



Danielita gailoti n.gen., n. sp., within the Evolutionary Framework of Middle–Late Permian Dagmaritins

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Abstract: The name *Danielita* is proposed for a new dagmaritin genus characterized by a biserial arrangement of chambers with spine-like extensions at chamber corners and a perforated wall. *Danielita* differs from *Dagmarita*, from which it was derived, by a perforated wall and constitutes one of the peculiar evolutionary trends of the dagmaritin stock. Early dagmaritins evolved from *Globivalvulina cyprica* by the appearance of *Sengoerina* in the Capitanian and the frequently encountered association *G. cyprica*-*Sengoerina*-*Dagmarita*-*Danielita* in Turkey suggests that the evolutionary derivations of dagmaritin genera occurred very rapidly in the Capitanian.

The subfamily Paradagmaritinae is synonymized under the subfamily Dagmaritinae. Among recently introduced genera, only *Paradagmacrusta* is included in the Dagmaritinae. *Labiodagmarita*, *Bidagmarita* and *Siphodagmarita* should be grouped in a new suprageneric taxon related to Paleotextulariidae. Characterized by different wall and chamber structures, *Paradagmaritella* and *Paremiratella* are also kept outside the subfamily Dagmaritinae. *Paradagmaritopsis* seems to be a product of iterative evolution in the Lopingian derived from *Globivalvulina cyprica*, similar to the evolution of *Sengoerina* in the Capitanian. However, its chamber structure suggests that it should be classified in the subfamily Globivalvulininae.

Key Words: Dagmaritins, Permian, evolution, taxonomy, *Danielita*

Orta–Geç Permiyen Dagmaritinlerin Evrimsel Çatısı İçinde *Danielita gailoti* Yeni Cins ve Yeni Tür

Özet: *Danielita* ismi kavkısı delikli ve loca kenarlarında dikensi uzantıları olan biserial bir dagmaritin cinsi için önerilmektedir. *Danielita* türemiş olduğu *Dagmarita*'dan delikli kavkısı ile farklılaşır ve dagmaritin stoğunun beklenmeyen evrimsel gelişimlerinden birini temsil eder. İlk dagmaritinler Kapitaniyen'de *Sengoerina*'ın ilk ortaya çıkışı ile *Globivalvulina cyprica*'dan türemişlerdir. Sık sık rastlanan *G.cyprica*-*Sengoerina*-*Dagmarita*-*Danielita* topluluğu dagmaritin cinslerin Kapitaniyen'de ortaya çıkışlarının çok hızlı ve kısa zaman aralıklarında gerçekleştiğini göstermektedir.

Paradagmaritinae altfamilyası Dagmaritinae altfamilyasının altında sinonimize edilmiştir. Son zamanlarda tanımlanan cinslerden sadece *Paradagmacrusta* Dagmaritinae olarak değerlendirilmektedir. *Labiodagmarita*, *Bidagmarita* ve *Siphodagmarita* Paleotextulariidae ile ilişkili başka bir cins üstü takson içinde gruplanmalıdır. Değişik kavki ve loca yapısına sahip *Paradagmaritella* ve *Paremiratella* Dagmaritinae altfamilyasının dışında tutulması lazımdır. *G. cyprica*'dan Lopingiyen'de iteratif bir evrim ürünü olarak ortaya çıkan *Paradagmaritopsis*'in evrimi Kapitaniyen'deki *Sengoerina*'nın evrimine benzerdir. Bununla beraber, *Paradagmaritopsis*'in loca yapısı bu cinsin Globivalvulininae altfamilyası içine dahil edilmesini gerektiğini göstermektedir.

Anahtar Sözcükler: Dagmaritinler, Permiyen, evrim, taksonomi, *Danielita*

Introduction

In biserial foraminifera the most spectacular evolutionary trend is the rise of dagmaritin stock in

the Middle Permian. Most authors who studied the origin of dagmaritins agree today that the root stock of dagmaritins, the genus *Sengoerina* Altner, 1999,

was derived from *Globivalvulina cyprica* Reichel 1946, which is one of the frequently encountered species in the Tethyan realm (Altner 1997, 1999; Altner & Özkan-Altner 2001; Mohtat-Aghai & Vachard 2003; Gaillot & Vachard 2007). Nestell & Nestell (2006), however, did not classify *Sengoerina* as a dagmaritin and treated it as a member of the family Globivalvulinidae Reitlinger, 1950.

Opinions differ on the interpretation of further evolutionary steps of dagmaritins. Although Altner (1997, 1999) stated that *Dagmarita* Reitlinger, 1965 was derived from *Sengoerina* and gave rise later to *Lousettita* Altner & Brönnimann, 1980 and to *Paradagmarita* Lys in Lys & Marcoux, 1978 via *Crescentia* Ciarapica, Cirilli, Martini & Zaninetti, 1986, Mohtat-Aghai & Vachard (2003) proposed a much older globivalvulinid ancestor for *Dagmarita* and *Sengoerina* as a possible ancestor of *Paradagmarita*. More recently, Vachard *et al.* (2006), Gaillot & Vachard (2007) and Gaillot *et al.* (2009) made quite a considerable change in the taxonomy of the dagmaritin stock. They divided the dagmaritin stock into two subfamilies, Dagmaritinae Bozorgnia, 1973 and Paradagmaritinae Gaillot & Vachard, 2007 and included them within the family of Globivalvulinidae Reitlinger, 1950. The generic contents of both subfamilies have been enlarged by some newly described genera, *Labiogdagmarita* Gaillot & Vachard, 2007; *Bidagmarita* Gaillot & Vachard in Gaillot *et al.* (2009) and *Siphogdagmarita* Gaillot & Vachard in Vachard *et al.* (2006) in the Dagmaritinae and *Paradagmaritella* Gaillot & Vachard, 2007; *Paradagmacrusta* Gaillot & Vachard, 2007; *Paremiratella* Gaillot & Vachard, 2007 and *Paradagmaritopsis* Gaillot & Vachard in Gaillot *et al.* (2009) in their newly described Paradagmaritinae. Gaillot & Vachard (2007), partially agreeing this time with the phylogeny reconstructed by Altner (1997, 1999), accepted the *G. cyprica*-*Sengoerina*-*Dagmarita* lineage by considering *Sengoerina* as a Wordian/Murghabian taxon. According to these authors, the Changsinghian genus *Paradagmarita* was derived from *Globivalvulina* ex gr. *cyprica* with some transitional forms in the early Wuchiapingian and split into several evolutionary trends, all belonging to their newly established subfamily Paradagmaritinae.

This study aims to add a new dagmaritin, *Danielita gailloti* n.gen., n. sp., to this rapidly changing taxonomic frame of dagmaritins as one of the additional steps in their evolution. In addition, a review on the taxonomic composition of dagmaritin stock is presented in order to define and refine the taxonomic limits of the group.

Systematic Descriptions

Class FORAMINIFERA Eichwald, 1830

Order FUSULINIDA Weedekind, 1937

Superfamily BISERIAMMINOIDEA
Chernysheva, 1941

Family GLOBIVALVULINIDAE Reitlinger, 1950

Subfamily DAGMARITINAE Bozorgnia, 1973

Synonyms: Biseriamminidae Chernysheva, 1941 (part); Globivalvulinidae Reitlinger, 1950 (part); Lousettinae Loeblich & Tappan, 1984; Lousettidae Rauzer-Chernousova *et al.*, 1996; Paradagmaritinae Gaillot & Vachard, 2007.

