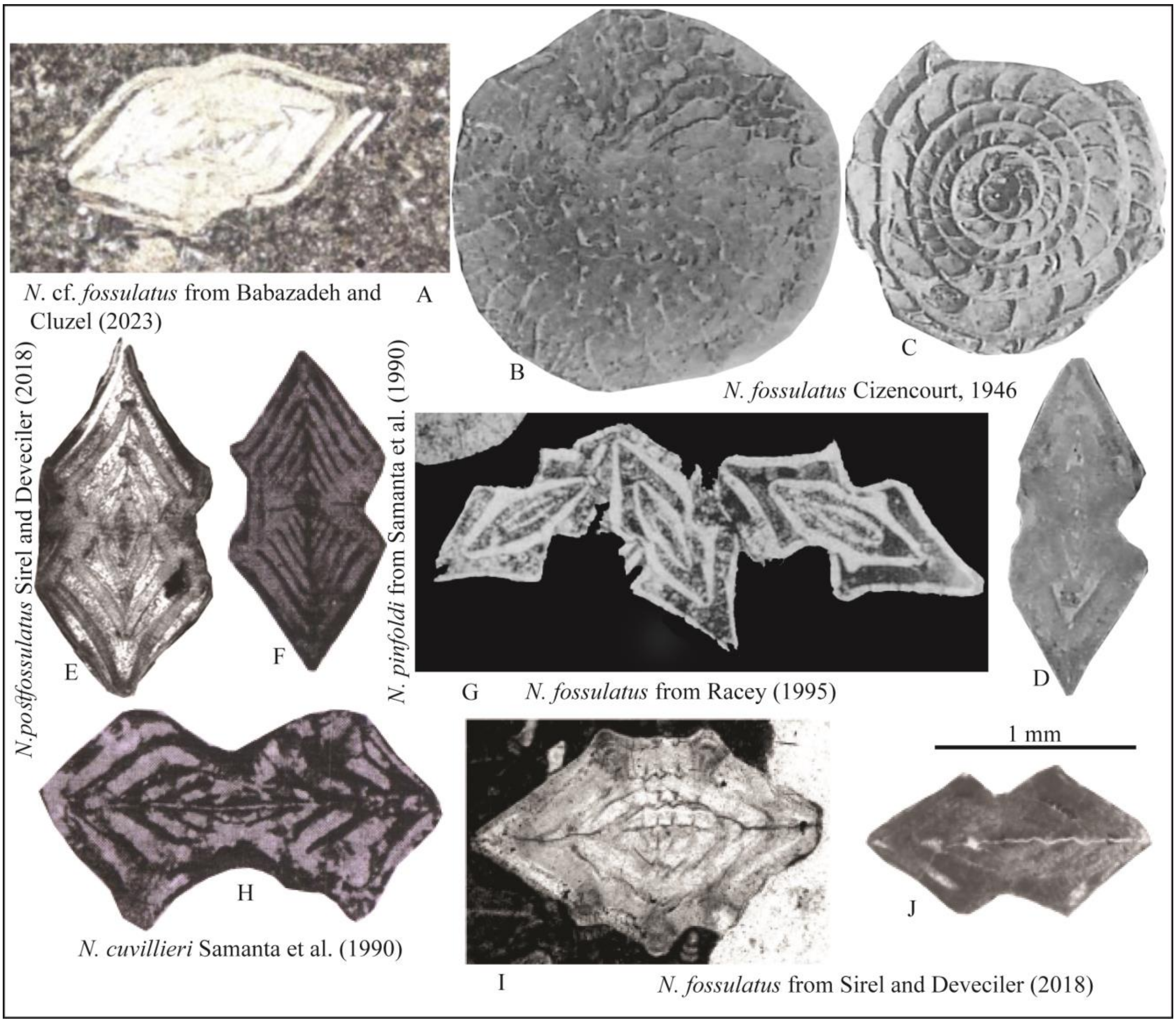

Fig. 2. *Nummulites fossulatus* illustrated from Babazadeh & Cluzel (2023) and comparison with other authors.

