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Selandian-Thanetian larger foraminifera from the lower Jafnayn Formation in the Sayq area (eastern Oman Mountains)

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ABSTRACT

The larger foraminifera of the lower part of the Jafnayn Formation outcropping in the Wadi Sayq, in the Paleocene series of the eastern Oman Mountains, have been studied and described in detail. The analysis have allowed us to develop a detailed systematic description of each taxa, constraining their biostratigraphic distribution and defining the associated foraminifera assemblages. The taxonomic study has permitted us to identify each morphotype precisely and describe three new taxa, namely, *Ercumentina sayqensis* n. gen. n. sp. *Lacazinella rogeri* n. sp. and Globoreticulinidae new family. The first assemblage is characterized by the presence of *Coskinon* sp., *Dictyoconus* cf. *turriculus* HOTTINGER AND DROBNE, *Anatoliella ozalpiensis* SIREL, *Ercumentina sayqensis* n. gen. n. sp. SERRA-KIEL AND VICEDO, *Lacazinella rogeri* n. sp. SERRA-KIEL AND VICEDO, *Mandanella* cf. *flabelliformis* RAHAGHI, *Azzarolina daviesi* (HENSON), *Lockhartia retiata* SANDER, *Dictyokathina simplex* SMOUT and *Miscellanites globularis* (RAHAGHI). The second assemblage is constituted by the forms *Pseudofallotella persica* (HOTTINGER AND DROBNE), *Dictyoconus* cf. *turriculus* HOTTINGER AND DROBNE, *Lacazinella rogeri* n. sp. SERRA-KIEL AND VICEDO, *Azzarolina daviesi* (HENSON), *Keramosphera*? cf. *iranica* RAHAGHI, *Lockhartia haimei* (DAVIES), *Lockhartia retiata* SANDER, *Sakesaria trichilata* SANDER, *Kathina delseota* SMOUT, *Elazigina harabekayisensis* SIREL, *Daviesina khatiyahi* SMOUT, and *Miscellanea juliettae* LEPPIG. The first assemblage can be considered to belong to the Shallow Bentic Zone SBZ2 (early Selandian age), and the second assemblage to the SBZ3 (late Selandian-early Thanetian age).This paper shows, for the first time in the Middle East area, a correlation between the Selandian larger foraminifera and planktonic foraminifera biozones.

KEYWORDS **Biostratigraphy. Larger foraminifera. *Lacazinella rogeri* n. sp. *Ercumentina* n. gen. Selandian-Thanetian. Sayq, Oman.**

INTRODUCTION

In recent decades, the interest in studying the carbonates deposited in shallow-water Tethyan platforms from the Paleogene-Neogene of the Middle East has been closely related to oil prospecting and, more recently, also to prospecting for groundwater. In general terms, the use of the biostratigraphical data constitute an important tool in all these prospections. The larger foraminifera, due to their abundance and diversity, are one of the most studied fossils in the biostratigraphy of materials deposited in shallow water environments, the global correlation achieved by the Shallow Benthic Zones (SBZ) being just one of the many achievements reported in the literature (Serra-Kiel *et al.*, 1998). However, in the particular case of the Paleocene of Middle East, as for some other locations, the use of larger foraminifera assemblages characterizing the sedimentary sequences has not always been preceded by studies dealing with detailed systematic descriptions. This could eventually result in misidentifications and, in turn, an undervaluation of these fossils as potential biostratigraphical markers. Taxa misinterpretations may be one of the reasons why, in many cases, stratigraphic studies have ignored the usefulness of the analysis of larger foraminifera as a robust biostratigraphical tool from both local and regional points of view. Over the past decades, only a few papers were published dealing with local larger foraminifera biostratigraphy in Qatar, Somalia and Yemen (Smout, 1954; Pignatti *et al.*, 1998; Ismail and Boukhary, 2008; Boukhary *et al.*, 2011), these being clearly essential for subsequent comprehensive work in the region, considering correlations, endemisms, migratory fluxes, etc.

The Oman Mountains, like other locations in the Middle East, provide a good illustration of the problematic issue outlined above. In Oman, the deposits are very well exposed due to the arid climatic conditions, a fact that has made it possible to make significant progress in the fields of geological mapping and stratigraphy, but few studies have been conducted focused on larger foraminifera. The only group of Paleogene larger foraminifera that has been studied in detail is the group of nummulitids from Oman (Racey, 1995).

The material considered in this paper corresponds to the lower part of the Jafnayn Formation (Fm.), in the Oman Mountains, sampled at the reference stratigraphic section of the Wadi Sayq. In this locality, the carbonates containing planktonic foraminifera were analyzed by previous authors, who distinguished the Danian, Selandian and Thanetian stages (Roger *et al.*, 1998) as far as Paleogene series is concerned. However, the larger foraminifera assemblages of the shallow-water limestones remained unclear and called for an extensive description. Thus, the main goal of this paper is to describe the rich assemblages of larger foraminifera from the lower part of the Jafnayn Fm. outcropping in the Wadi Sayq and to constrain their biostratigraphic distribution and correlation with the pelagic zonation based on planktonic foraminifera. Achieving this will represent a step forward in our knowledge of the representatives of this biotic fossil group in the study area, which is fundamental for future local or regional biostratigraphical projects.

GEOLOGICAL AND STRATIGRAPHICAL SETTING

The Oman Mountains are located on the northeastern margin of the Arabian plate, extending southeast of the Zagros collision zone and the southern edge of the Gulf of Oman. The Maastrichtian-Paleogene sedimentary series exposed in the Oman Mountains lie unconformably over various tectonic units resulting from the obduction of this portion of the Neotethyan paleomargin in the late Cretaceous (Glennie *et al.*, 1974; Nolan *et al.*, 1990; Le Métour *et al.*, 1995). These series called "post-nappes" were then deformed and raised during the Miocene-Pliocene phase of deformation.

These Maastrichtian-Paleogene series are mainly composed of shallow-water carbonates dominated in the Paleocene by large benthic foraminifera. These deposits accumulated on a broad platform that covered a large part of the Arabian plate at that time. The major part of the Arabian plate (Yemen, Saudi Arabia, Oman Interior, and Qatar) was then in a relatively stable tectonic setting as shown in the simplicity of the stratigraphic succession for that period. Three major sequences of carbonate platforms developed in response to major transgressive phases: the rudist carbonate Maastrichtian platform (Simsima Formation in Oman, Aruma Group), the upper Paleocene-Cuisian carbonate platform with large benthic foraminifera (Umm Er Rhaduma Fm./Jafnayn Fm.) then evaporite (Rus Fm.) and the Middle Eocene carbonate or mixed platform (Dammam and Seeb formations.) (Powers, 1968; Beydoun *et al.*, 1998; Forbes *et al.*, 2010). These sequences are separated by two major stratigraphic discontinuities: the discontinuity of the upper Maastrichtian-Selandian and the Cuisian discontinuity. Both discontinuities result from tectonic deformation of the Arabian plate related to its continued northward movement and subduction processes that affect its northern margin (Braud, 1970; Agard *et al.*, 2011).

The Paleogene series located in the northeastern edge of the Arabian plate, located in the Zagros and Oman Mountains, have a much more complex stratigraphic organization characterized by a more complete succession and important variations in facies and thickness. These characters reflect more unstable tectonic plate margins in relation to the convergent movements in the north and transformants in the east (Gnos *et al.*, 1997; Robinet, 2013).

The series studied are located in the eastern part of the Oman Mountains (Eastern Hajar) between the cities of Muscat and Sur (Fig. 1A-B). The "post-nappes" series, such as the allochthonous series (Hawasina Nappes and Ophiolite of Samail), lie here unconformably on the autochthonous Mesozoic series (Saih Hatat Unit) (Wynns *et al.*, 1992; Le Métour *et al.*, 1995; Fig. 1B). In the area studied, the Paleogene series are mainly represented by

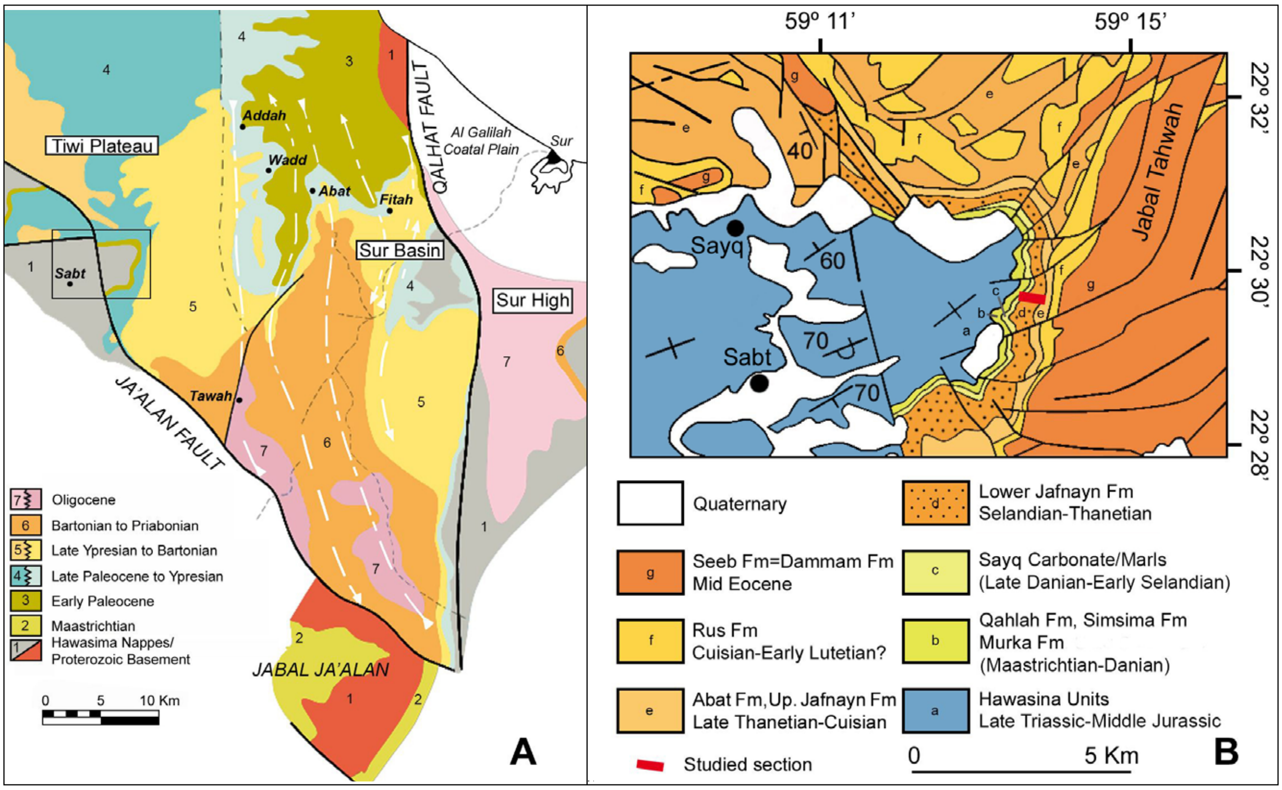

FIGURE 1. A) Geological map of the region of Sur. B) Detailed geological map of the Sayq area and location of studied section.

shallow carbonate platform facies (Tiwi Plateau). Eastward, they progressively pass to deeper hemipelagic and gravity deposits along the western edge of the Sur basin (Fig. 1). This configuration makes it possible to achieve relatively accurate stratigraphic correlations between the platform series with larger foraminifera and the basin series with planktonic foraminifera (Roger *et al*., 1998).

