

# A note on some Eocene benthic foraminifers of West and Central Iran, with remarks on palaeontology and biostratigraphy: Reply to Hadi and Schlagintweit comment (2024)<sup>☆</sup>

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**Abstract** – This article is a reply to the comment by Hadi and Schlagintweit (2024, *Acta Palaeontologica Romaniae* 2: 17–2) on the article by Babazadeh and Cluzel (2023, *Bulletin de la Société Géologique de France* 194: 1–24) about the internal structure and stratigraphic range of some benthic foraminifers from the Eocene carbonate deposits in the Shahr-e Kord and Mahallat regions of Iran. The comment focuses on the diagnosis of a limited number of species, and the introduction of new species of Eocene agglutinated foraminifers from the Mahallat region. In this reply, the disputed data are briefly reviewed and discussed in more detail. The interpretation of benthic foraminifers is based on their morphological variability and comparisons. Here the authors use re-illustrations of the types of nummulitids (*Nummulites*), orbitolinids (*Coskinolina*, *Daviesiconus*, *Coleiconus* and *Barattolites*), and other comparative material to confirm their determinations. Therefore, the hyaline foraminifers constitute the main subject of investigation, whereas the alveolinids are of secondary importance.

**Keywords:** Benthic foraminifers / Eocene / *Nummulites* / Orbitolinidae / Iran

## 1 Introduction

Babazadeh and Cluzel (2023) described the internal structure and stratigraphic range of several benthic foraminifers from Eocene carbonate deposits at three outcrops of the Shahr-e Kord and Mahallat regions in West and Central Iran. Hadi and Schlagintweit (2024) have commented on the correctness of the identification of a number of nummulitids and orbitolinids and considered their article superficial. However, the article in question reported the recognition of 44 species belonging to 28 genera, while Hadi and Schlagintweit (2024) have commented on only 10 species. In addition, the article in question was intended as a general introduction to certain foraminifer species and their accumulation in different facies and environments, without discussing systematics, which was considered out of scope. This paper displays thin-section data along with isolated forms of disputed taxa including hyaline and agglutinated foraminifers. Their comment on the introduction of new species of agglutinated foraminifers of the Eocene deposits from Mahallat region is briefly reviewed and discussed in this reply.

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The data are discussed in two distinct parts. In the first part, the comparison of species of hyaline foraminifers is described on the basis of their microscopic characteristics and structural comparison of *Nummulites*, which are reassessed in the light of their numerous records. In the second part, the new agglutinated foraminifers (coskinolinids) are described on the basis of their internal structures.

Please refer to the [online supporting information files available at for all figures, Plates and tables cited in this article.](#)

## 2 Biostratigraphy

The co-occurrence of hyaline foraminifers such as *Nummulites globulus* Leymerie, *N. atacicus* Leymerie and *Nummulites fossulata* de Cizencourt indicates an early Eocene age. This corresponds to the foraminiferal association of Assemblage Zone A in the North Gahrou section (Babazadeh and Cluzel, 2023). It is also correlated with SBZ 8 of Serra-Kiel *et al.* (1998).

An association of *Nummulites cf. perforatus* (de Montfort), *Nummulites ptukhiani* Kacharava, and *Nummulites mala-tyaensis* Sirel can be assigned to the Bartonian. This association corresponds to the Assemblage Zone B in the North Gahrou section (Babazadeh and Cluzel, 2023) and correlates with SBZ 17 and 18 of Serra-Kiel *et al.* (1998).

The co-occurrence of agglutinated conical foraminifera such as *Barattolites arghadehensis*, *Coleiconus minimus*, and

*Daviesiconus mahallatensis*, with alveolinid species such as *Alveolina cremae* Checchia-Rispoli, *Alveolina decastroii* Scotto Di Carlo, *Alveolina distefanoi* Checchia-Rispoli, *Alveolina levantina* Hottinger, and *Alveolina frumentiformis* Schwager indicates a middle–late Cuisian age (sensu Hottinger and Schaub, 1960) which corresponds to SBZ 11-12 (Serra-Kiel *et al.*, 1998; Babazadeh, 2022).

### 3 Discussion and Results

#### 3.1 Hyaline foraminifers (Nummulites)

##### 3.1.1 *Nummulites globulus* Leymerie and *N. atacicus* Leymerie (Pl. S1)

Regarding *Nummulites globulus* Leymerie and *N. atacicus* Leymerie, Hadi and Schlagintweit (2024) quoted: “based on some common features such as test size, surface ornamentation, and arrangement of internal structures; however neither figure I nor K (in Plate 3 of Babazadeh and Cluzel, 2023) shows the spiral intervals somewhat equal according to the number of septa and whorls per radius”. They also stated about *N. atacicus* Leymerie: “These parameters measured for *N. atacicus* Leymerie four whorls in radius of 1.75 —more likely refers to *N. globulus* Leymerie. However, for a reliable identification of *Nummulites*, we believe that these data are still unsuitable and inadequate”.

Comparison of chamber values (number of chambers per spiral whorl) from the literature compared to the studied materials.

	Number of chambers per spiral whorl				
	C1	C2	C3	C4	C5
Blondeau (1972)	8-12	16-20	20-24	24-32	
Tosquella <i>et al.</i> (1990)	12-14.	19-20	22-23	27-28.	
Racey (1995)	10	18	23	27	
Abdulsamad (2000)	9	14	18	24	
Saraswati <i>et al.</i> (2000)	9	17-18	22-23		
Saraswati <i>et al.</i> (2012)	10	19-20	25-24	33	
Ahmad <i>et al.</i> (2021)	10	18	20	29	37
This study GH21-2		17-18	23-24	28-29	
This study GH 26-1					
This study GH 27	9-10	17-18	21-22		

Comparison of radius of successive whorls (distance of successive whorls from the centre = W) from the literature to the studied materials.