2.2 Agglutinated conical foraminifera

Regarding the identification of conical agglutinated larger foraminifera in plate 2 of Babazadeh & Cluzel (2023), we just want to add some general remarks. The way of presentation (image section, magnification) rather accounts for representation of microfacies than taxonomically validatable images. These taxa require a deep revision with more materials because the provided figures are only partly identifiable, and mainly in open nomenclature. The specimens illustrated in plate 2A-C have been assigned to *Coskinolina* Stache, but while attributed to *C. perpera* Hottinger & Drobne, the comparably dense-set and numerous pillars point instead to *C. douvillei* (Davies) (see Hottinger & Drobne, 1980). The specimen illustrated in plate 2D referred to *Daviesiconus* cf. *balsilliei* (Davies) might also belong to *Coskinolina*, possibly representing a sub-axial section of *Coskinolina sistanensis* Schlagintweit and Hadi. The slightly oblique transverse section in pl. 2F of Babazadeh & Cluzel (2023) determined as *Barattolites* cf. *trentinarensis* Vecchio & Hottinger in our opinion does not belong to this species and also the genus remains open. The cone diameter of *Barattolites trentinarensis* does not exceed ~1.0 mm (Vecchio & Hottinger, 2007), and the Iranian specimens measure at least 2.0 mm or more in diameter; also, the radial main partitions are distinctly more close-set whereas the number of intercalary beams is unclear (it could be more than one).

The first author (Babazadeh, 2022) recently published another article on this biostratigraphic important group of LBF with some incorrect and/or doubtful taxonomic identifications, and these forms are also commented herein. From Eocene deposits of the the Mahallat region, located at the border of the Sanandaj-Sirjan zone and Central Iran, Babazadeh (2022) described three new taxa of agglutinated conical larger benthic foraminifera: *Barattolites arghadehensis*, *Daviesiconus mahallatensis*, and *Coleiconus minimus*. Before going into more details, it is worth mentioning that all species have been observed in the same samples and levels with *Coleiconus minimus* having a reduced vertical range (Babazadeh, 2022, fig. 3).