Diagnosis: Test biserially enrolled to biserial, entirely biserial or secondarily biserially enrolled. Chambers angular or laterally produced and spinose. Secondary partitions sometimes present in the outer part of chambers. Wall normally two layered and composed of an outer thin translucent layer and an inner microgranular layer, the latter sometimes perforated. In some genera a thick crust is present at the 'roof' of chambers. Aperture interiomarginal and protected usually by a valvular tooth extending from the edge of the septum.

Remarks: We agree with the latest taxonomical rearrangements proposed by Vachard *et al.* (2006), Gaillot & Vachard (2007) and Gaillot *et al.* (2009), who raised the subfamily Globivalvulinae of Reitlinger (1950) to a family status and transferred the subfamily Dagmaritinae within the family Globivalvulinidae. The family Globivalvulinidae differs from the family Biseriamminidae in having a rather evolved wall structure and a well-developed

valvular projection. Thus, the classification proposed by Zaninetti & Altiner (1981) claiming that the family Biseramminidae comprised the subfamily Biseriamminae, including the genus *Globivalvulina* and allied forms and the subfamily of Dagmaritinae, has been modified in this study and the subfamily Dagmaritinae has been placed within the family Globivalvulinidae.

We, however, still consider the taxonomic limits of the subfamily Dagmaritinae to be as defined in Zaninetti & Altiner (1981) and Altiner (1997, 1999). In this study we review evidence for an evolutionary link between *Dagmarita* and *Crescentia* and we reassign the recently described keeled species '*Paradagmarita*' *zaninettiae* Gaillot & Vachard, 2007 to *Crescentia*. In combination, these relationships suggest the derivation of *Paradagmarita* from dagmaritin stock and the synonymy of *Paradagmaritinae* under *Dagmaritinae*.

We also note that '*Paradagmarita*' *simplex*, introduced as the root stock of '*Paradagmaritinae*' of Gaillot & Vachard (2007), does not justify the direct relation between Globivalvulininae and '*Paradagmaritinae*'. The type of '*Paradagmarita*' *simplex* (Gaillot & Vachard, 2007, Plate 12, Figure 14) is a highly unoriented section of a small globivalvulinin, probably belonging to the *Globivalvulina cyprica* plexus. A tangential section of one of the individuals of this population clearly displays a globivalvulinin character (Gaillot & Vachard, 2007, Plate 49, Figure 1). In addition, the population of '*P*' *simplex*, illustrated in Gaillot & Vachard (2007), consists of individuals of differing taxonomic origin. The form illustrated in their plate 5, figure 9 is definitely a true *Paradagmarita*, probably belonging to *Paradagmarita monodi*.

Generic Composition: *Dagmarita* Reitlinger, 1965; *Sengoerina* Altiner, 1999; *Crescentia* Ciarapica, Cirilli, Martini & Zaninetti, 1986; *Paradagmarita* Lys in Lys & Marcoux, 1978; *Paradagmacrusta* Gaillot & Vachard, 2007; *Louissettita* Altiner & Brönnimann, 1981; *Danielita* n. gen.

Genus *Danielita* n. gen.

Type Species: *Danielita gailloti* n.sp.

Diagnosis: A biserial dagmaritin genus with a two-layered perforated wall and spine-like extensions at chamber corners.

Derivation of Name: The new genus is dedicated to Dr. Daniel Vachard (Université de Lille, France) for his great contributions to the study of Palaeozoic foraminifera.

Description: Test free and composed of biserially arranged chambers, which progressively increase in size, angular toward corners ornamented by spine-like extensions; wall calcareous, two-layered and perforated by oblique pores regularly distributed in the microgranular wall.

Remarks: *Danielita* n. gen. differs from the genus *Dagmarita* from which it was derived in having a perforated microgranular wall. Perforations connect chamber cavities to the exterior particularly in areas where the wall thickens to extend in the form of spines. Although septa are also perforated it is not clear whether pores cross through the outer thin hyaline layer.

In the evolution of whole globivalvulinids the presence of pores in the microgranular wall is quite unusual. The appearance of distinct perforations in the microgranular wall is a generic or even familial character in foraminifera. Although the genesis of pore development is not very well understood in microgranular walls of smaller Palaeozoic foraminifera the genus *Urushtenella* Nestell & Nestell, 2001 from globivalvulinina can be given as a good example to explain the pore development during the evolution. Derived from *Paraglobivalvulina* Reitlinger, 1965 (not from *Paraglobivalvulinoides* Zaninetti & Jenny-Deshusses, 1985) *Urushtenella* bears pores in the 'three layered' microgranular wall and connect chamber cavities to the exterior. This is partly so in *Danielita* because pores connect chamber cavities to the exterior at chamber corners where the wall thickens and extends in the form of spines.

Danielita gailloti n. gen., n.sp.

Plate 1, Figures 1–8, 12; Plate 2, Figures 1–31; Plate 3, Figures 1–6

Diagnosis: A large species of *Danielita* with 6–9 pairs of biserial chambers and a perforated microgranular wall.

Holotype: The specimen in longitudinal frontal section displaying six pairs of chambers is illustrated in Plate 1, Figure 7. It is from sample ORG-4/1, thin section number 7. The holotype is housed in the thin section laboratory of the Marine Micropaleontology Research Unit, Middle East Technical University, Ankara, Turkey.

Derivation of Name: The new species is dedicated to Dr. J. Gaillot (TOTAL, Pau, France) who, under the supervision of Dr. Daniel Vachard, made a considerable contribution to the taxonomy of Middle to Late Permian foraminifera including dagmaritins.

Type Locality: Fifty kilometres east of the city of Bursa. The type material comes from a large olistolith outcropping 0.5 km south of the village of Orhaniye and close to another village, called Dereyörük (Figure 1). This olistolith is embedded in a clastic unit of Late Triassic age which overlies a metamorphic unit intruded by a granite. The section measured in the upper part of the olistolith reveals a rich Permian (Capitanian) fauna. Triassic units containing this olistolith are unconformably overlain by Jurassic clastics and carbonates.

Type Level: Sample ORG-4/1, Capitanian. Stratigraphically in the upper part of the olistolith containing abundant foraminifera and algae.

Material: More than one hundred specimens have been examined in eight samples collected from the Orhaniye-Dereyörük section [samples OR(94)-3, OR(94)-4, ORG-2, ORG-2/1, ORG-2/2, ORG-4, ORG-4/1, ORG-4/2] (Figure 1). In addition, *Danielita gailloti* has also been recorded in the İznik (sample IZ-1) and Danişment (sample DAN-Ö-1c) regions and in one of the Permian pebbles collected from the Neogene conglomerate in the Ankara region (sample OM-1).

Microfossil Association: The new species is associated with several foraminiferal taxa. These are *Reichelina* sp., *Rauserella erratica*, *Minojapanella elongata*, *M.* sp., *Dunbarula* sp., *Codonofusiella* sp., *Lantchichites* sp., *Yangchienia iniqua*, *Y.* sp., *Kahlerina* sp., *Nankinella* sp., *Skinnerella* spp., *Pseudodoliolina* sp., *Neoschwagerina ventricosa*, *N.* spp., *Yabeina* sp., Pseudovidalinidae, *Lasiodiscus* sp., *Globivalvulina cyprica*, *G. vonderschmitti*, *Retroseptellina decrouzeae*, *Paraglobivalvulina* sp., *Septoglobivalvulina* sp., *Sengoerina argandi*, *Dagmarita* ex gr. *chanakchiensis*, Paleotextulariidae, *Endoteba controversa*, *E.* spp., *Neoendothyra* spp., *Geinitzina postcarbonica*, *G.* spp., *Pachyphloia ovata*, *P. iranica*, *P. pedicula*, *Froncina permica*, *Nodosinelloides* spp., *Langella cukurkoyi*, *Pseudolangella fragilis*, *Partisania* sp., *Hemigordius* spp., *Hemigordiopsis renzi*, *Multidiscus padangensis*, *Baisalina pulchra*.