	Radius of successive whorls in mm				
	W1	W2	W3	W4	W5
Racey (1995)	0.36	0.61	0.92	1.14	
Abdulsamad (2000)	0.30	0.59	0.85	1.11	1.22
Saraswati <i>et al.</i> (2000)	0.125-0.135	0.28-0.30	0.50-0.52	0.65-0.75	
Saraswati <i>et al.</i> (2012)	0.225	0.350	0.475	0.590	
Ahmad <i>et al.</i> (2021)	0.42	0.63	0.86	1.04	1.24
This study GH21-2	0.33				
This study GH26-1	0.28	0.57	0.87	1.18	
This study GH27	0.37	0.50	0.72		

The present specimens (*Nummulites globulus* Leymerie) show some similarities to those described by Blondeau (1972), Racey (1995), and Ahmad *et al.* (2021) based on chamber counts and spiral intervals. They are also comparable to samples documented by Hamam (1975), Tosquella *et al.* (1990), and Abdulsamad (2000), based on proloculi size (Pl. S1). The documented samples differ from the specimens collected by Saraswati *et al.* (2012) and Ahmad *et al.* (2021) in the size of proloculi. They also differ from samples collected by Saraswati *et al.* (2012) in spiral intervals of whorls such that the sample recorded by Saraswati *et al.* (2000, 2012) does not fall into the shaded area (Fig. S1B). While the chamber values of Saraswati *et al.* (2000, 2012) are almost the same as that of the studied materials. As a result, it seems that the chamber values (C) in the samples of Blondeau (1972), could overlap both the samples documented by and our materials. Stratigraphic range: early Eocene (SBZ 8, Serra-Kiel *et al.*, 1998)

##### 3.1.2 *Nummulites atacicus* Leymerie (Pl. S1)

Chamber values (C) in each whorl from Racey (1995), and Ahmad *et al.* (2021) compared to the present materials.

	Number of chambers per whorl			
	C1	C2	C3	C4
Racey (1995)	10	17	22	16
Sirel and Deveçiler (2018)	11-13	18	24	25
Ahmad <i>et al.</i> (2021)	8	16	22	30
This study GH 25-1	9-10	16-17	23-24	
This study GH 33	7-8	16-18	23-25	26-28

Comparison of radius of successive whorls (W) from Racey (1995) and Ahmad *et al.* (2021) with the present materials.

	Radius of successive whorls in mm				
	W1	W2	W3	W4	W5
Racey (1995)	0.54	0.98	1.42	1.80	2.10
Ahmad <i>et al.</i> (2021)	0.58	0.92	1.44	2.10	2.30
This study GH25	0.56	0.875	1.35	1.70	2
This study GH33	0.6	0.895	1.48	1.85	2.2

The present specimens (*Nummulites atacicus* Leymerie) have the similar chamber counts as the sample published by Racey (1995), and Ahmad *et al.* (2021). They are almost in the same shaded field as the *N. atacicus* Leymerie described by Schaub (1981), Racey (1995), and Ahmad *et al.* (2021) (Fig. S1E). Stratigraphic age is attributed to early Eocene (SBZ 8, Serra-Kiel *et al.*, 1998)

##### 3.1.3 *Nummulites cf. fossulata* de Cizencourt (Pl. S2)

In the case of *Nummulites cf. fossulata* de Cizencourt, Hadi and Schlagintweit (2024) stated the following: “*Nummulites fossulata* de Cizencourt is identifiable based on the deeply biumbilicate lenticular test resulting in a distinctive central

cavity in axial sections such that the last two whorls show a “dumbbell” shape (e.g., Cizencourt 1946, Fig. 1; Racey 1995, Pl. 1, Fig. 26.)” And also they stated that “instead of insisting on the occurrence of *N. cf. fossilatus*, the authors (Babazadeh and Cluzel 2023) should consequently have included comparison and discussion with *N. pinfoldi* Davies, *N. postfossilatus* Sirel and Deveciler and *N. cuvillieri* Sander”.

There are similarities and differences between this species and other similar species, for example *Nummulites postfossilatus* Sirel and Deveciler, *Nummulites pinfoldi* Davies and *Nummulites cuvillieri* Sander, which are described below:

In the recorded specimens (samples GH34 and GH35), the chamber values (C) and the radii of successive whorls (W) are as follows (Fig. S2):

	Number of chambers per whorl			
	C1	C2	C3	C4
This study GH 34	6-7	10-11	14-15	18-19
This study GH 35	?	12-13	14-15	17-18

  

	Radius of successive whorls in mm			
	W1	W2	W3	W4
This study GH34	0.18	0.37	0.59	0.83
This study GH35	0.19	0.32	0.52	0.73

The recorded specimens are comparable to *Nummulites fossilata* de Cizencourt as described by Racey (1995) based on chamber values in coiling whorls (Fig. S2). They are comparable to *Nummulites fossilata* de Cizencourt and *Nummulites cuvillieri* Sander, on the diameter and thickness of the test diameter (1.5–1.7 mm) and thickness (0.8–0.85 mm). However, it seems that the recorded specimens are more inflated than the *Nummulites postfossilatus* Sirel and Deveciler and *Nummulites fossilata* de Cizencourt, as reported by Sirel and Deveciler (2018) and Racey (1995), respectively.