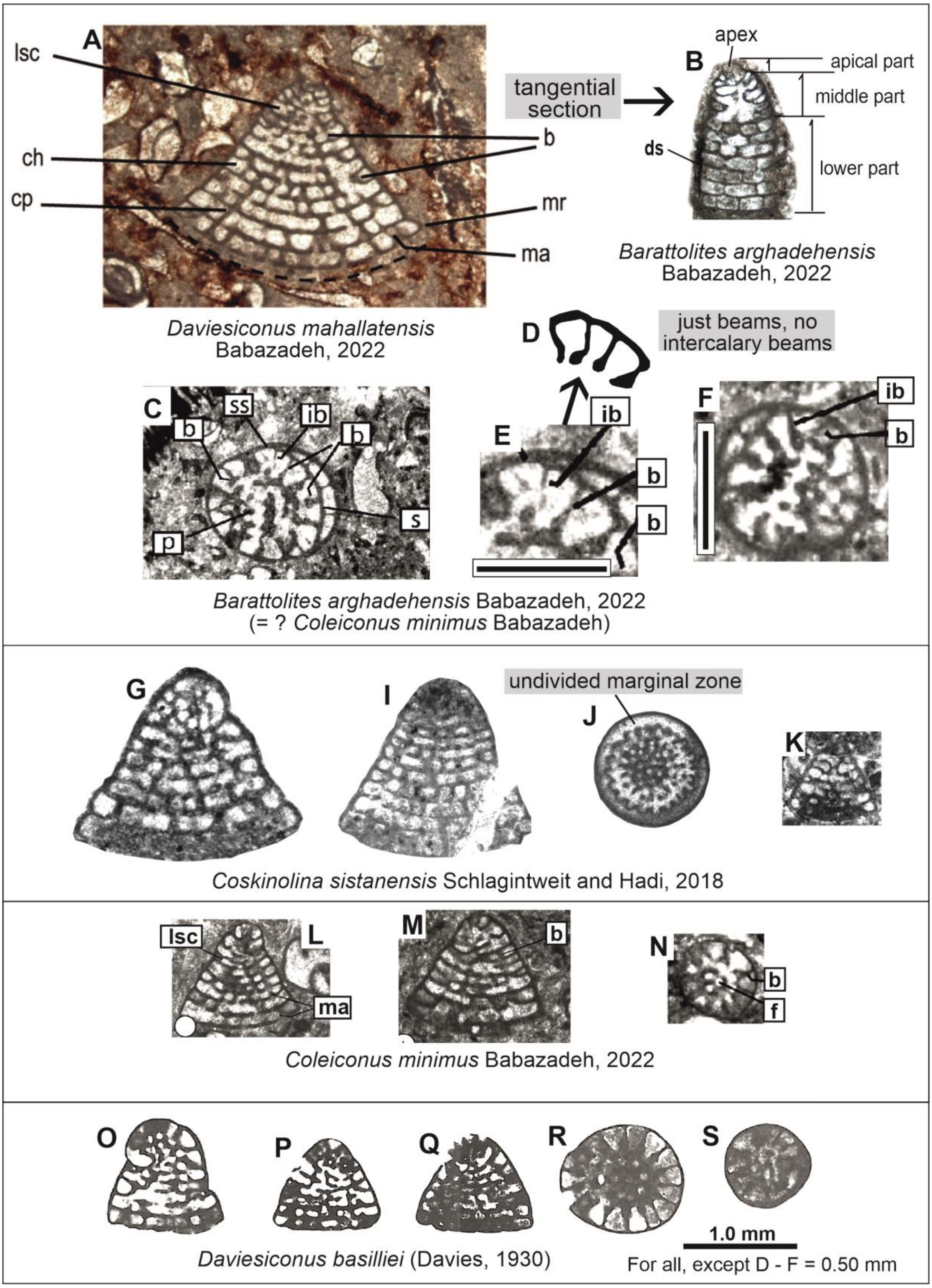

Fig. 3. Taxonomic considerations on *Daviesiconus mahallatensis* Babazadeh, 2022 (**A**), *Barattolites arghadehensis* Babazadeh, 2022 (**B-C, E-F** and interpretation in **D**), and *Coleiconus minimus* Babazadeh, 2022 (**L-N**); comparisons with *Coskinolina sistanensis* Schlagintweit & Hadi, 2018 (**G-K**) and *Daviesiconus balsilliei* (Davies, 1930) (**O-S**). From Babazadeh (2022): **A.** (fig. 6A), **B.** (fig. 6C), **C.** (fig. 8D-E), **F.** (fig. 8E), L (fig. 9B), M (fig. 9I), N (fig. 9E). From Schlagintweit & Hadi (2018): **G.** (fig. 4d), **I.** (fig. 5c); **J.** and **K.** (unpublished). From Hottinger & Drobne (1980): **O.** (pl. 17, fig. 5), **P.** (pl. 17, fig. 10), **Q.** (pl. 17, fig. 3), **R.** (pl. 17, fig. 22), S (pl. 17, fig. 16). Abbreviations: b = beam; ch = chamber; cp = continuous pillars; lsc = last spiral chamber; ma = marginal aperture; mr = marginal rim; p = pillar; s = septum; f = foramen; ss = spiral suture; ib = intercalary beams.

The three genera are not treated in all details herein, instead reference is made above all to Vecchio & Hottinger (2007) and Serra-Kiel et al. (2016) for *Barattolites*, Hottinger & Drobne (1980) for *Daviesiconus*, and to Hottinger & Drobne (1980) and Mitchell et al. (2020) for *Coleiconus*.

Barattolites arghadehensis **Babazadeh, 2022**

The genus *Barattolites* Vecchio & Hottinger, 2007 displays a simple exoskeleton characterized by the lack of rafters, and the presence of one intercalary beam between two radial main partitions (beams). Two oblique transverse sections have been provided (Babazadeh, 2022, fig. 8D-E), re-illustrated herein in Fig. 3E-F. The therein indicated intercalary beams (ib) belong in our opinion to the main radial partitions (beams), therefore pointing to the genus *Coleiconus* and excluding *Barattolites*. In fact, the two mentioned sections might well belong to *Coleiconus minimus*, namely one section closer to the cone base (Fig. 3C) and the other in the juvenile part (Fig. 3F). The holotype (Babazadeh, 2022, figs. 6C-D), as almost all other specimens (figs. 8A-C, H-I) described as axial sections are instead tangential sections. Therefore, the diagram of the basal cone diameter versus 'axial cone diameter' (obviously referring to the cone height in axial sections) with discriminatory field against other taxa is meaningless (Babazadeh, 2022, fig. 5B). Tangential sections do not allow the assessment of either the real cone height or the real cone diameter. Therefore, it is just logical that '*Barattolites arghadehensis'* displays 'a smaller size of the test, narrower apical angle' compared to *B. trentinarensis* Vecchio & Hottinger, 2007 and *B. andhuri* Gallardo-Garcia and Serra-Kiel in Serra-Kiel et al. (2016) (Babazadeh, 2022, p. 282). In fact, the tangential sections of '*B. arghadehensis*' can be well related to (sub) axial sections of *Daviesiconus mahallatensis* Babazadeh (Fig. 3A). In conclusion, we consider *B. arghadensis* as an invalid species representing a mixture of different taxa.