Description: The large test is composed of 6 to 9 pairs of chambers gradually increasing in height and width (Plate 1, Figures 7 & 12). Septa are perfectly curved and well defined giving chambers a rounded aspect in longitudinal frontal sections (Plate 1, Figures 1–2, 5–7 & 12; Plate 2, Figures 1 & 5–8). In longitudinal lateral and transversal sections, chambers appear rectangular (Plate 1, Figures 4, 8; Plate 2, Figures 17–18, 20–21 & 26; Plate 3, Figures 5–6) with well-developed spine-like extensions at chamber corners. The walls along septa thicken from the septal front toward the chamber corners (Plate 1, Figures 1–2, 7, 9; Plate 2, Figures 1, 7, 17–18). The abnormal thickenings seen in the septal wall in some sections are due to oblique sections where the plane of section becomes tangential to the frontal wall and the chamber corners (Plate 1, Figures 2, 5; Plate 2, Figures 2, 8 & 11).

The wall consists of two layers. The outer thin translucent layer is typical for dagmaritins. This translucent layer is sometimes recrystallized, giving the wall of *Danielita* an impression of being composed of a single microgranular layer. However, even if the translucent layer seems to be lacking due to recrystallization, a large number of individuals illustrated in this study exhibit this layer in various stages of their ontogeny (Plate 1, Figures 1, 3, 6–8 &

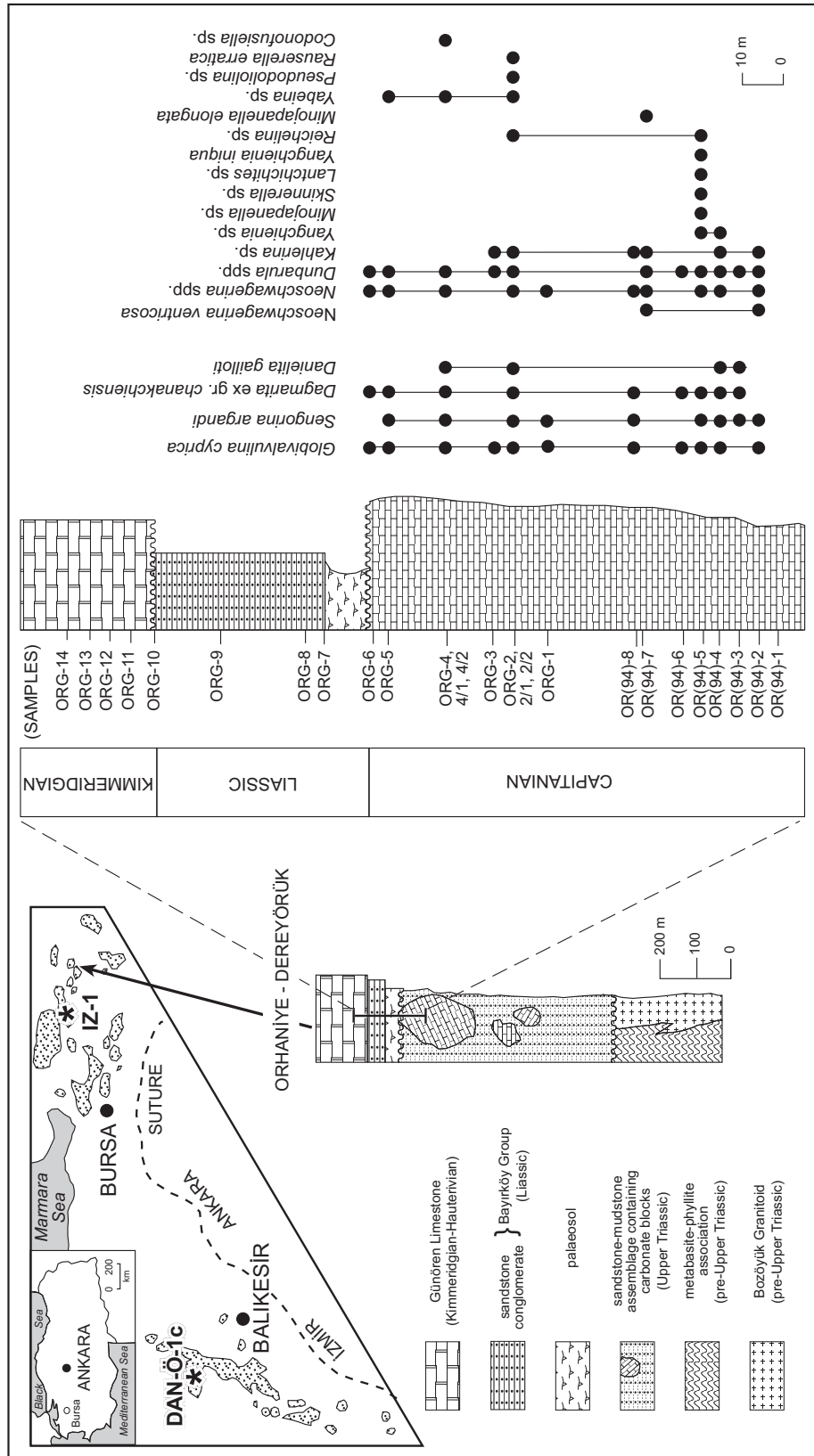


Figure 1. *Danielita gailloti* n. gen., n. sp. in the Orhaniye-Dereyörük section. IZ-1 (İznik region) and DAN-Ö-1c (Danişment region) are the other sample localities in northwestern Anatolia containing *Danielita gailloti* n. gen., n. sp.

12; Plate 2, Figures 1–3, 5, 14, 17 & 20; Plate 3, Figure 1). The two layered wall is best visible at the junction between the chamber of the left row of the penultimate pair and that of the ultimate pair in the specimen illustrated in Plate 1, Figure 6; the chamber of the right row of the penultimate pair and that of the ultimate pair in the holotype (Plate 1, Figure 7) and at the junction between the chamber of the left row of the 5th pair and that of the 6th pair of the specimen are illustrated in Plate 1, Figure 12. In all these cases, the outer hyaline layer is sandwiched between the two microgranular walls of the successive chambers and no additional layer is added as the third layer. However, the microgranular layer of the newly added chamber might extend and overlies the outer hyaline layer of the previous chamber and gives the wall an impression of being composed of three layers (Plate 1, Figures 7–8 & 12). The presence of a discontinuous, but relatively thicker microgranular layer at septal edges or even on the valvular tooth might be explained as secondary deposits or crusts formed after the construction of the chamber (Plate 1, Figure 6). The inner microgranular wall is perforated throughout by pores oblique to perpendicular to the wall (Plate 1, Figures 1–2 & 4–8). Pores, regularly distributed and spaced (Plate 1, Figure 1), connect the chamber cavities to the exterior (Plate 1, Figure 3; Plate 2, Figure 25). This is particularly so where the wall is thick and extends in the form of spines. It is not clear whether the pores are perforating through the outer thin translucent layer which is lining the microgranular wall at septa.