On the other hand, Hadi and Schlagintweit (2024) stated that “the difference in the ratio of diameter to thickness (D/T) is the determining factor in Racey’s specimen and the thickening septum and septa in the equatorial sections are noteworthy” (Racey, 1995).

It should be said that the parameter (D/T) in the samples introduced by other researchers (Zhang *et al.*, 2013; Boudagher-Fadel *et al.*, 2015; Sirel and Deveciler 2018) is very different from Racey’s sample (1995) and is closer to our measurement (Fig. S2). On the other hand, when referring to the published articles of Racey (1995) and Sirel and Deveciler (2018), the thickness of the septum and septa is not considered as a key parameter, but the size of the test and the opening of the coiled whorls are considered more important. Nevertheless, the thickened septum is observed in the equatorial section (Pl. S2, Figs. C, D).

Finally, Hadi and Schlagintweit (2024) accepted only one figure illustrated by Racey (1995) (Pl. 1, Fig. 26) and did not accept our determination (Babazadeh and Cluzel, 2023), but several specimens of different authors (Zhang *et al.*, 2013; Boudagher-Fadel *et al.*, 2015; Sirel and Deveciler, 2018; Sari, 2021) which show various forms of the axial section of this species were illustrated in this article (Pl. S2).

Meanwhile, considering that the axial section of *Nummulites fossilata* de Cizencourt is unique among other *Nummulites* species. It is easy to make a decision about this species. Therefore, author referred this specimen to *Nummulites cf. fossilatus* de Cizencourt, on the basis of limited material. Stratigraphic age: early Eocene.

### 3.1.4 Nummulites cf. perforatus (De Montfort) (Pl. S3)

Regarding *Nummulites cf. perforatus* (de Montfort), Hadi and Schlagintweit (2024) stated: “*N. cf. perforatus* (de Montfort) is documented by sub-axial and sub-equatorial sections with figures that show an incomplete view of the test (Plate 3 G-H in Babazadeh and Cluzel, 2023). The unsuitable sections allow only an estimation of the biometric data, thus leading to inaccurate data rather than reliable facts. In fact, a correct identification is practically impossible based solely on A-forms with poor preservation and random sections”.

Comparison of chamber values (C) in each whorl from the literature with the the present study.

	Number of chambers per whorl				
	C1	C2	C3	C4	C5
Blondeau (1972)			20-24		
Racey (1995)	8	12	17	23	29
Costa <i>et al.</i> (2013)	7-8	15-16	19-20/22-23	23-24/20-21	
Sirel and Deveciler (2018)	11	19	26	30	31
This study GH 40	7-8	16-18	24-26	27-29	
This study GH 51-3	7-8	15-16			
This study GH 51-4	7-8	15-16	21-24		

Comparison of radius of successive whorls (W) from Racey (1995) with the studied materials.

	Radius of successive whorls in mm					
	W1	W2	W3	W4	W5	W6
Racey (1995)	0.700	1.160	1.500	1.860	2.160	2.520
This study GH 40	0.750	1.062	1.450	1.875	2.140	
This study GH 51.3	0.750	1.100	1.550	2.080		
This study GH 51.4	0.800	1.140	1.500	1.875		

The studied specimens show similarities to those described by Racey (1995) based on spiral intervals (W/R). They are also comparable to samples documented by Racey (1995) and Sirel and Deveciler (2018), based on proloculi size (Pl. S3). They differ from the material described by Sirel and Deveciler (2018) in having fewer chambers in each coiling whorl. The chamber values in coiling whorl of studied samples are completely comparable to each other and also are comparable to the material described by Costa *et al.* (2013). Meanwhile, the chamber values in the third coiling whorl (C3) of Blondeau’s material are comparable to those of the studied samples. In contrast, the chamber values of the material described by Sirel and Deveciler (2018) differ significantly with those of Racey (1995). However, their figured megalospheric specimens

resemble more to each other. The stratigraphic age is considered to SBZ 17 (early Bartonian).

### 3.1.5 *Nummulites malatyaensis* Sirel, (Pl. S3)

Regarding *Nummulites malatyaensis* Sirel, Hadi and Schlagintweit (2024) stated: “This species was first described Sirel (2003), and thereafter recorded in the works of Deveciler (2014) and Sirel and Deveciler (2018) from Turkey, with a characteristic small proloculi (0.100–0.275 mm in diameter) that is followed by numerous sub-rectangular chambers; their height is greater than width”. They further stated that “according to Babazadeh and Cluzel (2023), the measured size of the proloculi ranges from 315 to 420  $\mu\text{m}$  (Pl. 3D-E) with relatively isometric chambers (see Pl. 3D-E)”.

Comparison of chamber values (C) in each whorl from Sirel (2003), Deveciler (2014), and the studied materials.