The Maastrichtian to Ilerdian series consist of three major depositional sequences (Roger *et al*., 1998). The first begins with a continental formation (Qalhat Fm.) gradually covered by a transgressive carbonate sequence with rudists and larger foraminifers (Simsima Fm.), Maastrichtian in age. The top of this sequence is marked by the installation of a series of carbonate platforms with a regressive character (lower part of Murka Fm.). A sedimentary discontinuity (emersion) and stratigraphic hiatus marks the K/Pg boundary. The second sequence, Danian to Selandian in age, begins with thin sandstone intervals overlain by calcareous shallow-platform deposits (upper part of Murka Fm.). This sequence shows a significant increase in subsidence, formed by a thick series of aggradational carbonate platform facies (Sayq Carbonate unit), passing eastward into green marls with planktonic foraminifera (Sayq Marls unit, Fig. 2; 3). These marls have been precisely dated as upper Danian-lower Selandian (Biozones P2-P3a) by associations of planktonic foraminifera (Bourdillon, in Roger *et al*., 1998). The top of the sequence is marked by a major regressive episode materialized by a continental terrigenous clay-sandstone interval, sometimes conglomeratic, passing eastward into the basin to a thin glauconitic interval of 50cm. Note that this second sequence, is preserved here by the presence of normal faults (Fig. 1A). Indeed, this sequence disappears immediately south of the Ja'alan fault (Fig. 1A), as does in the vast majority of the Arabian plate.

The third sequence, early Selandian-Early Eocene in age, begins with siliciclastic coastal-plain deposits surmounted by a thick transgressive carbonate sequence rich in larger foraminifera, named Jafnayn Fm. in the Oman Mountains, and Um Er Rhaduma Fm. across the rest of the Arabian plate. In detail, the Jafnayn/Umm Er Rhaduma formations include several higher-order sequences separated by regional discontinuities that can be mapped. In the Oman Mountains, the Jafnayn Fm. is laterally equivalent to both Abat and Fitah formations. (Fig. 2). This study focuses on the first of these higher-order sequences, Selandian-lower Thanetian in age. The section studied, about 320m thick, consists of siliciclastic rocks at the base that rapidly passes into shallow platform carbonates with larger foraminifera. These platform deposits grade eastward into deeper facies formed by hemipelagic calcareous-marl alternations and rare deposits of carbonate gravity debrites. Associations of planktonic foraminifera indicate a Selandian-lower Thanetian age (Biozones P3b-P4a, Bourdillon in Roger *et al*., 1998).

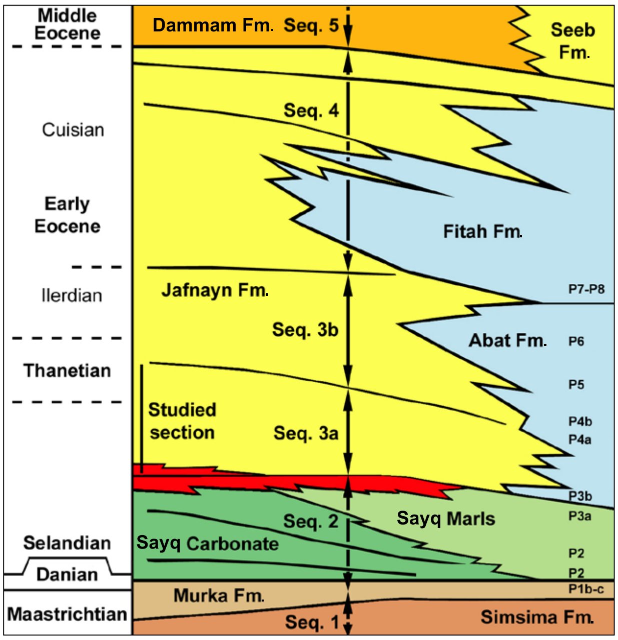

FIGURE 2. Stratigraphical framework of the Tiwi Plateau indicating the lithostratigraphic units, depositional sequences (seq.) and planktonic foraminifera biozones (P). Geological map from Wyns *et al.*, 1992.

SAMPLING AND PROCEDURES

The studied section is located in the vicinity of Sayq village about 40km west of Sur village (Figs. 1A-B). The samples were collected in a continuous stratigraphic section in the lower part of the first depositional sequence of the Jafnayn Fm. (Fig. 2). The first 40 metres are composed of siliciclastic rocks, with fine-to- coarse sandstones and conglomerates with cross-stratification and erosive basal contacts. This is an interval lacking larger foraminifera. Samples 1-13 were taken from the interval between 40 and 140m, which consists of wackestone-packstone beds of decimetre thickness alternating with marls. Samples 14-20 were taken from the interval between 140 and 210m, in a sequence of metric-scale coarsely bedded packstone beds. Finally, samples 21-23 were taken from the upper part of the section, between 210 and 310m in a difficult-to-access cliff formed by massive packstones.

All samples are housed at the micropalaeontological collection of the Department of Stratigraphy, Palaeontology and Marine Geosciences (University of Barcelona).

SYSTEMATICS (J. SERRA-KIEL AND V. VICEDO)

Phyllum: Foraminifera Eichwald, 1830
Class: Globothalamea Pawlowski, Holzmann, Jaroslaw and Tyszka, 2013
Order: Textulariida (Delage and Hérouard, 1896)

Superfamily: Ataxophragmoidea Schwager, 1877
Family: Coskinolinidae Moullade, 1965

GENUS: ***Fallotella*** Mangin, 1954
Type species: *Fallotella alavensis* Mangin, 1954
Pseudofallotella persica (Hottinger and Drobne, 1980) (Fig. 4.2)

1980 *Fallotella* (*Fallotella*) *kochanskae persica* n sp. Hottinger and Drobne, p. 53; pl. 15, figs. 15-29
1998. *Fallotella* (*Fallotella*) *kochanskae persica* Hottinger and Drobne. Sirel, p. 49, pl. 13, figs. 1-18
2009 *Dictyoconus baskilensis* Sirel, pl.6, figs. 13-24

Material. Sample SI 19.

Description. Agglutinated form with conical morphology and multiple apertures. Dimorphism not observed. The chamber wall is thin with no ultrastructure. The nepionic stage of megalospheric generation has not been adequately observed, but it seems that it is formed by an embryo in apical position followed by a few chambers in a low-trochospiral arrangement (see Fig. 4.2). The ephebic stage is composed of chambers arranged uniserially. The maximum axial (longitudinal) length observed is around 1.3mm with 18 uniserial chambers and a basal cone diameter of 1.3mm. There are 12-13 chambers per millimetre of axial length. The exoskeleton consists of beams and one generation of rafters, and the endoskeleton is composed of pillars (see Fig. 4.2). Multiple apertures are located on the basal surface of the cone, and marginal apertures arranged in the peripheral part (see Fig. 4.2).

Remarks. This species was originally attributed to *Fallotella* by Hottinger and Drobne (1980) and it was considered as a subspecies of *F. kochanskae* Hottinger and Drobne. However, the type species of *Fallotella* Mangin (*F. alavensis* Mangin) is characterized by the absence of true rafters. The presence of these exoskeletal elements (rafters) in *P. persica* (Hottinger and Drobne) allows us to suggest that this subspecies must be removed from the genus *Fallotella* Mangin (see Vicedo *et al.*, 2014) and assigned to *Pseudofallotella* Vicedo, Berlanga and Serra-Kiel, a genus found in Paleocene rocks from the Caribbean/American palaeobioprovince, on the basis of the presence of rafters, marginal apertures, and an embryo, with protoconch and deuteroconch, in apical position. This species, considering the differences in morphometrics with respect to *Fallotella*? *kochanskae* Hottinger and Drobne (see pl. 15 in Hottinger and Drobne, 1980), has been raised to species level. The morphotype defined as *F.*? *kochanskae* Hottinger and Drobne should be revised under the same premises as *P. persica* (Hottinger and Drobne).

The species *Dictyoconus baskilensis* Sirel is a junior synonym of *Pseudofallotella persica* (Hottinger and Drobne) as they have similar morphometric features.