The aperture is an interiomarginal and simple opening protected by a long and straight valvular tooth in the last pair of chambers (Plate 1, Figures 1, 6 & 12; Plate 2, Figures 1, 3, 7 & 14). Short extensions seen at septal fronts in previous chambers (Plate 1, Figure 6) could be either due to the rudimentary nature of the valvular tooth or the orientation of the section cutting the sloping margins of the valvular tooth.

Measurements: Height of the adult test: 690–710 μm ; width of the adult test in frontal view: 410–600 μm ; width of the adult test in lateral view: 225–280 μm ; height of the chambers: 150–210 μm (ultimate

pair), 110–190 μm (penultimate pair); thickness of the wall at septal front: 25–35 μm ; thickness of the wall at the chamber corner: 24–25 μm ; thickness of the translucent layer: 4 μm ; length of spine-like extensions: 110–130 μm .

Remarks: The present form differs from the type species of *Dagmarita* (*D. chanakchiensis* Reitinger, 1965; Plate 2, Figures 5–6) and all ‘other species’ of *Dagmarita* described by various authors (Sosnina in Sosnina & Nikitina 1977; Wang in Zhao *et al.* 1981; Hao & Lin 1982; Vuks in Kotlyar *et al.* 1984; Lin *et al.* 1990) by the perforated nature of the wall. The *Danielita gailloti* population is characteristically large, with massive extensions of the septal wall at chamber corners and oblique to perpendicular and regularly spaced pores in the wall.

Danielita sp. (n. sp.?)

Plate 3, Figures 10–15

More specimens resembling *Dagmarita*, but characterized by a thinner wall have been grouped as a distinct population in this study. Oblique lateral sections (Plate 3, Figures 10–13) display thickenings at chamber corners consisting of pores. In oblique longitudinal frontal sections (Plate 3, Figures 14–15) pores are observed when sections cut through the wall tangentially.

‘*Danielita*’ sp.

Plate 3, Figures 7–8 & 9?

Rare specimens with a distinctly coiled stage have been referred to ‘*Danielita*’ sp. Such forms, morphologically similar to *Danielita gailloti*; consists of at least one whorl in the coiled stage. Biseriality is evident in the last pairs of chambers. ‘*Danielita*’ sp. is phylogenetically related to *Danielita* and represents possibly a further step in the evolution, similar to what we observed in the *Dagmarita*-coiled *Dagmarita* (pre-*Crescentia* stage)-*Crescentia* lineage. Our specimens, described as ‘*Danielita*’ sp., are similar to the coiled *Dagmarita* stage (Plate 3, Figure 18) which was derived from true *Dagmarita* (Plate 3, Figures 18–27) in the Capitanian and led to a new

evolutionary step represented by *Crescentia* (Plate 3, Figure 17). However, we do not know whether ‘*Danielita*’ gave rise to a completely coiled form similar to *Crescentia*.

Evolutionary Framework of Early Dagmaritins

The strongest evidence supporting the evolutionary derivation of dagmaritins from *G. cyprica* (Figure 2) is the similarity in the wall composition and structure in both taxa. *G. cyprica* and dagmaritins possess in their walls a diaphanotheca-like (not sensu Pinard & Mamet 1998), hyaline and translucent outer layer 3–5 microns thick. This structure and the inner, main microgranular wall are persistently observed in all stages of ontogeny after the proloculus both in *G. cyprica* and all members of dagmaritins including *Sengoerina*, *Dagmarita*, *Danielita*, *Louisettita*, *Crescentia*, *Paradagmarita* and *Paradagmacrusta* (Figure 2).

The other strong evidence suggesting an evolutionary link between the early dagmaritins, represented by the genus *Sengoerina*, and *G. cyprica* is the similarity between the embryonic and nepionic chambers seen in equatorial, axial and tangential

sections. In the coiled portion of *Sengoerina*, 6 to 7 pairs of chambers gradually increase in size, tending to become angular at the end of the whorl (Figure 3; Plate 3, Figures 28–34). This angularity, developed markedly in the adult stage of *Sengoerina*, gives the test an aspect completely different than the morphology of globivalvulins which are basically characterized by globular chambers (Altiner 1999). In *G. cyprica* (Plate 3, Figures 35–38; Figure 3 of the text), following an embryonic stage very similar in size and volume to that of *Sengoerina*: later chambers remain globular all throughout the ontogeny.

Based on these two distinct morphological characters of dagmaritins, the wall structure and angularity of chambers, the suprageneric position of several genera recently introduced by Vachard *et al.* (2006), Gaillot & Vachard (2007) and Gaillot *et al.* (2009) under the subfamily Dagmaritinae and Paradagmaritinae (synonymized in this study with Dagmaritinae) have been analyzed in this study. Three genera introduced as dagmaritins, *Labiodagmarita*, *Bidagmarita* and *Siphodagmarita* are all characterized either by a granular wall or a composite wall structure including a granular layer. These taxonomically valid forms, together with

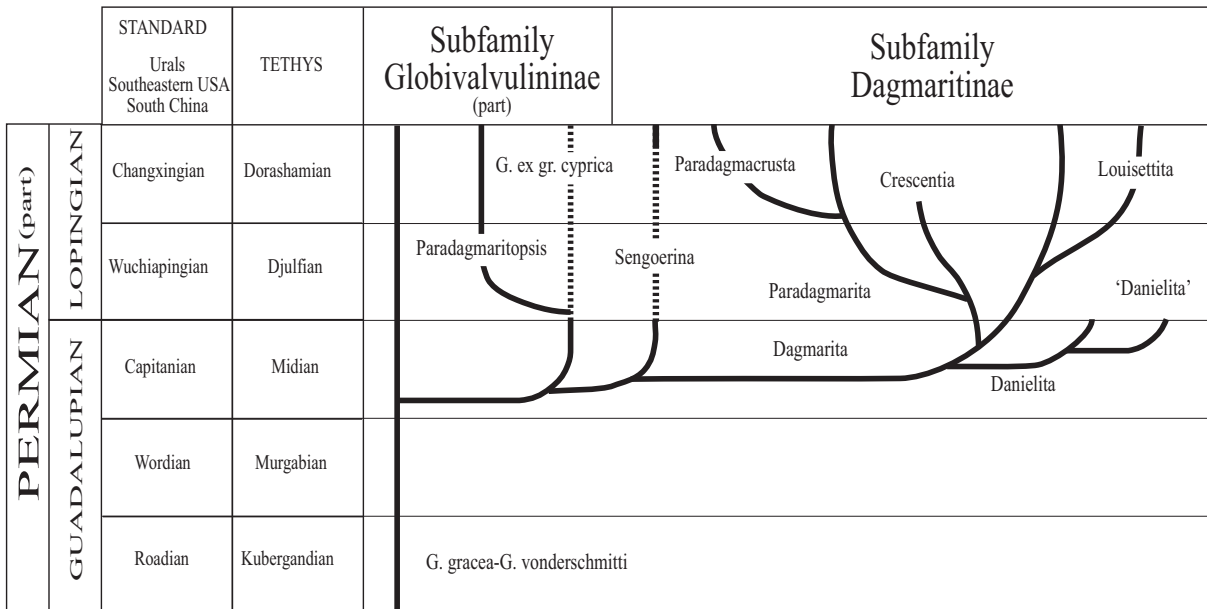
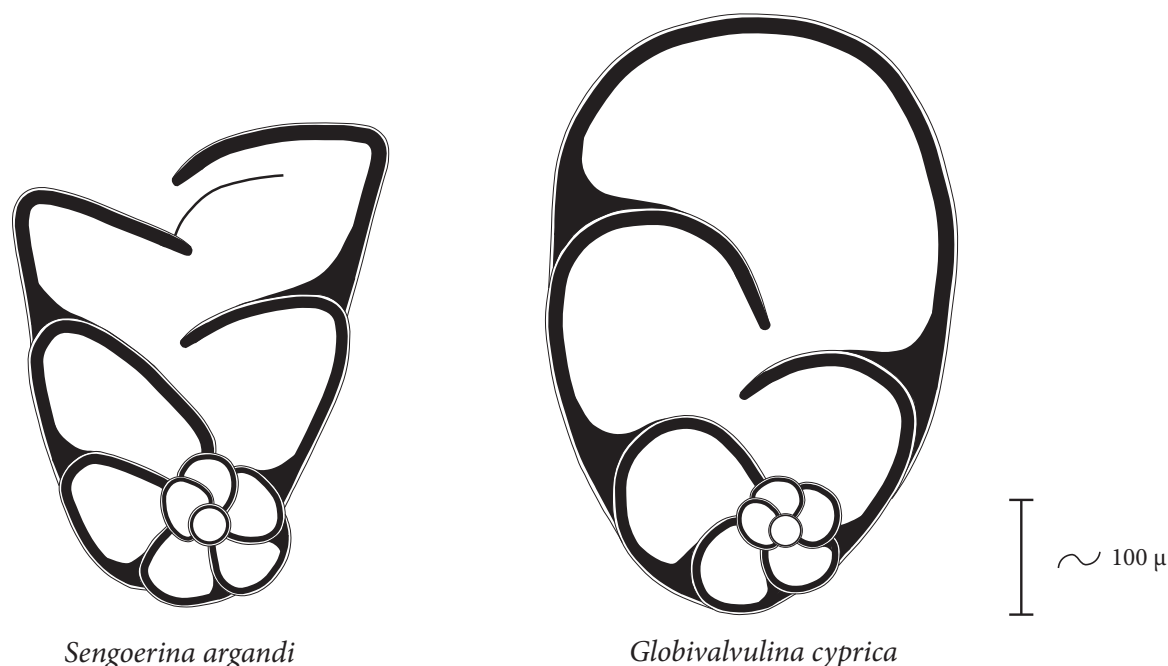