	Number of chambers				
	C1	C2	C3	C4	C5
Sirel (2003)			28-32		
Deveciler (2014)			32-36		
This study GH92-1			30-32		
This study GH92-2			28-32		
This study GH93-2			28-32		

Radius of successive whorls (W) (Fig. S1J):

	Radius of successive whorls in mm			
	W1	W2	W3	W4
This study GH 90-2	0.45	0.58	0.72	1.07
This study GH 92-2	0.41	0.56	0.76	
This study GH 93-2	0.50	0.62	0.87	1.04

When more samples were tested, the following information was obtained:

The diameter of the test ranges from 1.30 mm to 2.6 mm and the thickness 1.5–1.75 mm. The size of the proloculi is 0.19 – 0.35 mm, and followed by rectangular chambers, such that their height is greater than their width (Pl. S3, Fig. E, sample GH 92-2). The radial septal filaments and a central knob are visible on the tangential section of the test (Pl. S3, Fig. D, sample GH 92-1). The thick pillars are located in the centre of the test (Pl. S3, Figs. A and C, samples GH 90-1 and GH 91). The bilocular embryonic chamber is obvious in equatorial section (Pl. S3, Fig. B, sample GH 90-2). There are 5-6 spiral whorls in an axial section measuring 2.6 mm in diameter (Pl. S3, Fig. A, sample GH 90-1).

The size of megalosphere and the test thickness of test are compatible with Deveciler’s specimens (2014). The general outline of the axial section of the megalospheric form is slightly oval to subrectangular with a large central knob comparable to Sirel’s samples (Sirel, 2003; Sirel and Deveciler, 2018) (Pl. S3). The spire thickness is uniform across all whorls. Overall the data are more consistent with the specimens of Turkey (Deveciler 2014, Sirel and Deveciler, 2018). This species is associated with *Chapmanina gassiensis*,

*Silvestriella tetraedra*, *Halkyardia minima*, *Gyrodinella magna*, etc.

Remarks: the size of the proloculi (A-form) varies between 0.25mm (250  $\mu\text{m}$ ), and 0.35 mm (350  $\mu\text{m}$ ) (Fig. 9, Babazadeh and Cluzel, 2023), whereas Hadi and Schlagintweit (2024) reported a range between 315 and 420  $\mu\text{m}$ . Stratigraphic range: Bartonian.

### 3.1.6 *Nummulites ptukhiani* Kacharava (Pl. S4)

Regarding *Nummulites ptukhiani* Kacharava, Hadi and Schlagintweit (2024) stated: “The identification of reticulate *Nummulites* such as *N. ptukhiani*, is more complex than that of other forms during the Bartonian (Cotton *et al.*, 2015). This species is characterised by having a large proloculi up to 400  $\mu\text{m}$  in many recent works throughout the Tethys (Cotton *et al.*, 2015; Saraswati *et al.*, 2017; Özcan *et al.*, 2019). The size of the proloculi is a key parameter for discriminating other species such as *N. gargaricus* and *N. hormoensis*, which belong to the *N. fabianii*-lineage with much smaller proloculi (Cotton *et al.*, 2015; Saraswati *et al.*, 2017). Herein, the diameter of proloculi is measured as  $\sim 246 \mu\text{m}$  in Plate 3A of Babazadeh and Cluzel (2023).”

About *Nummulites ptukhiani* Kacharava, Hadi and Schlagintweit (2024) emphasized a lot on the large size of the proloculi (up to 400  $\mu\text{m}$ ) based on the findings of Cotton *et al.*, 2015, Saraswati *et al.* (2017), and Özcan *et al.* (2019). On the other hand, based on the articles published by Schaub (1981), Papazzoni (1998), Boukhary *et al.* (2005), Shukla (2008) and Saraswati *et al.* (2017), the size of the proloculi of this species is: 0.15-0.22 mm, 0.13-0.3 mm (mean 0.16-0.22mm), 0.1-0.15 mm, 0.2-0.5 mm and 0.375-0.45mm respectively (Pl. 2, Figs. B, C, D from Saraswati *et al.*, 2017).

According to Cotton *et al.*, 2015, the size of proloculi (P1= vertical proloculi height and P2= horizontal proloculi height), for three populations (TDP2, TDP 18 and TDP 4) are:

TDP 4: P1= 464-660  $\mu\text{m}$ , P2= 507-735  $\mu\text{m}$ , TDP 18: P1= 284-443  $\mu\text{m}$ , P2= 376-584  $\mu\text{m}$ , TDP2: P1=204-329  $\mu\text{m}$ , P2= 275-458  $\mu\text{m}$ .

In the studied materials, the vertical proloculi height ranges from 250 to 285  $\mu\text{m}$  and the horizontal proloculi height 280-375  $\mu\text{m}$ .

Based on Papazzoni (1998), the specimens of *Nummulites ptukhiani* Kacharava from western Europe and eastern Mediterranean have a much smaller protoconch (0.15–0.30 mm in diameter) and a spire of regularly increasing height. According to Cotton *et al.*, 2015, the proloculi measurements of *Nummulites ptukhiani* Kacharava vary among published populations (TDP2, TDP18 and TDP4). Meanwhile, Saraswati *et al.* (2017) stated that the size of proloculi of the reticulate species from India is larger than that of the corresponding species in western Tethys. Therefore from the west to the east of the Neo-Tethys, changes in the size of the embryonic chamber are very evident. Considering that the studied area is located in the middle part of the Neo-Tethys, it likely underwent such changes. Then, it is not possible to be satisfied only with the size of proloculi; therefore, it is necessary to test other parameters such as the radius of successive whorls, chamber values in each whorl, development and growth of successive whorls and size of the test. It is noteworthy that the development of successive spiral whorls in

our materials, is relatively uniform and constant throughout the spiral whorls in our materials.