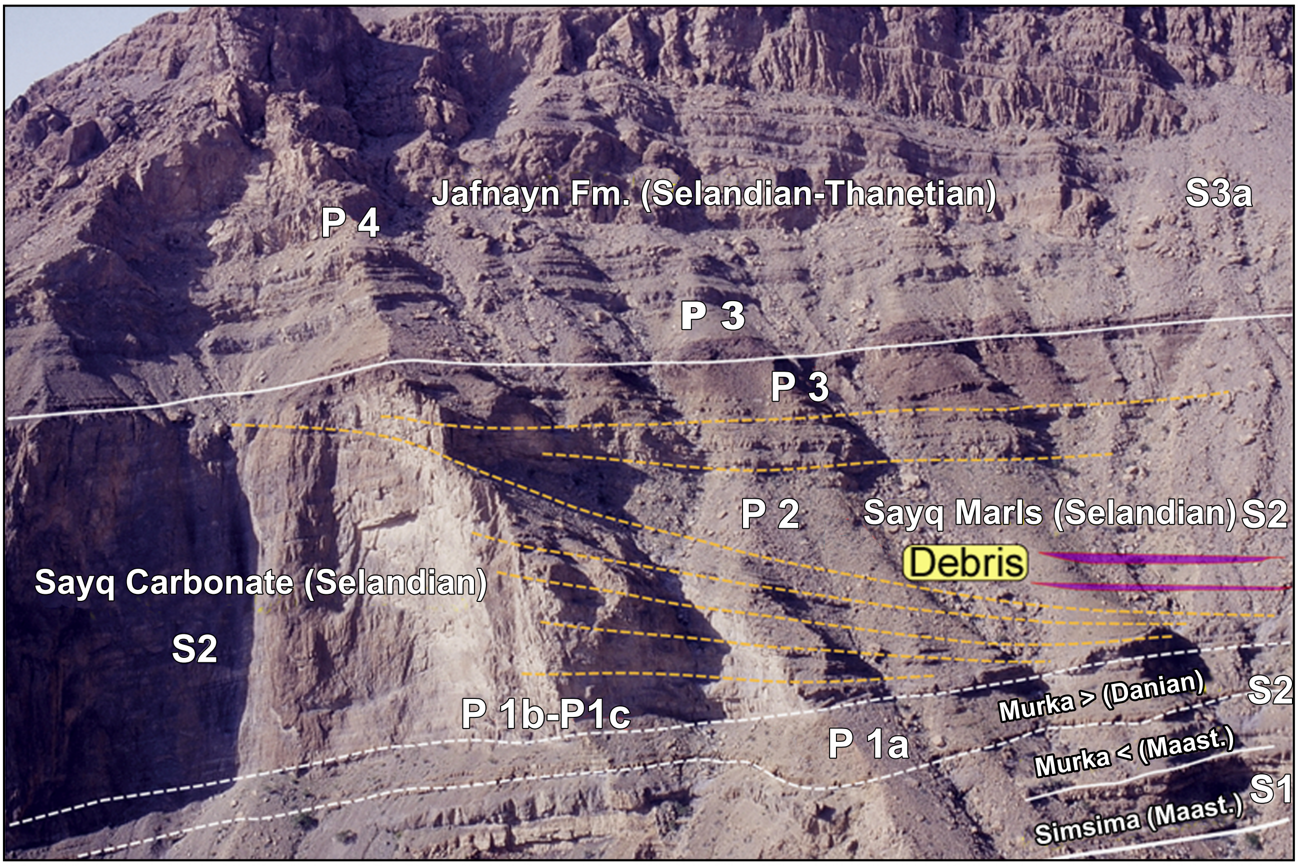

FIGURE 3. Field view of the Tiwi Plateau cliff indicating the lithostratigraphic units, depositional sequences (S) and planktonic foraminifer biozones.

Differential diagnosis. *Pseudofallotella persica* (Hottinger and Drobne) differs from *P. drobneae* Vicedo, Berlanga and Serra-Kiel in having a smaller protoconch (115 vs. 220μm) and deuteroconch (85 vs. 153μm, concerning the maximum diameter of the bean-shaped deuteroconch). The maximum diameter of the cone is also smaller in the former (1.2mm vs. 2mm). *Fallotella*? *kochanskae* Hottinger and Drobne has low-conical test, different from the medium to high-conical tests of *P. persica* (Hottinger and Drobne) and *P. drobneae* Vicedo, Berlanga and Serra-Kiel.

Associated larger foraminifera. This form occurs with *Dictyoconus* cf. *turriculus* Hottinger and Drobne, *Lacazinella rogeri* n. sp. and *Azzarolina daviesi* (Henson).

GENUS ***Coskinon*** Hottinger and Drobne, 1980

Type species: *Coskinolina* (*Coskinon*) *rajkae* Hottinger and Drobne, 1980
Coskinon sp. (Fig. 4.1)

Material. Sample SI 1.

Description. Agglutinated, conical form. The nepionic stage has not been adequately observed, but is believed to consist of a reduced coiled stage. The ephebic stage consists of chambers uniserially arranged. The endoskeleton is composed of pillars; no exoskeleton or chamber wall ultrastructure are present. The apertural face is concave with multiple apertures (see Fig. 4.1).

Remarks. The architectural features described above suggest that the specimens could be identified as *Coskinon* Hottinger and Drobne, but a centred section is necessary to observe the characteristics of the nepiont in order to confirm the generic and specific attributions.

Associated larger foraminifera. This form occurs with *Dictyoconus* cf. *turriculus* Hottinger and Drobne and *Ercumentina sayqensis* n. gen. n. sp.

Superfamily: Orbitolinoidea Martin, 1890
Family: Orbitolinidae Martin, 1890
Subfamily: Dictyoconinae Moullade, 1965

GENUS ***Dictyoconus*** Blanckenhorn, 1900

Type species: *Patellina egyptiensis* Chapman, 1900
Dictyoconus cf. *turriculus* Hottinger and Drobne, 1980 (Figs. 4.3-4.5)

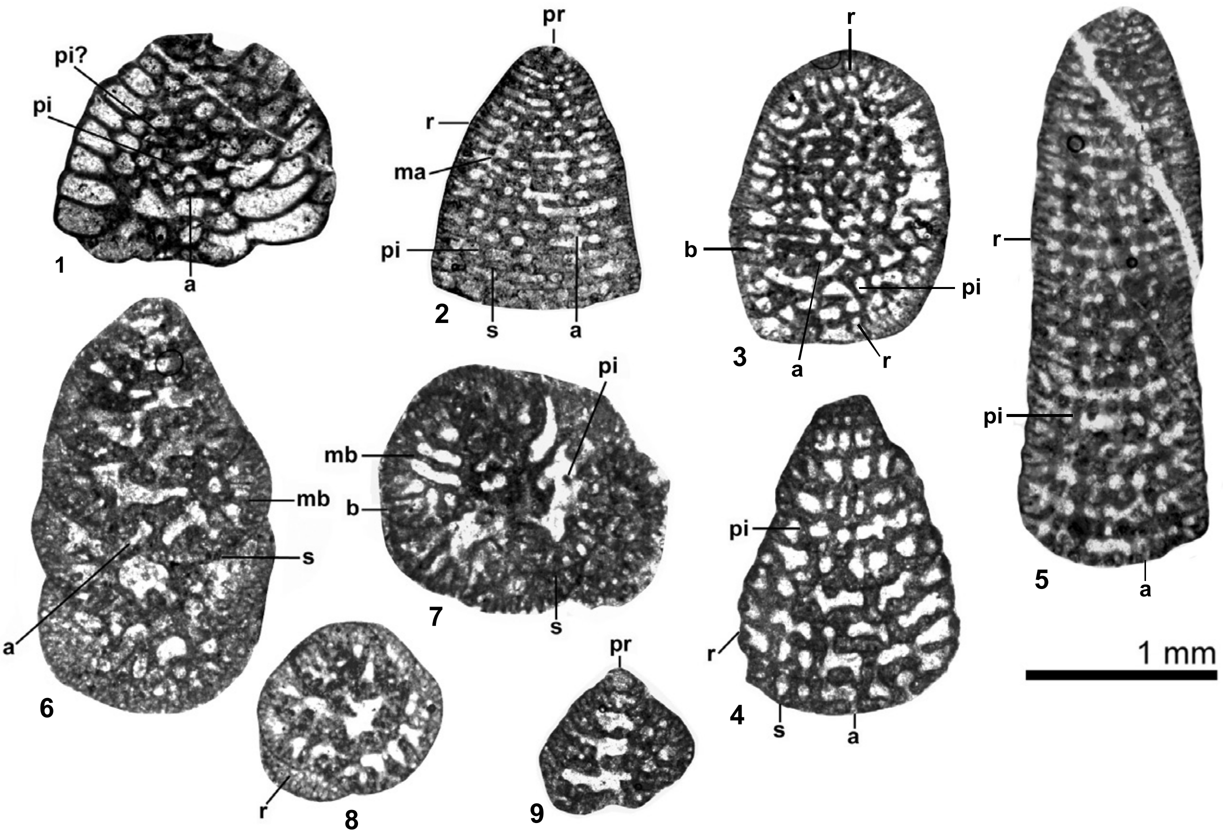

FIGURE 4. 1) *Coskinon* sp. oblique section cutting cone axis at large angle, specimen from sample SI 1. 2) *Pseudofallotella persica* (Hottinger and Drobne) longitudinal section; note the partially eroded proloculus in the apical zone, specimen from sample SI 19. 3-5) *Dictyoconus* cf. *turriculus* Hottinger and Drobne. 3) oblique section; note the apertures, pillars and rafters, specimen from sample SI 1. 4) oblique section; note the apertures, pillars and rafters, specimen from sample SI 15. 5) longitudinal section, showing rafters in the marginal zone; specimen from sample SI 21. 6-9) *Anatoliella ozalpiensis* Sirel. 6) Section perpendicular to coiling axis; note the main beams. 7) Section perpendicular to coiling axis. 8) Axial section slightly oblique. 9) Centred axial section showing the proloculus. Specimens 6, 7 and 9 from sample SI 3 and specimen 8 from sample SI 8. a: aperture; pi: pillar; pr: proloculus; s: septum; r: rafter; ma: marginal aperture; b: beam; mb: main beam.

1980 *Dictyoconus* (*Dictyoconus*) *turriculus* n. sp. Hottinger and Drobne, p. 224-246; pl. 19, figs. 1-10; text figure 13A, B and C.
1998 *Dictyoconus turriculus* Hottinger and Drobne. Accordi *et al*., 1998. pl. 13, fig. 4

Material. Samples SI 1, SI 15, SI 16, SI 19, SI 21 and SI 22.

Description. Agglutinated shells with high-conical morphology (see Fig. 4.5). The nepionic stage is not adequately observed. The ephebic stage is formed by uniserial chambers, with 7-8 chambers per millimetre of axial length. The maximum axial length observed is around 2.9mm with 23 uniserial chambers and basal cone diameter of 1mm. Microspheric forms unknown. The exoskeleton appears in chambers of the early coiled stage and consists of beams and rafters. The endoskeleton is composed of thick pillars with a circular outline in transverse section. The pillars alternate in position from one chamber to the next (see Fig. 4.3). The apertural face slightly convex, apertures showing a cribrate distribution (see Fig. 4.5).

Remarks. The endoskeleton and exoskeleton characteristics as well as the overall size of the shell of our specimens would support their attribution to the species *D. turriculus* Hottinger and Drobne. However, the absence of a centred section in our material does not allow us to give more than a tentative specific ascription.

Associated larger foraminifera. This form occurs with *Pseudofallotella persica* (Hottinger and Drobne), *Coskinon* sp., *Ercumentina sayqensis* n. gen. n. sp., *Lacazinella rogeri* n. sp., *Azzarolina daviesi* (Henson), *Keramosphera*? *cf. iranica* Rahaghi, *Lockhartia haimei* (Davies), *Kathina delseota* Smout, *Kathina* sp., *Elazigina harabekayensis* Sirel, *Daviesina khatiyahi* Smout and *Miscellanea juliettae* Leppig.