Figure 2. Evolutionary trends of dagmaritins in the Permian.



Sengoerina argandi

Globivalvulina cyprica

Figure 3. Highly schematic and idealized sections of *Sengoerina argandi* and *Globivalvulina cyprica* showing the similarity in the embryonic stage and the wall structure.

'*Dagmarita*' *shahrezahensis* of Mohtat-Aghai & Vachard (2003), should be classified in a different suprageneric taxon which could be related to the evolution of the Paleotextulariidae.

Among paradagmaritin type foraminifera introduced by Vachard *et al.* (2006), Gaillot & Vachard (2007) and Gaillot *et al.* (2009), *Paremiratella* and *Paradagmaritella* should not be regarded as dagmaritins. *Paremiratella*, with its dark brown single layered wall and globular chambers both in axial and tangential sections, should be classified within the subfamily Globivalvulininae. We should however note that the forms illustrated as *Paremiratella* from Hazro and Surmeh in figure 11 of Vachard *et al.* (2006) are true *Paradagmarita* and should not be considered *Paremiratella*. The coarse granular layer of *Paradagmaritella* suggests that this form should also be kept outside the dagmaritin group, and should probably be placed next to the genus *Spireitlina* Vachard in Vachard & Beckary (1991). Gaillot & Vachard (2007) have already suggested the possibility of an evolutionary link between *Paradagmaritella* and *Spireitlina*, although they finally opted for the derivation of

Paradagmaritella from a *Paradagmarita* stock (see figure 9 of Gaillot & Vachard 2007 and figure 12 of Vachard *et al.* 2006).

The two other genera, introduced as *Paradagmacrusta* and *Paradagmaritopsis*, are more forms allied to the dagmaritin stock. We totally agree with Vachard *et al.* (2006) and Gaillot & Vachard (2007) that *Paradagmacrusta* is a genus probably derived from the true *Paradagmarita* by the formation of a thick crust at the 'roof' of chambers and should be regarded as a dagmaritin. We consider *Paradagmaritopsis* as a product of iterative evolution derived in the Lopingian from the *Globivalvulina cyprica* stock following the derivation of *Sengoerina* from the same stock in the Capitanian. However, chambers have never formed angular profiles (see the near axial or longitudinal frontal sections in their plate 5, figure 11; plate 37, figure 7; plate 38, figure 8; plate 42, figures 1 & 6 of Gaillot & Vachard 2007 and also 7, 9 in figure 6 of Gaillot *et al.* 2009) suggesting that this taxon should be placed in the subfamily Globivalvulininae.

In the late Capitanian of Turkey, the globivalvulin ancestor of dagmaritins, *G. cyprica* and the early

dagmaritins, *Sengoerina*, *Dagmarita* and *Danielita* are usually found in association in the samples, suggesting rapid and successive derivations of the latter two taxa. Mohtat-Aghai & Vachard (2003) objected to this proposed relationship of *Sengoerina* and *Dagmarita* by stating that the appearance of *Dagmarita* had been earlier than that of *Sengoerina*. Basing themselves on neoschwagerinid zonation, they referred to the studies of Vachard (1980), Vachard & Montenat (1981) and Altiner (1981) and claimed that *Dagmarita* appeared in the Murgabian (=Wordian), earlier than the Capitanian *Sengoerina*. Recent studies, however, by Leven (1993) and ours in Turkey, reveal that the *Neoschwagerina* zonation in the Murgabian is no longer reliable. Many smaller foraminifera including *Abadehella*, *Dagmarita*, *Sengoerina*, *Neoendothyra*, *Paraglobivalvulina* appeared in the Capitanian above the levels with *Afghanella schencki*, in association with advanced *Afghanella* and *Neoschwagerina* species, *Yabeina*, *Sumatrina*, *Dunbarula*, *Kahlerina* etc. Therefore, we conclude that the appearance of *Dagmarita* and *Sengoerina* did not predate the Capitanian. We note that *Sengoerina* was still considered as a Wordian/Murgabian genus in Gaillot & Vachard (2007) (see also Vachard *et al.* 2006) who, however, admitted *Sengoerina* as a transitional genus between *Globivalvulina cyprica* and *Dagmarita*.

The newly described taxon, *Danielita*, with its perforated and thickened wall, peculiar for the

evolution of dagmaritins, is also added to the dagmaritin association as another evolutionary step in the Capitanian (Figure 2). Derived from *Dagmarita* with a peculiar pore system in the wall, *Danielita* probably gave rise to 'Danielita' (Plate 3, Figures 7 & 8) displaying a coiled stage in its early ontogenetical stage similar to the evolution of the coiled-*Dagmarita* stage (Plate 3, Figure 18) derived from a *Dagmarita* ancestor (Plate 3, Figures 19-27). The reason why we synonymize the Subfamily Paradagmaritinae of Gaillot & Vachard (2007) under the Subfamily Dagmaritinae is the presence of such intermediate forms displaying a secondarily enrolled phase in the evolution of dagmaritins between *Crescentia* and *Dagmarita*. These intermediate forms gave rise to the true *Crescentia* with its type, *Crescentia vertebralis* (Plate 3, Figure 17) which in turn led to the rise of 'Paradagmarita' *zaninettiae* population of Gaillot & Vachard (2007). In the evolution of *Danielita*-'Danielita' lineage, it is not certain, however, whether a totally coiled stage was reached similar to the derivation of *Crescentia*.