Comparison of chamber values (C) in each whorl from the literature with the studied materials:

	Number of chambers per whorl			
	C1	C2	C3	C4
Papazzoni (1998)	8-9	16-17	19-20	
Abdulsamad (2000)	8	13	16	19
Boukhary <i>et al.</i> (2005)	7-9	13-15	17-18	
Saraswati <i>et al.</i> (2017) Pl.2, p. 202	7	17-18	25-26	
Cotton <i>et al.</i> (2015) TDP 4	7-9	13-17	19	
Cotton <i>et al.</i> (2015) TDP 18	6-8	10-15	17-21	
Cotton <i>et al.</i> (2015) TDP 2	6-10	13-19	20-23	
This study GH 51-1	7-8	15-16	21-22	
This study GH 51-2	8-9	15-16	22-24	
This study GH 52	6-7	12-13	19-20	

Radius of the successive whorls (W) from the specimens collected by Boukhary *et al.* (2005, Pl. 4, Figs. 5, 6, 8) compared to the present study (Fig. S1K):

	Radius of successive whorls in $\mu\text{m}$				
	WD	W1	W2	W3	W4
Boukhary <i>et al.</i> (2005)	~120	~ 210	~ 460	~ 700	~ 1120
Boukhary <i>et al.</i> (2005)	~110	~ 250	~ 440	~ 680	~ 980
This study GH 51-1	250	565	890	1375	
This study GH 51-2	375	750	1000	1310	
This study GH 52	310	750	1200	1650	

#### Remarks:

The chamber values (C) in the populations TDP2 of Cotton *et al.*, 2015 have more overlap with the other two populations. This seems to indicate the average abundance of chambers. Therefore, the samples collected by Papazzoni (1998), Boukhary *et al.* (2005), Saraswati *et al.* (2017) and present specimens are also included in this range.

The radius (R) of successive whorls in the samples of Boukhary *et al.* (2005) is smaller than those reported by the present authors and Cotton *et al.*, 2015). Of course, this issue is worth considering. Stratigraphic range: SBZ 17-18 (Bartonian).

### 3.2 Agglutinated conical foraminifera:

Regarding agglutinated conical foraminifera, Hadi and Schlagintweit (2024) quoted:

These taxa require a thorough revision with additional materials because the provided figures are only partly identifiable, and mainly in open nomenclature. They stated that this method of presentation is indicative of sedimentary facies rather than useful for classification.

In response, it should be noted that the title of the article by Babazadeh and Cluzel (2023) is mainly about the facies, sedimentary environment and the introduction of the foraminiferal biozonation, of the Jahrum Formation.

Therefore, the number of samples analysed microscopically was sufficient. In Fig. 5B of Babazadeh's article (2022) according to the statistical community, the distribution graph of the numerous specimens was drawn and the best-fit line was proposed based on the term flattening index. So species descriptions and systematic taxonomy was beyond the scope of the article by Babazadeh and Cluzel (2023). In any case, are provided detailed explanations below:

Hadi and Schlagintweit (2024) also stated: "the specimens illustrated in Plate 2A-C (Babazadeh and Cluzel, 2023) have been assigned to *Coskinolina* Stache, but while attributed to *C. perpera* Hottinger and Drobne, the comparably dense-set and numerous pillars point instead to *C. douvillei* (Davies) (see Hottinger and Drobne, 1980). The specimen illustrated in Plate 2D referred to *Daviesiconus* cf. *balsilliei* (Davies) might also belong to *Coskinolina* Stache, possibly representing a sub-axial section of *Coskinolina sistansensis* Schlagintweit and Hadi".

In response to Hadi and Schlagintweit (2024), the genus *Coskinolina* Stache, 1875 is characterised by a high agglutinated conical test with discontinuous pillars in the internal structure without partitions (beams, intercalary beams and rafters).

In figure A of Plate S5 in this article, the test has a thick wall and thick internal structure with few and loose pillars which present an irregular arrangement. The conical shell is slightly broader than height and never double. This morphology corresponds to *Coskinolina perpera* (Hottinger and Drobne, 1980). By contrast, according to Hottinger and Drobne, 1980, the basal cone diameter is about twice as large as high in the microspheric shells of *C. douvillei* (Davies). Therefore, in the figure A1 of Plate S5 (sample AS46), has axial and basal cone diameters of 0.85mm and 1mm respectively, and figure A2 has axial and basal cone diameters of 1.625mm and 1.755 mm respectively.

In this article (Pl. S5, Figs. B and C, samples AS38 and AS50), a similarity of the distribution of pillars and their low number at the basal cone of our specimens (see Fig. B in Pl. 2, refer to Babazadeh and Cluzel, 2023), is clearly shown with the samples of other researcher such as Hottinger's specimens (2007) (Fig. D in this article). These specimens cannot be *Coskinolina douvillei* (Davies) (as Hadi and Schlagintweit, 2024 stated), because the shell dimensions is comparable to *Coskinolina perpera* Hottinger and Drobne. Moreover, the distribution of pillars is irregular and its number is significantly fewer than ten.

Figures E, F, G and H in Plate 5 (in this article), show a *Daviesiconus* Hottinger and Drobne (Figs. D and E in Pl. S2, refer to Babazadeh and Cluzel, 2023).

In figure E of Pl. S5, in this article, the test has an axial cone diameter of 1.25 mm and the basal cone diameter is about 1.25 mm. In fact, the conic shell is as broad as high. This specimen is almost isometric and has a flattening index (Rb/a) of approximately 1. Perhaps due to the equality of the width and height of the conic shell or the presence of sub-axial section, Hadi and Schlagintweit (2024) thought that this sample can be *Coskinolina sistansensis*, but another parameter such as radial partitions should also be considered.