Family: *Anatoliellidae* Sirel, 2013

GENUS ***Anatoliella*** SIREL, 1988

Type species: *Anatoliella ozalpiensis* SIREL, 1988
Anatoliella ozalpiensis SIREL, 1988 (Figs. 4.6-4.9)

1988 *Anatoliella ozalpiensis* n. gen. n. sp. SIREL, p. 478-481; fig. 2 and 3; pl. 1, figs. 1-9; pl. 2, figs. 1-11
1998 *Anatoliella ozalpiensis* SIREL. Sirel, p. 46; pl. 7, figs. 6-11; pl. 8, figs. 9 and 10
2004 *Anatoliella ozalpiensis* SIREL, Sirel, p. 46; pl. 42, figs. 1-9; pl. 43, figs. 1- 11
2013 *Anatoliella ozalpiensis* SIREL. Sirel, 28-29; pl. 1, figs. 1-12; fig. 2

Material. Samples SI 3 and SI 8.

Description. Agglutinated, high-conical tests. Dimorphism was not observed. The proloculus is in apical position with a diameter of about 0.1mm (see Fig. 4.9) and followed by chambers trochospirally-triserially arranged. The exoskeleton is composed of beams and rafters of different orders giving an appearance of an irregular polygonal subepidermal network (see Figs. 4.6-4.8), and the endoskeleton authors of a few pillars (see Figs. 4.6, 4.7). Multiple apertures.

Associated larger foraminifera. This form occurs with *Ercumentina sayqensis* n. gen. n. sp., *Lacazinella rogeri* n. sp., *Mandanella* cf. *flabelliformis* RAHAGHI and *Kathina* sp.

Class: Tubothalamea PAWLOWSKI, HOLZMANN, JAROSLAW AND TYSZKA, 2013
Order: Miliolida (DELAGE AND HÉROUARD, 1896)
Superfamily: Alveolinoidea EHRENBERG, 1839
Globoreticulinidae new family
Type genus: *Globoreticulina* RAHAGHI, 1978

Diagnosis. Porcelaneous shells with multiple apertures. Flexostylic megalosphere followed by chambers spirally arranged. Alveolar exoskeleton composed of beams and rafters. Endoskeleton restricted to slight ridges. Ridges fused with beams at the proximal part of the chamber. Multiple foramina distributed in one or more rows and aligned from one chamber to the next.

Remarks. This new family has been erected in order to include all morphotypes that are architecturally related, such as *Globoreticulina iranica*, *Globoreticulina paleocenica*, and *Ercumentina sayqensis* new genus new species. All these forms have to be removed from Alveolinidae EHRENBERG as they show basic architectural differences of suprageneric level, namely, presence of exoskeleton and no complete septula subdividing tubular chamberlets.

Ercumentina n. gen. SERRA-KIEL AND VICEDO

Type species: *Ercumentina sayqensis* n.sp. SERRA-KIEL AND VICEDO

Derivation of name. Given in honour of Dr Ercüment Sirel (Ankara University), distinguished specialist in larger foraminifera.

Diagnosis. Shells with porcelaneous wall and multiple apertures. Microspheric forms unknown. Flexostylic megalosphere followed by chambers with planispiral, involute arrangement. Alveolar exoskeleton composed of several beams and one generation of rafters. Endoskeleton restricted to slight ridges. Ridges fused with beams at the proximal part of the chamber. Multiple foramina distributed in two rows and aligned from one chamber to the next. Foramina of the lower row regularly alternated with ridges. Additional foramina irregularly distributed in a second upper row.

Remarks. The two species that Rahaghi attributed to *Globoreticulina* RAHAGHI, *G. iranica* RAHAGHI (the type species of the genus) and *G. paleocenica* RAHAGHI, show some essential architectural differences that constitute the base of their differentiation at genus level. The species *Globoreticulina iranica* RAHAGHI, from the Middle Eocene of the Shiraz area (Iran), shows a streptospiral nepiont, whereas *G. paleocenica* RAHAGHI, from the upper Paleocene of the same area, has a megalosphere followed by planispiral, involute chambers. Further, the exoskeleton is more complex in *G. iranica* RAHAGHI than *G. paleocenica* RAHAGHI. The former species has beams of at least two orders (larger and shorter intercalated) and more than one rafter in adult chambers. The latter species presents only one order of thicker beams and only one rafter per adult chamber, resulting in an exoskeleton with a slightly more massive appearance. This last feature maybe the reason why Hottinger (2007) erroneously considered the wall of *G. paleocenica* RAHAGHI to be finely agglutinated. The subfamily Malatyninae erected by Hottinger (2007) should be revised in a comprehensive study involving all *Globoreticulina*-like morphotypes.

Ercumentina sayqensis n. sp. SERRA-KIEL AND VICEDO (FIGS. 5.1-5.9)

Material. Samples SI 1, SI 2, SI 5, SI 6, SI 7, SI 8, SI 9 and SI 10.

Derivation of Name. The specific name refers to Sayq locality, Oman.

Holotype. SI 6.1 (Fig. 5.1).

Paratypes. SI 6.2, SI 6.3 (Figs. 5.4; 5.5).

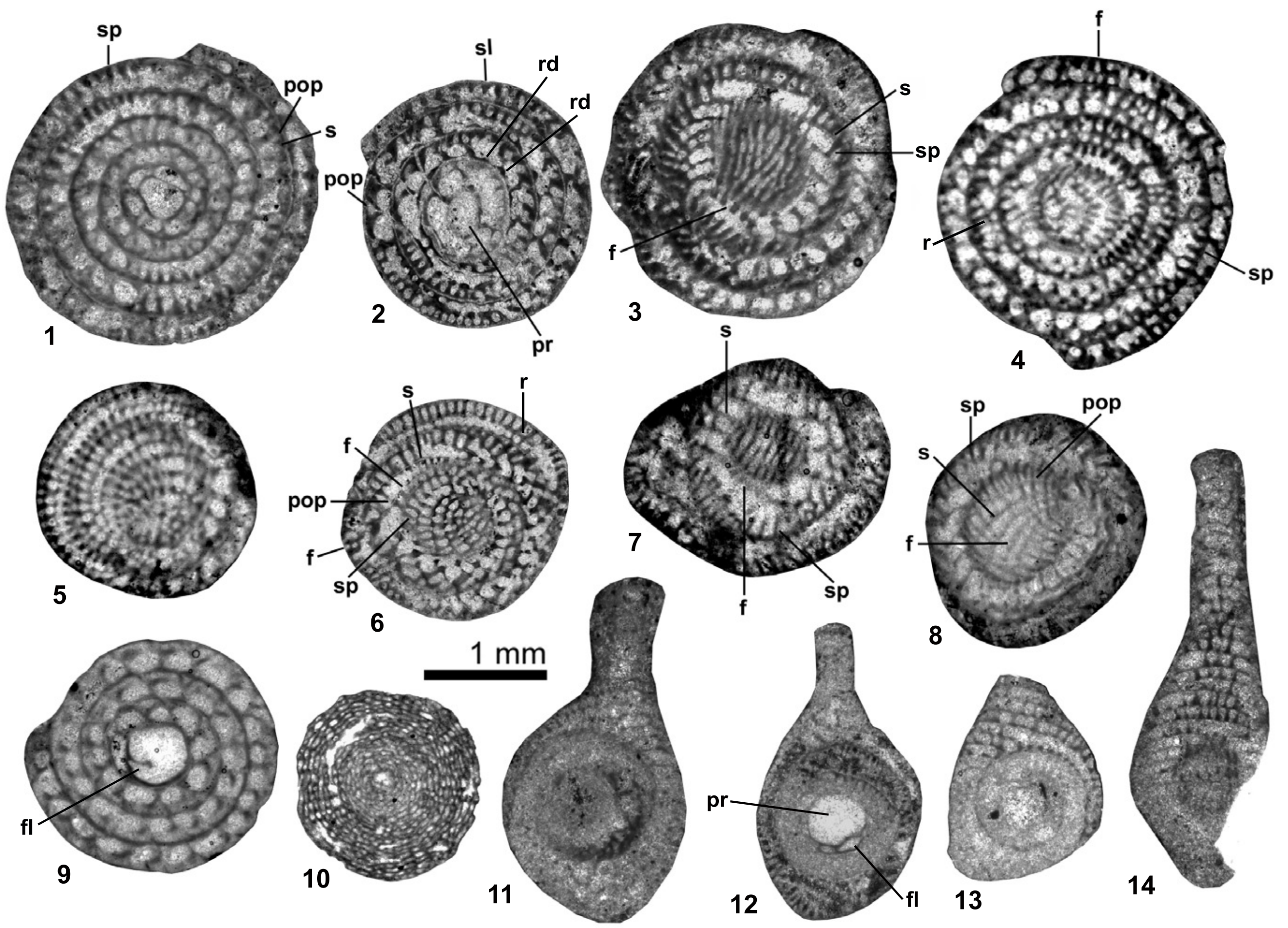

FIGURE 5. 1-9) *Ercumentina sayqensis* n. sp.1) centred equatorial section; note the septula and the postseptal passage. 2) slightly oblique and centred equatorial section. 3, 5-8) tangential sections; note the septulum aligned from one chamber to the next. 4) non-centred section close to the axial plane; note the apertures or foramina, septula and rafters. 9) diagenized specimen, centred equatorial section; note the flexostyle. 10) *Keramosphera*? cf. *iranica* Rahaghi specimen from sample SI 22. 11-14) *Mandanella* cf. *flabelliformis* Rahaghi. 11 and 14) equatorial sections not perfectly centred. 12-13) centred equatorial sections; note the diagenesis effect in 13 and proloculus with flexostyle in 12. Specimens 1, 4-5, 11-14 from sample SI 6; 2 and 6 from sample SI 1; 3 from sample SI 7; 7, 8 and 9 from sample SI 10 and specimen 10 from sample SI 4. f: foramen; fl: flexostyle; pr: proloculus; s: septum; sl: septulum; pop: post septal passage; rd: ridge.

Type Locality. Jafnayn Fm., Sayq area N 22º 30' 04.1"/E 59º 11' 12.8" (Sultanate of Oman).

Type Level. Selandian, Paleocene.

Diagnosis. Specimens with porcelaneous wall and the basic architecture of *Ercumentina* n. gen. Megalospheric forms with subglobular morphology (see Figs. 5.1, 5.2, 5.9). Megalospheric specimens characterized by having a subspherical to ovoid proloculus with a maximum diameter of around 0.24-0.29mm followed by chambers arranged planispirally (see Figs. 5.1, 5.9). Maximum diameter observed in adult specimens of about 2.5mm with 5 whorls. Exoskeleton composed of beams, around 15 per mm, and one rafter per chamber (see Fig. 5.4). Endoskeleton composed of slight ridges alternating in position with foramina (see Fig. 5.2). Apertures distributed in two rows (see Figs. 5.2, 5.4).

Differential diagnosis. On the one hand, the specimens of *G. paleocenica* Rahaghi have a maximum diameter of around 3.2mm with 6 whorls and 11 beams per mm in adult chambers. On the other hand, the specimens of *Ercumentina sayqensis* n. gen. n. sp. show a maximum diameter of about 2.5mm with 5 whorls and 14-15 beams per mm in adult chambers.