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References

- ALTINER, D. 1981. *Recherches stratigraphiques et micropaléontologiques dans le Taurus oriental au NW de Pinarbasi (Turquie)*. Thèse Université de Genève [unpublished].
- ALTINER, D. 1997. Origin, morphologic variation and evolution of dagmaritin-type biserialminid stock in the Late Permian. In: ROSS, C.A., ROSS, J.R.P. & BRECKLE, P.L. (eds), *Late Paleozoic Foraminifera: Their Biostratigraphy, Evolution, and Paleoecology, and the Mid-Carboniferous Boundary*. Cushman Foundation for Foraminiferal Research, Special Publication 36, 1-4.
- ALTINER, D. 1999. *Sengoerina argandi*, n. gen., n. sp., and its position in the evolution of Late Permian biserialminid foraminifera. *Micropaleontology* 45, 215-220.
- ALTINER, D. & BRÖNNIMANN, P. 1980. *Louissetita elegantissima*, n. gen., n. sp., un nouveau foraminifère du Permien supérieur du Taurus oriental (Turquie). *Notes du Laboratoire de Paléontologie de l'Université de Genève* 6, 39-42.
- ALTINER, D. & ÖZGÜL, N. 2001. *Carboniferous and Permian of the Allochthonous Terranes of the Central Tauride Belt, Southern Turkey*. PaleoForams 2001, International Conference on Paleozoic Benthic Foraminifera, Guide Book.
- ALTINER, D. & ÖZKAN-ALTINER, S. 2001. *Charliella rossae* n. gen., n.sp. from the Tethyan Realm remarks on the evolution of Late Permian biserialminids. *Journal of Foraminiferal Research* 31, 309-314.
- BOZORGNIA, F. 1973. Paleozoic foraminiferal biostratigraphy of central and east Alborz Mountains, Iran. *National Iranian Oil Company, Geological Laboratories, Publication* 4, 1-185.

- CHERNYSHEVA, N. E. 1941. A new genus of Foraminifera from the Tournaisian deposits of the Urals. *Doklady Akademiia Nauk SSSR* **32**, 69–78.
- CIARAPICA, G., CIRILLI, S., MARTINI, R. & ZANINETTI, L. 1986. Une microfaune à petits foraminifères d'âge permien remaniée dans le Trias moyen de l'Apennin méridional (Formation de Monte Facito, Lucanie occidentale): description de *Crescentia vertebralis*, n. gen., n. sp. *Revue de Paléobiologie* **5**, 207–215.
- GAILLOT, J. & VACHARD, D. 2007. The Khuff Formation (Middle East) and time equivalents in Turkey and South China: biostratigraphy from Capitanian to Changhsingian times (Permian), new foraminiferal taxa, and palaeogeographical implications. *Coloquios de Paleontologia* **57**, 37–223.
- GAILLOT, J., VACHARD, D., GOLFETTI, T. & MARTINI, R. 2009. New latest Permian foraminifera from Laren (Guangxi Province, South China): palaeobiogeographic implications. *Geobios* **42**, 141–168.
- HAO, X. & LIN, J. 1982. Foraminifera assemblages of Upper Carboniferous Huanglung Formation in Yangchun of Guangdong. *Earth Sciences, Journal of Wuhan College of Geology* **3**, 99–106.
- KOTLYAR, G.V., ZAKHAROV, Y.D., KOCYRKEVICZ, B.V., KROPATCHEVA, G.S., ROSTOVCEV, K.O., CHEIDIJA, I.O., VUKS, G.P. & GUSEVA, E.A. 1984. Evolution of the latest Permian biota, Dzhulfian and Dorashamian regional stages in the USSR (in russian). *Leningrad 'Nauka', Leningradskoe Otdelenie*, 1–200.
- LEVEN, E. Ya. 1993. Main events in Permian history of the Tethys and fusulinids. *Stratigraphy and Geological Correlation* **1**, 51–65.
- LIN, J.-X., LI, J. & SUN, Q. 1990. Late Paleozoic foraminifera in South China. *Science Publication House, Beijing*, 1–269.
- LOEBLICH JR., A.R. & TAPPAN, H. 1984. Suprageneric classification of the Foraminiferida (Protozoa). *Micropaleontology* **30**, 1–70.
- LYS, M. & MARCOUX, J. 1978. Les niveaux du Permien supérieur des nappes d'Antalya (Taurides occidentales, Turquie). *Comptes rendus de l'Académie des sciences Paris* **286** (sér. D), 1417–1420.
- MOHTAT-AGHAI, P. & VACHARD, D. 2003. *Dagmarita shahzaensis* n. sp. Globivalulinid foraminifer (Wuchiapingian, Late Permian, Central Iran). *Rivista Italiana di Paleontologia e Stratigrafia* **109**, 37–44.
- NESTELL, G.P. & NESTELL, M.K. 2006. Middle Permian (Late Guadalupian) foraminifera from Dark Canyon, Guadalupe Mountains, New Mexico. *Micropaleontology* **52**, 1–50.
- PINARD, S. & MAMET, B. 1998. Taxonomie des petits foraminifères du Carbonifère supérieur-Permien inférieur du bassin de Sverdrup, Arctique Canadien. *Paleontographica Canadiana* **15**, 1–253.
- RAUZER-CHERNOUSOVA, D.M., BENSCH, F.P., VDOVENKO, M.V., GIBSHMAN, N.B., LEVEN, E. YA., LIPINA, O.A., REITLINGER, E.A., SOLOVIEVA, M.N. & CHEDIYA, I.O. 1996. Spravochnik po sistematike foraminifer Paleozoya; endothyroidy, Fusulinoidy (Reference book on the systematics of Paleozoic foraminifera; Endothyroida and Fusulinoida). *Rossiiskaya Akademiya Nauk, Geologicheskii Institut, Mokva 'Nauka'*, 1–207.
- REICHEL, M. 1946. Sur quelques foraminifères nouveaux du Permien méditerranéen. *Eclogae Geologicae Helvetiae* **38**, 524–560.
- REITLINGER, E.A. 1950. Foraminifera from the deposits of the Middle Carboniferous of the central part of the Russian Platform (excepting the family Fusulinidae). *Academiia Nauk SSSR, Trudy, Geologischskogo Instituta*, 126, geologicheskaya seriya **47**, [in Russian, French translation BRGM, 1456].
- REITLINGER, E.A. 1965. On the development of the Foraminifera of the Upper Permian and Lower Triassic in Transcaucasia (in russian). *Akademiia Nauk SSSR, Voprosy Mikropaleontologii* **9**, 45–70.
- SOSNINA, M.I. & NIKITINA, A.P. 1977. Fossil flora and fauna of Far East and problems of stratigraphy of Phanerozoic (in russian). *Akademiya Nauk SSSR, Dalnevostochnyi Nauchnyi Tsent, Dalnevostochnyi Geologicheskikh Instituta*, 27–52.
- VACHARD, D. 1980. Téthys et Gondwana au Paléozoïque supérieur. Les données afghanes: biostratigraphie, micropaléontologie, paléogéographie. *Documents et Travaux IGAL* **2**, 1–463.
- VACHARD, D. & BECKARY, S. 1991. Algues et Foraminifères bachkiriens des coal balls de la Mine Rosario (Truebano, Léon, Espagne). *Revue de Paléobiologie* **10**, 315–357.
- VACHARD, D., GAILLOT, J., PILLE, L. & BLAZEJOWSKI, B. 2006. Problems on Biseriaminoidea, Mississippian-Permian biserially coiled foraminifera. A reappraisal with proposals. *Revista Española Micropaleontología* **38**, 453–492.
- VACHARD, D. & MONTENAT, C. 1981. Biostratigraphie, micropaléontologie et paléogéographie du Permien de la région de Tezak (Montagnes Centrales d'Afghanistan). *Paleontographica B* **178**, 1–88.
- ZANINETTI, L. & ALTINER, D. 1981. Les Biseriamminidae (foraminifères) dans le Permien supérieur mésogéen: evolution et biostratigraphie. *Notes du Laboratoire de Paléontologie de l'Université de Genève* **7**, 39–46.
- ZANINETTI, L. & JENNY-DESHUSSES, C. 1985. Les Paraglobivalvulines (foraminifères) dans le Permien supérieur téthysien: répartition géographique et description de *Paraglobivalvulinoides* n. gen., *Revue de Paléobiologie* **4**, 343–346.
- ZHAO, J., SHENG, G., YAO, Z., LIANG, X., CHENG, C., RUI, L. & LIAO, Z. 1981. The Changhsingian and Permian-Triassic boundary of South China. *Bulletin of Nanjing Institute of Geology and Paleontology, Academia Sinica* **2**, 1–85.