The genus *Daviesiconus* Hottinger and Drobne, 1980 is distinguished from the genus *Coskinolina* Stache by the presence of radial partitions (beams) (Hottinger and Drobne,

1980). In addition, the value of flattening index and the isometric form of the conic shell of *Daviesiconus balsilliei* are other significant factors in this case. The first radial partitions (beams) are obviously observed in the transverse section and illustrated in fig. E, Plate 2 (refer to Babazadeh and Cluzel, 2023) or in fig. F of Plate S5 in this article. Other samples (Fig. G, Pl. S5 in this article) of this species show the first radial partitions (beams). The illustrated figures (Figs. E, F, and G) in Plate S5 cannot be *Coskinolina sistansensis* (as Hadi and Schlagintweit 2024 stated), due to the presence of radial partitions (beams).

Hadi and Schlagintweit (2024) also declared that: “the slightly oblique transverse section in Pl. 2F of Babazadeh and Cluzel (2023) determined as *Barattolites* cf. *trentinarensis* Vecchio and Hottinger in our opinion does not belong to this species and also the genus remains open. The cone diameter of *Barattolites trentinarensis* Vecchio and Hottinger does not exceed ~1.0 mm (Vecchio and Hottinger, 2007), whereas, the Iranian specimens measure at least 2.0 mm in diameter. Additionally, the radial main partitions are distinctly more close-set whereas the number of intercalary beams is unclear (it could be more than one)”.

According to Vecchio and Hottinger (2007), the axial cone diameter of *Barattolites trentinarensis* Vecchio and Hottinger reaches approximately 3 mm in microspheric specimens and around 2 mm in megalospheric specimens. The flattening index (Rb/a) is 0.5 and 0.7 for megalospheric and microspheric specimens respectively. Accordingly, the basal cone diameter measured 1 mm for A-form and 2.1 mm for B-form. There is a contradiction here because Hadi and Schlagintweit (2024) stated that the cone diameter of *Barattolites trentinarensis* in Vecchio and Hottinger’s samples (2007) does not exceed 1 mm, and in Iranian samples it reaches 2 mm or more (without introducing reference for Iranian samples).

Figure H in Plate 5 (sample 80, in this article), shows an oblique section of *Barattolites* with a slope of about 75° relative to the axis of the cone, such that it is very comparable to an equatorial section. The basal cone diameter reaches up to 2 mm. This measurement is comparable to the measured value of the specimen of Vecchio and Hottinger (2007). Meanwhile, there is no mention of Vecchio and Hottinger (2009) in their reference list. The parameters such as pillars, chamber lumen, septum, septal suture, beams and intercalary beams can be observed in this section. Due to the low expansion of intercalary beams, we cannot confirm the identification of this species; therefore, we prefer to designate our specimen as *confer*.

Figure I in Plate S5 (sample AS80, in this article), shows a subaxial section of *Barattolites*. The first radial partitions (beams) are obviously observed in this illustrated specimen. The maximum axial cone diameter is 2.25 mm with a basal cone diameter of 1.87 mm. The flattening index (Rb/a) is 0.83.

Figure K in Plate S5 (sample AS41, in this article), represents a megalospheric form of juvenile *Barattolites*. The early growth stage has a megalosphere which ranges from 0.18 to 0.25 mm in diameter. The conical shell has an axial cone diameter of 1.15 mm and the basal cone diameter of about 0.875 mm.

The flattening index (Rb/a) is 0.58. The Hottinger’s specimen (2007) from figure L (Pl. S5) in this article, represents an oblique centred section of juvenile *Barattolites*

cf. *trentinarensis* Vecchio and Hottinger. It has an axial cone diameter of about 1.125 mm and the basal cone diameter of about 0.865 mm with a flattening index of about 0.76. Based on the information obtained from the illustrated specimens in figures I, J, and K, the flattening index is less than one and their distribution are plotted below the best-fit line in the field of elongated forms.

### 3.2.1 *Barattolites arghadehensis*

Regarding *Barattolites arghadehensis* Babazadeh, Hadi and Schlagintweit (2024) stated: “It is worth mentioning that all species have been observed in the same samples and levels with *Coleiconus minimus* Babazadeh, having a reduced vertical range (Babazadeh, 2022, Fig. 3). The three genera are not treated in all details herein, instead, reference is made above all to Vecchio and Hottinger (2007) and Serra-Kiel *et al.* (2016) for *Barattolites*, Hottinger and Drobne (1980) for *Daviesiconus*, and to Hottinger and Drobne (1980) and Mitchell *et al.* (2022) for *Coleiconus*”. They also noted: “All species have been observed in the same samples and levels with *Coleiconus minimus* Babazadeh having a reduced vertical range (Babazadeh, 2022, Fig. 3)”.

In response, referring to Figure 3 (in Babazadeh, 2022), *Daviesiconus mahallatensis* Babazadeh and *Barattolites arghadehensis* Babazadeh first appear in layer 216 and layer 217, respectively. But their frequenc occurred in member C from upper horizon (Fig. S3 in this article).

Then Hadi and Schlagintweit (2024) further stated: “The genus *Barattolites* Vecchio and Hottinger, 2007 displays a simple exoskeleton characterised 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 Pl. S6E-G. 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* Babazadeh, namely one section closer to the cone base (Fig. 3C, in Hadi and Schlagintweit, 2024) and the other in the juvenile part (Fig. 3F, in Hadi and Schlagintweit, 2024)”.