Associated larger foraminifera. This form occurs with *Coskinon* sp., *Dictyoconus* cf. *turriculus* Hottinger and Drobne, *Anatoliella ozalpiensis* Sirel, *Lacazinella rogeri* n. sp., *Mandanella* cf. *flabelliformis* Rahaghi, *Azzarolina daviesi* (Henson), *Lockhartia retiata* Sander and *Kathina* sp.

Family: Fabulariidae Ehrenberg, 1839

GENUS ***Lacazinella*** Crespin, 1962

Type species: *Lacazina wichmanni* Schlumberger, 1894
Lacazinella rogeri n. sp. (Fig. 6)

Material. Samples SI 2, SI 3, SI 5, SI 6, SI 13, SI 14, SI 15, SI 19 and SI 20.

Derivation of Name. In honour of Jack Roger who studied the geology of Sultanate of Oman.

Holotype. SI 13.1 (Fig. 6.1).

Paratypes. SI 13.2-12 (Fig. 6.2-6.5, 6.9-6.13, 6.15-6.16, 6.19-6.20).

Type Locality. Jafnayn Fm., Sayq area N 22º 30' 04.1''/E 59º 11' 12.8'' (Sultanate of Oman).

Type Level. Selandian-Thanetian.

Diagnosis. Porcelaneous test with ovoid morphology in axial section (see Fig. 6.6-6.9). Circular outline in equatorial section (see Fig. 6.1-6.4). Proloculus of megalospheric generation with a diameter between 0.25 and 0.45mm (see Fig. 6.1, 6.2, 6.4, 6.6, 6.9-6.10) followed by a flexostyle (see Fig. 6.2, 6.4, 6.10). Ephebic stage formed by monolocular concentric chamber arrangement with aperture alternating in polar position. Aperture characterized by a trematophore with central tooth and pillars (see Fig. 6.9, 6.11, 6.12, 6.14-6.17). Endoskeleton composed of longitudinal septula supported by the basal layer, reaching the chamber roof and extending from pole to pole (see Fig. 6.18). Between 14 and 15 chambers constitute an adult specimen with an axial diameter of around 3.1mm and an equatorial diameter of 2.3mm. Index of elongation of around 1.3. Exceptionally, equatorial diameters up to 3.2mm have been observed in rounded, non-centred sections (microspheric forms?).

Differences and similarities. The new species *Lacazinella rogeri* n. sp. differs from *Lacazinella wichmanni* (Schlumberger) in its smaller test size. The axial sections of *L. wichmanni* (Schlumberger) specimens, according to data of Crespin (1962) (see Crespin p. 339), reach more than 4mm for 14 chambers with an index of elongation of 1.7 and the diameter of proloculus can reach 0.60mm.

Remarks. Regarding the distribution of the genus *Lacazinella* Crespin, this seems to be confined to southern isolated arcs such as Papua New Guinea, the Arabian Peninsula and Somalia (Drobne *et al*., 2002, Drobne and Cosovic, 2009).

Associated larger foraminifera. This form occurs with *Pseudofallotella persica* (Hottinger and Drobne), *Dictyoconus* cf. *turriculus* Hottinger and Drobne, *Anatoliella ozalpiensis* Sirel, *Ercumentina sayqensis* n. gen. n. sp, *Lacazinella rogeri* n. sp., *Mandanella* cf. *flabelliformis* Rahaghi, *Azzarolina daviesi* (Henson), *Lockhartia retiata* Sander, *Lockhartia haimei* (Davies), *Dictyokathina simplex* Smout and *Kathina* sp.

Superfamily: Soritoidea Ehrenberg, 1839
Family: Soritidae Ehrenberg, 1839

GENUS ***Mandanella*** Rahaghi, 1983

Type species: *Mandanella persica* Rahaghi, 1983

Remarks. There are numerous unclear issues in the description of *Mandanella* Rahaghi given by Rahagi (1983) as well as in the descriptions of the five species ascribed to this genus: *M. persica* Rahagi, *M. flabelliformis* Rahagi, *M. bellasima* Rahagi, *M. paleocenica* Rahagi, and *M. minuta* Rahagi, all defined in the same study. Concerning the description of the genus, there are some architectural features that must be re-studied and redefined in the future in the light of new material**.** The presence of pillars continuously arranged from one chamber to the next, for instance, is one of the main observable characteristics of the morphotypes that is not described in the aforementioned work. The nature of a hypothetical "subepidermal reticulation" also remains to be characterized in detail. Regarding the species listed above, some are poorly figured and their status as independent species is not well justified because they have similar characteristics from architectural and morphometrical points of view. Besides, the species *Mandanella iranica* Rahagi is mentioned in the text (see Rahagi 1983 pg. 42 and 43), but it is neither described nor figured anywhere in the study.

Mandanella cf. *flabelliformis* Rahaghi, 1983 (Fig. 5.11-5.14)

1983 *Mandanella flabelliformis* n. sp. Rahaghi, p. 40-41; pl. 13, figs. 1-9

Material. Samples SI 2, SI 3, SI 4 and SI 6.

Description. Specimens with porcelaneous shells and multiple apertures. The microspheric generation has not been found. Megalospheric forms have planispiral, flabelliform growth (see Fig. 5.11-5.14). Foramina are aligned from one chamber to the next. The large proloculus has a diameter of about 0.45mm followed by a flexostyle (see Fig. 5.12). The endoskeleton is make up of pillars (see Fig. 5.14), and the exoskeleton of peripheral partitions (beams).

FIGURE 6. *Lacazinella rogeri* n. sp. 1-4) centred axial sections. 5) non-centred section close to the axial plane. 6-8) centred equatorial sections. 9-10) centred axial section slightly oblique. 11-17) oblique sections. 11-13) possible microspheric forms. 18) tangential section. 19 and 20) aboral sections; note the pillars of the trematophore (6-10, 12-13 and 15) and apertures (11 and 13). Specimens 1-5, 7, 9-13, 15-16, 19-20 from sample SI 13; 6 and 8 from sample SI 20; 14 from sample SI 14; 17 from sample SI 6 and 18 from sample SI 3. pr: proloculus; fl: flexostyle; a: aperture; bl: basal layer; pi: pillar; psp: preseptal space; s: septum; sl: septulum; th: trematophore.

Remarks. The poor preservation of the specimens (diagenized) does not allow us to observe certain other architectural features such as the relation between peripheral partitions and apertures. Further, the type material figured by Rahagi (1983) does not allow us to clarify these features.

Associated larger foraminifera. This form occurs with *Anatoliella ozalpiensis* SIREL, *Ercumentina sayqensis* n. gen. n. sp, *Lacazinella rogeri* n. sp., *Lockhartia retiata* SANDER and *Kathina* sp.

Subfamily: Soritinae EHRENBERG, 1839

GENUS ***Azzarolina*** VICEDO AND SERRA-KIEL, 2015

Type species: *Taberina daviesi* HENSON, 1950
Azzarolina daviesi (HENSON, 1950) (Fig. 7)

1950 *Taberina daviesi* n. sp. Henson, p. 51-52; pl. 1 figs. 1-3, pl. 2 figs. 1-3.
1983 *Orbitolites shirazensis* n. sp. Rahaghi, p. 46; pl. 18, figs. 1-3.
1993 *Taberina daviesi*. HENSON. Carbone *et al*., 1993, fig. 10b.
1998 *Taberina daviesi* HENSON 1950. Pignatti *et al*., pl. 3 figs. 1-3
2008 *Opertorbitolites* sp. Ismail and Boukhary, pl. 1, figs. 1 and 2.
2015 *Azzarolina daviesi* (HENSON, 1950). Vicedo and Serra-Kiel, p. 372-373, 375; figs. 4-7.

Material. Samples SI 7, SI 9, SI 10, SI 16, SI 17, SI 18 and SI 19.

Description. Porcelaneous discoidal tests, slightly biconcave. Microspheric generation unknown. The specimen illustrated in Fig. 8.10 could be tentatively attributed to a microspheric form because it is twice the size of other specimens. The nepionic stage of megalospheric specimens is composed of a sub-spherical embryo, comprising a large protoconch and a deuteroconch. The embryo is around 0.5mm in diameter (see Fig. 7.1-7.2). The neanic stage shows an annular chamber arrangement (see Fig. 7.7-7.8). The exoskeleton is composed of beams and the endoskeleton of pillars (see Fig. 7.2, 7.5, 7.10). The maximum diameter observed is up to 4mm for megalospheric specimens and around 11mm in the microspheric (?) form (see Fig. 7.10).

Associated larger foraminifera. This form occurs with *Pseudofallotella persica* (HOTTINGER AND DROBNE), *Dictyoconus* cf. *turriculus* HOTTINGER AND DROBNE, *Anatoliella ozalpiensis* SIREL, *Ercumentina sayqensis* n. gen. n. sp., *Lacazinella rogeri* n. sp., *Lockhartia haimei* (DAVIES), *Lockhartia retiata* SANDER and *Kathina* sp.

Family: Keramosphaeridae BRADY, 1884

GENUS ***Keramosphera*** Brady, 1882

Type species: *Keramosphera murrayi* BRADY, 1882
Keramosphera? cf. *iranica* RAHAGHI, 1983 (Fig. 5.10)

Material. Sample SI 22.

Description. Megalospheric form with spherical morphology and concentric arrangement of chambers. The diameter of the test reaches 1.5mm for 17-18 concentric “layers” of chambers. The embryonic apparatus is formed by a protoconch 110 microns in diameter, and a deuteroconch with lunate outline (see Fig. 5.10).

Remarks. The specimen illustrated is similar to the form assigned to *Keramosphera iranica* RAHAGHI (see pl. 19, figs. 1-9; pl. 20, figs. 1-11 in Raghaghi, 1983) and the form assigned to keramospherid genus 11 by SIREL (1998) (see p. 72-73; pl. 7, figs. 1-5; pl. 8, figs. 1-8 in *op. cit.*). However, more material is needed to confirm the specific and generic attribution of this keramospherid.

Associated larger foraminifera. This form occurs with *Dictyoconus* cf. *turriculus* HOTTINGER AND DROBNE, *Lockhartia haimei* (DAVIES), *Daviesina khatiyahi* SMOUT and *Miscellanea juliettae* LEPPIG.

Class: Globothalamea PAWLOWSKI, HOLZMANN, JAROSLAW AND TYSZKA, 2013
Suborder: Rotaliina DELAGE AND HÉROUARD, 1896
Superfamily: Rotalioidea EHRENBERG, 1839
Family: Rotaliidae EHRENBERG, 1839
Subfamily: Lockhartiinae HOTTINGER, 2014

Remarks. This subfamily, which has been recently described in Hottinger’s extensive book on rotaliids (2014), is characterized by including taxa with low-trochospiral shells and a particular umbilical structure consisting of piles and folia delimiting umbilical cavities. The dorsal side is highly ornamented.