PLATE 1

All specimens are from the Middle Permian limestone block embedded within the Upper Triassic Karakaya basinal sequence, Orhaniye-Dereyörük (Northwestern Anatolia, Turkey).

1–8, 12 *Danielita gailoti* n. gen. n.sp. 7: Holotype.

9–11 *Dagmarita* ex gr. *chanakchiensis* Reitlinger, 1965.

1–3, 5–6: Oblique longitudinal frontal sections. 3: Close-up view of Figure 6. Arrows indicate that pores are opening both to the chamber interior and the exterior. 1: Sample ORG-4, thin section 116; 2: ORG-4, ts 106; 3, 6: ORG-4, ts 135; 5: ORG-4, ts 121.

4: Transversal section. ORG-4, ts 121.

7, 9, 12: Longitudinal frontal sections. 7: ORG-4/1, ts 7; 9: OR(94)-8, ts 3; 12: ORG-4, ts 55.

8, 10–11: Longitudinal lateral sections. 8: ORG-4, ts 58; 10: ORG-4, ts 47; 11: ORG-4, ts 71.

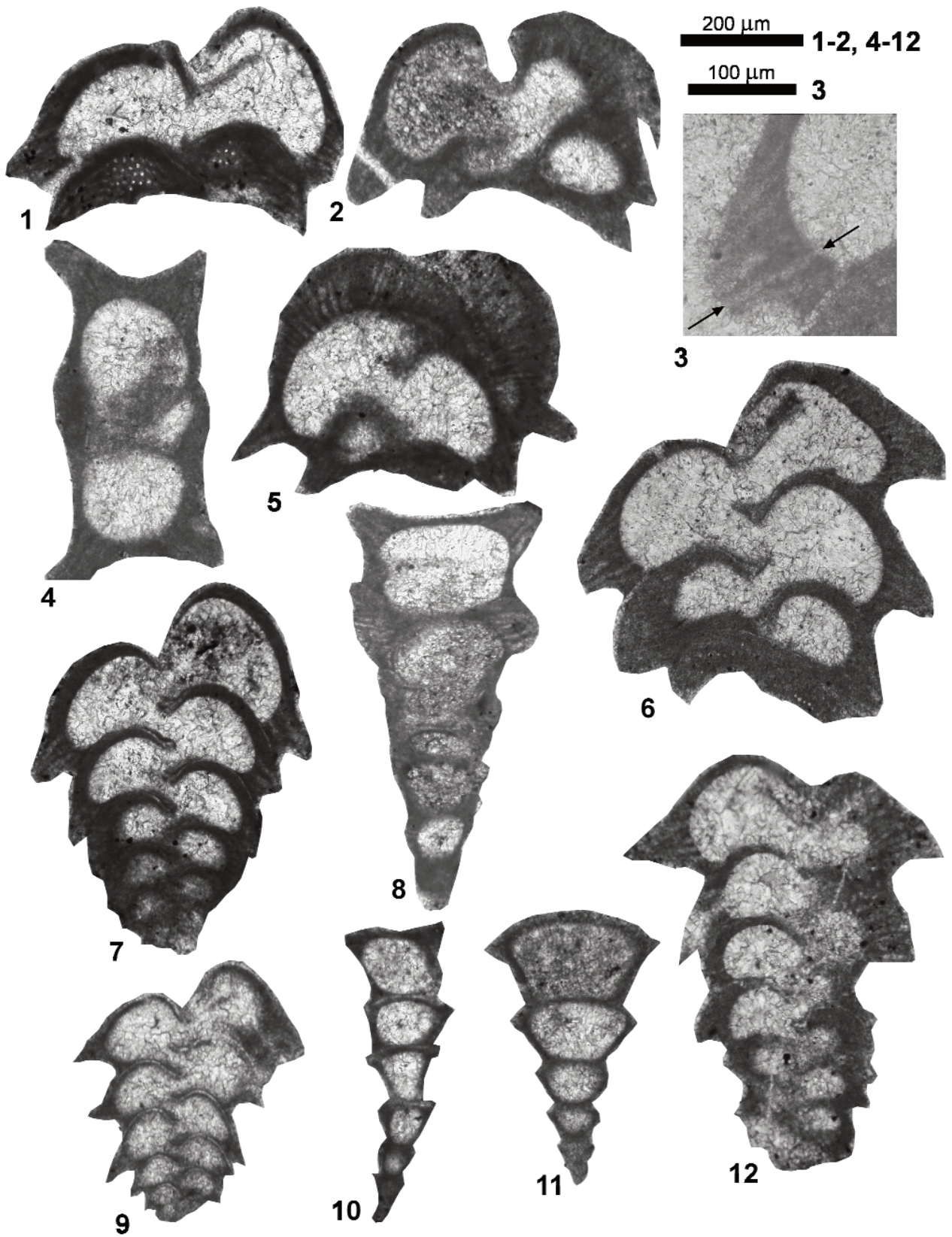


PLATE 2

All specimens, except Figure 20, are from the Middle Permian limestone block embedded within the Upper Triassic Karakaya basinal sequence, Orhaniye-Dereyörük (Northwestern Anatolia, Turkey. Figure 20 is from a pebble of a conglomerate of Neogene age from the Ankara region.

1–31 *Danielita gailoti* n. gen., n. sp.

1–14, 30–31: Oblique longitudinal frontal sections. 1: Sample ORG-4, thin section 121; 2: ORG-4, ts 115; 3: ORG-4, ts 100; 4: ORG-4, ts 98; 5: ORG-4, ts 85; 6: ORG-4, ts 132; 7: ORG-4, ts 120; 8: ORG-4, ts 81; 9: ORG-4, ts 58; 10: ORG-4, ts 54; 11: ORG-4, ts 112; 12: OR(94)-3, ts 5; 13: ORG-4, ts 127; 14: ORG-4, ts 92; 30: ORG-4, ts 65; 31: ORG-4, ts 134.