Daviesiconus mahallatensis **Babazadeh, 2022**

Daviesiconus Hottinger & Drobne, 1980 differs from *Coskinolina* Stache, 1875 mainly by the presence of main radial partitions (beams) whereas in the latter the marginal zone is undivided (Fig. 3J). *Coskinolina* displays a pseudo-keriothecal wall while the one of *Daviesiconus* is simple (non-canaliculate) (Hottinger & Drobne, 1980). This feature is often masked by diagenetic alteration and therefore not included in the present discussion the more as none of the specimens illustrated by Babazadeh (2002) shows this type of wall structure also due to the lacking adequate magnifications. Last but not least, transverse sections of *Daviesiconus* and *Coleiconus* are almost indistinguishable as both have rather short primary beams only in case that the pseudo-keriothecal wall of the latter is not preserved or recognizable. With respect to (subaxial) sections of '*Daviesiconus mahallatensis*' such as the holotype, these cannot be differentiated from sections of *Coskinolina sistanensis* Schlagintweit & Hadi, 2018 described from the Eocene of Eastern Iran (Fig. 3A versus 3G-H). In any case *Coskinolina sistanensis* is different with its undivided marginal zone (Fig. 3J) and pseudo-keriothecal wall also not preserved/recognizable in all specimens. It is worth mentioning that the reference of *C. sistanensis* has not been included by the authors and consequently also not been included in the discussion and comparisons. On the other side, the only oblique transverse section of '*D. mahallatensis*' showing short radial main partitions (Babazadeh, 2022, fig. 7E) can be well compared with equivalent sections provided for '*Coleiconus minimus'*. In conclusions, we consider *D. mahallatensis* an invalid species representing a mixture of different taxa.

Coleiconus minimus **Babazadeh, 2022**

These small sized conical forms have been assigned to *Coleiconus* Hottinger & Drobne, 1980 (Fig. 3L-N). The said pseudo-keriothecal wall is not illustrated or discernible in the illustrations provided by Babazadeh (2022). Instead, the specimens of '*Coleiconus minimus*' can be well compared with *Daviesiconus balsilliei* (Davies, 1930), from the Eocene of Pakistan, typically the smaller juvenile forms (Fig. 3O-S). The only illustrated transverse section provided by Babazadeh (2022, fig. 9E) cuts the cone through its early ontogenetic stage (Fig. 3N comparable to section 3S by Hottinger & Drobne, 1980, pl. 17, fig. 16). In conclusion, *C. minimus* is considered as an invalid species, inadequately distinguished from allied forms and might be referable to small specimens of *D. balsilliei* that has besides been described by Babazadeh (2022) from the same material.

CONCLUSIONS

The studies of Babazadeh & Cluzel (2023) and Babazadeh (2022) claim to present new biostratigraphic data and new taxa of LBF both articles require a critical review. For many of the identified index markers of LBF, biometric and morphometric methods important for their taxonomy, as well as oriented thin sections and applied statistical analysis of megalospheric individuals have not been conducted. Biostratigraphic conclusions are deeply dependent on reliable taxonomical identifications necessitating a careful and thorough investigation of the internal and external morphological characters of LBF tests, requiring also the accurate assessment of many biometric parameters. Thus, misidentification of taxa leads to erroneous results in biostratigraphic and paleoenvironmental assessments. In order to solve these issues in a satisfactorily way, it is recommended that the authors provide a correct an unequivocal systematic identification of LBF as a prerequisite for subsequent biostratigraphic and microfacies analyses and implications. It is indispensable to apply biometric methods for each taxon and to compare them with the original descriptions to provide a detailed and reliable taxonomic account. The three new orbitolinid-coskinolinid taxa described from the Eocene of Iran are all considered to represent invalid species, inadequately distinguished from allied forms, partly with incorrect generic assignments, taxonomic mixings and partly incorrect interpretation of structural elements as well as section planes.

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