GENUS ***Lockhartia*** DAVIES, 1932

Type species: *Dictyoconoides haimei* DAVIES, 1927
Lockhartia haimei (DAVIES, 1927) (Fig. 8.1)

1954 *Lockhartia haimei* (DAVIES). Smout, p. 49; pl. 2, figs. 1-14
1962 *Lockhartia haimei* (DAVIES). Sander, p. 19; pl. 5, figs. 1-37.
1980 *Lockhartia haimei* (DAVIES). Müller-Merz, p. 35; text figs. 18, 19; pl. 1, figs 2-5; pl. 9, figs, 5 and 6; pl. 10, fig. 7; pl. 15, fig. 2

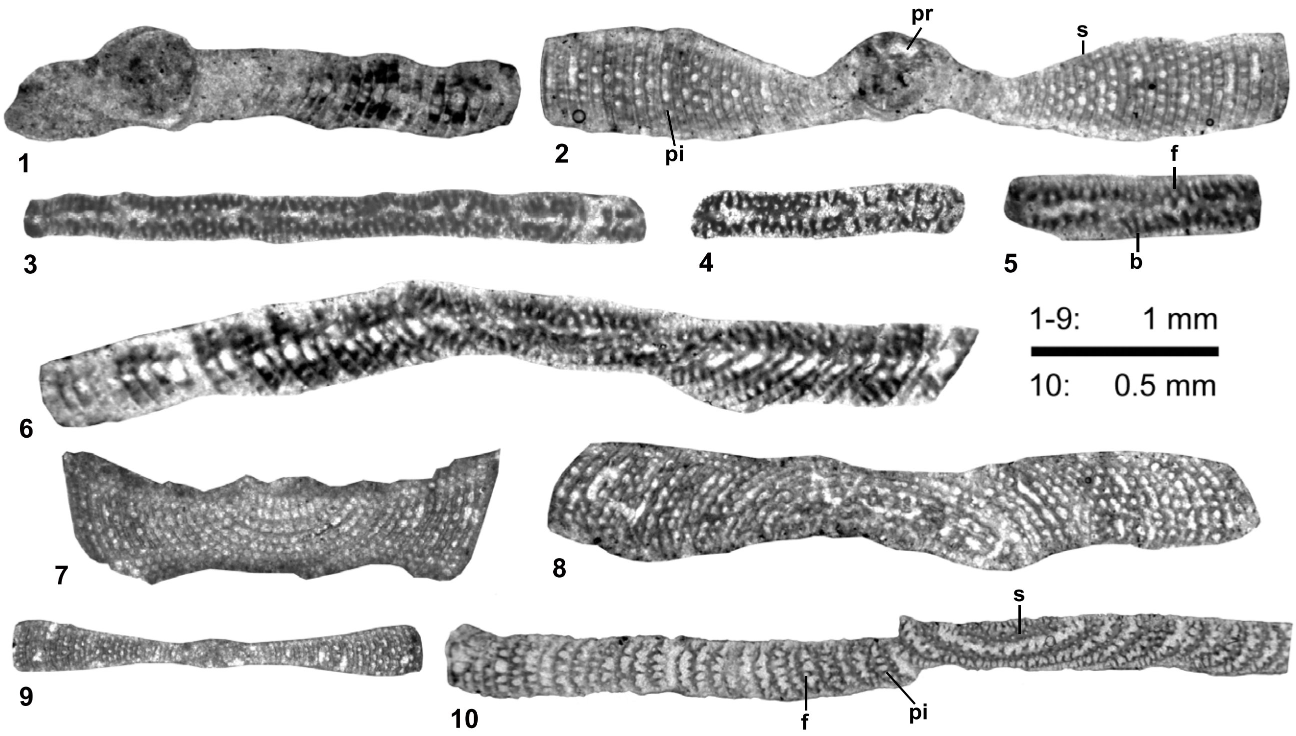

FIGURE 7. *Azzarolina daviesi* (Henson). 1 and 2) centred equatorial sections. 3-5) subaxial sections. 6-8) slightly oblique equatorial sections. 9) subequatorial section. 10) oblique section of possible microspheric form; note the markedly large size of this specimen. Specimens 1 and 3-6 from sample SI 10; 2 from sample SI 17; 7 and 9 from sample SI 16; 8 from sample SI 19 and 10 from sample SI 18. pr: proloculus; pi: pillar; s: septum; b: beam.

1985 *Lockhartia haimei* (Davies). Hasson, p. 360; pl. 4, fig. 12
1991 *Lockhartia haimei* (Davies). Wan, p. 13; pl. 2, figs. 1 and 2
1993 Lockhartia conditi (Nuttall). Weiss, p. 250; pl. 5, fig. 3
2006 *Lockhartia haimei* (Davies). Hottinger, p. 85; pl. 2, fig. 1
2014 *Lockhartia haimei* (Davies). Hottinger, p. 61, 62 and 65; pl. 5.3, figs. 1-2; pl. 5.5, figs. 1-12; pl. 5.6, figs. 1-17; pl. 5.7, figs. 1-12; pl. 5.8, figs. 1-14

Material. Samples SI 18 and SI 22.

Description. Specimen with lamellar, conical test and trochospiral chamber arrangement. The maximum cone diameter and height observed are 2.25mm and 1.2mm, respectively. The dorsal side with a rounded apex is highly ornamented with beads (see Fig. 8.1). The ventral side is convex with an umbilicus formed by folium and filled with 8-9 piles (see Fig. 8.1). The periphery is slightly concave, without a keel, and the proloculus is 0.2mm in diameter.

Associated larger foraminifera. This form occurs with *Dictyoconus* cf. *turriculus* Hottinger and Drobne, *Azzarolina daviesi* (Henson), *Keramosphera*? cf. *iranica* Rahaghi, *Daviesina khatiyahi* Smout and *Miscellanea juliettae* Leppig.

Lockhartia retiata Sander, 1962 (Fig. 8.2-8.5)

1954 *Lockhartia diversa* n. sp. Smout, pars: pl. 3, figs. 16-20
1962 *Lockhartia retiata* n. sp. Sander, p. 22; pl. 4, figs, 1-20
1978 *Lockhartia* sp. Rahaghi, p. 60; pl. 12, figs. 1-7
2009 *Lockhartia haimei* Davies. Afzal *et al.*, pl. 1, figs. 7, 9
2014 *Lockhartia retiata* Sander. Hottinger, p. 65, 67; figs. 5.1A-G and fig. 5.2A-G; pl. 5.9, figs. 1-20; pl. 5.10, figs. 1-16 (bottom)

Material. Samples SI 6, SI 12, SI 13 and SI 17.

Description. Lamellar, conical tests without keel. The chambers are arranged in a high-trochospiral spire. The maximum cone diameter and height observed are 1.6mm and 1.1mm, respectively (see Fig. 8.2). The narrow umbilicus is filled with a few piles. The dorsal side is covered by a peculiar ornamentation formed by short and long spines (see Fig. 8.4, 8.8), and the slightly convex ventral side is composed of folium, apertures and piles. The proloculus is 0.17mm in diameter.

Associated larger foraminifera. This form occurs with *Ercumentina sayqensis* n. gen. n. sp, *Lacazinella rogeri* n. sp., *Mandanella* cf. *flabelliformis* Rahaghi, *Azzarolina daviesi* (Henson), *Dictyokathina simplex* Smout, *Miscellanites globularis* (Rahaghi) and *Kathina* sp.