15–25, 28–29: Oblique longitudinal lateral sections. 25: Arrows indicate the pores opening to the chamber cavity. 15: OR(94)-3, ts 17; 16: ORG-4, ts 108; 17: ORG-4, ts 100; 18: ORG-4, ts 115; 19: ORG-4, ts 154; 20: OM-1, ts 4; 21: ORG-4, ts 57; 22: ORG-4, ts 72; 23: ORG-4, ts 51; 24: ORG-4, ts 41; 25: ORG-4, ts 104; 28: ORG-4, ts 73; 29: ORG-4, ts 48.

26–27: Oblique transversal sections. 26: ORG-4, ts 93; 27: ORG-4, ts 48.

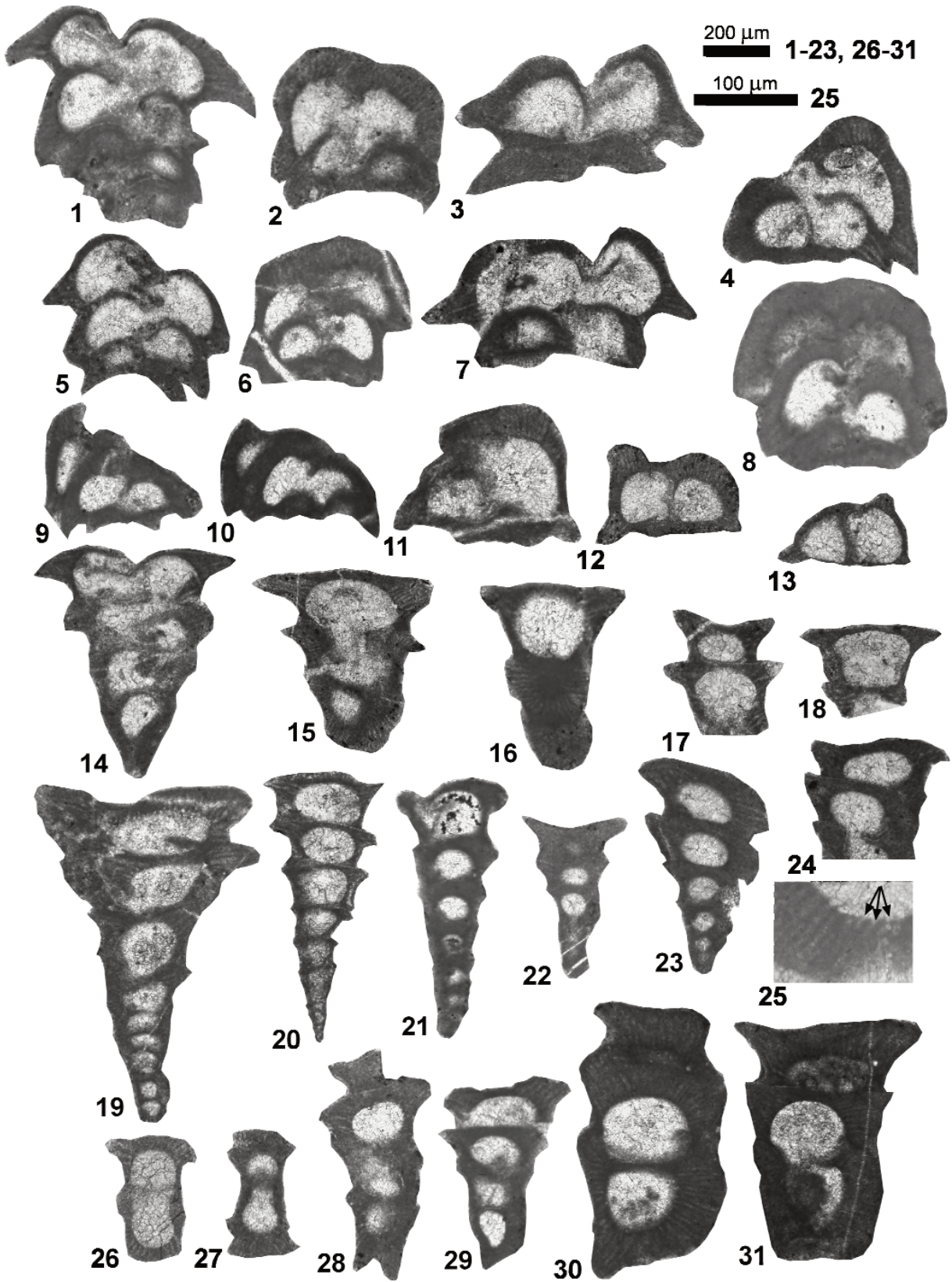


PLATE 3

All specimens, except Figures 17 and 33, are from the Middle Permian limestone block embedded within the Upper Triassic Karakaya basinal sequence, Orhaniye-Dereyörük (Northwestern Anatolia, Turkey). Figure 17 is from the Capitanian of the Aladağ Unit, Hadim-Taşkent area (Taurides) (Altiner & Özgül 2001, p.13). Figure 33 is from a pebble of a conglomerate of Neogene age from the Ankara region.

1–6 *Danielita gailloti* n. gen., n. sp.

7–8 '*Danielita*' sp. with a distinct coiled stage.

9: '*Danielita*' ? sp.

10–15: *Danielita* sp. (n. sp.?).

16: *Crescentia* ? sp.

17: *Crescentia vertebralis* Ciarapica, Cirilli, Martini & Zaninetti, 1986.

18: Coiled *Dagmarita* sp. ('pre-*Crescentia*' stage).

19–23, 25–27: *Dagmarita* ex gr. *chanakchiensis* Reitlinger, 1965.

24: *Sengoerina argandi* Altiner, 1999 (left) and *Dagmarita* ex gr. *chanakchiensis* Reitlinger, 1965 (right).

28–34: *Sengoerina argandi* Altiner, 1999. 34: Holotype.

35–38: *Globivalvulina cyprica* Reichel, 1946.

1, 3–4, 9, 14–15: Oblique longitudinal frontal sections. 1: Sample ORG-4, thin section 100; 3: ORG-4, ts 137; 4: ORG-4, ts 55; 9: ORG-4, ts 115; 14: ORG-4, ts 10; 15: ORG-4, ts 18.

2, 5, 10–13: Oblique longitudinal lateral sections. 2: ORG-4/1, ts 7; 5: ORG-4, ts 52; 10: ORG-4, ts 87; 11: ORG-4, ts 130; 12: ORG-4, ts 51; 13: ORG-4, ts 48.

6: Oblique transversal section. ORG-4, ts 130.

7–8, 16, 18: Partly coiled oblique sections. 7: ORG-4, ts 62; 8: ORG-4, ts 97; 16: ORG-4, ts 84; 18: ORG-4, ts 21.

17: Oblique equatorial section. AG-579, ts 2.

19–27: Nearly longitudinal frontal sections. 19: ORG-2, ts 15; 20: ORG-4, ts 20; 21: ORG-4, ts 66; 22: ORG-2, ts 13; 23: ORG-4, ts 102; 24: ORG-2, ts 12; 25: ORG-4, ts 80; 26: ORG-2, ts 9; 27: ORG-4, ts 84.

28–30, 33: Tangential to oblique or slightly oblique frontal sections. 28: ORG-2, ts 13; 29: OR (94)-8, ts 3; 30: ORG-4, ts 57; 33: OM-1, ts 1.

31, 34: Equatorial to oblique frontal sections. 31: ORG-2, ts 13; 34: ORG-2, ts 34.

32: Equatorial to oblique lateral section. ORG-2/2, ts 13.

35–38: Tangential to slightly oblique tangential sections. 35: ORG-2, ts 14; 36: ORG-2, ts 15; 37: ORG-2, ts 12; 38: ORG-4, ts 85.