Figures A, B, and C (Pl. S6, in this article) correspond to Vecchio and Hottinger (2007: Figs. 16i, 16f, and 14), are all oblique sections based on the statements of Vecchio and Hottinger (2007). These clearly show the shorter radial partitions (intercalary beams) are present in all these sections. So it can be concluded that the intercalary beams can be observed in oblique and basal- oblique sections. In the figures D1, D2, E1 and E2 (refer to Babazadeh, 2022, sample 237) and the figures E, F and G (in this article), the intercalary beams are clearly observed in the oblique sections. All these illustrated figures confirm the genus *Barattolites*.

Figures H, I, J, K and L (Pl. S6 in this study) represent the section parallel to the cone axis, approximately axial section, and oblique/ tangential section. The values of axial and basal cone diameters are 1–1.06–1.87 and 0.75–0.75–1.25 respectively. They are plotted below the best-fit line (Fig. S4A) and the flattening index is 0.67–0.70–0.75. Finally, the result is consistent across both tangential and semi-axial sections. *Barattolites arghadehensis* Babazadeh differs from the *B.*

*trentinarenis* Vecchio and Hottinger and *B. andhuri* Gallardo-Garcia and Serra-Kiel, in having a smaller test size, and the small proloculi followed by the low-trochospiral early chambers (Pl. S6, Figs. H and I).

Hadi and Schlagintweit (2024) stated that “The holotype (Babazadeh, 2022, Figs. 6C–D), as almost all other specimens (Figs. 8A–C, H–I) described as axial sections are actually tangential”.

Figures 6C–D (Babazadeh, 2022) are not tangential sections, as evidenced by the presence of continuous pillars (Pl. S6N, in this article). Figures 8A–C (refer to Babazadeh, 2022) show sub-axial to oblique section, whereas figures 8H–I represent tangential sections. For comparison, Hadi and Schlagintweit (2024) can refer to Figs. 15b (p. 526) and 17g–17i (p. 528) (Vecchio and Hottinger, 2007). The tangential sections are well shown there.

In my opinion, more thin sections from the original sample allowed excluding the presence of “intercalary beams” that characterize the genus *Barattolites* and this characteristic confirms a generic assignment of this new species. The doubts mainly concern the difficulty to establish whether the radial partitions are produced by invagination of the chamber floor; if so, the examined specimen should be comparable to *Daviesiconus*. Stratigraphic range: SBZ 11–12 (range).

### 3.2.2 *Coleiconus minimus*

Regarding *Coleiconus minimus* Babazadeh (Pl. S6, Figs. M–O in this article), Hadi and Schlagintweit (2024) stated: “*Coleiconus minimus* Babazadeh was compared twice in the article of Hadi and Schlagintweit (2024). Once with *Barattolites arghadehensis* Babazadeh and another time with *Daviesiconus balsilliei* (Davies). In fact, the two mentioned sections of *Barattolites arghadehensis* Babazadeh might well belong to *Coleiconus minimus* Babazadeh, namely one section closer to the cone base (Fig. 3C in Hadi and Schlagintweit, 2024) and the other in the juvenile part (Fig. 3F in Hadi and Schlagintweit, 2024)”.

Again, Hadi and Schlagintweit (2024) stated: “The specimens of *Coleiconus minimus* Babazadeh can be well compared with *Daviesiconus balsilliei* (Davies), from the Eocene of Pakistan, typically the smaller juvenile forms (Figs. 3O–S)”.

When Hadi and Schlagintweit (2024) compared *Coleiconus minimus* Babazadeh with *Daviesiconus balsilliei* (Davies), they only mentioned the smaller juvenile forms, but several other parameters should be considered, such as the shell dimension, the size of spiral stage, looser aspect of central pillars, and coarse internal structure. Stratigraphic range: SBZ 11–12 (early Eocene).

### 3.2.3 *Daviesiconus mahallatensis*

Regarding *Daviesiconus mahallatensis* Babazadeh, Hadi and Schlagintweit (2024) declared that: “As none of the specimens illustrated by Babazadeh (2022) shows this type of wall structure (pseudo-keriothecal wall for *Coskinolina* and simple or non-caliculate for *Daviesiconus*) also due to the lacking adequate magnifications (Hottinger and Drobne, 1980)”.

Hadi and Schlagintweit (2004) affirmed: “*Daviesiconus* differs from *Coskinolina* in having a main radial partition (beam)”. However, paying attention to the transverse sections of the both genera in Pl. S5 (Figs. B and C, related to *Coskinolina*) and Pl. S7 (Figs. D, H, L, and P) related to *Daviesiconus*) in this article, the difference is clearly visible. The radial partition is visible in basal section (transverse section).

As Hadi and Schlagintweit (2004) stated, the transverse sections of *Daviesiconus* and *Coleiconus* are almost indistinguishable because both have rather short primary beams only, when the pseudo-keriothecal wall of the latter is not preserved or recognizable. Of course, using the transverse sections, they cannot be distinguished from each other. Therefore, other factors such as the magnitude of the initial growth stage, the ratio of width to height, the presence of a pseudo-keriothecal wall and the density of central pillars in the central part of test should be used. Usually in *Coleiconus*, the density of the pillars is lower and more open.

*Daviesiconus mahallatensis* Babazadeh differs from *Daviesiconus balsilliei* in having a bell-shaped test with marginal rims, a low trochospiral early stage with a slightly eccentric position, a broader cone base, and a flattening index greater than one. As mentioned earlier *Daviesiconus balsilliei* (Davies) has an isometric axial form or is slightly longer than broad and its flattening index is approximately 1 (Fig. S4C). *Daviesiconus balsilliei* (Davies) has a short, nearly planispiral juvenile stage and less chambers per 1 mm axial length (Hottinger and Drobne, 1980). Stratigraphic range: SBZ 11–12 (early Eocene).