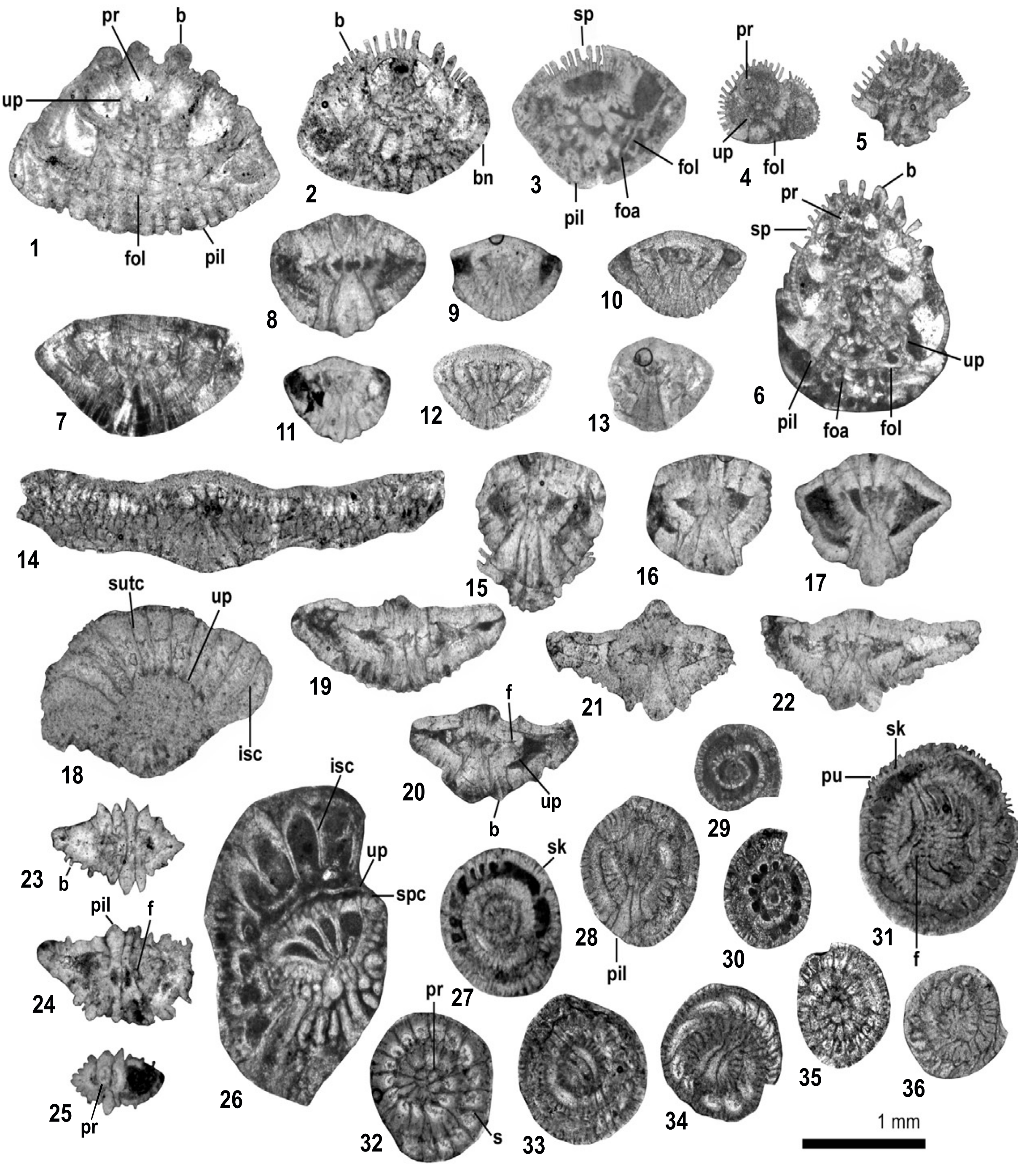

FIGURE 8. A1) *Lockhartia haimei* (Davies) axial section, slightly oblique, specimen from sample SI 18. 2-5) *Lockhartia retiata* Sander. 2) slightly oblique axial section. 3) oblique section. 4) centred axial section, young specimen. 5) peripheral tangential section. Specimens 2 from sample SI 13; 3 from sample SI 12 and 4 and 5 from sample SI 6. 6) *Sakesaria trichilata* Sander axial section; note the ornamentation, specimen from sample SI 23. 7 and 8) *Kathina delseota* Smout axial centred sections, both specimens from sample SI 21. 9-13) *Kathina* sp. axial sections. Specimens 9 from sample SI 17; 10 from sample SI 21; 11 from sample SI 20; and 12 and 13 from sample SI 16. 14) *Dictyokhatina simplex* Smout axial section, specimen from sample SI 13. 15-17) *Elazigina harabekayisensis* Sirel axial sections. All specimens from sample SI 21. 18-22) *Daviesina khatiyahi* Smout. 18) non-centred section close to the equatorial plane, possible microspheric form. 19-22) axial sections (20 centred). All specimens from sample SI 21. 23-26) *Miscellanea juliettae* Leppig. 23-25) axial sections, megalospheric forms. 26) microspheric form, subquatorial section. All specimens from sample SI 22. 27-36) *Miscellanites globularis* Raghaghi. 27) slightly oblique equatorial section. 28, 29, 33 and 36) subequatorial sections. 30, 32 and 35) centred equatorial sections. 31) subequatorial section, possible microspheric form. 34) tangential section. Specimens 27, 29-31 from sample SI 12 and 28, 32-36 from sample SI 13.

GENUS ***Sakesaria*** DAVIES, 1937

Type species: *Sakesaria cotteri* DAVIES, 1937
Sakesaria trichilata SANDER, 1962 (Fig. 8.6)

1962 *Sakesaria trichilata* n. sp. SANDER, p. 29; pl. 5, figs. 38-41
2014 *Sakesaria trichilata* SANDER. Hottinger, p. 95; pl. 5.25, fig. 6

Material. Sample SI 23.

Description. Lamellar, conical test with high-trochospiral chamber arrangement. Ventral sides are strongly convex (hemisphere). Strong ornamentation consists of beads and thin spines (see Fig. 8.6). The maximum cone diameter and height observed are 1.6mm and 1.2mm, respectively. The umbilicus has few piles (see Fig. 8.6), and the umbilical side is formed by folium with apertures and piles (see Fig. 8.6). The megalosphere has a diameter between 0.16-0.19mm.

Subfamily: Kathininae HOTTINGER, 2014

Remarks. This recently described subfamily includes morphotypes with a low trochospiral shell and a massive umbilical structure composed of thick piles and narrow funnels.

GENUS ***Kathina*** SMOUT, 1954

Type species: *Kathina delseota* SMOUT, 1954
Kathina delseota SMOUT, 1954 (Fig. 8.7, 8.8)

1954 *Kathina delseota* n. sp. SMOUT, p. 61; pl. 7, figs. 1-8
2008 *Kathina delseota* SMOUT. BouDagher-Fadel, p. 260; pl. 6.28, fig. 18
2014 *Kathina delseota* SMOUT. Hottinger, p. 101; pl. 6.1, figs. 15-17; pl. 6.2; figs. 1 (bottom), 8-11; pl. 6.5, figs. 1-18

Material. Sample SI 21.

Description. Lamellar, lenticular tests with rounded periphery, and low-trochospiral chamber arrangement. At a cone diameter of 1.5-1.6mm, the height is around 1.2-1.5mm. The dorsal side is flattened and smooth, only decorated with spiral sutures. The axial section shows a ventral side more convex than the dorsal one and a massive umbo with few funnels. The megalosphere has a diameter of about 0.4mm.

Associated larger foraminifera. This form occurs with *Dictyoconus* cf. *turriculus* HOTTINGER AND DROBNE, *Elazigina harabekayensis* SIREL and *Daviesina khatiyahi* SMOUT.

Kathina sp. (Fig. 8.9-8.13)

Material. Samples SI 8, SI 9, SI 13, SI 16, SI 17 and SI 20.

Description. Lamellar, lenticular tests with rounded periphery. Dorsal and ventral sides are smooth. The ventral side is involute and more convex than the dorsal one (see Fig. 8.9, 8.13). The ratio between equatorial and axial length varies from 1.5 to 1.6. The umbonal area is composed of numerous piles perforated by funnels (see Fig. 8.11, 8.13). The proloculus is globular with a diameter of around 0.08mm (see Fig. 8.13).

Associated larger foraminifera. This form occurs with *Dictyoconus* cf. *turriculus* HOTTINGER AND DROBNE, *Anatoliella ozalpiensis* SIREL, *Ercumentina sayqensis* n. gen. n. sp., *Lacazinella rogeri* n. sp., *Mandanella* cf. *flabelliformis* RAHAGHI, *Azzarolina daviesi* (HENSON), *Lockhartia retiata* SANDER, *Dictyokathina simplex* SMOUT and *Miscellanites globularis* (RAHAGHI).

GENUS ***Dictyokathina*** SMOUT, 1954

Type species: *Dictyokathina simplex* SMOUT, 1954
Dictyokathina simplex SMOUT, 1954 (Fig. 8.14)

1954 *Dictyokathina simplex* n. sp. SMOUT, p. 65; pl. 8, figs. 1-11
1985 *Dictyokathina simplex* SMOUT. Hasson, p. 360; pl. 6, figs. 4 and 5
1993 *Dictyokhatina simplex* SMOUT. Carbone *et al*., fig. 9 a
2008 *Dictyokhatina simplex* SMOUT. Ismail and Boukhary, p. 93; pl. 2, fig. 2, non fig. 1
2008 *Dictyokathina simplex* SMOUT. BouDagher-Fadel, p. 260; pl. 6.28, fig. 21
2014 *Dictyokathina simplex* SMOUT. Hottinger, p. 103, 105 and 110; pl. 6.6, figs. 1-13; pl. 6.7, figs. 1-13

Material. Samples SI 12 and SI 13.

Description. Lamellar, very low trochospiral tests with flat morphology, almost discoidal, and rounded periphery. The dorsal side is evolute and decorated by limbate sutures. The multiple spires are poorly observed. There is an umbo formed from strong piles. The maximum cone diameter is around 3.4mm.

Associated larger foraminifera. This form occurs with *Lacazinella rogeri* n. sp., *Lockhartia retiata* SANDER, *Kathina* sp. and *Miscellanites globularis* (RAHAGHI).

GENUS ***Elazigina*** SIREL, 2012

Type species**:** ***Kathina subsphaerica*** SIREL, 1972

Remarks. Rotalids with similar morphostructure to *Elazigina* were informally described as *Plumokathina* by

Hottinger in Peybernès *et al*. (2000) and illustrated by Pignatti in Accordi *et al*. (1998). Recently, this generic name was formally described and illustrated in Hottinger (2014), considering *Kathina subsphaerica* Sirel the type species of that genus. In the meantime, in 2012, Sirel published a paper in which a new genus for the species *Kathina* subsphaerica Sirel was formally described as Elazigina. Therefore, the name *Plumokathina* Hottinger should be considered synonym of *Elazigina* Sirel.

Elazigina harabekayisensis Sirel, 2012 (Fig. 8.15-8.17)

Material. Sample SI 21.

Description. Lamellar, lenticular tests with trochospiral chamber arrangement and acute periphery. The ventral side shows an umbo formed by pillars and a few vertical funnels. The dorsal side shows a few short pillars. The maximum diameter and height of the tests observed are 1.0-1.3mm and 0.6-0.9mm, respectively.

Associated larger foraminifera. This form occurs with *Dictyoconus* cf. *turriculus* Hottinger and Drobne, *Kathina delseota* Smout and *Daviesina khatiyahi* Smout.

Subfamily: Daviesininae Hottinger, 2014

Remarks. This subfamily is characterized by specimens with low to very low trochospiral tests, almost planispiral in some cases, and chambers increasing considerably in diameter through ontogeny. The shells are strongly ornate on ventral and dorsal sides.

GENUS ***Daviesina*** Smout, 1954

Type species: *Daviesina khatiyahi* Smout, 1954

Daviesina khatiyahi Smout, 1954 (Fig. 8.18-8.22)

1954 *Daviesina khatiyahi* Smout n. sp. Smout, p. 67; pl. 12, figs. 1-11; pl. 14, fig. 7
1980 *Daviesina khatiyahi* Smout. Caus *et al*., p. 1054; text fig. 6G, H; pl. 1, fig. 1-3
1985 *Daviesina khatiyahi* Smout. Hasson, p. 360; pl. 5, figs. 4-6
1991 *Daviesina khatiyahi* Smout. Wan, 15; pl. 2, figs. 15 and 16
1993 *Miscellanea miscella* (d'Archiac and Haime). Weiss, p. 252; pl. 1, fig. 6
1998 *Daviesina khatiyahi* Smout. Pignatti *et al*., p. 621; text-figs. 8.1-8
2008 *Daviesina khatiyahi* Smout. Ismail and Boukhary, p. 90; pl. 1, figs. 3-6, non fig. 7
2008 *Daviesina khatiyahi* Smout. Boudagher-Fadel, p. 362; pl. 6.28, fig, 20
2014 *Daviesina khatiyahi* Smout. Hottinger, p. 125; pl. 7.2, figs. 1-16; pl. 7.3, figs. 1-15

Material. Sample SI 21 and SI 22.

Description. Lamellar, lenticular tests with acute or slightly rounded periphery and low-trochospiral almost planispiral chamber arrangement. The ornamentation is based on beads on the dorsal side and piles forming an umbo on the ventral side. The form has an umbilical plate, and intraseptal and sutural canal system (see Fig. 8.18).

Associated larger foraminifera. This form occurs with *Dictyoconus* cf. *turriculus* Hottinger and Drobne, *Keramosphera*? cf. *iranica* Rahaghi, *Lockhartia haimei* (Davies), *Kathina delseota* Smout, *Elazigina harabekayensis* Sirel and *Miscellanea juliettae* Leppig.

Superfamily: Nonionoidea Schultze, 1854
Family: Miscellaneidae Sigal in Piveteau, 1952
Subfamily: Miscellaneinae Kacharava in Rauzer-Chernoussova and Furzenko, 1959

GENUS ***Miscellanea*** Pfender, 1935

Type species: *Nummulites miscella* d'Archiac and Haime, 1853

Miscellanea juliettae Leppig, 1988 (Fig. 8.23-8.26)

1988 *Miscellanea juliettae pfenderae* n. sp. n. ssp. Leppig, p. 700; pl. 1, fig. 4; pl. 2, fig. 4; pl. 3, figs. 4/1 and 4/2; pl. 4, figs. 1-8, non figs. 9-10
2009 *Miscellanea juliettae* Leppig. Hottinger, p. 6; pl. 1, figs. 21-27; pl. 10, figs. 1-20; pl. 11, figs. 1-11

Material. Sample SI 22.

Description. Lamellar, lenticular shells with acute periphery without keel and planispiral chamber arrangement. The ornamentation is composed of beads covering the surface and piles at the polar zone (see Fig. 8.23-8.26). The equatorial diameter in megalospheric forms varies from 1.0 to 1.2mm with three whorls, and with an axial thickness of about 0.6mm. The last whorl contains 16-17 chambers, with diameters varying between 0.8 and 0.16mm. There is a single aperture in an interiomarginal position with an arcuate outline (see Fig. 8.24). In our material, the umbilical plate and the intraseptal and spiral canals can be observed (see Fig. 8.26).

Associated larger foraminifera. This form occurs with *Dictyoconus* cf. *turriculus* Hottinger and Drobne, *Keramosphera*? cf. *iranica* Rahaghi, *Lockhartia haimei* (Davies) and *Daviesina khatiyahi* Smout.

Subfamily: Miscellanitinae Hottinger, 2009

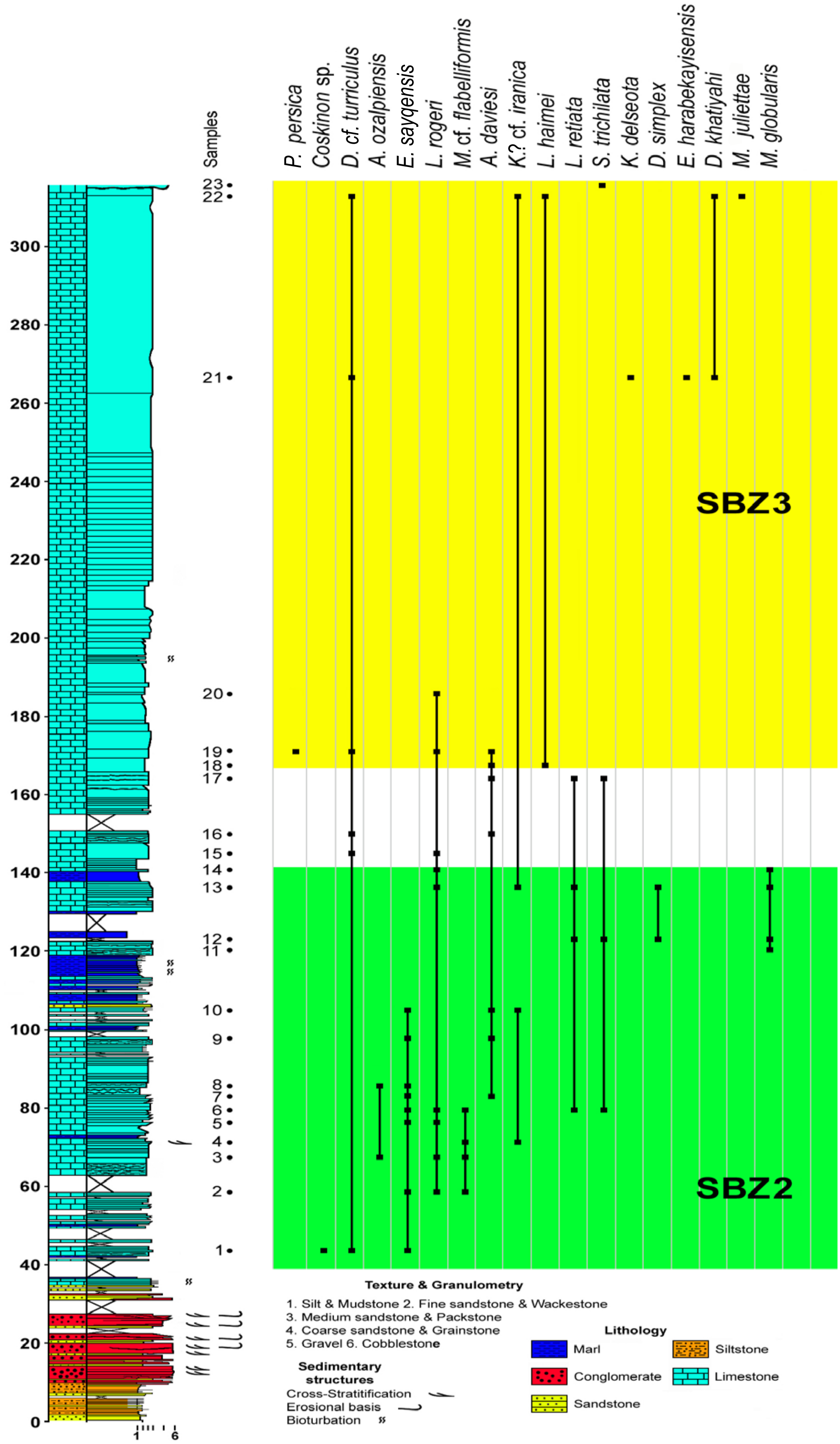

FIGURE 9. Stratigraphic distribution of larger foraminiferal species in the Wadi Sayq stratigraphic section (thickness in meters), eastern Oman Mountains.

GENUS ***Miscellanites*** HOTTINGER, 2009

Type species: *Miscellanea iranica* (RAHAGHI, 1983)

Miscellanites globularis (RAHAGHI, 1978) (Fig. 8.27-8.36)

1978 *Miscellanea globularis* n. sp. RAHAGHI, p. 61; pl. 12, figs. 10-20
1983 *Miscellanea globularis* RAHAGHI. Rahaghi, p. 61; pl. 42, figs. 1-5 and 7
1998 *Miscellanea globularis*? RAHAGHI. Sirel, p. 97; pl. 58, figs. 1-8, 10, 12-14
2009 *Miscellanites globularis* (RAHAGHI). Hottinger, p. 10; pl. 22, figs. 1-24; 7-13

Material. Samples SI 11, SI 12, SI 13 and SI 14.

Description. Lamellar, spherical to ovoid morphology and planispiral chamber arrangement. The surface covered by pustules (see Fig. 8.27, 8.28, 8.31). The equatorial diameter in megalospheric forms varies from 0.8 to 1.0mm, axial thickness of about 0.8mm. There are 3-4 piles at the polar zones (see Fig. 8.28). The protoconch is separated from deuteroconch by a thin wall. The diameter of the megalosphere varies from 0.07 to 0.11mm. Multiple apertures distributed in a single row in the apertural face (see Fig. 8.31). The supplemental skeleton is formed by a simple enveloping canal system (see Fig. 8.31).

Associated larger foraminifera. This form occurs with *Lacazinella rogeri* n. sp., *Lockhartia retiata* SANDER, *Dictyokathina simplex* SMOUT and *Kathina* sp.

BIOSTRATIGRAPHIC DISCUSSION AND CONCLUSIONS

The biostratigraphy of materials outcropping in the Wadi Sayq can be summarized as follows. The underlying Simsima Fm. is Maastrichtian in age according to Schlüter *et al.* (2008), and the Murka Fm. correlates to the Maastrichtian-Danian interval (Biozones P1a and P1b) according to Roger *et al.* (1998). The Cretaceous-Paleogene boundary is located at the upper part of the latter formation. The following lithostratigraphic unit, the Sayq Carbonate and Marls, is upper Danian-lower Selandian, containing the planktonic foraminifera biozones P2 to P3a according to Bourdillon in Roger *et al.*, 1998. These authors also suggested that the Abat Fm., which is the lateral equivalent of the lower part of the Jafnayn Fm., partially studied in this work, is upper Paleocene-lower Eocene, containing the planktonic foraminifera biozones P3b to P6 (Selandian-Cuisian).

The larger foraminifera identified in the Jafnayn Fm. allow us to characterize two assemblages (see Fig. 9). The first one is composed of the following species *Coskinon* sp., *Dictyoconus* cf. *turriculus* HOTTINGER AND DROBNE, *Anatoliella ozalpiensis* SIREL, *Ercumentina sayqensis* n. gen. n. sp., *Lacazinella rogeri* n. sp., *Mandanella* cf. *flabelliformis* RAHAGHI, *Azzarolina daviesi* (HENSON), *Lockhartia retiata* SANDER, *Dictyokathina simplex* SMOUT and *Miscellanites globularis* (RAHAGHI). The second one is composed of the following species: *Pseudofallotella persica* (HOTTINGER AND DROBNE), *Dictyoconus* cf. *turriculus* HOTTINGER AND DROBNE, *Lacazinella rogeri* n. sp., *Azzarolina daviesi* (HENSON), *Keramosphera*? cf. *iranica* RAHAGHI, *Lockhartia haimei* (DAVIES), *Lockhartia retiata* SANDER, *Sakesaria trichilata* SANDER, *Kathina delseota* SMOUT, *Elazigina harabekayisensis* SIREL, *Daviesina khatiyahi* SMOUT, and *Miscellanea juliettae* LEPPIG.

In the first assemblage, the presence of *Miscellanites globularis* (RAHAGHI) allows an assignment of this association to SBZ2, as indicated by Serra-Kiel *et al.* (1998) and Hottinger (2009). It correlates to the planktonic foraminifera biozone P3 indicating an early Selandian age (Roger *et al.*, 1998). The second assemblage with *Miscellanea juliettae* LEPPIG and *Lockhartia haimei* (DAVIES) can be considered to belong to SBZ3 according to Hottinger (2009, 2014), correlated to the planktonic biozone P4 and considered late Selandian-early Thanetian age (Roger *et al.*, 1998).

Regarding the two new taxa proposed in this paper, *Lacazinella rogeri* n. sp. is present in both assemblages (corresponding to the SBZ2 and SBZ3), but *Ercumentina sayqensis* n. gen. n. sp. seems to be restricted to the first assemblage (corresponding to SBZ2).

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