## 4 Conclusion

*Nummulites atacicus* Leymerie differs from *Nummulites globulus* Leymerie in having a larger proloculi (Pl. S1G,I) and more spiral whorl radius (larger spiral intervals). *Nummulites atacicus* Leymerie is comparable to *Nummulites globulus* Leymerie which has a regularly opening spire and also the height of the chambers exceeds their width. *Nummulites atacicus* Leymerie has a lenticular test with thin, sharp periphery and pillars are not well developed, whereas *Nummulites globulus* Leymerie is characterised by a globular test with well-developed umbilical pillars (Pl. S1E, F).

*Nummulites* cf. *fossulata* de Cizencourt differs from *Nummulites cuvillieri* Sander (Pl. S2L) published by Saraswati *et al.* (2000) in having less number of chambers per spiral whorl, more acute periphery and central shallow depression. It is distinguished from *Nummulites postfossulatus* Sirel and Deveciler by the smaller size of its test and tightly coiled whorls (Pl. S2). It also differs from *Nummulites pinfoldi* Davies in having smaller size of proloculi, smaller test size, and looser coiled whorls.

In addition, *Nummulites pinfoldi* Davies (Pl. S3M) differs from *Nummulites postfossulatus* Sirel and Deveciler, *Nummulites fossulatus* de Cizencourt and *Nummulites cuvillieri* Sander by its larger test and tightly coiled whorls (Pl. S2).

The studied specimens (GH40, GH51-3, GH51-4) belong to *Nummulites* cf. *perforatus* (de Montfort), characterised by a large proloculi (0.60–0.85 mm), rather inflated lenticular test

with rounded peripheral margin. There are 4 whorls in an equatorial section measured 4.5 mm in diameter (Pl. S3, sample GH40). The width of the chambers is greater than the height. The opening of the coiling whorls in the earlier stage is faster than the previous species such as *Nummulites globulus* Leymerie and *N. atacicus* Leymerie.

About *Nummulites malatyaensis* Sirel, according to Sirel (2003) the chambers are very small and their height is equal to their width, but based on Deveciler (2014), the heights of chambers are comparable to their widths, and again according to Sirel and Deveciler (2018), their height is greater than width. On the other hand, Sirel (2003) reported that the size of the proloculi of this species ranges from 0.100 to 0.275 mm, whereas its size ranges from 0.25 to 0.3 mm based on Deveciler (2014). As mentioned in the above paragraph, there are contradictions in the referencing process about *Nummulites malatyaensis* Sirel.

In the studied samples (GH51-1, GH52 and GH51-2) related to *Nummulites ptukhiani* Kacharava, the illustration of successive spiral intervals shows a relatively constant spire height such that the gradient of the growth of spiral whorl is almost uniform. *Nummulites ptukhiani* Kacharava is comparable to the samples of populations TDP2 of Cotton *et al.*, 2015. Therefore this parameter should be checked for more samples in the lower and upper horizons of stratigraphic section in the study area. However, it is beyond the scope of this note. The biometric data and the whorl diagrams of *Nummulites ptukhiani* Kacharava are described in this paper.

Based on the information obtained from different species of *Barattolites* (*Barattolites trentinarensis*, *B. andhuri* and *B. arghadehensis*) shows that their distribution are plotted below the best-fit line in the field of elongated forms (Fig. S4A). Whereas, *Coleiconus minimus* Babazadeh is located above the best-fit line in the field of flattened forms (Fig. S4C). Meanwhile, the first occurrence of *Coleiconus minimus* Babazadeh is observed in the layer 239 (member C3) but the first appearance of *Barattolites arghadehensis* Babazadeh is occurred in the layer 217 (Fig. S3).

When the values of axial and basal cone diameters of *Barattolites trentinarensis* Hottinger and Drobne and *B. andhuri* Serra-Kiel *et al.* are plotted on the flattening index diagram (Fig. S4A), it appears that they follow a logical relationship. As explained above, in axial sections, comparable to axial sections (semi-axial and sub-axial sections) and even in tangential sections, the distribution of all of them is plotted below the best-fit line in the field of elongated forms. This is also true for *Barattolites arghadehensis* Babazadeh (Fig. S5B, refer to Babazadeh, 2022). The biometrical data is shown in the figure Fig. S4D.

*Coleiconus* is distinguished from *Barattolites* by possessing a thick marginal wall (Pl. S6, Fig. M), a distinct marginal trough with a row of marginal apertures, a much more prominent spiral stage (Pl. S6, Figs. L, M, N), and a coarse internal structure with the large chamberlets in the marginal zone, and absence of intercalary beams. On the other hand, the genus *Coleiconus* is almost bell-shaped and slightly broader than high but *Barattolites* is pen-shaped, longer than wide, with intercalary beams and without marginal aperture.

*Coleiconus minimus* Babazadeh differs from *Daviesiconus balsilliei* (Davies) in having a broader apex with prominent early trochospiral stage, more wide (cone diameter) than high,

and discontinuous, few pillars in a wide space. *Daviesiconus balsilliei* (Davies) presents a conic shell with isometric form or slightly longer than broad (Hottinger and Drobne 1980; Serra-Kiel *et al.*, 2016). The ratio between basal length and axial length (flattening index, Rb/a) is approximately 1 (Fig. S4).

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